150 Borough Dr, Scarborough ON January 2025 Scarborough Civic Centre – Cooling Tower Replacement		Section 000110 Table of Contents Page 1 of 1
000110	Table Of Contents	
011100	Summary of Work	4
013300	Submittal Procedures	3
017700	Project Closeout	3
017800	Closeout Submittals	7
018290	Demonstration and Training	1
200500	Basic Mechanical Requirements	4
200510	Basic Mechanical Materials and Methods	11
210555	Variable Frequency Drive	5
230520	Condenser Water Piping	3
230715	Mechanical Thermal Insulation	4
236510	Cooling Tower	6
238313	Electric Heating Cable and Control	5
255500	Building Automation System	4
260500	Common Work Requirements - Electrical	12
260583	Electrical Basic Materials	16
262410	Electrical Distribution	7

# **END OF SECTION**

# PART 1 GENERAL

### 1.1 RELATED SECTIONS

.1 All other sections forming part of the contract documentation.

#### **1.2 WORK COVERED BY CONTRACT DOCUMENTS**

- .1 Contractor shall coordinate all construction activities with building operations.
- .2 Work of this Contract comprises replacement of a cooling tower as indicated below:
  - .1 Demolition and removal of existing cooling tower c/w controls, power wiring, control wiring and conduits.
  - .2 Demolition and removal of piping and valves as shown and as required.
  - .3 Demolition and removal of piping insulation and electric heating.
  - .4 Provision of cooling tower c/w basin heater, power wiring, control wiring and conduits as shown on the Contract Drawings and specified hereunder.
  - .5 Provision of condenser water piping c/w fittings, valves, supports and pipe insulation as shown on the Contract Drawings and specified hereunder.
  - .6 Provision of piping insulation c/w aluminum jacketing and electric heat tracing for the proposed cooling tower as specified hereunder.
  - .7 Replacement of the existing roof as indicated on the Contract Drawings.
  - .8 Piping and equipment identification.
  - .9 Associated Electrical work as shown on the Contract Drawings and specified hereunder.
  - .10 Integration of the proposed Cooling Tower into the existing BAS c/w all associated wiring, conduits, graphics, BAS points, and accessories.
  - .11 Testing, commissioning, adjusting and balancing.
  - .12 Warranty: Include all costs for an all inclusive (i.e. materials, labour, consumables, etc.) warranty of all installed components and systems for a period of <u>one (1) year from the date of Substantial Completion.</u>

#### **1.3 CONTRACT METHOD**

- .1 Construct Work under single contract.
- .2 Coordinate with the owner and engage the services of the existing BAS system service contractor for all controls/BAS work.
- .3 Relations and responsibilities between Contractor and Owner are as defined in Conditions of Contract. Assigned Subcontractors must, in addition: Furnish to Contractor bonds covering faithful performance of subcontracted work and payment of obligations there under when Contractor is required to furnish such bonds to Consultant.
  - .1 Purchase and maintain liability insurance to protect Contractor from claims for not less than limits of liability which Contractor is required to provide to Consultant.

1.4		WORK BY OTHERS	
	.1	Co-operate with other Contractors in carrying out their respective works and carry out instructions from Consultant.	
	.2	Co-ordinate work with that of other Contractors. If any part of work under this Contract depends for its proper execution or result upon work of another Contractor, report promptly to Consultant in writing, any defects which may interfere with proper execution of Work.	
	.3	Work of this Project must include provisions for co-ordinating additional work, identified in Contract Documents, for following principal items.	
		.1 Abatement of designated substances.	
1.5		WORK SEQUENCE	
	.1	Construct Work in stages to accommodate Owner's continued use of premises during construction.	
	.2	Co-ordinate Progress Schedule and co-ordinate with Owner Occupancy during construction.	
	.3	Construct Work in stages to provide for continuous public usage. Do not close off public usage of facilities until use of one stage of Work will provide alternate usage.	
	.4	Maintain fire access/control.	
1.6	6 CONTRACTOR USE OF PREMISES		
	.1	Limit use of premises for Work, for storage and for access to allow:	
		.1 Owner occupancy.	
		.2 Partial owner occupancy.	
		.3 Work by other contractors.	
		.4 Public usage.	
	.2	Co-ordinate use of premises under direction of Owner's representative.	
	.3	Obtain and pay for use of additional storage or work areas needed for operations under this Contract.	
	.4	Remove or alter existing work to prevent injury or damage to portions of existing work which remain.	
	.5	Repair or replace portions of existing work which have been altered during construction operations to match existing or adjoining work, as directed by Consultant.	
	.6	At completion of operations condition of existing work shall be equal to or better than that which existed before new work started.	

### 1.7 OWNER OCCUPANCY

.1 Owner will occupy premises during entire construction period for execution of normal operations.

.2 Co-operate with Owner in scheduling operations to minimize conflict and to facilitate Owner usage.

#### 1.8 ALTERATIONS, ADDITIONS OR REPAIRS TO EXISTING BUILDING

- .1 Execute work with least possible interference or disturbance to building operations, occupants, and normal use of premises. Arrange with Owner's representative to facilitate execution of work.
- .2 Use only elevators existing in building for moving workers and material.
  - .1 Protect walls of passenger elevators, to approval of Owner prior to use.
  - .2 Accept liability for damage, safety of equipment and overloading of existing equipment.

### 1.9 EXISTING SERVICES

- .1 Notify, Consultant and utility companies of intended interruption of services and obtain required permission.
- .2 Where Work involves breaking into or connecting to existing services, give the Owner a minimum of 48 hours notice for necessary interruption of mechanical or electrical service throughout course of work. Minimize duration of interruptions. Carry out work at times as directed by governing authorities with minimum disturbance to building operations.
- .3 Provide alternative routes for personnel, pedestrian and vehicular traffic, as deemed necessary by the Consultant or Owner.
- .4 Establish location and extent of service lines in area of work before starting Work. Notify Consultant of findings.
- .5 Submit schedule to and obtain approval from Consultant for any shut-down or closure of active service or facility including power and communications services. Adhere to approved schedule and provide notice to affected parties.
- .6 Provide temporary services to maintain critical building and tenant systems.
- .7 Provide adequate bridging over trenches which cross sidewalks or roads to permit normal traffic.
- .8 Where unknown services are encountered, immediately advise Consultant and confirm findings in writing.
- .9 Protect, relocate or maintain existing active services. When inactive services are encountered, cap off in manner approved by authorities having jurisdiction.
- .10 Record locations of maintained, re-routed and abandoned service lines.
- .11 Construct barriers, in accordance with the applicable standards, as required for execution of this project.

#### 1.10 DOCUMENTS REQUIRED

.1 Maintain at job site, one copy each document as follows:

- .1 Contract Drawings.
- .2 Specifications.
- .3 Addenda.
- .4 Reviewed Shop Drawings.
- .5 List of Outstanding Shop Drawings.
- .6 Change Orders.
- .7 Other Modifications to Contract.
- .8 Field Test Reports.
- .9 Copy of Approved Work Schedule.
- .10 Health and Safety Plan and Other Safety Related Documents.
- .11 Other documents as specified.

# PART 2 PRODUCTS

# 2.1 NOT USED

- .1 Not used.
- PART 3 EXECUTION
- 3.1 NOT USED
  - .1 Not used.

# **END OF SECTION**

# Part 1 GENERAL

### 1.1 SECTION INCLUDES

- .1 Administrative
- .2 Shop drawings and product data.
- .3 Operating Manuals

# 1.2 ADMINISTRATIVE

- .1 Submit to Consultant submittals listed for review. Submit with reasonable promptness and in orderly sequence so as to not cause delay in Work. Failure to submit in ample time is not considered sufficient reason for an extension of Contract Time and no claim for extension by reason of such default will be allowed.
- .2 Work affected by submittal shall not proceed until review is complete.
- .3 Present shop drawings, product data and samples in both Imperial and SI Metric units.
- .4 Where items or information is not produced in SI Metric units converted values are acceptable.
- .5 Review submittals prior to submission to Consultant. This review represents that necessary requirements have been determined and verified or will be, and that each submittal has been checked and coordinated with requirements of Work and Contract Documents. Submittals not stamped, signed, dated and identified as a specific project will be returned without being examined and shall be considered rejected.
- .6 Notify Consultant, in writing at time of submission, identifying deviations from requirements of Contract Documents stating reasons for deviations.
- .7 Verify field measurements and affected adjacent Work is coordinated.
- .8 Contractor's responsibility for errors and omissions in submission is not relieved by Consultant's review of submittals.
- .9 Contractor's responsibility for deviations in submission from requirements of Contract Documents is not relieved by Consultant review.
- .10 Keep one (1) reviewed copy of each submission on site.

#### **1.3 SHOP DRAWING AND PRODUCT DATA**

.1 The term "shop drawings" means drawings, diagrams, illustrations, schedules, performance charts, brochures and other data which are to be provided by Contractor to illustrate details of a portion of Work

- .2 Indicated m a t e r i a l s, m e t h o d s o f construction and attachment or anchorage, erection diagrams, connections, explanatory notes and other information necessary for completion of work. Where article or equipment attach or connect to other articles or equipment, indicate that such items will be supplied and installed. Indicate cross reference to design drawings and specifications.
- .3 Allow 5 days for Consultant's review of each submission.
- .4 Adjustments made on shop drawings by Consultant are not intended to change Contract Price. If adjustments affect value of Work, state such in writing to Consultant prior to proceeding with work.
- .5 Make changes in shop drawings as Consultant may require, consistent with Contract Documents. When resubmitting, notify Consultant in writing of any revision other than those requested.
- .6 Accompany submissions with transmittal letter, in duplicate, containing:
  - .1 Date.
  - .2 Project title and number.
  - .3 Contractors name and address.
  - .4 Identification and quantity of each shop drawing and product data.
  - .5 Other pertinent data.
- .7 Submission shall include:
  - .1 Date and revision dates
  - .2 Project title and number.
  - .3 Name and address of :
    - .1 Subcontractor.
    - .2 Supplier and manufacturers
- .8 Contractor's stamp, signed by Contractors authorized representative certifying approval of submissions, verification of field measurements and compliance with Contract Documents.
- .9 Details of appropriate portions of Work as applicable:
  - .1 Fabrication.
  - .2 Layout,
  - .3 Setting or erection details
  - .4 Capacities.
  - .5 Performance characteristics.
  - .6 Standards.
- .10 After Consultants review, distribute copies.

- .1 Submit one electronic copy of shop drawings for each requirement requested in specification Sections and as consultant may reasonably request.
- .11 Submit one electronic copy of product data sheets or brochures for requirements requested in specification Sections and as requested by Consultant where shop drawings will not be prepared due to standardized manufacture of product.
- .12 Delete information not applicable to project.
- .13 Supplement standard information to provide details applicable to project.
- .14 If upon review by Consultant, no errors or omissions are discovered or if only minor corrections are made, copies will be returned and fabrication and installation of Work may proceed. If shop drawings are rejected, noted copy will be returned and resubmission of corrected shop drawings, through same procedure indicated above, must be performed before fabrication and installation of Work may proceed.

### 1.4 OPERATING MAINTENANCE MANUALS

- .1 Refer to section 019151.
- .2 Two weeks prior to Substantial Performance of the Work, submit to the Consultant (3) three copies of operating and maintenance manuals.
- .3 Manuals to contain operational information on equipment, cleaning and lubrication schedules, filters, overhaul and adjustment schedules and similar maintenance information.
- .4 Bind contents in a three-ring, D ring style hard covered, plastic jacketed binder. Organize contents into applicable categories of work, parallel to specifications Sections.

# END OF SECTION

# PART 1 GENERAL

### 1.1 **REFERENCE STANDARD**

.1 Comply with provisions of OAA, OGCA Document No. 100, "Take-Over Procedures" except as modified in these Specifications.

### **1.2 OPERATING AND MAINTENANCE MANUALS**

- .1 Provide operation and maintenance manuals.
- .2 Provide operating and maintenance data, prepared on 8 1/2" X 11" sheets in printed or typewritten form.
- .3 Provide the following materials as applicable to work of this Contract:
  - .1 Complete list of equipment used in the work showing product name, part number or code and manufacturer for each listing; follow specification format.
  - .2 Brochures, cuts of all equipment and fixtures.
  - .3 Operating and maintenance instructions for all equipment.
  - .4 Valve manual.
  - .5 Controls schematics.
  - .6 Extended warranties.
  - .7 Other data required elsewhere in Contract Documents or deemed necessary by Consultant.

# **1.3 WARRANTIES**

- .1 Definition: Warranty = guarantee.
- .2 Submission Requirements:
  - .1 Submit extended warranties as part of "Operating and Maintenance Manuals".
  - .2 Each warranty must show:
    - .1 Name and address of Project
    - .2 Name of the Owner
    - .3 Section Number and Title
  - .3 All warranties must be presented under Contractor's letterhead, seal and signature and must bear similar wording to that specified in Contract Documents.
  - .4 Submit manufacturers' Product warranties.

# 1.4 RECORD DRAWINGS

.1 Prior to Substantial Performance obtain a CAD file of all Contract Drawings from Consultant and transfer changes, revisions, deletions and additions made throughout the execution of the Work, from the set of prints kept on site to the CAD file.

.2 Clearly and prominently mark each drawing "RECORD DRAWING prepared by (name of Contractor).

## 1.5 CERTIFICATES OF COMPLIANCE

- .1 Submit Certificates of Compliance, prior to the application for Substantial Performance, for each of the following items:
- .2 An affidavit relative to the use of lead-free solder for all domestic water lines, regardless of location.
- .3 Products for which Material Safety Data Sheets have been submitted and accepted.
- .4 Other work/products identified in the contract documents as requiring a certificate of compliance.
- .5 Each Certificate of Compliance shall indicate names and addresses of the project, the Owner, the date of issue, product description including name, number, manufacturer, with a statement verifying that the Work / Product installed meets specified requirements and, if applicable, complies with the submitted and accepted Material Safety Data Sheets.
- .6 Each Certificate of Compliance shall be issued on the subcontractor's letterhead, properly executed, under whose work the respective Work / Product has been provided.
- .7 Each Certificate of Compliance shall be endorsed by the Contractor with his authorized stamp / signature.
- .8 Ensure that submissions are made to allow sufficient time for review without delaying progress of scheduled completion.
- .9 The Completion Security Account will not be paid to the Contractor without submission of all required affidavits and requested material and safety data sheets.

#### **1.6 OPERATING AND MAINTENANCE INSTRUCTIONS**

- .1 Prior to requesting Substantial Performance, at a time acceptable to the Owner and Consultant, but not before operating and maintenance data has been reviewed and accepted by Consultant, instruct designated Owner's representatives in the operation and maintenance of all systems and equipment.
- .2 Arrange training sessions for each type of operating system and equipment. Sessions shall be conducted by qualified instructors and shall be of sufficient duration and depth to adequately instruct participants.
- .3 Throughout the training sessions make reference to reviewed operation and maintenance manuals to familiarize participants with the data provided.
- .4 Prepare an attendance record for each training session, to be signed by each participant upon conclusion of session. Show date and time of session, subject of session and name, title and organization of each participant. Submit a copy of each record to Consultant.
- .5 Subcontractor whose work is subject of training session and Contractor shall be represented during training session by qualified personnel.

### 1.7 SYSTEMS DEMONSTRATION

- .1 Prior to final inspection, demonstrate operation of each system to Owner and Consultant.
- .2 Instruct personnel in operation, adjustment, and maintenance of equipment and systems, using provided operation and maintenance data as the basis for instruction.
- .3 Include specific system demonstration instructions in all sections of the specifications.

#### **1.8 INSPECTION AND ACCEPTANCE OF WORK**

- .1 Prior to application for certificate of Substantial Performance, carefully inspect the Work and ensure it is complete, that major and minor construction deficiencies are complete, defects are corrected and the building is clean and in condition for occupancy. Notify the Consultant in writing, of satisfactory completion of the Work. If Consultant agrees that this stage has been reached, prepare a complete list of deficiencies and submit this list to Consultant.
- .2 On receipt of the above deficiency list in a satisfactory form, the Consultant, accompanied by Subconsultants, the Contractor and the Owner, if deemed necessary, will carry out an inspection of the Project.
- .3 Add to the deficiency list, in accordance with Consultant's directions, any additional deficiencies which are identified during inspection and reissue updated deficiency list.
- .4 When the Consultant considers deficiencies and defects have been corrected and it appears requirements of the Contract have been performed, and all required documents requested have been submitted and accepted, such as maintenance manuals, inspection certificates, acceptance certificates, etc., make application for certificate of Substantial Performance.

### **1.9 FINAL SUBMISSION**

- .1 Prior to claiming Final Payment do the following:
  - .1 Submit record drawings.
    - .1 Submit one complete set of reviewed shop drawings in PDF format.
    - .2 Submit record drawings and maintenance manuals and all instructions suitably labelled with project name and locations in PDF format.
    - .3 Submit a final accounting of all approved changes to the Contract Price, including adjustments to cash allowances.

#### END OF SECTION

# PART 1 GENERAL

# 1.1 RELATED REQUIREMENTS

.1 Section - 01 77 00 Project Closeout.

# 1.2 ADMINISTRATIVE REQUIREMENTS

- .1 Pre-warranty Meeting:
  - .1 Convene meeting one week prior to contract completion with contractor's representative and Owner's representative to:
    - .1 Verify Project requirements.
    - .2 Review manufacturer's installation instructions and warranty requirements.
  - .2 Consultant to establish communication procedures to:
    - .1 Notify construction warranty defects.
    - .2 Determine priorities for type of defects.
    - .3 Determine reasonable response time.
  - .3 Contact information for bonded and licensed company for warranty work action: provide name, telephone number and address of company authorized for construction warranty work action.
  - .4 Ensure contact is located within local service area of warranted construction, is continuously available, and is responsive to inquiries for warranty work action.

#### 1.3 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 Submittal Procedures.
- .2 Two weeks prior to Substantial Performance of the Work, submit to the Owner's Representative a final copy of operating and maintenance manuals in English.
- .3 Provide spare parts, maintenance materials and special tools of same quality and manufacture as products provided in Work.
- .4 Provide evidence, if requested, for type, source and quality of products supplied.

# 1.4 FORMAT

- .1 Organize data as instructional manual in PDF format.
- .2 When multiple binders are used correlate data into related consistent groupings.
  - .1 Identify contents of each binder on spine.
- .3 Cover: identify each binder with type or printed title 'Project Record Documents'; list title of project and identify subject matter of contents.
- .4 Text: manufacturer's printed data, or typewritten data.

- .5 Drawings: provide with reinforced punched binder tab.
  - .1 Bind in with text; fold larger drawings to size of text pages.
- .6 Provide scaled CAD files in dwg format.

### 1.5 CONTENTS - PROJECT RECORD DOCUMENTS

- .1 Table of Contents for Each Volume: provide title of project;
  - .1 Date of submission; names.
  - .2 Addresses, and telephone numbers of Consultant and Contractor and suppliers with name of responsible parties.
  - .3 Schedule of products and systems, indexed to content of volume.
- .2 For each product or system:
  - .1 List names, addresses and telephone numbers of subcontractors and suppliers, including local source of supplies and replacement parts.
- .3 Product Data: mark each sheet to identify specific products and component parts, and data applicable to installation; delete inapplicable information.
- .4 Drawings: supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams.

#### 1.6 AS -BUILT DOCUMENTS AND SAMPLES

- .1 Maintain, in addition to requirements in General Conditions, at site for the Owner's Representative one record copy of:
  - .1 Contract Drawings.
  - .2 Specifications.
  - .3 Addenda.
  - .4 Change Orders and other modifications to Contract.
  - .5 Reviewed shop drawings, product data, and samples.
  - .6 Field test records.
  - .7 Inspection certificates.
  - .8 Manufacturer's certificates.
- .2 Store record documents and samples in field office apart from documents used for construction.
  - .1 Provide files, racks, and secure storage.
- .3 Label record documents and file in accordance with Section number listings in List of Contents of this Project Manual.
  - .1 Label each document "PROJECT RECORD" in neat, large, printed letters.
- .4 Maintain record documents in clean, dry and legible condition.
  - .1 Do not use record documents for construction purposes.

.5 Keep record documents and samples available for inspection by Consultant.

### 1.7 RECORDING INFORMATION ON PROJECT RECORD DOCUMENTS

- .1 Record information on set of blue line opaque drawings, and in copy of Project Manual.
- .2 Use felt tip marking pens, maintaining separate colours for each major system, for recording information.
- .3 Record information concurrently with construction progress.
  - .1 Do not conceal Work until required information is recorded.
- .4 Contract Drawings and shop drawings: mark each item to record actual construction, including:
  - .1 Measured depths of elements of foundation in relation to finish first floor datum.
  - .2 Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
  - .3 Measured locations of internal utilities and appurtenances, referenced to visible and accessible features of construction.
  - .4 Field changes of dimension and detail.
  - .5 Changes made by change orders.
  - .6 Details not on original Contract Drawings.
  - .7 References to related shop drawings and modifications.
- .5 Specifications: mark each item to record actual construction, including:
  - .1 Manufacturer, trade name, and catalogue number of each product actually installed, particularly optional items and substitute items.
  - .2 Changes made by Addenda and change orders.
- .6 Other Documents: maintain manufacturer's certifications, inspection certifications, and field test records required by individual specifications sections.
- .7 Provide digital photos, if requested, for site records.

# **1.8 FINAL SURVEY**

.1 Submit final site survey certificate, certifying that elevations and locations of completed Work are in conformance, or non-conformance with Contract Documents.

### **1.9 EQUIPMENT AND SYSTEMS**

- .1 For each item of equipment and each system include description of unit or system, and component parts.
  - .1 Give function, normal operation characteristics and limiting conditions.
  - .2 Include performance curves, with engineering data and tests, and complete nomenclature and commercial number of replaceable parts.

- .2 Panel board circuit directories: provide electrical service characteristics, controls, and communications.
- .3 Include installed colour coded wiring diagrams.
- .4 Operating Procedures: include start-up, break-in, and routine normal operating instructions and sequences.
  - .1 Include regulation, control, stopping, shut-down, and emergency instructions.
  - .2 Include summer, winter, and any special operating instructions.
- .5 Maintenance Requirements: include routine procedures and guide for trouble-shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.
- .6 Provide servicing and lubrication schedule, and list of lubricants required.
- .7 Include manufacturer's printed operation and maintenance instructions.
- .8 Include sequence of operation by controls manufacturer.
- .9 Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.
- .10 Provide installed control diagrams by controls manufacturer.
- .11 Provide Contractor's co-ordination drawings, with installed colour coded piping diagrams.
- .12 Provide charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.
- .13 Provide list of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.
- .14 Include test and balancing reports as specified in Section 01 91 13 General Commissioning (Cx) Requirements.
- .15 Additional requirements: as specified in individual specification sections.

#### 1.10 MATERIALS AND FINISHES

- .1 Building products, applied materials, and finishes: include product data, with catalogue number, size, composition, and colour and texture designations.
  - .1 Provide information for re-ordering custom manufactured products
  - .2 Instructions for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.
- .2 Moisture-protection and weather-exposed products: include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.

.3 Additional requirements: as specified in individual specifications sections.

#### 1.11 MAINTENANCE MATERIALS

- .1 Spare Parts:
  - .1 Provide spare parts, in quantities specified in individual specification sections.
  - .2 Provide items of same manufacture and quality as items in Work.
  - .3 Deliver to site; place and store.
  - .4 Receive and catalogue items.
    - .1 Submit inventory listing to Owner's representative.
    - .2 Include approved listings in Maintenance Manual.
  - .5 Obtain receipt for delivered products and submit prior to final payment.
- .2 Extra Stock Materials:
  - .1 Provide maintenance and extra materials, in quantities specified in individual specification sections.
  - .2 Provide items of same manufacture and quality as items in Work.
  - .3 Deliver to site; place and store.
  - .4 Receive and catalogue items.
    - .1 Submit inventory listing to Owner's representative.
    - .2 Include approved listings in Maintenance Manual.
  - .5 Obtain receipt for delivered products and submit prior to final payment.

### 1.12 DELIVERY, STORAGE AND HANDLING

- .1 Store spare parts, maintenance materials, and special tools in manner to prevent damage or deterioration.
- .2 Store in original and undamaged condition with manufacturer's seal and labels intact.
- .3 Store components subject to damage from weather in weatherproof enclosures.
- .4 Store paints and freezable materials in a heated and ventilated room.
- .5 Remove and replace damaged products at own expense and for review by Owner's representative.

### 1.13 WARRANTIES AND BONDS

- .1 Develop warranty management plan to contain information relevant to Warranties.
- .2 Submit warranty management plan, 30 days before planned pre-warranty conference, to Owner's representative approval.
- .3 Warranty management plan to include required actions and documents to assure that Owner's representative receives warranties to which it is entitled.
- .4 Provide plan in narrative form and contain sufficient detail to make it suitable for use by future maintenance and repair personnel.

- .5 Submit, warranty information made available during construction phase, to Owner's representative for approval prior to each monthly pay estimate.
- .6 Assemble approved information in binder, submit upon acceptance of work and organize binder as follows:
  - .1 Separate each warranty or bond with index tab sheets keyed to Table of Contents listing.
  - .2 List subcontractor, supplier, and manufacturer, with name, address, and telephone number of responsible principal.
  - .3 Obtain warranties and bonds, executed in duplicate by subcontractors, suppliers, and manufacturers, within ten days after completion of applicable item of work.
  - .4 Verify that documents are in proper form, contain full information, and are notarized.
  - .5 Co-execute submittals when required.
  - .6 Retain warranties and bonds until time specified for submittal.
- .7 Except for items put into use with Owner's permission, leave date of beginning of time of warranty until Date of Substantial Performance is determined.
- .8 Conduct joint 4 month and 9 month warranty inspection, measured from time of acceptance, by Owner's representative.
- .9 Include information contained in warranty management plan as follows:
  - .1 Roles and responsibilities of personnel associated with warranty process, including points of contact and telephone numbers within the organizations of Contractors, subcontractors, manufacturers or suppliers involved.
  - .2 Listing and status of delivery of Certificates of Warranty for extended warranty items, to include HVAC systems.
  - .3 Provide list for each warranted equipment, item, feature of construction or system indicating:
    - .1 Name of item.
    - .2 Model and serial numbers.
    - .3 Location where installed.
    - .4 Name and phone numbers of manufacturers or suppliers.
    - .5 Names, addresses and telephone numbers of sources of spare parts.
    - .6 Warranties and terms of warranty: include one-year overall warranty of construction. Indicate items that have extended warranties and show separate warranty expiration dates.
    - .7 Cross-reference to warranty certificates as applicable.
    - .8 Starting point and duration of warranty period.
    - .9 Summary of maintenance procedures required to continue warranty in force.
    - .10 Cross-Reference to specific pertinent Operation and Maintenance manuals.
    - .11 Organization, names and phone numbers of persons to call for warranty service.

- .12 Typical response time and repair time expected for various warranted equipment.
- .4 Contractor's plans for attendance at 3 and 9 month post-construction warranty inspections.
- .5 Procedure and status of tagging of equipment covered by extended warranties.
- .6 Post copies of instructions near selected pieces of equipment where operation is critical for warranty and/or safety reasons.
- .10 Respond in timely manner to oral or written notification of required construction warranty repair work.
- .11 Written verification to follow oral instructions.
  - .1 Failure to respond will be cause for the Owner's representative to proceed with action against Contractor.

#### 1.14 WARRANTY TAGS

- .1 Tag, at time of installation, each warranted item. Provide durable, oil and water resistant tag approved by Owner's representative.
- .2 Attach tags with copper wire and spray with waterproof silicone coating.
- .3 Leave date of acceptance until project is accepted for occupancy.
- .4 Indicate following information on tag:
  - .1 Type of product/material.
  - .2 Model number.
  - .3 Serial number.
  - .4 Contract number.
  - .5 Warranty period.
  - .6 Inspector's signature.
  - .7 Construction Contractor.

#### PART 2 PRODUCTS

#### 2.1 NOT USED

.1 Not Used.

# PART 3 EXECUTION

#### 3.1 NOT USED

.1 Not Used.

#### Part 1 General

#### **1.1** Administrative Requirements

- .1 Demonstrate operation and maintenance of equipment and systems to Owner's personnel two weeks prior to date of substantial performance.
- .2 Owner: provide list of personnel to receive instructions, and co-ordinate their attendance at agreed upon times.
- .3 Preparation:
  - .1 Verify conditions for demonstration and instructions comply with requirements.
  - .2 Verify designated personnel are present.
  - .3 Ensure equipment has been inspected and put into operation.
  - .4 Ensure each doo's operation equipment and systems are fully operational.
- .4 Demonstration and Instructions:
  - .1 Demonstrate start up, operation, control, adjustment, trouble shooting, servicing, and maintenance of each item of equipment at scheduled times, at the designated location.
  - .2 Instruct personnel in phases of operation and maintenance using operation and maintenance manuals as basis of instruction.
  - .3 Review contents of manual in detail to explain aspects of operation and maintenance.
  - .4 Prepare and insert additional data in operations and maintenance manuals when needed during instructions.

#### 1.2 Action and Informational Submittals

- .1 Provide submittals in accordance with Section 01 33 00 Submittal Procedures.
- .2 Submit schedule of time and date for demonstration of each item of equipment and each system two weeks prior to designated dates, for Departmental Representative's approval.
- .3 Submit reports within one week after completion of demonstration, that demonstration and instructions have been satisfactorily completed.
- .4 Give time and date of each demonstration, with list of persons present.
- .5 Provide copies of completed operation and maintenance manuals for use in demonstrations and instructions.

#### 1.3 Quality Assurance

- .1 When specified in individual Sections requiring manufacturer to provide authorized representative to demonstrate operation of equipment and systems:
- .2 Instruct Owner's personnel.
- .3 Provide written report that demonstration and instructions have been completed.

#### End of Section

#### Part 1 General

### 1.1 SECTION INCLUDES

.1 Materials and methods for mechanical work.

### 1.2 RELATED SECTIONS

.1 Division 01 - General Requirements.

#### 1.3 INTENT

- .1 Provide complete and fully operational mechanical systems with facilities and services to meet requirements described herein and in complete accord with applicable codes and ordinances.
- .2 Drawings are diagrammatic and approximately to scale unless detailed otherwise. They establish scope, material and quality and are not detailed installation instructions.
- .3 Connect to equipment furnished in other sections and by Owner, including uncrating equipment, installing, starting, and testing.

### 1.4 CUTTING AND PATCHING - EXECUTION

- .1 Locate holes and provide sleeves, cutting and fitting required for mechanical work. Relocate improperly located holes and sleeves.
- .2 Perform patching in finished construction of building under the sections of specifications covering these materials.

#### 1.5 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit detailed shop drawings and product data complete with performance data, electrical data and physical data of all equipment and accessories.
- .2 Indicate manufacturer, trade name and model number. Include copies of applicable brochure or catalogue material. Indicate sizes, types, model numbers, ratings, capacities and options actually being proposed.
- .3 Include dimensional data for roughing in and installation, and technical data sufficient to confirm that equipment meets requirements of drawings and specifications.
- .4 Include wiring, piping and service connection data, motor sizes complete with voltage ratings and schedules.

#### 1.6 SUBMITTALS FOR INFORMATION

.1 Manufacturer's Certificate: Certify that specified products meet or exceed specified requirements.

### 1.7 CLOSEOUT SUBMITTALS

.1 Accurately record actual locations of equipment, accessories, structural reinforcement repairs, type of repair, and electrical details of all connected equipment.

#### **1.8 OPERATING AND MAINTENANCE MANUALS**

- .1 Provide a copy of O&M manuals.
- .2 Include in the O&M manuals all documentations as noted in Specifications Section 019151.

#### **1.9 RECORD DRAWINGS**

- .1 Keep on site, an extra set of drawings and specifications recording changes and deviations daily.
- .2 Include for the work required to transfer site changes to Consultant's original CAD files and providing the Owner with one set of hard copy and electronic files of all identified 'Record Drawings'.

#### 1.10 ACCEPTABLE MATERIALS AND EQUIPMENT

.1 Include for products that meet the requirements of the specifications and the design intent and that are manufactured by reputable manufacturers with a proven track record of at least 5 years or as noted within the individual Specification Sections.

#### 1.11 EQUIPMENT PROTECTION AND CLEAN-UP

- .1 Protect equipment and materials in storage on site, during and after installation until final acceptance. Leave factory covers in place and take special precautions to prevent entry of foreign material into working parts of piping and duct systems.
- .2 Protect equipment with polyethylene covers and crates.
- .3 Operate, drain and flush bearings and refill with change of lubricant before final acceptance.
- .4 Protect bearings and shafts during installation. Grease shafts and sheaves to prevent corrosion. Provide extended nipples for lubrication.
- .5 Ensure that existing equipment is carefully dismantled and not damaged or lost. Do not re-use existing materials and equipment unless specifically indicated.

#### 1.12 MATERIAL AND EQUIPMENT

- .1 Material and Equipment: New and quality specified. Statically and dynamically balanced rotating equipment for minimum vibration and low operating noise level.
- .2 Include for all concrete work for mechanical installations. Provide engineered structural drawings and dimensional drawings, templates, anchor bolts and accessories required for mounting and anchoring equipment.

## 1.13 MATERIAL IDENTIFICATION

- .1 Identify piping, ductwork and equipment throughout with labels and direction of flow arrows. Apply labels at 15 metre intervals, before and after pipes pass through walls, at access door openings or closer. Labels shall be black, 20 mm minimum letters on yellow backgrounds.
- .2 Provide 20 mm diameter brass number tags with number stamped in black, secured to valve wheel with key chain for valves not in plain sight of apparatus controlled. Provide neat, typewritten directories giving valve number, valve service and location of valves. Frame one copy under glass for wall mounting.
- .3 Identify electric starting switches and remote push-button stations with 6 mm laminated plastic plates.

#### 1.14 EQUIPMENT BASES AND SUPPORTS

- .1 Where indicated, mount major equipment of reinforced concrete housekeeping bases poured directly on structural floor slab 100 mm thick minimum, extended 100 mm beyond machinery bed-plates. Provide dimensional drawings, templates, anchor bolts and accessories required for mounting and anchoring equipment.
- .2 Construct supports of structural steel members or steel pipe and fittings. Brace and fasten with flanges bolted to structure.

#### 1.15 FLASHING

- .1 Flash and counter flash where mechanical equipment passes through weather or waterproofed walls, floors and roofs.
- .2 Flash vent and soil pipes projecting 80 mm minimum above finished roof surface with lead worked 25 mm minimum into hub, 200 mm minimum clear on sides with minimum 600 mm x 600 mm sheet size. For pipes through outside walls turn flange back into wall and caulk.
- .3 Provide curbs for mechanical roof installations 300 mm minimum high. Flash and counter flash with galvanized steel, soldered and made waterproof.

#### 1.16 SLEEVES

- .1 Set sleeves in position in advance of concrete work. Provide suitable reinforcing around sleeves.
- .2 Extend sleeves through potentially wet floors 25 mm above finished floor level. Caulk sleeves full depth and provide floor plate.
- .3 Where piping or ductwork passes through floor, ceiling or wall, close off space between pipe or duct and construction with non-combustible insulation. Provide tight fitting metal caps on both sides and caulk.
- .4 Install chrome plated escutcheons where piping passes through finished surfaces.

.5 Size large enough to allow for movement due to expansion and to provide for continuous insulation.

### 1.17 INSERTS

- .1 Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms.
- .2 Size inserts to suit threaded hanger rods.

#### 1.18 FLEXIBLE PIPE CONNECTIONS

- .1 Steel Piping: Stainless steel inner hose and braided exterior sleeve.
- .2 Copper Piping: Bronze inner hose and braided exterior sleeve.
- .3 Spool Pieces: Construct to exact size for insertion of flexible connection.

# END OF SECTION

# PART 1 GENERAL

### 1.1 RELATED WORK

- .1 Other Divisions
  - .1 Refer to other divisions of the Specifications and to the Drawings for work related to the mechanical work to avoid interferences with work of other trades (and other contractors) and to ensure proper completion of the work as a whole.

#### **1.2 GENERAL CONSTRUCTION REQUIREMENTS**

- .1 Applicable Codes and Standards
  - .1 Ontario Building Code
  - .2 Occupational Health and Safety Act and Regulations for Construction Projects, Ontario Regulation 691.
  - .3 Owners Health and Safety Requirements
- .2 Measurements and Deviations
  - .1 Where any parts of the mechanical work are specifically located by dimensions on the Drawings, check and verify these dimensions on site prior to installation.
  - .2 Before installing piping, review architectural, structural and electrical Drawings with mechanical Drawings
    - .1 Where interference may occur and departures from arrangements as shown are required, consult with other trades involved, come to agreement as to changed locations or elevations and obtain approval of the Consultant for proposed changes before proceeding with the work.
  - .3 Examine work of other trades or contractors, prior to commencement of mechanical installations.
    - .1 Report in writing, to the Consultant, any discrepancies which will affect mechanical installations.
    - .2 Failure to do so shall be considered acceptance of the conditions.
  - .4 Where site conditions require minor deviations from indicated arrangements or locations, make such changes on approval of the Consultant without additional cost to the Owner.
  - .5 Should any discrepancies occur during installation of mechanical work which will necessitate major revisions to the mechanical trades work or the work of other trades or contractors, notify the Consultant immediately and obtain written authorization before proceeding with the work.
- .3 Building Attachments:
  - .1 Obtain prior written Consultant's approval before drilling, cutting or welding of the building steel or building structure for erection of materials or equipment.
- .4 Overloading
  - .1 During installation of mechanical work, do not load any part of the building structure with a load greater than it is capable of bearing.

- .1 Should any accident occur or damage result through the violation of this requirement, the contractor shall be held solely responsible.
- .2 Design temporary supports used during installation as being equivalent to permanent supports.
- .3 Remove temporary supports at completion of work.
- .5 Cutting and Patching
  - .1 Do not cut, remove or burn structural parts or sections of the building, whether they are steel, concrete or masonry without the written authorization of the Consultant.
  - .2 Should cutting, repairing, and patching of previously finished work of other trades be required to allow installation of mechanical work, pay all costs for the trade concerned to perform the work.

# PART 2 PRODUCTS

# 2.1 BUILDING ATTACHMENTS

- .1 Welding Studs
  - .1 Maximum size: 10mm (3/8") for attaching miscellaneous materials and equipment to building steel.
  - .2 If the weight of materials or equipment require bolts or studs larger than 10mm (3/8") diameter, use steel clips or brackets, secured to building steel by (welding or) bolting as approved by the Consultant.
  - .3 Acceptable Manufacturers:
    - .1 Graham
    - .2 Omark
    - .3 Nelson
    - .4 Or approved equivalent
- .2 Self drilling expansion type concrete inserts:
  - .1 To secure miscellaneous equipment and materials to masonry or concrete construction already in place.
  - .2 Of sufficient number and size to prevent concrete from breaking away.
  - .3 The use of powder or power actuated fasteners will not be allowed unless prior written approval is obtained from the Consultant.
  - .4 Acceptable Manufacturers:
    - .1 ITW "Redhead"
    - .2 Star "SSS"
    - .3 USM "Parabolt"
    - .4 Or approved equivalent
- .3 Supports for any suspended items:
  - .1 Do not fasten/attach to or extend through steel pan type roofs or through concrete slab roofs.
- .4 Beam clamps:

- .1 2-bolt design and of such type that the rod load is transmitted only concentrically to the beam web centreline.
- .2 The use of "C" and "I" beam side clamps, etc., will not be allowed without written consent of the Consultant.
- .3 Acceptable Manufacturers:
  - .1 Grinnell
  - .2 Myatt
  - .3 Carpenter & Paterson
  - .4 Or approved equivalent
- .5 Truss or steel joist roof or floor framing:
  - .1 Locate hangers at or within 150mm (6") of the joist top or bottom chord panel points
  - .2 Otherwise provide additional structural steel as required where hanger spacing does not coincide with joist spacing.
  - .3 Transmit hanger load only concentrically to the supporting truss or joist.
- .6 Secondary structural steel members between trusses and/or joists:
  - .1 Locate at or within 150mm (6") of top or bottom chord panel points.
  - .2 Where the secondary structural steel member cannot be located at or near a truss or joist panel point, provide additional diagonal structural steel web member/members designed for the applicable load to the nearest panel point in the opposite chord member.
    - .1 The above condition may be waived if the load to be suspended between panel points is not in excess of 45kg (100 LB).
  - .3 Diagonal hangers which will induce lateral stresses in the chord members of the joist will not be permitted.

### 2.2 DRIVES AND ACCESSORIES

- .1 Drives
  - .1 V-belt drive selection: 150 percent of the motor size rating.
  - .2 Sheaves: cast iron construction with machined grooves.
    - .1 Sheaves 75mm (3") size and larger diameter: taper lock bushings.
    - .2 Multi-belt drives: matched sets.
    - .3 Statically and dynamically balance all sheaves as an operating unit.
- .2 Adjustable sheaves:
  - .1 Motors less than 1.1Kw (1.5 HP) rating: adjustable pitch motor sheave with diameter range selected to obtain specified RPM of the driven equipment at approximately the mid-point setting of the sheave.
- .3 Fixed Sheaves:
  - .1 Motors of 1.1Kw (1.5 HP) and greater: solid type.
  - .2 Should such sheaves not provide design requirements under operating conditions, supply and install a new drive sheave of proper size at no increase in Contract Price.

- .4 Drive Couplings
  - .1 Acceptable Manufacturers:
    - .1 Falk
    - .2 Fast
    - .3 Thomas
    - .4 Or approved equivalent
- .5 Lubricating Devices
  - .1 Equipment to have oil reservoirs with level indicators, or pressure grease fittings.
  - .2 Inaccessible fittings: provide extended tubes to an accessible location.
  - .3 Grease fittings: Zerk or Alemite.
    - .1 All fittings of one type.
- .6 Drive Guards
  - .1 To OSHA requirements.
  - .2 Build guards of all welded construction on exposed rotating parts or elements and on all drives including the following:
    - .1 V-belt drives
    - .2 Flexible couplings
    - .3 Gear drives
  - .3 Construction (except fan drives):
    - .1 Total enclosure type fabricated of minimum 1.3mm (18 ga.) black sheet steel.
    - .2 Hinged side to allow access for lubrication, inspection or removal of the drive parts.
    - .3 Maximum clearance of openings in guards to rotating parts: not to exceed 13mm (1/2").
    - .4 Make provision for slide rail adjustment.
  - .4 Construction for fan drives:
    - .1 V-belt drives: total enclosure type as specified above.
    - .2 Enclosure sides: 13mm (1/2") mesh, 2.7mm (0.105") wire screening.
    - .3 Tachometer holes at shaft centres, reinforced as required to maintain rigidity of guard.
  - .5 Flexible drive coupling guards:
    - .1 Location: between motor and driven equipment
    - .2 Minimum 1.3mm (18 ga.) black sheet steel, securely fastened to the equipment baseplate and readily removable.
    - .3 Leave a clearance of approx. 13mm to 25mm(1/2" to 1") between the guard and the coupling.
    - .4 Extend the guard to within 13 mm (1/2") of both motor and driven equipment housing.
  - .6 Rework any substandard guards supplied with mechanical equipment to conform to the above requirements.

### 2.3 SEALANTS, CONCRETE AND GROUTS

- .1 Pipe Sleeve Seals
  - .1 Acceptable Manufacturers:
    - .1 Thunderline "Link-Seal" Series LS
    - .2 Or approved equivalent
- .2 Concrete
  - .1 Strength: Unless otherwise noted, 25 MPa concrete: to CSA-A23.1/A23.2
- .3 Concrete Grouts
  - .1 Acceptable Manufacturers:
    - .1 Sternson "M-Bed Standard"
    - .2 Sika "Sikagrout 212"
    - .3 Master Builders "Construction Grout"
    - .4 Meadows "CG-86"
    - .5 Euclid "Euco NS Grout"
    - .6 CPD "Non-Shrink Grout"
    - .7 Or approved equivalent
- .4 Bonding Agents
  - .1 Acceptable Manufacturers:
    - .1 Sika "Sikadur 32" Hi-Mod
    - .2 Or approved equivalent
- .5 Caulking Compounds
  - .1 Acceptable Manufacturers:
    - .1 Denso-Plast
    - .2 Or approved equivalent
- .6 Firestopping
  - .1 ULC listed firestopping assembly
  - .2 Rating to suit wall and floor penetrations
  - .3 Acceptable Manufacturers:
    - .1 Hilti
    - .2 Fire Stop Systems
    - .3 Dow Corning
    - .4 3M
    - .5 Tremco
    - .6 A/D Fire Protection System
    - .7 Johns Manville
    - .8 Or approved equivalent

# PART 3 EXECUTION

# 3.1 EQUIPMENT

- .1 General
  - .1 Install equipment in a compact, neat and workmanlike manner.
    - .1 Align, level and adjust for satisfactory operation.
    - .2 Install in such a manner that connecting and disconnecting of piping and accessories can be made readily and that all parts are easily accessible for inspection, operation, maintenance and repair.
  - .2 Install and start up items of equipment in accordance with the manufacturer's printed installation and operating instructions.
- .2 Noise and Vibration
  - .1 Noise and vibration levels of equipment and systems shall be within design intent.
  - .2 If noise or vibration levels created by any mechanical equipment and systems and transmitted to occupied portions of building or other mechanical work are over the limits, make all necessary changes and additions as approved by the Consultant without additional cost.
- .3 Lubrication
  - .1 Lubricate all equipment prior to start up in accordance with the manufacturer's printed instructions.
  - .2 Supply all lubrication including sufficient quantity for drainage and refilling of oil sumps, etc., when required by manufacturer's instructions.
- .4 Equipment Bases and Pads
  - .1 Construct bases and pads for all mechanical equipment. Pads shall be constructed of concrete c/w reinforcement and dowels.
    - .1 Exception: bases and pads detailed on the structural Drawings.
  - .2 Construction:
    - .1 10 M deformed dowel anchors to concrete slabs (6 per base or pad).
    - .2 Drill slabs and grout dowels in place.
    - .3 Bond pads and bases to floor. Use grout and bonding agent according to manufacturer's printed instructions.
    - .4 Height of bases and pads: minimum of 150mm (6") or as shown.
    - .5 Width and length: sufficient to extend 75mm (3") beyond centreline of anchor bolts, or to extend a minimum of 50mm (2") beyond equipment base.
    - .6 Chamfer all upper perimeter edges of base.
    - .7 On approval of the Consultant, concrete pads of 150mm (6") maximum thickness may be poured under equipment after equipment is set in place, with concrete fully vibrated into place under the equipment base plate.
  - .3 Layout coordination:

- .1 Verify size of bases shown on structural Drawings with actual requirements and advise the Consultant and the respective trades if change in size or shape of pad is required.
- .4 Anchor bolts:
  - .1 Supply anchor bolts required for mechanical equipment unless indicated otherwise on the Drawings.
  - .2 Sleeve anchor bolts.
  - .3 Supply anchor bolts and sleeves to trade constructing bases in sufficient time for setting in formwork prior to placing concrete and provide anchor bolt location drawing or template for locating anchor bolts.
    - .1 Check anchor bolt locations for proper position before concrete is poured.
- .5 Setting and Alignment of Equipment
  - .1 Rotating equipment (fans, pumps, etc):
    - .1 Use millwrights to set and align to lines established with an engineer's level.
    - .2 Shim equipment using standard brass or bronze shim stock of suitable thickness to provide proper level and alignment.
    - .3 Place 25mm (1") minimum thick grout between equipment base and concrete pad or foundation.
    - .4 Have the Consultant approve equipment settings for equipment mounted on concrete pads or foundations prior to grouting.
    - .5 Re-check alignment prior to start-up of equipment.
- .6 Floor Stands
  - .1 Provide stands for floor mounted equipment.
  - .2 Secure to the floor by mild steel floor pads or pipe flanges with bolts or anchors.
- .7 Ceiling or Wall Mounting
  - .1 Where ceiling or wall mounting is indicated or required, provide a suspended platform, bracket or shelf.
  - .2 Materials: standard steel members and steel plates of welded construction throughout.
  - .3 Attach to building steel with rod hangers and beam clamps, or attach to precast structure as the case may be.
  - .4 Place additional structural steel as required between building steel where beam spacing does not meet requirements.
  - .5 Do not use inserts unless specifically shown on the Drawings or approved by the Consultant for any particular item of equipment.
  - .6 Attach brackets or shelves to vertical member or sections of the building structure as hereinbefore specified.
- .8 Suspended Equipment Support: Provide double locknuts on suspended equipment supports as follows:
  - .1 Upper attachment
    - .1 Beam clamp: provide a double nut on end of beam clamp tie rod.

- .2 Supplemental steel: double nut all mechanical fasteners fixing supplemental steel to building structural steel.
- .2 Middle attachment
  - .1 Upper load bearing point, to beam clamp: not applicable.
  - .2 Upper load bearing point, to supplemental steel: double nut on top of load bearing point, single locknut on underside of bearing point
  - .3 Lower load bearing point, all: double nut on underside of bearing point, single locknut on top of bearing point.
- .3 Lower attachment
  - .1 Trapeze hanger or equipment fastening: refer to middle attachment requirements above.
- .4 Apply Loctite 242 to the second nut (and matchmark both nuts).

# 3.2 MISCELLANEOUS STEEL

- .1 General
  - .1 Hang or support equipment, piping, ductwork etc., with miscellaneous structural supports, platforms, braces as may be required unless Drawings or other Sections of the Specifications state otherwise.
- .2 Materials and Fabrication
  - .1 Conform to:
    - .1 CAN/CSA-S16.1-M for materials, design of details and execution of the work.
    - .2 CSA-G40.20/G40.21 grade 300W for structural shapes, plates, etc.
    - .3 CSA W47.1 for qualification of welders.
    - .4 CSA W48.1-M for electrodes (only coated rods allowed).
    - .5 CSA W59-M for design of connections and workmanship.
    - .6 CSA W117.2 for safety.
  - .2 Construction:
    - .1 Welded construction wherever practicable.
    - .2 Chip welds to remove slag, and grind smooth.
    - .3 Bolted joints allowed for field assembly using high strength steel bolts.
- .3 Painting and Cleaning
  - .1 Clean steel to Steel Structures Painting Council SSPC-SP6, Commercial Blast Cleaning.
  - .2 Apply one coat of oil alkyd primer conforming to CISC/CPMA 2.75 to all miscellaneous steel.
  - .3 In the field, touch up all bolt heads and nuts, previously unpainted connections and surfaces damaged during erection with primer as hereinbefore specified.
  - .4 Apply two coats of primer to all surfaces which will be inaccessible after erection.
  - .5 Thoroughly remove all foreign matter from steelwork on completion of installation.

## 3.3 FLASHINGS

- .1 Coordination
  - .1 Coordinate with general trades and roofing supplier.
- .2 Provide flashing and counter-flashing for all mechanical and related electrical penetrations through roof. Costs resulting from failure to comply with this requirement are the sole responsibility of the contractor.
  - .1 Acceptable Manufacturer: Thaler Metal or approved equal.
    - .1 Plumbing Vent: Thaler model MEF-1
    - .2 Flexible steel conduit: Thaler model MEF-2x
    - .3 Hot pipe: MEF-3A with stainless steel collar
    - .4 Type B vents: MEF-4A
    - .5 Rigid conduit: MEF-AE1
    - .6 Gas Piping: MEF-9

#### **3.4 FIRE STOPPING**

- .1 Submittals
  - .1 Submit shop Drawings, including the following information:
    - .1 ULC/CUL listing number
    - .2 Installation Drawings for each type of penetration
    - .3 Installation materials
- .2 General
  - .1 Seal piping, ductwork, conduits and miscellaneous support steel penetrating fire separations.
  - .2 Install fire stopping in accordance with manufacturer's instructions and ULC listing requirements.
  - .3 Provide a written report on completion of fire stopping, by area or floor if necessary, indicating the work is completed and ready for inspection. Do not cover over fire stopping, including installation of walls and ceilings, until work is inspected.

#### 3.5 ADJUSTMENT AND OPERATION OF SYSTEMS

- .1 General
  - .1 When the work is complete:
    - .1 Adjust equipment items of the various systems for proper operation within the framework of design intent, and the operating characteristics as published by the equipment manufacturer.
    - .2 Complete additional instructions are specified under the respective Sections of Division 15.
  - .2 The Consultant reserves the right to require the services of an authorized representative of the manufacturer in the event that any item of equipment is not adjusted properly.
    - .1 Arrange for such services and pay all costs thereof.

.2 After completion of adjustments, place systems in full operating condition and advise the Consultant that the work is ready for acceptance.

# **3.6 ACCEPTANCE**

- .1 General
  - .1 After all equipment has been installed and adjusted and all systems balanced:
    - .1 Conduct performance tests in the presence of the Consultant and the Owner.
    - .2 Arrange the time for these tests at the convenience of the Consultant and the Owner.
    - .3 Conduct tests under climatic circumstances to ensure complete and comprehensive tests and of such a manner and duration as the Consultant may deem necessary.
  - .2 During these tests:
    - .1 Demonstrate the correct performance of all equipment items and of the systems they comprise.
    - .2 Should any system or any equipment item fail to function as required, make such changes, adjustments or replacements necessary to meet performance requirements.
    - .3 Repeat tests until requirements have been fully satisfied and all systems accepted by the Consultant.

# 3.7 COORDINATION WITH SEPARATE TESTING AND BALANCING WORK

- .1 General
  - .1 Review with the Mechanical Contractor before fabrication:
    - .1 Location of balancing devices
    - .2 Test connections
    - .3 Access openings
  - .2 Report conditions which could affect optimum system performance.
  - .3 Inspection:
    - .1 Assure that all testing, balancing and metering devices are installed properly and in pre-selected locations.
    - .2 Report any errors to the Consultant.
    - .3 The Mechanical Contractor will obtain the approval of the Testing and Balancing Firm before relocating these devices due to field conditions.
- .2 TAB Contractor Coordination
  - .1 Cooperate with the Mechanical Contractor giving adequate prior notification of request for services of tradesmen.
  - .2 Coordinate efforts so that items requiring replacement and/or delivery time (sheaves, motors, etc.) are tested as early as possible.
- .3 Mechanical Contractor Coordination
  - .1 Cooperate with the Testing and Balancing Firm.

- .2 Provide the following assistance and/or services:
  - .1 Schedule sufficient time so that the initial testing and balancing can be completed before occupancy begins and coordinate with the trades involved.
  - .2 Keep the Testing and Balancing Company informed of any major changes made during construction and provide same with a set of project Drawings and reviewed Shop Drawings.
  - .3 Provide balancing devices, test connections access openings, balancing probe inlets and plugs.
  - .4 Clean and pre-run all equipment, filters, etc. and place all heating, ventilating and air conditioning systems into full operation and continue same during each working day of testing and balancing.
  - .5 Provide immediate labour from pertinent mechanical trades and tools, equipment and materials to make equipment and system alterations and adjustments, as required including control adjustments.
  - .6 Make available all equipment data (Shop Drawing performance data and operating instructions) to the Testing and Balancing Firm.
- .3 As part of the coordination effort, the Mechanical Contractor will be fully responsible for systems constructed, installed and adjusted to Provide optimum performance as required by design intent. Any re-adjusting required as the result of spot checks by the Consultant shall be done at no increase in Contract Price.
- .4 Nothing contained in this Section voids the responsibility of the Mechanical Contractor (Subcontractor) for systems constructed, installed and adjusted to achieve the design intent.

# **END OF SECTION**

# Part 1 GENERAL

#### 1.1 General

- .1 Conform to all applicable Sections of Division 1 and Section 21 05 00 General Instructions for Mechanical Sections.
- .2 Provide all labour, materials, products, equipment and services to supply and install variable speed drives as indicated on the Contract Drawings and specified in this Section of the Specification.

#### 1.2 Quality Assurance

- .1 The Variable Frequency Drive (VFD) manufacturing facility shall be ISO 9001 certified. The VFD shall be UL, ULC and CSA listed.
- .2 Provide a minimum 100,000 hours mean time before failure (MTBF).
- .3 The manufacturer or their representatives shall be provided the project electrical power single line diagram, providing the data required by IEEE-519, to perform an analysis to initially demonstrate the supplied equipment will meet the IEEE standards after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then this equipment shall be provided. A harmonic analysis shall be submitted with the approval drawings to verify compliance with the latest version of IEEE-519 voltage and current distortion limits as shown in table 10.2 and 10.3 at the point of common coupling (PCC). The PCC shall be defined as the consumer–utility interface or primary side of the main distribution transformer.
- .4 The term Variable Frequency Drive (VFD) shall be synonymous with Variable Speed Drives (VSD) and Adjustable Frequency Drives (AFD).
- .5 All Variable Frequency Drives for this project shall be of a single manufacturer for all specified systems.

#### Part 2 PRODUCTS

#### 2.1 General Requirements

- .1 Variable frequency drives (VFD) shall be from Danfoss, Allan-Bradley, ABB or approved equivalent, as specified herein for the equipment designated on the schedules.
- .2 All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. The VFD's UL listing shall allow it to be mounted in a plenum or other air handling compartments.
- .3 The VFD shall be housed in a UL Type-1 ventilated enclosure, Type-12 totally enclosed, gasketed enclosure.
- .4 The VFD shall be a digitally controlled drive, using, the Pulse Width Modulation (PWM) technology with sensorless vector control. It shall utilize Insulated-Gate Bi-Polar Transistors (IGBT's) in its inverter section.

- .5 The VFD shall allow the motor to produce full rated power at rated amps, root mean square (RMS) fundamental volts, and speed without using the motor's service factor when the motors rated voltage is applied to the VFD input.
- .6 The VFD including all specified options shall be assembled by the ANSI/UL Standard 508 certified manufacturer for the building and assembly of option panels and the complete unit shall be tested to ANSI/UL Standard 508. Assembly of the option panels by a third-party panel shop shall not be acceptable. Where the components are separate, the appropriate CSA or C-UL stickers shall be applied to both the VFD and option panel. Both the VFD and option panel shall be manufactured in ISO 9001 certified facilities.
- .7 The VFD shall have 5 per cent DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. VFD's without DC link reactors shall provide a minimum 5 per cent impedance input line reactor.
- .8 The VFD's full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110 per cent of rated current for 60 seconds and 160 per cent of rated current for up to 0.5 second while starting.
- .9 The VFD shall be able to provide full torque at any selected frequency from 28Hz to base speed to allow driving direct drive fans without derating.
- .10 Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output. Disconnects located between the drive and the motor shall be interlocked into the VFD's safety circuitry.
- .11 An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.
- .12 VFD power components to shall be designed for 600VAC where intended for 575V/600V service. Components designed for 480VAC installed on 575V/600V service shall not be acceptable.
- .13 VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.
- .14 VFD's output switching shall be maintained within the requirements of NEMA standard, VFD's with output exceeding 1000V shall employ motor protection filters.

# 2.2 Protective Features

- .1 A minimum of Class-20 I2t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.
- .2 Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over-voltage, under-voltage, VFD over-temperature and motor over-temperature. The VFD shall display all faults in plain English. Codes shall not be acceptable.
- .3 Protect the VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90 per cent of the nominal.
- .4 The VFD shall be rated for 100,000 amp interrupting capacity (AIC).
- .5 The VFD shall have built-in or externally mounted electromagnetic interference (EMI) filters to limit the EMI and radio frequency interference (RFI) output from the VFD, designed to meet standard EN61800-3.
- .6 The VFD shall have a wide operating supply power range and shall continue to operate without faulting or tripping until the input voltage reaches at least 701VAC on 600 volt systems and 300VAC on 208/230 volt systems and 539VAC on 460 volt systems.

#### 2.3 Interface Features

- .1 Each VFD shall have the same operator's keypad, including digital display with "Hand/Start", "Off/Stop", "Auto/Start" and "Help" selector switches or buttons shall be provided to start and stop the VFD and determine the speed reference. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings. The keypad shall include a built-in real time clock with date function. Speed transfer between 'Hand' and 'Auto' shall be "bumpless".
- .2 Each VFD shall include an open system communication protocol interface, either BACnet as defined by ANSI/ASHRAE standard 135-2001 as defined by ANSI/CEA standard 709.1 for seamless integration with Section 25 55 00– Building Automation System (BAS).
- .3 Run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.
- .4 The VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.
- .5 If the temperature of the VFD's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD's heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.
- .6 At least six programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- .7 The following hardware points shall be available for direct connection to Section 25 55 00 Building Automation System (BAS):
  - .1 VFD Start/Stop
  - .2 VFD Speed Control
  - .3 VFD Speed Feedback
- .8 Under smoke control or special fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed or bypass.

2.4 Service Conditions

.1 Ambient temperature, -10°C to 40°C without derating.
.2 0 to 95 per cent relative humidity, non-condensing.
.3 AC line voltage variation, -10 to 10 per cent of nominal with full output.
.4 No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

#### 2.5 By-Pass

- .1 Supply either a manual 3 contactor by-pass as per Item 2.5.2 of this Section, or supply an electronic by-pass system as per Item 2.5.3 and as noted herewithin.
- .2 Provide a manual 3-contactor by-pass, were indicated in schedules or specified, consisting of a door interlocked main fused disconnect pad lockable in the off position, a built-in motor starter and a four position "DRIVE/OFF/BY-PASS/TEST" switch controlling three contactors. In the "DRIVE" position, the motor is operated at an adjustable speed from the VFD. In the "OFF" position, the motor and VFD are disconnected. In the "BY-PASS" position, the motor is operated at full speed from the AC power line and power is disconnected from the VFD so that service can be performed. In the "TEST" position, the motor is operated at full speed from the AC line power while power is applied to the input of the VFD. This allows the VFD to be given an operational test while continuing to run the motor at full speed in by-pass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in "DRIVE" or "BY-PASS" mode. Supply VFD specific only fuses. Service personnel shall be able to defeat the main power disconnect and open the by-pass enclosure without disconnecting power. This shall be accomplished through the use of a specially designed tool and mechanism while meeting all local and national code requirements for safety.
- .3 Provide a complete factory wired and tested electronic by-pass system, consisting of an output contactor and bypass contactor. Overload protection shall be provided in both drive and by-pass modes:
  - .1 Include a door interlocked, pad lockable circuit breaker or disconnect switch to disconnect all input power to the drive and by-pass system.
  - .2 Supply fast acting fuses exclusive to and in front of the VFD only.
  - .3 The electronic by-pass shall have its own keypad with, "Drive", "By-Pass", "Hand", "Off", "Auto" and "Reset" operator keys.
  - .4 The keypad shall also have the following LED indication, "Ready, Enable, Drive running, By-pass running, Drive fault, By-pass fault, By-pass H-O-A mode, Auto transfer to by-pass selected, Drive selected, By-pass selected".
  - .5 All external safety interlocks shall remain fully functional whether the system is in "Hand", "Auto" or "By-pass" modes.
  - .6 The electronic by-pass shall be fully operable from the Serial Communications system which shall have capability to monitor the VFD/By-pass mode, check status of Hand-Off-Auto (H-O-A), By-pass fault, and Override and also force the motor into By-pass mode.

#### Part 3 EXECUTION

#### 3.1 Installation

- .1 Comply strictly with manufacturer's installation instructions.
- .2 Provide a disconnect switch at the motor where required by the authorities having jurisdiction. Where such a switch is installed, provide an auxiliary contact or switch at the disconnect, mounted to open when the disconnect switch is opened and wired to a terminal strip in the VFD such that opening the disconnect switch initiates a drive shut down and prevents the drive from starting in either 'Line' or 'Drive' positions.
- .3 Locate and mount VFD panels in Mechanical Rooms and/or where shown on the Contract Drawings.
- .4 Arrange for manufacturer's technical representative or local qualified representative to:
  - .1 Inspect the installation of the drives and to start-up.
  - .2 Test and commission the drives. The VFD shall operate a dynamometer at full load and speed and shall be cycled during the test.
  - .3 Be present during testing and commissioning performed under Section 23 09 00 Building Automation System (BAS).
- .5 Measure the distortion of each phase at the load terminals of the branch breaker and report the results to the Consultant. Any deficiency shall be corrected and re-evaluated.
- .6 Implement a communication protocol for remote interface to match the communication protocol under Section 25 55 00 Building Automation System (BAS).
- .7 BAS connection to drives provided under Section 25 55 00 Building Automation System (BAS).

#### 3.2 Warranty

.1 Warranty shall be two (2) years from the date of Substantial Performance of the Work. Warranty shall be on-site parts and labour inclusive.

#### **END OF SECTION**

#### Part 1 General

#### 1.1 RELATED REQUIREMENTS

.1 Refer to division 1 for all other sections.

#### **1.2 REFERENCE STANDARDS**

- .1 American Society of Mechanical Engineers (ASME)
  - .1 ASME B16.1, Grey Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
  - .2 ASME B16.3, Malleable Iron Threaded Fittings: Classes 150 and 300.
  - .3 ASME B16.5, Pipe Flanges and Flanged Fittings: NPS <sup>1</sup>/<sub>2</sub> through NPS 24 Metric/Inch Standard.
  - .4 ASME B16.9, Factory-Made Wrought Buttwelding Fittings.
  - .5 ASME B18.2.1, Square Hex, Heavy Hex and Askew Head Bolts and Hex, Heavy Hex, Hex Flange. Loded Head and Lag Screws (Inch Series).
  - .6 ASME B18.2.2, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
- .2 ASTM International (ASTM)
  - .1 ASTM A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
  - .2 ASTM A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.

#### Part 2 Products

#### 2.1 Threaded/Welded Pipe and Fittings

- .1 Grooved (Victaulic, etc.) piping is not acceptable for this application.
- .2 Use pipes, fittings and valves as shown below unless specifically shown or specified otherwise:
  - .1 Low Temperature and/or Pressure Water. Heating water less than 121°C at 1035kPa, or heating water less than 93.2°C at 1139kPa.
    - .1 Pipes 300mm and larger, black steel ASTM A53, 9.5mm wall, plain ends, ANSI B36.10.
    - .2 Pipes 65mm to 250mm ASTM A53, Schedule 40, plain ends, ANSI B36.10.
    - .3 Pipes 50mm and smaller, black steel ASTM A53, Schedule 40, threaded, ANSI B36.10.
    - .4 Fittings 300mm and larger, black steel ASTM A234, 9.5mm wall, buttwelding ends, ANSI B16.9.

- .5 Fittings 65mm to 250mm black steel ASTM A234, Schedule 40, buttwelding ends, ANSI B16.9.
- .6 Fittings 50mm and smaller, cast iron ASTM A126, 860kPa WSP threaded, ASNI B16.4.
- .2 Globe valves 50mm and smaller, bronze 1035kPa WSP, renewable composition disc, threaded shall be Crane #7TF, Jenkins #106-B, Toyo 221 or Kitz 9.
- .3 Butterfly valves shall be iron body, one-piece alloy steel shaft, top and bottom bearings, bronze disc or iron disc with stainless steel trim, resilient elastomer replaceable seat with integral reinforcing ring or keyed to body. Body with threaded lugs. Bubble-tight shut-off to 1035kPa pressure in either direction when the piping and connecting flange is removed from one side of the valve. Valves 100mm and smaller with lever operator with lock. Valves 150mm and larger with worm gear manual operator with indication of valve opening. Butterfly valves shall be manufactured by Bray or approved equivalent.
- .4 Drain valves for blow-off of sediment from strainers and tank drainage shall be 19mm size 4140kPa WOG ball valve with bronze or forged brass body, virgin Teflon seat and packing, male threaded garden hose end, brass cap and chain shall be Watts B6000, Crane 9202, Jenkins 201J, Toyo 5046, Kitz 58CC or Apollo 78-100.

#### Part 3 Execution

#### 3.1 FLUSHING OF PIPING SYSTEMS

- .1 Applicable Systems
  - .1 Thoroughly flush and clean all new piping and existing piping as recommended by piping fabricators and as per code and Authorities having jurisdiction.
  - .2 Flush water piping with water flowing at a velocity of not less than 1.8 m/sec, for a period of 15 minutes or longer as required to remove all dirt, scale, and cuttings from the entire length of the piping.
  - .3 Thoroughly clean insofar as possible, welded joints by swabbing interior of pipe with swabs soaked with caustic solutions.
  - .4 Demonstrate to the Owner and ensure that the pipes are fully clean prior to pressure testing.

#### 3.2 PIPE LEAKAGE AND PRESSURE TESTING

- .1 After piping has been placed in position and all branch piping installed, but before the piping has been concealed, test all piping in accordance with manufacturer's recommendations and in the presence of the Owner of his authorized representative.
- .2 Temporarily remove all piping system specialties, which may be damaged by test pressures prior to pressure testing the systems. Include for temporary piping connections required to properly complete the tests.
- .3 Make tight, leaks found during tests while the piping is under pressure, and if this is impossible, remove and refit the piping and re-apply the test until satisfactory results are obtained.

- .4 Maintain written logs of all tests performed and keep the logs available at the site for review upon request.
- .5 Pressure test all new water piping system at 1.5 times the operating pressure, minimum 690 kPa (100 psi), whichever is greater, using water for a minimum 24 hours c/w reports.
- .6 Confirm system operating pressures at site prior to pressure testing.
- .7 The pressure tests shall be performed prior to insulation or painting, and shall be witnessed by the Owner or his/her authorized representative.

#### **END OF SECTION**

#### Part 1 General

#### 1.1 SUMMARY

- .1 Section Includes:
  - .1 Thermal insulation for piping and piping accessories in commercial type applications.

#### 1.2 **REFERENCES**

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
  - .1 ASHRAE Standard 90.1-, Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA co-sponsored; ANSI approved; Continuous Maintenance Standard).
- .2 American Society for Testing and Materials International (ASTM)
  - .1 ASTM B209M-04, Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate Metric.
  - .2 ASTM C335-04, Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
  - .3 ASTM C449/C449M-00, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
  - .4 ASTM C547-2003, Mineral Fiber Pipe Insulation.
  - .5 ASTM C921-03a, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .3 Canadian General Standards Board (CGSB)
  - .1 CGSB 51-GP-52Ma-89, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
  - .1 Material Safety Data Sheets (MSDS).
- .5 Manufacturer's Trade Associations
  - .1 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (Revised 2004).
- .6 Underwriters' Laboratories of Canada (ULC)

#### 1.3 SUBMITTALS

- .1 Product Data:
  - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 Submittal Procedures. Include product characteristics, performance criteria, and limitations.
- .2 Shop Drawings:

- .1 Submit shop drawings in accordance with Section 01 33 00 Submittal Procedures.
- .3 Quality assurance submittals: submit following in accordance with Section 01 33 00 Submittal Procedures.
  - .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 QUALITY ASSURANCE

- .1 Manufacturer shall be ISO 9000, 9001 or 9002 certified. Manufacturer of product shall be produced similar product for a minim of five (5) years.
- .2 Installer: specialist in performing work of this Section, and have a minimum of five (5) years successful experience in this size and type of project, qualified to standards of TIAC.
- .3 Products and work to comply with applicable authorities having jurisdiction.

#### 1.5 Warranty

.1 Provide warranty for all products and workmanship for a minimum of two (2) years from the date of Substantial Completion.

#### 1.6 DELIVERY, STORAGE AND HANDLING

- .1 Packing, shipping, handling and unloading:
  - .1 Deliver, store and handle materials in accordance with manufacturer's written instructions.
  - .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Storage and Protection:
  - .1 Protect from weather, construction traffic.
  - .2 Protect against damage.
  - .3 Store at temperatures and conditions required by manufacturer.

#### Part 2 Products

#### 2.1 FIRE AND SMOKE RATING

- .1 In accordance with CAN/ULC-S102.
  - .1 Maximum flame spread rating: 25.
  - .2 Maximum smoke developed rating: 50.

#### 2.2 INSULATION

.1 Mineral fibre specified includes glass fibre, rock wool, slag wool.

- .2 Thickness: 50mm.
- .3 Thermal conductivity "k" factor not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C335.
- .4 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.
  - .1 Mineral fibre: to CAN/ULC-S702, ASTM C547.
  - .2 Maximum "k" factor: to CAN/ULC-S702.

#### 2.3 INSULATION SECUREMENT

- .1 Tape: self-adhesive, aluminum, reinforced, 50 mm wide minimum.
- .2 Contact adhesive: quick setting.
- .3 Canvas adhesive: washable.
- .4 Bands: stainless steel, 19 mm wide, 0.5 mm thick.

#### 2.4 JACKETS

- .1 Aluminum:
  - .1 To ASTM B209.
  - .2 Thickness: 0.50 mm sheet.
  - .3 Finish: smooth.
  - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
  - .5 Fittings: die-shaped fitting covers with factory-attached protective liner.
  - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5mm thick at 300 mm spacing.

#### 2.5 Acceptable manufacturer's:

- .1 Owens Corning.
- .2 Johns Manville Inc.
- .3 Manson Insulation Inc.

#### PART 3 <u>EXECUTION</u>

#### 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 PRE-INSTALLATION REQUIREMENT

- .1 Pressure testing of piping systems and adjacent equipment to be complete, witnessed and certified.
- .2 Surfaces clean, dry, free from foreign material.

#### 3.3 INSTALLATION

- .1 Install in accordance with TIAC National Standards.
- .2 Apply materials in accordance with manufacturers instructions and this specification. Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm.
- .3 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
  - .1 Install hangers, supports outside vapour retarder jacket.
- .4 Supports, Hangers:
  - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.

#### 3.4 PIPING INSULATION SCHEDULES

- .1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.TIAC Code: A-1.
  - .1 Securements: SS bands at 300 mm on centre.
  - .2 Seals: lap seal adhesive, lagging adhesive.
  - .3 Installation: TIAC Code 1501-H.
- .2 Thickness of insulation shall be 38mm.
- .3 Finishes:
  - .1 Outdoors: water-proof aluminum jacket.
  - .2 Finish attachments: SS bands, at 150 mm on centre. Seals: closed.
  - .3 Installation: to appropriate TIAC code CRF/1 through CPF/5.

#### 3.5 CLEANING

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

#### **END OF SECTION**

#### PART 1 GENERAL

#### 1.1 SUMMARY

- .1 Section Includes:
  - .1 Materials, components, framing, installation and testing for an open circuit induced draft, crossflow cooling tower(s).

#### **1.2 REFERENCES**

- .1 American Society for Testing and Materials International (ASTM)
  - .1 ASTM A48/A48M-03, Standard Specification for Gray Iron Castings.
  - .2 ASTM A123/A/123M-2001, Standard Specification for Zinc Hot-Dip Galvanized Coatings on Iron and Steel Products.
  - .3 ASTM A153/A153M-04, Standard Specification for Zinc Coating Hot-Dip on Iron and Steel Hardware.
  - .4 ASTM B117-2003, Standard Practice for Operating Salt Spray (Fog) Apparatus.
  - .5 ASTM C67-2003, Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile.
  - .6 ASTM D520-2000, Standard Specification for Zinc Dust Pigment.
- .2 Canadian Standards Association (CSA International)
  - .1 CSA B52-[1999(R2004)], Mechanical Refrigeration Code.
- .3 Cooling Technology Institute (CTI)
  - .1 CTI-ATC-105-2000, Acceptance Test Code.
  - .2 CTI-STD-201-2004, Standard for the Certification of Commercial Water-Cooling Tower Thermal Performance.
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
  - .1 Material Safety Data Sheets (MSDS).
- .5 National Electrical Manufacturers Association (NEMA)
  - .1 NEMA MG 1, Motors and Generators.

#### 1.3 SUBMITTALS

- .1 Shop Drawings:
  - .1 Submit shop drawings in accordance with Section 01 33 00 Submittal Procedures.
  - .2 Indicate:
    - .1 Connections, piping, fittings, valves, strainers, control assemblies and ancillaries, identifying factory and field assembled.
    - .2 Wiring as assembled and schematically.
    - .3 Dimensions, construction details, recommended installation and support, mounting bolt hole sizes and locations and point loads.
    - .4 Vibration and seismic control measures.

- .5 Manufacturers recommended clearances.
- .6 Manufacturer's complete installation instructions.
- .2 Quality assurance submittals: submit following in accordance with Section 01 33 00 Submittal Procedures.
  - .1 Test reports:
    - .1 Submit certified test reports for cooling tower from approved independent testing laboratories, indicating compliance with specifications for specified performance characteristics and physical properties.
  - .2 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
  - .3 Instructions: submit manufacturer's installation instructions.
  - .4 Manufacturer's Field Reports: manufacturer's field reports specified.
- .3 Closeout Submittals:
  - .1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 Closeout Submittals.
  - .2 Include:
    - .1 Description of equipment giving manufacturers name, type, model year, capacity.
    - .2 Start-up and commissioning procedures.
    - .3 Details of operation, servicing and maintenance.
    - .4 Recommended spare parts list.

#### 1.4 Warranty

- .1 Provide warranty on all parts and labour for a period of minimum two (2) years from the date of substantial completion.
- .2 Fan(s), fan shafts, bearings, sheaves, gearboxes, drive shafts, couplings and mechanical equipment support must be warranted against defects in materials and workmanship for a period of minimum five (5) years.

#### 1.5 QUALITY ASSURANCE

- .1 Manufacturer: Company shall be ISO 9001 certified with documented experience of minimum 20-years.
- .2 Qualifications: Company and personnel specializing in cooling tower installation with a minimum of ten (10) years of documented experience.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- .1 Storage and Protection:
  - .1 Store materials indoors in dry location.
  - .2 Store and protect materials from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.

#### PART 2 PRODUCTS

#### 2.1 GENERAL

- .1 The design is based on Baltimore Aircoil Company. The design intent is to re-use the existing structural steel frame to support the proposed cooling tower. Critical dimensions are indicated on the design drawings.
- .2 Reputable alternative, equivalent cooling tower products from other manufacturers will be considered at the Owner/Engineer's discretion provided the following conditions are met in its entirety.
  - .1 The configuration, dimensional details, electrical power consumption and the operating weight of the proposed alternative tower closely matches the specified tower.
  - .2 Alternatively, if the dimensions/weights are marginally different from the specified tower, in the bid, bidders shall include all associate costs for necessary changes to existing design including but not limited to:
    - .1 Re-engineering of the existing structural steel frame and supports,
    - .2 Ensuring that all necessary clearances are met,
    - .3 Cost of modification of steel structure.
    - .4 Cost of additional piping, pipe insulation and electrical power and control wiring and conduits, if required.
- .3 Furnish and install one (1) factory fabricated, induced draft crossflow, axial fan, open cooling tower with vertical air discharge, conforming in all aspects to the specifications and schedules as shown on the plans.

#### 2.2 Components

- .1 Cold Water Basin:
  - .1 Type 304 welded stainless-steel panels and structural members. A removable anti-vortexing hood shall be provided to prevent air entrainment. Large area lift out strainers shall be provided with perforated openings sized smaller than the water distribution system nozzles. Sloped with depressed section with drain/clean-out connection.
  - .2 Bypass Connection: A bypass connection shall be built into the cold water basin on the side with a pipe diameter appropriate for the design flowrate of the tower. Refer to the Contract drawings for location and size of the opening.
- .2 Water Distribution System:
  - .1 The hot water distribution basins shall be gravity-fed and accessible from the outside of the unit for service or inspection while unit is in operation. Lift-off distribution covers shall be constructed of steel and designed to withstand a 50 psf (244 kg/m2) live load or 200 pound (90.7 kg) concentrated load.
- .3 Casing Panels and Framework:
  - .1 Casing panels will be constructed of corrosion and UV-resistant fiberglass reinforced polyester (FRP).
- .4 Air Inlet Louvers:

- .1 Fiberglass Reinforced Polyester (FRP): Air Inlet louvers shall be separate from the fill and removable to provide easy access for inspection of the air/water interface at the louver face. Louvers shall prevent water splash out during fan cycling and be constructed of maintenance free, corrosion and UV resistant FRP.
- .2 Air Intake Screens:
  - .1 A removable galvanized steel wire mesh screen with 1"x1" openings shall cover air intake areas.
- .5 Fans: Multi-blade, axial type. Fans shall be factory test-mounted, balanced, and aligned to ensure reliable operation and ease of maintenance. Provide a welded steel rod and wire guard, hot dipped galvanized after fabrication.
- .6 Motor(s):
  - .1 Single speed (1800 rpm) premium efficiency, cooling tower duty motor mounted on adjustable steel base. Fan motors will be inverter duty type designed per NEMA Standard MG1, Section IV Part 31. Motors will include an internal space heater that can be wired to remove condensation when motor is not in use.
  - .2 Provide extended grease fittings and lines on the exterior casing to facilitate easy periodic bearing maintenance without entering the tower.
- .7 Fill:
  - .1 The fill and integral drift eliminators shall be formed from self-extinguishing (per ASTM-568) polyvinyl chloride (PVC) having a flame spread rating of 5 per ASTM E84 and shall be impervious to rot, decay, fungus and biological attack. The fill shall be suitable for entering water temperatures up to and including 130°F.
- .8 Drift Eliminators: Three pass design made of PVC material. Primary eliminators shall be integrated into the fill media.
- .9 Cooling Tower Interface Panel;
  - .1 Provide an interface panel in NEMA 1 (indoor) rated enclosures. Panel shall be complete with the following:
    - .1 Lockable main power disconnect switch;
    - .2 Power "ON" indicator light;
    - .3 Two (2) rated contactors for basin heaters.
    - .4 Basin heater "OFF/AUTO" selector switch;
    - .5 Basin heater "ON" indicator light;
    - .6 Vibration fault indicator light;
    - .7 Interposing relay and power provisions for fan motor space heater;
    - .8 Panel power and 120V power provisions for basin heater control circuit, Electronic water level control system, make-up water solenoid valve and fan motor space heater.
    - .9 Power provisions for remote mounted 25 HP fan motor variable frequency drive (VFD).
    - .10 Provide shall be configured for single 575/3/60 incoming electrical service and provide loose for field mounting and wiring by the Electrical Contractor.

- .10 Accessories:
  - .1 Basin Heaters:
    - .1 Provide in-pan heaters suitable to maintain temperature of water in basin at 40°F when ambient temperature is -20 degrees F. Electrical requirements shall match the motor.
    - .2 Heating elements shall be constructed of copper or approved equivalent.
  - .2 Vibration Switch:
    - .1 Provide a mechanical local reset vibration switch. The vibration cutout switch shall be guaranteed to trip at a point so as not the cause damage to the cooling tower. To ensure this, the trip point will be set in a frequency range of 0 to 3,600 RPM and a trip point of 0.2 to 2.0 g's.
  - .3 Maintenance Access Package:
    - .1 Plenum Access: Two hinged access doors shall be provided for access into the plenum section. Include an internal walkway for inspection and maintenance. All working surfaces will be able to withstand 50 psf (244 kg/m<sup>2</sup>) live load or 200 pound (90.7 kg) concentrated load.
    - .2 Fan Deck Ladder with Handrails: A ladder with steel safety cage and safety gate shall be provided for access to the fan deck. Provide 32 mm (1-1/4 inch) galvanized steel pipe handrail around the perimeter of the cooling tower. The handrails shall be provided with knee and toe rails and shall conform to OSHA requirements applicable at the time of shipment.

#### 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 GENERAL

- .1 Provide the services of the manufacturer's approved field representative to supervise rigging, hoisting, and installation. Allow for a minimum of one (1) eight-hour day. Contractor shall coordinate the hoisting date and timelines with the manufacturer directly.
- .2 Mount on structural supports as indicated and to manufacturer's recommendations.
- .3 Ensure clearance for servicing and maintenance as recommended by manufacturer.
- .4 Manufacturers field service representative to approve installation, to supervise start up and to instruct operators.

#### 3.3 FIELD QUALITY CONTROL

- .1 Site Tests:
  - .1 Test under actual operating conditions in accordance with CTI-ATC-105 to verify specified performance.

- .2 Manufacturer's Field Services:
  - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 SUBMITTALS.
  - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
  - .3 Schedule site visits, to review Work, as directed in PART 1 QUALITY ASSURANCE.
- .3 Seasonal commissioning:
  - .1 Arrange for seasonal commissioning as required.

#### 3.4 ADJUSTING

- .1 Lubricate bearings with oil or grease as recommended by manufacturer.
- .2 Tighten belts to manufacturer's specified tension.

#### 3.5 CLEANING

- .1 Wipe equipment clean, and remove traces of oil, dust, dirt, or paint spots.
- .2 Maintain system in clean condition until final acceptance.
- .3 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 SCOPE OF WORK

.1 Provide a fully functional electric heat tracing system to protect freezing of piping exposed to freezing conditions complete with suitable cables, sensors, pipe insulation and electrical components/controls as required and as specified herein.

#### **1.2 REFERENCE STANDARDS**

- .1 Standards and codes to be latest editions adopted by and enforced by local governing authorities.
- .2 API American Petroleum Institute RP500A for Area Classification.
- .3 CEC Canadian Electrical Code, Part I, (CSA C22.1) and Saskatchewan Amendments and including Ontario Electrical Safety Code.
- .4 CSA Standard C22.2 No. 130, Requirements for Electrical Resistance Trace Heating and Heating Device Sets Class No: 2872 01, Heaters Cable and CableSets.
- .5 NFPA National Fire Protection Association.
- .6 Applicable other IEEE, ANSI, CSA and EEMAC standards for equipment.

#### 1.3 WARRANTY

.1 Products and workmanship to be guaranteed by manufacturer, for a period of minimum of five (5) years after the date of substantial completion.

#### 1.4 DELIVERY, STORAGE AND HANDLING

.1 Handle and store products in accordance with manufacturer's instructions, in locations approved by the owner. Include one copy of these instructions with product at time of shipment.

#### 1.5 SUBMITTALS

- .1 Product Data
  - .1 technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists;
  - .2 performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol;
  - .3 product transportation, storage, handling, and installation requirements;
  - .4 product identification in accordance with owner's requirements.
- .2 Shop Drawings
  - .1 capacity and ratings;
  - .2 mounting details to suit locations shown, indicating methods and hardware to be used;
  - .3 installation drawings completely dimensioned in metric units, showing all components applicable and control wiring schematic of the electric tracing system and the layout and routing of the heating cable;
  - .4 heater circuit number;
  - .5 heater catalogue number;

- .6 line number and dimensions;
- .7 tag number where applicable;
- .8 heater length;
- .9 voltage required;
- .10 maximum ampere load of heater;
- .11 total output of heaters in watts;
- .12 output of heater in watts per foot;
- .13 spiral pitch (if applicable);
- .14 design parameters (heat loss, insulation, temperature maintenance, etc.);
- .15 startup current at lowest design temperature.

#### 1.6 QUALITY ASSURANCE

- .1 Products are to comply with codes, regulations and standards listed above and applicable local codes and regulations.
- .2 All electric heat tracing materials are to be tested at the factory using the manufacturer's standards which must be in accordance with the latest CSA Standard C22.2 No 130.
- .3 Manufacturers Qualifications
  - .1 Manufacturer shall be ISO 9000, 9001 or 9002 certified. Manufacturer of product shall have produced similar product for a minimum period of five years. When requested by Consultant, an acceptable list of installations with similar product shall be provided demonstrating compliance with this requirement.
  - .2 Where manufacturers provide after installation onsite inspection of product installations, include for manufacturer's authorized representative to perform onsite inspection and certificate of approvals.
- .4 Installers Qualifications
  - .1 Installers for work under Mechanical Division to be performed by or work under licensed Mechanical Contractor.
  - .2 Installers for electrical work to be performed by or work under licensed Electrical Contractor.
  - .3 Where manufacturers provide training sessions to installers and certificates upon successful completion, installers to have obtained such certificates and submit copies with shop drawings.
- .5 Regulatory Requirements
  - .1 Products and work to comply with applicable local governing authority regulations, bylaws and directives.
  - .2 Include for required inspections and certificate of approvals of installation work from local governing authorities.

#### Part 2 PRODUCTS

#### 2.1 PIPE FREEZE PROTECTION HEATING SYSTEM

.1 ULC listed, CSA certified, self-regulating piping freeze protection cable sets as specified and/or scheduled on drawings, each set complete with:

150 Borough D	r, Scarbo	orough ON Section 23 83 13						
January 2025		ELECTRIC HEATING CABLE AND CONTROL						
Scarborough (	Civic Ce	entre – Cooling Tower Replacement Page 3 of 5						
	.1	Electrical heat tracing cable shall be provided with necessary lengths of self-regulating heating cable and shall consist of a continuous core of conductive polymer that is radiation cross- linked, extruded between two - 16 AWG nickel-plated copper bus wires that varies its power output in response to pipe temperature change.						
	.2	Heat tracing cable shall be constructed from modified polyolefin inner jacket and a tinned-copper braid to provide a ground path and enhance the cables ruggedness and complete with a fluoropolymer outer jacket to suit application.						
	.3	Heat tracing cable shall be compatible with piping being heated as verified by independent testing company.						
	.4	The cable shall operate at voltages shown, without use of transformers.						
	.5	Provide necessary power connection with end seal per circuit and tee connections with end seals as required for pipe branches;						
	.6	Glass tape shall secure cable on pipe, and "Electric Traced" adhesive labels to be secured to pipe insulation;						
	.7	Provide a pipe temperature sensing thermostat.						
.2	Compo Compo	onents exposed to elements to be weatherproof and corrosion resistant. onent enclosures to be NEMA 4X rated.						
.3	For all minimu length an engi	piping exposed to ambient conditions (i.e. freezing conditions), provide a um of 50 mm thick rigid fibreglass insulation materials along the entire of the exposed piping and fittings and cover the insulation materials with ineered heavy duty, Aluminum jacketing system.						
.4	Standard of quality assurance manufacturers are:							
	.1	nVent - Ravchem:						
	.1 nvent - Raychem; .2 3M;							
	.3	Thermon:						
	.4	or approved equivalent.						
2.2	HEAT TRACING SYSTEM CONTROLS							
.1	Contro	llers shall suit specific applications as described below:						
	.1	Single Circuit Controller: surface wall mounting, microprocessor 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 heating cable from excessive temperature.						
	.2	Multi-Circuit Controller: similar to single circuit controller but with pre- programmed parameters to provide concurrent control for heating cables. Controller includes ground fault protection, configurable alarm settings and remote annunciation of various operating parameters. Include required auxiliary contacts (form C type) for third party interface.						
.2	Standard of quality assurance manufacturers are:							
	.1 nVent - Raychem;							
	.2	3M;						
	2							

- .3 Thermon;
- .4 or approved equivalent.

150 Borough Dr, Scarborough ON	Section 23 83 13
January 2025	ELECTRIC HEATING CABLE AND CONTROL
Scarborough Civic Centre - Cooling Tower Repla	acement Page 4 of 5

#### 2.3 SYSTEM TESTING AND VERIFICATION:

- .1 Include for manufacturer's authorized representative to inspect system installation, test system, and verify system.
- .2 Manufacturer's authorized technician to prepare and sign verification report letter that states system has passed manufacturer's testing and performs to manufacturer's requirements for application.

#### Part 3 EXECUTION

#### 3.1 GENERAL INSTALLATION REQUIREMENTS

- .1 Engage system manufacturer to review documents to ensure that requirements are included for proper operation and functionality of system for specific application in compliance with drawings parameters and specification. Confirm type materials be heated, area, length and diameter as applicable, insulation as applicable, and design temperature parameters and include in design and selection of system. Provide required components suitable for operation at voltages and for connection to breakers as noted on drawings and as required.
- .2 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.
- .3 Install electric heating cables in strict accordance with manufacturer's requirements and installation instructions.
- .4 Lay cables out at spacing as per system manufacturer's recommendations.
- .5 Where traced pipe enters a building, extend heater minimum of 300 mm (1') inside building.
- .6 Locate junction boxes in accessible areas. Locate junction boxes above grade level, not in heated slab. Covers boxes at all times when not working therein.
- .7 Protect terminations from weather and from physical damage. Bond gland assembly to system ground.
- .8 Provide alarm/communications circuits as required to monitor system controller status and alarms. Connect to fire alarm system as required by local governing codes or to building automation system.
- .9 After installation, conduct recommended tests under supervision of cable manufacturer's representative and subject self-regulating heating cable to insulation resistance testing using Megger. Minimum insulation resistance to be
- .10 1000 megohms or greater. All heating cables are to be field tested to assure correct operation before and after installation. The cables shall be tested for ground resistance and continuity after installation. Perform insulation resistance test and continuity test as recommended by manufacturer. Heating-cable circuit capacitance to also be recorded as a means of verifying continuous cable lengths. Submit completed test form to Consultant and the owner as work progresses.
- .11 Replace any cable that fails testing.

#### 3.2 INSTALLATION OF FREEZE PROTECTION HEATING CABLE

.1 Supply electric tracing cable sets to prevent piping from freezing.

150 Borough Dr, Scarborough ON	Section 23 83 13
January 2025	ELECTRIC HEATING CABLE AND CONTROL
Scarborough Civic Centre - Cooling Tower Repla	Acement Page 5 of 5

- .2 Hand cable sets and accessories and cable manufacturer's installation instructions to electrical trade at site for installation on piping. Clearly identify piping to be traced. Ensure piping has been pressure tested prior to cable installation and manufacturer's installation instructions are observed.
- .3 After cable installation but before application of piping insulation, megger test and commission cable in presence of Consultant and in accordance with cable manufacturer's installation and operation manual. Replace any damaged or faulty cable, and when satisfactory results have been obtained, submit signed test reports to Consultant.
- .4 When traced piping has been insulated, install "Electrically Traced" labels on opposite sides of pipe at 3 m (10') intervals.
- .5 When cable installations are complete, check and test operation of each cable set with heater manufacturer's representative, make any required adjustments, and have cable manufacturer certify in writing that cable sets have been properly installed and operate as intended.

#### 3.3 INSTALLATION OF CONTROLS AND SENSORS

- .1 Prior to submission of Bid, engage system manufacturer to review system controls and sensors to ensure that all requirements are included for proper operation of complete system and cables for each specific application. Provide specified required controller, control panel and sensors in locations as shown on drawings and as reviewed with Consultant and system manufacturer. Mount devices and connect complete to control heating cables.
- .2 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.
- .3 If controller does not have ground fault detection protection, ensure that power to system is ground fault protected as per local governing code requirements.
- .4 Sensors to be suitable for installation in exposed, elevated locations, or for flush installation in pavement and ramps in accordance with system manufacturer's recommendations.
- .5 Where ambient sensors are not included with control panel, provide high limit thermostats with capillary end bulbs inserted into a metal conduit under surface being heated, to prevent operation of system in warm weather or over heating of panels. Include for means of manual override switch to power ON/OFF system.
- .6 Review with owner's requirement for remote manual override switch. Install in single gang electrical outlet box complete with suitable faceplate, connect with required wiring.
- .7 Ground and bond system components as per system manufacturer's instructions.
- .8 Provide for system manufacturer authorized representative to program controller and to test and verify the automatic control system. Conduct recommended tests under supervision of manufacturer's representative.

#### END OF SECTION

#### Part 1 GENERAL

#### 1.1 General Requirement

- .1 The existing building has a DDC based BAS (Distech). Provide necessary modifications and/or upgrades to the existing Building Automation System (BAS) and field sensors to provide monitoring and control of the proposed Cooling Tower and associated Electrical Heat Tracing.
- .2 The City's general BAS specification "Standard Building Automation System Owner Requirements" (Refer to Appendix-A) shall be read in conjunction with the project specific design and specifications for this project. BAS contractor shall follow this specification for general requirements, and for BACnet Communication, products, system graphics and general standards.
- .3 Ainsworth is the existing base building BAS contractor. Engage the services of Ainsworth for all BAS related work. The existing as-builts drawings are provided within Appendix B.
- .4 Refer to BAS points list at the end of this specifications section. All noted points and functions shall be provided for the proposed systems.
- .5 The documentation contained in this section and other contract documents pertaining to Controls is schematic in nature. The Contractor shall provide all necessary hardware and software to implement the functions shown or as implied in the contract documents. All hardware and software components provided as part of this section shall meet or exceed the latest industry standards.
- .6 Provide all accessories, sensor, software, hardware, wiring, programming etc as required.
- .7 Modify existing controls hardware and/or provide additional field controllers as necessary (as per standard BAS spec attached) to accommodate the total requirements of this specifications.
- .8 Verify all existing controls components connected to the equipment being replaced and also include costs for verification of control sequences. Allow for complete recommissioning of the BAS as it pertains to the equipment being replaced including changes to graphics and verification of BAS points and addresses.
- .9 The Contractor shall allow for all programming efforts related to transferring of data points from other devices and also include for modification of existing graphics and/or creation of suitable new graphics to clearly and fully represent all components of the mechanical and electrical systems on the BAS workstation/server & to provide web access for all interconnected systems and for all transferred data points.

#### 1.2 DELIVERY, STORAGE AND HANDLING

.1 Handle and store products in accordance with manufacturer's instructions, in locations approved by the City. Include one copy of these instructions with product at time of shipment.

#### **1.3 REFERENCES**

.1 Standards and codes to be latest editions adopted by and enforced by local governing authorities.

#### 1.4 QUALITY ASSURANCE

.1 Installer shall be able to respond within 3 hours for critical failures, and within 24hrs for noncritical failures.

#### 1.5 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle in accordance with manufacturer's recommendations.

#### Part 2 PRODUCTS

#### 2.1 General

.1 Reconnect the existing BAS points and provide additional points as specified and as necessary. The BAS for all new equipment shall be configured to deliver all existing control sequences (Refer to attached Appendix-B), graphics and functionality of the system.

#### 2.2 WIRING

- .1 Provide copper wiring, plenum cable. Insulated wire shall use copper conductors and shall be ULC listed for 90°C (200°F) minimum service.
- .2 Wiring to be in accordance with system manufacturer's recommendations and in compliance with local governing authority requirements and codes.

#### Part 3 EXECUTION

#### 3.1 BAS POINTS LIST

.1 At a minimum, the following (As listed below in the BAS points list) monitoring and control actions shall be performed by the BAS in addition to all existing points.

BAS Points List								
Cooling Tower						Alarm	Remarks	
Point Name and Description	AO	AI	BO	BI	Software			
Enable/Disable System					X			
Mode: Occupied/Unoccupied					X			
Condenser Water Supply Temp		X				X	Low & High Temperature Alarm.	
Condenser Water Return Temp		X				X	Low & High Temperature Alarm.	
Basin Water Controller				X		X	Low & High- Water Level Alarm.	
Cooling Tower Basin Temperature		X				X	Low & High Temperature Alarm.	
Tower Basin Heater 1 Status				X				
Tower Basin Heater 2 Status				X				
Cooling Tower Fan (Start/Stop and Status)	X	X				X	Fan Failure Alarm.	
Cooling Tower Fan VFD (Speed Control, Status and Fault)	X			X		X		
Cooling Tower Bypass Valve (Open/Close)			X	X		X	Valve Failure Alarm.	
Cooling Tower Vibration Switch				X		X	Interlock to shut down the Tower Fan.	

Electric Heat Tracing Systems (Points per circuit)						Alarm	Remarks
Point Name and Description	AO	AI	BO	BI	Software		
Enable/Disable System					Х	Х	Heat Tracing Fault.
Mode: Occupied/Unoccupied					Х		
Status				Х			
Enable/Disable			Х				

#### **END OF SECTION**

### **APPENDIX-A**



# Standard Building Automation <u>System (BAS) Owner</u> <u>Requirements</u>

## November, 2019

Version & revision number: 6.1.5

This document is the standard for use in new construction, retrofits and upgrades in City of Toronto facilities and shall not be amended in any way without written consent from the Corporate Real Estate Management (CREM) Division.

PART	1 - GENERAL	2
1 0		·• 2
2.0		· · ∠
2.0		••
3.0		•••>
4.0		
5.0		3
0.0		••4
7.0		5
8.0	BAChet	5
9.0		6
10.0		6
11.0	REAL-TIME CLOCK	7
12.0	SERVICEABILITY	7
13.0	MEMORY	7
14.0		7
15.0	POWERFAIL RESTART	7
16.0	DYNAMIC DATA ACCESS	8
17.0	INPUT AND OUTPUT INTERFACE	8
18.0	POWER SUPPLIES AND LINE FILTERING	8
19.0	AUXILIARY CONTROL DEVICES	9
20.0	NETWORKS	12
21.0	SERVER FUNCTION	.13
22.0	SCOPE OF WORK	14
23.0	PERMITS, FEES AND CODES	.14
24.0	COORDINATION	.15
24.0	SUPERVISION OF PERSONNEL	.15
25.0	ELECTRICAL WORK AND SAFETY REQUIREMENTS	.15
26.0	COMMUNICATION WIRING	.16
27.0	LOCKABLE PANELS	. 17
28.0	WARNING LABELS	. 17
29.0	IDENTIFICATION OF HARDWARE AND WIRING	. 17
30.0	PRELIMINARY DESIGN REVIEW	18
31.0	DRAWING REQUIREMENTS	. 18
32.0	START-UP AND CHECKOUT	19
33.0	STANDARDS COMPLIANCE	21
34.0	FINAL ACCEPTANCE	21
35.0		21
36.0	TRAINING	22
37.0	WARRANTY	- 22 23
38.0		20
<b>DADT</b>		· 24
		・ ∠ つ っ ⊑
1.0		. ZD
2.U 2.0		. 20
3.U 4.0		. 26
4.0		. 26
5.0		26

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This section includes the central building automation system components and network protocol specifications. It may be used as section 23 09 23 or 23 09 93 depending on specification format used.

In addition to this section it will be necessary to add project specific sections for control components and sequences of operation.

The intent of this specification is to describe the minimum features required for a new installation. For renovation or refit type projects, it will be necessary to determine to what extent any existing system can be upgraded or modified within the parameters of the project budget to achieve the general intent of this specification and provide appropriate edits.

#### PART 1 - GENERAL

#### 1.0 GENERAL REQUIREMENTS

- 1.1 Conform to all, "Mechanical General Provisions".
- 1.2 The "provide" in this Division shall be interpreted as "supply and install".
- 1.3 All work shall conform to Canadian Metric Practice Guide CSA CAN3-2234.1.76
- 1.4 Provide all required adapters between metric and imperial components.
- 1.5 Metric descriptions in this Division are nominal equivalents of Imperial values.
- 1.6 All equipment and material to be new, CSA certified, manufactured to minimum standard quoted including additional specified requirements.
- 1.7 Where there is no alternative to supply equipment that is not CSA certified, submit such equipment to Inspection Authorities for special inspection and obtain approval before delivery of equipment to site.
- 1.8 Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by the owner. Spare parts shall be available for at least five years after completion of this contract.
- 1.9 Use material and equipment available from a regular production by manufacturer concerned.

#### 2.0 WORK INCLUDED

#### 

Add to this section any site specific qualifications that may apply to the specific project with respect to application of the specified requirements for the system.

- 2.1 The City of Toronto has standardized Building Automation Systems utilizing native BACnet area, system and application controllers. Extend the existing Framework as detailed herein.
- 2.2 The system shall support standard Web browser access via the City's Intranet/Internet. It shall support a minimum of 100 simultaneous users with the ability to access the graphical data and real time values simultaneously. (Refer to Section7.16)
- 2.3 Provide an open protocol Building Automation System (BAS) incorporating Direct Digital Control (DDC), equipment monitoring, and control consisting of: A PC based Operator Work Station (OWS) with colour graphic data displays; Microcomputer based Building Controllers (BCs) and Microcomputer based Advanced Application Controllers (AACs) and Application Specific Controllers (ASCs) interfacing **directly** with sensors,

#### SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

actuators and environmental delivery systems (i.e., HVAC units, boilers, chillers, lighting systems, etc.); electric controls and mechanical devices for all items indicated on drawings described herein including dampers, valves, panels and compressed air plant.

- 2.4 City of Toronto has standardized the use of Direct Digital Controllers (DDC) and End Devices. No **NEW** pneumatic control devices shall be connected or incorporated into the BAS network. It applies to new installations as well as retrofit applications.
- 2.5 Open Protocols by definition are to be BACnet (ASHRAE Standard 135 Annex J) and Haystack only.
- 2.6 Provide BAS controllers (BCs, AACs and ASCs) based on native BACnet (ASHRAE Standard 135 Annex J) protocols.
- 2.7 Provide submittals, data entry, electrical installation, programming, startup, test and validation acceptance documentation, and system warranty.

#### 3.0 WORK BY OTHERS

3.1 Access doors and setting in place of valves, flow meters, water pressure and differential taps, flow switches, thermal wells, dampers, air flow stations, and current transformers shall be by others.

#### 4.0 QUALITY ASSURANCE

- 4.1 Codes and Approvals:
  - 4.1.1 Work, materials, and equipment shall comply with the Ontario Building Code, Ontario Electrical Code, ANSI/ASHRAE 135-2004: Data Communication Protocol for Building Automation and Control Systems (BACnet) and Authorities having jurisdiction over this work. All devices shall be ULC, UL or FM listed and labeled for the specific use, application and environment to which they are applied.
  - 4.1.2 The BAS shall comply with NFPA 90A Air Conditioning and 90B Warm Air Heating, Air Conditioning.
  - 4.1.3 All electronic equipment shall conform to the requirements of CSA for electromagnetic emissions standards and placed in approved locations such that it does not interfere with building equipment or computers.
- 4.2 Provide satisfactory operation without damage at 110% above and 85% below rated voltage and at 3 hertz variation in line frequency. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and induced magnetic interference. Bus connected devices shall be AC coupled, or equivalent so that any single device failure will not disrupt or halt bus communication.

#### 5.0 ABBREVIATIONS AND SYMBOLS

- 5.1 All letter symbols and engineering unit abbreviations utilized in information displays ANSI/ISA S5.5 and printouts shall conform to ANSI 710.19/IEEE 260-letter symbols for SI and certain other units of measurement.
- 5.2 Specification Nomenclature Acronyms used in this specification are as follows:
  - AAC Advanced Application Controller
  - ASC Application Specific Controller
  - BAS Building Automation System
  - BC Building Controller

- BIBB BACnet Interoperability Building Blocks
- DDC Direct Digital Controls

GUI Graphical User Interface

HTTP Hyper Text Transfer Protocol

LAN Local Area Network

ODBC Open Database Connectivity protocol

- OOT Object Oriented Technology
- OPC Object linking and embedding for Process Control
- OWS Operator Workstation
- PDA Personnel Data Assistant device
- PICS Protocol Implementation Conformance Statement
- PWS Portable Workstation
- SNVTS Standard Network Variables Types
- SQL Standard QueryLanguage
- TCP/IP Transmission Control Protocol / Internet Protocol
- TCU Terminal Control Unit
- WAN Wide Area Network
- WAP Wireless Application Protocol device
- WBI Web Browser Interface
- XML Extensible Markup Language
- XIF External Interface Files

#### 6.0 APPROVED CONTROL SYSTEMS

#### 

Applicable to new construction projects, new installations within existing buildings and major retrofit/overhaul of existing BAS systems.

- 6.1 Any vendors that are authorized dealers or distributors of the following control systems are acceptable:
  - 6.1.1 Delta Controls
  - 6.1.2 Reliable Controls
  - 6.1.3 Schneider Electric SmartX series
  - 6.1.4 Distech Controls
  - 6.1.5 Johnson Controls Facility Explorer
  - 6.1.6 Honeywell CIPer series, Spyder models 5 or 7
- 6.2 BAS Systems Integration:
  - 6.2.1 All control systems must be integrated to the City's J2 Innovations Fluid Integration (FIN) server, including but not limited to the following:
    - 6.2.1.1 graphical user interface (monitoring & control)
    - 6.2.1.2 alarming
    - 6.2.1.3 data trending
    - 6.2.1.4 data archiving
    - 6.2.1.5 Project Haystack naming convention
  - 6.2.2 The installer must be licensed by J2 Innovations to sell, install, program and configure Fluid INtegration (FIN).
  - 6.2.3 Building Controllers (BC) must be Tridium Niagara JACE with the Haystack module and driver. The installer must be a licensed Tridium system integrator for any Tridium BCs or embedded or edge Niagara Framework products used. Soft JACE is not accepted.
- 6.3 Licensing Requirements
  - 6.3.1 Licenses shall be provided to and in the name of the City of Toronto
  - 6.3.2 Licenses shall be perpetual, transferrable, assignable and royalty-free

- 6.3.3 Tridium licenses shall allow all Workbench/Supervisor brands complete system access and functionality.
- 6.4 Installer and Manufacturer Qualifications
  - 6.4.1 Installer shall have an established working relationship with Control System Manufacturer.
  - 6.4.2 Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.
  - 6.4.3 It is the intent of this specification to define an open protocol state-of-the-art distributed computerized Building Management and Control System which is user friendly, has known reliability, is extremely responsive, and which is to be designed, installed, implemented, and supported by a <u>local office of approved bidders</u>.
  - 6.4.4 BAS contractor shall provide three locations of successful installations of similar open protocol computer based systems. Sites provided must consist of more than 150 hardware inputs/outputs. Project sites must be local to the location of this project.
- 6.5 System Administration
  - 6.5.1 Administrator credentials shall be sent to BAS@Toronto.ca for retention by the City. Credentials shall include any and all accounts and passwords required for complete system access, including but not limited to Station and Platform credentials.

#### 7.0 SYSTEM DESIGN

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For retrofit projects where a gateway might be considered the most appropriate economic decision for interface to an existing automation system, remove article 7.2.

#### \*\*\*\*\*\*\*

- 7.1 The system shall consist of a network of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), and Smart Actuators (SA). Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.
- 7.2 Systems utilizing gateways will not be considered. A gateway device is considered to be a device where only mapping of system points from one protocol to another occurs. A gateway device cannot perform higher-level energy management functions such as Outdoor Air Optimization, Electrical Demand Limiting and the like.
- 7.3 The Building Automation System software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a BAS server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.
- 7.4 A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a flat single tiered architecture shall not be acceptable. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces. Maximum acceptable response time from any alarm occurrence (at the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

#### 8.0 BACnet.

- 8.1 Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) ProductListing.
- 8.2 Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
- 8.3 Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
- 8.4 Smart Actuators (SAs). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.
- 8.5 Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.
- 8.6 BACnet Communication.
  - 8.6.1 Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
  - 8.6.2 BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
  - 8.6.3 Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.
  - 8.6.4 Each ASC shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.
  - 8.6.5 Each SA shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.
  - 8.6.6 Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
  - 8.6.7 The maximum number of controllers on an MS/TP network/subnet shall be no more than 64 or the manufacturer recommended limit, whichever is less.
  - 8.6.8 An approved addressing scheme must be obtained from BAS@Toronto.ca and be included on project shop drawings (specifically the BAS network architecture diagrams) prior to installation. Buildings without approved schemes shall not exist on the City WAN.
  - 8.6.9 BAS shall transfer data between controllers on a stand-alone BAS network. One (1) data drop per building will be provided to establish connection to central server. Should back end programming and configuration be inaccessible via this one (1) data drop, an additional data drop will be provided to allow City BAS Team to communicate to the base building control system using manufacturer software tools.
  - 8.6.10 Access to City central servers will <u>not</u> be provided during construction. Database and graphics are merged with central server after project deficiency lists have been cleared (including graphics deficiencies). This merging must be coordinated with the application

8.6.11 The City Ethernet connection shall be fully segregated and isolated from the BAS LAN via the secondary BC Ethernet port. A City static IP address will be provided by Technical Services Division (TSD) for this connection. The City's divisional project manager or designate will coordinate this request.

#### 9.0 COMMUNICATION

- 9.1 Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
- 9.2 Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
- 9.3 Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
- 9.4 Stand-Alone Operation. Each piece of equipment specified in the sequence of operation shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

#### 10.0 ENVIRONMENT

Controller hardware shall be suitable for anticipated ambient conditions.

- 10.1 Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
- 10.2 Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

#### 11.0 REAL-TIME CLOCK

11.1 Controllers that perform scheduling shall have a real-time clock.

#### 12.0 SERVICEABILITY

- 12.1 Controllers shall have diagnostic LEDs for power, communication, and processor.
- 12.2 Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.
- 12.3 Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

#### 13.0 MEMORY

13.1 Controller memory shall support operating system, database, and programming requirements.

SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

- Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
- 13.3 Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

#### 14.0 IMMUNITY TO POWER AND NOISE

14.1 Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3ft).

#### 15.0 POWERFAIL RESTART

- 15.1 In the event of the loss of normal power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
- 15.2 Upon restoration of normal power, the controller shall automatically resume full operation without manual intervention. The controllers shall incorporate random start sequences to ensure a power spike does not result.
- 15.3 Controller memory shall not be lost during a power failure.
- 15.4 The user shall have the capability of loading or re-loading all software via the OWS or the local terminal port.

#### 16.0 DYNAMIC DATA ACCESS

16.1 All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

#### 17.0 INPUT AND OUTPUT INTERFACE

- 17.1 General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.
- 17.2 Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.
- 17.3 Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.
- 17.4 Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shallaccumulate up to 10 pulses per second.
- 17.5 Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.
- 17.6 Binary Outputs. Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.
- 17.7 Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.
- 17.8 Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.
- 17.9 Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

#### 18.0 POWER SUPPLIES AND LINE FILTERING

- 18.1 Power Supplies: Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with CEC requirements. Limit connected loads to 80% of rated capacity.
  - 18.1.1 DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes.
#### SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

- 18.1.2 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
- 18.1.3 Line voltage units shall be UL recognized and CSA listed.
- 18.2 Power Line Filtering.
  - 18.2.1 Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
    - 18.2.1.1Dielectric strength of 1000 V minimum
    - 18.2.1.2Response time of 10 nanoseconds or less
    - 18.2.1.3Transverse mode noise attenuation of 65 dB or greater
    - 18.2.1.4Common mode noise attenuation of 150 dB or greater at 40-100 Hz

#### 19.0 AUXILIARY CONTROL DEVICES

- 19.1 Electric Damper and Valve Actuators.
  - 19.1.1 Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.
  - 19.1.2 Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).
  - 19.1.3 Signal and Range. Proportional actuators shall accept a 0-10 Vdc or a 0-20 mA control signal and shall have a 2-10 Vdc or 4-20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 16.8)
  - 19.1.4 Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
  - 19.1.5 Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N⋅m (60 in.-lb) torque capacity shall have a manual crank.
- 19.2 Binary Temperature Devices.
  - 19.2.1 Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetaloperated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
  - 19.2.2 Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.

19.2.3 Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

#### 19.3 Temperature Sensors

- 19.3.1 Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor (10K).
- 19.3.2 Duct Sensors. Duct sensors shall be single point or averaging. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m <sup>2</sup>(10 ft <sup>2</sup>) of duct cross-section.
- 19.3.3 Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.
- 19.3.4 Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port.
- 19.3.5 Differential Sensors. Provide matched sensors for differential temperature measurement.
- 19.4 Humidity Sensors.
  - 19.4.1 Differential Sensors. Provide matched sensors for differential temperature measurement.
  - 19.4.2 Duct and room sensors shall have a sensing range of 20%-80%.
  - 19.4.3 Duct sensors shall have a sampling chamber.
  - 19.4.4 Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of 40°C-75°C (40°F-170°F).
  - 19.4.5 Humidity sensors shall not drift more than 1% of full scale annually.
- 19.5 Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service). Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).
  - 19.5.1 Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
  - 19.5.2 Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- 19.6 Relays.
  - 19.6.1 Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
  - 19.6.2 Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.
- 19.7 Override Timers.
  - 19.7.1 Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

#### 19.8 Current Transmitters.

- 19.8.1 AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
- 19.8.2 Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
- 19.8.3 Unit shall be split-core type for clamp-on installation on existing wiring.
- 19.9 Current Transformers.
  - 19.9.1 AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plasticmaterial.
  - 19.9.2 Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
  - 19.9.3 Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.
- 19.10 Voltage Transmitters.
  - 19.10.1 AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.
  - 19.10.2 Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
  - 19.10.3 Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vacrating.
- 19.11 Voltage Transformers.
  - 19.11.1 AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
  - 19.11.2 Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.
  - 19.11.3 Windings (except for terminals) shall be completely enclosed with metal or plastic.
- 19.12 Power Monitors.
  - 19.12.1 Power monitors shall be three-phase type and shall have three-phase disconnect and shorting switch assembly, UL listed voltage transformers, and UL listed split-core current transformers.
  - 19.12.2 Power monitors shall provide selectable output: rate pulse for kWh reading or 4-20 mA for kW reading. Power monitors shall operate with 5 A current inputs and maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.
- 19.13 Current Switches.
  - 19.13.1 Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.
- 19.14 Pressure Transducers.

- 19.14.1 Transducers shall have linear output signal and field-adjustable zero and span.
- 19.14.2 Continuous operating conditions of positive or negative pressure 50% greater than calibrated span shall not damage transducer sensing elements.
- 19.14.3 Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4-20 mA output, suitable mounting provisions, and block and bleed valves.
- 19.14.4 Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300 psi.) Transducer shall have 4-20 mA output, suitable mounting provisions, and 5-valve manifold.
- 19.15 Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

#### 20.0 NETWORKS

- 20.1 BAS contractor to coordinate with the City's IT department for the connections to the City's Network.
- 20.2 Design for the Network LAN (BC LAN) shall include the following provisions:
  - 20.2.1 Provide access to the BC LAN from a remote location, via the Intranet.
  - 20.2.2 The network LAN shall utilize BACnet/IP (ASHRAE standard SPC-135A-2004 Annex L) for communication between BCs. Manufacturer specific proprietary protocols, gateways, or protocol converters are not acceptable for this project. The OWS shall communicate to the BCs utilizing standard Ethernet to IEEE 802.3 Standards.
  - 20.2.3 High-speed data transfer rates for alarm reporting, quick report generation form multiple controllers and upload/download efficiency between network devices.
  - 20.2.4 Detection and accommodation of single or multiple failures of workstations, controller panels and the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.
  - 20.2.5 Message and alarm buffering to prevent information from being lost.
  - 20.2.6 Error detection, correction, and retransmission to guarantee data integrity.
  - 20.2.7 Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.
  - 20.2.8 Commonly available, multiple sourced, networking components shall be used to allow the system to coexist with other networking applications such as office automation. ETHERNET is the only acceptable technology.
  - 20.2.9 Synchronization of the real-time clocks in all BC panels shall be provided.
  - 20.2.10 The BC LAN shall be a 100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Building Controllers (BCs), user workstations and where specified, a local server. Local area network minimum physical and media access requirements: 20.2.10.1 Ethernet; IEEE standard 802.3

#### SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

- 20.2.10.2 Cable; 100 Base-T, UTP-8 wire, category5
- 20.2.10.3 Minimum throughput; 10 Mbps, with ability to increase to 100 Mbps
- 20.2.11 Provide access to the BC LAN via a Wireless Application Protocol (WAP) device as well. Through this connection the BC LAN will provide authorized staff with the ability to monitor and control the BAS from any location within the City network through a web browser, cellular phone, pager, WebPads, or PDA. (Pocket Computer).

#### 21.0 SERVER FUNCTION

- 21.1 Local connections shall be via an Ethernet LAN.
- 21.2 It shall be possible to provide access to all Building Control Units (BC) via a single connection to the server. In this configuration, each Building Control Unit (BC) can be accessed from an Operator Workstation (OWS) using a standard Web browser by connecting to the BAS LAN. The server shall provide the following functions, as a minimum:
  - 21.2.1 Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.
  - 21.2.2 Distributed Control: The server shall provide the ability to execute global control strategies based on control and data objects in any Building Control Unit (BC) in the network, local or remote.
  - 21.2.3 The server shall include a master clock service for its subsystems and provide time synchronization for all Building Control Units (BC).
  - 21.2.4 The server shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
  - 21.2.5 The server shall provide scheduling for all Building Control Units and their underlying field control devices.
  - 21.2.6 The server shall provide demand limiting that operates across all Building Control Units. The server must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shedding lists for effective demand control.
  - 21.2.7 The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to Building Control Units. Systems not employing this prioritization shall not be accepted.
  - 21.2.8 Each Building Control Unit supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
  - 21.2.9 The server shall provide central alarm management for all Building Control Units supported by the server. Alarm management shall include:
  - 21.2.10 Routing of alarms to display, printer, email and pagers
  - 21.2.11 View and acknowledge alarms
  - 21.2.12 Query alarm logs based on user-defined parameters
  - 21.2.13 The server shall provide central management of log data for all Network Control Units supported by the server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
  - 21.2.14 Viewing and printing log data
  - 21.2.15 Exporting log data to other software applications
  - 21.2.16 Query log data based on user-defined parameters
  - 21.2.17 Minimum BACnet features supported are

-Standard BACnet Objects (Analog In/Out/Value, BinaryInput/Output/Value, Multi-State --Input/Output/Value, Schedule(export), Calendar(export), Trend(Export), Device ).

-Segmented Capability (Segmented Request-Segmented Response).

-Application Services (Read Property, Read Property Multiple, Write Property, Write Property Multiple, Confirmed Event, Notification, Acknowledge Alarm, Get Alarm Summary Who-has, I-have, Who-is, I-am, Subscribe COV, Confirmed COV notification, Unconfirmed COV notification).

#### -BACnet Broadcast Management

#### 22.0 SCOPE OF WORK

- 22.1 The work covered by this specification and related sections consists of providing shop drawings, equipment, labour, materials, engineering, technical supervision, and transportation as required to furnish and install a fully operational BAS to monitor and control the facilities listed herein, and as required to provide the operation specified in strict accordance with these documents, and subject to the terms and conditions of the contract. The work in general consists of but is not limited to, the following:
  - 22.1.1 The preparation of submittals and provision of all related services.
  - 22.1.2 Operator workstations located as listed in the specifications (OWS will be provided by the City's IT, SEE PART 2, SECTION 1.1.4).
  - 22.1.3 Furnish and install all controllers to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.
  - 22.1.4 Furnish and load all software required to implement a complete and operational BAS.
  - 22.1.5 Furnish complete operating and maintenance manuals and field training of operators, programmers, and maintenance personnel.
  - 22.1.6 Perform acceptance tests, commissioning or re-commissioning as indicated.
  - 22.1.7 Provide full documentation for all application software and equipment.
  - 22.1.8 Miscellaneous work as indicated in these specifications.

#### 23.0 PERMITS, FEES AND CODES

- 23.1 Apply for, obtain and pay for all permits, licenses, inspections, examinations and fees required. Also submit, if required, information and other data that may be obtained from the Engineer. Should the authorities require the information on specific forms, fill in these forms by transcribing the information provided by the Engineer.
- 23.2 BAS contractor shall obtain and pay for the police clearance certificates if required for the project.
- 23.3 Arrange for inspection of all work by the authorities having jurisdiction over the Work. On completion of the Work, present to the Engineer the final unconditional certificate of approval of the inspecting authorities.
- 23.4 Comply with the requirements of the latest edition of the applicable ULC or CSA standards, the requirements of the Authorities, Federal, Provincial/Territorial and Municipal Codes, the applicable standards of ULC and all other authorities having jurisdiction. These Codes and Regulations constitute an integral part of these Specifications.
- 23.5 Where there is no alternative to supply equipment which is CSA certified, submit such equipment to the local electrical authority for special inspection and obtain approval before delivery of equipment to site.
- 23.6 In case of conflict, applicable Codes take precedence over the Contract Documents. In no instance reduce the standard or Scope of Work or intent established by the Drawings and Specifications by applying any of the Codes referred to herein.
- 23.7 Before starting any work, submit the required number of copies of documentation to the authorities for their approval and comments. Comply with any changes requested as part of the Contract, but notify the

Engineer immediately of such changes, for proper processing of these requirements. Prepare and furnish any additional drawings, details or information as may be required.

#### 24.0 COORDINATION

- 24.1 All work shall be performed at times acceptable to the Engineer/Construction Manager. Provide work schedule at the start of the job for the approval of the Engineer/Construction Manager. Schedule shall show when all staff and sub-contractors shall be on-site.
- 24.2 Organize all sub-contractors and ensure that they maintain the schedule.
- 24.3 Full cooperation shall be shown with other sub-contractors to facilitate installations and to avoid delays in carrying out the work.
- 24.4 Notify Engineer/Construction Manager of any changes to the schedule. Send any schedule changes and weekly progress reports via fax to Engineer/Construction Manager.
- 24.5 Where, in the judgment of the Engineer/Construction Manager, the work could disrupt the normal operations in or around the building, contractor shall schedule work to eliminate or minimize interference, subject to owner's approval.
- 24.6 When connecting to the existing systems, advise the Engineer/Construction Manager and obtain permission to so. Perform work at a time acceptable to the Engineer/Construction Manager and Owner.

#### 24.0 SUPERVISION OF PERSONNEL

- 24.1 Maintain at this building qualified personnel and supporting staff with proven experience in erecting, supervising, testing, and adjusting projects of comparable nature and complexity.
- 24.2 Supervisory personnel and their qualifications are subject to the approval of the Owner.
- 24.3 All personnel working on-site shall sign in as required by the Owner and shall wear company identification.
- 24.4 When requested and for whatever reason, remove personnel and/or support staff from project. Take immediate action. Contractors and subcontractors may require police clearance.

#### 25.0 ELECTRICAL WORK AND SAFETY REQUIREMENTS

- 25.1 Control and interlock wiring and installation shall comply with national and local electrical codes, and manufacturer's recommendations.
- 25.2 CEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by CEC.
- 25.3 Low-voltage wiring shall meet CEC Class 2 requirements. Subfuse low-voltage power circuits as required to meet Class 2 current limit.
- 25.4 CEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.
- 25.5 Install wiring in raceway where subject to mechanical damage and at levels below 3 m (10ft) in mechanical, electrical, or service rooms.
- 25.6 Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

- 25.7 Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.
- 25.8 Do not install wiring in raceway containing tubing.
- 25.9 Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 3 m (10 ft) intervals.
- 25.10 Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.
- 25.11 Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.
- 25.12 Size raceway and select wire size and type in accordance with manufacturer's recommendations and CEC requirements.
- 25.13 Include one pull string in each raceway 2.5 cm (1 in.) or larger.
- 25.14 Use color-coded conductors throughout.
- 25.15 Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.
- 25.16 Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 15 cm (6 in.) between raceway and high-temperature equipment such as steam pipes or flues.
- 25.17 Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.
- 25.18 Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.
- 25.19 Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.
- 25.20 Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes withbushings.
- 25.21 All equipment and systems installed under this Contract shall be grounded, isolated, or conditioned as required to permit equipment to continue to function normally, without interruption, in the event of radio frequency interference (RFI), electromagnetic interference (EMI), power surges/dips or other electrical anomalies.
- 25.22 It shall be the responsibility of the Contractor or his Sub-contractor to ensure that any coring of holes through the walls or floors will not penetrate existing conduits, cables or mechanical equipment in or under the floor slabs or walls. He shall be responsible to take any and all action as deemed necessary by the Project Manager to correct any such penetrations at his cost. No coring shall be undertaken unless the Project Manager gives permission. Scan walls and floors prior to core drilling to identify hidden piping. Ensure that water does not flow into equipment and below floors. Waterproof and fire stop all penetrations.

#### 26.0 COMMUNICATION WIRING

26.1 Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 25 (Electrical Work).

26.2 Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

- 26.3 During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.
- 26.4 Verify entire network's integrity following cable installation using appropriate tests for each cable.
- 26.5 Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.
- 26.6 Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.
- 26.7 Label communication wiring to indicate origination and destination.
- 26.8 Ground coaxial cable according to OEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

#### 27.0 LOCKABLE PANELS

- 27.1 Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.
- 27.2 Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.
- 27.3 Each local panel shall have a control power source power switch (on-off) with overcurrent protection.

#### 28.0 WARNING LABELS

- 28.1 All Controller panelsAffix permanent warning labels to equipment that can be automatically started by the control system.
  - 1. Labels shall use white lettering (12-point type or larger) on a red background.
  - 2. Warning labels shall read as follows.



- B. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.
  - 1. Labels shall use white lettering (12-point type or larger) on a red background.
  - 2. Warning labels shall read as follows.

#### C A U T I O N This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

29.0 IDENTIFICATION OF HARDWARE AND WIRING

#### SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

- 29.1 Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 5 cm (2 in.) of termination.
- 29.2 Permanently label or code each point of field terminal strips to show instrument or item served.
- 29.3 Label control panels with minimum 1 cm ( $\frac{1}{2}$  in.) letters on laminated plastic nameplates.
- 29.4 Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement (lamacoids).
- 29.5 Label room sensors related to terminal boxes or valves with nameplates (lamacoids).
- 29.6 Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.
- 29.7 Label identifiers shall match record documents.
- 29.8 Insert laminated points list in the control panel

#### 30.0 PRELIMINARY DESIGN REVIEW

- 30.1 The BAS contractor shall submit a preliminary design document for review. This document shall contain the following information:
  - 30.1.1 Provide a description of the proposed system along with a system architecture diagram with the intention of showing the contractors solution to meet this specification.
  - 30.1.2 Provide product data sheets and a technical description of BC, AAC, ASC hardware required to meet specifications listed herein.
  - 30.1.3 Provide product brochures and a technical description of the Server, Operator Workstation, and Building Control Unit (BC) software required to meet this specification. Provide a description of software programs included.
  - 30.1.4 Open Protocols For all hardware Building Controllers, Advanced Application Controllers (AAC) and Advanced Specific Controllers (ASC), provide BACnet Interoperability Building Blocks BIBBs certification. Provide complete description and documentation of any proprietary services and/or objects where used in the system.
  - 30.1.5 Provide a description and samples of Operator Workstation graphics and reports.
  - 30.1.6 Provide an overview of the BAS contractor's local/branch organization, local staff, recent related project experience with references, and local service capabilities.
  - 30.1.7 Provide information on the BAS contractors project team including project organization, project manager, project engineer, programmers, project team resumes, and location of staff.

#### **31.0 DRAWING REQUIREMENTS**

- 31.1.1 Within 45 days of award of contract and before start of construction, submit 3 hard copies and 1 soft copy of manufacturers information and shop drawings. Soft copy to be in AutoCAD or VISIO and WordPerfect or Word formats (latest versions) structured using menu format for easy loading and retrieval on the OWS.
- 31.1.2 Manufacturer's Data: Provide in completely coordinated and indexed package to assure full compliance with the contract requirements. Piecemeal submittal of data is not acceptable and such submittals will be returned without review. Information shall be submitted for all material and equipment the contractor proposes to furnish under terms of this contract work. Arrange the

#### SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

submittals in the same sequence as these specifications and reference at the upper right-hand corner the particular specification provision for which each submittal is intended. Submittals for each manufactured item shall be manufacturer's descriptive literature (equipment specification), equipment drawings, diagrams, performance and characteristic curves, and catalog cuts, and shall include the manufacturer's name, trade name, catalog model or number, nameplate data, size layout dimension, capacity, specification reference, applicable specification references, and all other information necessary to establish contract compliance.

- 31.1.3 Shop drawings: Provide in completely coordinated and indexed package:
  - 31.1.3.1Wiring and piping diagrams.
  - 31.1.3.2 Control schematics with narrative description and control descriptive logic fully showing and describing operation and/or manual procedures available to operating personnel to achieve proper operation of the building, including under complete failure of the BAS.
  - 31.1.3.3 Shop drawings for each input/output point showing all information associated with each particular point including sensing element type and location; details of associated field wiring schematics and schedules; point address; software and programming details (CDL's) associated with each point; and manufacturer's recommended installation instructions and procedures for each type of sensor and/or transmitter.
  - 31.1.3.4 Detailed system architecture showing all points associated with each controller, controller locations, and describing the **spare points capacity** at each controller and BAS LAN.
  - 31.1.3.5Each BC shall contain a minimum of 20% spare resource capacity. The BC shall provide a throughput capable of transmitting all BAS LAN data connected to it within 10 seconds.
  - 31.1.3.6 Each AAC and ASC shall have a minimum of 10% spare capacity for each point type for future point connection. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring. As a minimum, provide one of each type of point available on the controller.
  - 31.1.3.7 Specification sheets for each item including manufacturers descriptive literature, drawings, diagrams, performance and characteristic curves, manufacturer and model number, size, layout, dimensions, capacity, etc
  - 31.1.3.8Colour graphic displays detailing hierarchical structure of facility, including floor plans, with multi-level penetration to equipment level.

#### 32.0 START-UP AND CHECKOUT

#### City's BAS Project Manager shall be present during the Start-Up and Checkout- FOR FACILITIES MANAGEMENT PROJECTS ONLY, FOR OTHER DIVISIONS THIS IS OPTIONAL

32.1 This work shall include field testing and adjustment of the complete BAS, and on-site final operational acceptance test of the complete operational BAS. The Engineer shall be advised at least 14 days in advance of the dates of all tests and may attend at his discretion. If the Engineer witnesses the test, such tests shall be subject to his approval prior to the release of equipment. If the Engineer elects not to witness the tests, the contractor shall provide performance certification. Acceptance of tests by the Engineer and Project Manager shall not relieve the contractor of responsibility for the complete system meeting the requirements of these specifications after installation.

32.2 Static testing:

#### SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

- 32.2.1 Static testing shall include point-by-point testing of the entire system and completion of Component Test Sheets. The contractor shall forward proposed Test Sheets at the shop drawing review stage. These Component Test Sheets shall be completed during the contractor's own testing and verification procedure that is done prior to the request for a final inspection. The completed Component Test Sheets shall then be returned to the Engineer for review and approval. The Engineer may repeat a random sampling of at least 50% of the tests during the Engineers commissioning procedure to corroborate their accuracy. The Contractor shall be on site with test equipment during this verification process. The test procedures shall include the following.
  - 32.2.1.1 Digital input component test sheet:
    - 32.2.1.1.1 DI status shall be verified at the POT and OWS for ON and OFF status.
    - 32.2.1.1.2 All digital alarm inputs shall be proven using actual field conditions where possible or be jumpered at the field device for testing with the approval of the Engineer.
  - 32.2.1.2 Digital output component testsheet:
    - 32.2.1.2.1 Status to be verified at the equipment location. Verification at the OWS shall be completed for ON and OFF status, software DISABLE indicator and OVERRIDEN indicator
  - 32.2.1.3 Analog input component test sheet:
    - 32.2.1.3.1 All temperature sensors shall be calibrated using a hand held meter with equal or better accuracy.
    - 32.2.1.3.2 Selected temperature sensors chosen by the Engineer shall be verified by spraying with a cold spray or other means to ensure response and to test the low temperature alarm condition.
    - 32.2.1.3.3 All pressure sensing devices and analog output feedback shall be verified using a device with equal or better accuracy to ensure correct calibration.
    - 32.2.1.3.4 All humidity sensing devices must be verified using a recently calibrated device with equal or betteraccuracy
    - 32.2.1.3.5 All CTs shall be set to accurately reflect motor status, including removing belts on belt driven equipment
    - 32.2.1.3.6 All other devices shall be verified using appropriate devices of equal or better accuracy
    - 32.2.1.3.7 Adjust span on feedback devices so that input matches the end device
- 32.2.2 Analog output component testsheet:
  - 32.2.2.1 Al points shall be tested by sending a command from the PWS or OWS to incrementally stroke the field device from full CLOSED to full OPEN and measuring the signal at the field device. The increments of the test shall be no larger than 10% of the output span.
  - 32.2.2.2The AO feedback requirement shall also be tested by failing the field device and verifying that the alarm registers
  - 32.2.2.3 Each output shall be exercised over the full output capability of the panel

32.2.2.4 Field device hysteresis shall be measured at a minimum of three output levels for each direction of travel. Output increments shall not exceed 2% of span for this test

#### 33.0 STANDARDS COMPLIANCE

33.1 Where materials or equipment are specified to conform to requirements of the standards of organizations, such as the Canadian Standards Association (CSA) that use a label or listing as method of indicating compliance, proof of such conformance shall be submitted and approved, indexed and cross-referenced with the specification. The label or listing of the specified organization will be acceptable evidence. In lieu of the label or listing, the contractor shall submit a certificate from a testing organization adequately equipped and competent to perform such services, and approved by the Engineer, stating that the item has been tested in accordance with the specified organization's test methods and that the item conforms to the specified organization's standard or code. For materials whose compliance with organizational standards or specifications is not regulated by an organization using its own listing or label as proof of compliance, a certificate from the manufacturer shall be furnished to the Engineer stating that the material complies with the applicable referenced standard or specification.

#### 34.0 FINAL ACCEPTANCE

- 34.1 Final acceptance shall commence only after satisfactory completion of start-up, verification of performance and the 30-day test period described earlier. When the Contractor has satisfied himself as to proper system operation he shall advise the BAS Commissioning Engineer/Consultant to establish a date for Final Acceptance. This will involve a point-by-point check of all hardware and software items including graphics and displayed data, as well as performing tasks as directed.
- 34.2 Supply 2-way radios and all test equipment as previously specified. Have on-site technical personnel capable of re-calibrating all field hardware and modifying software.
- 34.3 Test each system independently and then in unison with other related systems. Test weather sensitive systems twice- once near winter design conditions and again near summer design conditions.
- 34.4 Optimize operation and performance of each system. Test full-scale emergency operation and integrity of smoke management and other life safety systems.
- 34.5 Demonstrate to the Engineer the operation of each system including sequence of operations in regular and emergency modes, under all normal and emergency conditions, start-up, shut-down, interlocks, and lock-outs.
- 34.6 Upon completion of the testing submit a report to the Engineer to summarize all testing.

#### **35.0 DOCUMENTATION**

- 35.1 Documentation shall consist of 4 hard copies and one soft copy for all information described below
- 35.2 The final documentation package shall include:
  - 35.2.1 Hard and soft copies of all control drawings (As-Builts).
  - 35.2.2 Manufacturer's technical data sheets for all hardware and software
  - 35.2.3 Factory operating and maintenance manuals with any customization required
  - 35.2.4 Soft copies of programming and front-end software and each controller's database. Hard copy output of programming is not necessary

- 35.2.5 Provide clear, concise, typewritten and soft copy descriptions of all control sequences in the working language.
- 35.2.6 Soft copy text files shall be in MS-Word.
- 35.3 Each instruction and reference manual shall be bound in hardback, 3 ring, binders or an approved equivalent shall be provided to the Engineer. Binders to be no more than 2/3 full. Each binder to contain index to full volume. One complete set of manuals shall be furnished prior to the time that the system or equipment tests are performed, and the remaining manuals shall be furnished at acceptance. The identification of each manual's contents shall be inscribed on the cover and spine. The manuals shall include the names, addresses and telephone numbers of each subcontractor installing equipment systems and of the local representatives for each item of equipment and each system. The manuals shall have a table of contents and be assembled to conform to the table of contents with the tab sheets placed before instructions covering the subject. Additionally, each manual shall contain a comprehensive index of all manuals submitted in accordance with this paragraph. Manuals and specifications shall be furnished which provide full and complete coverage of the following subjects:
- 35.4 <u>Operational Requirements</u>: This document shall describe in concise terms, all the functional and operational requirements for the system and its functions that have been implemented. It shall be written using common terminology for building operation staff and shall not presume knowledge of digital computers, electronics or in-depth control theory.
- 35.5 <u>System Operation</u>: Complete step by step procedures for operation of the system, including required actions at each operator station; operation of computer peripherals; input and output formats; and emergency, alarm and failure recovery. Step-by-step instructions for system startup, back-up equipment operation, and execution of all system functions and operating modes shall be provided.
- 35.6 <u>Maintenance</u>: Documentation of all maintenance procedures for all system components including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective module. This shall include calibration, maintenance, and repair or replacement of all system hardware.
- 35.7 <u>Test Procedures and Reports</u>: The test implementation shall be recorded with a description of the test exercise script of events and documented as test procedures. A provision for the measurement or observation of results, based on the previously published test specification, forms the test reports. The procedures record and the results of these exercises shall be conveniently bound and documented together.
- 35.8 <u>Configuration Control</u>: Documentation of the basic system design and configuration with provisions and procedures for planning, implementing, and recording any hardware or software modifications required during the installation, test, and operating lifetime of the system. This shall include all information required to ensure necessary coordination of hardware and software changes, data link or message format/content changes, and sensor or control changes in the event system modification are required, and to fully document such new system configurations.

#### 36.0 TRAINING

- 36.1 The Contractor shall provide the services of competent instructors who will provide instruction to designated personnel in the adjustment, operation and maintenance, including pertinent safety requirements, of the equipment and system specified. The training shall be oriented towards the system installed rather than being a general "canned" training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The number of person-days (eight hours) of instruction furnished shall be as specified below as a minimum. A training manual shall be provided for each trainee that describes in detail the data included in each training program.
- 36.2 All equipment and material required for classroom training shall be provided by the contractor. A personweek shall be considered as 37.5 hours, 8:00 am to 12:00 noon, and 12:30 pm to 4:30 pm Monday through Friday. Provide 5 days of training as specified herein.

- 36.3 Training shall enable operators to accomplish the following objectives:
  - 36.3.1 Proficiently operate system
  - 36.3.2 Understand control system design and configuration
  - 36.3.3 Create and change system graphics
  - 36.3.4 Create, delete, and modify alarms, including configuring alarm reactions
  - 36.3.5 Configure and run reports
  - 36.3.6 Add, remove, and modify system's physical points
  - 36.3.7 Create, modify, and delete application programming
  - 36.3.8 Add a new controller to system
  - 36.3.9 Download firmware and advanced applications programming to a controller
  - 36.3.10 Configure and calibrate I/O points
  - 36.3.11 Maintain software and prepare backups
  - 36.3.12 Understand DDC system components
  - 36.3.13 Understand system operation, including DDC system control and optimizing routines (algorithms)
  - 36.3.14 Operate workstation and peripherals
  - 36.3.15 Log on and off system
  - 36.3.16 Access graphics, point reports, and logs
  - 36.3.17 Adjust and change system setpoints, time schedules, and holiday schedules
  - 36.3.18 Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
  - 36.3.19 Access data from DDC controllers
  - 36.3.20 Add new users and understand password security procedures

#### **37.0 WARRANTY**

- 37.1 Provide warranty certificates showing the name of the firm giving the warranty, dated from the issuance of the Certificate of Substantial Performance and acknowledged on specific equipment and systems.
- 37.2 Include these certificates with the Operation and Maintenance Manual in the appropriate sections.
- 37.3 Contractor shall give a minimum <u>two-year</u> warranty for parts and labor on all equipment and materials installed and shall select materials and equipment where the Manufacturer gives the same warranty arrangements. Warranty shall commence on the date of the Engineers issuance of the Certificate of Substantial Completion.
- 37.4 Provide a warranty as indicated in 38.0 Maintenance/Service.

- 37.5 The Contractor shall agree to make good at his own expense any equipment that fails to operate due to poor workmanship, manufacturing defect or improper installation. Any repairs shall be made at the convenience of the Engineer during normal working hours, unless deemed an emergency.
- 37.6 Provide upgrades to all software or all panel firmware issued during the warranty period at no charge to Owner.

#### 38.0 MAINTENANCE/SERVICE

BAS contractor to show the price of service contract as separate line item. Applicable to New System Installations OR Major overhaul of existing BAS system/s

- 38.1 Provide warranty in accordance with the warranty section of this specification. In addition provide scheduled maintenance and service during the warranty period on all control system apparatus including but not limited to valves, dampers, linkages, control panels, interfaces, direct digital control systems, OWS, Server, BC, AAC, ASC, Software and application programs.
- 38.2 Scheduled preventive maintenance inspections will provide those services required to maintain the system at maximum performance and reliability levels and may include the following:
- 38.3 Analyze, adjust, calibrate the applicable temperature sensors, humidity sensors, diagnostic LEDs, printers, power supplies, work stations, controllers, modems, input/output points, communication cabling, transmitters, transducers, UPS for the BAS system.
- 38.4 Conduct inspections and thorough preventive maintenance routine on each piece of covered equipment. In addition, make tests and adjustments to ensure efficient and reliable operation of other major components.
- 38.5 Examine, clean and calibrate as required sensors, thermostats, humidity controls, temperature controls, pressure controls, relays, damper actuators, instrumentation and accessories directly pertaining to the Building Automation System.
- 38.6 Check and confirm control system sequence of operation to insure optimum system efficiency and economy.
- 38.7 A log of each loop tested and each control sequence verified shall be reviewed with the owner.
- 38.8 All components of the Pneumatics Control System will be serviced according to manufacturer's recommendations during each year of the contract. This will include (but not be limited to) all lubricant changes, filter changes, adjustments, calibrations and cleaning.
- 38.9 The system includes, but is not limited to, the air compressor, air receiver, pressure reducing valves, air dryers and all sensors, controllers, transducers, damper and valve operators, thermostats, pilot positioners, electro-pneumatic switches, linkages and any other pneumatic and electronic devices used to maintain the environmental comfort in the building.
- 38.10 The Contractor will provide preventative maintenance and diagnostic inspections to all electronic system components on a frequency established by manufacturer's recommendations, component age and condition and discussion with the Supervisor of Operations responsible for the site.
- 38.11 Provide a fully trained BAS service technician and a Pneumatic fitter (Required for Pneumatic/DDC system) a minimum of one day per month (8 hours for DDC technician and 8 hours for pneumatic fitter) during the warranty period to provide the preventive maintenance and service described above. Provide

written reports to the owner outlining the work performed. <u>Allow for 12 annual visits of one day each (24 days</u> total for 2 years) during the warranty period to provide required service. (*This may change in accordance with the size of the project*).

- 38.12 Provide emergency service for parts and labor on an as needed basis. Response to an emergency call shall be 2 hours maximum on Mon.-Fri. including on holidays and weekends.
- 38.13 Provide remote service diagnostic monitoring from the local office. At the request of the owner, a service diagnostic call will be made to troubleshoot and resolve (if possible) any reported system complaints.
- 38.14 Provide a price for a three-year service agreement based on the above requirements to come in to effect upon the completion of the warranty period. Show this price as OPTION: Service Agreement.

#### PART 2 - OPERATOR WORKSTATION (OWS) AND SOFTWARE

- 1.0 GENERAL
  - 1.1 General Requirements: Section 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)
  - 1.2 Performance requirements of the Operator WorkStation (OWS) and the Graphical Users Interface are specified in this section.
  - 1.3 Environmental Conditions: The OWS and its immediate associated devices shall be able to operate properly under environmental conditions of 10 deg.C to 32 deg.C and a relative humidity of 20 to 90% non-condensing.
  - 1.4 **OWS shall be provided by the City's IT department.** BAS contractor shall **NOT** include the cost of the computer for the pricing of the project. The OWS shall be provided for centralized system control, information management, alarm management and data base management functions. All real time control functions shall be resident in the standalone Building Control Unit (BC) and local controllers (AACs and ASCs).
  - 1.5 Provide two copies of all Programming Software; one each for OWS and a laptop; <u>if requirement of a</u> <u>laptop is deemed necessary otherwise provide only one copy. Requirement of a laptop is site</u> <u>specific and shall be provided by the City's IT department. City's project manager shall consult</u> with the district operation manager/supervisor to determine if a laptop is required for the project.
  - 1.6 Any computer on the BAS LAN shall be capable of displaying the systems in a graphical and dynamic format utilizing a standard web browser. Screen refresh shall be automatic. Manual refresh is not acceptable.

#### 2.0 WORKSTATION HARDWARE REQUIREMENTS

- 2.1 Reference 1.1.5
- 2.2 BAS contractor shall coordinate with the City's IT department through the project manager to discuss minimum requirement of the workstation's (computer) hardware, software (operating system) to ensure BAS system will meet or exceed the performance requirement of this specifications.
- 2.3 Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.
- 2.4 Provide \_\_\_\_\_ Workstations. The Workstation(s) will be located as directed by the engineer.
- 2.5 **This Item is for guidance only.** Hardware Base. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications. Hard disk shall have sufficient memory to store system software, one year of data for trended points specified by the conusItant's sequence of operation and the points list. Workstations shall be with a minimum of:

- 2.5.1 Intel Pentium 2.66 GHz processor (Pentium IV- Duo Core)
- 2.5.2 8 GB RAM
- 2.5.3 100 GB hard disk providing data at 100 MB/sec
- 2.5.4 48x CD-ROM drive
- 2.5.5 Keyboard
- 2.5.6 Mouse
- 2.5.7 24-inch 24-bit color monitor with at least 1024 x 768 resolution
- 2.5.8 Serial, parallel, and network communication ports and cables as required for proper system operation
- 2.5.9 Two (2) USB 2.0 or 3.0 ports

#### 3.0 PRINTERS

- 3.1 BAS contractor to coordinate with the City's IT department through the project manager to ensure a network printer is connected to the Operator Workstation that is provided by the City's IT department.
- 3.2 If the site doesn't have a printer available then City's IT department shall provide a desktop printer.
- 3.3 **Printer Specifications- For Guidance only:** The printer shall be a bubble jet or inkjet printer, 1440 x1440 dpi resolution, internal 1MB buffer memory, minimum 8 ppm in black. No colour printer is required.

#### 4.0 UNINTERRUPTABLE POWER SUPPLIES

4.1 Provide the OWS, Server (if applicable), and each BC with individual UPS to provide clean, reliable, noisefiltered power at all times and to protect and maintain systems operation throughout short term power interruptions of at least 15 minutes duration. (site specific)

#### 5.0 PROGRAMMING SOFTWARE

- 5.1 Custom Application Programming. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
  - 5.1.1 Language. Language shall be graphically based or English language oriented. If graphically based, language shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks. If English language oriented, language shall be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and shall allow for free-form programming that is not column-oriented or "fill-in-the-blanks."
  - 5.1.2 Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
  - 5.1.3 Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
  - 5.1.4 Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate

actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

- 5.1.5 Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
- 5.1.6 Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
- 5.1.7 Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.
  - 5.1.7.1 Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.
  - 5.1.7.2 System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.
- 5.2 The software shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of the software shall be through password access as assigned by the system administrator.
- 5.3 Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.
- 5.4 Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage of the building's flywheel effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day's performance.

# FOR TRIDIUM INTEGRATION (IF APPLICABLE) BAS CONTRACTOR SHALL CONFORM TO ITEMS 5.1, 5.2, 5.3, 5.4 PLUS ITEM 5.5

5.5 A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide real-time data updates. Any real-time data value or object property may be connected to display its current value on a user display.

Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.

- 5.5.1 Programming Methods
  - 5.5.1.1 Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in colour depending on the type of link; i.e., internal, external, hardware, etc.
  - 5.5.1.2 Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
  - 5.5.1.3 The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
  - 5.5.1.4 All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.
  - 5.5.1.5 The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.
  - 5.5.1.6 The user shall be able to pick a graphical function block from the menu and place on the screen. Programming tools shall place lines connecting appropriate function blocks together automatically. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.
  - 5.5.1.7 The programming tools shall include a test mode. Test mode shall show user real-time data on top of graphical display of selected function blocks. Data shall be updated real-time with no interaction by the user. Function blocks shall be animated to show status of data inputs and outputs. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.
  - 5.5.1.8 Composite Object Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the contained application that are represented on the graphical shell of this container.

#### 5.6 OPERATOR WORKSTATION SOFTWARE

#### 5.6.1 Operating System: City's IT department will provide OWS including operating system.

5.6.2 The BAS software shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to,

forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

- 5.6.3 Real-Time Displays. The OWS, shall at a minimum, support the following graphical features and functions:
  - 5.6.3.1 Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
  - 5.6.3.2 Graphic screens shall have the capability to contain objects for text, real-time values, animation, colour spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.
  - 5.6.3.3 Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.
- 5.6.4 Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
- 5.6.5 Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
- 5.6.6 Right-clicking the selected object and using a graphical slider to adjust the value shall make adjustments to analog objects, such as set points. No entry of text shall be required.
- 5.6.7 System Configuration. At a minimum, the OWS shall permit the operator to perform the following tasks, with proper password access:
  - 5.6.7.1 Create, delete or modify control strategies.
  - 5.6.7.2 Add/delete objects to the system.
  - 5.6.7.3 Tune control loops through the adjustment of control loop parameters.
  - 5.6.7.4 Enable or disable control strategies.
  - 5.6.7.5 Generate hard copy records or control strategies on a printer.
  - 5.6.7.6 Select points to be alarm-able and define the alarm state.
  - 5.6.7.7 Select points to be trended over a period of time and initiate the recording of values automatically.
- 5.6.8 On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.
- 5.6.9 Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This

auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

- 5.6.10 System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
- 5.6.11 Alarm Console. The system shall be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and unacknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator.
- 5.6.12 Operator's workstation software shall contain an easy-to-operate system; allowing configuration of system-wide controllers, including management and display of the controller programming. This system shall provide the capability to configure controller binary and analog inputs/outputs.
- 5.6.13 The system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages. Graphics generation shall be done using standard Windows packages. No proprietary graphics generation software shall be needed.
- 5.6.14 Provide software, which enables the non-programmer operator to easily perform, tasks which are likely to be part of his daily routine.
- 5.6.15 The operator's console shall provide facilities for manual entries and visual displays enabling an operator to enter information into the system and obtain displays and logs of system information. All requests for status, analog, graphic displays, logs, and control shall be selected from the operator's console. The operator interface shall minimize the use of typewriter style keyboard by implementing a mouse or similar pointing device and "point and click" approach to command selection. The facility shall be provided to permit the operator to perform the following tasks: 5.6.15.1Automatic logging of digital alarms and change of status message.
  - 5.6.15.2 Automatic logging of all analogalarms.
  - 5.6.15.3 System changes (alarm limits, set-points, alarm lock-outs, etc.).
  - 5.6.15.4 Display specific points as requested by the operator.
  - 5.6.15.5Provide reports as requested by the operator and on Scheduled basis where so required.
  - 5.6.15.6 Display graphics as requested by the operator.
  - 5.6.15.7 Display help information.
  - 5.6.15.8 Provide trend logs as required by the operator.
  - 5.6.15.9 Provide manual control of digital and analog outputs as required by the operator.
  - 5.6.15.10 Direct the hard copy output of information to the device selected by the operator.
  - 5.6.15.11 Data displayed on monitor to cyclic update as appropriate.
- 5.6.16 Online changes:
  - 5.6.16.1 Alarm limits

- 5.6.16.2 Setpoints
- 5.6.16.3 Deadbands
- 5.6.16.4 Changes/deletions/additions ofpoints.
- 5.6.16.5 Control and change of state changes.
- 5.6.16.6 Time of day, day, month, year.
- 5.6.16.7 Control loop control description changes for NCU based CDM's.
- 5.6.16.8 Control loop tuning changes
- 5.6.16.9 Schedule changes
- 5.6.16.10 Changes/additions/deletions to system graphics
- 5.6.16.11 Changes/additions/deletions to total systems
- 5.6.17 It shall be possible for the OWS operator to initiate analog and digital output commands. Where the BAS software normally originates these outputs, the provision shall exist for the operator to terminate automatic BAS control of any particular output and to originate a manual analog or digital output command. The provision shall exist for the operator to return analog or digital output command functions to automatic BAS software control.
- 5.6.18 It shall be possible for the OWS operator to place any computed system setpoint to a computed basis or manual value as and when required.
- 5.6.19 All above functions shall operate under the password protection system.
- 5.6.20 A vocabulary of at least 25 different descriptions using at least six alphanumeric characters to identify engineering units for analog input and output points. Typical description is as follows: %, Deg.C, KPA, KW, KWH, L/S, CFM, Deg.F, PSI. The descriptions shall be alterable from the OWS console with the system on-line.
- 5.6.21 Upon operator's request, the system shall present the condition of any single point, any system, and area or the whole system on printer or CRT. The output device shall be by operator's choice. Analog values and status displayed on the CRT shall be updated whenever new values are received. Points in alarm shall be flagged by blinking, inverse video different colour, bracketed, or by some other means to differentiate them from points not in alarm. Overridden (not in auto) points/values shall similarly be identified.
- 5.7 REPORTING ACCURACY
  - System shall report values with minimum end-to-end accuracy listed in Table 1. 5.7.1
- CONTROL STABILITY AND ACCURACY 5.8
  - 5.8.1 Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table 1	
Reporting	Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C (±1°F)
Ducted Air	±0.5°C (±1°F)
Outside Air	±1.0°C (±2°F)
Dew Point	±1.5°C (±3°F)

Water Temperature	±0.5°C (±1°F)	
Delta-T	±0.15°C (±0.25°F)	
Relative Humidity	±5% RH for monitor only, ±3% RH for control	
Water Flow	±2% of full scale	
Airflow (terminal)	±10% of full scale (see Note 1)	
Airflow (measuring stations)	±5% of full scale	
Airflow (pressurized spaces)	±3% of full scale	
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)	
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)	
Water Pressure	±2% of full scale (see Note 2)	
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)	
Carbon Monoxide (CO)	±5% of reading	
Carbon Dioxide (CO <sub>2</sub> )	±50 ppm	
Note 1: 10% - 100% of scale		
Note 2: For both absolute and differential pressure		
Note 3: Not including utility-supplied meter	s	

#### Table 2

**Control Stability and Accuracy** 

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0-1.5 kPa (0-6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.5°C (±3°F)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1-150 psi) 0-12.5 kPa (0-50 in. w.g.) differential

#### 5.9 ERROR MESSAGES

- 5.9.1 Inform operator of all errors in data, errors in entry instructions, failure of equipment to respond to requests or commands, or failure of communications between components of EMCS.
- 5.9.2 Error messages to be comprehensive and communicate clearly to operator precise nature of problem.

#### 5.10 PASSWORD PROTECTION

- 5.10.1 Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator's terminal functions unless user is logged on. This includes displays as outlined above.
- 5.10.2 Each user shall have an individual User ID, User Name and Password. Entries are alphanumeric characters only and are case sensitive (except for User ID). User ID shall be 8 characters, User Name shall be 29 characters, and Password shall be 8 characters long. Each system user shall be allowed individual assignment of only those control functions and menu items to which that user requires access. All passwords, user names, and access assignments shall be adjustable online at the operator's terminal. Each user shall also have a set security level, which defines

access to displays and individual objects the user may control. System shall include 10 separate and distinct security levels for assignment to users.

#### 5.11 AUDIT LOGS

- 5.11.1 Provide and maintain an Audit Log that tracks all activities performed on the NCU. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached it=s user-defined buffer size. Provide the ability to archive the log locally (to the NCU), to another NCU on the network, or to a server. For each log entry, provide the following data:
- 5.11.2 Time and date
- 5.11.3 User ID
- 5.11.4 Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

#### 5.12 TREND DATA

- 5.12.1 System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the operator's workstation (server) hard disk. Archived files shall be appended with new sample data, allowing samples to be accumulated over several years. Systems that write over archived data shall not be allowed, unless limited file size is specified. Samples may be viewed at the operator's terminal in a trendlog. Logged data shall be stored in spreadsheet format. Operator shall be able to scroll through all trendlog data. System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically. All trendlog information shall be displayed in standard engineering units.
- 5.12.2 Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colours. Graphs shall show object type value relative to time.
- 5.12.3 Operator shall be able to change trend log setup information. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged. All operations shall be password protected. Setup and viewing may be accessed directly from any and all graphics on which object is displayed.
- 5.12.4 System shall be capable of periodically gathering energy log data stored in the field equipment and archive the information on the operator workstation's hard disk. Log data shall include both instantaneous and accumulated values. Archive files shall be appended with the new data, allowing data to be accumulated over several years. Systems that write over archived data shall not be allowed unless limited file size is specified. System shall automatically open archive files as needed to display archived data when operator scrolls through the data. Display all energy log information in standard engineeringunits.
- 5.12.5 System software shall be provided that is capable of graphing the energy log data. Software shall be capable of creating two-axis (x,y) graph that show recorded data, relative to time. All data shall be stored in comma-delimited file format for direct use by third-party spreadsheet or other database programs. Operation of system shall not be affected by this operation. In other words, it shall stay completelyonline.
- 5.12.6 Operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. All operations shall be password protected.

#### 5.13 GRAPHICS

5.13.1 The operator's workstation shall display all data associated with the project. The operator's terminal software shall accept Windows BITMAP (\*.bmp) format graphic files for display purposes. Graphic files shall be created using scanned, full colour photographs of system

installation, AutoCAD drawing files of field installation drawings and wiring diagrams from as-built drawings. Operator's terminal shall display all data using 3-D graphic representations of all mechanical equipment.

- 5.13.2 Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 seconds.
- 5.13.3 Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 seconds and shall automatically refresh every 15 seconds
- 5.13.4 Colour graphic displays detailing hierarchical structure of facility, including floor plans, with multilevel penetration to equipment level.
- 5.13.5 System shall be capable of displaying graphic file, text, and dynamic object data together on each display. Information shall be labelled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user. Terminal shall allow user to change all field-resident BAS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.
- 5.13.6 All displays shall be generated and customized in such a manner that they fit the project as specified. Canned displays shall not be acceptable. Displays shall use standard English for labelling and readout. Systems requiring factory programming for graphics or DDC logic are specifically prohibited. The installing contractor without factory dependency or assistance shall support all graphics and DDC programming locally.
- 5.13.7 Binary objects shall be displayed as ON/OFF/NULL or with customized text. Text shall be justified left, right or centre as selected by the user. Also, allow binary objects to be displayed as individual change-of-state bitmap objects on the display screen such that they overlay the system graphic. Each binary object displayed in this manner shall be assigned up to three bitmap files for display when the point is ON, OFF or in alarm. For binary outputs, toggle the objects commanded status when the bitmap is selected with the system digitizer (mouse). Similarly, allow the terminal operator to toggle the object's status by selecting (with the mouse) a picture of a switch or light, for example, which then displays a different picture (such as an ON switch or lighted lamp). Additionally, allow binary objects to be displayed as an animated graphic.
- 5.13.8 Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion. For example: when a pump is in the OFF condition, display a stationary picture of the pump. When the operator selects the pump picture with the mouse, the represented objects status is toggled and the picture of the pumps impeller rotates in a time-based animation. The operator shall be able to click on an animated graphical object or switch it from the OFF position to ON, or ON to OFF. Allow operator to change bitmap file assignment and also create new and original bitmaps online. System shall be supplied with a library of standard bitmaps, which may be used unaltered or modified by the operator. Systems that do not allow customisation or creation of new bitmap objects by the operator (or with third-party software) shall not be allowed.
- 5.13.9 Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual bitmap items on the display screen as an overlay to the system graphic. Each analog input object may be assigned to a minimum of five bitmap files, each with high/low limits for automatic selection and display of the bitmaps. As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint. Analog output objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box. Selection for display type shall be individual for each object. Analog object values may be changed by selecting either the increase or decrease arrow in the analog object spinner box without using the keypad. Pressing the button on the right side of the analog object spinner box allows direct entry of an analog value and accesses various menus where the analog value may be used, such as trendlogs.

#### SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

- 5.13.10 Analog objects may also be assigned to an area of a system graphic, where the colour of the defined area would change based on the analog objects value. For example, an area of a floorplan graphic served by a single control zone would change colour with respect to the temperature of the zone or its deviation from setpoint. All editing and area assignment shall be created or modified online using simple icon tools.
- 5.13.11 A customized menu label (push-button) shall be used for display selection. Menu items on a display shall allow penetration to lower level displays or additional menus. Dynamic point information and menu label push buttons may be mixed on the same display to allow sub-displays to exist for each item. Each display may be protected from viewing unless operator has appropriate security level. A separate security level may be assigned to each display and system object.
- 5.13.12 A mouse, or other form of digitizer, shall be used to move the pointer arrow to the desired item for selection of new display or to allow the operator to make changes to object data.
- 5.13.13 Displays may be modified on site or via remote communications.
- 5.13.14 Entire system shall operate without dependency on the operator's terminal. Provide graphic generation software at each workstation.

#### 5.14 ALARMS

- 5.14.1 Operator's terminal shall provide audible, visual, and printed means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s), currently running (such as a word processor). Printout of alarms shall be sent to the assigned terminal and port.
- 5.14.2 System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator's terminal. Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.
- 5.14.3 Alarm messages shall be in user-definable text English (or other specified language) and shall be entered either at the operator's terminal or via remote communication.

#### 5.15 SCHEDULING

- 5.15.1 Operator's terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule. This includes all ON/OFF times (to the minute) for each days events.
- 5.15.2 Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules. These speciality schedules shall be displayed at the operator's terminal in a format similar to the weekly schedules, again allowing easy data entry. Exception schedule data is entered by the following methods: date entries (one day entries), date-to-date (a range or span of days), and by weekday (for example, a given day of a given week each month). User shall be able to scroll easily through the months for each year as a minimum.
- 5.15.3 At the operator's terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.

#### 5.16 ARCHIVING

SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

- 5.16.1 Store back-up copies of all controllers databases in at least one OWS and/or the server(if applicable).
- 5.16.2 Provide continuous supervision of integrity of all controller databases. If controller loses database, system to automatically download new copy of database to restore proper operation.
- 5.16.3 Data base back up and downloading to occur over LAN without operator intervention. Operator to be able to manually download entire controller database or parts thereof.

#### 5.17 REPORTS

- 5.17.1 Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section. If display output (CRT) is requested, it shall be scrollable; scroll bars will be used to allow easy and flexible movement within the report. Output to be sorted by area, system, point.
- 5.17.2 Periodic/Automatic Report: Provide the software to automatically generate any report specified, the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device. The software will allow the operator to modify the periodic/automatic reporting profile at any time.
- 5.17.3 As a minimum, the following reports shall be configured on the system:
  - 5.17.3.1 <u>Dynamic Reports:</u> To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency. It shall be possible to select points on the following basis:
    - 5.17.3.1.1 All points in all areas
    - 5.17.3.1.2 Area (all points in area)
    - 5.17.3.1.3 Area system (all points in system)
    - 5.17.3.1.4 Area system point (individual point)
    - 5.17.3.1.5 System (all points by system and point type)
    - 5.17.3.1.6 System point (all points by system and point type)
    - 5.17.3.1.7 Area point (all points by area and point type).
  - 5.17.3.2 <u>Summary Report</u>: To permit the display or printing the dynamic value for the user specified points which shall indicate the status at the time the CLM was entered. Reports to be available on same basis as dynamic reports. Output will be to the user selected output device.
  - 5.17.3.3 <u>Trend Reports</u>: To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.
  - 5.17.3.4 <u>Historical Data Collection</u>: Provision shall be made to ensure historical data is not lost. The ability to off-load historical data to removable media, and to later load data previously backed-up, will be provided. Historical data values, for an operator specified time range and for operator specified points, may be output the same as for trend data.
  - 5.17.3.5 <u>Critical Alarm Summary</u>: Provide a summary of those points in the critical alarm state and include as a minimum; point acronym, point description, alarm type, limit exceed, current value, alarm type, time and date of occurrence.
  - 5.17.3.6 <u>Maintenance Alarm Summary</u>: Provide a summary of those points in maintenance alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceed, time and date of occurrence.

#### SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

- 5.17.3.7 <u>Alarm Summary</u>: Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.
- 5.17.3.8 <u>Disable Point Summary</u>: Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.
- 5.17.3.9 <u>Run Time Summary</u>: Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.
- 5.17.3.10 <u>Schedule Summary</u>: Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.
- 5.17.3.11 <u>User Record Summary</u>: Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

#### 5.18 UTILITY SOFTWARE

- 5.18.1 Supply and install software products to allow the owner to access and manipulate the control schematic diagrams, and to access product data sheets in an electronic format.
- 5.18.2 Enter all soft copy submissions; including "Record" drawings as specified herein [Shop Drawings, Product Data, etc.] in OWS.

#### 5.19 WEB BROWSER CLIENTS

- 5.19.1 The system shall be capable of supporting at least 100 simultaneous users using a standard Web browser such as Internet Explorer. Systems requiring additional software to be resident on the client machine to enable a standard Web browser, or manufacturer-specific browsers shall not be acceptable.
- 5.19.2 The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BAS, shall not be acceptable.
- 5.19.3 The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
- 5.19.4 The Web browser client shall support as a minimum, the following functions:
  - 5.19.4.1User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
  - 5.19.4.2Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the Software shall be supported by the Web browser interface.

#### SECTION 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

- 5.19.4.3 HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
- 5.19.4.4 Storage of the graphical screens shall be in the Network Control Unit (NCU), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
- 5.19.4.5 Real-time values displayed on a Web page shall update automatically without requiring a manual refresh of the Web page.
- 5.19.5 User's shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
  - 5.19.5.1 Modify common application objects, such as schedules, calendars, and set points in a graphical manner. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
    - 5.19.5.1.1 Commands to start and stop binary objects shall be done by rightclicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
    - 5.19.5.1.2 View logs and charts
    - 5.19.5.1.3 View and acknowledge alarms
    - 5.19.5.1.4 Setup and execute SQL queries on log and archive information
- 5.19.6 The system shall provide the capability to specify a user's home page (as determined by the logon user identification). Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
- 5.19.7 Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

# **APPENDIX-B**

## **SEQUENCE OF OPERATIONS – TABLE OF CONTENTS**

<u>GENERAL COMMENTS</u>	
BOILER PLANT	210.S01
OUTDOOR AIR CONDITIONS 1	210.S05
CHILLER PLANT	211.S01
DOMESTIC HOT WATER PLANT	212.S01
AS-1 (WING A NORTH)	213.S01
AS-2 (WING A SOUTH)	214.S01
OUTDOOR AIR CONDITIONS 2	214.S04
AS-3 (WING B NORTH)	215.S01
AS-4 (WING B SOUTH)	216.S01
AS-5 (WING B – L1 COUNCIL CHAMBERS)	217.S01
AS-7 (L3 COMMON AREA)	218.S01
<u>AS-8</u>	219.S01
AS-9 (WING B – VIP PARKING GARAGE)	220.S01
DCW BOOSTER PUMPS	220.S04
AS-10 (PRINTING SHOP)	221.S01
AS-13 (WING C – TORONTO PUBLIC HEALTH BUILDING)	222.S01
WING A PENTHOUSE VENTILATION	223.S01
WING A PENTHOUSE MISCELLANEOUS EXHAUST	223.S02
WING A PENTHOUSE MISCELLANEOUS MONITORING	223.S03
WING B PENTHOUSE VENTILATION	224.S01
WING B PENTHOUSE MISCELLANEOUS EXHAUST	224.S02
WING B PENTHOUSE MISCELLANEOUS MONITORING	224.S03
CHILLER ROOM MISCELLANEOUS	225.S01
DECORATIVE WATER FOUNTAIN	226.S01
FIRE ALARM MONITORING	227.S01
ELECTRIC METER MONITORING	227.S02
ROTUNDA LIGHTING CONTROL	228.S01
TYPICAL FCU (TYPE A) & VARIATIONS	229.S01
TYPICAL FCU (TYPE B) W/ BC	232.S01
TYPICAL BC & VARIATIONS	235.S01
TYPICAL EC & VARIATIONS	256.S01
TYPICAL CUH (TYPE A/B/D) & VARIATIONS	259.S01
TYPICAL CUH (TYPE C)	260.S01

TYPICAL CUH (TYPE BB)
TYPICAL UH (TYPE E) & VARIATIONS
WING D PARKING GARAGE VENTILATION (EF-18/19/20)
WING D PARKING GARAGE VENTILATION (EF-21/22/23)
WING D PARKING GARAGE MECHANICAL ROOM



 261.S01
 270.S01
 272.501
 273.S01
 275.S01
 276.S01
 278.S01
 280.501
 284.S01
 285.S01
 286.S01
 287.S01

### **GENERAL COMMENTS**

#### **BAS INTERFACE TO CITY OF TORONTO NETWORK**

- All Alarming Extension's will be provided at the Supervisor Level. (By the City of Toronto)
- All Trending Extension's will be provided at the Supervisor Level. (By the City of Toronto)
- MNBC will Provide three (x3) JACE Server's for Integration onto the City of Toronto Network. (Integration Provided by the City of Toronto)
  - Wing A JACE Server (EC-BOS-7) Located in the Level 5 Electrical Room in Panel MNBC-A-L5-01
  - Wing B JACE Server (EC-BOS-7) Located in the Level 4 Electrical Room in Panel MNBC-B-L4-01
  - Wing C & D JACE Server (EC-BOS-7) Located in the Basement Building Operator's Room in Panel MNBC-B-B1-00



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S01 GENERAL COMMENTS AS-BUILT (REV 1) – December 22, 2016

### 210 – BOILER PLANT

#### GENERAL

This sequence applies to the **BOILER PLANT** which supplies hot water to the following systems:

- Air handling units AS-5, S-7 AS-8 & AS-10 •
- Glycol heat exchanger HE-1 serving air handling unit AS-1 •
- Glycol heat exchanger HE-2 serving air handling unit AS-2 •
- Glycol heat exchanger HE-3 serving air handling unit AS-3 •
- Glycol heat exchanger HE-4 serving air handling unit AS-4 •
- Glycol heat exchanger HE-9 serving air handling unit AS-9 •
- DHW Plant •
- Fan coil units, booster coils, cabinet unit heaters & unit heaters

The heating plant is composed of the following components:

- Heating Boiler B-1 with Constant Volume Circulating Pump CP-1
- Heating Boiler B-2 with Constant Volume Circulating Pump CP-2 •
- Heating Boiler B-3 with Constant Volume Circulating Pump CP-3 •
- Constant Volume Primary Loop Pumps P-1 & P-2 •
- Constant Volume Heating Loop Pumps IP-1 & IP-2 •
- Variable Volume Riser Wing A Heating Pumps P-3A & P-3B
- Constant Volume New Reheat Loop Heating Pump P-301 •
- Heating Loop Hot Water Mixing Valve

#### **RUN CONDITIONS**

The system will be automatically enabled if:

- The outdoor air temperature is less than or equal to the system's OAT enable threshold.
- The *time of day schedule* is occupied •

The system will be automatically disabled if:

- <u>Seasonal override</u> is manually set to Disabled,
- The outdoor air temperature rises above the system's <u>OAT enable threshold</u> for a period exceeding the systems OAT disable setpoint,
- The lead and lag primary pumps fail to start;

The system can be manually enabled or manually disabled from the graphic for either a:

- <u>manual override time period</u>
- seasonal override

\*The Primary Loop and Heating Loop Pumps will be commanded on for one minute when they have been off for a period of 24 hours.\*

\*The Heating Loop Pumps that are used for Distribution/Circulation to the Domestic Hot Water Plant shall be commanded on based on time of day schedule.\*

On failure of the outdoor air temperature sensor the system will be placed in <u>Safe Mode</u>, which will implement the following:

- Outdoor air temperature will be assumed to be -20.0°C
- Hot Water Supply Setpoint reset schedule will be disabled



#### **CONTROL STRATEGY**

#### Primary Loop Pumps: P-1 & P-2

**Pump Rotation** 

- The heating pumps will operate in a duty-standby configuration.
- The duty pump designation will be switched at <u>scheduled pump rotation</u>.
  - If no pumps are running the designation will be switch immediately.
    - designation.

Pump Failure

- to the failed pump will remain enabled during a pump failure.
- be returned to the rotation.

#### Pump Staging

- When the system is disabled, both the duty and the standby pump will be commanded off.
- When the system is enabled the duty pump will be commanded on.

#### Heating Loop Pumps: IP-1 & IP-2

#### Pump Rotation

- The heating pumps will operate in a duty-standby configuration.
- The duty pump designation will be switched at <u>scheduled pump rotation</u>.
  - If no pumps are running the designation will be switch immediately.
  - designation.

#### Pump Failure

- to the failed pump will remain enabled during a pump failure.
- Once the failed pump status is confirmed on for longer than the *pump return from failure delay* the pump will be returned to the rotation.

#### **Pump Staging**

- When the system is disabled based on time of day schedule, both the duty and the standby pump will be commanded off.
- When the system is enabled based on time of day schedule the duty pump will be commanded on.

#### Riser Wing A Heating Pumps: P-3A & P-3B

#### **Pump Rotation**

- The secondary heating pumps will operate in a duty-standby configuration.
- The lead pump designation will be switched at *scheduled pump rotation*.
  - If no pumps are running the designation will be switch immediately.
    - designation.

Pump Failure

MODERN NIAGARA BUILDING CONTROLS

T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

• If a single pump is running the system will wait for the duty pump to shut down before switching the

• If the duty pump fails for longer than the *pump failure delay*, the standby pump will be enabled. The command Once the failed pump status is confirmed on for longer than the *pump return from failure delay* the pump will

• If a single pump is running the system will wait for the duty pump to shut down before switching the

• If the duty pump fails for longer than the *pump failure delay*, the standby pump will be enabled. The command

• If a single pump is running the system will wait for the duty pump to shut down before switching the

- If the duty pump fails for longer than the *pump failure delay*, the standby pump will be enabled. The command to the failed pump will remain enabled during a pump failure.
- Once the failed pump status is confirmed on for longer than the *pump return from failure delay* the pump will • be returned to the rotation.

#### Pump Staging

- When the system is disabled, both the duty and the standby pump will be commanded off. •
- When the system is enabled the duty pump will be commanded on. •
- When a pump is enabled it will be modulated to *pump minimum speed*. •
- When either pump is on, they will modulate their speed to maintain the *differential pressure setpoint*. •

#### Reheat Loop Pump: P-301

Pump Staging

- When the system is disabled, the pump will be commanded off.
- When the system is enabled the pump will be commanded on.

#### Heating Boilers: B-1, B-2 & B-3 & Circulating Pumps: CP-1, CP-2 & CP-3

Boilers Enable and Modulation

- Boiler B-1 uses a 0-10V output signal to enable and modulate the boiler. Boiler B-1 will be disabled when the • output signal is between 0-1.999V. Boiler B-1 will be enabled and will modulate when the output signal is between 2-10V.
- Boilers B-2 and B-3 do not modulate. They are controlled by an enable/disable command.

#### **Boiler Safeties**

- The heating boilers are equipped with factory mounted hardwired safety limits which will override BAS commands.
- When a boiler is enabled it will be enabled for at least the *minimum boiler runtime*. The boiler will be disabled immediately regardless of *minimum boiler runtime* if the:
  - Boiler enters into an alarm condition, or
  - Boiler circulating pump fails.
- When a boiler is disabled its circulating pump will remain on for the *circulating pump disable delay* period to dissipate heat.

#### **Boiler Rotation**

- The heating boilers will operate in a lead-lag-standby configuration. •
- Boiler B-1 is the fixed lead boiler.
- The lag and standby boiler designation will be switched between B-2 and B-3 at scheduled boiler rotation.
  - If no boilers or at least two boilers are running the designation will be switched immediately.
  - If a single boiler is running the system will start the new lead boiler and confirm operation before shutting down previous lead boiler.

#### Boiler Circulating Pump Failure

- If a heating boiler is enabled and its circulating pump fails for longer than the circulating pump failure delay, the boiler will be disabled and the standby boiler will enabled. The circulating pump command will remain enabled during a pump failure.
- Once the circulating pump status is confirmed on for longer than the <u>circulating pump return from failure delay</u> • the boiler will be re-enabled.

#### **Boiler Circulating Pump Staging**

• If a heating boiler is enabled its associated circulating pump will be commanded on for *circulating pump start*up delay prior to the boiler being commanded on.



- temperature is less than *circulating pump shut-down threshold*,
- Boiler has been off for longer than *circulating pump shut-down delay*.

#### Boiler Failure

- If a boiler is in alarm it will be removed from the rotation.
- If a boiler enters into an alarm condition during operation, the boiler will be disabled and the next boiler in the rotation will be enabled.
- When the alarm condition is cleared for longer than the *boiler return from failure delay*, the boiler will be returned to the rotation.

#### Boiler Staging

- water supply temperature is below *boilers common hot water supply temperature setpoint*.
- A heating boiler will be disabled until its circulating pump run status is confirmed on.
- the startup maximum boiler rise temperature.
- Boilers will be controlled to maintain the boiler supply water temperature at *boilers common hot water supply* temperature setpoint.
- The next boiler in the rotation will be staged on if:
- the system hot water supply temperature is not at setpoint and
  - lead boiler supply water temperature is at maximum temperature, or
  - lead boiler modulation output is at maximum.
- The lead boiler will be maintained at maximum capacity, and the lag boiler will be commanded on on, and the stand-by boiler will be commanded on independently.
- When the system hot water supply temperature is above setpoint and the last enabled boiler is at minimum capacity for more than the setpoint achieved delay, the last enabled boiler will be disabled.

Heating Loop Mixing Valve

- When the system is enabled the boiler loop hot water supply mixing valve will be modulated to maintain injection loop hot water supply temperature setpoint.
- above minimum speed, the differential pressure valve will be closed.

### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
OAT Enable Threshold	Below 13.0°C	Between 12.0°C and 18.0°C	Operator
<u>OAT Disable Setpoint</u>	3.0°C	Between 2.0°C and 5.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
<u>Seasonal Override</u>	ENABLED	ENABLED or DISABLED	Admin



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

o Difference between boiler leaving hot water temperature and boilers common hot water return

• Boiler operation is enabled only when the system is enabled, circulating pump status is confirmed on, and hot If the boiler return water temperature is less than *minimum boiler return water temperature* the BAS will limit

independently or the lead boiler will be maintained at maximum capacity, the lag boiler will be commanded

• When pumps are off, the differential pressure valve will be open. When the scheduled duty pump modulates
DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Scheduled Pump Rotation	10:00 am every Tuesday	Any Value	Admin
Pump Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Pump Return from Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Pump Minimum Speed	30% (18 Hz)	Between 30% and 40%	Admin
Differential Pressure Setpoint	100 kPa	Between 100 and 200 kPa	Admin
Minimum Boiler Runtime	5 minutes	Between 0 and 10 minutes	Admin
Circulating Pump Disable Delay	5 minutes	Between 0 and 10 minutes	Admin
Scheduled Boiler Rotation	10:00 am every Tuesday	Any Value	Admin
Circulating Pump Failure Delay	10 seconds	Between 0 and 60 seconds	Admin
Circulating Pump Return from Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Circulating Pump Start-Up Delay	30 seconds	Between 30 and 60 seconds	Admin
Circulating Pump Shut-Down Thershold	3.0°C	Between 2.0°C and 5.0°C	Admin
Circulating Pump Shut-Down Delay	5 minutes	Between 5 and 30 minutes	Admin
Boiler Return from Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Minimum Boiler Return Water Temperature	40.0°C	Between 35.0°C and 45.0°C	Operator
Startup Maximum Boiler Rise Temperature	15.0°C	Between 10.0°C and 20.0°C	Operator
Setpoint Achieved Delay	15 minutes	Between 0 and 10 minutes	Operator
Injection Loop Hot Water Supply Temperature Setpoint	43.3°C	Between 30.0°C and 50.0°C	Operator

The Boilers Common Hot Water Supply Temperature Setpoint will be linearly reset according to the following schedule:

WHEN THE OAT IS:	THE SETPOINT IS:		ADJUSTABLE RANGE	PERMISSION
0.0°C	60.0°C	OAT: Setpoint:	Between 0.0°C and 15.0°C Between 50.0°C and 70.0°C	Operator

WHEN THE OAT IS:	THE SETPOINT IS:		ADJUSTABLE RANGE	PERMISSION
-20.0°C	80.0°C	OAT: Setpoint:	Between -15.0°C and -20.0°C Between 70.0°C and 82.0°C	
• If a heating flag is received from an associated system the base setpoint will be increased by 2°C every 5				

- ited system t minutes.
- If no heating flags are received the base setpoint will be decreased by 2°C every 10 minutes. • Associated heating flags will be monitored from:
  - Scheduled Water Loop
  - Glycol Heat Exchangers HE-1, HE-2, HE-3

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

## ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
Differential Pressure	0 kPa (differential)	345 kPa (diff.)	5 min
<u>Boilers Common Hot Water Supply</u> <u>Temperature</u>	0.0°C	105.0°C	5 min
<u>Boilers Common Hot Water Return</u> <u>Temperature</u>	0.0°C	100.0°C	5 min
Boiler B-1 Hot Water Supply Temperature	0.0°C	105.0°C	5 min
Boiler B-2 Hot Water Supply Temperature	0.0°C	105.0°C	5 min
Boiler B-3 Hot Water Supply Temperature	0.0°C	105.0°C	5 min
Injection Loop Hot Water Supply Temperature	0.0°C	105.0°C	5 min
Primary Loop Hot Water Supply Temperature	0.0°C	105.0°C	5 min
Wing A Hot Water Return Temperature	0.0°C	100.0°C	5 min



#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>Seasonal Disable Warning</u>	The system is seasonally disabled; and Outdoor air temperature is below 0°C
<u>System in Safe Mode</u>	Outdoor air temperature in off-normal Alarm
<u>Differential Pressure Above</u>	Either riser wing a pump is on; and
<u>Setpoint</u>	Differential pressure is 25 kPa above setpoint for 5 minutes.
<u>Differential Pressure Below</u>	Either riser wing a pump is on; and
<u>Setpoint</u>	Differential pressure is 25 kPa below setpoint for 5 minutes.
<u>Supply Water Temperature Above</u>	Either primary loop pump is on; and
<u>Setpoint</u>	Supply temperature is 5°C above setpoint for 5 minutes
<u>Supply Water Temperature Below</u>	Either primary loop pump is on; and
<u>Setpoint</u>	Supply temperature is 10°C below setpoint for 5 minutes
<u>B-1 Supply Water Temperature</u>	Circulating pump is on; and
<u>Above Setpoint</u>	Supply temperature is 5°C above setpoint for 5 minutes
<u>B-1 Supply Water Temperature</u>	Circulating pump is on; and
<u>Below Setpoint</u>	Supply temperature is 10°C below setpoint for 5 minutes
<u>B-2 Supply Water Temperature</u>	Circulating pump is on; and
<u>Above Setpoint</u>	Supply temperature is 5°C above setpoint for 5 minutes
<u>B-2 Supply Water Temperature</u>	Circulating pump is on; and
<u>Below Setpoint</u>	Supply temperature is 10°C below setpoint for 5 minutes
<u>B-3 Supply Water Temperature</u>	Circulating pump is on; and
<u>Above Setpoint</u>	Supply temperature is 5°C above setpoint for 5 minutes
<u>B-3 Supply Water Temperature</u>	Circulating pump is on; and
<u>Below Setpoint</u>	Supply temperature is 10°C below setpoint for 5 minutes
<u>P-1 Failed to Start</u>	Pump is commanded on; and Pump is off for 15 seconds.
<u>P-1 On in Hand</u>	Pump is commanded off; and Pump is on for 90 seconds.
<u>P-2 Failed to Start</u>	Pump is commanded on; and Pump is off for 15 seconds.
P-2 On in Hand	Pump is commanded off; and Pump is on for 90 seconds.
IP-1 Failed to Start	Pump is commanded on; and Pump is off for 15 seconds.
<u>IP-1 On in Hand</u>	Pump is commanded off; and Pump is on for 90 seconds.

DESCRIPTION	CONDITION
IP-2 Failed to Start	Pump is commanded on; and Pump is off for 15 seconds.
IP-2 On in Hand	Pump is commanded off; and Pump is on for 90 seconds.
<u>P-3A Failed to Start</u>	Pump is commanded on; and Pump is off for 15 seconds.
<u>P-3A VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>P-3A On in Hand</u>	Pump is commanded off; and Pump is on for 90 seconds.
<u>P-3B Failed to Start</u>	Pump is commanded on; and Pump is off for 15 seconds.
<u>P-3B VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>P-3B On in Hand</u>	Pump is commanded off; and Pump is on for 90 seconds.
<u>P-301 Failed to Start</u>	Pump is commanded on; and Pump is off for 15 seconds.
P-301 On in Hand	Pump is commanded off; and Pump is on for 90 seconds.
<u>System Fail</u>	Heating plant is enabled; and Neither secondary pump is on for 5 minutes.



# **210 - OUTDOOR AIR CONDITIONS 1**

#### GENERAL

This sequence applies to the **OUTDOOR AIR CONDITIONS 1**.

#### **RUN CONDITIONS**

The system will be enabled continuously.

#### **CONTROL STRATEGY**

- There are two sensor locations. One sensor is on the northeast side of "B" Block in Level B1, and the other sensor is on the northeast side of "A" Block penthouse.
- Outdoor Air Temperature and Humidity values used for control purposes will be calculated as follows:
  - When both OAT readings are within 3°C of one another, an average from both sensors shall be used for the OAT and the OAH.
  - When both readings differ by more than 3°C of one another, the OAT and OAH from the sensor reading the lowest temperature shall be used.
- All readings from the sensors and the values used for control purposes shall be displayed on the OWS.
- Outdoor Air Temperature (OAT) and Outdoor Air Humidity (OAH) values used for control purposes will be broadcast on the BAS network.

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

POINT DESCRIPTION	INTERVAL	DURATION	
Outdoor Air Temperature	Every 15 minutes	2,880 samples	Approx. 30 days
<u>Outdoor Air Humidity</u>	Every 15 minutes	2,880 samples	Approx. 30 days

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Outdoor Air Temperature</u>	-50.0°C	100.0°C	5 min



S05 210 – OUTDOOR AIR CONDITIONS 1 AS-BUILT (REV 1) – December 22, 2016

# **211 – CHILLER PLANT**

#### GENERAL

This sequence applies to the **CHILLER PLANT** which supplies chilled water to the following systems:

- Air handling units AS-1, AS-2, AS-3, AS-4, AS-5, AS-7, AS-8, AS-10 & AS-13
- Fan coil units

The chiller plant is composed of the following components:

- Chillers: CH-1 & CH-2
- Cooling Tower: CT-1 •
- Variable Volume Condenser Water Loop Pumps: P-1A & P-1B
- Variable Volume Chilled Water Loop Pumps P-2A & P-2B

#### **RUN CONDITIONS**

The system will be automatically enabled if:

The outdoor air temperature is greater than or equal to the system's <u>OAT enable threshold</u>.

The system will be automatically disabled if:

- Seasonal override is manually set to Disabled.
- The outdoor air temperature drops below the system's <u>OAT enable threshold</u> for a period exceeding the systems OAT disable delay;
- The lead and lag primary pumps fail to start; •
- No cooling requests have been received for a period longer than the *cooling disable delay*.

The system can be manually enabled or manually disabled from the graphic for either a:

- <u>manual override time period</u>
- <u>seasonal override</u>

\*The Chilled Water and Condenser Water Loop Pumps will be commanded on for one minute when they have been off for a period of 24 hours.\*

#### **CONTROL STRATEGY**

Condenser Water Loop Pumps: P-1A & P-1B

Pump Rotation

- The condenser water pumps will operate in a lead-lag configuration.
- The lead pump designation will be switched at *pump rotation*.
  - If no pumps or both pumps are running the designation will be switch immediately.
  - If a single pump is running the system will start the new lead pump and confirm operation before shutting down previous lead pump.

#### Pump Failure

- If the lead pump fails for longer than the *pump failure delay*, the lag pump will be enabled. The command to the failed pump will remain enabled during a pump failure.
- Once the failed pump status is confirmed on for longer than the *pump return from failure delay* the pump will • be returned to the rotation.

Pump Staging

• When the system is disabled, both the lead and the lag pump will be commanded off.

- When the system is enabled the lead pump will be commanded on.
- When a pump is enabled it will be modulated to *minimum pump speed*. •
- When either pump is on, they will modulate their speed to maintain *minimum chiller condenser water flow*. •

#### Chilled Water Loop Pumps: P-2A & P-2B

#### Pump Rotation

- The chilled water pumps will operate in a lead-lag configuration.
  - The lead pump designation will be switched at *chilled water pump rotation*.
    - If no pumps or both pumps are running the designation will be switch immediately.
    - shutting down previous lead pump.

#### Pump Failure

- If the lead pump fails for longer than the *pump failure delay*, the lag pump will be enabled. The command to the failed pump will remain enabled during a pump failure.
- Once the failed pump status is confirmed on for longer than the *pump return from failure delay* the pump will be returned to the rotation.

#### Pump Staging

- When the system is disabled, both the lead and the lag pump will be commanded off.
- When the system is enabled the lead pump will be commanded on.
- When a pump is enabled it will be modulated to *minimum pump speed*.
- When either pump is on, they will modulate their speed to maintain
  - the *remote differential pressure setpoint*; or • <u>minimum chiller chilled water flow</u>
- If lead pump is running alone and its speed rises above the *pump stage up threshold* the lag pump will be
- be commanded off.

#### **Remote Differential Pressure Valve**

- If one chilled water pump is running at minimum speed, the remote differential pressure valve will be modulated to maintain *remote differential pressure setpoint*.
- When pumps are off, the differential pressure valve will be open. When lead pump modulates above minimum position, differential pressure valve will be closed.

#### **Remote Differential Pressure Sensor Failure**

- If the remote differential pressure sensor is in off-normal alarm condition, or there is a network failure, the system will utilize the local differential pressure for secondary pump staging control.
- Local differential pressure is calculated by the local differential sensor.
- The secondary pumps will control to *local differential pressure setpoint*. •

#### Chillers: CH-1 & CH-2

#### **Chiller Safeties**

The chiller is equipped with factory mounted hardwired safety limits which will override BAS commands.

#### **Chiller Rotation**

- The chillers will operate in a lead-lag configuration.
- The lead chiller designation will be switched at *chiller rotation*.
  - If no chillers or both chillers are running the designation will be switch immediately.

T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS



• If a single pump is running the system will start the new lead pump and confirm operation before

commanded on and both pumps will modulate together to maintain the *remote differential pressure setpoint*. If both pumps are running together and their speed falls below the *pump stage down threshold*, lag pump will

 If a single chiller is running the system will start the new lead chiller and confirm operation before shutting down previous lead chiller.

#### Chiller Failure

- If the lead chiller fails for longer than the *chiller failure delay*, the lag chiller will be enabled. The command to • the failed chiller will remain enabled during a chiller failure.
- Once the failed chiller status is confirmed on for longer than the <u>chiller return from failure delay</u> the chiller will • be returned to the rotation.

#### **Chiller Staging**

- The BAS will interface to the chiller through the Carrier Comfort Network interface. Chiller controller will provide all functionality with regards to staging of the chiller.
- The BAS will enable the chiller and provide the chiller with a *chilled water supply temperature setpoint*. •

#### Cooling Tower: CT-1

Tower Staging

- When the system is disabled the cooling tower fan will be commanded off.
- When the system is enabled the cooling tower fan will be commanded on. •
- When the cooling tower fan is enabled it will be initially modulated to *minimum fan speed*. •
- The cooling tower fan will be modulated to maintain <u>condenser water supply temperature setpoint</u>. •
- The BAS will limit the vfd's ramp up to the <u>cooling tower fan vfd ramp up delay</u> to prevent rapid cycling. •
- The BAS will limit the vfd's ramp down to the <u>cooling tower fan vfd ramp down delay</u> to prevent rapid cycling. •
- When the primary condenser water supply temperature rises above the *primary condenser water supply* temperature setpoint by more than the primary stage 1 cooling enable band, the towers fan will be commanded on at tower fan minimum speed.
- When the primary condenser water supply temperature rises above the *primary condenser water supply* • *temperature setpoint* by more than the *primary stage 2 cooling enable band*, the towers fan will be modulated to maintain setpoint.
- When the primary condenser water supply temperature drops below the *primary condenser water supply* temperature setpoint by more than the primary stage 2 cooling disable band, the towers fan will be modulated to tower fan minimum speed.
- When the primary condenser water supply temperature drops below the *primary condenser water supply* • *temperature setpoint* by more than the *primary stage 1 cooling disable band*, the towers fan will be commanded off.

Sump Heater Staging

- When the system is disabled the cooling tower sump heater will be commanded off. •
- When the system is enabled and the outdoor air temperature is below <u>sump heater enable setpoint</u>, the • cooling tower sump heater will be commanded on.

#### **Cooling Tower Bypass Valve**

- When the system is disabled, the bypass valve will be commanded open.
- When the system is enabled the bypass valve will be modulated to maintain *condenser water supply*. • temperature setpoint.
- When the system is enabled, and the outdoor air temperature is below *low limit outdoor air temperature* • setpoint the bypass valve will be modulated to bypass the cooling tower in order to suppress chiller surging when mechanical cooling is still required.



The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
OAT Enable Threshold	18.0°C	Between 12.0°C and 18.0°C	Operator
<u>OAT Disable Delay</u>	4 hours	Between 1 and 12 hours	Operator
Cooling Disable Delay	30 minutes	Any Value	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
<u>Seasonal Override</u>	ENABLED	ENABLED or DISABLED	Admin
Pump Rotation	10:00 am every Tuesday	Any Value	Admin
<u>Pump Failure Delay</u>	60 seconds	Between 0 and 120 seconds	Admin
Pump Return from Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Minimum Pump Speed	30% (18 Hz)	Between 30% and 40%	Admin
Minimum Chiller Chilled Water Flow	TBD	TBD	Admin
Minimum Chiller Condenser Water Flow	TBD	TBD	Admin
Pump Stage Up Threshold	Above 80% for 5 minutes	Any value	Admin
Pump Stage Down Threshold	Above 30% for 5 minutes	Any value	Admin
<u>Remote Differential Pressure Setpoint</u>	40 kPa	Between 30 and 100 kPa	Admin
Local Differential Pressure Setpoint	175 kPa	Between 100 and 200 kPa	Admin
<u>Chiller Rotation</u>	10:00 am every Tuesday	Any Value	Admin
<u>Chiller Failure Delay</u>	60 seconds	Between 0 and 120 seconds	Admin
<u>Chiller Return From Failure Delay</u>	60 seconds	Between 0 and 120 seconds	Admin
Chilled Water Supply Temperature Setpoint	8.0°C	Between 6.0°C and 10.0°C	Operator
Minimum Fan Speed	30% (18 Hz)	Between 30% and 40%	Admin
<u>Condenser Water Supply Temperature</u> <u>Setpoint</u>	27.0°C	Between 25.0°C and 30.0°C	Operator



DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
<u>Cooling Tower Fan VFD Ramp Up Delay</u>	MinMax. speed over 0 minutes	Between 0 and 5 minutes	Admin
<u>Cooling Tower Fan VFD Ramp Down Delay</u>	MaxMin. speed over 0 minutes	Between 0 and 5 minutes	Admin
Sump Heater Enable Setpoint	3.0°C	Between 2.0°C and 5.0°C	Operator
Low Limit Outdoor Air Temperature Setpoint	10.0°C	Between 8.0°C and 15.0°C	Operator
Low Limit Cooling Tower Sump Temperature Setpoint	10.0°C	Between 3.0°C and 10.0°C	Operator

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
Chilled Water Return Temperature	0.0°C	100.0°C	5 min

• If a cooling flag is received from an associated system the base setpoint will be decreased by 1°C every 5 minutes.

• If no cooling flags are received the base setpoint will be decreased by 1°C every 10 minutes.

• Associated cooling flags will be monitored from:

• Air handling units AS-1, AS-2, AS-3, AS-4, AS-5, AS-7, AS-8, AS-10 & AS-13

#### HISTORY EXTENSIONS (TRENDS)

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Remote Differential Pressure</u>	0 kPa (differential)	345 kPa (diff.)	5 min
Local Differential Pressure	0 kPa (differential)	345 kPa (diff.)	5 min
CT-1 Condenser Water Supply Temperature	0.0°C	100.0°C	5 min
<u>CT-1 Sump Temperature</u>	0.0°C	100.0°C	5 min
CH-1 Condenser Water Return Temperature	0.0°C	100.0°C	5 min
<u>CH-2 Condenser Water Return Temperature</u>	0.0°C	100.0°C	5 min
CH-1 Chilled Water Supply Temperature	0.0°C	100.0°C	5 min
<u>CH-1 Chilled Water Return Temperature</u>	0.0°C	100.0°C	5 min
CH-2 Chilled Water Supply Temperature	0.0°C	100.0°C	5 min
CH-2 Chilled Water Return Temperature	0.0°C	100.0°C	5 min
Chilled Water Supply Temperature	0.0°C	100.0°C	5 min



#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Seasonal Disable Warning	The system is seasonally disabled; and Outdoor air temperature is above 25°C
<u>Differential Pressure Above</u> <u>Setpoint</u>	Either chilled water pump is on; and Differential pressure is 25 kPa above setpoint for 5 minutes.
<u>Differential Pressure Below</u> <u>Setpoint</u>	Either chilled water pump is on; and Differential pressure is 25 kPa below setpoint for 5 minutes.
<u>Local Differential Pressure - High</u>	
Local Differential Pressure - Low	
Supply Chilled Water Temperature Above Setpoint	Either chilled water pump is on; and Supply temperature is 2°C above setpoint for 5 minutes
<u>Supply Chilled Water Temperature</u> <u>Below Setpoint</u>	Either chilled water pump is on; and Supply temperature is 2°C below setpoint for 5 minutes
<u>Supply Condenser Water</u> <u>Temperature Above Setpoint</u>	Either condenser water pump is on; and Supply temperature is 2°C above setpoint for 5 minutes
<u>Supply Condenser Water</u> <u>Temperature Below Setpoint</u>	Either condenser water pump is on; and Supply temperature is 2°C below setpoint for 5 minutes
<u>Cooling Tower Sump Temperature</u> <u>Below Setpoint</u>	The cooling tower sump temperature is below <u>Low Limit Cooling Tower</u> <u>Sump Temperature Setpoint</u>
<u>CH-1 Failed to Start</u>	Chiller is commanded on; and Chiller is off for 15 seconds.
<u>CH-1 On in Hand</u>	Chiller is commanded off; and Chiller is on for 90 seconds.
<u>CH-1 Fault</u>	Chiller fault alarm is active for 15 seconds.
<u>CH-2 Failed to Start</u>	Chiller is commanded on; and Chiller is off for 15 seconds.
<u>CH-2 On in Hand</u>	Chiller is commanded off; and Chiller is on for 90 seconds.
<u>CH-2 Fault</u>	Chiller fault alarm is active for 15 seconds.
P-1A Failed to Start	Pump is commanded on; and Pump is off for 15 seconds.
<u>P-1A VFD Fault</u>	VFD fault alarm is active for 15 seconds.
P-1A On in Hand	Pump is commanded off; and Pump is on for 90 seconds.
P-1B Failed to Start	Pump is commanded on; and Pump is off for 15 seconds.

DESCRIPTION	CONDITION
<u>P-1B VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>P-1B On in Hand</u>	Pump is commanded off; and Pump is on for 90 seconds.
<u>P-2A Failed to Start</u>	Pump is commanded on; and Pump is off for 15 seconds.
<u>P-2A VFD Fault</u>	VFD fault alarm is active for 15 seconds.
P-2A On in Hand	Pump is commanded off; and Pump is on for 90 seconds.
<u>P-2B Failed to Start</u>	Pump is commanded on; and Pump is off for 15 seconds.
<u>P-2B VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>P-2B On in Hand</u>	Pump is commanded off; and Pump is on for 90 seconds.
<u>CT-1 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>CT-1 VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>CT-1 On in Hand</u>	Fan is commanded off; and Fan is on for 90 seconds.



# **212 - DOMESTIC HOT WATER PLANT**

#### GENERAL

This sequence applies to the **DOMESTIC HOT WATER PLANT** which supplies domestic hot water to the building.

The system is composed of the following components:

- Domestic Hot Water Boiler B-4 with Circulating Pump CP-4
- Domestic Hot Water Storage Tanks DHWT-1, DHWT-2, DHWT-3 & DHWT-4
- Zamboni Hot Water Storage Tanks DHWT-5 & DHWT-6 •
- Zamboni Hot Water Loop Recirculation Pump P-5 •
- Domestic Hot Water Loop Recirculation Pump P-6 •
- Domestic Hot Water Tank Loop Recirculation Pump P-7 •

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

• Disabled Mode

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

Domestic Hot Water Boiler: B-4 & Circulating Pump: CP-4

**Boiler Safeties** 

- The heating boilers are equipped with factory mounted hardwired safety limits which will override BAS commands.
- When a boiler is enabled it will be enabled for at least the *minimum boiler runtime*. The boiler will be disabled • immediately regardless of *minimum boiler runtime* if the:
  - Boiler enters into an alarm condition, or
  - Boiler circulating pump fails.
- When a boiler is disabled its circulating pump will remain on for the circulating pump disable delay period to dissipate heat.

**Boiler Circulating Pump Staging** 

- If a heating boiler is enabled its associated circulating pump will be commanded on for *circulating pump start*up delay prior to the boiler being commanded on.
- When the heating boiler is disabled its associated circulating pump will be commanded off when;
  - o Difference between boiler leaving hot water temperature and boilers common hot water return temperature is less than circulating pump shut-down threshold,
  - Boiler has been off for longer than *circulating pump shut-down delay*.

Boiler Staging

- Boiler operation is enabled only when the system is enabled, circulating pump status is confirmed on, and • domestic hot water supply temperature is below *domestic hot water supply temperature setpoint*.
- A heating boiler will be disabled until its circulating pump run status is confirmed on.



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

- If the boiler return water temperature is less than *minimum boiler return water temperature* the BAS will limit the startup maximum boiler rise temperature.
- temperature setpoint.

**Boiler Bypass Valve** 

- When the system is disabled, the bypass valve will be commanded open.
- temperature setpoint.

Domestic Hot Water Tanks: DHWT-1, DHWT-2, DHWT-3 & DHWT-4

Domestic Hot Water Valve

• Domestic hot water return valve will be modulated to maintain tank hot water temperature setpoint.

Zamboni Hot Water Tanks: DHWT-5 & DHWT-6

Zamboni Hot Water Valve

Zamboni hot water return valve will be modulated to maintain tank hot water temperature setpoint.

Zamboni Hot Water Loop Recirculation Pump: P-5

Pump Staging

- Zamboni hot water loop recirculation pump will be commanded off when the system is disabled.
- Zamboni hot water loop recirculation pump will be enabled when the system is enabled. •
- When the hot water supply static pressure drops below *pump enable setpoint*, the pump will be commanded • on.

Domestic Hot Water Loop Recirculation Pump: P-6

• When Pump P-6 operates, it over-pressurizes the hot pipes and heat transfers into the Domestic cold water line. For this reason, this pump will stay disabled.

Domestic Hot Water Tank Loop Recirculation Pump: P-7

Pump Staging

- Domestic hot water tank loop recirculation pump will be commanded off when the system is disabled.
- Domestic hot water tank loop recirculation pump will be commanded on when the system is enabled.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
<u>Minimum Boiler Runtime</u>	5 minutes	Between 0 and 10 minutes	Admin
Circulating Pump Disable Delay	5 minutes	Between 0 and 10 minutes	Admin
Circulating Pump Start-Up Delay	30 seconds	Between 30 and 60 seconds	Admin

The boiler will be staged to maintain the boiler supply water temperature at *boiler domestic hot water supply* 

When the system is enabled the bypass valve will be modulated to maintain *boiler domestic hot water supply* 

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Circulating Pump Shut-Down Threshold	3.0°C	Between 2.0°C and 5.0°C	Admin
Circulating Pump Shut-Down Delay	5 minutes	Between 5 and 30 minutes	Admin
<u>Boiler Domestic Hot Water Supply</u> <u>Temperature Setpoint</u>	55.0°C	Between 50.0°C and 60.0°C	Admin
Minimum Boiler Return Water Temperature	40.0°C	Between 35.0°C and 45.0°C	Operator
Start-Up Maximum Boiler Rise Temperature	15.0°C	Between 10.0°C and 20.0°C	Operator
Pump Enable Setpoint	30 psi	Between 10 psi and 50 psi	Operator

HISTORY	<b>EXTENSIONS</b>	(TRENDS)
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All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Boiler B-4 Domestic Hot Water Supply</u> <u>Temperature</u>	0.0°C	100.0°C	5 min
<u>Boiler B-4 Domestic Hot Water Return</u> <u>Temperature</u>	0.0°C	100.0°C	5 min
<u>Loop Domestic Hot Water Supply</u> <u>Temperature</u>	0.0°C	100.0°C	5 min
<u>DHWT-1 Tank Temperature</u>	0.0°C	100.0°C	5 min
DHWT-2 Tank Temperature	0.0°C	100.0°C	5 min
DHWT-3 Tank Temperature	0.0°C	100.0°C	5 min
<u>DHWT-4 Tank Temperature</u>	0.0°C	100.0°C	5 min
<u>DHWT-5 Tank Temperature</u>	0.0°C	100.0°C	5 min
DHWT-6 Tank Temperature	0.0°C	100.0°C	5 min
Domestic Hot Water Supply Temperature	0.0°C	100.0°C	5 min
<u>Domestic Hot Water Tank 1 Domestic Cold</u> <u>Water Temperature</u>	0.0°C	100.0°C	5 min





Т	HIGH LIMIT	DELAY
	100.0°C	5 min
	100.0°C	5 min
	100.0°C	5 min
	690 kPa (gauge)	5 min
	690 kPa (gauge)	5 min

## **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>B-4 Supply Temperature Alarm</u>	Boiler is commanded on; Boiler circulating pump status is on; (Heater SWT – Heater RWT) < 5°C for 5 minutes
<u>DHWT-1 Tank Temperature High</u>	Tank temperature is above 60°C
<u>DHWT-1 Tank Temperature Low</u>	Tank temperature is below 50°C
DHWT-2 Tank Temperature High	Tank temperature is above 60°C
DHWT-2 Tank Temperature Low	Tank temperature is below 50°C
DHWT-3 Tank Temperature High	Tank temperature is above 60°C
DHWT-3 Tank Temperature Low	Tank temperature is below 50°C
<u>DHWT-4 Tank Temperature High</u>	Tank temperature is above 60°C
DHWT-4 Tank Temperature Low	Tank temperature is below 50°C
DHWT-5 Tank Temperature High	Tank temperature is above 60°C
DHWT-5 Tank Temperature Low	Tank temperature is below 50°C
DHWT-6 Tank Temperature High	Tank temperature is above 60°C
DHWT-6 Tank Temperature Low	Tank temperature is below 50°C
DHW Supply Temperature High	Supply water temperature is above 75°C
<u>CP-4 Failed to Start</u>	Pump is commanded on; and Pump is off for 15 seconds.
<u>CP-4 On in Hand</u>	Pump is commanded off; and Pump is on for 10 minutes.
<u>P-5 Failed to Start</u>	Pump is commanded on; and Pump is off for 15 seconds.
<u>P-5 On in Hand</u>	Pump is commanded off; and Pump is on for 10 minutes.
P-6 Failed to Start	Pump is commanded on; and Pump is off for 15 seconds.
P-6 On in Hand	Pump is commanded off; and Pump is on for 10 minutes.
P-7 Failed to Start	Pump is commanded on; and Pump is off for 15 seconds.

DESCRIPTION	c
<u>P-7 On in Hand</u>	Pump is commanded off; and Pump is on for 10 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

## CONDITION

# 213 – AS-1 (WING A NORTH)

#### GENERAL

This sequence applies to **AS-1** which provides heating, cooling, humidification and ventilation to supplied zones.

The system is composed of the following components:

- Variable Volume Return Fan
- Mixed Air Dampers (Exhaust, Return, Outdoor) •
- Minimum Outdoor Air Damper •
- Heating Coil •
- Heat Exchanger HE-1 & Heating Pumps P-211A & P-211B •
- Humidifier 1.1 •
- Humidifier 1.2 •
- Cooling Coil •
- Variable Volume Supply Fan

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode: This mode will override the Disabled Mode if the number of supplied zones in an unoccupied override condition exceeds the *minimum night setback zone limit*

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Safeties

A freezestat set at 4.0°C is hardwired to shut down the supply fan, position the mixed air dampers for • recirculation, and fail open the heating valve. The freezestat alarm must be manually reset from the system graphics as well as the unit for the air handling unit to return to normal operation.

#### Supply Fan and Return Fan

Fan Staging

- The supply fan and return fan will be enabled in the Day Mode and Night Setback Modes. •
- When the fans are enabled, the return fan will be commanded to minimum speed. When return fan status is received, the supply fan will be commanded to minimum speed.
- In the Disabled Mode the supply and return fans will be commanded off. •

Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on. •
- The supply fan will be modulated to maintain <u>supply air static pressure setpoint</u>.
- The return fan will be modulated to maintain supply fan speed minus a return fan offset. •

#### Mixed Air Damper Control

- Mixed air dampers include the combination of the Exhaust Air Damper, Return Air Damper, and Outdoor Air controlled to the inverse of the Return Air Damper.
- In the Disabled Mode the Mixed Air dampers will be positioned for recirculation with the Exhaust Air and Outdoor Air Dampers commanded closed, and the Return Air damper commanded open.
- In the Day Mode and Night Setback Mode the Mixed Air damper will initially be positioned for recirculation.
- In the Day Mode, the Mixed Air Dampers will be controlled for either free cooling or CO2 control.

Free Cooling Control

- Free Cooling will be enabled when:
  - supply fan status is confirmed on;

  - outdoor air temperature is less than *free cooling enable OAT*.
- Free Cooling is disabled when the above conditions are not met.
- When free cooling is enabled, mixed air dampers will be modulated to maintain *supply air temperature* temperature offset;

#### Return Air CO2 Control

- Return air CO2 control will be enabled in the Day Mode when:
  - supply fan status is confirmed on; and
  - return air co2 is above *return air co2 setpoint*.
- Return air CO2 control will be enabled in the Night Setback Mode when:
  - supply fan status is confirmed on;
  - minimum outdoor air damper is at maximum open position; and
  - return air co2 is above *return air co2 setpoint*.
- When return air CO2 control is enabled, the mixed air dampers will increase the minimum outdoor air setpoint to maintain return air co2 setpoint.
- Return air CO2 control will be disabled when:
- Mixed Air Damper control will be limited to ensure the following: • that mixed air temperature is above *minimum mixed air temperature setpoint* plus *mixed air temperature offset;* 
  - Supply air temperature is within the deadband range of *supply air temperature setpoint*.

#### Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain mixed air temperature at *minimum* mixed air temperature setpoint.
- In the Night Setback Mode and Day mode, the heating valve will be enabled when: • supply fan status is confirmed on;

  - outdoor air temperature is less than *heating enable OAT*; and • supply air temperature is below supply air temperature setpoint minus supply air temperature deadband; or
  - outdoor air temperature is less than *heating enable low limit OAT*.
- When enabled the heating valve will be modulated to maintain <u>supply air temperature setpoint</u>.
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The • heating flag is removed when the heating valve closes below the *heating flag disable percentage*.

MODERN NIAGARA BUILDING CONTROLS

T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

Damper. All dampers are controlled together through a common output. Exhaust and Outdoor dampers are

• outdoor air temperature is below return air temperature by more than the *free cooling offset*; and setpoint, while keeping mixed air temperature above minimum mixed air temperature setpoint plus mixed air

return air co2 drops below <u>return air co2 setpoint</u> for more than the <u>CO2 setpoint achieved delay</u>.

#### Heating Pumps: P-211A & P-211B

• The heating pumps come with a pump package that controls how the pumps are commanded and sequenced. They operate stand-alone. The BAS System monitors the status of the pumps.

#### Humidifiers: 1.1 & 1.2

- The humidifier shall be commanded off at all times during the summer season.
- Humidification is enabled when: •
  - supply fan status is confirmed on;
  - outdoor air temperature is below *humidifier enable OAT*
- When humidifier is enabled, it will be modulated to maintain *return air humidity setpoint*.
- BAS will limit humidifier output to maintain supply air humidity below supply air humidity high limit. •
- When the humidifier is disabled, it will be commanded off. •

#### Cooling Valve

- In the Disabled Mode the cooling valve will be commanded closed.
- In the Night Setback Mode and Day mode, the cooling valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is greater than *cooling enable OAT*; and
  - supply air temperature is above <u>supply air temperature setpoint</u> plus <u>supply air temperature deadband</u>.
- When enabled the cooling valve will be modulated to maintain *supply air temperature setpoint*.
- A cooling flag is issued when the cooling valve is open more than the <u>cooling flag enable percentage</u>. The • cooling flag is removed when the cooling valve closes below the *cooling flag disable percentage*.

#### Minimum Outdoor Air Damper

- The minimum outdoor air damper will be enabled in the Day Mode and Night Setback Mode.
- The minimum outdoor air damper will modulate to maintain the *minimum outdoor air setpoint*. •
- In the Disabled Mode the minimum outdoor air damper is commanded closed.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Night Setback Zone Limit	3	Any Value	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator
<u>Return Fan Offset</u>	5%	Between 0% and 15%	Operator
Free Cooling Offset	3.0°C	Between 1°C and 10°C	Operator
Free Cooling Enable OAT	15°C	Between 13°C and 18°C	Operator
Supply Air Temperature Setpoint	15°C	Between 13°C and 25°C	Operator
Minimum Mixed Air Temperature Setpoint	10°C	Between 5°C and 13°C	Operator



DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Mixed Air Temperature Offset	2.5°C	Between 1°C and 10°C	Operator
<u>Return Air CO2 Setpoint</u>	1000 ppm	Between 800 and 1500 ppm	Operator
Minimum Outdoor Air Setpoint	1500 CFM	Between 1000 and 2000 CFM	Admin
<u>CO2 Setpoint Achieved Delay</u>	5 minutes	Between 1 and 30 minutes	Operator
<u>Heating Enable OAT</u>	18°C	Between 15°C and 20°C	Operator
Supply Air Temperature Deadband	1°C	Between 0.5°C and 2°C	Operator
Heating Enable Low Limit OAT	10°C	Between 10°C and 15°C	Operator
Heating Flag Enable Percentage	95%	Between 90% and 100%	Operator
Heating Flag Disable Percentage	80%	Between 75% and 85%	Operator
Schedules Pump Rotation	10:00 am every Tuesday	Any Value	Admin
<u>Pump Failure Delay</u>	60 seconds	Between 0 and 120 seconds	Admin
Pump Return From Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
<u>Humidifier Enable OAT</u>	10°C	Between 5°C and 13°C	Operator
<u>Return Air Humidity Setpoint</u>	See Reset Schedule	See Reset Schedule	Operator
Supply Air Humidity High Limit	90%	Between 80% and 90%	Operator
<u>Cooling Enable OAT</u>	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator

The *Supply Air Temperature Setpoint* will be reset according to the following:

- If a cooling request is received from an associated system the base setpoint will be decreased by 1°C every 10 minutes. (Minimum Setpoint = 11°C, Maximum Setpoint = 18°C)
- If no cooling requests are received and a heating request is received from an associated system the base
- Heating and cooling requests will be monitored from: • Associated Zones

The *<u>Return Air Humidity Setpoint</u>* will be reset according to the following schedule:

WHEN THE OAT IS:	THE SETPOINT IS:	AD
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T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

setpoint will be increased by 0.5°C every 10 minutes. (Minimum Setpoint = 16°C, Maximum Setpoint = 21°C)

**JUSTABLE RANGE** 

PERMISSION

WHEN THE OAT IS:	THE SETPOINT IS:		ADJUSTABLE RANGE	PERMISSION
10.0°C	40% RH	OAT: Setpoint:	Between 5.0°C and 15.0°C Between 35% and 45% RH	Operator
-20.0°C	30% RH	OAT: Setpoint:	Between -15.0°C and -20.0°C Between 25% and 35% RH	Operator

## **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air CO2</u>	0 PPM	2000 PPM	5 min
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
<u>Return Air Humidity</u>	0.0%RH	100.0%RH	5 min
Heating Coil Return Water Temperature	0.0°C	100.0°C	5 min
Cooling Coil Return Water Temperature	0.0°C	100.0°C	5 min
Supply Air Temperature	-20.0°C	100.0°C	5 min
Supply Air Humidity	0.0%RH	100.0%RH	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>Return Air CO2 Above Setpoint</u>	Return fan is on; and Return air CO2  is 100ppm above setpoint for 30 minutes;
<u>Return Fan Failed to Start</u>	Fan is commanded on; and Fan is off for 120 seconds.
<u>Return Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>Return Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
Mixed Air Temperature Low	Mixed Air Temperature is below 4°C for 5 minutes.
<u>Mixed Air Temperature Below</u> <u>Setpoint</u>	Mixed air temperature is 2.0°C below setpoint for 5 minutes;

DESCRIPTION	
<u>Heating Coil Leaving Water</u> <u>Temperature Low</u>	Heating Coil Leaving Wate
<u>Low Temperature Alarm</u> <u>(Freezestat)</u>	Low temperature alarm is
Supply Fan Failed to Start	Fan is commanded on; ar Fan is off for 120 seconds
Supply Fan VFD Fault	VFD fault alarm is active f
<u>Supply Fan On in Hand</u>	Fan is commanded off; ar Fan is on for 10 minutes.
<u>Supply Air Temperature Above</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is
<u>Supply Air Temperature Below</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is
Supply Air Temperature High	Supply fan is on; and Supply Air Temperature is
<u>Supply Air Temperature High Limit</u> <u>Shutdown</u>	Supply Air Temperature is
Supply Air Humidity High Limit	Supply fan is on; and Supply Air Humidity is ab
Duct Static Pressure Above Setpoint	Supply fan is on; and Static pressure is 100 Pa
Duct Static Pressure Below Setpoint	Supply fan is on; and Static pressure is 100 Pa l
P-211A Failed to Start	Heating is enabled; and Pump is off for 120 secon
P-211B Failed to Start	Heating is enabled; and Pump is off for 120 secon



CONDITION
er Temperature is below 5°C for 5 minutes.
s active.
nd 
or 15 seconds.
nd
5.0°C above setpoint for 5 minutes;
5.0°C below setpoint for 5 minutes;
s above 40°C for 5 minutes.
s above 55°C for 5 minutes.
ove 90%RH for 5 minutes.
above setpoint for 5 minutes.
pelow setpoint for 5 minutes.
ds.
ds.

# 214 – AS-2 (WING A SOUTH)

#### GENERAL

This sequence applies to **AS-2** which provides heating, cooling, humidification and ventilation to supplied zones.

The system is composed of the following components:

- Variable Volume Return Fan
- Mixed Air Dampers (Exhaust, Return, Outdoor) •
- Minimum Outdoor Air Damper •
- Heating Coil •
- Heat Exchanger HE-2 & Heating Pump P-212 •
- Humidifier 2 •
- Cooling Coil •
- Variable Volume Supply Fan •

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode: This mode will override the Disabled Mode if the number of supplied zones in an unoccupied override condition exceeds the *minimum night setback zone limit*

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Safeties

• A freezestat set at 4.0°C is hardwired to shut down the supply fan, position the mixed air dampers for recirculation, and fail open the heating valve. The freezestat alarm must be manually reset from the system graphics as well as the unit for the air handling unit to return to normal operation.

#### Supply Fan and Return Fan

Fan Staging

- The supply fan and return fan will be enabled in the Day Mode and Night Setback Modes.
- When the fans are enabled, the return fan will be commanded to minimum speed. When return fan status is • received, the supply fan will be commanded to minimum speed.
- In the Disabled Mode the supply and return fans will be commanded off.

#### Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on. •
- The supply fan will be modulated to maintain *supply air static pressure setpoint*. •
- The return fan will be modulated to maintain supply fan speed minus a *return fan offset*.

#### Mixed Air Damper Control

- Mixed air dampers include the combination of the Exhaust Air Damper, Return Air Damper, and Outdoor Air controlled to the inverse of the Return Air Damper.
- In the Disabled Mode the Mixed Air dampers will be positioned for recirculation with the Exhaust Air and Outdoor Air Dampers commanded closed, and the Return Air damper commanded open.
- In the Day Mode and Night Setback Mode the Mixed Air damper will initially be positioned for recirculation.
- In the Day Mode, the Mixed Air Dampers will be controlled for either free cooling or CO2 control.

#### Free Cooling Control

- Free Cooling will be enabled when:
  - supply fan status is confirmed on;

  - outdoor air temperature is less than *free cooling enable OAT*.
- Free Cooling is disabled when the above conditions are not met.
- When free cooling is enabled, mixed air dampers will be modulated to maintain *supply air temperature* temperature offset;

#### Return Air CO2 Control

- Return air CO2 control will be enabled in the Day Mode when:
  - supply fan status is confirmed on; and
  - return air co2 is above <u>return air co2 setpoint</u>.
- Return air CO2 control will be enabled in the Night Setback Mode when:
  - supply fan status is confirmed on;
  - minimum outdoor air damper is at maximum open position; and
  - return air co2 is above *return air co2 setpoint*.
- When return air CO2 control is enabled, the mixed air dampers will increase the minimum outdoor air setpoint to maintain return air co2 setpoint.
- Return air CO2 control will be disabled when:
- Mixed Air Damper control will be limited to ensure the following: • that mixed air temperature is above *minimum mixed air temperature setpoint* plus *mixed air temperature offset;* 
  - Supply air temperature is within the deadband range of *supply air temperature setpoint*.

#### Hot Water Heating Valve

- The heating valve located on the hot water supply side of Heat Exchanger HE-2 will be commanded to the open position when the system is enabled.
- The heating valve located on the hot water supply side of Heat Exchanger HE-2 will be commanded to the closed position when the system is disabled.

#### Glycol Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain mixed air temperature at *minimum* mixed air temperature setpoint.
- In the Night Setback Mode and Day mode, the heating valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is less than *heating enable OAT*; and



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

Damper. All dampers are controlled together through a common output. Exhaust and Outdoor dampers are

• outdoor air temperature is below return air temperature by more than the *free cooling offset*; and setpoint, while keeping mixed air temperature above minimum mixed air temperature setpoint plus mixed air

return air co2 drops below <u>return air co2 setpoint</u> for more than the <u>CO2 setpoint achieved delay</u>.

•	supply air temperature is below <i>supply air temperature setpoint</i> minus <i>supply air temperature</i>
	<u>deadband</u> ; or

- outdoor air temperature is less than *heating enable low limit OAT*.
- When enabled the heating valve will be modulated to maintain <u>supply air temperature setpoint</u>.
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The heating flag is removed when the heating valve closes below the *heating flag disable percentage*.

#### Heating Pump: P-212

Pump Staging

- When the heating is disabled, the pump will be commanded off.
- When the heating is enabled, the pump will be commanded on.

#### Humidifier

•

- The humidifier shall be commanded off at all times during the summer season.
- Humidification is enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is below *humidifier enable OAT*
- When humidifier is enabled, it will be modulated to maintain *return air humidity setpoint*. •
- BAS will limit humidifier output to maintain supply air humidity below supply air humidity high limit. •
- When the humidifier is disabled, it will be commanded off. •

#### Cooling Valve

•

- In the Disabled Mode the cooling valve will be commanded closed.
  - In the Night Setback Mode and Day mode, the cooling valve will be enabled when:
    - supply fan status is confirmed on;
    - outdoor air temperature is greater than *cooling enable OAT*; and
    - supply air temperature is above <u>supply air temperature setpoint</u> plus <u>supply air temperature deadband</u>.
- When enabled the cooling valve will be modulated to maintain supply air temperature setpoint.
- A cooling flag is issued when the cooling valve is open more than the *cooling flag enable percentage*. The cooling flag is removed when the cooling valve closes below the *cooling flag disable percentage*.

#### Minimum Outdoor Air Damper

- The minimum outdoor air damper will be enabled in the Day Mode and Night Setback Mode.
- The minimum outdoor air damper will modulate to maintain the *minimum outdoor air setpoint*. •
- In the Disabled Mode the minimum outdoor air damper is commanded closed. •

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Night Setback Zone Limit	3	Any Value	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator
<u>Return Fan Offset</u>	5%	Between 0% and 15%	Operator



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Free Cooling Offset	3.0°C	Between 1°C and 10°C	Operator
Free Cooling Enable OAT	15°C	Between 13°C and 18°C	Operator
Supply Air Temperature Setpoint	15°C	Between 13°C and 25°C	Operator
Minimum Mixed Air Temperature Setpoint	10°C	Between 5°C and 13°C	Operator
Mixed Air Temperature Offset	2.5°C	Between 1°C and 10°C	Operator
<u>Return Air CO2 Setpoint</u>	1000 ppm	Between 800 and 1500 ppm	Operator
<u>Minimum Outdoor Air Setpoint</u>	1500 CFM	Between 1000 and 2000 CFM	Admin
<u>CO2 Setpoint Achieved Delay</u>	5 minutes	Between 1 and 30 minutes	Operator
Heating Enable OAT	18°C	Between 15°C and 20°C	Operator
Supply Air Temperature Deadband	1°C	Between 0.5°C and 2°C	Operator
Heating Enable Low Limit OAT	10°C	Between 10°C and 15°C	Operator
Heating Flag Enable Percentage	95%	Between 90% and 100%	Operator
Heating Flag Disable Percentage	80%	Between 75% and 85%	Operator
Schedules Pump Rotation	10:00 am every Tuesday	Any Value	Admin
<u>Pump Failure Delay</u>	60 seconds	Between 0 and 120 seconds	Admin
Pump Return From Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Humidifier Enable OAT	10°C	Between 5°C and 13°C	Operator
<u>Return Air Humidity Setpoint</u>	See Reset Schedule	See Reset Schedule	Operator
Supply Air Humidity High Limit	90%	Between 80% and 90%	Operator
Cooling Enable OAT	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator

The <u>Supply Air Temperature Setpoint</u> will be reset according to the following:

minutes. (Minimum Setpoint = 11°C, Maximum Setpoint = 18°C)

• If a cooling request is received from an associated system the base setpoint will be decreased by 1°C every 10

- If no cooling requests are received and a heating request is received from an associated system the base setpoint will be increased by 0.5°C every 10 minutes. (Minimum Setpoint = 16°C, Maximum Setpoint = 21°C)
- Heating and cooling requests will be monitored from:

• Associated Zones

The *<u>Return Air Humidity Setpoint</u>* will be reset according to the following schedule:

WHEN THE OAT IS:	THE SETPOINT IS:	ADJUSTABLE RANGE		PERMISSION
10.0°C	40% RH	OAT: Setpoint:	Between 5.0°C and 15.0°C Between 35% and 45% RH	Operator
-20.0°C	30% RH	OAT: Setpoint:	Between -15.0°C and -20.0°C Between 25% and 35% RH	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air CO2</u>	0 PPM	2000 PPM	5 min
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
<u>Return Air Humidity</u>	0.0%RH	100.0%RH	5 min
Heating Coil Return Water Temperature	0.0°C	100.0°C	5 min
Cooling Coil Return Water Temperature	0.0°C	100.0°C	5 min
Supply Air Temperature	-20.0°C	100.0°C	5 min
Supply Air Humidity	0.0%RH	100.0%RH	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>Return Air CO2 Above Setpoint</u>	Return fan is on; and Return air CO2 is 100ppm above setpoint for 30 minutes;
<u>Return Fan Failed to Start</u>	Fan is commanded on; and Fan is off for 120 seconds.
<u>Return Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>Return Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.





CONDITION
below 4°C for 5 minutes.
2.0°C below setpoint for 5 minutes;
er Temperature is below 5°C for 5 minutes.
s active.
nd s.
or 15 seconds.
nd
5.0°C above setpoint for 5 minutes;
5.0°C below setpoint for 5 minutes;
s above 40°C for 5 minutes.
s above 55°C for 5 minutes.
ove 90%RH for 5 minutes.
above setpoint for 5 minutes.
below setpoint for 5 minutes.
and ids.
and s.

# **214 - OUTDOOR AIR CONDITIONS 2**

#### GENERAL

This sequence applies to the **OUTDOOR AIR CONDITIONS 2**.

#### **RUN CONDITIONS**

The system will be enabled continuously.

#### **CONTROL STRATEGY**

- There are two sensor locations. One sensor is on the northeast side of "B" Block in Level B1, and the other sensor is on the northeast side of "A" Block penthouse.
- Outdoor Air Temperature and Humidity values used for control purposes will be calculated as follows:
  - When both OAT readings are within 3°C of one another, an average from both sensors shall be used for the OAT and the OAH.
  - When both readings differ by more than 3°C of one another, the OAT and OAH from the sensor reading the lowest temperature shall be used.
- All readings from the sensors and the values used for control purposes shall be displayed on the OWS.
- Outdoor Air Temperature (OAT) and Outdoor Air Humidity (OAH) values used for control purposes will be broadcast on the BAS network.

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

POINT DESCRIPTION	INTERVAL	DURATION	
Outdoor Air Temperature	Every 15 minutes	2,880 samples	Approx. 30 days
<u>Outdoor Air Humidity</u>	Every 15 minutes	2,880 samples	Approx. 30 days

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
Outdoor Air Temperature	-50.0°C	100.0°C	5 min
<u>Outdoor Air Humidity</u>	0% RH	100% RH	5 min



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S04 214 – OUTDOOR AIR CONDITIONS 2 AS-BUILT (REV 1) – December 22, 2016

# 215 – AS-3 (WING B NORTH)

#### GENERAL

This sequence applies to **AS-3** which provides heating, cooling, humidification and ventilation to supplied zones.

The system is composed of the following components:

- Variable Volume Return Fan
- Mixed Air Dampers (Exhaust, Return, Outdoor) •
- Minimum Outdoor Air Damper •
- Heating Coil •
- Heat Exchanger HE-3 & Heating Pump P-213 •
- Humidifier 3 •
- Cooling Coil •
- Variable Volume Supply Fan •

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode: This mode will override the Disabled Mode if the number of supplied zones in an unoccupied override condition exceeds the *minimum night setback zone limit*

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Safeties

• A freezestat set at 4.0°C is hardwired to shut down the supply fan, position the mixed air dampers for recirculation, and fail open the heating valve. The freezestat alarm must be manually reset from the system graphics as well as the unit for the air handling unit to return to normal operation.

#### Supply Fan and Return Fan

Fan Staging

- The supply fan and return fan will be enabled in the Day Mode and Night Setback Modes.
- When the fans are enabled, the return fan will be commanded to minimum speed. When return fan status is • received, the supply fan will be commanded to minimum speed.
- In the Disabled Mode the supply and return fans will be commanded off.

#### Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on. •
- The supply fan will be modulated to maintain *supply air static pressure setpoint*. •
- The return fan will be modulated to maintain supply fan speed minus a *return fan offset*.

#### Mixed Air Damper Control

- Mixed air dampers include the combination of the Exhaust Air Damper, Return Air Damper, and Outdoor Air controlled to the inverse of the Return Air Damper.
- In the Disabled Mode the Mixed Air dampers will be positioned for recirculation with the Exhaust Air and Outdoor Air Dampers commanded closed, and the Return Air damper commanded open.
- In the Day Mode and Night Setback Mode the Mixed Air damper will initially be positioned for recirculation.
- In the Day Mode, the Mixed Air Dampers will be controlled for either free cooling or CO2 control.

#### Free Cooling Control

- Free Cooling will be enabled when:
  - supply fan status is confirmed on;

  - outdoor air temperature is less than *free cooling enable OAT*.
- Free Cooling is disabled when the above conditions are not met.
- When free cooling is enabled, mixed air dampers will be modulated to maintain *supply air temperature* temperature offset;

#### Return Air CO2 Control

- Return air CO2 control will be enabled in the Day Mode when:
  - supply fan status is confirmed on; and
  - return air co2 is above <u>return air co2 setpoint</u>.
- Return air CO2 control will be enabled in the Night Setback Mode when:
  - supply fan status is confirmed on;
  - minimum outdoor air damper is at maximum open position; and
  - return air co2 is above *return air co2 setpoint*.
- When return air CO2 control is enabled, the mixed air dampers will increase the minimum outdoor air setpoint to maintain return air co2 setpoint.
- Return air CO2 control will be disabled when:
- Mixed Air Damper control will be limited to ensure the following: • that mixed air temperature is above *minimum mixed air temperature setpoint* plus *mixed air temperature offset;* 
  - Supply air temperature is within the deadband range of *supply air temperature setpoint*.

#### Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain mixed air temperature at *minimum* mixed air temperature setpoint.
- In the Night Setback Mode and Day mode, the heating valve will be enabled when: • supply fan status is confirmed on;

  - outdoor air temperature is less than *heating enable OAT*; and • supply air temperature is below supply air temperature setpoint minus supply air temperature deadband; or
  - outdoor air temperature is less than *heating enable low limit OAT*.
- When enabled the heating valve will be modulated to maintain <u>supply air temperature setpoint</u>.
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The heating flag is removed when the heating valve closes below the *heating flag disable percentage*.



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

Damper. All dampers are controlled together through a common output. Exhaust and Outdoor dampers are

• outdoor air temperature is below return air temperature by more than the *free cooling offset*; and setpoint, while keeping mixed air temperature above minimum mixed air temperature setpoint plus mixed air

return air co2 drops below <u>return air co2 setpoint</u> for more than the <u>CO2 setpoint achieved delay</u>.

#### Heating Pump: P-213

Pump Staging

- When the heating is disabled, the pump will be commanded off.
- When the heating is enabled, the pump will be commanded on.

#### Humidifier

- The humidifier shall be commanded off at all times during the summer season.
- Humidification is enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is below *humidifier enable OAT*
- When humidifier is enabled, it will be modulated to maintain *return air humidity setpoint*.
- BAS will limit humidifier output to maintain supply air humidity below *supply air humidity high limit*.
- When the humidifier is disabled, it will be commanded off.

#### Cooling Valve

- In the Disabled Mode the cooling valve will be commanded closed.
- In the Night Setback Mode and Day mode, the cooling valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is greater than *cooling enable OAT*; and
  - supply air temperature is above *supply air temperature setpoint* plus *supply air temperature deadband*.
- When enabled the cooling valve will be modulated to maintain *supply air temperature setpoint*.
- A cooling flag is issued when the cooling valve is open more than the *cooling flag enable percentage*. The cooling flag is removed when the cooling valve closes below the *cooling flag disable percentage*.

#### Minimum Outdoor Air Damper

- The minimum outdoor air damper will be enabled in the Day Mode and Night Setback Mode.
- The minimum outdoor air damper will modulate to maintain the *minimum outdoor air setpoint*.
- In the Disabled Mode the minimum outdoor air damper is commanded closed.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Night Setback Zone Limit	3	Any Value	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator
<u>Return Fan Offset</u>	5%	Between 0% and 15%	Operator
Free Cooling Offset	3.0°C	Between 1°C and 10°C	Operator
Free Cooling Enable OAT	15°C	Between 13°C and 18°C	Operator
Supply Air Temperature Setpoint	15°C	Between 13°C and 25°C	Operator

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Mixed Air Temperature Setpoint	10°C	Between 5°C and 13°C	Operator
Mixed Air Temperature Offset	2.5°C	Between 1°C and 10°C	Operator
<u>Return Air CO2 Setpoint</u>	1000 ppm	Between 800 and 1500 ppm	Operator
Minimum Outdoor Air Setpoint	1500 CFM	Between 1000 and 2000 CFM	Admin
<u>CO2 Setpoint Achieved Delay</u>	5 minutes	Between 1 and 30 minutes	Operator
Heating Enable OAT	18°C	Between 15°C and 20°C	Operator
Supply Air Temperature Deadband	1°C	Between 0.5°C and 2°C	Operator
Heating Enable Low Limit OAT	10°C	Between 10°C and 15°C	Operator
Heating Flag Enable Percentage	95%	Between 90% and 100%	Operator
Heating Flag Disable Percentage	80%	Between 75% and 85%	Operator
Schedules Pump Rotation	10:00 am every Tuesday	Any Value	Admin
Pump Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Pump Return From Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Humidifier Enable OAT	10°C	Between 5°C and 13°C	Operator
<u>Return Air Humidity Setpoint</u>	See Reset Schedule	See Reset Schedule	Operator
Supply Air Humidity High Limit	90%	Between 80% and 90%	Operator
Cooling Enable OAT	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator



The *Supply Air Temperature Setpoint* will be reset according to the following:

- If a cooling request is received from an associated system the base setpoint will be decreased by 1°C every 10 minutes. (Minimum Setpoint = 11°C, Maximum Setpoint = 18°C)
- If no cooling requests are received and a heating request is received from an associated system the base setpoint will be increased by 0.5°C every 10 minutes. (Minimum Setpoint = 16°C, Maximum Setpoint = 21°C)
- Heating and cooling requests will be monitored from:
  - Associated Zones

The *<u>Return Air Humidity Setpoint</u>* will be reset according to the following schedule:

WHEN THE OAT IS:	THE SETPOINT IS:		ADJUSTABLE RANGE	PERMISSION
10.0°C	40% RH	OAT: Setpoint:	Between 5.0°C and 15.0°C Between 35% and 45% RH	Operator
-20.0°C	30% RH	OAT: Setpoint:	Between -15.0°C and -20.0°C Between 25% and 35% RH	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air CO2</u>	0 PPM	2000 PPM	5 min
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
<u>Return Air Humidity</u>	0.0%RH	100.0%RH	5 min
Heating Coil Return Water Temperature	0.0°C	100.0°C	5 min
Cooling Coil Return Water Temperature	0.0°C	100.0°C	5 min
Supply Air Temperature	-20.0°C	100.0°C	5 min
Supply Air Humidity	0.0%RH	100.0%RH	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>Return Air CO2 Above Setpoint</u>	Return fan is on; and Return air CO2 is 100ppm above setpoint for 30 minutes;
<u>Return Fan Failed to Start</u>	Fan is commanded on; and Fan is off for 120 seconds.
<u>Return Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.



DESCRIPTION	
<u>Return Fan On in Hand</u>	Fan is commanded off; an Fan is on for 10 minutes.
<u>Mixed Air Temperature Low</u>	Mixed Air Temperature is
<u>Mixed Air Temperature Below</u> <u>Setpoint</u>	Mixed air temperature is
<u>Heating Coil Leaving Water</u> <u>Temperature Low</u>	Heating Coil Leaving Wate
<u>Low Temperature Alarm</u> <u>(Freezestat)</u>	Low temperature alarm is
<u>Supply Fan Failed to Start</u>	Fan is commanded on; ar Fan is off for 120 seconds
Supply Fan VFD Fault	VFD fault alarm is active f
Supply Fan On in Hand	Fan is commanded off; an Fan is on for 10 minutes.
<u>Supply Air Temperature Above</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is
<u>Supply Air Temperature Below</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is
Supply Air Temperature High	Supply fan is on; and Supply Air Temperature i
<u>Supply Air Temperature High Limit</u> <u>Shutdown</u>	Supply Air Temperature i
Supply Air Humidity High Limit	Supply fan is on; and Supply Air Humidity is ab
Duct Static Pressure Above Setpoint	Supply fan is on; and Static pressure is 100 Pa
Duct Static Pressure Below Setpoint	Supply fan is on; and Static pressure is 100 Pa
P-213 Failed to Start	Pump is commanded on; Pump is off for 120 secor
<u>P-213 On in Hand</u>	Pump is commanded off; Pump is on for 10 minute

CONDITION
nd
below 4°C for 5 minutes.
2.0°C below setpoint for 5 minutes;
er Temperature is below 5°C for 5 minutes.
s active.
id
or 15 seconds.
nd
5.0°C above setpoint for 5 minutes;
5.0°C below setpoint for 5 minutes;
s above 40°C for 5 minutes.
s above 55°C for 5 minutes.
ove 90%RH for 5 minutes.
above setpoint for 5 minutes.
pelow setpoint for 5 minutes.
and ds.
and s.

# 216 – AS-4 (WING B SOUTH)

#### GENERAL

This sequence applies to **AS-4** which provides heating, cooling, humidification and ventilation to supplied zones.

The system is composed of the following components:

- Variable Volume Return Fan
- Mixed Air Dampers (Exhaust, Return, Outdoor) •
- Minimum Outdoor Air Damper •
- Heating Coil •
- Heat Exchanger HE-4 & Heating Pump P-214 •
- Humidifier 4 •
- Cooling Coil •
- Variable Volume Supply Fan •

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode: This mode will override the Disabled Mode if the number of supplied zones in an unoccupied override condition exceeds the *minimum night setback zone limit*

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Safeties

• A freezestat set at 4.0°C is hardwired to shut down the supply fan, position the mixed air dampers for recirculation, and fail open the heating valve. The freezestat alarm must be manually reset from the system graphics as well as the unit for the air handling unit to return to normal operation.

#### Supply Fan and Return Fan

Fan Staging

- The supply fan and return fan will be enabled in the Day Mode and Night Setback Modes.
- When the fans are enabled, the return fan will be commanded to minimum speed. When return fan status is • received, the supply fan will be commanded to minimum speed.
- In the Disabled Mode the supply and return fans will be commanded off.

#### Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on. •
- The supply fan will be modulated to maintain *supply air static pressure setpoint*. •
- The return fan will be modulated to maintain supply fan speed minus a *return fan offset*.

#### Mixed Air Damper Control

- Mixed air dampers include the combination of the Exhaust Air Damper, Return Air Damper, and Outdoor Air controlled to the inverse of the Return Air Damper.
- In the Disabled Mode the Mixed Air dampers will be positioned for recirculation with the Exhaust Air and Outdoor Air Dampers commanded closed, and the Return Air damper commanded open.
- In the Day Mode and Night Setback Mode the Mixed Air damper will initially be positioned for recirculation.
- In the Day Mode, the Mixed Air Dampers will be controlled for either free cooling or CO2 control.

#### Free Cooling Control

- Free Cooling will be enabled when:
  - supply fan status is confirmed on;

  - outdoor air temperature is less than *free cooling enable OAT*.
- Free Cooling is disabled when the above conditions are not met.
- When free cooling is enabled, mixed air dampers will be modulated to maintain *supply air temperature* temperature offset;

#### Return Air CO2 Control

- Return air CO2 control will be enabled in the Day Mode when:
  - supply fan status is confirmed on; and
  - return air co2 is above <u>return air co2 setpoint</u>.
- Return air CO2 control will be enabled in the Night Setback Mode when:
  - supply fan status is confirmed on;
  - minimum outdoor air damper is at maximum open position; and
  - return air co2 is above *return air co2 setpoint*.
- When return air CO2 control is enabled, the mixed air dampers will increase the minimum outdoor air setpoint to maintain return air co2 setpoint.
- Return air CO2 control will be disabled when:
- Mixed Air Damper control will be limited to ensure the following: • that mixed air temperature is above *minimum mixed air temperature setpoint* plus *mixed air temperature offset;* 
  - Supply air temperature is within the deadband range of *supply air temperature setpoint*.

#### Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain mixed air temperature at *minimum* mixed air temperature setpoint.
- In the Night Setback Mode and Day mode, the heating valve will be enabled when: • supply fan status is confirmed on;

  - outdoor air temperature is less than *heating enable OAT*; and • supply air temperature is below supply air temperature setpoint minus supply air temperature deadband; or
  - outdoor air temperature is less than *heating enable low limit OAT*.
- When enabled the heating valve will be modulated to maintain <u>supply air temperature setpoint</u>.
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The heating flag is removed when the heating valve closes below the *heating flag disable percentage*.



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

Damper. All dampers are controlled together through a common output. Exhaust and Outdoor dampers are

• outdoor air temperature is below return air temperature by more than the *free cooling offset*; and setpoint, while keeping mixed air temperature above minimum mixed air temperature setpoint plus mixed air

return air co2 drops below <u>return air co2 setpoint</u> for more than the <u>CO2 setpoint achieved delay</u>.

#### Heating Pump: P-214

Pump Staging

- When the heating is disabled, the pump will be commanded off.
- When the heating is enabled, the pump will be commanded on.

#### Humidifier

- The humidifier shall be commanded off at all times during the summer season.
- Humidification is enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is below *humidifier enable OAT*
- When humidifier is enabled, it will be modulated to maintain *return air humidity setpoint*.
- BAS will limit humidifier output to maintain supply air humidity below *supply air humidity high limit*.
- When the humidifier is disabled, it will be commanded off.

#### Cooling Valve

- In the Disabled Mode the cooling valve will be commanded closed.
- In the Night Setback Mode and Day mode, the cooling valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is greater than *cooling enable OAT*; and
  - supply air temperature is above *supply air temperature setpoint* plus *supply air temperature deadband*.
- When enabled the cooling valve will be modulated to maintain *supply air temperature setpoint*.
- A cooling flag is issued when the cooling valve is open more than the *cooling flag enable percentage*. The cooling flag is removed when the cooling valve closes below the *cooling flag disable percentage*.

#### Minimum Outdoor Air Damper

- The minimum outdoor air damper will be enabled in the Day Mode and Night Setback Mode.
- The minimum outdoor air damper will modulate to maintain the *minimum outdoor air setpoint*.
- In the Disabled Mode the minimum outdoor air damper is commanded closed.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Night Setback Zone Limit	3	Any Value	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator
<u>Return Fan Offset</u>	5%	Between 0% and 15%	Operator
Free Cooling Offset	3.0°C	Between 1°C and 10°C	Operator
Free Cooling Enable OAT	15°C	Between 13°C and 18°C	Operator
Supply Air Temperature Setpoint	15°C	Between 13°C and 25°C	Operator

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Mixed Air Temperature Setpoint	10°C	Between 5°C and 13°C	Operator
Mixed Air Temperature Offset	2.5°C	Between 1°C and 10°C	Operator
<u>Return Air CO2 Setpoint</u>	1000 ppm	Between 800 and 1500 ppm	Operator
<u>Minimum Outdoor Air Setpoint</u>	1500 CFM	Between 1000 and 2000 CFM	Admin
CO2 Setpoint Achieved Delay	5 minutes	Between 1 and 30 minutes	Operator
Heating Enable OAT	18°C	Between 15°C and 20°C	Operator
Supply Air Temperature Deadband	1°C	Between 0.5°C and 2°C	Operator
Heating Enable Low Limit OAT	10°C	Between 10°C and 15°C	Operator
Heating Flag Enable Percentage	95%	Between 90% and 100%	Operator
Heating Flag Disable Percentage	80%	Between 75% and 85%	Operator
Schedules Pump Rotation	10:00 am every Tuesday	Any Value	Admin
<u>Pump Failure Delay</u>	60 seconds	Between 0 and 120 seconds	Admin
Pump Return From Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Humidifier Enable OAT	10°C	Between 5°C and 13°C	Operator
<u>Return Air Humidity Setpoint</u>	See Reset Schedule	See Reset Schedule	Operator
Supply Air Humidity High Limit	90%	Between 80% and 90%	Operator
<u>Cooling Enable OAT</u>	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator



The *Supply Air Temperature Setpoint* will be reset according to the following:

- If a cooling request is received from an associated system the base setpoint will be decreased by 1°C every 10 minutes. (Minimum Setpoint = 11°C, Maximum Setpoint = 18°C)
- If no cooling requests are received and a heating request is received from an associated system the base setpoint will be increased by 0.5°C every 10 minutes. (Minimum Setpoint = 16°C, Maximum Setpoint = 21°C)
- Heating and cooling requests will be monitored from:
  - Associated Zones

The *<u>Return Air Humidity Setpoint</u>* will be reset according to the following schedule:

WHEN THE OAT IS:	THE SETPOINT IS:		ADJUSTABLE RANGE	PERMISSION
10.0°C	40% RH	OAT: Setpoint:	Between 5.0°C and 15.0°C Between 35% and 45% RH	Operator
-20.0°C	30% RH	OAT: Setpoint:	Between -15.0°C and -20.0°C Between 25% and 35% RH	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air CO2</u>	0 PPM	2000 PPM	5 min
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
<u>Return Air Humidity</u>	0.0%RH	100.0%RH	5 min
Heating Coil Return Water Temperature	0.0°C	100.0°C	5 min
Cooling Coil Return Water Temperature	0.0°C	100.0°C	5 min
Supply Air Temperature	-20.0°C	100.0°C	5 min
Supply Air Humidity	0.0%RH	100.0%RH	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>Return Air CO2 Above Setpoint</u>	Return fan is on; and Return air CO2 is 100ppm above setpoint for 30 minutes;
<u>Return Fan Failed to Start</u>	Fan is commanded on; and Fan is off for 120 seconds.
<u>Return Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.



DESCRIPTION	
<u>Return Fan On in Hand</u>	Fan is commanded off; ar Fan is on for 10 minutes.
<u>Mixed Air Temperature Low</u>	Mixed Air Temperature is
<u>Mixed Air Temperature Below</u> <u>Setpoint</u>	Mixed air temperature is
<u>Heating Coil Leaving Water</u> <u>Temperature Low</u>	Heating Coil Leaving Wate
<u>Low Temperature Alarm</u> <u>(Freezestat)</u>	Low temperature alarm is
<u>Supply Fan Failed to Start</u>	Fan is commanded on; ar Fan is off for 120 seconds
Supply Fan VFD Fault	VFD fault alarm is active f
Supply Fan On in Hand	Fan is commanded off; ar Fan is on for 10 minutes.
<u>Supply Air Temperature Above</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is
<u>Supply Air Temperature Below</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is
Supply Air Temperature High	Supply fan is on; and Supply Air Temperature i
<u>Supply Air Temperature High Limit</u> <u>Shutdown</u>	Supply Air Temperature is
Supply Air Humidity High Limit	Supply fan is on; and Supply Air Humidity is ab
Duct Static Pressure Above Setpoint	Supply fan is on; and Static pressure is 100 Pa
Duct Static Pressure Below Setpoint	Supply fan is on; and Static pressure is 100 Pa
<u>P-214 Failed to Start</u>	Pump is commanded on; Pump is off for 120 secor
<u>P-214 On in Hand</u>	Pump is commanded off; Pump is on for 10 minute

CONDITION
nd
below 4°C for 5 minutes.
2.0°C below setpoint for 5 minutes;
er Temperature is below 5°C for 5 minutes.
s active.
id
or 15 seconds.
nd
5.0°C above setpoint for 5 minutes;
5.0°C below setpoint for 5 minutes;
s above 40°C for 5 minutes.
s above 55°C for 5 minutes.
ove 90%RH for 5 minutes.
above setpoint for 5 minutes.
pelow setpoint for 5 minutes.
and ds.
and s.

# 217 – AS-5 (WING B – L1 COUNCIL CHAMBERS)

#### GENERAL

This sequence applies to **AS-5** which provides heating, cooling, humidification and ventilation to supplied zones.

The system is composed of the following components:

- Variable Volume Return Fan
- Mixed Air Dampers (Exhaust, Return, Outdoor)
- Pre-Heat Heating Coil & Heating Pump P-215 •
- Cooling Coil
- Humidifier 5
- Variable Volume Supply Fan

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode. This mode will override the Disabled Mode if:
  - Space temperature is above *unoccupied space temperature cooling setpoint* and the cooling season is active; or
  - Space temperature is below *unoccupied space temperature heating setpoint* and the heating season is active;

When the Time of Day Schedule is unoccupied, and occupancy is detected by the motion sensor, the schedule will be set to occupied.

When the Time of Day Schedule is unoccupied, and no occupancy is detected by the motion sensor for the *unoccupied* override delay, the schedule will be set to unoccupied.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Safeties

• A freezestat set at 4.0°C is hardwired to shut down the supply fan, position the mixed air dampers for recirculation, and fail open the heating valve. The freezestat alarm must be manually reset from the system graphics as well as the unit for the air handling unit to return to normal operation.

#### Supply Fan and Return Fan

Fan Staging

- The supply fan and return fan will be enabled in the Day Mode and Night Setback Modes.
- When the fans are enabled, the return fan will be commanded to minimum speed. When return fan status is received, the supply fan will be commanded to minimum speed.
- In the Disabled Mode the supply and return fans will be commanded off.



Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on.
- The supply fan will be modulated to maintain supply air static pressure setpoint.
- The return fan will be modulated to maintain supply fan speed minus a *return fan offset*. •

#### Mixed Air Damper Control

- Mixed air dampers include the combination of the Exhaust Air Damper, Return Air Damper, and Outdoor Air controlled to the inverse of the Return Air Damper.
- In the Disabled Mode the Mixed Air dampers will be positioned for recirculation with the Exhaust Air and Outdoor Air Dampers commanded closed, and the Return Air damper commanded open.
- In the Day Mode and Night Setback Mode the Mixed Air damper will initially be positioned for recirculation. •
- In the Day Mode, the Mixed Air Dampers will be controlled for either free cooling or CO2 control.

#### Free Cooling Control

- Free Cooling will be enabled when:
  - supply fan status is confirmed on;

  - outdoor air temperature is less than *free cooling enable OAT*.
- Free Cooling is disabled when the above conditions are not met.
- When free cooling is enabled, mixed air dampers will be modulated to maintain space temperature setpoint, while keeping mixed air temperature above *minimum mixed air temperature setpoint* plus *mixed air* temperature offset;

#### Return Air CO2 Control

- Return air CO2 control will be enabled in the Day Mode and Night Setback Mode when:
  - supply fan status is confirmed on; and
  - return air co2 is above *return air co2 setpoint*.
- When return air CO2 control is enabled, the mixed air dampers will increase the minimum outdoor air setpoint to maintain *return air co2 setpoint*.
- Return air CO2 control will be disabled when:
- Mixed Air Damper control will be limited to ensure the following:
  - that mixed air temperature is above *minimum mixed air temperature setpoint* plus *mixed air* temperature offset;
  - Space temperature is within the deadband range of <u>space temperature setpoint</u>.

#### Preheat Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain preheat leaving air temperature at minimum mixed air temperature setpoint.
- When the system is in Day mode, the heating valve will be enabled when:
  - supply fan status is confirmed on; and
  - outdoor air temperature is less than *heating enable OAT*; and
  - space temperature is below space temperature setpoint minus space temperature deadband; or
  - outdoor air temperature is less than <u>heating enable low limit OAT</u>.
- When the system is in Night Setback Mode, the heating valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is less than *heating enable OAT*; and

T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

Damper. All dampers are controlled together through a common output. Exhaust and Outdoor dampers are

• outdoor air temperature is below return air temperature by more than the *free cooling offset*; and

• return air CO2 drops below return air co2 setpoint for more than the CO2 setpoint achieved delay.

- space temperature is below <u>space temperature setpoint</u> minus <u>space temperature deadband</u>; or
- outdoor air temperature is less than <u>heating enable low limit OAT</u>.
- When enabled the heating valve will be modulated to maintain <u>preheat leaving air temperature setpoint</u>. •
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The heating flag is removed when the heating valve closes below the *heating flag disable percentage*.

#### Reheat Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain mixed air temperature at *preheat* leaving air temperature setpoint.
- In the Day mode, the heating valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is less than *heating enable OAT*; and
  - space temperature is below <u>space temperature setpoint</u> minus <u>space temperature deadband</u>; or
  - outdoor air temperature is less than *heating enable low limit OAT*.
- In the Night Setback mode mode, the heating valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is less than *heating enable OAT*; and
  - space temperature is below *unoccupied space temperature heating setpoint*; or
  - outdoor air temperature is less than <u>heating enable low limit OAT</u>.
- When enabled in Day mode, the heating valve will be modulated to maintain <u>space temperature setpoint</u>.
- When enabled in Night Setback mode, the heating valve will be modulated to maintain <u>unoccupied space</u> • temperature heating setpoint.
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The ٠ heating flag is removed when the heating valve closes below the *heating flag disable percentage*.

#### Preheat Heating Pump: P-215

Pump Staging

- When the heating is disabled, the pump will be commanded off.
- When the heating is enabled, the pump will be commanded on.

#### Humidifier

- The humidifier shall be commanded off at all times during the summer season.
- Humidification is enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is below *humidifier enable OAT*
- When humidifier is enabled, it will be modulated to maintain <u>return air humidity setpoint</u>. •
- BAS will limit humidifier output to maintain supply air humidity below supply air humidity high limit.
- When the humidifier is disabled, it will be commanded off.

#### Cooling Valve

- In the Disabled Mode the cooling valve will be commanded closed.
- In the Day mode, the cooling valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is greater than *cooling enable OAT*; and
  - space temperature is above <u>space temperature setpoint</u> plus <u>space temperature deadband</u>.
- In the Night Setback mode, the cooling valve will be enabled when:
  - supply fan status is confirmed on;



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

- outdoor air temperature is greater than *cooling enable OAT*; and
- space temperature is above <u>unoccupied space temperature cooling setpoint</u>.
- When enabled in Night Setback mode, the cooling valve will be modulated to maintain <u>unoccupied space</u> temperature cooling setpoint.
- A cooling flag is issued when the cooling valve is open more than the *cooling flag enable percentage*. The cooling flag is removed when the cooling valve closes below the *cooling flag disable percentage*.

#### Occupancy Sensor

Occupancy status of the Council Chambers will be monitored by an EC-Smart-Vue-M space sensor.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue-M sensor:

• Space Temperature

#### The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
<u>Space Temperature Setpoint</u>	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Heating</u> <u>Setpoint</u>	View	Yes	±2.0°C

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
<u>Unoccupied Override Delay</u>	Adjustable by Operator	Between 0 and 8 hours	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator
<u>Return Fan Offset</u>	5%	Between 0% and 15%	Operator
Free Cooling Offset	3.0°C	Between 1°C and 10°C	Operator
Free Cooling Enable OAT	15°C	Between 13°C and 18°C	Operator
<u>Space Temperature Setpoint</u>	22°C	Between 20°C and 24°C	Operator

When enabled in Day mode, the cooling valve will be modulated to maintain <u>space temperature setpoint</u>.

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
<u>Unoccupied Space Temperature Heating</u> <u>Setpoint</u>	18.0°C	Between 15.0°C and 18.0°C	Operator
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	26.0°C	Between 26.0°C and 30.0°C	Operator
Minimum Mixed Air Temperature Setpoint	10°C	Between 5°C and 13°C	Operator
Mixed Air Temperature Offset	2.5°C	Between 1°C and 10°C	Operator
<u>Return Air CO2 Setpoint</u>	1000 ppm	Between 800 and 1500 ppm	Operator
Minimum Outdoor Air Setpoint	2302 CFM	Between 2000 and 3000 CFM	Admin
<u>CO2 Setpoint Achieved Delay</u>	5 minutes	Between 1 and 30 minutes	Operator
Preheat Leaving Air Temperature Setpoint	10°C	Between 8°C and 15°C	Operator
Heating Enable OAT	18°C	Between 15°C and 20°C	Operator
Space Temperature Deadband	1°C	Between 0.5°C and 2°C	Operator
Heating Enable Low Limit OAT	10°C	Between 10°C and 15°C	Operator
Heating Flag Enable Percentage	95%	Between 90% and 100%	Operator
Heating Flag Disable Percentage	80%	Between 75% and 85%	Operator
Schedules Pump Rotation	10:00 am every Tuesday	Any Value	Admin
<u>Pump Failure Delay</u>	60 seconds	Between 0 and 120 seconds	Admin
Pump Return From Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
<u>Humidifier Enable OAT</u>	10°C	Between 5°C and 13°C	Operator
<u>Return Air Humidity Setpoint</u>	See Reset Schedule	See Reset Schedule	Operator
Supply Air Humidity High Limit	90%	Between 80% and 90%	Operator
Cooling Enable OAT	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator

The *<u>Return Air Humidity Setpoint</u>* will be reset according to the following schedule:



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS

WHEN THE OAT IS:	THE SETPOINT IS:		ADJUSTABLE RANGE	PERMISSION
10.0°C	40% RH	OAT: Setpoint:	Between 5.0°C and 15.0°C Between 35% and 45% RH	Operator
-20.0°C	30% RH	OAT: Setpoint:	Between -15.0°C and -20.0°C Between 25% and 35% RH	Operator

## **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

## ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air CO2</u>	0 PPM	2000 PPM	5 min
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
<u>Return Air Humidity</u>	0.0%RH	100.0%RH	5 min
Heating Coil Return Water Temperature	0.0°C	100.0°C	5 min
Cooling Coil Return Water Temperature	0.0°C	100.0°C	5 min
Supply Air Temperature	-20.0°C	100.0°C	5 min
Supply Air Humidity	0.0%RH	100.0%RH	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	
Return Air CO2 Above Setpoint	Return fan is on; and Return air CO2 is 100ppr
<u>Return Fan Failed to Start</u>	Fan is commanded on; ar Fan is off for 120 seconds
<u>Return Fan VFD Fault</u>	VFD fault alarm is active f
<u>Return Fan On in Hand</u>	Fan is commanded off; ar Fan is on for 10 minutes.
Mixed Air Temperature Low	Mixed Air Temperature is
<u>Mixed Air Temperature Below</u> <u>Setpoint</u>	Mixed air temperature is

#### CONDITION

m above setpoint for 30 minutes;

nd

i.

for 15 seconds.

nd

below 4°C for 5 minutes.

s 2.0°C below setpoint for 5 minutes;

DESCRIPTION	CONDITION
<u>Heating Coil Leaving Water</u> <u>Temperature Low</u>	Heating Coil Leaving Water Temperature is below 5°C for 5 minutes.
<u>Low Temperature Alarm</u> (Freezestat)	Low temperature alarm is active.
Supply Fan Failed to Start	Fan is commanded on; and Fan is off for 120 seconds.
<u>Supply Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.
Supply Fan On in Hand	Fan is commanded off; and Fan is on for 10 minutes.
Space Temperature Above Setpoint	Supply fan is on; and Supply air temperature is 5.0°C above setpoint for 5 minutes;
Space Temperature Below Setpoint	Supply fan is on; and Supply air temperature is 5.0°C below setpoint for 5 minutes;
Supply Air Temperature High	Supply fan is on; and Supply Air Temperature is above 40°C for 5 minutes.
<u>Supply Air Temperature High Limit</u> <u>Shutdown</u>	Supply Air Temperature is above 55°C for 5 minutes.
Supply Air Humidity High Limit	Supply fan is on; and Supply Air Humidity is above 90%RH for 5 minutes.
Duct Static Pressure Above Setpoint	Supply fan is on; and Static pressure is 100 Pa above setpoint for 5 minutes.
Duct Static Pressure Below Setpoint	Supply fan is on; and Static pressure is 100 Pa below setpoint for 5 minutes.
P-215 Failed to Start	Pump is commanded on; and Pump is off for 120 seconds.
<u>P-215 On in Hand</u>	Pump is commanded off; and Pump is on for 10 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S04 217 – AS-5 (WING B – L1 COUNCIL CHAMBERS) AS-BUILT (REV 1) – December 22, 2016

# 218 – AS-7 (L3 COMMON AREA)

#### GENERAL

This sequence applies to **AS-7** which provides heating, cooling and humidification to supplied area.

The system is composed of the following components:

- Heating Coil
- Humidifier
- Cooling Coil •
- Variable Volume Supply Fan

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode: This mode will override the Disabled Mode if the number of supplied zones in an • unoccupied override condition exceeds the *minimum night setback zone limit*

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Supply Fan

Fan Staging

- The supply fan will be enabled in the Day Mode and Night Setback Modes.
- When the fan is enabled, the supply fan will be commanded to minimum speed. •
- In the Disabled Mode the supply fan will be commanded off.

Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on.
- The supply fan will be modulated to maintain supply air static pressure setpoint. •

#### Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain supply air temperature at *minimum* supply air temperature setpoint.
- In the Night Setback Mode and Day mode, the heating valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is less than *heating enable OAT*; and
  - space temperature is below <u>space temperature setpoint</u> minus <u>space temperature deadband</u>; or
  - outdoor air temperature is less than *heating enable low limit OAT*.
- When enabled the heating valve will be modulated to maintain <u>space temperature setpoint</u>.
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The heating flag is removed when the heating valve closes below the *heating flag disable percentage*.

#### Humidifier

- The humidifier shall be commanded off at all times during the summer season.
- Humidification is enabled when:
- supply fan status is confirmed on;
  - outdoor air temperature is below *humidifier enable OAT*
- When humidifier is enabled, it will be modulated to maintain *return air humidity setpoint*.
- BAS will limit humidifier output to maintain supply air humidity below supply air humidity high limit.
- When the humidifier is disabled, it will be commanded off.

#### Cooling Valve

- In the Disabled Mode the cooling valve will be commanded closed.
- In the Night Setback Mode and Day mode, the cooling valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is greater than *cooling enable OAT*; and
  - supply air temperature is above space temperature setpoint plus space temperature deadband.
- When enabled the cooling valve will be modulated to maintain <u>space temperature setpoint</u>.
- A cooling flag is issued when the cooling valve is open more than the *cooling flag enable percentage*. The cooling flag is removed when the cooling valve closes below the *cooling flag disable percentage*.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor:

• Space Temperature

#### The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
<u>Space Temperature Setpoint</u>	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Heating</u> <u>Setpoint</u>	View	Yes	±2.0°C

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Night Setback Zone Limit	1	Any Value	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator



•

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Supply Air Temperature Setpoint	12°C	Between 8°C and 13°C	Operator
Heating Enable OAT	18°C	Between 15°C and 20°C	Operator
Space Temperature Setpoint	22°C	Between 20°C and 24°C	Operator
Space Temperature Deadband	1°C	Between 0.5°C and 2°C	Operator
Heating Enable Low Limit OAT	10°C	Between 10°C and 15°C	Operator
Heating Flag Enable Percentage	95%	Between 90% and 100%	Operator
Heating Flag Disable Percentage	80%	Between 75% and 85%	Operator
<u>Humidifier Enable OAT</u>	10°C	Between 5°C and 13°C	Operator
<u>Return Air Humidity Setpoint</u>	See Reset Schedule	See Reset Schedule	Operator
Supply Air Humidity High Limit	90%	Between 80% and 90%	Operator
<u>Cooling Enable OAT</u>	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator

The *<u>Return Air Humidity Setpoint</u>* will be reset according to the following schedule:

WHEN THE OAT IS:	THE SETPOINT IS:		ADJUSTABLE RANGE	PERMISSION
10.0°C	40% RH	OAT: Setpoint:	Between 5.0°C and 15.0°C Between 35% and 45% RH	Operator
-20.0°C	30% RH	OAT: Setpoint:	Between -15.0°C and -20.0°C Between 25% and 35% RH	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
<u>Return Air Humidity</u>	0.0%RH	100.0%RH	5 min

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
Heating Coil Return Water Temperature	0.0°C	100.0°C	5 min
Cooling Coil Return Water Temperature	0.0°C	100.0°C	5 min
Supply Air Temperature	-20.0°C	100.0°C	5 min
<u>Supply Air Humidity</u>	0.0%RH	100.0%RH	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	
Supply Fan Failed to Start	Fan is commanded on; ar Fan is off for 120 seconds
<u>Supply Fan VFD Fault</u>	VFD fault alarm is active f
Supply Fan On in Hand	Fan is commanded off; ar Fan is on for 10 minutes.
Supply Air Temperature High	Supply fan is on; and Supply Air Temperature is
<u>Supply Air Temperature High Limit</u> <u>Shutdown</u>	Supply Air Temperature is
Supply Air Humidity High Limit	Supply fan is on; and Supply Air Humidity is abo
Duct Static Pressure Above Setpoint	Supply fan is on; and Static pressure is 100 Pa a
Duct Static Pressure Below Setpoint	Supply fan is on; and Static pressure is 100 Pa l



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS

# CONDITION nd s. for 15 seconds. nd ... is above 40°C for 5 minutes. is above 55°C for 5 minutes. oove 90%RH for 5 minutes. above setpoint for 5 minutes. below setpoint for 5 minutes.

## 219 – AS-8

#### GENERAL

This sequence applies to **AS-8** which provides heating, and cooling to the supplied zones.

The system is composed of the following components:

- Heating Coil
- Cooling Coil
- Variable Volume Supply Fan •

#### **RUN CONDITIONS**

The system will operate based on a *<u>Time of Day Schedule</u>*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode: This mode will override the Disabled Mode if the number of supplied zones in an • unoccupied override condition exceeds the *minimum night setback zone limit*

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Safeties

• A freezestat set at 4.0°C is hardwired to shut down the supply fan, position the mixed air dampers for recirculation, and fail open the heating valve. The freezestat alarm must be manually reset from the system graphics as well as the unit for the air handling unit to return to normal operation.

#### Supply Fan

Fan Staging

- The supply fan will be enabled in the Day Mode and Night Setback Modes.
- When the fan is enabled, the supply fan will be commanded to minimum speed. •
- In the Disabled Mode the supply fan will be commanded off. •

#### Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on. •
- The supply fan will be modulated to maintain supply air static pressure setpoint.

#### Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain supply air temperature at *minimum* supply air temperature setpoint.
- In the Night Setback Mode and Day mode, the heating valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is less than *heating enable OAT*; and



- outdoor air temperature is less than *heating enable low limit OAT*.
- When enabled the heating valve will be modulated to maintain <u>supply air temperature setpoint</u>.
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The heating flag is removed when the heating valve closes below the *heating flag disable percentage*.

#### Cooling Valve

- In the Disabled Mode the cooling valve will be commanded closed.
- In the Night Setback Mode and Day mode, the cooling valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is greater than *cooling enable OAT*; and
- When enabled the cooling valve will be modulated to maintain <u>supply air temperature setpoint</u>.
- A cooling flag is issued when the cooling valve is open more than the <u>cooling flag enable percentage</u>. The cooling flag is removed when the cooling valve closes below the *cooling flag disable percentage*.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
<u>Minimum Night Setback Zone Limit</u>	1	Any Value	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator
Supply Air Temperature Setpoint	15°C	Between 13°C and 25°C	Operator
Minimum Supply Air Temperature Setpoint	12°C	Between 8°C and 13°C	Operator
Heating Enable OAT	18°C	Between 15°C and 20°C	Operator
Supply Air Temperature Deadband	1°C	Between 0.5°C and 2°C	Operator
Heating Enable Low Limit OAT	10°C	Between 10°C and 15°C	Operator
Heating Flag Enable Percentage	95%	Between 90% and 100%	Operator
Heating Flag Disable Percentage	80%	Between 75% and 85%	Operator
Cooling Enable OAT	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

• supply air temperature is above supply air temperature setpoint plus supply air temperature deadband.

The *Supply Air Temperature Setpoint* will be reset according to the following:

- If a cooling request is received from an associated system the base setpoint will be decreased by 1°C every 10 minutes. (Minimum Setpoint = 11°C, Maximum Setpoint = 18°C)
- If no cooling requests are received and a heating request is received from an associated system the base setpoint will be increased by 0.5°C every 10 minutes. (Minimum Setpoint = 16°C, Maximum Setpoint = 21°C)
- Heating and cooling requests will be monitored from:
  - Associated Zones

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
Heating Coil Return Water Temperature	0.0°C	100.0°C	5 min
Cooling Coil Return Water Temperature	0.0°C	100.0°C	5 min
Supply Air Temperature	-20.0°C	100.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Supply Fan Failed to Start	Fan is commanded on; and Fan is off for 120 seconds.
<u>Supply Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>Supply Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>Supply Air Temperature Above</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is 5.0°C above setpoint for 5 minutes;
<u>Supply Air Temperature Below</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is 5.0°C below setpoint for 5 minutes;
Supply Air Temperature High	Supply fan is on; and Supply Air Temperature is above 40°C for 5 minutes.
<u>Supply Air Temperature High Limit</u> <u>Shutdown</u>	Supply Air Temperature is above 55°C for 5 minutes.
Duct Static Pressure Above Setpoint	Supply fan is on; and Static pressure is 100 Pa above setpoint for 5 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS

DESCRIPTION	
Duct Static Pressure Below Setpoint	Supply fan is on; and Static pressure is 100 Pa b

#### CONDITION

below setpoint for 5 minutes.

# 220 – AS-9 (WING B – VIP PARKING GARAGE)

#### GENERAL

This sequence applies to **AS-9** which provides heating, cooling and ventilation to the supplied area.

The system is composed of the following components:

- Variable Volume Exhaust Fan
- Mixed Air Dampers (Exhaust, Return, Outdoor)
- Heating Coil •
- Heat Exchanger HE-9 & Heating Pump P-217
- Variable Volume Supply Fan

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode: This mode will override the Disabled Mode if the number of supplied zones in an • unoccupied override condition exceeds the *minimum night setback zone limit*

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Supply Fan and Exhaust Fan

Fan Staging

- The supply fan and exhaust fan will be enabled in the Day Mode and Night Setback Modes.
- When the fans are enabled, the exhaust fan will be commanded to minimum speed. When return fan status is received, the supply fan will be commanded to minimum speed.
- In the Disabled Mode the supply and exhaust fans will be commanded off.

#### Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on. •
- The supply fan will be modulated to maintain <u>supply air static pressure setpoint</u>. •
- The return fan will be modulated to maintain supply fan speed minus a *return fan offset*. •

#### Mixed Air Damper Control

- Mixed air dampers include the combination of the Exhaust Air Damper, Return Air Damper, and Outdoor Air Damper. All dampers are controlled together through a common output. Exhaust and Outdoor dampers are controlled to the inverse of the Return Air Damper.
- In the Disabled Mode, the Mixed Air dampers will be positioned for recirculation with the Exhaust Air and Outdoor Air Dampers commanded closed, and the Return Air damper commanded open.

- In the Day Mode and Night Setback Mode, the Mixed Air dampers will initially be positioned for recirculation. setpoint.
- In the Day Mode, the Mixed Air Dampers will be controlled for free cooling.

#### Free Cooling Control

- Free Cooling will be enabled when:
  - supply fan status is confirmed on;

  - outdoor air temperature is less than *free cooling enable OAT*.
- Free Cooling is disabled when the above conditions are not met.
- When free cooling is enabled, mixed air dampers will be modulated to maintain space temperature setpoint, while keeping mixed air temperature above *minimum mixed air temperature setpoint* plus *mixed air temperature offset;*
- Mixed Air Damper control will be limited to ensure the following:
  - that mixed air temperature is above minimum mixed air temperature setpoint plus mixed air *temperature offset;*
  - space temperature is within the deadband range of space temperature setpoint.

#### Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain mixed air temperature at *minimum* mixed air temperature setpoint.
- In the Night Setback Mode and Day mode, the heating valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is less than *heating enable OAT*; and

  - outdoor air temperature is less than *heating enable low limit OAT*.
- When enabled the heating valve will be modulated to maintain <u>space temperature setpoint</u>.
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The heating flag is removed when the heating valve closes below the *heating flag disable percentage*.

#### Heating Pump: P-217

#### Pump Staging

- When the heating is disabled, the pump will be commanded off.
- When the heating is enabled, the pump will be commanded on.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor:

• Space Temperature

#### The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C



Once the supply fan is confirmed on, the mixed air dampers will modulate to maintain *minimum outdoor air* 

• outdoor air temperature is below return air temperature by more than the *free cooling offset*; and

• space temperature is below space temperature setpoint minus space temperature deadband; or

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Heating</u> <u>Setpoint</u>	View	Yes	±2.0°C

### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION	
<u>Minimum Night Setback Zone Limit</u>	1	Any Value	Operator	
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator	
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator	
<u>Return Fan Offset</u>	5%	Between 0% and 15%	Operator	
Free Cooling Offset	3.0°C	Between 1°C and 10°C	Operator	
Free Cooling Enable OAT	15°C	Between 13°C and 18°C	Operator	
Space Temperature Setpoint	22°C	Between 20°C and 24°C	Operator	
Minimum Mixed Air Temperature Setpoint	10°C	Between 5°C and 13°C	Operator	
Mixed Air Temperature Offset	2.5°C	Between 1°C and 10°C	Operator	
Return Air CO2 Setpoint	1000 ppm	Between 800 and 1500 ppm	Operator	
Minimum Outdoor Air Setpoint	650 CFM	Between 500 and 800 CFM	Admin	
CO2 Setpoint Achieved Delay	5 minutes	Between 1 and 30 minutes	Operator	
Heating Enable OAT	18°C	Between 15°C and 20°C	Operator	
Space Temperature Deadband	1°C	Between 0.5°C and 2°C	Operator	
Heating Enable Low Limit OAT	10°C	Between 10°C and 15°C	Operator	
Heating Flag Enable Percentage	95%	Between 90% and 100%	Operator	
Heating Flag Disable Percentage	80%	Between 75% and 85%	Operator	
Schedules Pump Rotation	10:00 am every Tuesday	Any Value	Admin	
Pump Failure Delay	60 seconds	Between 0 and 120 seconds	Admin	

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Pump Return From Failure Delay	60 seconds	Between 0 and 120 seconds	Admin
Humidifier Enable OAT	10°C	Between 5°C and 13°C	Operator
<u>Return Air Humidity Setpoint</u>	See Reset Schedule	See Reset Schedule	Operator
Supply Air Humidity High Limit	90%	Between 80% and 90%	Operator
<u>Cooling Enable OAT</u>	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator

## **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

## ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
Heating Coil Return Water Temperature	0.0°C	100.0°C	5 min
Supply Air Temperature	-20.0°C	100.0°C	5 min



#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>Exhaust Fan Failed to Start</u>	Fan is commanded on; and Fan is off for 120 seconds.
<u>Exhaust Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>Exhaust Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
Mixed Air Temperature Low	Mixed Air Temperature is below 4°C for 5 minutes.
<u>Mixed Air Temperature Below</u> <u>Setpoint</u>	Mixed air temperature is 2.0°C below setpoint for 5 minutes;
<u>Heating Coil Leaving Water</u> <u>Temperature Low</u>	Heating Coil Leaving Water Temperature is below 5°C for 5 minutes.
Supply Fan Failed to Start	Fan is commanded on; and Fan is off for 120 seconds.
<u>Supply Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.
Supply Fan On in Hand	Fan is commanded off; and Fan is on for 10 minutes.
<u>Supply Air Temperature Above</u> Setpoint	Supply fan is on; and Supply air temperature is 5.0°C above setpoint for 5 minutes;
<u>Supply Air Temperature Below</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is 5.0°C below setpoint for 5 minutes;
Supply Air Temperature High	Supply fan is on; and Supply Air Temperature is above 40°C for 5 minutes.
<u>Supply Air Temperature High Limit</u> <u>Shutdown</u>	Supply Air Temperature is above 55°C for 5 minutes.
Duct Static Pressure Above Setpoint	Supply fan is on; and Static pressure is 100 Pa above setpoint for 5 minutes.
Duct Static Pressure Below Setpoint	Supply fan is on; and Static pressure is 100 Pa below setpoint for 5 minutes.
P-217 Failed to Start	Pump is commanded on; and Pump is off for 120 seconds.
P-217 On in Hand	Pump is commanded off; and Pump is on for 10 minutes.
<u>CO High Level Alarm</u>	CO Level is above ##PPM for 5 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S03

# **220 - DCW BOOSTER PUMPS**

#### GENERAL

This sequence applies to the **DOMESTIC COLD WATER BOOSTER PUMPS** which supplies domestic cold water to the building.

The system is composed of the following components:

- Domestic Cold Water Booster Pump P-112A
- Domestic Cold Water Booster Pump P-112B

#### **RUN CONDITIONS**

The system will be enabled continuously. The system can be manually disabled from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Domestic Cold Water Booster Pumps: P-112A & P-112B

- The domestic cold water booster pumps will operate in a duty-standby configuration.
- The duty pump will be assigned to P-112B and the standby pump will be assigned to P-112A.

#### Pump Failure

- If the duty pump fails for longer than the *pump failure delay*, the standby pump will be enabled. The command to the failed pump will remain enabled during a pump failure.
- Once the failed pump status is confirmed on for longer than the *pump return from failure delay*, the pump will be returned to the rotation.

Pump Staging

- When the system is disabled, both the duty and the standby pump will be commanded off.
- When the system is enabled, the duty pump will be commanded on.
- The duty pump will not be modulated below the *minimum pump speed* which is set in the VFD.
- When the duty pump is enabled, the speed will be modulated to maintain *static pressure setpoint*.
- If the duty pump is running alone and the static pressure drops below the *pump stage up threshold*, the standby pump will be commanded on and the duty pump will modulate to maintain *static pressure setpoint*.
- If both pumps are running together and the speed of the duty pump falls below the *pump stage down threshold*, the standby pump will be commanded off.
- Once enabled, a pump will operate for a minimum runtime of 10 minutes in order to limit short cycling.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Pump Failure Delay	60 seconds	Between 0 and 120 seconds	Admin



#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

HISTORY EXTENSIONS (TRENDS)	INTERVAL	SAMPLES	DURATION
P-112A Status	Every 15 minutes	2,880 samples	Approx. 30 days
<u>P-112B Feedback</u>	Every 15 minutes	2,880 samples	Approx. 30 days
<u>Static Pressure</u>	Every 15 minutes	2,880 samples	Approx. 30 days

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>P-112A Failed to Start</u>	Command ON & Status OFF; Alarm is latched; Alarm will auto reset
P-112A On in Hand	Command OFF & Status ON
<u>P-112B Failed to Start</u>	Command ON & Status OFF; Alarm is latched; Alarm will auto reset
P-112B On in Hand	Command OFF & Status ON



ADJUSTABLE RANGE	PERMISSION
Between 0 and 120 seconds	Admin
Between 30% and 40%	Admin
Any value	Admin

# 221 – AS-10 (PRINTING SHOP)

#### GENERAL

This sequence applies to **AS-10** which provides heating, cooling and humidification to supplied area.

The system is composed of the following components:

- Heating Coil
- Humidifier
- Cooling Coil •
- Variable Volume Supply Fan

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode: This mode will override the Disabled Mode if the number of supplied zones in an • unoccupied override condition exceeds the *minimum night setback zone limit*

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

#### Safeties

A freezestat set at 4.0°C is hardwired to shut down the supply fan, position the mixed air dampers for • recirculation, and fail open the heating valve. The freezestat alarm must be manually reset from the system graphics as well as the unit for the air handling unit to return to normal operation.

#### Supply Fan

Fan Staging

- The supply fan will be enabled in the Day Mode and Night Setback Modes.
- When the fan is enabled, the supply fan will be commanded to minimum speed. •
- In the Disabled Mode the supply fan will be commanded off.

#### Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on.
- The supply fan will be modulated to maintain supply air static pressure setpoint.

#### Heating Valve

- In the Disabled Mode the heating valve will be modulated to maintain supply air temperature at *minimum* supply air temperature setpoint.
- In the Night Setback Mode and Day mode, the heating valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is less than *heating enable OAT*; and



- supply air temperature is below supply air temperature setpoint minus supply air temperature deadband; or
- outdoor air temperature is less than *heating enable low limit OAT*.
- When enabled the heating valve will be modulated to maintain <u>supply air temperature setpoint</u>.
- A heating flag is issued when the heating valve is open more than the *heating flag enable percentage*. The heating flag is removed when the heating valve closes below the *heating flag disable percentage*.

#### Humidifier

- The humidifier shall be commanded off at all times during the summer season.
- Humidification is enabled when:
  - supply fan status is confirmed on;
- outdoor air temperature is below humidifier enable OAT
- When humidifier is enabled, it will be modulated to maintain *return air humidity setpoint*.
- BAS will limit humidifier output to maintain supply air humidity below supply air humidity high limit.
- When the humidifier is disabled, it will be commanded off. •

#### Cooling Valve

- In the Disabled Mode the cooling valve will be commanded closed.
- In the Night Setback Mode and Day mode, the cooling valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is greater than *cooling enable OAT*; and
- A cooling flag is issued when the cooling valve is open more than the *cooling flag enable percentage*. The cooling flag is removed when the cooling valve closes below the *cooling flag disable percentage*.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Night Setback Zone Limit	1	Any Value	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator
Supply Air Temperature Setpoint	15°C	Between 13°C and 25°C	Operator
Minimum Supply Air Temperature Setpoint	12°C	Between 8°C and 13°C	Operator
<u>Heating Enable OAT</u>	18°C	Between 15°C and 20°C	Operator
Supply Air Temperature Deadband	1°C	Between 0.5°C and 2°C	Operator
Heating Enable Low Limit OAT	10°C	Between 10°C and 15°C	Operator
Heating Flag Enable Percentage	95%	Between 90% and 100%	Operator
Heating Flag Disable Percentage	80%	Between 75% and 85%	Operator

T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

 supply air temperature is above <u>supply air temperature setpoint</u> plus <u>supply air temperature deadband</u>. • When enabled the cooling valve will be modulated to maintain supply air temperature setpoint.
DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
<u>Humidifier Enable OAT</u>	10°C	Between 5°C and 13°C	Operator
<u>Return Air Humidity Setpoint</u>	See Reset Schedule	See Reset Schedule	Operator
Supply Air Humidity High Limit	90%	Between 80% and 90%	Operator
<u>Cooling Enable OAT</u>	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator

The *Supply Air Temperature Setpoint* will be reset according to the following:

- If a cooling request is received from an associated system the base setpoint will be decreased by 1°C every 10 minutes. (Minimum Setpoint = 11°C, Maximum Setpoint = 18°C)
- If no cooling requests are received and a heating request is received from an associated system the base setpoint will be increased by 0.5°C every 10 minutes. (Minimum Setpoint = 16°C, Maximum Setpoint = 21°C)
- Heating and cooling requests will be monitored from:
  - Associated Zones

The *<u>Return Air Humidity Setpoint</u>* will be reset according to the following schedule:

WHEN THE OAT IS:	THE SETPOINT IS:		ADJUSTABLE RANGE	PERMISSION
10.0°C	40% RH	OAT: Setpoint:	Between 5.0°C and 15.0°C Between 35% and 45% RH	Operator
-20.0°C	30% RH	OAT: Setpoint:	Between -15.0°C and -20.0°C Between 25% and 35% RH	Operator

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
<u>Return Air Humidity</u>	0.0%RH	100.0%RH	5 min
Heating Coil Return Water Temperature	0.0°C	100.0°C	5 min
Cooling Coil Return Water Temperature	0.0°C	100.0°C	5 min
Supply Air Temperature	-20.0°C	100.0°C	5 min

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Supply Air Humidity</u>	0.0%RH	100.0%RH	5 min

### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>Supply Fan Failed to Start</u>	Fan is commanded on; and Fan is off for 120 seconds.
<u>Supply Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>Supply Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>Supply Air Temperature Above</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is 5.0°C above setpoint for 5 minutes;
<u>Supply Air Temperature Below</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is 5.0°C below setpoint for 5 minutes;
Supply Air Temperature High	Supply fan is on; and Supply Air Temperature is above 40°C for 5 minutes.
<u>Supply Air Temperature High Limit</u> <u>Shutdown</u>	Supply Air Temperature is above 55°C for 5 minutes.
Supply Air Humidity High Limit	Supply fan is on; and Supply Air Humidity is above 90%RH for 5 minutes.
Duct Static Pressure Above Setpoint	Supply fan is on; and Static pressure is 100 Pa above setpoint for 5 minutes.
Duct Static Pressure Below Setpoint	Supply fan is on; and Static pressure is 100 Pa below setpoint for 5 minutes.



# 222 – AS-13 (WING C – TORONTO PUBLIC HEALTH BUILDING)

### GENERAL

This sequence applies to **AS-13** which provides cooling and ventilation to supplied zones.

The system is composed of the following components:

- Variable Volume Return Fan
- Mixed Air Dampers (Exhaust, Return, Outdoor)
- Humidifier •
- Cooling Coil
- Variable Volume Supply Fan

# **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Day Mode

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Disabled Mode
- Night Setback Mode: This mode will override the Disabled Mode if the number of supplied zones in an unoccupied override condition exceeds the *minimum night setback zone limit*

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

#### Safeties

• A freezestat set at 4.0°C is hardwired to shut down the supply fan, position the mixed air dampers for recirculation, and fail open the heating valve. The freezestat alarm must be manually reset from the system graphics as well as the unit for the air handling unit to return to normal operation.

# Supply Fan and Return Fan

Fan Staging

- The supply fan and return fan will be enabled in the Day Mode and Night Setback Modes.
- When the fans are enabled, the return fan will be commanded to minimum speed. When return fan status is received, the supply fan will be commanded to minimum speed.
- In the Disabled Mode the supply and return fans will be commanded off.

#### Static Pressure Control

- Static pressure control will be enabled when supply fan status is confirmed on. •
- The supply fan will be modulated to maintain *supply air static pressure setpoint*. •
- The return fan will be modulated to maintain supply fan speed minus a return fan offset.

#### Mixed Air Damper Control

- Mixed air dampers include the combination of the Exhaust Air Damper, Return Air Damper, and Outdoor Air controlled to the inverse of the Return Air Damper.
- In the Disabled Mode the Mixed Air dampers will be positioned for recirculation with the Exhaust Air and Outdoor Air Dampers commanded closed, and the Return Air damper commanded open.
- In the Day Mode and Night Setback Mode the Mixed Air damper will initially be positioned for recirculation.
- In the Day Mode, the Mixed Air Dampers will be controlled for either free cooling or CO2 control.

# Free Cooling Control

- Free Cooling will be enabled when:
  - supply fan status is confirmed on;

  - outdoor air temperature is less than *free cooling enable OAT*.
- Free Cooling is disabled when the above conditions are not met.
- When free cooling is enabled, mixed air dampers will be modulated to maintain *supply air temperature* temperature offset;

#### Return Air CO2 Control

- Return air CO2 control will be enabled in the Day Mode and Night Setback Mode when:
  - supply fan status is confirmed on; and
  - return air co2 is above *return air co2 setpoint*.
- When return air CO2 control is enabled, the mixed air dampers will increase the minimum outdoor air setpoint to maintain return air co2 setpoint.
- Return air CO2 control will be disabled when:
- Mixed Air Damper control will be limited to ensure the following:
  - that mixed air temperature is above *minimum mixed air temperature setpoint* plus *mixed air temperature offset;*
  - Supply air temperature is within the deadband range of supply air temperature setpoint.

#### Humidifier

- The humidifier shall be commanded off at all times during the summer season.
- Humidification is enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is below *humidifier enable OAT*
- When humidifier is enabled, it will be modulated to maintain <u>return air humidity setpoint</u>.
- BAS will limit humidifier output to maintain supply air humidity below supply air humidity high limit.
- When the humidifier is disabled, it will be commanded off. •

#### Cooling Valve

- In the Disabled Mode the cooling valve will be commanded closed.
- In the Night Setback Mode and Day mode, the cooling valve will be enabled when:
  - supply fan status is confirmed on;
  - outdoor air temperature is greater than *cooling enable OAT*; and
- When enabled the cooling valve will be modulated to maintain supply air temperature setpoint.



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

Damper. All dampers are controlled together through a common output. Exhaust and Outdoor dampers are

• outdoor air temperature is below return air temperature by more than the *free cooling offset*; and setpoint, while keeping mixed air temperature above minimum mixed air temperature setpoint plus mixed air

• return air co2 drops below return air co2 setpoint for more than the CO2 setpoint achieved delay.

supply air temperature is above supply air temperature setpoint plus supply air temperature deadband.

• A cooling flag is issued when the cooling valve is open more than the *cooling flag enable percentage*. The cooling flag is removed when the cooling valve closes below the *cooling flag disable percentage*.

## SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Minimum Night Setback Zone Limit	3	Any Value	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Supply Air Static Pressure Setpoint	375 Pa	Between 175 and 450 Pa	Operator
<u>Return Fan Offset</u>	5%	Between 0% and 15%	Operator
Free Cooling Offset	3.0°C	Between 1°C and 10°C	Operator
Free Cooling Enable OAT	15°C	Between 13°C and 18°C	Operator
Supply Air Temperature Setpoint	15°C	Between 13°C and 25°C	Operator
Minimum Mixed Air Temperature Setpoint	10°C	Between 5°C and 13°C	Operator
Mixed Air Temperature Offset	2.5°C	Between 1°C and 10°C	Operator
<u>Return Air CO2 Setpoint</u>	1000 ppm	Between 800 and 1500 ppm	Operator
Minimum Outdoor Air Setpoint	300 CFM	Between 200 and 400 CFM	Admin
CO2 Setpoint Achieved Delay	5 minutes	Between 1 and 30 minutes	Operator
Humidifier Enable OAT	10°C	Between 5°C and 13°C	Operator
<u>Return Air Humidity Setpoint</u>	See Reset Schedule	See Reset Schedule	Operator
Supply Air Humidity High Limit	90%	Between 80% and 90%	Operator
Cooling Enable OAT	18°C	Between 16°C and 24°C	Operator
Cooling Flag Enable Percentage	95%	Between 90% and 100%	Operator
Cooling Flag Disable Percentage	80%	Between 75% and 85%	Operator

The *Supply Air Temperature Setpoint* will be reset according to the following:

- If a cooling request is received from an associated system the base setpoint will be decreased by 1°C every 10 minutes. (Minimum Setpoint = 11°C, Maximum Setpoint = 18°C)
- If no cooling requests are received and a heating request is received from an associated system the base setpoint will be increased by 0.5°C every 10 minutes. (Minimum Setpoint = 16°C, Maximum Setpoint = 21°C)
- Heating and cooling requests will be monitored from: • Associated Zones

The *<u>Return Air Humidity Setpoint</u>* will be reset according to the following schedule:

WHEN THE OAT IS:	THE SETPOINT IS:		ADJUSTABLE RANGE	PERMISSION
10.0°C	40% RH	OAT: Setpoint:	Between 5.0°C and 15.0°C Between 35% and 45% RH	Operator
-20.0°C	30% RH	OAT: Setpoint:	Between -15.0°C and -20.0°C Between 25% and 35% RH	Operator

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air CO2</u>	0 PPM	2000 PPM	5 min
<u>Return Air Temperature</u>	-20.0°C	105.0°C	5 min
<u>Return Air Humidity</u>	0.0%RH	100.0%RH	5 min
Cooling Coil Return Water Temperature	0.0°C	100.0°C	5 min
<u>Supply Air Temperature</u>	-20.0°C	100.0°C	5 min
Supply Air Humidity	0.0%RH	100.0%RH	5 min



# **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>Return Air CO2 Above Setpoint</u>	Return fan is on; and Return air CO2 is 100ppm above setpoint for 30 minutes;
<u>Return Fan Failed to Start</u>	Fan is commanded on; and Fan is off for 120 seconds.
<u>Return Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>Return Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
Mixed Air Temperature Low	Mixed Air Temperature is below 4°C for 5 minutes.
<u>Mixed Air Temperature Below</u> <u>Setpoint</u>	Mixed air temperature is 2.0°C below setpoint for 5 minutes;
<u>Low Temperature Alarm</u> ( <u>Freezestat)</u>	Low temperature alarm is active.
Supply Fan Failed to Start	Fan is commanded on; and Fan is off for 120 seconds.
<u>Supply Fan VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>Supply Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>Supply Air Temperature Above</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is 5.0°C above setpoint for 5 minutes;
<u>Supply Air Temperature Below</u> <u>Setpoint</u>	Supply fan is on; and Supply air temperature is 5.0°C below setpoint for 5 minutes;
<u>Supply Air Temperature High</u>	Supply fan is on; and Supply Air Temperature is above 40°C for 5 minutes.
<u>Supply Air Temperature High Limit</u> <u>Shutdown</u>	Supply Air Temperature is above 55°C for 5 minutes.
Supply Air Humidity High Limit	Supply fan is on; and Supply Air Humidity is above 90%RH for 5 minutes.
Duct Static Pressure Above Setpoint	Supply fan is on; and Static pressure is 100 Pa above setpoint for 5 minutes.
Duct Static Pressure Below Setpoint	Supply fan is on; and Static pressure is 100 Pa below setpoint for 5 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S03 222 – AS-13 (WING C – TORONTO PUBLIC HEALTH BUILDING) AS-BUILT (REV 1) – December 22, 2016

# **223 – WING A PENTHOUSE VENTILATION**

#### GENERAL

This sequence applies to the **WING A PENTHOUSE VENTILATION** which provides a source of heating and ventilation to the supplied space.

The system is composed of the following components:

- Constant Volume EF-14 w/Outdoor & Exhaust Air Dampers
- Unit Heater UH-E

#### **RUN CONDITIONS**

The system will be enabled continuously.

The system can be manually disabled from the graphic for a pre-set *manual override time period*. The system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above the space temperature cooling setpoint.
- Heating Mode will be enabled if space temperature is below the space temperature heating setpoint.

#### **CONTROL STRATEGY**

#### Exhaust Fan

- The exhaust fan will be enabled when the system is in cooling mode.
- When the exhaust fan is enabled it's outdoor and exhaust air dampers will be opened. When damper open • statuses are confirmed through the damper end-switches the fan will be started through a hardwire interlock.
- When the space temperature is below setpoint for more than the <u>setpoint achieved delay</u>, the fan will be • disabled. When the fan is disabled the outdoor & exhaust dampers will be closed.

#### Unit Heater

- When the system enters heating mode the unit heater will be commanded on.
- When the space temperature is above setpoint for more than the setpoint achieved delay, the unit heater will • be commanded off.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor:

• Space Temperature

#### The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Heating</u> <u>Setpoint</u>	View	Yes	±2.0°C

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Space Temperature Cooling Setpoint	24.0°C	Between 24.0°C and 32.0°C	Operator
Space Temperature Heating Setpoint	20.0°C	Between 14.0°C and 22.0°C	Operator
Setpoint Achieved Delay	5 minutes	Between 0 and 10 minutes	Operator

### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	
Space Temperature Above Setpoint	Space temperature is 2.0°
Space Temperature Below Setpoint	Space temperature is 2.0°
<u>EF-14 Failed to Start</u>	Fan is commanded on; an Fan is off for 15 seconds.
EF-14 On in Hand	Fan is commanded off; ar Fan is on for 10 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

# CONDITION

°C above setpoint for 5 minutes;

°C below setpoint for 5 minutes;

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# **223 – WING A PENTHOUSE MISCELLANEOUS EXHAUST**

#### GENERAL

This sequence applies to the **WING A PENTHOUSE MISCELLANEOUS EXHAUST** which provides a source of ventilation to various supplied spaces.

The system is composed of the following components:

• Exhaust Fans: EF-1, EF-2

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

- The system will be enabled when the time of day schedule is occupied
- The system will be disabled when time of day schedule is unoccupied

The system can be manually enabled or manually disabled from the graphic for a pre-set *manual override time period*.

### **CONTROL STRATEGY**

Exhaust Fans: EF-1, EF-2

- When the system is enabled the exhaust fan will be commanded on.
- When the exhaust fan is enabled its exhaust air damper will be opened. When damper open status is confirmed through the damper end-switch the fan will be started through a hardwire interlock.
- When the system is disabled the exhaust fan will be commanded off.
- When the fan is disabled the exhaust air damper will be closed.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

## **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>EF-1 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-1 On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>EF-2 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-2 On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.



# 223 - WING A PENTHOUSE MISCELLANEOUS MONITORING

#### GENERAL

This sequence applies to the **WING A PENTHOUSE MISCELLANEOUS MONITORING** which provides a source of monitoring of the Wing A Penthouse Miscellaneous systems.

The system is composed of the following components:

• Wing A Domestic Water Pump

#### RUN CONDITIONS

- The system will operate based on a *<u>Time of Day Schedule</u>*.
- The system will be enabled when the time of day schedule is occupied
- The system will be disabled when time of day schedule is unoccupied
- The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

## **CONTROL STRATEGY**

Wing A Domestic Water Pump

- When the system is disabled the domestic water pump will be commanded off.
- When the system is enabled the domestic water pump will be commanded on.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S03 223 – WING A PENTHOUSE MISCELLANEOUS MONITORING AS-BUILT (REV 1) – December 22, 2016

# **224 – WING B PENTHOUSE VENTILATION**

# GENERAL

This sequence applies to the **WING B PENTHOUSE VENTILATION** which provides a source of heating and ventilation to the supplied space.

The system is composed of the following components:

- Constant Volume EF-15 w/Outdoor & Exhaust Air Dampers
- Unit Heater UH-E

#### **RUN CONDITIONS**

The system will be enabled continuously.

The system can be manually disabled from the graphic for a pre-set *manual override time period*. The system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above the <u>space temperature cooling setpoint</u>.
- Heating Mode will be enabled if space temperature is below the <u>space temperature heating setpoint</u>.

### **CONTROL STRATEGY**

#### Exhaust Fan

- The exhaust fan will be enabled when the system is in cooling mode.
- When the exhaust fan is enabled it's outdoor and exhaust air dampers will be opened. When damper open • statuses are confirmed through the damper end-switches the fan will be started through a hardwire interlock.
- When the space temperature is below setpoint for more than the <u>setpoint achieved delay</u>, the fan will be disabled. When the fan is disabled the outdoor & exhaust dampers will be closed.

#### Unit Heater

- When the system enters heating mode the unit heater will be commanded on. •
- When the space temperature is above setpoint for more than the <u>setpoint achieved delay</u>, the unit heater will • be commanded off.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor:

• Space Temperature

The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C



#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Space Temperature Cooling Setpoint	24.0°C	Between 24.0°C and 32.0°C	Operator
Space Temperature Heating Setpoint	20.0°C	Between 14.0°C and 22.0°C	Operator
Setpoint Achieved Delay	5 minutes	Between 0 and 10 minutes	Operator

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min

# **OPERATIONAL ALARMS**

DESCRIPTION	
Space Temperature Above Setpoint	Space temperature is 2.0
Space Temperature Below Setpoint	Space temperature is 2.0
<u>EF-15 Failed to Start</u>	Fan is commanded on; ar Fan is off for 15 seconds.
EF-15 On in Hand	Fan is commanded off; ar Fan is on for 10 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

( )	PASSWORD PROTECTED	ADJUSTMENT RANGE
	Yes	±2.0°C
	Yes	±2.0°C

# CONDITION

°C above setpoint for 5 minutes;

°C below setpoint for 5 minutes;

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# 224 - WING B PENTHOUSE MISCELLANEOUS EXHAUST

#### GENERAL

This sequence applies to the **WING B PENTHOUSE MISCELLANEOUS EXHAUST** which provides a source of ventilation to various supplied spaces.

The system is composed of the following components:

• Exhaust Fans: EF-3, EF-4, EF-7, EF-9 & EF-10

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

- The system will be enabled when the time of day schedule is occupied
- The system will be disabled when time of day schedule is unoccupied

The system can be manually enabled or manually disabled from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

Exhaust Fans: EF-3, EF-4, EF-7 & EF-9

- When the system is enabled the exhaust fan will be commanded on.
- When the exhaust fan is enabled its exhaust air damper will be opened. When damper open status is confirmed through the damper end-switch the fan will be started through a hardwire interlock.
- When the system is disabled the exhaust fan will be commanded off.
- When the fan is disabled the exhaust air damper will be closed.

#### Exhaust Fan: EF-10

• When the system is enabled the exhaust fans speed feedback will be monitored.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
EF-3 Failed to Start	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-3 On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>EF-4 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-4 On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
EF-7 Failed to Start	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-7 On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
EF-9 Failed to Start	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-9 On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.



# 224 - WING B PENTHOUSE MISCELLANEOUS MONITORING

#### GENERAL

This sequence applies to the **WING B PENTHOUSE MISCELLANEOUS MONITORING** which provides a source of monitoring of the Wing B Penthouse Miscellaneous systems.

The system is composed of the following components:

• Wing B Domestic Water Pump

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

- The system will be enabled when the time of day schedule is occupied
- The system will be disabled when time of day schedule is unoccupied

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

### **CONTROL STRATEGY**

Wing B Domestic Water Pump

- When the system is disabled the domestic water pump will be commanded off.
- When the system is enabled the domestic water pump will be commanded on.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S03 224 – WING B PENTHOUSE MISCELLANEOUS MONITORING AS-BUILT (REV 1) – December 22, 2016

# **225 - CHILLER ROOM MISCELLANEOUS**

### GENERAL

This sequence applies to TYPICAL 2 FCU's (TYPE B) w/ICE PLANT COMPRESSOR MONITORING which provides a source of cooling and monitoring to the supplied space.

The system is composed of the following components:

- Fan Coil Units FC-B (x2)
- Ice Plant Compressors: C-1 & C-2

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Cooling Mode will be enabled if space temperature is above *occupied cooling space temperature setpoint* plus occupied space temperature deadband and the cooling season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

• Cooling Mode will be enabled if space temperature is above *unoccupied cooling space temperature setpoint* and the cooling season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

Fan Coil Unit Type B (FC-B)

Supply Fan

- In the occupied cooling mode the fan will be commanded on when the space temperature rises above occupied cooling space temperature setpoint.
- In the unoccupied cooling mode the fan will be commanded on when the space temperature rises above unoccupied cooling space temperature setpoint.

Cooling Valve

- In the occupied cooling mode the cooling valve will be modulated to maintain <u>occupied cooling space</u> temperature setpoint.
- In the unoccupied cooling mode the cooling valve will be modulated to maintain *unoccupied cooling* space temperature setpoint.

#### *Ice Plant Compressors: C-1 & C-2*

• When the system is enabled, the ice plant compressors status will be continuously monitored.

#### *EC-Smart-Vue Interface*

The following views are continuously displayed at the EC-Smart-Vue sensor:



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

#### • Space Temperature

The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C

### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Cooling Space Temperature Setpoint	24.0°C	Between 20.0°C and 24.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
<u>Unoccupied Cooling Space Temperature</u> <u>Setpoint</u>	26.0°C	Between 26.0°C and 30.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	
Space Temperature Above Setpoint	Space temperature is 5.0°
Space Temperature Below Setpoint	Space temperature is 5.0°

#### CONDITION

°C above setpoint for 10 minutes.

°C below setpoint for 10 minutes.

# **226 – DECORATIVE WATER FOUNTAIN**

#### GENERAL

This sequence applies to the **DECORATIVE WATER FOUNTAIN** which provides a source of pump control and flow monitoring of the water fountain system.

The system is composed of the following components:

- Variable Volume Fountain Pump: P-WF
- Domestic Cold Water Flow Meter

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

The system can be manually enabled or manually disabled from the graphic.

#### **CONTROL STRATEGY**

#### Fountain Pump: P-WF

- The pump will be commanded on when:
  - The system is enabled.
- In order to prevent cavitation, the VFD is programmed with an extended period of soft-start.
- The pump will be commanded off if the pump flow switch remains open after the VFD has been commanded on for a period greater than the <u>VFD start-up delay</u>.
- When the pump status is on, the pump will be modulated to *pump minimum speed*.
- When the Time of Day schedule is occupied, the pump will be modulated to maintain <u>occupied pump speed</u> <u>setpoint</u>.
- When the Time of Day schedule is unoccupied, the pump speed will be reduced to maintain <u>unoccupied pump</u> <u>speed setpoint</u>.

#### DCW Flow Meter

• The flow meter will totalize the consumption of domestic cold water to the water fountain.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Pump Minimum Speed	30% (18 Hz)	Between 30% and 40%	Admin
Occupied Pump Speed Setpoint	TBD	TBD BY OWNER	Admin
Unoccupied Pump Speed Setpoint	TBD	TBD BY OWNER	Admin



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
<u>VFD Start-Up Delay</u>	1 minute	Between 0 and 2 minutes	Admin

#### **HISTORY EXTENSIONS (TRENDS)**

HISTORY EXTENSIONS (TRENDS)	INTERVAL	SAMPLES	DURATION
<u>Water Fountain Domestic Cold Water</u> <u>Consumption</u>	Every 15 minutes	2,880 samples	Approx. 30 Days
<u>P-WF Feedback</u>	Every 15 minutes	2,880 samples	Approx. 30 days
<u>P-WF Alarm</u>	Change of Value	100 samples	_

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
Domestic Cold Water Flow	0 L/s	55 L/s	5 min

## **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>P-WF Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>P-WF VFD Fault</u>	VFD fault alarm is active for 15 seconds.
<u>P-WF On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.

# **227 – FIRE ALARM MONITORING**

#### GENERAL

This sequence applies to the **FIRE ALARM SYSTEM MONITORING** which provides a source of monitoring of the Fire Alarm system.

The system is composed of the following components:

• Fire Alarm Panel

#### **RUN CONDITIONS**

The system will be enabled continuously.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Fire Alarm Panel

- The BAS will monitor the following points from the fire alarm panel:
  - General Fire Alarm

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

HISTORY EXTENSIONS (TRENDS)	INTERVAL	SAMPLES	DURATION
<u>General Fire Alarm</u>	Change of Value	100 samples	-

#### **OPERATIONAL ALARMS**

ALARM EXTENSIONS (OPERATIONAL)	CONDITION	DELAY	CATEGORY
<u>General Fire Alarm</u>	General fire alarm is active.	N/A	Emergency



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S01 227 – FIRE ALARM MONITORING AS-BUILT (REV 1) – December 22, 2016

# **227 – ELECTRIC METER MONITORING**

#### GENERAL

This sequence applies to the **ELECTRICAL METER MONITORING** which provides a source of monitoring of the electrical meter #1 and electrical meter #2.

The system is composed of the following components:

- Electrical Meter #1
- Electrical Meter #2

#### **RUN CONDITIONS**

The system will be enabled to operate continuously.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

### **CONTROL STRATEGY**

#### Electrical Meter #1

- The BAS will totalize the consumption and demand from electrical meter #1.
- The BAS will monitor the instantaneous load of electrical meter #1. •

#### Electrical Meter #2

- The BAS will totalize the consumption and demand from electrical meter #2.
- The BAS will monitor the instantaneous load of electrical meter #2. •

# **HISTORY EXTENSIONS (TRENDS)**

HISTORY EXTENSIONS (TRENDS)	INTERVAL	SAMPLES	DURATION
Electrical Meter #1 Consumption	Every 15 minutes	8,640 samples	Approx. 90 Days
Electrical Meter #2 Consumption	Every 15 minutes	8,640 samples	Approx. 90 Days

#### **OPERATIONAL ALARMS**

ALARM EXTENSIONS (OPERATIONAL)	CONDITION	DELAY	CATEGORY
Loss of Power from Electrical Meter #1 Circuit	Input pulse not received from Electrical Meter #1 for greater than three minutes.	N/A	Critical
Loss of Power from Electrical Meter #2 Circuit	Input pulse not received from Electrical Meter #2 for greater than three minutes.	N/A	Critical



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

#### **ADDITIONAL GRAPHIC ELEMENTS**

The following will be available from the Electrical Meter Monitoring graphic for each electrical meter:

- Current day consumption totalization.
- Previous day consumption totalization.
- Current month consumption totalization.
- Previous month consumption totalization.
- Same month last year consumption totalization.
- Current day peak kW demand.
- Previous day peak kW demand.
- Current month peak kW demand.
- Previous month peak kW demand. ٠
- Same month last year peak kW demand. •
- Outdoor air temperature.

# 228 – ROTUNDA LIGHTING CONTROL

### GENERAL

This sequence applies to the **ROTUNDA LIGHTING CONTROL** which provides a source of control for the Rotunda lighting banks.

#### **RUN CONDITIONS**

The system will operate based on a *<u>Time of Day Schedule</u>*.

# **CONTROL STRATEGY**

- All Rotunda lighting banks will be commanded on when the time of day schedule is occupied.
- All Rotunda lighting banks will be commanded off when the time of day schedule is unoccupied.

#### **OPERATIONAL ALARMS**

ALARM EXTENSIONS (OPERATIONAL)	CONDITION	DELAY	CATEGORY
Rotunda Lighting Bank # Failed to Switch On	Rotunda Lighting Bank # is commanded on; and Rotunda Lighting Bank # status is off	15 seconds	Maintenance



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S01 228 – ROTUNDA LIGHTING CONTROL AS-BUILT (REV 1) – December 22, 2016

# 229 – TYPICAL FCU (TYPE A) & VARIATIONS

# GENERAL

This sequence applies to TYPICAL FCU (TYPE A/C) & VARIATIONS which provides a source of heating to the supplied space.

This sequence applies to the following systems:

- 229 Typical VAULT FCU
- 230 Typical 2 FC-A's
- 231 Typical FC-A w/BC
- 233 Typical 2 FC-A's w/BC & EBH
- 234 Typical 3 FC-A's w/EBH

# **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below occupied heating space temperature setpoint plus occupied space temperature deadband and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

Heating Mode will be enabled if space temperature is below <u>unoccupied heating space temperature setpoint</u> and the heating season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Fan Coil Unit Type A (FC-A)

Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below unoccupied heating space temperature setpoint.

Vault Fan Coil Unit

Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below unoccupied heating space temperature setpoint.

Heating Valve

- In the occupied heating mode the heating valve will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- below unoccupied heating space temperature setpoint.

## Booster Coil (BC)

Heating Valve

- In the occupied heating mode the heating valve will be modulated to maintain occupied heating space temperature setpoint.
- In the unoccupied heating mode the heating valve will be modulated to maintain <u>unoccupied heating space</u> • temperature setpoint.

### Electric Baseboard Heating (EBH)

- In the occupied heating mode the electric baseboard heating will be staged to maintain occupied heating space temperature setpoint.
- In the unoccupied heating mode the electric baseboard heating will be staged to maintain *unoccupied heating* space temperature setpoint.
- The electric baseboard heating will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.

# EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor:

- Space Temperature
- Space Humidity (only for EC-Smart-Vue-H)

# The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
<u>Space Temperature Setpoint</u>	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C



• In the unoccupied heating mode the heating valve will be commanded on when the space temperature drops

# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
<u>Occupied Heating Space Temperature</u> <u>Setpoint</u>	21.0°C	Between 19.0°C and 24.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min
<u>Space Humidity (only for EC-Smart-Vue-H)</u>	0 %RH	100 %RH	5 min
Booster Coil Supply Air Temperature	5.0°C	50.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Space Temperature Above Setpoint	Space temperature is 5.0°C above setpoint for 10 minutes.
Space Temperature Below Setpoint	Space temperature is 5.0°C below setpoint for 10 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S02 229 – TYPICAL FCU (TYPE A) & VARIATIONS AS-BUILT (REV 1) – December 22, 2016

# 232 -TYPICAL FCU (TYPE B) W/BC

### GENERAL

This sequence applies to **TYPICAL FCU-B** (**TYPE B**) w/BC which provides a source of heating and cooling to the supplied spaces.

This sequence applies to the following systems:

• 232 – Typical FC-B w/BC

The system is composed of the following components:

- Fan Coil Unit: FC-B
- Booster Coil: BC

# **RUN CONDITIONS**

The system will operate based on a *<u>Time of Day Schedule</u>*.

When the Time of Day Schedule is occupied the system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above <u>occupied cooling space temperature setpoint</u> plus occupied space temperature deadband and the cooling season is active.
- Heating Mode will be enabled if space temperature is below <u>occupied heating space temperature setpoint</u> plus occupied space temperature deadband and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above *unoccupied cooling space temperature setpoint* and the cooling season is active.
- Heating Mode will be enabled if space temperature is below *unoccupied heating space temperature setpoint* and the heating season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Fan Coil Unit Type B (FC-B)

Supply Fan

- In the occupied cooling mode the fan will be commanded on when the space temperature rises above occupied cooling space temperature setpoint.
- In the unoccupied cooling mode the fan will be commanded on when the space temperature rises above • unoccupied cooling space temperature setpoint.

#### Cooling Valve

- In the occupied cooling mode the cooling valve will be modulated to maintain <u>occupied cooling space</u> temperature setpoint.
- In the unoccupied cooling mode the cooling valve will be modulated to maintain <u>unoccupied cooling space</u> • temperature setpoint.

### Booster Coil (BC)

#### Heating Valve

- In the occupied heating mode the heating valve will be modulated to maintain occupied heating space temperature setpoint.
- In the unoccupied heating mode the heating valve will be modulated to maintain <u>unoccupied heating space</u> temperature setpoint.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor: • Space Temperature

# The following views are called the through the EC Growt Muse povidentian h

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C

## SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Cooling Space Temperature Setpoint	24.0°C	Between 20.0°C and 24.0°C	Operator
<u>Unoccupied Cooling Space Temperature</u> Setpoint	26.0°C	Between 26.0°C and 30.0°C	Operator
<u> Occupied Heating Space Temperature</u> Setpoint	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> Setpoint	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator



# HISTORY EXTENSIONS (TRENDS)

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min
Booster Coil Supply Air Temperature	5.0°C	50.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Space Temperature Above Setpoint	Space temperature is 5.0°C above setpoint for 10 minutes.
Space Temperature Below Setpoint	Space temperature is 5.0°C below setpoint for 10 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S02 232 –TYPICAL FCU (TYPE B) W/BC AS-BUILT (REV 1) – December 22, 2016

# **235 - TYPICAL BC & VARIATIONS**

## GENERAL

This sequence applies to **TYPICAL BC & VARIATIONS** which provides a source of heating, cooling and monitoring to the supplied spaces.

This sequence applies to the following systems:

- 235 Typical BC
- 236 Typical 2 BC's w/Common Space Temp.
- 237 Typical 2 BC's w/Separate Space Temp.
- 238 Typical 3 BC's
- 239 Typical BC w/EC & Common Space Temp.
- 240 Typical BC w/EC & Separate Space Temp.
- 241 Typical 2 BC's w/EC
- 243 Typical 3 BC's w/EC
- 244 Typical BC w/CUH-A/B/D (1)
- 245 Typical BC w/CUH-A/B/D (2)
- 246 Typical BC w/CUH-BB
- 247 Typical BC w/2 CUH-A/B/D's
- 248 Typical BC w/UH-E
- 249 Typical 2 BC's w/EUH
- 250 Typical BC w/EBH & Common Space Temp.
- 251 Typical BC w/2 EBH's
- 252 Typical 2 BC's w/EBH
- 253 Typical 3 BC's w/EBH
- 254 Typical 2 BC's w/AIRC
- 255 Typical BC w/Sump Pump Monitoring

# **RUN CONDITIONS**

The system will operate based on a *<u>Time of Day Schedule</u>*.

When the Time of Day Schedule is occupied the system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above <u>occupied cooling space temperature setpoint</u> plus <u>occupied space temperature deadband</u> and the cooling season is active.
- Heating Mode will be enabled if space temperature is below <u>occupied heating space temperature setpoint</u> plus <u>occupied space temperature deadband</u> and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above *unoccupied cooling space temperature setpoint* and the cooling season is active.
- Heating Mode will be enabled if space temperature is below <u>unoccupied heating space temperature setpoint</u> and the heating season is active.

When the Time of Day Schedule is unoccupied, if a motion sensor is located in the room and occupancy is detected, the schedule will be set to occupied.

When the Time of Day Schedule is unoccupied, if a motion sensor is located in the room and no occupancy is detected by the motion sensor for the *unoccupied override delay*, the schedule will be set to unoccupied.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

## **CONTROL STRATEGY**

#### Booster Coil (BC)

#### Heating Valve

- In the occupied heating mode the heating valve will be modulated to maintain <u>occupied heating space</u> <u>temperature setpoint</u>.
- In the unoccupied heating mode the heating valve will be modulated to maintain <u>unoccupied heating space</u> <u>temperature setpoint</u>.
- If the space uses two temperature sensors, then the space temperature is determined by calculating the average of the two temperature inputs.

### Electric Coil (EC)

- In the occupied heating mode the electric heating coil will be staged to maintain <u>occupied heating space</u> <u>temperature setpoint</u>.
- In the unoccupied heating mode the electric heating coil will be staged to maintain <u>unoccupied heating space</u> <u>temperature setpoint</u>.
- The electric heating coil will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.
- When serving the same zone as hydronic heating, the electric heating coil will be staged on when space temperature is below setpoint more than <u>secondary heating enable space temperature deadband</u>.

# Cabinet Unit Heater Type A/B/D (CUH-A/B/D) On/Off Valve

#### Supply Fan

- In the occupied heating mode the fan will be commanded on when the return air temperature drops below <u>occupied heating return air temperature setpoint</u>.
- In the unoccupied heating mode the fan will be commanded on when the return air temperature drops below unoccupied heating return air temperature setpoint.

#### Heating Valve

- In the occupied heating mode the heating valve will be commanded on when the return air temperature drops below <u>occupied heating return air temperature setpoint</u>.
- In the unoccupied heating mode the heating valve will be commanded on when the return air temperature drops below <u>unoccupied heating return air temperature setpoint</u>.

#### Electric Coil

- In the occupied heating mode the electric heating coil will be staged to maintain <u>occupied heating return air</u> <u>temperature setpoint</u>.
- In the unoccupied heating mode the electric heating coil will be staged to maintain <u>unoccupied heating return</u> <u>air temperature setpoint</u>.
- The electric heating coil will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS

### Cabinet Unit Heater Type A/B/D (CUH-A/B/D) Modulating Valve

Supply Fan

- In the occupied heating mode the fan will be commanded on when the return air temperature drops below occupied heating return air temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the return air temperature drops below • unoccupied heating return air temperature setpoint.

#### Heating Valve

- In the occupied heating mode the heating valve will be modulated to maintain the occupied heating return air temperature setpoint.
- In the unoccupied heating mode the heating valve will be modulated to maintain *unoccupied heating return air* • temperature setpoint.

### Electric Coil

- In the occupied heating mode the electric heating coil will be staged to maintain <u>occupied heating return air</u> temperature setpoint.
- In the unoccupied heating mode the electric heating coil will be staged to maintain <u>unoccupied heating return</u> air temperature setpoint.
- The electric heating coil will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.

# Cabinet Unit Heater Type BB (CUH-BB) On/Off Valve

Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below unoccupied heating space temperature setpoint.

# Heating Valve

- In the occupied heating mode the heating valve will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the heating valve will be commanded on when the space temperature drops below unoccupied heating space temperature setpoint.

# Electric Baseboard Heating (EBH)

- In the occupied heating mode the electric baseboard heating will be staged to maintain occupied heating space temperature setpoint.
- In the unoccupied heating mode the electric baseboard heating will be staged to maintain <u>unoccupied heating</u> space temperature setpoint.
- The electric baseboard heating will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.

Unit Heater Type E (UH-E)

Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below • unoccupied heating space temperature setpoint.

## Electric Unit Heater (EUH)

- In the occupied heating mode the electric unit heater will be staged to maintain <u>occupied heating space</u> temperature setpoint.
- In the unoccupied heating mode the electric unit hearer will be staged to maintain <u>unoccupied heating space</u> temperature setpoint.
- The electric unit heater will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.

# Air Curtain (AIRC)

# Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below unoccupied heating space temperature setpoint.

### Heating Valve

- In the occupied heating mode the heating valve will be modulated to maintain occupied heating space temperature setpoint.
- In the unoccupied heating mode the heating valve will be modulated to maintain <u>unoccupied heating space</u> temperature setpoint.

#### Sump Pump: P-111

• The BAS will monitor the Sump Pump Pit Control Panel status and alarm.

# Space Sensor

• The BAS will monitor and broadcast on the network the temperature of the space.

# Wet Differential Pressure Sensor

• The BAS will monitor and broadcast on the network the hot water differential pressure. Value will be networked back to the Boiler Plant controller.

#### Occupancy Sensor

• Occupancy status of the space will be monitored by an EC-Smart-Vue-M space sensor.

T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS



# EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor:

• Space Temperature

The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C

# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Cooling Space Temperature Setpoint	24.0°C	Between 20.0°C and 24.0°C	Operator
<u>Unoccupied Cooling Space Temperature</u> <u>Setpoint</u>	26.0°C	Between 26.0°C and 30.0°C	Operator
<u>Occupied Heating Space Temperature</u> <u>Setpoint</u>	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
<u>Unoccupied Override Delay</u>	Adjustable by Operator	Between 0 and 8 hours	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
Occupied Heating Return Air Temperature Setpoint	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Return Air Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
<u>Secondary Heating Enable Space Temperature</u> <u>Deadband</u>	2.0°C	Between 0.5°C and 3.0°C	Operator

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

## ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min
Booster Coil Supply Air Temperature	5.0°C	50.0°C	5 min

# **OPERATIONAL ALARMS**

DESCRIPTION	
Space Temperature Above Setpoint	Space temperature is 5.0°
Space Temperature Below Setpoint	Space temperature is 5.0°
Sump Pump Pit P-11 Alarm	Sump pit alarm is active.



# CONDITION

°C above setpoint for 10 minutes.

°C below setpoint for 10 minutes.

# **256 - TYPICAL EC & VARIATIONS**

## GENERAL

This sequence applies to **TYPICAL EC & VARIATIONS** which provides a source of heating to the supplied spaces.

This sequence applies to the following systems:

- 256 Typical EC
- 257 Typical 2 EC's
- 258 Typical 3 EC's

# **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

 Heating Mode will be enabled if space temperature is below <u>occupied heating space temperature setpoint</u> plus occupied space temperature deadband and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below *unoccupied heating space temperature setpoint* and the heating season is active.

When the Time of Day Schedule is unoccupied, if a motion sensor is located in the room and occupancy is detected, the schedule will be set to occupied.

When the Time of Day Schedule is unoccupied, if a motion sensor is located in the room and no occupancy is detected by the motion sensor for the *unoccupied override delay*, the schedule will be set to unoccupied.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Electric Coil (EC)

- In the occupied heating mode the electric heating coil will be staged to maintain <u>occupied heating space</u> temperature setpoint.
- In the unoccupied heating mode the electric heating coil will be staged to maintain <u>unoccupied heating space</u> • temperature setpoint.

#### Occupancy Sensor

• Occupancy status of the space will be monitored by an EC-Smart-Vue-M space sensor.

## EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor: • Space Temperature

The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C

# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Cooling Space Temperature Setpoint	24.0°C	Between 20.0°C and 24.0°C	Operator
<u>Unoccupied Cooling Space Temperature</u> <u>Setpoint</u>	26.0°C	Between 26.0°C and 30.0°C	Operator
<u>Occupied Heating Space Temperature</u> <u>Setpoint</u>	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
Unoccupied Override Delay	Adjustable by Operator	Between 0 and 8 hours	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator



# HISTORY EXTENSIONS (TRENDS)

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min
Booster Coil Supply Air Temperature	5.0°C	50.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Space Temperature Above Setpoint	Space temperature is 5.0°C above setpoint for 10 minutes.
Space Temperature Below Setpoint	Space temperature is 5.0°C below setpoint for 10 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S02 256 –TYPICAL EC & VARIATIONS AS-BUILT (REV 1) – December 22, 2016

# 259 - TYPICAL CUH (TYPE A/B/D) & VARIATIONS

# GENERAL

This sequence applies to **TYPICAL CUH (TYPE A/B/D) & VARIATIONS** which provides a source of heating to the supplied spaces.

This sequence applies to the following systems:

- 259 Typical CUH-A/B/D
- 264 Typical 2 CUH-A/B/D's & Common Space Temp •
- 265 Typical 2 CUH-A/B/D's & Separate Space Temp
- 266 Typical CUH-A/B/D w/EUH
- 267 Typical CUH-A/B/D w/UH-H & EUH
- 268 Typical 2 UH-G & EF
- 269 Typical CUH-A/B/D w/EBH

# **RUN CONDITIONS**

The system will operate based on a Time of Day Schedule.

When the Time of Day Schedule is occupied the system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above <u>occupied cooling space temperature setpoint</u> plus occupied space temperature deadband and the cooling season is active.
- Heating Mode will be enabled if space temperature is below occupied heating space temperature setpoint plus occupied space temperature deadband and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above *unoccupied cooling space temperature setpoint* and the cooling season is active.
- Heating Mode will be enabled if space temperature is below <u>unoccupied heating space temperature setpoint</u> and the heating season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Cabinet Unit Heater Type A/B/D (CUH-A/B/D) On/Off Valve

Supply Fan

- In the occupied heating mode the fan will be commanded on when the return air temperature drops below occupied heating return air temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the return air temperature drops below • unoccupied heating return air temperature setpoint.

Heating Valve

• In the occupied heating mode the heating valve will be commanded on when the return air temperature drops below occupied heating return air temperature setpoint.

• In the unoccupied heating mode the heating valve will be commanded on when the return air temperature drops below unoccupied heating return air temperature setpoint.

## **Electric Coil**

- In the occupied heating mode the electric heating coil will be staged to maintain <u>occupied heating return air</u> temperature setpoint.
- In the unoccupied heating mode the electric heating coil will be staged to maintain <u>unoccupied heating return</u> air temperature setpoint.
- The electric heating coil will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.

Cabinet Unit Heater Type A/B/D (CUH-A/B/D) Modulating Valve

Supply Fan

- In the occupied heating mode the fan will be commanded on when the return air temperature drops below occupied heating return air temperature setpoint.
- unoccupied heating return air temperature setpoint.

Heating Valve

- In the occupied heating mode the heating valve will be modulated to maintain the occupied heating return air temperature setpoint.
- temperature setpoint.

#### Electric Coil

- In the occupied heating mode the electric heating coil will be staged to maintain occupied heating return air temperature setpoint.
- air temperature setpoint.
- The electric heating coil will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.

Unit Heater Type H (UH-H)

Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below unoccupied heating space temperature setpoint.

#### Heating Valve

- In the occupied heating mode the heating valve will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- below unoccupied heating space temperature setpoint.



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

In the unoccupied heating mode the fan will be commanded on when the return air temperature drops below

In the unoccupied heating mode the heating valve will be modulated to maintain *unoccupied heating return air* 

In the unoccupied heating mode the electric heating coil will be staged to maintain <u>unoccupied heating return</u>

In the unoccupied heating mode the heating valve will be commanded on when the space temperature drops

#### Electric Unit Heater (EUH)

- In the occupied heating mode the electric unit heater will be staged to maintain <u>occupied heating space</u> <u>temperature setpoint</u>.
- In the unoccupied heating mode the electric unit hearer will be staged to maintain <u>unoccupied heating space</u> <u>temperature setpoint</u>.
- The electric unit heater will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.
- If the space sensor is placed on a different module, the space temperature is networked back to the controller with the electric unit heater.

#### Unit Heater Type G (UH-G)

#### Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below *unoccupied heating space temperature setpoint*.

#### Exhaust Fan (EF)

- The BAS will monitor the exhaust fan status.
- A manual switch is used to command the exhaust fan. It is only used when the Ice Plant is running.

#### Electric Baseboard Heating (EBH)

- In the occupied heating mode the electric baseboard heating will be staged to maintain <u>occupied heating space</u> <u>temperature setpoint</u>.
- In the unoccupied heating mode the electric baseboard heating will be staged to maintain <u>unoccupied heating</u> <u>space temperature setpoint</u>.
- The electric baseboard heating will always be the 2<sup>nd</sup> stage of heating when serving the same zone as a hydronic heating element.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor:

• Space Temperature

The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C

# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Cooling Space Temperature Setpoint	24.0°C	Between 20.0°C and 24.0°C	Operator
<u>Unoccupied Cooling Space Temperature</u> <u>Setpoint</u>	26.0°C	Between 26.0°C and 30.0°C	Operator
<u>Occupied Heating Space Temperature</u> <u>Setpoint</u>	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
<u>Manual Override Time Period</u>	12 hours	Between 0 and 24 hours	Operator
<u>Occupied Heating Return Air Temperature</u> <u>Setpoint</u>	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Return Air Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min
Booster Coil Supply Air Temperature	5.0°C	50.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	
Space Temperature Above Setpoint	Space temperature is 5.0°
Space Temperature Below Setpoint	Space temperature is 5.0°



# CONDITION

- °C above setpoint for 10 minutes.
- °C below setpoint for 10 minutes.

# **260 - TYPICAL CUH (TYPE C)**

# GENERAL

This sequence applies to **TYPICAL CUH (TYPE C)** which provides a source of heating to the supplied spaces.

This sequence applies to the following systems:

• 260 – Typical CUH-C

The system is composed of the following components:

• Cabinet Unit Heater: CUH-C

# **RUN CONDITIONS**

The system will operate based on a *<u>Time of Day Schedule</u>*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below <u>occupied heating space temperature setpoint</u> plus <u>occupied space temperature deadband</u> and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below <u>unoccupied heating space temperature setpoint</u> and the heating season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Cabinet Unit Heater Type C (CUH-C)

Supply Fan

- In the occupied heating mode the fan will be commanded on when the return air temperature drops below <u>occupied heating return air temperature setpoint</u>.
- In the unoccupied heating mode the fan will be commanded on when the return air temperature drops below <u>unoccupied heating return air temperature setpoint</u>.

Heating Valve

- In the occupied heating mode the heating valve will be modulated to maintain the <u>occupied heating return air</u> <u>temperature setpoint</u>.
- In the unoccupied heating mode the heating valve will be modulated to maintain <u>unoccupied heating return air</u> <u>temperature setpoint</u>.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor:

• Space Temperature

The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C

# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Return Air Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
<u>Occupied Heating Return Air Temperature</u> <u>Setpoint</u>	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Return Air Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator

# HISTORY EXTENSIONS (TRENDS)

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Return Air Temperature</u>	10.0°C	35.0°C	5 min

# **OPERATIONAL ALARMS**

DESCRIPTION	
<u>Return Air Temperature Above</u> <u>Setpoint</u>	Space temperature is 5.0°
<u>Return Air Temperature Below</u> <u>Setpoint</u>	Space temperature is 5.0°

T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS



# CONDITION

°C above setpoint for 10 minutes.

°C below setpoint for 10 minutes.

# 261 -TYPICAL CUH (TYPE BB)

### GENERAL

This sequence applies to **TYPICAL CUH (TYPE BB)** which provides a source of heating to the supplied spaces.

The system is composed of the following components:

- 261 Typical CUH-BB (1)
- 262 Typical CUH-BB (2)
- 263 Typical CUH-BB (3)

# **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

Heating Mode will be enabled if space temperature is below <u>occupied heating space temperature setpoint</u> plus occupied space temperature deadband and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below *unoccupied heating space temperature setpoint* and the heating season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Cabinet Unit Heater Type BB (CUH-BB) On/Off Valve

Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below • unoccupied heating space temperature setpoint.

Heating Valve

- In the occupied heating mode the heating valve will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the heating valve will be commanded on when the space temperature drops below unoccupied heating space temperature setpoint.

Cabinet Unit Heater Type BB (CUH-BB) Modulating Valve

Supply Fan

• In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.



Heating Valve

- In the occupied heating mode the heating valve will be modulated to maintain the occupied heating space temperature setpoint.
- In the unoccupied heating mode the heating valve will be modulated to maintain the <u>unoccupied heating space</u> temperature setpoint.

EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor: • Space Temperature

### The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
<u>Space Temperature Setpoint</u>	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C

# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Cooling Space Temperature Setpoint	24.0°C	Between 20.0°C and 24.0°C	Operator
<u>Unoccupied Cooling Space Temperature</u> <u>Setpoint</u>	26.0°C	Between 26.0°C and 30.0°C	Operator
Occupied Heating Space Temperature Setpoint	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

# HISTORY EXTENSIONS (TRENDS)

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Space Temperature Above Setpoint	Space temperature is 5.0°C above setpoint for 10 minutes.
Space Temperature Below Setpoint	Space temperature is 5.0°C below setpoint for 10 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S02 261 –TYPICAL CUH (TYPE BB) AS-BUILT (REV 1) – December 22, 2016

# **270 - TYPICAL UH (TYPE E) & VARIATIONS**

### GENERAL

This sequence applies to **TYPICAL UH (TYPE E) & VARIATIONS** which provides a source of heating and ventilation to the supplied spaces.

This sequence applies to the following systems:

- 270 Typical UH-E
- 271 Typical UH-E w/EF

# **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above <u>occupied cooling space temperature setpoint</u> plus occupied space temperature deadband and the cooling season is active.
- Heating Mode will be enabled if space temperature is below occupied heating space temperature setpoint plus occupied space temperature deadband and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Cooling Mode will be enabled if space temperature is above <u>unoccupied cooling space temperature setpoint</u> and the cooling season is active.
- Heating Mode will be enabled if space temperature is below <u>unoccupied heating space temperature setpoint</u> and the heating season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Unit Heater Type E (UH-E)

Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below • unoccupied heating space temperature setpoint.

#### Exhaust Fan (EF)

- In the occupied cooling mode the fan will be commanded on when the space temperature rises above • occupied cooling space temperature setpoint.
- In the unoccupied cooling mode the fan will be commanded on when the space temperature rises above unoccupied cooling space temperature setpoint.
- When the exhaust fan is enabled its exhaust air damper will be opened. When damper open status is ٠ confirmed through the damper end-switch the fan will be started through a hardwire interlock.
- When the fan is disabled the exhaust air damper will be closed.



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

EC-Smart-Vue Interface

- The following views are continuously displayed at the EC-Smart-Vue sensor:
  - Space Temperature

The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
<u>Space Temperature Setpoint</u>	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C

### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Cooling Space Temperature Setpoint	24.0°C	Between 20.0°C and 24.0°C	Operator
<u>Unoccupied Cooling Space Temperature</u> <u>Setpoint</u>	26.0°C	Between 26.0°C and 30.0°C	Operator
<u>Occupied Heating Space Temperature</u> <u>Setpoint</u>	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

# HISTORY EXTENSIONS (TRENDS)

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Space Temperature Above Setpoint	Space temperature is 5.0°C above setpoint for 10 minutes.
Space Temperature Below Setpoint	Space temperature is 5.0°C below setpoint for 10 minutes.
<u>EF Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S02 270 –TYPICAL UH (TYPE E) & VARIATIONS AS-BUILT (REV 1) – December 22, 2016

# 272 -TYPICAL 2 UH'S (TYPE H) W/CO MONITORING

### GENERAL

This sequence applies to **TYPICAL CUH (TYPE A/B/D) & VARIATIONS** which provides a source of heating to the supplied spaces.

The system is composed of the following components:

• Unit Heater: UH-H

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below occupied heating space temperature setpoint plus occupied space temperature deadband and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

Heating Mode will be enabled if space temperature is below <u>unoccupied heating space temperature setpoint</u> and • the heating season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

Unit Heater Type H (UH-H)

Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below • unoccupied heating space temperature setpoint.

#### Heating Valve

- In the occupied heating mode the heating valve will be commanded on when the space temperature drops • below occupied heating space temperature setpoint.
- In the unoccupied heating mode the heating valve will be commanded on when the space temperature drops • below unoccupied heating space temperature setpoint.

#### **CO** Monitoring

The BAS will monitor the Zamboni Room CO Level.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor:

• Space Temperature



The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C

### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
<u>Occupied Heating Space Temperature</u> <u>Setpoint</u>	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Space Temperature Above Setpoint	Space temperature is 5.0°C above setpoint for 10 minutes.
Space Temperature Below Setpoint	Space temperature is 5.0°C below setpoint for 10 minutes.
<u>Zamboni Room Space CO High</u> <u>Level Alarm</u>	Space CO is above ##ppm for 5 minutes.

T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

# **273 - TYPICAL EUH & VARIATIONS**

## GENERAL

This sequence applies to **TYPICAL EUH & VARIATIONS** which provides a source of heating to the supplied spaces.

This sequence applies to the following systems:

- 273 Typical EUH
- 274 Typical 2 EUH's

#### **RUN CONDITIONS**

The system will operate based on a *<u>Time of Day Schedule</u>*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below <u>occupied heating space temperature setpoint</u> plus occupied space temperature deadband and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below <u>unoccupied heating space temperature setpoint</u> and the heating season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Electric Unit Heater (EUH)

- In the occupied heating mode the electric unit heater will be staged to maintain occupied heating space temperature setpoint.
- In the unoccupied heating mode the electric unit hearer will be staged to maintain <u>unoccupied heating space</u> temperature setpoint.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Heating Space Temperature Setpoint	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator



# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min

### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Space Temperature Above Setpoint	Space temperature is 5.0°
Space Temperature Below Setpoint	Space temperature is 5.0°



°C above setpoint for 10 minutes.

°C below setpoint for 10 minutes.

# **275 - TYPICAL EBH**

## GENERAL

This sequence applies to **TYPICAL EBH** which provides a source of heating to the supplied spaces.

This sequence applies to the following systems:

• 275 – Typical EBH

The system is composed of the following components:

• Electric Baseboard Heater: EBH

# **RUN CONDITIONS**

The system will operate based on a *<u>Time of Day Schedule</u>*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below <u>occupied heating space temperature setpoint</u> plus occupied space temperature deadband and the heating season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

• Heating Mode will be enabled if space temperature is below <u>unoccupied heating space temperature setpoint</u> and the heating season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# **CONTROL STRATEGY**

Electric Baesboard Heater (EBH)

- In the occupied heating mode the electric baseboard heating will be staged to maintain <u>occupied heating space</u> temperature setpoint.
- In the unoccupied heating mode the electric baseboard heating will be staged to maintain *unoccupied heating* space temperature setpoint.

# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
<u>Occupied Heating Space Temperature</u> <u>Setpoint</u>	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

## ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min

# **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Space Temperature Above Setpoint	Space temperature is 5.0°
Space Temperature Below Setpoint	Space temperature is 5.0°

°C above setpoint for 10 minutes.

°C below setpoint for 10 minutes.

# **276 - TYPICAL EF & VARIAITONS**

#### GENERAL

This sequence applies to **TYPICAL EF** which provides a source of cooling to the supplied spaces.

This sequence applies to the following systems:

- 276 Typical EF Temperature Control
- 277 Typical 2 EF's Time-Of-Day

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following mode:

 Cooling Mode will be enabled if space temperature is above occupied cooling space temperature setpoint plus occupied space temperature deadband and the cooling season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following mode:

• Cooling Mode will be enabled if space temperature is above *unoccupied cooling space temperature setpoint* and the cooling season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

### **CONTROL STRATEGY**

Exhaust Fan (EF)

- In the occupied cooling mode the fan will be commanded on when the space temperature rises above occupied cooling space temperature setpoint.
- In the unoccupied cooling mode the fan will be commanded on when the space temperature rises above • unoccupied cooling space temperature setpoint.
- When the exhaust fan is enabled its exhaust air damper will be opened. When damper open status is ٠ confirmed through the damper end-switch the fan will be started through a hardwire interlock.
- When the fan is disabled the exhaust air damper will be closed.

#### Exhaust Fan (EF) – Time-Of-Day

- The exhaust fan will be commanded on when the Time of Day Schedule is occupied.
- When the exhaust fan is commanded on its exhaust air damper will be opened. When damper open status is • confirmed through the damper end-switches the fan will be started through a hardwire interlock.
- The exhaust fan will be commanded off when the Time of Day Schedule is unoccupied.
- When the fan is commanded off the exhaust air damper will be closed. •

#### *EC-Smart-Vue Interface*

The following views are continuously displayed at the EC-Smart-Vue sensor:

• Space Temperature



SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
Space Temperature Setpoint	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
Unoccupied Space Temperature Cooling Setpoint	View	Yes	±2.0°C

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Cooling Space Temperature Setpoint	24.0°C	Between 20.0°C and 24.0°C	Operator
Unoccupied Cooling Space Temperature Setpoint	26.0°C	Between 26.0°C and 30.0°C	Operator
Occupied Space Temperature Deadband	0.5°C	Between 0.0°C and 2.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min



T-15-7010 SCARBOROUGH CIVIC CENTRE **BAS RETROFIT** SEQUENCE OF OPERATIONS

# **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION	
Space Temperature Above Setpoint	Space temperature is 5.0°C above setpoint for 10 min.	
Space Temperature Below Setpoint	Space temperature is 5.0°C below setpoint for 10 min.	
<u>EF Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.	
<u>EF On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.	



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S02 276 –TYPICAL EF & VARIAITONS AS-BUILT (REV 1) – December 22, 2016
# **278 - TYPICAL SUMP PUMP PIT MONITORING & VARIATIONS**

#### GENERAL

This sequence applies to the **TYPICAL SUMP PUMP PIT MONITORING & VARIATIONS** which provides a source of monitoring of the various sump pit systems.

This sequence applies to the following systems:

- 278 Typical Sump Pump Pit Monitoring
- 279 Typical 2 Sump Pump Pit Monitoring

#### **RUN CONDITIONS**

The system will be enabled continuously.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

Sump Pump Pit

• The BAS will monitor the sump pits pump status and alarm.

# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

#### **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Sump Pump Alarm	Pump alarm float is active.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S01 278 – TYPICAL SUMP PUMP PIT MONITORING & VARIATIONS AS-BUILT (REV 1) – December 22, 2016

# **280 – TYPICAL ACCESS HATCH MONITORING**

# GENERAL

This sequence applies to the **TYPICAL ACCESS HATCH MONITORING** which provides a source of monitoring of the Access Hatches.

#### **RUN CONDITIONS**

The system will be enabled continuously.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

#### **CONTROL STRATEGY**

• The BAS will monitor the access hatch alarm.

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Access Hatch Alarm	An access hatch is open.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S01 280 – TYPICAL ACCESS HATCH MONITORING AS-BUILT (REV 1) – December 22, 2016

# **284 – LIGHTING CONTROL**

# GENERAL

This sequence applies to the **LIGHTING CONTROL** which provides a source of control for the building lighting zones.

The BAS will integrate with the lighting control JACE and control the building lighting zones over BACnet/IP.

# **RUN CONDITIONS**

The system will operate based on a *<u>Time of Day Schedule</u>*.

# **CONTROL STRATEGY**

- All lighting zones will be commanded on when the Time of Day Schedule is occupied.
- All lighting zones will be commanded off when the Time of Day Schedule is unoccupied.

Refer to Page 284.X01 of BAS Schematics for list of BACnet/IP integration points.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S01 284 – LIGHTING CONTROL AS-BUILT (REV 1) – December 22, 2016

# 285 - WING D PARKING GARAGE VENTILATION (EF-18/19/20)

# GENERAL

This sequence applies to the **WING D PARKING GARAGE VENTILATION** which provides a source of ventilation to the supplied space.

The system is composed of the following components:

- Exhaust Fans: EF-18, EF-19 & EF-20
- Carbon Monoxide (CO) Sensors (x3 Total)

# **RUN CONDITIONS**

The system will be enabled continuously.

The system can be manually disabled from the graphic for a pre-set *manual override time period*.

Carbon Monoxide ventilation is based on the following rates:

- Time Weighted Average Exposure Value: to be limited to 25 ppm over 8 hours
- Short Term Exposure Value: to be limited to 50 ppm over 15 minutes
- Instantaneous Value: 100 ppm

#### **CONTROL STRATEGY**

#### Exhaust Fan

- The exhaust fan will be enabled when any CO sensor locally exceeds any of the listed exposure values,
- The exhaust fan will be release from CO ventilation when all CO sensors locally read below the <u>CO setpoint</u> for a period exceeding the <u>CO setpoint achieved delay</u>.
- When the exhaust fan is enabled its exhaust air damper will be opened. When damper open status is confirmed through the damper end-switch the fan will be started through a hardwire interlock.
- When the system is disabled the exhaust fan will be commanded off.
- When the fan is disabled the exhaust air damper will be closed.

#### SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
<u>CO Setpoint</u>	35 ppm	Between 30 and 50 ppm	Operator
CO Setpoint Achieved Delay	5 minutes	Between 0 and 10 minutes	Operator

# HISTORY EXTENSIONS (TRENDS)

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>EF-18 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-18 Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>EF-19 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-19 Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>EF-20 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-20 Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
Space CO High Level Alarm	Space CO is above ##ppm for 10 minutes.



# 286 - WING D PARKING GARAGE VENTILATION (EF-21/22/23)

# GENERAL

This sequence applies to the **WING D PARKING GARAGE VENTILATION** which provides a source of ventilation to the supplied space.

The system is composed of the following components:

- Exhaust Fans: EF-21, EF-22 & EF-23
- Carbon Monoxide (CO) Sensors (x3 Total)

# **RUN CONDITIONS**

The system will be enabled continuously.

The system can be manually disabled from the graphic for a pre-set *manual override time period*.

Carbon Monoxide ventilation is based on the following rates:

- Time Weighted Average Exposure Value: to be limited to 25 ppm over 8 hours
- Short Term Exposure Value: to be limited to 50 ppm over 15 minutes
- Instantaneous Value: 100 ppm

#### **CONTROL STRATEGY**

Exhaust Fan

- The exhaust fan will be enabled when any CO sensor locally exceeds any of the listed exposure values,
- The exhaust fan will be release from CO ventilation when all CO sensors locally read below the <u>CO setpoint</u> for a period exceeding the <u>CO setpoint achieved delay</u>.
- When the exhaust fan is enabled its exhaust air damper will be opened. When damper open status is confirmed through the damper end-switch the fan will be started through a hardwire interlock.
- When the system is disabled the exhaust fan will be commanded off.
- When the fan is disabled the exhaust air damper will be closed.

# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator
<u>CO Setpoint</u>	35 ppm	Between 30 and 50 ppm	Operator
CO Setpoint Achieved Delay	5 minutes	Between 0 and 10 minutes	Operator

# HISTORY EXTENSIONS (TRENDS)

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
<u>EF-21 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-21 Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>EF-22 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-22 Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>EF-23 Failed to Start</u>	Fan is commanded on; and Fan is off for 15 seconds.
<u>EF-23 Fan On in Hand</u>	Fan is commanded off; and Fan is on for 10 minutes.
<u>Space CO High Level Alarm</u>	Space CO is above ##ppm for 10 minutes.



# 287 – WING D PARKING GARAGE MECHANICAL ROOM

#### GENERAL

This sequence applies to WING D PARKING GARAGE MECHANICAL ROOM which provides a source of heating, cooling and monitoring to the supplied spaces.

The system is composed of the following components:

- 2 Unit Heaters
- 2 Sump Pump Pits
- Exhaust Air Damper

#### **RUN CONDITIONS**

The system will operate based on a *Time of Day Schedule*.

When the Time of Day Schedule is occupied the system will be enabled in the following modes:

- Heating Mode will be enabled if space temperature is below <u>occupied heating space temperature setpoint</u> plus occupied space temperature deadband and the heating season is active.
- Cooling Mode will be enabled if space temperature is above <u>occupied cooling space temperature setpoint</u> plus • occupied space temperature deadband and the cooling season is active.

When the Time of Day Schedule is unoccupied the system will be enabled in the following modes:

- Heating Mode will be enabled if space temperature is below <u>unoccupied heating space temperature setpoint</u> and the heating season is active.
- Cooling Mode will be enabled if space temperature is above *unoccupied cooling space temperature setpoint* and the cooling season is active.

The system can be set to the Disabled Mode from the graphic for a pre-set *manual override time period*.

# CONTROL STRATEGY

Unit Heaters

Supply Fan

- In the occupied heating mode the fan will be commanded on when the space temperature drops below occupied heating space temperature setpoint.
- In the unoccupied heating mode the fan will be commanded on when the space temperature drops below • unoccupied heating space temperature setpoint.

#### Exhaust Air Damper

- In the occupied cooling mode the damper will be commanded on when the space temperature rises above occupied cooling space temperature setpoint.
- In the unoccupied cooling mode the damper will be commanded on when the space temperature rises above • unoccupied cooling space temperature setpoint.



• The BAS will continuously monitor the sump pits pump status and alarm.

#### EC-Smart-Vue Interface

The following views are continuously displayed at the EC-Smart-Vue sensor: • Space Temperature

#### The following views are selectable through the EC-Smart-Vue navigation buttons:

SCENE	VIEW ONLY / EDIT	PASSWORD PROTECTED	ADJUSTMENT RANGE
<u>Space Temperature</u>	View	No	N/A
<u>Space Temperature Setpoint</u>	View	Yes	±2.0°C
Occupied Space Temperature Deadband	View	Yes	±2.0°C
<u>Unoccupied Space Temperature Cooling</u> <u>Setpoint</u>	View	Yes	±2.0°C



# SETPOINTS, PARAMETERS AND RESET SCHEDULES

The following setpoints and parameters are referenced in this sequence of operation:

DESCRIPTION	VALUE	ADJUSTABLE RANGE	PERMISSION
Occupied Heating Space Temperature Setpoint	21.0°C	Between 19.0°C and 24.0°C	Operator
<u>Unoccupied Heating Space Temperature</u> <u>Setpoint</u>	18.0°C	Between 18.0°C and 15.0°C	Operator
Occupied Cooling Space Temperature Setpoint	24.0°C	Between 20.0°C and 24.0°C	Operator
<u>Unoccupied Cooling Space Temperature</u> <u>Setpoint</u>	26.0°C	Between 26.0°C and 30.0°C	Operator
<u>Occupied Mode Space Temperature</u> <u>Deadband</u>	0.5°C	Between 0.0°C and 2.0°C	Operator
Manual Override Time Period	12 hours	Between 0 and 24 hours	Operator

# **HISTORY EXTENSIONS (TRENDS)**

All system inputs and outputs will be trended according to the typical configuration, unless otherwise listed in the table below.

# ALARM EXTENSIONS (SENSOR OFF-NORMAL NOTIFICATIONS)

SENSOR DESCRIPTION	LOW LIMIT	HIGH LIMIT	DELAY
<u>Space Temperature</u>	10.0°C	35.0°C	5 min

#### **OPERATIONAL ALARMS**

DESCRIPTION	CONDITION
Space Temperature Above Setpoint	Space temperature is 5.0°C above setpoint for 10 minutes.
Space Temperature Below Setpoint	Space temperature is 5.0°C below setpoint for 10 minutes.
<u>Sump Pump A Alarm</u>	Pump alarm float is active.
Sump Pump B Alarm	Pump alarm float is active.



T-15-7010 SCARBOROUGH CIVIC CENTRE BAS RETROFIT SEQUENCE OF OPERATIONS S02

#### Part 1 General

#### 1.1 GENERAL REQUIREMENTS

.1 Comply with the City of Toronto General Conditions, Division 1, Tender Documents and Division 26.

#### 1.2 APPLICATION

.1 This Section applies to and is an integral part of all succeeding Sections of this Division of the specification.

#### 1.3 **DEFINITIONS**

- .1 The following are definitions of words found in Sections of this Specification and on associated drawings:
- .2 "Concealed" hidden from normal sight in furred spaces, shafts, crawl spaces, ceiling spaces, walls and partitions;
- .3 "Exposed" all work normally visible to building occupants;
- .4 "Provide" (and tenses of "Provide") supply, install and connect complete.
- .5 "Install" (and tenses of "install") install, and connect complete;
- .6 "Supply" Supply only.
- .7 "Work" all equipment, permits, materials and labour to provide a complete electrical installation as required and detailed in Drawings and Specification.
- .8 "Authorities" or "Authorities Having Jurisdiction" any and all current laws and/or by-laws of any federal, provincial or local authorized agencies having jurisdiction over the sum total or parts of the work including, but not restricted to the Municipal Planning and Building Department, Municipal Fire Department, Labour Canada, The Provincial Fire Marshall, The Local Hydro Supply Authority, The Ontario Building Code, The Construction Safety Act, Municipal Public Works Department, the Canadian Electrical Code with Ontario Supplement (Ontario Electrical Safety Code), hereinafter referred to as the "Code", the Electrical Safety Authority and all Inspection Bulletins.
- .9 "Drawings and Specifications" "the TENDER Drawings and Specifications".
- .10 "Consultant" shall mean the firm of Moon Matz Ltd., or other person authorized to act on their behalf.

#### 1.4 WORK INCLUDED

- .1 The work shall include all labour, materials, equipment, permits, inspections and tools required for a complete supply and installation of new HVAC equipment at Scarborough Civic Centre including but not limited to power distribution equipment, cables, conduit, breakers, all equipment accessories as indicated on drawings and otherwise required for operation as described but not necessarily limited to items, in the following sections:
  - .1 Section 26 05 00 Common Work Results for Electrical
  - .2 Section 26 05 83 Electrical Basic Materials
  - .3 Section 26 24 10 Electrical Distribution

#### **1.5 SCHEDULING OF PRODUCT DELIVERY**

.1 Every effort must be made to ensure delivery of all materials and products in the TENDER Documents on time. At commencement of TENDER, prepare schedule of order dates for items requiring long delivery periods.

#### 1.6 EXAMINATION OF SITE

- .1 Prior to submitting a bid carefully examine conditions at the site, which may or will affect the work. Refer to and examine all TENDER documents, including room finish schedules to determine finished, partially finished and unfinished areas of the building.
- .2 Ensure that materials and equipment are delivered to the site at the proper time and in such assemblies and sizes so as to enter into the building and to be moved into the spaces where they are to be located without difficulty. Be responsible for any cutting and patching involved in getting assemblies into place.

# 1.7 QUALITY ASSURANCE:

- .1 General Codes and Standards:
  - .1 Comply with the Ontario Building Code and Canada Labour Code, Part 4.
  - .2 Where provisions of pertinent codes or local by-laws conflict with these Specifications and Drawings or each other, comply with the more stringent provisions.
  - .3 Operating voltages shall comply with CAN3-C235-83 (R2015).
  - .4 Ground system shall comply with CSA Standard C22.1.
  - .5 Abbreviations for electrical terms: to CSA Z85-1983
- .2 Provide new materials bearing certification marks or labels acceptable under Ontario Electrical Safety Code.
  - .1 Equipment must bear, on manufacturer's label, certification mark or label acceptable under Electrical Safety Authority.
- .3 Provide units of same manufacture where two or more units of same class or type of equipment are required.
- .4 Manufacturer's names are stated in this Specification to establish a definite basis for bid submission and to clearly describe the quality of product that is desired for the work.
- .5 Standard Specifications
  - .1 Ensure that the chemical and physical properties, design, performance characteristics and methods of construction of all products provided comply with latest issue of applicable Standard Specifications issued by authorities having jurisdiction, but such Standard Specifications shall not be applied to decrease the quality of workmanship, products and services required by the TENDER Documents.
- .6 Codes and Permits:
  - .1 The work shall be bid on and shall be carried out in accordance with these Drawings and Specifications and shall comply with the essential requirements of the latest editions of the Canadian Electrical Code C. 22.1 and the Electrical Safety Code (together with applicable bulletins issued by the Inspection Department of Electrical Safety Authority). In no instance, however, shall the standards established by the Drawings and Specifications be reduced by any of the codes referred to above. In the

event of conflicting requirements, the codes shall take precedence over these TENDER Documents and the Engineer's decision shall be final.

- .2 Arrange for and obtain all necessary permits, inspection and approvals from authorities having jurisdiction, and also pay all applicable fees. The Contractor shall conform with all Municipal Codes and By-laws which affect the work.
- .3 The Consultant shall convey the Building Permit to the Contractor. Upon receipt of the Building Permit, the Contractor shall be responsible for all correspondence with City Building Officials, arranging and being present for all required inspections, rectifying deficiencies to the satisfaction of the City Building Officials and closing of the Building Permit. The Contractor shall be responsible for complying with all terms of the issued Building Permit.
- .4 Applicable Codes
  - .1 Ontario Electrical Safety Code
  - .2 Canadian Electrical Code with applicable regional amendments
  - .3 Ontario Building Code
  - .4 National Building Code of Canada
  - .5 Ontario Fire Code
  - .6 National Fire Code
- .5 Before starting any work, submit the required number of copies of Drawings and Specifications to the Electrical Safety Authority and the local authority for approval and comments. Comply with any changes requested as part of the TENDER, but notify the Engineer immediately of such changes for proper processing of these requirements. Prepare and furnish any additional Drawings, details or information as may be required by the Engineer.
- .6 On or before the completion of this TENDER, obtain at own expense, the necessary certificates of inspection from the Inspection Branch of the Electrical Safety Authority of Ontario and forward same to the Engineer.
- .7 Equipment and material shall be acceptable to Electrical Safety Authority.
- .8 Where materials are specified which require special inspection and approval, obtain such approval for the particular installation with the co-operation of the material supplier.
- .9 Supply and install warning signs and nameplates as required by the Electrical Safety Authority.
- .10 Submit required Documents and shop drawings to authorities having jurisdiction in order to obtain approval for the Work. Copies of TENDER Drawings and Specifications may be used for this purpose.

# **1.8 REQUIREMENTS OF DRAWINGS:**

- .1 TENDER:
  - .1 The Drawings for electrical work are essentially performance drawings, partly schematic, intended to convey the scope of work and extent of work. They only indicate general arrangement and approximate location of apparatus, fixtures and general typical sizes and locations of equipment and connections. The Drawings do not intend to show architectural, structural or mechanical details.
  - .2 Do not scale Drawings, but obtain information involving accurate dimensions to structure from those shown on Architectural and Structural Drawings, or by site

measurements of existing areas. Follow the Electrical Drawings in laying out the work but consult general Construction Drawings as well as detail Drawings to become familiar with all conditions affecting the work, and verify spaces in which the work will be installed and structures to which it will be attached.

- .3 Make, at no additional cost, any changes or additions to materials, and/or equipment necessary to accommodate structural conditions (runs around beams, columns, etc.). Alter, at no additional cost, the location of materials and/or equipment up to 3m, or as directed, provided that the changes are made before installation and do not necessitate additional material or labour.
- .4 Leave space clear and install work to accommodate future materials and/or equipment as indicated and to accommodate equipment and/or material supplied by other trades. Verify all equipment sizes in relation to space allowed and check all clearances.
- .5 Confirm on the site, the exact location and mounting elevation of equipment and fixtures as related to Architectural or Structural details. Confirm location of outlets and/or connection points for equipment supplied by other trades.

#### 1.9 **Shop Drawings:**

- .1 Pay careful attention to all shop drawings and review comments and ensure that all requirements are fully complied with.
- .2 Submit manufacturer's or vendor's drawings for all products being furnished except cable (up to 1000V), wire and conduit for review prior to commencement of work. Include rating, performance, specification sheets, descriptive literature, schematic and wiring diagrams, dimensional layouts and weights of components as well as complete assembly. Ensure submissions contain adequate data to easily confirm equipment meets the requirements of these Specifications.
- .3 Carefully examine Work and Drawings of all related trades and thoroughly plan the Work so as to avoid interferences. Report defects which would adversely affect the Work. Do not commence installation until such defects have been corrected.
- .4 Submit prior to commencement of work for review, properly identified shop drawings showing in detail the design and construction of all equipment and materials as requested in sections of the specification governed by this Section.
- .5 Obtain and comply with the manufacturer's installation instructions.
- .6 Endorse each shop drawing copy "CERTIFIED TO BE IN ACCORDANCE WITH ALL REQUIREMENTS", stamp each copy with contractor company name, date each copy with the submittal date, and sign each copy. Shop drawings which are received and are not endorsed, dated and signed will be returned for re-submittal.
- .7 The Consultant will stamp shop drawings as follows:

.1	Drawing: Reviewed	( )	
.2	Reviewed as Modified	( )	
.3	Revise and Resubmit	( )	
.4	Rejected		()

.8 If "REVIEWED" is checked-off, the shop drawing is satisfactory. If "REVIEWED AS MODIFIED" is checked-off, the shop drawing is satisfactory provided requirements of remarks put on shop drawing copies are met. No resubmissions are required for "REVIEWED AS MODIFIED" shop drawings if the requirements of the remarks are met. If "REVISE AND

RE-SUBMIT" is checked-off, the shop drawing and equipment selection must be revised in accordance with comments written on shop drawing copies and resubmitted. If "REJECTED" is checked-off, the shop drawing is in error of submission and the equipment described therein is not suitable for this project and shall not be used on this project.

- .9 This review by the Consultant is for the sole purpose of ascertaining conformance with the general design concept. This review shall not mean that the Consultant approved the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor and such review shall not relieve the Contractor of responsibility for errors or omissions in the shop drawings or of responsibility for meeting all requirements of the TENDER documents. Be responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation, and for co- ordination of the work as well as compliance with codes and inspection authorities such as C.S.A., etc.
- .10 Co-ordinate Work of this Division such that items will properly interface with Work of other Divisions.
- .11 Architectural Drawings, or in the absence of Architectural Drawings, Mechanical Drawings govern all locations.
- .12 Prior construction, contractor shall submit a detailed work plan for review and comment by Owner and Consultant as a shop drawing submission. The work plan shall include the conduit routing plan, schedule and working drawings to illustrate the relocation of the wall, splicing of existing wiring, installation of new generator, installation of new distribution equipment, temporary power servicing arrangements, commissioning of new emergency power system with new and existing loads and tested sequences of operation, temporary emergency power servicing requirements and other activities.

# 1.10 Substitutions

- .1 When only one manufacturer's catalogued trade name is specified, provide only that catalogued trade name, material or product.
- .2 When more than one manufacturer's trade name is specified for a material or product, the choice is the bidder's.
- .3 No substitution is allowed upon award of TENDER.

# 1.11 Dimensions and Quantities

- .1 Dimensions shown on Drawings are approximate. Verify dimensions by reference to shop drawings and field measurement.
- .2 Quantities or lengths indicated in TENDER Documents are approximate only and shall not be held to gauge or limit the Work.
- .3 Make necessary changes or additions to routing of conduit, cables, and the like to accommodate structural, mechanical and architectural conditions. Where raceways are shown diagrammatically run them parallel to building column lines.

# 1.12 Equipment Locations

.1 Devices, fixtures and outlets may be relocated, prior to installation, from the location shown on the TENDER Drawings, to a maximum distance of 3 m without adjustment to TENDER price.

- .2 Any changes of device locations from the TENDER Drawings shall be brought to the attention of the Owner and Consultant prior movement from the location on the Drawings for review and comment. Any changes of device locations from the TENDER Drawings shall be approved by the Owner in writing prior installation.
- .3 Switch, control device and outlet locations are shown diagrammatically.

#### 1.13 Working Drawings and Documents

- .1 Contractor may be required to prepare working detail drawings supplementary to the TENDER drawings, when deemed necessary by the Consultant, for all areas where a multiplicity of materials and or apparatus occur, or where work due to architectural and structural considerations involves special study and treatment. Such drawings may be prepared jointly by all trades affected, or by the one (1) trade most affected with due regard for and approval of the other trades, all as the Consultant will direct in each instance. Such drawings must be reviewed by the Consultant before the affected work is installed.
- .2 Carry out all alterations in the arrangement of work which has been installed without proper study and approval, even if in accordance with the TENDER documents, in order to make such work come within the finished lines of walls, floors and ceilings, or to allow the installation of other work, without additional cost. In addition, make any alterations necessary in other work required by such alterations, without additional cost.

#### 1.14 Installation Drawings

.1 Prepare installation drawings for equipment, based upon approved Vendor drawings, to check required Code clearances, raceway, busway and cable entries, sizing of housekeeping pads and structure openings. Submit installation drawings to Consultant for review.

#### 1.15 "As Built" Drawings

- .1 Maintain a set of TENDER Drawings on site and maintain all deviations from the TENDER Documents. As a mandatory requirement, recording must be done on the same day deviation is made. Be responsible for full compliance with this requirement.
- .2 Mark locations of feeder conduits, junction and terminal boxes and ducts or conduits run underground either below the building or outside the building.
- .3 Where conduit and wiring are underground or underfloor, furnish field dimension with respect to building column lines and inverts with respect to finished floor levels or grades.
- .4 Record deviations from branch circuit numbers shown on Drawings.
- .5 Prepare diagrams of interconnecting wiring between items of equipment including equipment supplied by Owner and under other Specification Sections.

#### 1.16 Test Reports

- .1 For each check and test performed prepare and submit a Test Report, signed by the Test engineer, and where witnessed, by the Consultant.
- .2 Include record of all tests performed, methods of calculation, date and time of test, ambient conditions, names of testing company, test engineer, witnesses, also calibration record of all test instruments used together with manufacturers name, serial number and model number.
- .3 Include calibration record, percentage error and applicable correction factors.

.4 Submit a Certified Test Report from each manufacturer, signed by the certifying inspector, confirming correct installation and operation of each product and part of Work. Include name of certifying inspector, date and times of inspection, ambient conditions.

# 1.17 Housekeeping Pads

.1 Provide steel re-enforced concrete housekeeping pads under all floor mounted electrical equipment and where noted on the TENDER Drawings. All housekeeping pads to be a minimum of 100mm high above finished floor and shall not extend beyond 50mm beyond the electrical equipment unless shown otherwise on the TENDER Drawings.

#### 1.18 Fire Barriers

- .1 Where electrical material or devices pass through fire rated separations, make penetrations and provide fire barrier seals with a fire resistance rating equivalent to the rating of the separation.
- .2 Prior to installation, submit for review, proposed fire barrier seal materials, method of installation and ULC system number.
- .3 Acceptable Manufacturers:
  - .1 A/D Fire Protection Systems
  - .2 Dow Corning
  - .3 Fire Stop Systems
  - .4 IPC Flamesafe Firestop
  - .5 Nelson Electric
  - .6 3M
  - .7 Tremco

# 1.19 Miscellaneous Metal Fabrications

.1 Provide miscellaneous structural supports, platforms, braces, brackets and preformed channel struts necessary for suspension, attachment or support of electrical. All supports, platforms, brackets and channel struts shall be made of stainless steel material.

#### 1.20 SLEEVE AND FORMED OPENING LOCATION DRAWINGS

.1 Prepare and submit to the Consultant for review and forward to the appropriate Sub-trade drawings indicating all required sleeves. Such drawings shall be completely and accurately dimensioned and shall relate sleeves, recesses, and formed openings to suitable grid lines and elevation datum. Begin to prepare such drawings immediately upon notification of acceptance of bid and award of TENDER. Make all modifications to locations as directed by a Structural Engineer at no extra cost to TENDER.

#### **1.21 SUPERINTENDENCE**

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

#### 1.22 PATENTS

.1 Pay all royalties and licence fees, and defend all suits or claims for infringement of any patent right, and save the Owner and Consultant harmless of loss or annoyance on account of suit, or

claims of any kind for violation of infringement of any letters, patent or patent rights, by this Subcontractor or anyone directly or indirectly employed by him or by reason of the use by him or them of any part, machine, manufacture or composition of matter on the work, in violation or infringement or such letters, patent or rights.

# 1.23 RIGHTS RESERVED

.1 Rights are reserved to furnish any additional detail drawings, which in the judgment of the Consultant may be necessary to clarify the work and such drawings shall form a part of this TENDER.

#### 1.24 METALS

.1 Steel construction required solely for the work of electrical trades and not shown on architectural or structural drawings shall be provided by this trade in accordance with applicable code requirements.

# 1.25 FLASHING

- .1 Flash electrical parts passing through or built into a roof, an outside wall, or a waterproof floor.
- .2 Provide sleeves passing through outside walls with lead or copper flashing as directed.

#### 1.26 WORKMANSHIP

- .1 Install equipment, ductwork, conduit and cables in a workmanlike manner to best suit space, to present a neat appearance and to function properly to the satisfaction of the Consultant.
- .2 Install equipment and apparatus requiring maintenance, adjustment or eventual replacement with due allowance therefore.
- .3 Include in the work all requirements of manufacturers shown on the shop drawings or manufacturers installation instruction.
- .4 Replace work unsatisfactory to the Consultant without extra cost.
- .5 Make provision to accommodate future plant and equipment indicated on drawings.
- .6 Protect from damage all equipment delivered to the site and during installation. Any damage or marking of finished surfaces shall be made good to the satisfaction of the Consultant.

#### 1.27 MOUNTING HEIGHTS

- .1 Mounting height of equipment is from finished floor to centreline of equipment unless specified or indicated otherwise.
- .2 If mounting height of equipment is not indicated verify before proceeding with installation.

# 1.28 OWNER RIGHT TO RELOCATE ELECTRICAL ITEMS

- .1 The Owner reserves the right to relocate electrical items (light fixtures, battery pack) during construction, but prior to installation, without cost, assuming that the relocation per item does not exceed 3 m (10'-0") from the original location. No credits shall be anticipated where relocation per item of up to and including 3m reduces materials, products and labour.
- .2 Should relocations per item exceed 3m from the original location the TENDER price will be adjusted accordingly.

.3 Necessary changes, due to lack of co-ordination, and as required and when approved, shall be made at no additional cost, to accommodate structural and building conditions. The location of pipes and other equipment shall be altered without charge to the Owner, if approved, provided the change is made before installation.

# 1.29 OPERATING AND MAINTENANCE INSTRUCTION MANUALS

- .1 Each copy of the manual shall include:
  - .1 Complete list of products used in the work showing product name, part number or code and manufacturer for each listing; follow specification format.
  - .2 Brochures, reviewed set of shop drawings of all equipment.
  - .3 Installation, operating and maintenance instructions for all equipment.
  - .4 Wiring diagrams.
  - .5 Controls schematics.
  - .6 Operation sequences.
  - .7 System start-up reports.
  - .8 Verification reports.
  - .9 Certificates of Inspection.
  - .10 Signed warranty letter on Contractor letterhead.
  - .11 Extended warranties provided by sub-contractors or suppliers.
  - .12 Other data required elsewhere in TENDER Documents or deemed necessary by Consultant.
  - .13 A set of as-built prints;
  - .14 Letters of Owners Instructions;
  - .15 Electrical Safety Authority Certificates of Inspection and Final Electrical Safety Authority Certificate of Acceptance;
  - .16 A copy of "reviewed" shop drawings;
  - .17 Complete explanation of operation principles and sequences;
  - .18 Complete part lists with numbers;
  - .19 Recommended maintenance practices and precautions;
  - .20 Parts manual and repair manuals
  - .21 Complete wiring and connections diagrams;
  - .22 Certificates of guarantee;
- .2 Ensure that operating and maintenance instructions are specific and apply to the models and types of equipment provided.
- .3 Submit one hard copy of the maintenance manuals in heavy-duty binders complete with record drawings and all instructions suitably labelled with project name and locations at project close-out. Submit two copies on USB key with all of the same contents as the hard copies of the maintenance manuals at project close-out.

# 1.30 TRIAL USAGE

.1 The Consultant/Engineer reserves the right to use any system, piece of equipment, device, or material for such reasonable lengths of time and at such times as may be required to make a complete and thorough test of the same, or for the purpose of learning operational procedures, before the final completion and acceptance of the work. Such tests shall not be construed as

evidence of acceptance of the work, and it is agreed and understood that no claim for damage will be made for injury or breakage to any part or parts of the above due to the aforementioned tests, where such injuries or breakage are caused by a weakness or inaccuracy of parts, or by defective materials or workmanship of any kind. Supply all labour and equipment required for such tests.

.2 Perform and pay for all costs associated with any testing required on the system components where, in the opinion of the Consultant/ Engineer the equipment manufacturer's ratings or specified performance is not being achieved.

# 1.31 INSTRUCTION TO OWNERS

- .1 Instruct the Owner's designated representatives in all aspects of the operation and maintenance of all systems and equipment.
- .2 Arrange for, and pay for services of service engineers and other manufacturer's representatives required for instruction in the operation of systems and equipment.
- .3 Submit to the Consultant at the time of final inspection a complete list of systems stating for each system:
  - .1 Date instructions were given to the Owner's staff.
  - .2 Duration of instructions.
  - .3 Name of persons instructed.
  - .4 Other parties present (manufacturer's representative, consultants, etc.)
- .4 Obtain the signature of the Owner's staff verifying that they properly understood the system installation, operation and maintenance requirements, and that they have received the specified manuals and "as-built" drawings.

# **1.32 SYSTEM ACCEPTANCE**

- .1 Submit original copies of letters from the manufacturers of all systems indicating that their technical representatives have inspected and tested the respective systems and are satisfied with the method of installation, connection and operation.
- .2 These letters shall state the names of persons present at testing, the methods used, and a list of functions performed with location and room numbers where applicable.

# 1.33 CLEANING

- .1 Before energizing any systems, inspect and clean the inside of panel boards, switchgear, and cabinets to ensure that they are completely free from dust and debris.
- .2 Clean all polished, painted and plated work bright.
- .3 Remove all debris, surplus material and all tools
- .4 Carry out additional cleaning of systems as specified in other sections of this Division.

# **1.34 PAINTING WORK SUPPLIED UNDER DIVISION 26**

- .1 Touch up minor chips or damage to electrical equipment, installed in this Division, with standard, factory supplied, enamel finish.
- .2 Colour code, as specified herein, outlet boxes, pull boxes, junction boxes by applying a small dab of paint to inside of each item during installation.

.3 Colour code, as specified herein, all exposed ducts, conduits, outlet boxes, and similar items by applying a 25 mm (1") wide band of paint around ducts and conduits adjacent to boxes described in above paragraph and on both sides of wall penetration.

#### 1.35 removals

- .1 Co-ordination Between New and Existing Installations
  - .1 Provide interfacing components between new and existing systems as necessary for proper performance and operation.
- .2 Existing Services
  - .1 Ensure existing services remain undisturbed and energized except where indicated.
  - .2 Disconnect and remove abandoned wiring materials and devices.
- .3 Modifications to Existing Structures
  - .1 Provide new electrical equipment to existing structures as detailed on drawings. Remove existing devices as shown and as required. Salvage existing circuits for reuse as noted.
- .4 Interruption of Services
  - .1 Maintain existing systems in existing building at all times during construction.
  - .2 Contractor shall apply to the Owner in writing for permission for any power interruptions a minimum of one (1) week before requested shutdown date and obtain the Owner's written approval for any shutdowns. The Contractor shall indicate the approximate length of the shutdown and services affected in their written request for permission.
  - .3 Obtain Consultant's and Owner's written approval before interrupting any service. Long outages are not acceptable.
  - .4 Provide temporary services (i.e. temporary generator) to maintain continuity in the event that services must be interrupted at contractor's expense. Include all costs.
- .5 Premium Time
  - .1 Power shutdowns to the site will only be allowed on weekends between the hours of Friday 12.00 midnight to Sunday 12.00 midnight and on dates agreeable to the Owner. Include all costs for this overtime work in the contractor's bid. Contractor shall apply to the Owner in writing for permission for any power interruptions a minimum of two (2) weeks before requested shutdown date and obtain the Owner's written approval for any shutdowns. The Contractor shall indicate the approximate length of the shutdown and services affected in their written request for permission.
  - .2 Include cost of premium time in bid price for work during nights, weekends or other time outside normal working hours necessary to do the work and maintain electrical services in operation.
  - .3 Premium time is to include work by local hydro authority, ESA and any other authorities having jurisdiction as required.
- .6 Use of Existing Material And Equipment
  - .1 Unless noted otherwise, do not use any existing panels, boxes and wiring materials unless shown on drawings.

# .7 Demolition

- .1 Demolish existing work, where indicated, and remove from site.
- .2 Execute all demolition work so as to create minimum vibration or dust within and outside the building. Obtain Consultant's approval of methods before proceeding.
- Part 2 Products
- 2.1 NOT USED
- Part 3 Execution
- 3.1 NOT USED
  - END OF SECTION

#### Part 1 General

# 1.1 GENERAL REQUIREMENTS

.1 Comply with the City of Toronto General Conditions, Division 1, Tender Documents and Division 26.

#### **1.2 SCOPE OF WORK**

.1 Supply all labour, tools, service and equipment and provide all the materials required to complete the electrical work specified in Division 26.

#### **1.3 SHOP DRAWINGS**

.1 Shop drawings need not be submitted for standard manufactured items and materials provided they are as specified.

# 1.4 SUBMITTALS

- .1 Submit the following to the Consultant for review prior to commencement of work:
  - .1 A sample of lamicoid nameplates and list of proposed nameplate legends.

#### 1.5 QUALITY ASSURANCE

.1 All components shall be C.S.A. and/or U.L.C approved listed and labelled for the application for which they are to be used.

# Part 2 Products

# 2.1 CONDUIT AND RACEWAYS

- .1 Conduits and Fittings
  - .1 Electrical Metallic Tubing (EMT)
    - .1 To CSA C22.2 No. 83
      - .2 EMT galvanized cold rolled steel tubing
  - .2 PVC/Epoxy-Coated Rigid Galvanized Steel Conduit
    - .1 Hot-dipped galvanized steel conduit to CAN/CSA C22.2 No. 45 with 40 mils gray PVC or epoxy coating with no sags, blisters or other surface defects. Metallic rigid conduit other than hot-dipped galvanized rigid steel is unacceptable.
    - .2 PVC/Epoxy shall be applied at factory of origin. All fittings shall be of the same type and treatment as the adjoining conduit. All repairs done on deficient conduit requiring PVC/epoxy coating shall be done at factory of origin.
    - .3 Conduit shall be threaded at both ends.
  - .3 Liquid Tight Flexible Steel Conduit
    - .1 To CSA 22.2 No. 56.
    - .2 Liquid-tight flexible steel conduit with PVC cover.

- .3 Watertight connectors with nylon insulated throat.
- .4 EMT Fittings
  - .1 Compression type, pressed steel (cast iron, zinc and set-screw fittings are not acceptable).
  - .2 Gland compression connectors with insulated throats
  - .3 Water-tight compression couplings. Set-screw connectors shall not be.
- .5 PVC-Coated Rigid Galvanized Steel Conduit Fittings
  - .1 Fittings: All fittings (e.g. threaded hubs, couplings, conduit bodies, straps, elbows) shall be PVC coated rigid galvanized steel and shall have no sags, blisters or other surface defects.
  - .2 Enclosures: Pull boxes and junction boxes shall be constructed of iron and PVC coated.
- .6 Liquid Tight Flexible Steel Conduit Fittings
  - .1 Watertight connectors with nylon insulated throat
- .7 Minimum size conduit will be 21mm diameter.
- .8 All conduit shall contain a separate dedicated ground conductor.
- .9 All conduit must have adequate support systems complete with CSA-approved fittings, outlet boxes, junction boxes, sealing fittings and drains as indicated or as required. Provide hot-dipped galvanized steel beam clamps, hot-dipped galvanized steel channel-type (i.e. strut) supports. Provide six (6)mm threaded hot-dipped galvanized steel rods to support suspended channels and provide all necessary galvanized steel spring loaded bolts, nuts, washers and lock washers. Support systems shall be Thomas & Betts Superstrut or equal.
- .10 Provide all conduit, fittings and ducts necessary to complete the distribution of all power, lighting and control conductors to electrical equipment specified under the corresponding Section. Include that necessary for connecting to mechanical heating and ventilating equipment, also equipment specified under other Divisions.
- .11 Fasten conduit with malleable PVC coated galvanized steel two-hole straps at intervals to suit code requirements and job conditions.

# 2.2 FASTENINGS, SUPPORTS AND SLEEVES

- .1 Hot-dipped galvanized steel, size and load rating to suit application.
- .2 All anchors shall be stainless steel type and of the double expander type where possible.
- .3 One hole steel straps to secure surface mounted conduits or surface mounted cables 50 mm dia. and smaller. Two hole steel straps for conduits and cables larger than 50 mm.
- .4 Beam clamps to secure conduits to exposed steel work.
- .5 Channel type supports for two or more conduits.
- .6 6 mm minimum dia. threaded rods to support suspended channels.
- .7 6 mm minimum dia. U-bolts.
- .8 Sleeves schedule 40 steel pipe minimum I.D. 13 mm larger than O.D. of conduit or cable passing through.

- .9 Strut
  - .1 Continuous slotted channel
  - .2 12 gauge pre-galvanized steel
  - .3 41.2 mm x 41.2 mm minimum
  - .4 Acceptable manufacturers:
    - .1 B-Line
    - .2 Pilgrim
    - .3 Pursley
    - .4 Unistrut
    - .5 Or approved equal
- .10 Acceptable Manufacturers: Burndy, Electrovert, Unistrut, Hilti.

# 2.3 JUNCTION BOXES

- .1 Galvanized steel EEMAC Type 12 indoors size as required by code for number and size of conduits, conductors and devices, complete with covers, corrosion resistant screws, terminal blocks and mounting rails.
- .2 Screw-on sheet steel covers to match enclosure for surface mounting boxes.
- .3 Covers with 25 mm minimum extension around for flush-mounted junction boxes.
- .4 EEMAC3R steel junction boxes outdoors.
- .5 Galvanized steel barriers as required.

#### 2.4 PULL BOXES

- .1 Galvanized sheet steel welded construction, EEMAC Type 12 indoors.
- .2 EEMAC3R steel pull boxes outdoors.
- .3 Screw-on galvanized sheet steel covers for surface mounting boxes.
- .4 Covers with 25mm minimum extension around, for flush mounted pull boxes.
- .5 Galvanized steel barriers as required.

#### 2.5 CONDUIT BOXES - GENERAL

- .1 Size boxes in accordance with latest edition of Electrical Safety Authority (ESA) Electrical Safety Code.
- .2 Code gauge, galvanized pressed steel for EMT.
- .3 200 mm square or larger outlet boxes as required for special devices.
- .4 Gang boxes where wiring devices are grouped except in classified hazardous areas.
- .5 Blank cover plates for boxes without wiring devices.
- .6 50 mm x 100 mm outlet boxes for devices, ganged for grouped devices, barriers where required by code.
- .7 Boxes serving PVC/epoxy-coated conduit systems shall be constructed of iron and PVC coated.

#### 2.6 OUTLET BOXES - FITTINGS

- .1 Bushings and connectors with nylon insulated throats.
- .2 Knock-out fillers to prevent entry of foreign materials.
- .3 Conduit outlet bodies for conduit up to 32 mm and pull boxes for larger conduits.
- .4 Double locknuts and insulated bushings for sheet steel metal boxes.
- .5 Thomas and Betts 1110 and similar boxes shall not be used for surface-mounted installations. Cast boxes must be used for all surface-mounted installations.

#### 2.7 **RIGID CONDUIT BOXES**

.1 Zinc electroplate and polymer enamelled cast FS boxes with factory-threaded hubs and mounting feet for surface mounted switches and receptacles, with gasketted coverplate for exterior work and wet areas.

#### 2.8 BRANCH CIRCUIT CONDUCTORS

- .1 Conductors
  - .1 ASTM Class B, soft drawn, electrolytic copper
  - .2 Stranded
- .2 Insulation
  - .1 CSA type RW90 XLPE (-40°C)
    - .1 Heat and moisture resistant
    - .2 Low temperature, chemically cross-linked thermosetting polyethylene material
    - .3 600V-rated for 120/208V circuits and 1000V-rated for 347/600V circuits
    - .4 For maximum 90°C conductor temperature
    - .5 For installation at minimum -40°C temperature
    - .6 To CSA C22.2 No. 38
- .3 Branch circuit conductors up to and including #12 AWG shall be solid. Branch circuit conductors in sizes larger than #12 AWG shall be stranded. All branch circuit conductors shall be constructed of 90% conductive copper, unless otherwise noted, and shall be approved for 600 volts.
- .4 Electric service, distribution and special conductors are specified in this Section and/or on the drawings.

# 2.9 WIRE AND CABLE CONNECTORS

.1 Factory-insulated copper compression connectors sized for installed conductors approved by ESA for use in the location in which they are installed manufactured by Thomas & Betts, Ideal, Hubbell Burndy, nVent Erico, ILSCO or approved equivalent.

#### 2.10 HEAT SHRINKABLE TUBING INSULATION, HEAVY WALL

.1 Acceptable Manufacturers: Thomas & Betts, Shrink-Kon series, Ideal Thermo-Shrink, TS-46, Raychem tubing WCSM, 3M cable sleeve ITCSN.

#### 2.11 FUSES

- .1 H.R.C. fuses to CSA C22.2 No. 59-M, CSA C22.2. No. 106-M with interrupting capacity minimum 200,000 amps symmetrical.
- .2 Unless otherwise noted, provide time delay fuses as follows:
  - .1 Fuses 600V, up to 600A HRCI-R, Form I: Class R Bussman FRS-R600 volt, Gould Shawmut TRSR.
- .3 Submit a list of spare fuses to Consultant for approval.

#### 2.12 SLEEVES

- .1 In concrete slabs, except as noted below, sleeves shall be #24 gauge galvanized steel or factory fabricated plastic sleeves, each with an integral flange to secure the sleeve to form work construction.
- .2 In waterproof concrete slabs and in other slabs where waterproof sleeves are required sleeves shall be Schedule 40 mild steel galvanized.

#### 2.13 ESCUTCHEON PLATES

.1 One-piece chrome plated steel sized to completely cover sleeves and complete with set screws to secure the plates to the conduit. Split plates will not be acceptable.

# 2.14 INSERTS, BEAM CLAMPS FASTENERS, EQUIPMENT HANGERS AND SUPPORTS

- .1 Inserts for concrete formwork shall be Crane Canada type, #4-M Unistrut, or approved equal cast iron inserts, multiple type where required.
- .2 Inserts for precast concrete and existing concrete shall be lead cinch anchors of "WEJ-IT" or self-drilling "STARR" or "PHILLIPS" anchors.
- .3 Beam clamps for hanging and support to structural steel shall be Crane Canada Ltd., or equal.

#### 2.15 ACCESS DOORS

- .1 Minimum #12 gauge prime coat painted bonderized steel flush access doors, each complete with a heavy frame and anchor, heavy duty rust-resistant concealed hinges, a positive locking screwdriver lock, and mounting and finishing provisions to suit the particular construction in which it is installed. Access door sizes shall suit the concealed work for which they are supplied. Access doors in fire rated ceilings, walls, partitions, structures, etc., shall be U.L.C. listed and labelled and of a rating to maintain the fire separation integrity.
- .2 Where access doors are located in surfaces where special finishes are required, they shall 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.
- .3 Access doors shall be, wherever possible, of a standard size, for all applications. Confirm exact dimensions with the Consultant, prior to ordering.
- .4 Submit a sample of each proposed type of access door to the Consultant for approval.

# 2.16 WATER RESISTANT PROTECTION

- .1 Where the area is sprinklered and electrical distribution equipment is located in sprinklered areas, enclosures shall be louvred and gasketed and provided with water-tight roof assemblies with overhanging drip shields. The equipment shall be fabricated by the manufacturer in such a way as to prevent sprinkler fluid from entering the equipment and/or interfering with its operation as per the requirements of C.S.A. C22.1 Rule 26-006.
- .2 Weatherproof equipment where noted in the specifications and or drawings shall have EEMAC 3R enclosures in accordance with the requirements of C.S.A. C22.2 No. 94 Standard.

#### 2.17 FINISH

.1 Equipment enclosure finish: baked grey enamel, ANSI 49 or ANSI 61.

#### 2.18 GROUNDING EQUIPMENT

- .1 Clamps for grounding of conductor: size as required to electrically conductive underground water pipe.
- .2 Grounding conductors: bare stranded copper, soft annealed, size as indicated.
- .3 Insulated grounding conductors: green, type RWU.
- .4 Ground bus: copper, size as indicated, complete with insulated supports, fastenings, connectors.
- .5 Non-corroding accessories necessary for grounding system, type, size, material as indicated, including but not necessarily limited to:
  - .1 Grounding and bonding bushings.
  - .2 Protective type clamps.
  - .3 Bolted type conductor connectors.
  - .4 Thermit welded type conductor connectors.
  - .5 Bonding jumpers, straps.
  - .6 Pressure wire connectors.

#### Part 3 Execution

#### 3.1 GENERAL CONDUIT AND CONDUCTOR INSTALLATION REQUIREMENTS

- .1 Install conduit and conductors concealed in all finished areas, and concealed to the degree made possible by finishes in partially finished and unfinished areas. Conduit may be exposed in unfinished area such as Electrical Rooms and Mechanical Rooms, unless otherwise noted on the drawings or specified herein. Refer to and examine the architectural drawings and room finish schedules to determine finished, partially finished and unfinished areas of the building.
- .2 Where conduit and/or conductors are exposed, arrange same to avoid interference with other work and parallel to the building lines, where horizontal conduits and/or conductors are exposed, install as high as possible. Do not install conduit and/or conductors within 150mm of flue or heating pipes or equipment.

# 3.2 CONDUIT AND EMT - GENERAL

- .1 Run parallel or perpendicular to building lines.
- .2 Group raceways wherever possible. Support on channels.
- .3 Install expansion joints as required.
- .4 Run raceways in web portion of structural steel columns and beams.
- .5 Do not drill structural members to pass through.
- .6 Locate raceways not less than 125 mm clear where parallel to steam or hot water lines with a minimum of 75 mm at crossovers.
- .7 Use metallic raceway where temperatures exceed 75°C or where enclosed in thermal insulation.
- .8 All conduits to contain insulated green ground wire.
- .9 Install 6 mm diameter nylon pull cord in empty raceways.
- .10 Install 6 mm<sup>1</sup>/4" diameter nylon pull cord in empty raceways.

# **3.3 CONDUIT AND FITTINGS**

- .1 Minimum conduit sizes:
  - .1 21mm conduit
- .2 Connection to motors and equipment subject to vibration use liquid tight flexible steel conduit.
- .3 Do not install conduit in or under slab.
- .4 Use factory "ells" where 90° bends are required for 27mm trade size and larger conduits.
- .5 Bend conduit offsets cold. Do not install crushed or deformed conduits and avoid trapped runs in damp or wet locations. Prevent the entrance of water and lodging of concrete, plaster, dirt, or trash in conduit, boxes, fittings, and equipment during course of construction.
- .6 Where conduit joints occur in damp or wet locations, make joints watertight by applying an approved compound on the entire thread area before assembling. Draw up all conduit joints as tightly as possible.
- .7 Cap exposed empty conduits which do not terminate in outlets, panels, cabinets, etc., with standard galvanized plumber's pipe caps.
- .8 Plug empty conduits which terminate flush with floors or walls with flush coupling and brass plug.
- .9 Install conduit sleeves for all exposed conduits and cables passing through walls, ceilings, or floors, and fill void between sleeve and conduit with caulking. If fire-rated caulking is required by code, use same class as walls, ceilings or floors.
- .10 Terminate conduit stubbed up through concrete floor for connection to free standing equipment with a coupling flush with finish floor, and extend conduit to equipment, except where required, use flexible conduit from a point 150 mm above floor.
- .11 Install double locknuts and bushings on all conduit terminations into threadless openings. Increase length of conduit threads at terminations sufficiently to permit bushing to be fully seated against end of conduit.

- .12 Mechanically bend steel conduit.
- .13 Install sealing condulets in conduits at hazardous area boundaries.
- .14 Use EMT indoors unless noted otherwise.
- .15 Use PVC/epoxy-coated rigid galvanized steel conduits and associated components outdoors.
- .16 Final connection to vibrating equipment shall be made with liquid-tight flexible metal conduit. Lengths of liquid-tight flexible metal conduit shall not exceed 1m.
- .17 Use of BX is not allowed on this project. Use liquid-tight flexible metal conduit.
- .18 All conduits and raceways shall be provided with a dedicated ground wire.

#### 3.4 FASTENINGS AND SUPPORTS

- .1 Provide supports and fastenings for the Work of this Division. Do not use supports or equipment provided by other Trades.
- .2 Equipment fastenings and supports shall conform to manufacturers recommendations.
- .3 Do not attach to, or suspend any electrical product or service from the roof deck, mechanical ductwork or piping.
- .4 Do not use wire lashing or perforated strap to support or secure raceways or cable.
- .5 Support rods for any suspended item must not be attached to or extended through steel pan type roofs or through concrete slab roofs. Provide anchors and all accessories required.
- .6 For surface mounting of two or more raceways or cables use channels.
- .7 Where there is no wall support for raceways and cables dropped vertically to equipment, provide channel properly secured to floor and structure.
- .8 Hang supports from structural members. Where location does not permit direct support from structure provide necessary brackets, frames, channels secured to structural members.
- .9 Fasten exposed conduit and cables to building construction or support systems using straps. Use beam clamps on exposed steelwork.
- .10 Masonry, tile and plaster surfaces: use lead anchors.
- .11 Poured concrete: use expandable inserts. Low velocity powder activated fastenings may be used only in poured concrete.
- .12 Steel structures: use clips, spring loaded bolts, cable clamps, designed as accessories to basic channel members.
- .13 Do not use powder activated fasteners in, tile, precast concrete or steel structure.
- .14 Do not install conduits or cables on the bottom chord of joists or trusses.
- .15 Use beam clamps of the 2-bolt design and of such type that the rod load is transmitted only concentrically to the beam web centreline. The use of "C" and "I" beam side clamps will not be allowed.

#### 3.5 JUNCTION BOXES

.1 Install junction boxes in inconspicuous but accessible locations. Secure to structure.

- .2 Install terminal blocks on mounting rails, for termination of each wire and cable regardless of size.
- .3 Only one voltage source is permitted in a junction box.
- .4 Install barriers to separate different auxiliary systems.

#### 3.6 PULL BOXES

- .1 Install pull boxes in inconspicuous but accessible locations. Secure to structure.
- .2 Install pull boxes so as not to exceed 30 m of conduit run between pull boxes.
- .3 Only one voltage source is permitted in a pull box.
- .4 Install barriers to separate different auxiliary systems.

#### 3.7 OUTLET AND CONDUIT BOXES

- .1 Install conduit outlet boxes for conduit up to 35 mm and pull boxes for larger conduits.
- .2 Support boxes independently of connecting conduits.
- .3 Seal boxes during construction to prevent entry of debris, dust and dirt.
- .4 All outlets must be flush-mounted unless approved by Owner's representative.
- .5 For flush installations mount plaster rings to box, flush with wall surface to permit wall finish to come within 6 mm of opening.
- .6 Provide correct size of openings in boxes for conduit, armoured cable connections. Reducing washers will not be acceptable.
- .7 Install switches and other controls close to door lock or latch jambs and other openings, maintaining a minimum of 100 mm from trims of doors (except where installed in door frames of metal partitions) check door swings.

#### 3.8 INSTALLATION OF BRANCH CIRCUIT CONDUCTORS

- .1 Install wiring in conduit and raceways unless noted otherwise.
- .2 Minimum wire sizes:
  - .1 Power and lighting -No. 12 AWG
  - .2 Control -No. 14 AWG
- .3 Wire and cable application and type:
  - .1 Branch circuits other than those covered above use RW90
  - .2 Equipment feeders and circuits use RW90
- .4 Each power circuit requiring a neutral wire shall be provided with a dedicated neutral wire.
- .5 Each power circuits shall be provided with a dedicated ground wire.
- .6 Use lubricant when pulling wires into conduit. Ensure that wires are kept straight and are not twisted or abraded.
- .7 Neatly secure exposed wire in apparatus enclosures with approved supports or ties.
- .8 Junctions of all conductors shall be done with Ideal Wing nut #450 Series (Black) for conductors from #14 AWG to #8 AWG.

- .9 For all conductors larger than #8 AWG junctions shall be done with Burndy Servit connectors wrapped with 3M #33 Scotch tape.
- .10 Drop cords complete with cast boxes for receptacles or similar applications where persons may be within the vicinity of the drop must be mounted a minimum of 6' 6" above the finished floor or low enough to be fastened to a work table or similar item. The purpose of this requirement is to prevent someone from swinging the drop and hitting a person.

# 3.9 CONNECTORS

- .1 Install compression terminations and splices in accordance with manufacturer's written instructions.
- .2 Make splices in junction boxes.
- .3 Make connections in lighting circuits with twist type splicing connectors.
- .4 Terminate and splice conductors No. 8 and larger at terminal blocks in junction boxes.
- .5 Seal terminations and splices exposed to moisture, corrosive conditions or mechanical abrasions with heavy wall heat shrinkable insulation.

#### 3.10 FUSES

- .1 Store fuses in a moisture free location until ready to energize.
- .2 Install fuses, in accordance with manufacturer's printed instructions, immediately prior to energization, only of circuits which fuses protect.
- .3 Prior to acceptance of the Work, clearly mark manufacturer's labels on inside cover of each fusible unit, with ampere rating and catalogue symbol of replacement fuses to be used.

# 3.11 INSTALLATION OF ESCUTCHEON PLATES

.1 Provide escutcheon plates over all exposed conduit passing through walls, floors, ceilings, partitions, furrings etc., in finished areas.

#### 3.12 FIELD FABRICATED METAL WORK

- .1 Clean and prime paint field fabricated metal work.
- .2 After fabrication deburr, scrape, grind smooth, wire brush with power brush and degrease metal work.
- .3 Prime paint steel with 1 coat of CISC/CPMA 2.75 oil alkyd primer.
- .4 Prime paint aluminum as follows: wash with detergent solution and wipe down with SSPC-SP1 solvent. Apply Glidden #Y-5229 primer to 1.5 mils DFT.
- .5 For brass and bronze alloy materials, prepare as for aluminum but apply 1 coat of CAN/CGSB-1.40-M zinc chromate primer.

# 3.13 CUTTING AND PATCHING

.1 Inform other trades in time concerning required openings. In work already finished, cutting and patching shall be done by the trades installing the affected work at the expense of Division 16. Obtain the approval of the Consultant, before doing any cutting.

.2 Repair damaged or otherwise affected surfaces to match condition of existing adjacent surfaces prior construction.

#### 3.14 PENETRATIONS IN EXISTING STRUCTURE

- .1 Perform cutting, patching and repairing. Obtain Consultant's approval before proceeding.
- .2 Where necessary to penetrate existing floors, walls, ceiling, roof or structural members provide sleeve and follow Consultant's instructions.
- .3 Restore surfaces to same finish and condition as existed prior to penetration.
- .4 Core Drilling Procedure
  - .1 Examine locations to be core drilled where:
  - .2 Diameter is greater than 25 mm
  - .3 Multiple drillings required and where the distance between centres is less than 10 times the diameter of the hole
- .5 Examine by most suitable method including:
  - .1 X-ray
  - .2 Ferro scan
  - .3 Cable detection
- .6 Examine from both sides of the structure to be drilled.
- .7 Examine proposed core drilling locations to determine:
  - .1 Possible interference with
    - .1 Services
    - .2 Structural components
- .8 Select locations as suitable for core drilling and label them:
  - .1 Uniquely number each drilling location and core so that markings will be legible after drilling
  - .2 Mark each core with a north pointing arrow where drilling a slab or upward pointing arrow where drilling a wall
- .9 Without interfering with or damaging any services or structural elements, drill pilot holes sufficient to verify location of potential obstructions or for alignment purposes.
- .10 Use impact drill when drilling holes of 25 mm diameter or less. For holes of greater diameter use core drill.
- .11 Prepare report showing intended core drill locations including printouts, X-ray images. Submit the report for approval prior to drilling to Consultant.
- .12 Proceed with core drilling only after approval has been received from Consultant.
- .13 Confine drilling operation to time-of-day as stipulated by Consultant.
- .14 Position suitable warning notices of a type acceptable to Consultant and exercise caution to ensure safety and protection of personnel and property during drilling especially from effects of water, dust damage, or falling objects below the slab or behind the wall being drilled.

- .15 Stop drilling immediately, and report to Consultant, if contact is made with foreign objects such as reinforcing steel (rebar), electrical conduit, water pipes, drainage pipes.
- .16 Cover open holes with secured covers to guard against fall through of objects.
- .17 Provide necessary firestopping, temporary or otherwise, sufficient to firestop holes that would be otherwise open during hours that the location is unattended. Coordinate placement of firestopping with Consultant.
- .18 Provide firestopping of any existing openings in walls or ceilings in the same rooms as new work that are not sufficiently fire-stopped.
- .19 Provide trims and caulking at T-bar ceiling tiles around conduit cuts to close ceilings exposed by conduit penetrations in T-bar ceiling tiles.
- .20 Store all cores or core fragments on site and make them available for inspection by Consultant. Dispose of the cores or core fragments after permission is received from Consultant.

#### 3.15 INSTALLATION OF SLEEVES

- .1 Where conduits, raceways and conductors pass through structural poured concrete, install sleeves, to suit structural details.
- .2 Size sleeves, unless otherwise noted, to leave 12mm clearance around the conduit, raceway, etc. Pack and seal the void between the sleeves and the conduit, raceway, conductor etc. for the length of the sleeves as follows:
  - .1 Pack sleeves set in interior concrete slabs, masonry walls, fire rated partitions, etc., with a U.L.C. and C.S.A. approved fire barrier caulk equal to 3M #CP25.
  - .2 Pack sleeves set in exterior walls with lead wool or oakum and seal the ends of the sleeves water-tight with an approved non-hardening sealant compound. Co-ordinate with the waterproofing trade.
  - .3 Submit to the concrete reinforcement detailed at the proper times, drawings, indicating all required sleeves, recesses and formed openings in poured concrete work. Such drawings shall be completely and accurately dimensioned and shall relate sleeves, recesses and formed openings to suitable grid lines and elevation datum.
  - .4 Install sleeves of a water protecting type in the following locations:
    - .1 In Mechanical Room floor slabs except where on grades.
    - .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.
  - .5 "Gang" type sleeving will be permitted only with the Consultant's approval. All sleeves locations in precast slabs shall be approved by structural Engineer.
  - .6 Terminate sleeves for work which will be exposed so that the sleeve is flush at both ends with the wall, partition or slab surface so that the sleeves may be completely covered by escutcheon plates.
  - .7 Openings for multiple conduit or conductor runs, etc., will be provided by the Division responsible for the particular construction in which the opening is required. Carefully co- ordinate the opening locations with the particular Division and ensure

that openings are suitably sized and located. Seal the space between the opening and the conduit, conductors, etc., for the length of the opening as for sleeves above.

.8 Where a round or formed opening is required, where placement of a sleeve has been missed, or where provision of an opening has not been properly, coordinated with the Concrete Division, neatly cut a suitably sized hole or opening using proper tools to the approval of the Consultant. Prior to cutting any such hole or openings, determine whether or not any reinforcing steel or services, are concealed behind the surface where the holes or opening is to be cut and be responsible for all costs incurred for correcting any damage caused to the structure or services due to cutting holes or openings without prior study and approval.

# 3.16 INSTALLATION OF INSERTS, BEAM CLAMPS, FASTENERS, HANGERS AND SUPPORTS

- .1 Install all inserts, beam clamps, fasteners, and similar hardware required for conduit, duct, raceway, conductor, etc., and equipment hanger and/or support materials to best suit structural details.
- .2 Accurately and properly set concrete inserts in the concrete framework.
- .3 For runs of three (3) or more conduits, raceways, or conductors in concrete formwork, use multiple type inserts used for the smallest conduit in the group.
- .4 Where inserts are required in precast concrete and in concrete work where concrete inserts have not been installed, drill a neat hole of the proper diameter and depth in the concrete and insert an anchor to accept the hanger rod, bolt, etc., or where concrete mass permits, use self-drilling concrete anchors.
- .5 Fasten hangers and support provisions to brick or masonry with expansion shields and machine bolts, or for light loads, use plugs, and screws.
- .6 In cavity walls and/or ceilings use two (2) wing toggles and for heavy loads, provide steel anchor plates with two (2) or more toggles to spread the load.
- .7 Provide beam clamps for attaching, hanging and/or support provisions to the Consultant, weld the hanging and support provisions to the structural steel.
- .8 Explosive power actuated fasteners will not be permitted unless specific approval for their use has been obtained from the Consultant.
- .9 Securely mount plywood backboards to structure or use independent mounting channels, secured to floor.

# 3.17 STANDARD IDENTIFICATION

- .1 Identify electrical work as specified below.
- .2 For each piece of electrical equipment and for any other piece of equipment where specified in this Section, provide engraved lamacoid identification nameplates. Nameplates shall generally be lamacoid black with white letters and with bevelled edges, secured to apparatus with stainless steel screws. Warning signs, if and when required, shall be red with white lettering.
- .3 Exact nameplate wording and sizes must be approved by and confirmed by the Consultant prior to manufacture.

- .4 Clearly identify main pull or junction boxes (excluding obvious outlet boxes) by painting the outside of the covers. Paint colours shall be in accordance with the following schedule:
- .5 Colour code conductors, throughout to identify phases, neutrals and grounds by means of self-laminating coloured tape, coloured conductor insulation, or properly secured coloured plastic discs. Colours shall be as follows:
  - .1 Phase A Red
  - .2 Phase B Black
  - .3 Phase C Blue
  - .4 Ground Green
  - .5 Neutral White

# 3.18 INSTALLATION OF ACCESS DOORS

- .1 Install access doors to give access to all junction boxes, pullboxes, conductor joints and other similar electrical work which may need maintenance or repair but which is concealed in inaccessible construction except as otherwise specified herein or on the drawings.
- .2 Before commencing installation of electrical work, prepare on a set of reflected ceiling plans with complete layouts of all ceiling access door which will be required. Submit these layouts to the Consultant for approval and show the exact sizes and locations of such ceiling access doors. Locate access doors in walls and partitions to the Consultant's approval, and arrange electrical work to suit.
- .3 Access doors will be installed by the Division responsible for the particular type of construction in which the access doors are required. Supply the access doors to the Division installing same at the proper time.
- .4 Access doors shall be, wherever possible, of a standard size, for all applications. Confirm exact dimensions with the Consultant, prior to ordering.
- .5 Submit a sample of each proposed type of access door to the Consultant for approval.

#### 3.19 PAINTING AND FINISHES

- .1 Provide all painting and patching to match existing services as required.
- .2 All exposed electrical fittings, supports, hangers, frames conduit, racks, boxes, raceways and similar material and apparatus shall be galvanized or finished with corrosion resistant primer ready to accept paint. Take special care when priming work exposed to the elements or in wet areas to prevent rust or corrosion from damaging adjacent surfaces.
- .3 Touch up and/or repaint any factory finished equipment that has been scratched or otherwise damaged during installations.
- .4 Provide for all patching and painting for all removals and as required. Painting shall be completed to the approval of the Consultant and Owner. Paint shall match adjacent surfaces. Include all costs.
- .5 Where cutting, patching, fire stopping and construction involves painted surfaces these must be painted to match the surrounding surfaces or as directed by Consultant.

# 3.20 PROVISIONS FOR SERVICES CROSSING BUILDING EXPANSION JOINT

.1 Wherever services (conduit, cables, etc.) cross building expansion joints, install the services in to permit free movement without imposing additional stress or loading upon the support system, and to prevent excessive movement at joints and connections.

#### 3.21 PLYWOOD BACKBOARDS

- .1 Install plywood backboards.
- .2 Paint with fire-rated paint.
- .3 Install equipment on plywood backboards with uni-strut standoffs.
- .4 Ensure integrity of plywood backboards with equipment mounted on them after installation of equipment.

# 3.22 GROUNDING INSTALLATION GENERAL

- .1 Install complete permanent, continuous grounding system including, conductors, connectors, accessories and connect to the existing building ground system. Where EMT is used, run ground wire in conduit.
- .2 Install connectors in accordance with manufacturer's instructions.
- .3 Protect exposed grounding conductors from mechanical injury.
- .4 Make buried connections, and connections to conductive water main, electrodes, using copper welding by thermit process.
- .5 Use mechanical connectors for grounding connections to equipment provided with lugs.
- .6 Soldered joints not permitted.
- .7 Install bonding wire for flexible conduit, connected at one end to grounding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.
- .8 Make grounding connections in radial configuration only, with connections terminating at single grounding point. Avoid loop connections.
- .9 Bond single conductor, metallic armoured cables to cabinet at supply end, and provide non-metallic entry plate at load end.

# 3.23 SYSTEM AND CIRCUIT GROUNDING

.1 Install system and circuit grounding connections to neutral of secondary 120/208V systems.

# 3.24 GROUNDING FIELD QUALITY CONTROL

- .1 Perform ground continuity and resistance tests using method appropriate to site conditions and to approval of local authority having jurisdiction over installation.
- .2 Perform tests before energizing electrical system.

# 3.25 TESTS

.1 Branch circuit balancing.

- .1 Connect all new branch power circuits to existing panelboards so as to balance the actual loads (wattage) within 5%.
- .2 Upon completion of work all equipment shall be thoroughly cleaned, connections tightened, covers secured, and in satisfactory operating condition, with correct phase rotation.
- .3 Carry out insulation resistance (Megger) tests, ground continuity and resistance tests, satisfactory to the Consultant.
- .4 Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential to be 1000 volts dc for one minute.
  - .1 Minimum insulation-resistance values shall not be less than 50 megohms.
  - .2 Investigate deviations between adjacent phases.
  - .3 Include the test result records in the Operations and Maintenance Manuals. **END OF SECTION**

#### Part 1 General

#### 1.1 GENERAL REQUIREMENTS

.1 Comply with the City of Toronto General Conditions, Section 01000, Request for Quotations and Division 26.

#### 1.2 References

- .1 Section 26 05 00 Common Work Results for Electrical also applies to and is a part of this Section of the Specification.
- .2 Conform to latest issues, amendments and supplements of following standards:
  - .1 CSA C22.2 No. 5.1M Moulded Case Circuit Breakers
  - .2 CSA C22.2 No.39-M1987 (R2007), Fuseholder Assemblies.

#### **1.3** SCOPE OF WORK

.1 Supply all labour, tools, services and equipment and provide all materials and equipment required to complete service and distribution work in accordance with this section of the specification and the drawings.

#### 1.4 QUALITY ASSURANCE

- .1 All low voltage distribution work shall be executed by skilled tradesmen fully experienced in the installation of electrical power systems.
- .2 All equipment shall be constructed to EEMAC standard and shall carry the CSA label or the contractor shall obtain Electrical Safety Authority approval.
- .3 All equipment shall be suitably noted for the system available fault and HRC fuses shall comply with CSA C22.2 No. 106.

## 1.5 SUBMITTALS

- .1 Refer to Division 1 General Requirements and submit shop drawings for the following:
  - .1 Breakers
  - .2 Panelboards
  - .3 Transformers
  - .4 Fusible and Non-Fusible Disconnect Switches
  - .5 Wiring Devices

#### Part 2 PRODUCTS

#### 2.1 **REFERENCES**

.1 Refer to Section 26 05 83 Electrical Basic Materials. This Section also applies to and is part of this section of the specifications.
#### 2.2 BREAKERS GENERAL

- .1 Bolt on moulded case circuit breaker, quick make, quick break type, for manual and automatic operation with temperature compensation for 40°C ambient.
- .2 Common trip breakers with single handle for multipole applications.
- .3 Moulded case circuit breakers shall operate automatically by means of thermal and magnetic tripping devices to provide inverse time current tripping.
- .4 Magnetic instantaneous trip elements in circuit breakers, to operate only when the value of current reaches setting. Trip settings on breakers with adjustable trips to range from 3 10 times current rating.
- .5 Circuit breakers with interchangeable trips as indicated.
- .6 Short circuit rating of circuit breakers shall be 22kA rms sym.

# 2.3 PANELBOARDS

- .1 The panelboards shall be as scheduled on drawings and as specified herein after.
- .2 Ratings
  - .1 Panelboards shall have short circuit ratings not less than 22,000 amperes RMS symmetrical.
  - .2 Panelboards shall be labelled with a CSA short circuit rating.
  - .3 When series ratings are applied with integral or remote upstream devices, a label shall be provided. Series ratings shall cover all trip ratings of installed frames. It shall state the conditions of the CSA series ratings including:
    - .1 Size and type of upstream device.
    - .2 Branch devices that can be used.
    - .3 CSA series short circuit rating.
- .3 Construction
  - .1 Interiors shall be completely factory assembled devices. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
  - .2 Trims for panelboards shall be supplied with a hinged door over all circuit breaker handles. Doors in panelboard trims shall not uncover any live parts. Furnish semi flush cylinder lock and catch assembly to secure hinged door over circuit breaker handles. Provide door-in-door type construction so that the trim may be opened to access wireways without removing the trim from the panel. All trims shall have concealed mounting hardware when the door is closed.
  - .3 Panelboard trims shall cover all live parts. Switching device handles shall be accessible.
  - .4 Surface trims shall be same height and width as box.
- .4 A fully labelled directory card with a clear plastic cover shall be supplied and mounted on the inside of each door.
- .5 All locks shall be keyed alike.

# .6 Bus

- .1 Main bus bars shall be silver flashed copper, sized in accordance with CSA standards to limit temperature rise on any current carrying part to a maximum of 65 degrees C above an ambient of 40 degrees C maximum.
- .2 An insulated ground bus shall be included in all panels. Ground bus shall be copper.

#### .7 Enclosure

- .1 Enclosures shall be at least 20 inches wide made from galvanized steel. Provide minimum gutter space in accordance with the Canadian Electrical Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.
- .2 Enclosures shall be provided with one (1) blank end and one end with knockouts.
- .3 Enclosures shall be EEMAC type 2 sprinkler-proof and provided with drip hood.
- .8 The panelboard shall be selected so that it can fit into the space available in the room with the other equipment mounted and shall meet the requirements of the Ontario Electrical Safety Code.
- .9 Acceptable manufacturers are Eaton, Schneider Group (Square D), Siemens or approved equal.

#### 2.4 TRANSFORMERS

- .1 Use transformers of one manufacturer throughout the Project.
- .2 Design:
  - .1 Type: ANN. All transformers to be delta-wye configuration unless otherwise noted on the TENDER Drawings.
  - .2 3-phase, kVA and voltages as indicated on the plans, 60Hz.
  - .3 Provide voltage taps of  $2 \pm 2.5$  per cent FCAN (Full Capacity above Normal) and FCBN (Full Capacity below Normal).
  - .4 Insulation: 220°C Class-H, 150°C temperature rise.
  - .5 All windings shall be copper.
  - .6 Basic Impulse Level (BIL): Standard.
  - .7 Hipot: Standard.
  - .8 Average Sound Level: 65dBA (measure 1 metre from enclosure).
  - .9 Impedance at 170°C: Five (5) per cent.
  - .10 Enclosure: Type 3R sprinkler proof, removable metal front panel.
  - .11 Mounting: Floor or wall, as indicated on the TENDER Drawings.
- .3 Transformer to meet CSA C802.2 efficiencies at 35 per cent of rated load.
- .4 Finish in accordance with sections 26 05 00 and sections 26 05 83.
- .5 Accessories:
  - .1 Grounding Terminal: Inside enclosure.
  - .2 External vibration pads equal to Mason Super 'W'.
  - .3 Nameplate shall be stainless steel.

- .4 Equipment Identification:
  - .1 Provide equipment identification in accordance with sections 26 05 00 and sections 26 05 83.
  - .2 Label Size: 6mm(1/4") letters.
- .5 Finish:
  - .1 Finish enclosure exterior in accordance with sections 26 05 00 and sections 26 05 83.
  - .2 Transformer to be painted ANSI-61 grey.
- .6 Acceptable Manufacturers:
  - .1 Delta
  - .2 Marcus Transformer
  - .3 Hammond Power Solutions
  - .4 Rex Power Magnetics
  - .5 or approved equal

# 2.5 FUSIBLE AND NON-FUSIBLE SAFETY SWITCHES (DISCONNECTS)

- .1 Safety switches shall be heavy duty series safety switches.
- .2 Each safety switch shall be front operated with red handle suitable for padlocking in the "OFF" position and arranged so that the enclosure cover cannot be opened with the handle in the "ON" position. Operating mechanisms shall be quick make, quick break, positive acting with visible blades, and a line terminal shield. Fusible units shall be complete with fuse clips suitable for H.R.C., Class "J" fuses unless otherwise noted. Each unit shall also be equipped with solderless lugs and a front cover nameplate identifying the catalogue number and electrical characteristics.
- .3 Enclosures for safety switches shall be, unless otherwise noted, EEMAC 3R raintight (sprinkler-proof) enclosures provided with drip hood.
- .4 The ampere rating, number of poles, and fuse requirements for safety switches shall be as specified on the drawings.
- .5 The discount switches shall be selected so that they will fit into the space available in the electrical room and meet the requirements of the Ontario Electrical Safety Code.
- .6 Electrical Interlock: Mechanically operated from switch mechanism, rated 120 VAC, 15A, 1 NO and 1 NC contact.
- .7 Acceptable manufacturers are Schneider Group, Siemens, Eaton or approved equivalent.

# 2.6 GROUNDING EQUIPMENT

- .1 Clamps for grounding of conductor: size as required to electrically conductive underground water pipe.
- .2 Grounding conductors: bare stranded copper, soft annealed, size as indicated.
- .3 Insulated grounding conductors: green, type RWU.
- .4 Ground bus: copper, size as indicated, complete with insulated supports, fastenings, connectors.

- .5 Non-corroding accessories necessary for grounding system, type, size, material as indicated, including but not necessarily limited to:
- .6 Grounding and bonding bushings.
- .7 Protective type clamps.
- .8 Bolted type conductor connectors.
- .9 Thermit welded type conductor connectors.
- .10 Bonding jumpers, straps.
- .11 Pressure wire connectors.

# 2.7 WIRING DEVICES

- .1 Ground fault circuit interceptor receptacles (GFCI) Class A:
  - .1 Shall be an integral unit, hospital-grade, suitable for mounting in a standard outlet box, with end-of-life indication and provisions to isolate the face due to improper wiring, rated single phase, 20 amperes, 125 V, 2-pole, 3-wire.
  - .2 Where a specialty control or communication box is installed requiring a duplex GFCI or regular receptacle with equipment, components transformers and the like it must be CSA or ESA approved with stickers.
  - .3 Ground fault interrupter shall be consisting of a differential current transformer, solid state sensing circuitry and a circuit interrupter switch. Device shall have nominal sensitivity to ground leakage current of 4-6 mA and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes (± 1 mA) on the load side of the device. Device shall have a minimum nominal tripping time of 0.025 second.
  - .4 Ivory high strength nylon.
  - .5 Suitable for No. 10 AWG for back and side wiring.
  - .6 20 amp feed through rating
  - .7 Shallow body type.
- .2 Provide ground fault circuit interrupter (GFI) receptacles as shown on the Contract Drawings.
- .3 Provide weather-proof GFI receptacles complete with weather-proof extra duty-rated in-use covers for all outdoor receptacles.

#### Part 3 EXECUTION

#### 3.1 GENERAL

- .1 Protect equipment from dust, debris, moisture, and physical damage, with sealed envelope of plastic or other impervious material until building is enclosed and cleaned and equipment is energized.
- .2 Protect from condensation by maintaining at suitable temperature above  $0 \square C$ .
- .3 Finish equipment enclosures to ANSI 49 or ANSI 61, baked grey enamel.

# 3.2 INSTALLATION OF BREAKERS

.1 Install breakers per the manufacturer's recommendations and the Tender Drawings.

#### 3.3 DISCONNECT SWITCHES

.1 Install disconnect switches complete with fuses as indicated.

### 3.4 DISTRIBUTION PANELS

- .1 Locate panelboards and fasten to wall.
- .2 Connect main secondary service to line terminals of main breaker.
- .3 Connect load terminals of distribution devices to feeders.
- .4 Check factory made connections for mechanical security and electrical continuity.
- .5 Run grounding conductors from ground bus to building ground to suit the Electrical Safety Code.
- .6 Check trip unit settings and or fuse sizes to ensure proper working and protection of components.
- .7 Balance phases to the maximum extent possible.

#### 3.5 TRANSFORMER INSTALLATION

- .1 Mount dry type transformers, as per TENDER Documents. Transformers 75kVA and under may be wall-mounted. If transformers are to be floor mounted, provide and mount on a raised concrete pad (100mm). Structure to take into account the building structure within the respective room.
- .2 Provide external vibration isolation pads under transformer.
- .3 Ensure adequate clearance around transformer for ventilation.
- .4 Install transformers in level upright position.
- .5 Remove shipping supports only after transformer is installed and just before putting into service.
- .6 Loosen isolation pad bolts until no compression is visible.
- .7 Make primary and secondary connections with flexible conduit and in accordance with wiring diagram.
- .8 Energize transformers after installation is complete.

#### 3.6 GROUNDING INSTALLATION GENERAL

- .1 Install complete permanent, continuous grounding system including, conductors, connectors, accessories and connect to the existing building ground system. Run ground wire in all conduit.
- .2 Install connectors in accordance with manufacturer's instructions.
- .3 Protect exposed grounding conductors from mechanical injury.
- .4 Make buried connections, and connections to conductive water main, electrodes, using copper welding by thermit process.
- .5 Use mechanical connectors for grounding connections to equipment provided with lugs.
- .6 Soldered joints not permitted.

- .7 Install bonding wire for flexible conduit, connected at one end to grounding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.
- .8 Make grounding connections in radial configuration only, with connections terminating at single grounding point. Avoid loop connections.
- .9 Bond single conductor, metallic armoured cables to cabinet at supply end, and provide non-metallic entry plate at load end.

### 3.7 SYSTEM AND CIRCUIT GROUNDING

.1 Install system and circuit grounding connections to neutral of secondary 120/208V and 347/600V systems.

### 3.8 GROUNDING FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Section 26 05 00 Common Work Results for Electrical.
- .2 Perform ground continuity and resistance tests using method appropriate to site conditions and to approval of local authority having jurisdiction over installation.
- .3 Perform tests before energizing electrical system.

# 3.9 TESTING AND INSPECTION OF POWER DISTRIBUTION SYSTEM

- .1 Provide on-site inspection and testing of the following main distribution equipment:
  - .1 Distribution Equipment
  - .2 Grounding System
- .2 This inspection and testing shall be done prior to the system being energized and shall include the following items where applicable:
  - .1 Testing, cleaning and where necessary, calibrating all relays and circuit breaker trip devices.
  - .2 Function test of protection and control devices.
  - .3 Megger test interconnecting cables.
  - .4 Replacement of fuses, breakers, contactors or any other equipment destroyed or damaged during the start- up or testing;
- .3 Provide reports confirming resistance to ground and megger test reports for wiring installed under this project. Include reports in Operations and Maintenance Manuals.
- .4 Make good any defects indicated in the equipment and in the installation by the tests.

# END OF SECTION