



ADDENDUM

ADD 01

Project Name:	Toronto Public Library: Pleasant View Library	ADD No.	01
Project Address:	575 Van Horne Ave North York, ON M2J 4S8	No Pages :	73 (Including Cover)
Project No.	22-008	Owner: :	TPL
Prepared By:	Tiffany Tse		
Date:	2025.09.19		

The following information supplements and / or supersedes the bid documents issued on the tender submission date noted above and all previously issued addenda. This addendum is to be read, interpreted, and coordinated with all other parts. The cost of all contained herein is to be included in the contract sum. The following revisions supersede the information contained in the original drawings and specifications issued for the above named project to the extent referenced and shall become part thereof. Acknowledge receipt of this Addendum by inserting its number and date on the Tender Form. Failure to do so may subject to disqualification.

1.0 General Answers to Questions

As per 251-25-TPL-RFT document

Responses shall be based upon the materials and products specified within the deliverables. The Library will allow equivalents to the products or materials specified only as follows:

- *Full descriptive literature regarding the suggested equivalent is submitted in writing to the Library, prior to the deadline for questions for Consultant's review.*
- *The Library has provided written approval of the suggested equivalent, via addenda.*

The following substitutions have already been approved from the original RFT via Addendum.

- *Regupol America in place of Tarkett for RAF-1. GC to ensure that it matches the specifications and finish of the Tarkett product and that it is a rolled product and can be mounted on the wall. Also, please replace L-1 Vinyl Tarkett Acczent Excellence 80 with Polyflor Expona Light Industrial Concrete 9860.*
- *Sol Shades is an acceptable manufacturer of blinds as long as finish, colour, transparency and functionality levels match specification.*

As per specification: Drawings, specifications, and schedules are complementary each to the other and what is called for by one to be binding as if called for by all. Should any discrepancy appear between documents which leaves doubt as to the intent or meaning, abide by Precedence of Documents article below or obtain direction from the Consultant. Examine all discipline drawings, specifications, and schedules and related documents to ensure that Work can be satisfactorily executed. Conflicts or additional work beyond work described to be brought to attention of Consultant.

1.1 Question: 1.The following specification sections are missing from the spec:

01 71 00 Examination and Preparation
01 91 11 Life Safety Commissioning
07 26 16 Underslab Vapour Retarder
32 13 13 Concrete Pads, Sidewalks, Curbs and Gutters.

Response:

01 71 00 Examination and Preparation - Remove from table of contents, items covered in other sections of the specification
01 91 11 Life Safety Commissioning - Please see attached section here
07 26 16 Underslab Vapour Retarder - Please see attached section here
32 13 13 Concrete Pads, Sidewalks, Curbs and Gutters, remove from table of contents, 03 33 11 - Concrete, covers all landscape related concrete work



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2.0 Architectural items

- 2.1 Question: Drawing A1.04 includes the note: "Remove all existing accesses, curb cuts, and traffic control signs..." However, the note is general and lacks specific details. Unless further clarification is provided through an addendum, bidders will assume that all items referenced in this note are included in A1.04. The note, as written, is too broad to allow for accurate assumptions.**
Response: As requested by the City of Toronto during the Site Plan Approval stage, this note applies to anywhere where City property may be affected due to work done during construction needs to be reinstated. For example, the corner location where the project is requiring new paving and tactile markers, vehicle entry/exit and the new sidewalk. This note is directly from the City.
- 2.2 Question: Note 5 on A1.31 states: "Repair foundations as required...provide temporary supports as required."**
Response: Reference Questions 2.1
- 2.3 Question: Please provide the details and clarify on the details what type of supports and repairs are required. At this time, it is unclear what specific repairs are intended. This request also applies to detail 23/A1.21.**
Response: Please refer to the existing building condition report where the foundations are marked and describe the need for repair.
- 2.4 Question: Could you please specify the size and manufacture of precast concrete Panel (brick pattern-W3 wall Type)?**
Response: No, this is a performance specification, GC to provide a manufacturer that meets the requirements. Custom panels to meet the shape and form of the building, standard thickness as per specification section 03 45 10.
- 2.5 Question: Can you please provide specifications MT5 finish on A8.15 for handrail or assist us to locate the specifications in the tender documents?**
Response: GC to reference specification, metal to match specifications outlines in section 05 50 00 Metal Fabrications with the finish to be brushed brass
- 2.6 Question: Drawing A2.12 notes tapered panels along grid line 8 without detail no specification of tapered panel material. Can you please provide this information?**
Response: The tapered panels are the polyisocyanurate insulation panels that are required to taper/shape towards the rain water outlet/ drain. Reference related specification sections.
- 2.7 Question: Please confirm if VIN1 graphics will be part of sign cash allowance or not?**
Response: No it will not be a part of the sign cash allowance, please include for it in your pricing package
- 2.8 Question: Could you please explain how bidders suppose to provide price if 11/A6.02 has note that WP-2 design to be confirmed? Can bidders assume for pricing purpose that lay-out for WP-2 will be similar to the depicted on the drawings?**
Response: Yes, please use the lay-out for WP-2 as depicted on drawing A6.02 for pricing purpose, final design will not deviate significantly
- 2.9 Question: The dimensions between Architectural Grid Lines 4-5 on A2.11 are different than the dimensions between the Structural Grid Lines 4-5 on S2.02, both using 1:100 scales. In addition the architectural have grid lines 1-8 while the structural only have grid lines 1-6. Please advise.**
Response: The dimensions are consistent; however please see attached A2.11 for consistency



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- 2.10 **Question:** Can you please indicate on the RCP exactly where we are to wrap existing joists in wood veneer shown on 10/A8.04

Response: Please see attached diagram highlighting location on A2.31

- 2.11 **Question:** Is there a finish / colour chosen for S-1, W-5 or MT-1

Response: They are all to match the metal screen and curtain wall (Basis of design Champagne 76 - Alumicor , Champagne Bronze 52 - BVGlazing Systems)

- 2.12 **Question:** Can you provide the drawing number that specifies dimensions or tag number W5 parapets length please

Response: Please reference A4.2 series

- 2.13 **Question:** Can you clarify that bug screen is to used only where S-1 meets W5

Response: Not necessarily, please reference drawing section A4.0 series for additional details

3.0 Mechanical Items

- 3.1 **Question:** Please see below note from Mechanical Contractor how it was written:

I am looking through the specifications and noticed section 25 for BAS (Building Automation System) is missing, although noted that its in there. Do you know if there is a BAS System?

Response: Please see attached section

25 13 01 - B.A.S Building Controllers

25 13 01 - B.A.S Building Controllers

24 14 01 - B.A.S Equipment Controllers

25 35 01 - B.A.S Instrumentation and Actuators

25 90 01 - B.A.S Sequence of Operations

- 3.2 **Question:** Please send the Engineer an RFI, some confusion on the pipe size of the LPR / LPS. On drawing M-411 the note #3 on the top right-hand side of the page is telling me that the (2) LPR are ¾" and on the drawing the LPS is 3", is this correct ??

Response: The low pressure steam supply is 3". Per drawing Note 3, the contractor is to provide a steam trap and a ¾" LPR at low points of the steam supply line. The low points will be dictated by site conditions, therefore, the return lines are not explicitly shown on the drawings. That is why the note calls for an allowance of up to 50 ft of piping for the LPR.

- 3.3 **Question:** Also ,I need to know what type of piping that can be used for the LPR/LPS, the specs. mention Copper Type K. Can Sch80 steel pipe be use in lieu of copper?

Response: Steam and condensate return piping to be copper per specifications.



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4.0 Electrical Items

- 4.1 Question: Regarding the access control, 14 card reader doors are noted on the door schedule but not shown on the drawings, Please confirm are those to be carried by security contractor? Also if these system to be stand alone system?**

Response:

All electrical wiring and cabling work shall be carried by the General Contractor as part of the base contract. Supply, installation and commissioning of the access card readers shall be completed by one of TPL's pre-qualified security vendor, which will be carried by the General Contractor. Refer to RFP where it states "GC to carry a pre-qualified security sub-trade to install the fully commission the cameras, access card readers, and intrusion detection system." The access card reader system is a stand-alone fob access connected to the Keyscan Fob access system owned by TPL.

- 4.2 Question: Please confirm that card readers will be supplied and installed by contractors including electrical wiring.**

TPL response : Refer to response from previous (4.1)

- 4.3 Question: Please note that car readers on the door schedule are not noted on electrical drawings. Without the card readers noted on electrical drawings they will be supplied and installed without the electrical connection.**

Response: Contractor to provide conduit and junction box for security device as per drawing note 4 on E-311 and A7.01.

- 4.4 Question: Please confirm that the security system will be a stand-alone system provided by contractor, or it will be connected to the remote central terminal by TPL**

Response: The keyscan security system hardware included in this project will connect to an existing Keyscan Aurora Software platform. The Security integrator on the project will be required to supply, install, and fully license/commission all components to make the system fully functional.

- 4.5 Question: Please specify how many access cards for card readers will be required.**

Response: Please reference previous questions as well A7.01 and E311.

- 4.6 Question: Our electrical suppliers are requesting to provide Lighting Fixture specifications for the following types, as they aren't included in the Lighting Schedule or shop drawings: Types - ACFA, ACFB, ACFC, E2, E3 & E4**

Response: ACF-A/B/C are non lit / electrical versions of the LS4 A/B/C. They are acoustical systems, please reference A2.31, A7.21 and specifications for additional details. For emergency lighting please reference specification sections 26 52 00

5.0 Civil Items

N/A

6.0 Landscape Items

- 6.1 Question: Please provide drawing which shows new curbs in the parking lot. It is impossible to understand from architectural and landscape drawings location of new curbs.**

Response: Please see attached A1.04 diagram

- 6.2 Question: Landscape drawing notes 9 removable bollards, (detail 6/L-D2) but landscape drawing show only 3 bollards (blue circles). Can you please explain this discrepancy?**

Response: The detail callout for the removable bollard has been updated to reflect correct amount (3). Please refer to the Reference note Schedule for the correct quantities.

- 6.3 Question: Please provide a detail for dropped curb on parking with location of tactile. It is impossible to understand from the city of Toronto detail on LD-2 how many tactiles will be installed and how tactiles will interface with pavers pattern.**

Response: The City of Toronto tactile and drop curb details shown on drawing L-D2 apply to the proposed sidewalk only.



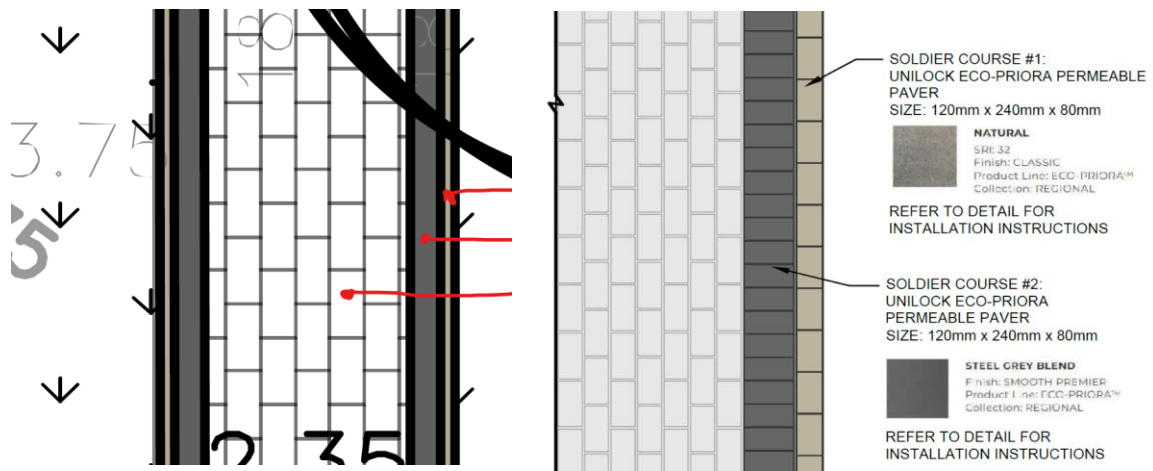
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- 6.4 **Question:** Detail 7/LD-1 indicates a paver pattern incorporating a soldier course; however, the overall site plan on L-L-1 does not depict this pattern. L-L1 shows only one paver colour Steel Grey Blend on the edge, however 7/LD-1 shows two paver colours on the edge (Grey Blend and Regional). Can you please explain this discrepancy?

Response: The landscape plan does illustrate the correct paver pattern as per Detail 7/LD-1. Due to the drawing scale and line weight, the pattern may not be immediately visible – we recommend zooming in for clarity. Please note that the overall landscape plan is intended for reference only; the actual paver layout is to match Detail 7/LD-1 precisely.

Regarding the colour notation, the outer soldier course#2 is specified as Natural. "Regional" is not a paver colour – please refer to the screenshots below, as well as review drawings and specifications for clarification.



- 6.5 **Question:** L-D3 includes a note stating: "Contractor to provide structural stamped drawings for review and approval." The bidders are requesting clarification on why Engineering Link is not reviewing the landscape drawings. Please be advised that if Engineering Link will not review and stamp the structural drawings related to landscape works, then any contractor-proposed changes to concrete and rebar noted on the landscape drawings after tender closing will be considered extras to the contract.

Response: The General Contractor's fee must cover the review of drawings, any suggested revisions or alterations, materials for any proposed elements, and the cost of obtaining structurally stamped drawings for the constructability of the entrance sign shown on LD-3.

- 6.6 **Question:** Please confirm if sign on L-D3 will be paid from the sign cash allowance or not.

Response: No this is to be included in the base fee

- 6.7 **Question:** Please provide drawing noted asphalt area for replacement. Without this information each contractor will have different interpretation new asphalt area.

Response: Please refer to the existing building condition report where the locations are marked and describe the need for repair.



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7.0 Structural Items

7.1 **Question:** Can you please explain the meaning of CB abbreviation on S2.02 and S2.03?

Response: Please reference Structural Abbreviations on S1.03

7.0 Attached Items

01 91 11 - Commissioning of Life Safety and Fire Protection Systems
07 26 16 - Underslab Vapour Retarder
25 05 01 - Building Automation Systems General
25 13 01 - B.A.S Building Controllers
24 14 01 - B.A.S Equipment Controllers
25 35 01 - B.A.S Instrumentation and Actuators
25 90 01 - B.A.S Sequence of Operations
L-L1 Landscape Plan
A1.04 Site Plan - Diagram Only
A2.11 Plan - Level 01
A2.31 RCP- Level 01 Diagram Only

ADDENDUM 1
00 91 13 01

The information listed below is to form part of the Contract Documents. All associated costs are to be included in Tender Price shown on Tender Form. Acknowledgment of this Addendum, by number, to be shown in space provided on Tender Form.

1 GENERAL SPECIFICATIONS

1.1 Section 01 91 11 – Commissioning of Life Safety and Fire Protection Systems (Issued)

.1 Add specification section in its entirety.

2 MECHANICAL SPECIFICATIONS

2.1 Section 25 05 01 – Building Automation Systems General (Issued)

.1 Add specification in its entirety.

2.2 Section 25 13 01 – B.A.S. Building Controllers (Issued)

.1 Add specification in its entirety.

2.3 Section 25 14 01 – B.A.S. Building Equipment Controllers (Issued)

.1 Add specification in its entirety.

2.4 Section 25 35 01 – B.A.S. Instrumentation and Actuators (Issued)

.1 Add specification in its entirety.

2.5 Section 25 90 01 – B.A.S. Sequence of Operations (Issued)

.1 Add specification in its entirety.

END OF ADDENDUM

END OF SECTION

COMMISSIONING OF LIFE SAFETY AND FIRE PROTECTION SYSTEMS

01 91 11

1 GENERAL

1.1 Scope

- .1 Provide coordinated commissioning for all life safety and fire protection systems and related equipment as per the latest CAN/ULC S1001 requirements and per the requirements described within this section.
- .2 Coordinate and jointly prepare with the Division 20 and 26 contractors to conduct complete and thorough testing and documentation of the systems interface and integration between various LSFP systems provided under those Divisions, and equipment and/or systems provided under other Divisions of the Work including but not limited to;
 - .1 Fire Alarm Systems
 - .2 Mass Notification Systems
 - .3 Audio/Visual Systems
 - .4 Sprinkler Systems
 - .5 Standpipe Systems
 - .6 Hold-open and electromagnetic devices
 - .7 Ventilation Systems
- .3 Include all labor and material as required to manage, develop and implement the life safety and fire protection commissioning process.
- .4 This section, including Schedule A, does not limit or otherwise intend to assign the responsibility to solely manage the development and implementation of the LSFPCx program to either the Division 20 contractor or Division 26 contractor.
 - .1 For clarity, it is the joint responsibility of the General Contractor or Construction Manager and the trade contractors to manage, develop and implement this program with respect to the Work performed under their respective divisions.
 - .2 For clarity, reference to Division 20 means the Work under Divisions 20, 21, 22, 23 and 25.
 - .3 For clarity, reference to Division 26 means the Work under Divisions 26, 27 and 28.
 - .4 For clarity, it is not the intent of this specification to assign responsibility for commissioning of other fire protection or life safety equipment or systems which form part of other divisions of the Work to the Division 20 and 26 contractors.

1.2 Abbreviations and Definitions

- .1 Abbreviations:
 - .1 *LSFP* – life safety and fire protection systems provided under Division 20 or 26 as applicable..
 - .2 *LSFPCx* – life safety and fire protection systems commissioning.
- .2 Definitions:
 - .1 *Major deficiency* – an item which if not corrected renders the equipment or system unsuitable or un-safe for use by the Owner. Major deficiencies must be corrected as a condition for achieving Substantial Performance and Occupancy Permit.
 - .2 *Minor deficiency* – an item which does not impact on the operation of the equipment or system and will allow the Owner to use the system safely. Minor deficiencies may be corrected before or

after Substantial Performance, but will not prevent certification of Substantial Performance of the Work.

1.3 Applicable codes and standards

.1 Installation standards and codes:

- .1 NFPA 3 Recommended Practice for Commissioning and Integrated Testing of Fire Protection and Life Safety Systems

1.4 Submittals

.1 First submittal:

- .1 Submit a draft of the LSFPCx plan including, the table of contents and test forms for each integrated system, for review and approval by the Owner and Consultant at least six months prior to start of commissioning.

.2 Second submittal:

- .1 Submit the completed draft LSFPCx plan and all test procedures for review and approval by the Owner and Consultant at least two months prior to start of commissioning.

2 PRODUCTS

2.1 Not Applicable

3 EXECUTION

3.1 Roles and Responsibilities

.1 Owner;

- .1 establishes acceptance criteria and approves LSFP commissioning plan and procedures;
- .2 provides operations staff to receive training, and to witness any or all tests at their discretion;
- .3 final acceptance of commissioning results;
- .4 the Owner reserves the right to approve proposed technicians with regard to the technical skill level required for each type of equipment and/or system, and a willingness by the individual(s) to work within the commissioning team.

.2 Design Consultant;

- .1 responsible for the construction review activities in accordance with local building code requirements;
- .2 review of LSFP commissioning plan, procedures and test results.

.3 General Contractor / Construction Manager;

- .1 manages and coordinates the LSFP commissioning activities;
- .2 integrates commissioning activities into the construction schedule;
- .3 ensures commissioning procedures are completed and documented, and commissioning records including any required attachments are submitted;
- .4 provide access for all participants in the LSFPCx program to the contract plans, shop drawings, and equipment cut sheets of all installed equipment.

.4 Division 20 and Division 26 Contractors;

- .1 Participate in the development and implementation of the LSFPCx program for the equipment and systems provided under Division 20 and 26, including the development of commissioning test plans.
- .2 provide the services of qualified technician(s) who are familiar with the construction and operation of the system, to start-up and debug equipment and systems within the Division 20 and Division 26 scope of Work; ensure the qualified technician(s) are available and present during commissioning testing to complete the tests, make adjustments and to assist in problem resolutions,
- .3 should any equipment or system experience performance problems and/or if reconstruction or replacement of components is required, include for additional technician time for subsequent retesting of systems until required system performance is achieved,
- .5 Equipment suppliers;
 - .1 provide the services of manufacturers' service personnel to provide assistance with pre-start and initial start-up of the equipment, as required.

3.2 LSFP Commissioning Process

- .1 LSFPCx mandate: to ensure that project life safety and fire protection systems perform interactively and in strict accordance with the design intent and Owner's operational needs as set forth in the Contract Documents and as required by the Building Code and Fire Code.
- .2 Implementation of the LSFPCx work includes, but is not limited to;
 - .1 chair and manage LSFPCx meetings during the construction period associated with the scheduling, coordination, and implementation of the LSFPCx activities within the overall construction program,
 - .2 developing a coordinated commissioning plan including test procedures,
 - .3 providing qualified personnel for implementing LSFPCx test procedures,
 - .4 start-up of equipment,
 - .5 conduct complete and thorough testing and documentation of the operation and performance of all LSFP equipment, sub-systems and systems,
 - .6 providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the LSFPCx process,
 - .7 preparation of a final LSFPCx report documenting all test results and submit the report to the Owner and Consultant.

3.3 LSFPCx Schedule

- .1 Completion of the LSFPCx program is a condition precedent for the application for occupancy permit. Schedule and complete the LSFPCx program in its entirety and provide the final report and test results to the Consultant at least one week prior to application for occupancy permit.
- .2 Develop a detailed LSFPCx commissioning schedule for consolidation into the main construction schedule, which identifies each equipment and system by task as well as system integration testing. Include;
 - .1 commissioning plan by each Division,
 - .2 equipment and systems start-up predecessors,
 - .3 time periods for pre-start and start-up testing, verification and validation testing for each equipment and system.

3.4 Commissioning Procedures

- .1 Develop commissioning test procedures and reports for LSFP systems which include, but are not limited to, the following requirements:
 - .1 a comprehensive functional matrix depicting all system inputs and associated output functions,
 - .2 the extent of systems to be tested under the direct supervision of the Division 20 and Division 26 contractors,
 - .3 test processes,
 - .4 test scenarios developed to verify appropriate system responses to the functional matrix, and
 - .5 a test event schedule which identifies the tasks and the applicable stakeholders.
- .2 Test procedures are to include start-up verification checklists, performance/control validation checks, integrated system checks, and result records for each test.
- .3 Start-up verification checklists minimum requirements:
 - .1 confirmation of authorities inspections, pre-start safety checks (where applicable), and coordination of required supporting systems,
 - .2 verify the installation of equipment, including design document requirements, manufacturer installation requirements, and other experience-related items,
 - .3 verification of the installation of the complete system,
 - .4 use of pre-printed manufacturer installation and start-up checklists are permitted and encouraged.
- .4 Performance/controls validation procedure:
 - .1 specific test procedures and record documentation requirements for performance measurements and control validation of the various systems,
 - .2 step-by-step testing methodologies to prove the functional operation of control systems, for normal and abnormal operating conditions, and alarm conditions.
- .5 Integrated system testing procedure:
 - .1 step-by-step test methodology to prove functional operation of integrated control systems, interlocks, and system response performance, including power failure re-start on generator power, and revert to normal power.

3.5 Operator Training

- .1 In addition to training requirements described in other specification sections, provide the following training on LSFP system integration.
 - .1 Include classroom instruction, delivered by competent instructors such as manufacturer installation and service personnel.
 - .2 Training topics to include;
 - (a) types of installed systems,
 - (b) overall integration structure,
 - (c) integration and interlocking hardware and wiring,
 - (d) workflow sequences between interlocked systems,
 - (e) system timing response,
 - (f) system initialization and resetting,
 - (g) different operating modes – automatic smoke control, manual fan operation, etc
 - (h) operation of smoke control station,
 - (i) service, maintenance, diagnostics and repairs,
 - (j) use of reports and logs,

(k) troubleshooting.

- .3 Structure each session to start with the classroom instruction for the overall system, followed by hands-on instruction for each equipment, with the services of the manufacturers' representative as required. Demonstrate the start-up and shut-down of each system.
 - .4 Organize and schedule each training session to deliver the required instruction in an efficient and effective manner on a schedule agreed upon with the Owner. Allow for two (2) training sessions for each topic, separated by approximately one week each, to allow for Owner's shift coverage.
 - .5 Structure each training session based on type of maintenance personnel attending the training session, i.e. electricians, general maintenance, controls technicians, etc. Develop the proposed training plan and obtain approval from the Owner before commencing the training.
 - .6 Complete the training as close to Substantial Performance as possible, so that the Owner's operations staff are prepared to operate the system after Substantial Performance is certified.
- .2 Provide training manuals which documents the above specified training topics.
 - .1 Provide training material hand-outs for each session.
 - .2 Collect training material and bind into separate binders.

3.6 Test Issues Log

- .1 Maintain a record of faults, failures, and discrepancies discovered through the testing process in a deficiency test record, which lists;
 - .1 each separate finding and its corresponding resolution, including dates of discovery and resolution, and
 - .2 corrective action taken which describes the specific and detailed description of actions taken to remediate faults, failures, and discrepancies discovered during the testing process,
- .2 Manage the test log documentation, tracking and disposition of issues, and make a copy available of the test log to the Owner or Consultant when requested.
- .3 Verify the rectification of each fault, failure or discrepancy. Include in the test log the date the correction was verified and the person who conducted the verification.
- .4 At completion of LSFP commissioning, include the final test log with the LSFPCx completed commissioning report.

3.7 Test Equipment

- .1 Furnish tools and equipment required during all stages of the LSFPCX processes.
- .2 Utilities (water, gas, fuel oil, electrical power) are provided by the Owner or as specified in the Contract documents.
- .3 Provide any test equipment and software required for pretesting and start-up testing, whether specified or not.
- .4 Manufacturer provides test equipment and personnel as required for the startup and testing of their equipment and assists in the LSFPCX process as needed.

3.8 Acceptance

- .1 Any identified deficiencies will be reviewed by the Consultant to determine if correction of the deficiency is as a result of a defect in the equipment or installation and whether it is a major or minor deficiency.
- .2 Correction of all major deficiencies is required for application for occupancy permit.
- .3 If it is determined the performance deficiency is as a result of a defect in the equipment or its installation, rectify the deficiency and repeat the performance test until the required performance levels are achieved.
- .4 If it is determined the equipment or system has been constructed in accordance with the contract documents, the Owner shall decide whether to accept the performance as is, or, the Owner through the Consultant shall direct the installation contractor to make changes to the system as required to obtain performance levels which meet the design intent, and retest the system.

3.9 Close-out Documentation Deliverable

- .1 At completion of the LSFP commissioning, submit three (3) bound hard-copies and an electronic copy in PDF format of the completed and approved commissioning program including;
 - .1 LSFPCx commissioning plan,
 - .2 LSFPCx commissioning test procedures,
 - .3 completed LSFPCx commissioning test records,
 - .4 completed training log and a copy of the final training manuals,
 - .5 completed test issues log,
- .2 Provide two (2) back-up copies on CD or DVD media of control software code or configuration that has been modified as a result of the commissioning process,
- .3 The above requirements are in addition to any other requirements for general commissioning and submittals.

END OF SECTION

BUILDING AUTOMATION SYSTEMS GENERAL

25 05 01

1 GENERAL

1.1 Scope

- .1 Provide Building Automation System (BAS) with Direct Digital Control (DDC), and Energy Management for building mechanical and electrical systems.
 - .1 System to be Tridium Niagara framework
- .2 Integrate BAS into Toronto Public Library Johnson Controls Facility Explorer server for remote monitoring and control.
- .3 Integrate BAS into the TPL IT Network.

1.2 Related Sections

- .1 Building Automation System includes Sections:
 - .1 25 00 88 Commissioning - BAS
 - .2 25 13 01 B.A.S. Building Controllers
 - .3 25 14 01 B.A.S. Equipment Controllers
 - .4 25 35 01 B.A.S. Instrumentation and Actuators
 - .5 25 90 01 B.A.S. Sequence of Operations

1.3 Equipment Supplied for installation under Other Sections

- .1 Supply the following equipment for installation under other Sections of Division 20;
 - .1 automatic control valves,
 - .2 temperature wells for controllers and sensors provided under this Section,
 - .3 terminal unit controllers, actuators for volume dampers and velocity pressure sensors including transformers. Arrange and pay for shipping to terminal unit manufacturer's facility for factory installation.
 - .4 actuators for motorized dampers and smoke dampers including associated end switches and relays.

1.4 Equipment Provided under Other Sections

- .1 The following equipment is provided under other Sections of Division 20;
 - .1 liquid flow measuring devices
 - .2 steam humidifiers with automatic control valves
 - .3 unit heater and cabinet unit heater line voltage thermostats
 - .4 manual dampers, fire dampers, gravity dampers, and smoke dampers
 - .5 motorized dampers

1.5 Applicable standards

- .1 ANSI/ASHRAE standard 135-2004 BACnet

- .2 Interfacing Standard:
 - .1 Input/output devices to use ASCII (American Standard for Communication and Information Interchange) code and standard EI (Electronic Industry Association) interfaces.
 - .2 CSA T530: Building Facilities, Design Guidelines for Telecommunications (same as EIA/TIA 569).
 - .3 IEEE 802.3 Ethernet 10Base-T LAN.

1.6 Abbreviations and definitions

- .1 The following definitions, abbreviations, and acronyms apply:
 - .1 AI Analog Input: continuously variable value, usually a sensor, referenced to a controller
 - .2 AO Analog Output: continuously variable value, usually a control signal to an actuator device, referenced to a controller.
 - .3 BI Binary (digital) Input: a two-state (On-Off) value, usually associated with a switch or state, referenced to a controller.
 - .4 BO Binary (digital) Output: a two-state (On-Off) value, usually associated with starting or stopping equipment or generating an alarm, referenced to a controller.
 - .5 BCU Building Control Unit
 - .6 ECU Equipment Control Unit
 - .7 FAS Fire Alarm System
 - .8 GUI Graphic User Interface: an LED, LCD or monitor display
 - .9 I/O Input/Output
 - .10 LAN Local Area Network
 - .11 NC Normally Closed: position of device in a de-energized state.
 - .12 NO Normally Open: position of device in a de-energized state.
 - .13 OWS Operator workstation: a PC based server or computer
 - .14 Tier 1 High level network providing communication between BCU's and workstations.
 - .15 Tier 2 Lower level network providing communications between ECU's and BCU's
 - .16 WAN Wide Area Network

1.7 Manufacturers and Installers

- .1 Provide BAS with DDC and Energy management for mechanical and electrical systems by an organization:
 - .1 specializing in design, installation, commissioning and service of open protocol Tridium Niagara Framework systems,
 - .2 having completed five (5) projects of similar size and complexity within the preceding five (5) years,
 - .3 employing certified journeymen experienced in this type of work.

1.8 Continuity of Staff and Subcontractors

- .1 Project Manager is to be nominated at time of shop drawing submission and is to remain involved with project, from shop drawing preparation through to Acceptance, unless request for change is submitted and approved.

- .2 Subcontractors listed in preliminary design submission are to execute work defined as sublet in preliminary design document, unless request for change is submitted and approved.
- .3 Requests for changes in staff, subcontractors, or extent of work subcontracted are to be submitted for approval and such approval is not to be unreasonably withheld.

1.9 Identification of non-conforming materials and equipment.

- .1 Submit documentation at time of bid, identifying nature and extent of non-conformance and variances from specifications or referenced standards.
- .2 Failure to submit this documentation at time of bid will be interpreted as confirmation that materials, workmanship, hardware and software will be in strict accordance with specifications and standards.

1.10 Licences and Ownership

- .1 Ownership of, and licences for, hardware and software supplied or used for this project or for ongoing system operation, maintenance and modification to be registered, without restrictions, in Owner's name.
- .2 This is applicable to System Software, Workstation Application Editors, and Controller Software.
 - .1 Licensing to permit an unlimited number of users to access system without additional fees.
 - .2 As of last day of warranty period, software is to be upgraded to current version or release.
 - .3 Project-developed software and resulting documentation to be treated as part of system and subject to these same requirements for ownership and licensing. This material includes;
 - (a) Project graphic images
 - (b) CAD generated record drawings
 - (c) Project database
 - (d) Project-specific application programming code and documentation.

1.11 Shop Drawings

- .1 Submit one completely engineered and coordinated shop drawing package. Partial or incomplete submission of data and/or drawings will be returned without review.
- .2 Submit shop drawings for designed elements;
 - .1 list of materials of equipment to be used indicating manufacturer, model number, and other relevant technical data.
 - .2 BAS riser diagram showing system controllers, operator workstations, network repeaters, and network wiring.
 - .3 single-line schematics and system flow diagrams showing location of control devices.
 - .4 detailed analysis of each Sequence of Operation from design documents, ready for development of actual programming code.
 - .5 Sequence of Operations to cover normal operation and operation under various alarm conditions applicable to that system.
- .3 Submit shop drawings schedules for;
 - .1 control damper; spreadsheet type, to include separate line for each damper and columns for damper attributes.
 - .2 control valve; spreadsheet type, to include separate line for each valve and separate columns for valve attributes.

- .4 Submit catalogue cut-sheets for;
 - .1 manufacturer's description and technical data, such as performance curves, product specification sheets, and installation/maintenance instructions for equipment and hardware items as follows;
 - (a) Controllers (BCU's and ECU'S)
 - (b) Transducers/Transmitters and Sensors with
 - accuracy data, range and scale information,
 - one sheet for each device marked with applicable options. (Where several devices of same type are to be used, submit one sheet for each device, individually marked.)
 - (c) Actuators
 - (d) Valves
 - (e) Relays/Switches
 - (f) Panels
 - (g) Power Supplies
 - (h) Batteries
 - (i) Operator Interface
 - (j) Wiring and wiring accessories
 - .2 hardware data sheets for Operator Interfaces, local panels, and portable operator terminals.
 - .3 Software manuals for applications programs for Operator Interface, portable operator terminals, and programming devices.
 - .4 Protocol Implementation Conformance (PIC) statement for BACnet devices.
 - .5 Where interfaces occur with control or wiring diagrams of other sections, obtain reproducible copies of these diagrams and revise to show terminal numbers at interface and include diagrams as part of interconnection schematic shop drawings.

1.12 Graphics

- .1 Submit supporting documentation:
 - .1 examples of graphics for Operator Interface to include;
 - (a) BAS network schematics
 - (b) typical terminal unit floor plan graphic that shows conditions on occupied floor
 - (c) typical equipment room floor plan graphic
 - (d) typical graphics for each system and terminal unit at least one sample graphic for each type of equipment,
- .2 New BAS graphics shall be design consistent with the existing Toronto Public Library graphics.
 - .1 Upon request by contractor, Toronto Public Library can provide a sample building station, so graphics objects are consistent across all facilities.

1.13 Project schedules

- .1 At time of shop drawing submission provide Gantt type Schedule of Work with;
 - .1 project broken down into discrete work items
 - .2 start date of each work item
 - .3 duration of each work item
 - .4 relationships between work items and showing constraints on work flow.
 - .5 planned delivery dates for ordered material and equipment with expected lead times.
 - .6 procedures.

- .2 During design, installation and start-up of installation provide monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated Schedule of Work with each report.

1.14 Warranty

- .1 At completion of Work, submit written guarantee undertaking to remedy defects in work for period of two (2) years from date of acceptance, which includes:
 - .1 rectification of control system failures attributable to defects in workmanship, materials, hardware, and software,
 - .2 Service Technician to arrive on site within 24 hours of warranty service request, to install and de-bug software patches, to replace defective parts, materials or equipment, and to provide incidental supplies, and labour for remedial work,
 - .3 Technician to remain in attendance until system is returned to operating condition.
- .2 Submit similar guarantee for any part of work accepted by Owner, before completion of whole work.

2 PRODUCTS

2.1 General

- .1 Provide equipment which functions and meets detailed performance criteria when operating in following minimum ambient condition ranges:
 - .1 Temperature - 0°C to 32.2°C (32°F to 90°F)
 - .2 Relative Humidity 10% to 90% non-condensing
 - .3 Electrical power service of single phase, 120 VAC +/- 10%, 60 Hz nominal.
- .2 Components installed within motor control devices to be designed to operate with transient electrical fields occurring within these devices.

2.2 Licensing

- .1 Supervisory controllers shall be installed with open licenses for full access from Toronto Public Library's Facility Explorer server.
- .2 All licenses shall be provided to and in the name of Toronto Public Library.
- .3 Licenses shall be perpetual, transferrable, assignable and royalty-free

2.3 Equipment standard

- .1 Products and software: manufacturer/developer/supplier's catalogued current stock.
- .2 This installation is not to be used as test site for newly developed product or software, without explicit written approval.
- .3 Equipment and systems installed under this Contract to meet;
 - .1 performance specifications when subjected to VHF, UHF, FM, AM or background RFI as generated by commercial or private, portable or fixed transmitters that meet regulatory codes.
 - .2 Federal Communication Commission (FCC) Rules and Regulations, Part 15, Subpart J for computing devices.

2.4 BAS Systems Integration

- .1 All controls systems must be integrated to Toronto Public Library's Johnson Controls Facility Explorer® (FX) server to monitor and control HVAC equipment.

2.5 General BAS architecture

- .1 Control system:
 - .1 All new building automation system (BAS) shall be based on the open environment Tridium Niagara framework, compatible with the existing FX server, and shall be integrated within the FX server over the TPL IT network. No PC hardware shall be installed. Parameters for TPL IT network connection will be provided by TPL IT.
 - (a) Installer must be a licensed Tridium systems integrator.
 - .2 each mechanical system, building floor plan, and control device to be displayed through point-and-click graphics,
 - .3 Web server with network interface card to gather data from this system and generate web pages that can be accessed through conventional web browser on any PC connected to network,
 - .4 Operators to access this system through web browser, and browser interface to perform normal operator functions.
- .2 Open protocol:
 - .1 Provide an integrated, open protocol building automation system, either/ or in combination:
 - (a) BACnet to ANSI/ASHRAE Standard 135-2001,
- .3 BAS network architecture - Dedicated LAN for BAS:
 - .1 BAS communication architecture to consist of at least two tiers with each tier using local area networks.
 - .2 Tier 1: Building Controller network;
 - (a) Ethernet communications (ISO 8802-3/IEEE 802-3), using high speed local area network communications. TCP/IP to be used as communication protocol on first tier network.
 - .3 Tier 2: Equipment Controller network;
 - (a) open, peer-to-peer control networks to interconnect BAS controllers (BCU's and/or ECU's) on ring or star topology bus.
 - (b) Peer-to-peer configuration means units exist and speak equally on same bus.
 - (c) Controllers in peer-to-peer configuration can share data without assistance from Operator Interface.

2.6 General functional requirements

- .1 Control mechanical and electrical equipment as specified in Control Sequences, shown on Control Schematics, and described in Equipment Schedules.
- .2 System architecture to be modular, permitting stepped expansion of application software, system peripherals, and field hardware.
- .3 Each controller;
 - .1 operates with local closed loop programming, independent from server, if peer-to-peer communication is interrupted;
 - .2 performs resident control routines;

- (a) receiving information from field mounted sensors and switches and
- (b) transmitting instructions to actuators to perform control sequences.
- .3 manages local hardware and software alarms;
 - (a) to collect historical data,
 - (b) to facilitate operator input and output and
 - (c) to communicate with Central BAS web server and operator interface.

2.7 Performance

- .1 General:
 - .1 information transmission and display times are based upon network, rather than modem, connections.
 - .2 test systems using manufacturer's recommended hardware and software for operator interface.
- .2 Performance criteria:
 - .1 Graphic Display;
 - (a) display graphic with 20 dynamic points with current data within 10 seconds.
 - .2 Graphic Refresh;
 - (a) update graphic with 20 dynamic points with current data within 10 seconds and
 - (b) automatically refresh every 15 seconds.
 - .3 Configuration and Tuning Screens;
 - (a) special screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic to refresh every 5 seconds.
 - .4 Object Command response;
 - (a) time between command of binary object at Operator Interface (OI) and reaction by device to be less than 5 seconds.
 - (b) time between command of analog object at Operator Interface (OI) and start of adjustment to be less than 5 seconds.
 - .5 Alarm Response Time;
 - (a) time between when an object goes into alarm and when it is annunciated at Operator Interface (OI) to be less than 15 seconds.
 - .6 Program Execution Frequency;
 - (a) execution repeat frequency to be selected in manner consistent with mechanical process under control.
 - (b) custom and standard applications to be capable of executing as often as once every 5 seconds.
 - (c) programmable controllers to be able to perform PID control loop routines at selectable frequency, adjustable at Operator Interface (OI) down to once every second.
 - (d) workstations connected to network to receive alarms with not more than 5 seconds spread between first and last annunciation.
 - .7 Reporting Accuracy;

- (a) system to report values with an end-to-end accuracy equal to or better than those listed below.
- (b) control loops to maintain measured variable at set point value within tolerances equal to or better than those listed below.

2.8 Capacity for Future Expansion

.1 Supervisory Controller

- .1 Each BAS shall have a supervisory controller sized to handle the points and sequences of operation, plus a 25% additional spare capacity for future expansion. Supervisory controllers shall be installed with open licenses for full access from the existing FX server.

3 EXECUTION

3.1 Examination

- .1 Inspect site and thoroughly examine documents to establish locations for control devices and equipment and report discrepancies, conflicts, or omissions for resolution before starting rough-in work.
- .2 Be responsible for correction of defects caused through neglect of inspections and examinations or failure to report and resolve discrepancies.

3.2 Protection

- .1 Protect work and material against damage during construction and be responsible for work and equipment until inspected, tested, and accepted.
- .2 Protect material not immediately installed and close open ends with temporary covers or plugs during storage and construction to prevent entry of foreign objects.
- .3 Protect electronic equipment from elements during construction.

3.3 Coordination

- .1 Coordinate and schedule control work with other work in same area to ensure orderly progress.
- .2 Testing and balancing:
 - .1 Supply set of tools for Testing and Balancing Technicians to interface to control system, train these technicians in use of tools and provide qualified Control Technician to assist with testing and balancing first 10 terminal units.
 - .2 Tools to be turned over to Owners on completion of testing and balancing.
- .3 Controls work by others:
 - .1 Integrate and coordinate this control work with controls and control devices provided or installed by others.
 - .2 Each supplier of control product to configure, program, start up, and test that product to satisfy requirements of Sequence of Operation regardless of where within contract documents product is specified or described.
 - .3 Resolve compatibility issues between control products provided under this section and those provided under other sections or divisions of this specification.

3.4 General Workmanship

- .1 Installation to be performed by skilled and certified technicians.
- .2 Install equipment, piping, and wiring or raceways horizontally, vertically, and parallel to building lines.
- .3 Provide sufficient slack and flexibility in connections to allow for vibration isolation between conduit, raceways, piping and equipment.
- .4 Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.
- .5 Install instrumentation and devices in locations providing adequate ambient conditions.
- .6 Protect components placed in areas of potentially high humidity.
- .7 All thermostats installed on perimeter wall shall be mounted on insulated backing.

3.5 Cleaning

- .1 Clean up debris, remove packaging material, collect waste and place in designated location, on a daily basis.
- .2 Keep work areas free from dust, dirt, and debris.
- .3 On completion of work, check finish of equipment provided under this section for damage and repair damaged factory-finished paint, replace deformed cabinets and enclosures with new material, and repaint to match original.

3.6 Field Quality Control

- .1 Ensure work, materials, and equipment comply with this specification and approved shop drawings.
- .2 Monitor field installation for code compliance and workmanship quality.
- .3 Arrange and pay for inspections by local or provincial authorities having jurisdiction.

3.7 Wiring

- .1 Electrical materials, equipment and installation procedures under to conform to Ontario Electrical Safety Code as amended to date and standards established in Division 26.
- .2 Conduit:
 - .1 thin wall (EMT) conduit up to and including 32mm (1 1/4 in) size for exposed wiring up to 3 m (10 ft) above floor level,
 - .2 rigid galvanized steel conduit in locations accessible to public, subject to mechanical injury, or outdoors; and for conduit 40mm (1 1/2 in) size and larger,
 - .3 watertight compression fittings in exterior locations.
- .3 Run conduit and raceways parallel to building lines and be secured to building structure.
- .4 Wiring not to be installed in conduit to be installed parallel to building lines and be secured to building structure with clips at minimum 3m (6 ft) centres. Where possible, wiring to run above corridors and in service spaces.

- .5 Wiring in return air ceiling spaces to be plenum rated.
- .6 Where conduit leaves heated areas and enters unheated areas, seal conduit.
- .7 Provide interposing and motor control relays at local item of equipment or at associated MCC as applicable.
- .8 Provide 120 VAC wiring as needed to support operation of system networking hardware, field panels, and controllers. Refer to Section 20 05 13 for description of division of work and responsibility.
- .9 Provide control transformers for system components requiring power supply that do not have integral control transformers.
- .10 Where point schematics and specifications indicate auxiliary contact provision, provide instrumentation, wiring, conduit, power supplies and services as to integrate these points into BAS.
- .11 Mount transformers in enclosures.

3.8 Identification of Equipment

- .1 Identify discrete items of equipment with plastic nameplates, identifying equipment and function.
- .2 Identification plates are in addition to manufacturers plates.
- .3 Manufacturers' nameplates and UL or CSA labels to be visible and legible after equipment is installed.
- .4 Identification plates:
 - .1 provided for equipment identified with number designations in schedules and equipment shop drawings.
 - .2 marked with equipment type, number and service following wording and numbering used in contract documents and shop drawings
 - .3 laminated plastic
 - .4 white face and black centre
 - .5 minimum size 75 mm x 40 mm x 3 mm (3 in x 1½ in x ⅜ in),
 - .6 engraved with 6.5 mm (¼ in) high lettering.
 - .7 securely attached to equipment.
- .5 Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 50 mm (2 in) of termination.
- .6 Permanently label or code each point of field terminal strips to show instrument or item served.
- .7 Label each control component with permanent label. Label plug-in components so that label remains stationary during component replacement.
- .8 Label room sensors related to terminal boxes or valves with nameplates. Place labels on back of sensors.
- .9 Identify starters that are interfaced to BAS system with self-adhesive labels, white letters on red background as follows;

W A R N I N G

THIS EQUIPMENT IS OPERATING UNDER AUTOMATIC CONTROL AND MAY START OR STOP AT ANY TIME WITHOUT WARNING. SWITCH DISCONNECT TO "OFF" POSITION BEFORE SERVICING.

- .10 Submit samples of labels and nameplates for review prior to installation.

3.9 Acceptance

- .1 After tests described in this specification are performed satisfactorily and checklists and reports are submitted and approved, certify acceptance of control system including:
 - .1 Control system checkout and testing
 - .2 Control system demonstration
 - .3 Training
 - .4 As-built documentation
- .2 Certification document may identify tests that cannot be performed due to extenuating circumstances such as weather conditions. Append program to certification document for rectification and completing these tests during warranty period.

3.10 Control System Checkout and Testing

- .1 Provide schedule for start-up testing.
- .2 Calibrate and prepare for service; equipment, instruments, controls, and accessories.
- .3 Start-up testing to verify substantial completion of control system before system demonstrations begin.
 - .1 Verify that control wiring is connected and free of shorts and ground faults. Verify that terminations are tight.
 - .2 Enable control systems and verify input device calibration.
 - .3 Verify that binary output devices operate and that normal positions are correct.
 - .4 Check control valves and automatic dampers for proper action and closure and adjust valve stem and damper blade travel.
 - .5 Verify that analog output devices are functional, that start and span are correct, and that direction and normal positions are correct.
 - .6 Verify that system operates according to Sequences of Operation. Simulate changes in variables by overriding and varying inputs and schedules and observe and record each operational mode response.
 - .7 Tune PID loops and control routines.
 - .8 Check each alarm with an appropriate signal at value that will trip alarm.
 - .9 Trip interlocks using field contacts to check logic and to ensure that actuators fail in proper direction.
 - .10 Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

- .4 Prepare and submit log documenting start-up testing of each input and output device and each control routine, with technician's initials certifying each device and each routine is functioning correctly and sensors have been calibrated. Include list of deficiencies, if any, and schedule setting out rectification program with time lines.

3.11 Control System Demonstration

- .1 Obtain approval of start-up testing log and rectification program before scheduling demonstrations.
- .2 Provide notification not less than 10 days before system demonstration begins.
- .3 Demonstration to follow previously submitted and approved procedures;
 - .1 submit checklists and report forms for each system as part of demonstration,
 - .2 lists and forms to have initials of technicians conducting demonstrations,
 - .3 date of each demonstration and signatures of Owner's representatives witnessing each demonstration section.
- .4 Prior to acceptance, perform following tests to demonstrate system operation and compliance with specification after and in addition to tests specified above in Control System Checkout and Testing.
- .5 Show field operation of;
 - .1 each Sequence of Operation.
 - .2 Operator Interface
 - .3 DDC loop response with graphical trend data output showing
 - (a) Each DDC loop response to set point change producing an actuator position change of at least 25% of full range.
 - (b) Trend sampling rate to be from 10 seconds to 3 minutes, depending on loop speed.
 - (c) Loop trend data to show set point, actuator position, and controlled variable values.
 - (d) Documentation of further tuning of any loop that displays significantly under- or over-damped control
 - .4 Demand limiting routine with trend data output showing demand-limiting algorithm action;
 - (a) trend data to document action sampled each minute over at least 30-minute period and to show building kW, demand-limiting set point, and status of set-points and other affected equipment parameters.
 - .5 Building fire alarm system interface.
 - .6 Trend logs for each system point with;
 - (a) trend data to indicate set-points, operating points, valve positions, and other data as specified in points list provided with each Sequence of Operation,
 - (b) each log to cover three 48-hour periods and to have sample frequency not less than 10 minutes,
 - (c) show that Logs are accessible through operator interface and can be retrieved for use in other software programs.
 - .7 Substantiate calibration and response of any input and output points requested.
 - .8 Provide at least two technicians equipped with two-way communication.
 - .9 Provide and operate test equipment to establish calibration and prove system operation.
- .6 Tests that fail to demonstrate system operation to be repeated after repairs and/or revisions to hardware or software is completed.

- .7 Project record Submittals.
 - .1 Submit three copies of project record documents and obtain approval during acceptance procedures.
 - .2 Submit inspection certificates.
 - .3 Certificate of Acceptance to be withheld until Submittals are approved.

3.12 Training

- .1 Materials:
 - .1 Provide course outline and materials for each class at least six weeks before first class.
 - .2 Provide training through instructor-led sessions, with computer-based, or web-based techniques.
 - .3 Instructors to be factory-trained and experienced in presenting this material.
 - .4 Perform classroom training using network of working controllers representative of installed hardware
- .2 Operating staff training:
 - .1 Provide training for Owners operating staff using abovementioned training materials in self-paced mode, web-based or computer-based mode, classroom mode, or combination of these methods.
 - .2 Allow for 1 repeat sessions for each category to cover operator shift rotation.
- .3 Training to enable students to accomplish following objectives.
 - .1 Group 1:
 - (a) Proficiently operate system
 - (b) Understand control system architecture and configuration
 - (c) Understand BAS system components
 - (d) Understand system operation, including BAS system control and optimizing routines (algorithms)
 - (e) Operate workstation and peripherals
 - (f) Log on and off system
 - (g) Access graphics, point reports, and logs
 - (h) Adjust and change system set-points, time schedules, and holiday schedules
 - (i) Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
 - (j) Understand system drawings and Operation and Maintenance manual
 - (k) Understand project layout and location of control components
 - (l) Access data from BAS controllers
 - (m) Operate portable operator's terminals
 - .2 Group 2:
 - (a) Create and change system graphics
 - (b) Create, delete, and modify alarms, including configuring alarm reactions
 - (c) Create, delete, and modify point trend logs (graphs) and multi-point trend graphs
 - (d) Configure and run reports
 - (e) Add, remove, and modify system's physical points
 - (f) Create, modify, and delete application programming
 - (g) Add operator interface stations
 - (h) Add new controller to system
 - (i) Download firmware and advanced applications programming to controller
 - (j) Configure and calibrate I/O points

- .3 Group 3:
 - (a) Maintain software and prepare backups
 - (b) Interface with job-specific, third-party operator software
 - (c) Add new users and understand password security procedures
- .4 Divide presentation of objectives into three sessions:
 - .1 Group 1: Day-to-day Operators.
 - .2 Group 2: Advanced Operators
 - .3 Group 3: System Managers and Administrator
 - .4 Participants will attend one or more of sessions, depending on knowledge and expertise level required.
 - .5 Provide each student with one copy of training material.

3.13 Submittals for Acceptance

- .1 Provide system documentation at time of acceptance.
- .2 As-built drawings;
 - .1 As-built interconnection wiring diagrams, or wire lists of field installed system with identified, ordering number of each system component and service.
 - .2 Floor plans with accurate depiction of location of system devices, controllers, and trunk wiring. Drawings to be constructed using Architectural backgrounds provided.
 - .3 Provide 2 copies on CD-ROM of above drawings in AutoCAD Release 2000 format without compression.
 - .4 Provide 5 full size hard copies of floor plan drawings.
- .3 Operation and Maintenance (O&M) Manuals:
 - .1 Provide two paper copies of material and five copies on CD-ROM in Adobe PDF format.
 - .2 Describe operation, maintenance and servicing requirements of system and associated equipment.
 - .3 Provide following information in separate sections, each with an index.
 - (a) Service and parts;
 - Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
 - List of recommended spare parts with part numbers and suppliers.
 - (b) System description;
 - English language outline of BAS system and system architecture
 - As-built versions of shop drawing product data.
 - Reduced size (11 in x 17 in) copies of record drawings
 - Graphic files, programs, and database on magnetic or optical media.
 - Licenses, guarantees, and warranty documents for equipment and systems.
 - (c) Technical literature for equipment, including;
 - catalogue sheets,
 - calibration, adjustments and operation instructions,
 - installation instructions,
 - hardware and software manuals, with information supplied by original product developer, on application programs and on computers and controllers supplied

- Operator's manual with procedures for operating control systems; logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set-points and variables.
 - Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
 - Original-issue documentation with installation and maintenance information for third-party hardware including computer equipment and sensors.
 - Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
 - Programming manual or set of manuals with description of programming language and syntax, explanation of statements for algorithms and calculations used, procedures for point database creation and modification, documentation of techniques for program creation and modification, and instructions for use of editor.
 - Documentation of programs created using custom programming language including set-points, tuning parameters, and object database. Electronic copies of programs to modify and create control logic, set-points, tuning parameters, and objects that can be viewed using programming tools.
- .4 Original Software:
- .1 Furnish one original set of application and system software on original media. Disks to bear manufacturer's label. Field copies are not acceptable.
 - .2 Original-issue copies of software to include operating systems, custom programming language, application generation, graphic support, maintenance support, operator workstation or web server software, and other utilities provided in support of installed system.
- .5 On-line record documentation:
- .1 After completion of testing and adjustment, install the following additional information on the server OWS.
 - (a) As-built record drawing files,
 - (b) detailed catalog data on all installed system components, with supplier contact information for purchasing and factory authorized repair service.

3.14 Correction After Completion

- .1 After start-up, testing, and commissioning phase when satisfactory and reliable operation of equipment and systems has been demonstrated, acceptance to be certified. Guarantee period to begin on date established on certificate of acceptance.
- .2 Provide (supply, install, de-bug and commission) updates and patches to resolve software deficiencies in operator workstation or web server software, project-specific software, graphic software, database software, and firmware during guarantee period.
- .3 Provide (supply, install, de-bug and commission) upgrades that improve routines and procedures of operator workstation software, web server software, project-specific software, graphic software, or database software, free of charge, during guarantee period .
- .4 Provide details of proposed changes and obtain written authorization before installation of updates, patches, or upgrades.
- .5 Include preventative maintenance, with allowance for spare parts, labour, and emergency (24 hour) service for system and equipment during guarantee period.

- .6 Equipment manufacturers to submit written undertakings to make circuit board repairs and provide spare parts, software support and patches, and technical assistance for at least five years after acceptance is certified.

END OF SECTION

B.A.S. BUILDING CONTROLLERS

25 13 01

1 GENERAL

1.1 Scope

- .1 Provide Building Controllers ("BCU") for Building Automation System.

2 PRODUCTS

2.1 General

- .1 Provide equipment which functions and meets detailed performance criteria when operating in following minimum ambient condition ranges:
 - .1 Temperature - 0°C to 32.2°C (32°F to 90°F),
 - .2 Relative Humidity 10% to 90% non -condensing,
 - .3 Electrical power service of single phase, 120 VAC +/- 10%, 60 Hz nominal,
 - .4 Operating voltage: operate at 90% to 110% of nominal voltage rating and to perform an orderly shutdown below 80% nominal voltage,
 - .5 Operation to be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
- .2 Components installed within motor control devices to be designed to operate with transient electrical fields occurring within these devices..

2.2 Building Controllers

- .1 General:
 - .1 stand-alone, multi-tasking, multi-user, real time digital processors with hardware, software, and communications interfaces, power supplies, and input/output modular devices.
 - .2 Based on the open environment Tridium Niagara framework
 - .3 Compatible with Toronto Public Library's Johnson Controls Facility Explorer server
 - .4 removable (hot swappable) without disconnection of terminals and wiring,
 - .5 have access to data within network to accomplish global control strategies.
 - .6 support firmware upgrades without need to replace hardware and to have spare capacity for I/O.
 - .7 continuously perform self-diagnostics, communication diagnosis, and provide both local and remote annunciation of any detected component failures, low battery condition; and upon failure to assume predetermined failure mode.
 - .8 monitor status of overrides and inform operator if automatic control has been inhibited, and allow operator to manually override automatic or centrally executed inhibit command.
- .2 Input/ Output points:
 - .1 hardwired inputs and outputs to tie into system through various Building Control Units (BCU's).
 - .2 protected such that shorting of point to itself, shorting of point to another point, or shorting of point to ground will not damage controller.
 - .3 protected such that voltage spikes of up to 24 V, of any duration, and any polarity will not damage controller.

- .4 Analog input: compatible with, and field configurable to commonly available sensing devices using low voltage signals (0 -10 VDC), current signals (4 -20 ma), or resistance signals from thermistors or RTD.
 - .5 Analog output: in form of modulating electronic signal, either voltage mode (0 -10VDC) or current mode (4 -20mA).
 - .6 Digital inputs: allow monitoring of on/off signals from remote devices. Digital inputs to provide wetting current of at least 12 ma and to be compatible with commonly available control devices.
 - .7 Digital outputs: provide on/off operation, or pulsed low voltage signal for pulse width modulation control. Digital outputs to be relays, 24 Volts AC or DC maximum, having 3 Amp maximum current. Each relay to be configured as normally open or normally closed, and either dry contact or bussed.
 - .8 Universal inputs: Thermistor Precon Type II, dry contacts, or 0 -5VDC with 0 -10K Ohm input impedance.
- .3 Spare I/O capacity, each BCU:
- .1 minimum of 25% spare I/O point capacity for each point type found at each location.
 - .2 25% of each type if input points are not universal,
 - .3 25% of each type if outputs are not universal,
 - .4 Minimum of one spare is for each type of point used.
 - .5 Future use of spare capacity to involve provision of field device, field wiring, point database definition, and custom software. These spare points to be configurable without additional controller boards or point modules. Wiring connections to be made to field-removable, through modular terminal strips or termination cards connected by ribbon cable.
- .4 Time Clock:
- .1 Controllers that perform scheduling operations to have on board real-time clock.
- .5 Communications:
- .1 communication port (RS-232 DB-9, RJ-11 or RJ-45) for connection to laptop computer or operator interface device to allow memory downloads and other commissioning and troubleshooting operations.
 - .2 communication services over BAS networks to support operator interface performance, and value passing as follows;
 - (a) connection of an operator interface device to any one controller on network to allow operator to interface with other controllers as if that interface were directly connected to those other controllers.
 - (b) data, status information, control algorithms, inputs, outputs, etc., from any controller on network is to be available for viewing and editing through operator interface device that is connected to any controller on network.
 - (c) links to execute control strategies to be programmed and tested so that an operator with appropriate password privileges is able to edit these links either by typing in standard object addresses, or by using simple point and click commands.
 - (d) daily routine automatically synchronize time clocks in controllers. An operator initiated change to master time clock setting to be automatically broadcast to other controllers on network.
 - (e) minimum baud rate for peer-to-peer communication between controllers in system LAN to be at 10 Mbps and communication with low level controllers, to be at 76 Kbps.
- .6 GUI:

- .1 face mounted LED type annunciation to display operational mode, and power and communication status.
- .7 Tier 1 LAN:
 - .1 BCU's reside on Ethernet (ISO 8802-3) first tier Building Systems LAN, on same high-speed network as Server, and provide Read (Initiate) and Write (Execute) services to communicate with BACnet objects or LON SNVT's.
- .8 BACnet devices, Tier 1 network;
 - .1 Conformance Class 6,
 - .2 meet all the requirements for all of the lowered numbered classes as specified herein for Class 3, and
 - .3 in accordance with the requirements of ANSI BACnet 135-1995 for Classes 4 and 5, support the BACnet functional groups for;
 - (a) Clock,
 - (b) Time Master,
 - (c) Reinitialize,
 - (d) PCWS (Personal Computer Workstation),
 - (e) Event Initiation,
 - (f) Event Response and Files,
 - .4 support the standard BACnet object types of;
 - (a) Calendar,
 - (b) Command,
 - (c) Event Enrollment,
 - (d) File and Schedule, and
 - (e) support the Local_Time, Local-Date, UTC_Offset, Daylight_Savings_Status and Time_Synchronization_Recipient properties of the Device Object.
- .9 Power interruption:
 - .1 In event of normal power loss;
 - (a) provide orderly shut down of controllers to prevent loss of database or software programming,
 - (b) incorporate non-volatile memory for critical configuration data,
 - (c) battery backup to be provided to support real time clock and volatile memory for minimum of 72 hours.
- .10 Memory:
 - .1 sufficient memory to support operating system, program, and database requirements including;
 - (a) device and network management.
 - (b) data sharing.
 - (c) alarm and event management including custom alarm messages for each alarm level for each point noted in I/O Schedule.
 - (d) energy management.
 - (e) collection of historical trend data for operator selected points.
 - (f) maintenance support.
 - (g) scheduling.
 - (h) dial up communications.
 - (i) manual override monitoring.

2.3 Building Controller Software

.1 General

- .1 Applications software for building systems operation and monitoring and energy management to reside and operate in system controllers (BCU's).
- .2 Using and editing of applications to be available to an operator with appropriate authorization, through operator workstation/browser interface or at other engineering workstations.
- .3 Software to support concurrent operation of multiple standard and non-standard protocols including but not limited to:
 - (a) BACnet
 - (b) LonTalk
 - (c) MODBUS
 - (d) OPC
 - (e) SNMP

.2 Software application programs:

.1 Scheduling

- (a) capable of scheduling each object or group of objects,
- (b) separate schedules for each day of week with up to five start/stop pairs. (10 events)
- (c) exception schedules defined up to year in advance and once events on exception schedule day have been executed, definition of the exception schedule day will be discarded and replaced by standard schedule for that day of week.
- (d) up to 24 holiday schedules may be placed on scheduling calendar and will be repeated each year.
- (e) ability to override programmed start/stop based on outside temperature reaching or exceeding an adjustable value, operator initiated, individual for each system,
- (f) temporary scheduler, ability to alter current schedule on a one time basis.

.2 Optimal Start/Stop

- (a) Delay startup of each HVAC system to latest possible time which will allow building space to reach target conditions occupancy time
- (b) Also advance shutdown of each system to earliest possible time.
- (c) Include modeling techniques using building mass temperature and outdoor air temperature to predict building warm up and cool down times under different outdoor and indoor conditions.
- (d) Generate reports to show current value of variables, inputs and outputs involved and estimates of energy savings.

.3 Temperature based load control

- (a) Provide temperature setback or set up according to programmed occupancy schedules with capability to assign separate schedules to each control zone.
- (b) Control of setback or set up achieved through setpoint adjustment, cycling of systems or cooling plant temperature conditions occupancy time
- (c) Generate reports to show current value of variables, inputs and outputs involved and estimates of energy savings.

.4 Supply air reset

- (a) Monitor heating and cooling loads in building spaces and adjust HVAC discharge sensors to most energy efficient levels which will still satisfy measured load zone.
- (b) Generate reports to show current value of variables, inputs and outputs involved and estimates of energy savings.

.5 Enthalpy Economizer:

- (a) Program to control outside and return and exhaust air dampers during the cooling season based on inside and outside enthalpy comparisons.
 - (b) modulate dampers to mix outside and return air for free cooling whenever outside temperature is less than the supply air temperature setpoint
 - (c) Use either return or outdoor air to effect smallest enthalpy change across the cooling coil whenever outside temperature is above the supply air setpoint.
- .6 Grouping of objects
- (a) able to group together objects associated with equipment based on function and location so that group may be used for scheduling, logging, assigning global commands and other applications.
 - (b) at a minimum, assemble the following groups
 - each air handling unit and objects from all terminal units controllers associated with the specific air handling unit
 - (c) assemble other groups as directed by the Consultant, Commissioning Agent and Client
- .7 Alarms
- (a) each binary input and binary value object capable of generating an alarm based on an operator-specified state and to have capability to enable or disable this alarm.
 - (b) each analog object capable of generating an alarm based on an operator-specified high and low alarm limit and to have capability to enable or disable this alarm.
 - (c) delivered with alarms enabled as listed in Sequences of Operation.
- .8 Electrical demand management
- (a) capable of managing electrical demand by monitoring power consumption from signals received from pulse generator provided by others mounted at building power meter or from watt transducer or current transformers attached to building electrical feeder lines.
 - (b) If power consumption exceeds operator definable levels, system to be capable of automatically adjusting set-points, de-energizing low priority equipment, and taking other pre-programmed actions as described in Sequences of Operation to reduce demand.
 - (c) If demand drops below operator defined levels, action will be taken to restore loads in predetermined order.
- .9 Maintenance Management.
- (a) able to monitor equipment status and generate maintenance alarms based upon user-designated run-time, starts, or performance limits.
 - (b) configured to deliver maintenance alarms based upon Sequences of Operation.
- .10 Sequencing.
- (a) able to sequence chillers, boilers, and pumps with lead, lag, standby, priority assignment based upon run time,
 - (b) configured as specified in Sequences of Operation.
- .11 PID Control.
- (a) PID (proportional-integral-derivative) algorithm with direct or reverse action, controlled variable, set point, and PID gains user-selectable.
 - (b) this algorithm to calculate time-varying analog value that is used to position an output object or stage series of output objects.
 - (c) integral windup protection as a fundamental part of PID algorithm.
- .12 Staggered Start.
- (a) able to prevent controlled equipment from restarting simultaneously on power restoration after power outage.
 - (b) user-selectable sequence to establish order in which equipment (or groups of equipment) is started, and time delay between starts.

.13 Duty Cycling

- (a) Periodically cycles run and stand-by equipment to equalize usage, on a calendar basis.

.14 Power Interruption Restart

- (a) automatic system restart after a power failure,
- (b) on resumption of power (normal or emergency transfer), command all equipment and devices to a de-energized state (system stop program).
- (c) provide field verified time delay to permit all associated rotating equipment to come to a stop.
- (d) initiate restart of systems in accordance with current operating schedule requirements, and Staggered Start program.

.15 Smoke Management

- (a) Provide smoke management, smoke venting and pressurization control and communication integration with Fire Alarm System.

.16 Energy Calculations.

- (a) calculation routines to establish and accumulate instantaneous power demand in kW, flow rates in L/s temperature differences in C° and convert information to energy usage data.
- (b) two algorithms;
 - first one calculates sliding window average with operator specified window intervals.
 - second one calculates fixed-window average with digital input signal to define start of window period and synchronize fixed-window average calculation with start time used by utility.

.17 Anti-Short Cycling.

- (a) routines to protect binary output objects from short cycling with operator selected on-time and off-time minimums.

.18 On/Off Control with Differential.

- (a) direct-acting or reverse-acting algorithm that cycles binary output object based on operator selected controlled variable, set point and differential.

.19 Run-Time Totalization.

- (a) calculation routine that totalizes run-times for any binary input or object with operator selected high runtime alarms.
- (b) delivered with run time totalization and alarms configured as specified in Sequences of Operation.

3 EXECUTION

3.1 Equipment mounting

- .1 Install equipment in accordance with manufacturer's recommendations.
- .2 Mount units on modular channel frames (Unistrut or equivalent) adjacent to equipment being controlled.
 - .1 for free-standing frames, provide cross bracing and spread footing to withstand a horizontal seismic force equal to 150% of weight of BCU and support frame.
 - .2 BCU's may be mounted directly to fixed building elements, including columns and walls.
 - .3 Do not mount or attach BCU or mounting frames to any equipment subject to vibration.
- .3 Install piping securely anchored to structure or equipment.
- .4 Make power connections to controller units and sensors.

3.2 Configuration

- .1 Total number of devices on each Building LAN Bus not to exceed 80% of maximum device limitations (with the use of repeater devices).

END OF SECTION

B.A.S. EQUIPMENT CONTROLLERS

24 14 01

1 GENERAL

1.1 Scope

- .1 Provide Equipment Controllers ("ECU") for Building Automation System.
- .2 Connect Field Controllers to Building Controller via a BAS on a dedicated BACnet network.

2 PRODUCTS

2.1 General

- .1 Provide equipment which functions and meets detailed performance criteria when operating in following minimum ambient condition ranges:
 - .1 Temperature - 0°C to 32.2°C (32°F to 90°F)
 - .2 Relative Humidity 10% to 90% non -condensing
 - .3 Electrical power service of single phase, 120 VAC +/- 10%, 60 Hz nominal,
 - .4 Operating voltage: operate at 90% to 110% of nominal voltage rating and to perform an orderly shutdown below 80% nominal voltage,
 - .5 Operation to be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
- .2 Components installed within motor control devices to be designed to operate with transient electrical fields occurring within these devices.

2.2 Equipment Controllers - General

- .1 ECU's separated into two types: Programmable, and Configurable.
- .2 General:
 - .1 stand-alone, multi-tasking, multi-user, real time digital processors with hardware, software, and communications interfaces, power supplies, and input/output modular devices.
 - .2 removable (hot swappable) without disconnection of terminals and wiring,
 - .3 have access to data within network to accomplish global control strategies.
 - .4 support firmware upgrades without need to replace hardware and to have spare capacity for I/O.
 - .5 continuously perform self-diagnostics, communication diagnosis, and provide both local and remote annunciation of any detected component failures, low battery condition; and upon failure to assume predetermined failure mode.
 - .6 monitor status of overrides and inform operator if automatic control has been inhibited, and allow operator to manually override automatic or centrally executed inhibit command.
- .3 Input/Output points:
 - .1 hardwired inputs and outputs to tie into system through various Equipment Control Units (ECU's).
 - .2 protected such that shorting of point to itself, shorting of point to another point, or shorting of point to ground will not damage controller.

- .3 protected such that voltage spikes of up to 24 V, of any duration, and any polarity will not damage controller.
 - .4 Analog input: compatible with, and field configurable to commonly available sensing devices using low voltage signals (0 -10 VDC), current signals (4 -20 ma), or resistance signals from thermistors or RTD.
 - .5 Analog output: in form of modulating electronic signal, either voltage mode (0 -10VDC) or current mode (4 -20mA).
 - .6 Digital inputs: allow monitoring of on/off signals from remote devices. Digital inputs to provide wetting current of at least 12 ma and to be compatible with commonly available control devices.
 - .7 Digital outputs: provide on/off operation, or pulsed low voltage signal for pulse width modulation control. Digital outputs to be relays, 24 Volts AC or DC maximum, having 3 Amp maximum current. Each relay to be configured as normally open or normally closed, and either dry contact or bussed.
 - .8 Universal inputs: Thermistor Precon Type II, dry contacts, or 0 -5VDC with 0 -10K Ohm input impedance.
- .4 Spare I/O capacity, each ECU:
- .1 minimum of 15% spare I/O point capacity for each point type found at each location.
 - .2 15% of each type if input points are not universal,
 - .3 15% of each type if outputs are not universal,
 - .4 Minimum of one spare is for each type of point used.
 - .5 Future use of spare capacity to involve provision of field device, field wiring, point database definition, and custom software. These spare points to be configurable without additional controller boards or point modules. Wiring connections to be made to field-removable, through modular terminal strips or termination cards connected by ribbon cable.
- .5 Time Clock:
- .1 Controllers that perform scheduling operations to have on board real-time clock.
 - .2 In network application, time clock synced to associated BCU.
- .6 Communications:
- .1 communication port (RS-232 DB-9, RJ-11 or RJ-45) for connection to laptop computer or operator interface device to allow memory downloads and other commissioning and troubleshooting operations.
 - .2 communication services over BAS networks to support operator interface performance, and value passing as follows:
 - (a) connection of an operator interface device to any one controller on network to allow operator to interface with other controllers as if that interface were directly connected to those other controllers.
 - (b) data, status information, control algorithms, inputs, outputs, etc., from any controller on network is to be available for viewing and editing through operator interface device that is connected to any controller on network.
 - (c) links to execute control strategies to be programmed and tested so that an operator with appropriate password privileges is able to edit these links either by typing in standard object addresses, or by using simple point and click commands.
 - (d) daily routine automatically synchronize time clocks in controllers. An operator initiated change to master time clock setting to be automatically broadcast to other controllers on network.

- (e) minimum baud rate for peer-to-peer communication between controllers in system LAN to be at 10 Mbps and communication with low level controllers, to be at 76 Kbps.

.7 Power interruption:

- .1 continue to provide control functions in event of network communication failures.
- .2 incorporate sufficient non-volatile memory to store critical configuration data in event of loss of normal power, and sufficient battery backup to support real time clock and volatile memory for minimum of 72 hours.

.8 Memory:

- .1 sufficient memory to support its own operating system, including data sharing.

.9 GUI:

- .1 face mounted LED type annunciation to display operational mode, and power and communication status.

.10 Tier 2 LAN:

- .1 ECU's reside on either ARCNET or MS/TP physical data link layer protocol to provide BACnet internetworking and

.11 BACNet devices, Tier 2 Network;

- .1 Conformance Class 3,
- .2 support the BACnet functional groups for
 - (a) Change-of-Value (COV) Event Initiation,
 - (b) Change-of-Value (COV) Event Response,
 - (c) Event Initiation,
 - (d) Event Response,
- .3 support the BACnet standard application services of;
 - (a) Read Property,
 - (b) Write Property.
- .4 support the standard BACnet object types of;
 - (a) Device,
 - (b) Analog Input,
 - (c) Analog Output,
 - (d) Analog Value,
 - (e) Binary Input,
 - (f) Binary Output and Binary Value,
 - (g) Loop,
 - (h) Multi-State Input,
 - (i) Multi-State Output,
 - (j) Notification Class at a minimum.
- .5 The described functionality provides reading and writing of all analog or digital inputs and outputs between BACnet devices on the network and provides for change-of-value initiation and reporting.

2.3 Equipment Control Unit (ECU) - Programmable

.1 General:

- .1 capable of stand-alone, microprocessor-based operation.

- .2 fully programmable controller for larger equipment and small systems such as hydronic air handling system, simple chiller or boiler plants, cooling towers and pumps.
- .3 support firmware upgrades without need to replace hardware and to have minimum of 15 percent spare capacity of I/O functions.
 - (a) type of spares to be in same proportion as implemented functions on controller, but in no case there to be less than one point of each implemented I/O type.
- .4 continuously perform self-diagnostics, communication diagnosis, and provide both local and remote annunciation of any detected component failures, low battery condition; and upon failure to assume predetermined failure mode.

2.4 Equipment Control Units (ECU) - Configurable

- .1 General:
 - .1 capable of stand-alone, microprocessor-based operation.
 - .2 purpose-built for specific application to which they are applied, including;
 - (a) terminal unit (VAV, CAV, FPVAV) box,
 - (b) unit heaters,
 - (c) fan coils,
 - (d) rooftop unit
 - (e) heat pumps
 - (f) local reheat zones
 - (g) perimeter heating control
 - (h) free-standing fans
 - .3 Optically isolated from other controllers on communication loop.
 - .4 Memory: maintain all BIOS and programming information in the event of a power loss for at least 90 days.
- .2 Local zone control:
 - .1 wired to wall mounted temperature sensor with jack-style communications wiring.

2.5 Equipment Controller Software

- .1 General:
 - .1 applications software for building systems operation and monitoring and energy management to reside and operate in system controllers (ECU's),
 - .2 using and editing of applications to be available to an operator with appropriate authorization, through operator workstation/browser interface or at other engineering workstations,
 - .3 software to support concurrent operation of multiple standard and non-standard protocols including but not limited to:
 - (a) BACnet
 - (b) LonTalk
 - (c) MODBUS
 - (d) OPC
 - (e) SNMP
 - .4 Memory resident and available to the programs a full library of DDC algorithms, intrinsic control operators, arithmetic, logic, and relational operators for implementation of control sequences.
 - .5 Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self learning).

- .6 Adaptive Control algorithm used on control loops, as indicated in the I/O summary, where the controlled medium flow rate is variable (such as VAV units and variable flow pumping loops).
- .7 Adaptive control algorithm monitor the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm operates in a continuous self learning manner and retains in memory a stored record of the system dynamics so that on system shutdown and restart, the learning process starts from where it left off and not from ground zero.
- .8 Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.
- .9 Make available DDC setpoints, gains and time constants associated with DDC programs to the operator for display and modification via the central operator interface and portable operators terminal.
- .10 Adjustable execution interval of each DDC loop from two to 120 seconds in one second increments.
- .11 Assignment of initialization values to all outputs to assure that controlled devices assume a fail safe position on initial system start up.
- .2 Configurable ECU programming:
 - .1 Series of user selectable and configurable pre-programmed control functions.
 - .2 Control parameters field adjustable during balancing to compensate for variations in terminal unit installation, type and size.
- .3 Software application programs:
 - .1 Scheduling
 - (a) capable of scheduling each object or group of objects.
 - (b) separate schedules for each day of week with up to five start/stop pairs. (10 events)
 - (c) exception schedules defined up to year in advance and once events on exception schedule day have been executed, definition of the exception schedule day will be discarded and replaced by standard schedule for that day of week.
 - (d) up to 24 holiday schedules may be placed on scheduling calendar and will be repeated each year.
 - (e) ability to override programmed start/stop based on outside temperature reaching or exceeding an adjustable value, operator initiated, individual for each system
 - .2 Optimal Start/Stop
 - (a) Delay startup of each HVAC system to latest possible time which will allow building space to reach target conditions occupancy time
 - (b) Also advance shutdown of each system to earliest possible time.
 - (c) Include modeling techniques using building mass temperature and outdoor air temperature to predict building warm up and cool down times under different outdoor and indoor conditions.
 - (d) Generate reports to show current value of variables, inputs and outputs involved and estimates of energy savings.
 - .3 Temperature based load control
 - (a) Provide temperature setback or set up according to programmed occupancy schedules with capability to assign separate schedules to each control zone.
 - (b) Control of setback or set up achieved through setpoint adjustment, cycling of systems or cooling plant temperature conditions occupancy time
 - (c) Generate reports to show current value of variables, inputs and outputs involved and estimates of energy savings.
 - .4 Supply air reset

- (a) Monitor heating and cooling loads in building spaces and adjust HVAC discharge sensors to most energy efficient levels which will still satisfy measured load zone.
 - (b) Generate reports to show current value of variables, inputs and outputs involved and estimates of energy savings.
- .5 Enthalpy Economizer:
- (a) Program to control outside and return and exhaust air dampers during the cooling season based on inside and outside enthalpy comparisons.
 - (b) modulate dampers to mix outside and return air for free cooling whenever outside temperature is less than the supply air temperature setpoint
 - (c) Use either return or outdoor air to effect smallest enthalpy change across the cooling coil whenever outside temperature is above the supply air setpoint.
- .6 Grouping of objects
- (a) able to group together objects associated with equipment based on function and location so that group may be used for scheduling, logging, assigning global commands and other applications.
 - (b) at a minimum, assemble the following groups;
 - each air handling unit and objects from all terminal units controllers associated with the specific air handling unit
 - (c) assemble other groups as directed by the Consultant, Commissioning Agent and Client
- .7 Alarms
- (a) each binary input and binary value object capable of generating an alarm based on an operator-specified state and to have capability to enable or disable this alarm.
 - (b) each analog object capable of generating an alarm based on an operator-specified high and low alarm limit and to have capability to enable or disable this alarm.
 - (c) delivered with alarms enabled as listed in Sequences of Operation.
- .8 Electrical demand management
- (a) capable of managing electrical demand by monitoring power consumption from signals received from pulse generator provided by others mounted at building power meter or from watt transducer or current transformers attached to building electrical feeder lines.
 - (b) If power consumption exceeds operator definable levels, system to be capable of automatically adjusting set-points, de-energizing low priority equipment, and taking other pre-programmed actions as described in Sequences of Operation to reduce demand.
 - (c) If demand drops below operator defined levels, action will be taken to restore loads in predetermined order.
- .9 Maintenance Management.
- (a) able to monitor equipment status and generate maintenance alarms based upon user-designated run-time, starts, or performance limits.
 - (b) configured to deliver maintenance alarms based upon Sequences of Operation.
- .10 Sequencing.
- (a) able to sequence chillers, boilers, and pumps with lead, lag, standby, priority assignment based upon run time,
 - (b) configured as specified in Sequences of Operation.
- .11 PID Control.
- (a) PID (proportional-integral-derivative) algorithm with direct or reverse action, controlled variable, set point, and PID gains user-selectable.
 - (b) this algorithm to calculate time-varying analog value that is used to position an output object or stage series of output objects.
 - (c) integral windup protection as a fundamental part of PID algorithm.

.12 Staggered Start.

- (a) able to prevent controlled equipment from restarting simultaneously on power restoration after power outage.
- (b) user-selectable sequence to establish order in which equipment (or groups of equipment) is started, and time delay between starts.

.13 Energy Calculations.

- (a) calculation routines to establish and accumulate instantaneous power demand in kW, flow rates in L/s temperature differences in C° and convert information to energy usage data.
- (b) two algorithms;
 - first one calculates sliding window average with operator specified window intervals.
 - second one calculates fixed-window average with digital input signal to define start of window period and synchronize fixed-window average calculation with start time used by utility.

.14 Anti-Short Cycling.

- (a) routines to protect binary output objects from short cycling with operator selected on-time and off-time minimums.

.15 On/Off Control with Differential.

- (a) direct-acting or reverse-acting algorithm that cycles binary output object based on operator selected controlled variable, set point and differential.

.16 Run-Time Totalization.

- (a) calculation routine that totalizes run-times for any binary input or object with operator selected high runtime alarms.
- (b) delivered with run time totalization and alarms configured as specified in Sequences of Operation.

3 EXECUTION

3.1 General

- .1 Provide ECU's for control and instrumentation strategies as detailed in sequence of operation, and as shown.
- .2 Provide custom programming to meet the control strategies as called for in the sequence of operation sections.
- .3 Install equipment in accordance with manufacturer's recommendations.
- .4 Mount units on modular channel frames (Unistrut or equivalent) adjacent to equipment being controlled.
 - .1 for free-standing frames, provide cross bracing and spread footing to withstand a horizontal seismic force equal to 150% of weight of ECU and support frame.
 - .2 ECU's may be mounted directly to fixed building elements, including columns and walls.
 - .3 Do not mount or attach ECU or mounting frames to any equipment subject to vibration.
- .5 Install piping securely anchored to structure or equipment.
- .6 Make power connections to controller units and sensors.

3.2 Tier 2 LAN device density

- .1 Total number of devices on each Tier 2 LAN not to exceed 80% of maximum device limitations (with the use of repeater devices).

3.3 ECU database

- .1 Configure each ECU and provide database to include:
 - .1 Terminal unit box type,
 - .2 Terminal unit box size,
 - .3 minimum and maximum air flows,
 - .4 reheat air flow: minimum turndown air flow prior to use of reheat,
 - .5 current air flow,
 - .6 calibration factor: for field calibration determines by air balancing,
 - .7 room temperature setpoint,
 - .8 maximum room temperature setpoint: occupant selectable,
 - .9 minimum room temperature setpoint: occupant selectable,
 - .10 cooling setpoint,
 - .11 heating setpoint,
 - .12 unoccupied cooling setpoint,
 - .13 unoccupied heating setpoint,
 - .14 afterhours maximum Timer: maximum time occupant may override unoccupied cycle,
 - .15 internal cooling Signal: used to reset supply air temperature if more cooling is required,
 - .16 internal Heating Signal: used to reset supply air temperature is less cooling is required

END OF SECTION

B.A.S. INSTRUMENTATION AND ACTUATORS

25 35 01

1 GENERAL

1.1 Scope

- .1 Provide Instrumentation, dampers, control valves, and Actuators for Building Automation System.
- .2 Provide actuators for operating dampers provided as part of factory built air handling units.

2 PRODUCTS

2.1 General

- .1 Provide equipment which functions and meets detailed performance criteria when operating in following minimum ambient condition ranges:
 - .1 Temperature - 0°C to 32.2°C (32°F to 90°F)
 - .2 Relative Humidity 10% to 90% non -condensing
 - .3 Electrical power service of single phase, 120 VAC +/- 10%, 60 Hz nominal.
- .2 Components installed within motor control devices to be designed to operate with transient electrical fields occurring within these devices.

2.2 Power Supplies and Line Filtering

- .1 Power Supplies:
 - .1 control transformers to be UL listed,
 - .2 line voltage units to be CSA listed,
 - .3 provide over-current protection in primary and secondary circuits,
 - .4 limit connected loads to 80% of rated capacity.
- .2 DC power supplies:
 - .1 output to match equipment current and voltage requirements,
 - .2 units to be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation to be 1.0% line and load combined, with 100-microsecond response time for 50% load changes,
 - .3 units to have built-in over-voltage and over-current protection and to be able to withstand 150% current overload for at least three seconds without trip-out or failure,
 - .4 units to operate between 0°C and 50°C (32°F and 120°F). EM/RF to meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
- .3 Power Line Filtering:
 - .1 provide internal or external transient voltage and surge suppression for workstations and control modules,
 - .2 surge protection:
 - (a) dielectric strength of 1000 V minimum,
 - (b) response time of 10 nanoseconds or less,
 - (c) transverse mode noise attenuation of 65 dB or greater,
 - (d) common mode noise attenuation of 150 dB or greater at 40-100 Hz.

2.3 Motorized Control Dampers

- .1 Construction:
 - .1 in accordance with section 23 33 14 - Dampers - Operating.

2.4 Electric/electronic actuators – air dampers

- .1 Actuators for Air Handling Units dampers and general purpose plenum/duct mounted dampers:
 - .1 electric/electronic type for two position or proportional operation as shown,
 - .2 enclosure:
 - (a) general purpose, drip proof enclosure for indoor applications,
 - (b) NEMA 4 enclosure for outdoor use and where dampers are exposed to the airstream inside an air intake plenum.
 - .3 gear type mechanism with spring-return to failed position as shown,
 - .4 mounted over damper shaft or with connecting linkage and with fastening clamp assembly,
 - .5 sized and selected in accordance with manufacturer's instructions,
 - .6 electronic overload or digital rotation sensing circuitry to protect damper operator through entire range of rotation,
 - .7 angle of rotation adjustable between 0° to 90°,
 - .8 control signals:
 - (a) 0 - 10VDC or 0 - 20ma for proportional control,
 - (b) power On-Off for two position service,
 - .9 feedback signals:
 - (a) proportional service: 2 - 10 VDC position feedback signal.
 - (b) two position service: two SPDT auxiliary switches for end stop position indication.
 - .10 suitable for operation down to -35°C when installed outdoors.
 - .2 Actuators for dampers serving fuel-fired appliances and stationary engines – equipment and rooms:
 - .1 as above for general purpose duct mounted dampers and as follows.
 - .2 spring return to fail position on loss of power supply:
 - (a) combustion air dampers : fail-to-open
 - (b) ventilation inlet air dampers: fail-to-open
 - (c) recirculation air dampers: fail-to-close
 - (d) exhaust air dampers: fail-to-open.
 - .3 spring operating cycle time: <20 seconds at -20°C to 50°C (-4°F to 122°F)
 - .4 operating control:
 - (a) combustion air dampers: two position open/closed
 - (b) all other dampers: modulating with 0-10VDC or 4-20 mA input signal
- Standard of Acceptance*
- ° Belimo – EFB24-S N4/EFB120-S N4 series for two position dampers
 - ° Belimo – EFB24-SR-S N4 series for modulating dampers

- .3 Actuators for Terminal unit dampers:
 - .1 integrated DDC controller and damper actuator,

- .2 sized and selected in accordance with terminal box damper manufacturer's specifications,
- .3 gear drive, direct coupled type operators mounted to shaft with universal V-bolt clamp,
- .4 proportional type control,
- .5 selectable / reversible rotation direction,
- .6 input type and range as suitable for interfacing to output of terminal unit controller,
- .7 angle of rotation adjustable between 30 to 90° with mechanical limit stops,
- .8 damper position indication visible without cover removal,
- .9 manual override to set damper position without power applied to actuator,
- .10 electronic stall protection,
- .11 general purpose dust proof enclosure,
- .12 actuator running time of not more than 100 seconds,
- .13 delivered to terminal unit manufacturer's factory for installation.

2.5 Control Valves

- .1 General:
 - .1 Body and trim materials selected in accordance with specification for globe valves, ball valves, or high performance butterfly valves, and in accordance with manufacturer's recommendations for design conditions and service.
 - .2 Size control valves for pressure drops and heating and cooling loads as scheduled with same pressure rating as globe valves under same service and pressure conditions.
 - .3 Size valves for two port and three port, two position service;
 - (a) line size,
 - (b) ball valves, sizes NPS 1 ½ and smaller,
 - (c) butterfly valves, sizes NPS 2 and larger.
 - .4 For two port and three port modulating service;
 - (a) use globe valves for CV rating 160 and smaller,
 - .5 Control valve type selections and sizes are shown on drawings, schematics and schedules.
- .2 Water and glycol valves:
 - .1 two position service;
 - (a) straight through two port type, single seated, with replaceable disc or ball,
 - (b) quick opening linear or equal percentage flow characteristics.
 - .2 modulating service;
 - (a) straight through two port type, single seated,
 - (b) equal percentage flow characteristics.
 - .3 modulating diverting service; three port mixing valves,
 - (a) linear for each port to give constant total flow or,
 - (b) equal percentage flow characteristics with 25% valve authority (valve pressure drop equal to 33% pressure drop through load at full flow).
 - .4 actuator and trim selected for close-off pressure ratings as follows;
 - (a) two-way modulating or two position service; 150% of pump shut off head.
 - (b) three-way modulating service; 300% of pressure differential between ports A and B at design flow or 100% of pump shut off head.
 - (c) shut off head to be based on maximum rpm when pump is fitted with VFD

- .5 sized as follows;
 - (a) for two-position service; line size.
 - (b) for two-way modulating service unless otherwise shown; pressure drop at design flow equal to greatest of;
 - 200% of pressure drop through heat exchanger,
 - 100% of pressure drop through coil,
 - 50% of pressure difference between supply and return mains, or
 - 35 kPa (5 psi).
 - (c) for three-way modulating service; pressure drop equal to smaller of;
 - twice pressure drop through coil or heat exchanger, or
 - 35 kPa (5 psi).
 - (d) for valves for radiation, terminal units and reheat coils;
 - pressure drop of 7kPa (1 psig)
- .6 failed position on isolation from control signal as follows;__
 - (a) Heating water and glycol zone valves; normally open.
 - (b) Heating coil valves in AHU; normally open.
 - (c) Chilled water control valves; normally closed.
 - (d) Chilled water differential pressure by-pass control valves; normally open.
 - (e) Hot water and glycol differential pressure by-pass control valves; normally closed.

2.6 Electric/electronic actuators - valves

- .1 Valve actuators for service other than radiation, radiant panel and reheat coil valve applications:
 - .1 sized and selected in accordance with manufacturer's specifications,
 - .2 electric/electronic for two position, or proportional control action, coupled to valves with linkage,
 - .3 electronic interface control board, solid state drive, reversible motor, oil immersed gear train,
 - .4 electronic overload or digital rotation sensing circuitry to protect damper operator through entire range of rotation,
 - .5 span and zero travel adjustment,
 - .6 position feedback signal on actuators used for proportional control,
 - .7 provision for manual positioning of valve when actuator is not powered,
 - .8 spring return mechanism to return valve to "normal" position on power failure (i.e. Normally Open (NO), or Normally Closed (NC)),
 - .9 control signals:
 - (a) 0 to 10VDC or 0 to 20ma,
 - (b) modulate damper position with 2 to 10VDC or 4 to 20ma input signal operating range when in proportional service.
 - (c) input type and range as suitable for interfacing to output of BAS controller
 - .10 feedback signals:
 - (a) two independent adjustable travel limit switches and wiring to BAS for indication of valve position.
 - .11 general purpose, drip proof NEMA 2 die-cast housing with corrosion resistant steel cover for indoor applications, watertight NEMA 4 enclosure for outdoor use,
 - .12 electric actuators suitable for operation down to -35°C where installed outdoors.
- .2 Valve actuators for service on radiation, radiant panel, and reheat coil valve applications:

- .1 output shaft driven by gear train mechanism.
- .2 reversible motor with automatic load limit,
- .3 input type and range as suitable for interfacing to output of BAS controllers,
- .4 adjustable span and offset travel ,
- .5 position feedback signal on actuators used for proportional control,
- .6 general purpose, dustproof, die-cast aluminum housing,
- .7 actuator rotation limit.

2.7 Temperature switches

- .1 Low temperature limit thermostat (freezestat):
 - .1 6m (20 ft) of sensing capillary sensitive to freezing air over any 400mm (15 in) section,
 - .2 manual reset switch
 - .3 installed in multiples with one unit serving not more than 5 m² (40 sq ft) of duct area.
 - .4 single pole single throw (SPST) contacts or single pole double throw (SPDT) contacts where used as digital input to BAS
 - .5 1.7°C to 7.2°C (35°F to 45°F) operating temperature range
 - .6 adjustable set point within specified range
 - .7 protective enclosure.
- .2 Temperature switches:
 - .1 sensing element of liquid, vapour or bimetallic type,
 - .2 adjustable set-point and differential of at least 0.22°C to 1.7°C (0.4°F to 3.0°F),
 - .3 snap action type rated at 120 volts, 15 amps or 24 volts DC,
 - .4 automatic in operation and automatically reset when condition returns to normal.
 - .5 suitable for wall mounting on standard electrical box with protective guard, or suitable for insertion into air ducts with insertion length of 450 mm (18 in), or
 - .6 thermowell type with compression fitting for 20 mm (0.8 in) NPT well, mounting length of 100 mm (4 in), and immersion wells of type 316 stainless steel, or
 - .7 Strap-on-type with helical screw stainless steel clamps.
 - .8 23°C to 57°C (75°F to 138°F) operating temperature range
 - .9 adjustable set point within specified range
 - .10 single pole single throw (SPST) contacts or single pole double throw (SPDT) contacts where used as digital input to BAS
 - .11 protective enclosure.

2.8 Temperature sensors/transmitters

- .1 Sensor alternative technologies:
 - .1 Resistance temperature device (RTD) of precision thin film platinum element type;
 - (a) linear characteristics over sensor range,
 - (b) 1000 ohm, ±20 ohms (2%) reference resistance at 0°C (32°F),
 - (c) 0/.0385ohms/ohm/°C (0.0212 ohms/ohm/°F) temperature coefficient of resistance and
 - (d) ±0.36°C at 21°C (±0.65°F at 70°F) accuracy

- .2 Resistance temperature device (RTD) of precision thin film nickel element type, with
 - (a) linear characteristics over sensor range,
 - (b) 1000 ohm, ± 20 ohms (2%) reference resistance at 21°C (70°F),
 - (c) 5.4 ohm/°C (3.0 ohm/°F) temperature coefficient of resistance and
 - (d) $\pm 0.18^\circ\text{C}$ at 21°C ($\pm 0.34^\circ\text{F}$ at 70°F) accuracy
- .3 Thermistor with
 - (a) non-linear negative temperature coefficient of resistance,
 - (b) 10,000 ohms reference resistance at 25°C (77°F),
 - (c) curve matched to $\pm 0.2^\circ\text{C}$ ($\pm 0.36^\circ\text{F}$) temperature accuracy over 0°C to 70°C (32°F to 158°F), and
 - (d) long term stability of 0.025°C (0.045°F) drift per year
- .2 Each sensor:
 - .1 2 integral anchored lead wires
 - .2 waterproof sensor to sheath seal
 - .3 strain minimizing construction
 - .4 standard conduit box termination with cover
 - .5 pig-tail wire leads with wire nuts or screwed terminal connector block
 - .6 factory calibrated and capable of end to end (sensing element to BAS) accuracy of $\pm 0.25^\circ\text{C}$ ($\pm 0.5^\circ\text{F}$) over full range of measured variable.
 - .7 transducing circuit to convert output to signal compatible with equipment controller
 - .8 concealed USB or serial communications port for portable PC or hand held commissioning equipment.
- .3 Averaging element type temperature sensors:
 - .1 average style element for ducts of greater cross section than 0.4 m² (4 sq ft).
 - .2 sensor operating temperature range from -40°C to 121°C (-40°F to 250°F)
 - .3 copper sheathed construction
 - .4 non-condensing 5 to 95% RH
 - .5 minimum immersion length of 4000 mm (13 feet)
 - .6 probe field formable to minimum radius of 100mm (4 in) at any point along probe length, other than with 200 mm (8 in) of connector box, without degradation of specified performance
 - .7 provided as multiple sensors where single averaging element cannot be located to provide proper duct or plenum temperature sampling.
- .4 Duct mount probe type temperature sensors:
 - .1 provided for ducts of cross section less than 0.4 m² (4 sq ft)
 - .2 sensor operating temperature range from -40°C to 121°C (-40°F to 250°F)
 - .3 copper or brass or stainless steel sheathed construction
 - .4 non-condensing 5 to 95% RH
 - .5 metal mounting plate
 - .6 length such that sensing element is no less than a of duct width or diameter from duct wall greater

- .7 provided as multiple sensors where single element cannot be located to provide proper duct or plenum temperature sampling.
- .5 Thermowell mount type temperature sensors:
 - .1 insertion elements for measurement of fluid temperatures with stainless steel sheath
 - .2 sensor operating temperature range from -40°C to 121°C (-40°F to 250°F)
 - .3 spring loaded construction with compression fitting for 20mm (NPS $\frac{3}{4}$) well mounting
 - .4 length suitable for application
 - .5 stainless steel or chrome plated brass thermowells of size and material to suit relevant sensor, pipe and service
- .6 Outside air temperature sensors:
 - .1 insertion type for through-the-wall installation with stainless steel sheath
 - .2 sensor operating temperature range from -25°C to 60°C (-13°F to 140°F)
 - .3 waterproof seal at wall
 - .4 non-condensing 5 to 95% RH
 - .5 total active probe length of 100 mm to 150 mm (4 in to 6 in)
 - .6 with non-corroding outdoor shield to minimize solar heating effect and
 - .7 inert section passing through wall to allow precise measurement of outdoor temperature.
- .7 Space temperature sensors, Type 1:
 - .1 for measurement of space temperatures throughout facility
 - .2 sensor operating temperature range from 4°C to 60°C (40°F to 140°F)
 - .3 surface mounted plastic mono-chromatic guard with surface mounting plate and wall anchors.
 - .4 guard secured to mounting plate by screws.
 - .5 no display

2.9 Humidity sensors - electronic

- .1 Each humidity sensor:
 - .1 suitable for operating ranges of 10 to 100% R.H.
 - .2 sensor operating temperature range from -40°C to 121°C (-40°F to 250°F)
 - .3 solid state sensing element,
 - .4 accuracy of $\pm 3\%$ over range of 5 to 95% R.H.
 - .5 independent, non-interactive span and zero adjustments
 - .6 0-100% linear proportional output signal indicating relative humidity, 4-20 mA, 0-5 Vdc or 0-10 Vdc
 - .7 strain minimizing construction
 - .8 dust proof enclosure
 - .9 screwed terminal connector block.
- .2 Duct mount probe type humidity sensors:
 - .1 metal mounting plate
 - .2 constructed with 304 stainless steel element enclosure

- .3 length such that sensing element is not less than $\frac{1}{4}$ of duct width or diameter from duct wall.
- .3 Outside air type humidity sensors:
 - .1 weatherproof enclosure with cover
 - .2 waterproof seal.
- .4 Space humidity sensors:
 - .1 surface mounted plastic guard with surface mounting plate and wall anchors
 - .2 guard secured to mounting plate by screws
 - .3 analogue LCD humidity display.

2.10 Pressure sensors/transmitters and pressure switches

- .1 General:
 - .1 Rating of chilled and condenser water units: 1000 kPa (125 psi).
 - .2 Rating of hot water units: 1000 kPa (125 psi).
 - .3 Rating of steam units: 1200 kPa (150 psi).
 - .4 Rating of high temperature water units: 2700 kPa (400 psi)
 - .5 Pressure sensors monitoring fan operation to have set point adjustable from 0 to 3600 Pa (0 to 10 in wg.) and adjustable differential between 10 to 300 Pa (0.03 to 1 in wg).
- .2 Static pressure and differential pressure sensors for air or inert gas - electronic:
 - .1 diaphragm driven, capacitance change type, 0-100% linear proportional output signal indicating static pressure or differential pressure at station, 4-20 mA, 0-5 Vdc or 0-10 Vdc
 - .2 field adjustable zero and span
 - .3 selected with span of not greater than twice maximum static pressure and not less than twice differential pressure at shut-off.
 - .4 accuracy, including non-linearity, hysteresis and non-repeatability; $\pm 1\%$ full scale
 - .5 operating temperature range; -18°C to 80°C (0°F to 175°F)
 - .6 operating humidity range; 10 to 90% non-condensing
 - .7 high and low pressure ports, brass hose barbed pressure fittings suitable for 8 mm ($\frac{1}{4}$ in) tubing
 - .8 mounting bracket, suitable for duct mounting
 - .9 dust proof enclosure, and
 - .10 screw terminal connector block.
- .3 Pressure transducers - electronic:
 - .1 suitable for use in water, glycol, steam, ammonia and non-corrosive refrigerants,
 - .2 series 300 stainless steel construction, stainless steel diaphragm
 - .3 sealed electronics
 - .4 0-100% linear proportional output signal indicating pressure at station, 4-20 mA, 0-5 Vdc or 0-10 Vdc
 - .5 designed for 3 times rated range over pressure without damage
 - .6 low pressure range 1 to 700 kPa (0 to 100 psig)

- .7 high pressure range 1 to 3400 kPa (0 to 500 psig)
 - .8 accuracy including non-linearity, hysteresis, and non-repeatability; $\pm 1\%$ full range span
 - .9 operating temperature range; -40°C to 100°C (-40°F to 212°F)
 - .10 operating humidity range; 10 to 90% non-condensing
 - .11 suitable for direct mounting to pressure port
 - .12 dust proof enclosure, and
 - .13 screw terminal connector block.
- .4 Differential pressure transmitters for terminal units:
- .1 suitable for use in air with pressure independent terminal units (constant volume, variable volume or fan powered)
 - .2 capacitive sensor technology
 - .3 pressure range 0 Pa to 373 Pa (0 to 15 in.w.g.)
 - .4 linear output proportional to velocity pressure of unit inlet air stream, and suitable as analog input to terminal unit controller
 - .5 accuracy including non-linearity, hysteresis, and non-repeatability; $\pm 1\%$ full scale
 - .6 operating temperature range; 0°C to 50°C (32°F to 122°F)
 - .7 operating humidity range; 10 to 90% non-condensing
 - .8 high and low pressure ports, barbed pressure fittings suitable for 8 mm ($\frac{1}{4}$ in) tubing for connection to air flow pick up device provided with terminal box
 - .9 mounting kit, suitable for installation within terminal unit controller enclosure
 - .10 coded screw terminals
- .5 Differential pressure switches:
- .1 spring loaded diaphragm type
 - .2 suitable for use with air or inert gas,
 - .3 adjustable set-point and differential,
 - .4 snap acting SPDT contacts suitable for use as digital input to BAS
 - .5 switch mounted with diaphragm in vertical plane
 - .6 automatic in operation and automatically reset when condition returns to normal.
 - .7 operating temperature range; 0°C to 60°C (35°F to 140°F)
 - .8 operating humidity; 10 to 90% RH non-condensing
 - .9 high and low pressure ports, brass hose barbed pressure fittings suitable for 8 mm ($\frac{1}{4}$ in) tubing
 - .10 mounting bracket suitable for duct mounting,
 - .11 dust proof enclosure, and
 - .12 screw terminal block

2.11 Electrical devices

- .1 Current sensing relays:
 - .1 metering transformer ranged to match load being metered,
 - .2 plug in base and shorting shunt to protect current transformer when relay is removed from socket,

- .3 current transformer for single or three phase metering connected into single relay,
 - .4 adjustable latch level, adjustable delay on latch and minimum differential of 10% of latch setting between latch level and release level,
 - .5 discrimination between phases in three phase applications to allow worst case selection,
 - .6 mounted in motor starter enclosure and fed from starter control transformer,
 - .7 relay contacts capable of handling 10 amps at 240 volts.
- .2 Current transducer:
- .1 output signal proportional to measured line current,
 - .2 output signal in one of following ranges; 4-20 mA, 0-5 Vdc or 0-10 Vdc
- .3 Control Relays:
- .1 plug-in type, UL listed, with dust cover and LED "energized" indicator.
 - .2 contact rating, configuration, and coil voltage suitable for application.
 - .3 NEMA 1 enclosure for relays not installed in local control panels.
- .4 Time Delay Relays:
- .1 solid-state plug-in type, UL listed, with adjustable time delay adjustable $\pm 100\%$ from set point shown.
 - .2 contact rating, configuration, and coil voltage suitable for application.
 - .3 NEMA 1 enclosure for relays not installed in local control panels.
- .5 Override Timers:
- .1 spring-wound line voltage, UL Listed, with contact rating and configuration by application unless implemented in control software.
 - .2 0-6 hour calibrated dial.
 - .3 flush mounted on local control panel face.
- .6 AC Current Transmitters:
- .1 self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output.
 - .2 full-scale unit ranges of 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment.
 - .3 $\pm 1\%$ full-scale accuracy at 500 ohm maximum burden.
 - .4 UL/CSA listed and meet or exceed ANSI/ISA 50.1 requirements.
- .7 AC Current Transformers:
- .1 UL/CSA listed
 - .2 completely encased (except for terminals) in approved plastic material.
 - .3 selected for appropriate current ratios with $\pm 1\%$ accuracy at full-scale output.
 - .4 fixed-core transformers for new wiring installation
- .8 AC Voltage Transmitters:
- .1 self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.

- .2 adjustable full-scale unit ranges; 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac.
- .3 $\pm 1\%$ full-scale accuracy at 500 ohm maximum burden.
- .4 UL/CSA listed, 600 Vac rated and conforming to ANSI/ISSA 50.1.
- .9 AC Voltage Transformers:
 - .1 UL/CSA listed, 600 Vac rated with built-in fuse protection.
 - .2 suitable for ambient temperatures of 4°C to 55°C (40°F to 130°F) and
 - .3 $\pm 0.5\%$ accuracy at 24 Vac and 5 Vac load.
 - .4 windings (except for terminals) enclosed with metal or plastic.
- .10 Power Monitors:
 - .1 three-phase type with three-phase disconnect and shorting switch assembly,
 - .2 UL listed voltage transformers, and
 - .3 UL listed split-core current transformers.
 - .4 selectable output either rate pulse for kWh reading or 4-20 mA for kW reading.
 - .5 maximum error of $\pm 2\%$ at 1.0 power factor or $\pm 2.5\%$ at 0.5 power factor.
- .11 Current Switches:
 - .1 self-powered, solid-state type with adjustable trip current
 - .2 integral current transformers and relays to indicate motor status
 - .3 SPDT output relay suitable for use as digital input
 - .4 field adjustable output relay trip setting, over 0-100% of range. Deadband adjustment to maximum of 10% of range
 - .5 integral zero-leakage LED's indicating sensor power and switch status
 - .6 long term setting drift of current transformer and relay combination not more than 5% full range over 6 months
 - .7 over current and over voltage protection for current transformer and relay
 - .8 operating temperature range; -10°C to 50°C (14°F to 122°F)
 - .9 operating humidity range; 5% to 90% RH non condensing
- .12 Electronic signal isolation transducers:
 - .1 provided whenever;
 - (a) an analog output signal from BAS is connected to an external control system as an input (such as chiller control panel) or
 - (b) BAS is to receive an analog input signal from an external remote system.
 - .2 designed for ground plane isolation between systems.

2.12 Local equipment panels

- .1 General:
 - .1 NEMA 2 sheet metal cubicles with vertically hinged lockable doors,
 - .2 sensors, transducers, BAS controllers, and relays mounted on backing board and/or DIN rails within inner section,
 - .3 enclosures sized to house controllers and associated transformers, control relays, wiring, conduits and other auxiliary equipment.

- .4 engraved lamacoid labels with white lettering indicating function of each sensor, transducer, controller, gauge and instrument.
- .5 wiring terminations labelled
- .6 EMT conduit openings and adapters in sufficient quantities and sizes to accommodate wiring terminating within enclosure
- .7 wiring within enclosure installed in neat and protected manner, enclosed in wireways or plastic conduit.
- .8 inside each panel, one set of as built, plasticized control Shop Drawings for equipment served by that panel permanently affixed to cabinet frame.

2.13 Wiring and Raceways

- .1 Wiring, conduit, and raceways to Section 20 05 13.
- .2 Wire used for power and control:
 - .1 insulated copper conductors,
 - .2 UL listed for minimum 90°C (200°F) service.
 - .3 Power wiring minimum 12 gauge.
 - .4 Control wiring for digital functions: 18 AWG minimum with 300 Volt insulation.
 - .5 Control wiring for analog functions: 18 AWG minimum with 300 Volt insulation, twisted and shielded, 2 or 3 wire to match analog function hardware.
 - .6 Transformer current wiring: 16 AWG minimum.
 - .7 Sensor wiring: 22 AWG minimum twisted and shielded, 2 or 3 wire to match analog function hardware. Provide additional conductors as to support supplemental features of sensor (i.e. set-point adjustment, override, etc.)

3 EXECUTION

3.1 Installation of Sensors

- .1 General:
 - .1 Mount sensor assemblies and elements;
 - (a) in clean areas wherever possible,
 - (b) accessible to allow for replacement and servicing without interfering with access for adjacent equipment and personnel traffic in surrounding space,
 - (c) provide access doors where assemblies and elements are concealed.
 - .2 Install transmitters, transducers, controllers, solenoid air valves and relays in NEMA2 enclosures;
 - (a) install wiring and tubing within enclosures in trays or individually clipped to back of panel with identification tags and terminal numbers visible.
 - .3 Rigidly support field mounted transmitters, transducers, and sensors on pipe stands or channel brackets.
 - .4 Orient sensing elements to correctly sense measured variable and to be isolated from vibrations and environmental conditions that could affect measurement or calibration.
 - .5 Identify each cable and wire at every termination point.
 - .6 Air seal wires attached to sensors at entry into junction box.

- .2 Temperature sensors:
 - .1 Install room temperature sensors on concealed junction boxes supported by wall framing.
 - .2 Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in serpentine manner vertically across duct. Support each bend with capillary clip.
 - .3 Install mixing plenum low-limit sensors in serpentine manner horizontally across duct. Support each bend with capillary clip. Provide sensor element length to coil area ratio of 3 m per 1 m² (1 ft per 1 sq ft).
 - .4 Install pipe-mounted liquid temperature sensors in wells with heat-conducting material. Where thermowell installation necessitates shutting down of pumps or draining of pumps, coordinate with Consultant and Owner.
 - .5 Cut and recover piping insulation to one foot either way for installation of strap-on temperature sensors. Provide removable insulation box over sensor and patch insulation to match existing.
 - .6 Install outdoor air temperature sensors on north facing wall with sun shield.
 - .7 Mount space temperature and humidity sensors 1200 mm (4 ft) above finished floor.
- .3 Pressure sensors:
 - .1 Mount gauge tees adjacent to water differential pressure taps. Install shut-off valves before tee for water gauges.
- .4 Differential air static pressure sensor installations:
 - .1 Supply duct static pressure;
 - (a) pipe high-pressure tap to duct using pitot tube,
 - (b) make pressure tap connections according to manufacturer's recommendations.
 - .2 Return duct static pressure;
 - (a) pipe high-pressure tap to duct using pitot tube,
 - (b) make pressure tap connections according to manufacturer's recommendations.
 - .3 Building static pressure;
 - (a) pipe pressure sensor's low-pressure port to static pressure port located on outside of building through high-volume accumulator,
 - (b) pipe high-pressure port to location behind thermostat cover.
 - .4 Piping to air pressure transducer pressure taps to contain capped test port adjacent to transducer.
 - .5 Locate air pressure transducers, except those controlling terminal unit boxes;
 - (a) in control panels, not on monitored equipment or on ductwork,
 - (b) mount transducers in vibration-free location accessible for service without use of ladders or special equipment.
- .5 Flow Switch Installation
 - .1 Fit correct length paddle for diameter of pipe.
 - .2 Adjust switch for specified flow condition in accordance with manufacturer's instructions

3.2 Actuators

- .1 General:
 - .1 Mount actuators and adapters according to manufacturer's recommendations.
- .2 Electric and Electronic Damper Actuators:

- .1 Mount damper actuators directly on damper shaft or jackshaft
 - .2 Mount valve actuator directly on shaft or with linkages according to manufacturer's recommendations.
 - .3 For low-leakage dampers with seals, mount actuator with minimum 5° travel available for damper seal tightening.
 - .4 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close damper, then tighten linkage.
 - .5 Provide mounting hardware and linkages for actuator installation.
- .3 Valve Actuators:
- .1 Connect actuators to valves with adapters approved by actuator manufacturer.

END OF SECTION

B.A.S. SEQUENCE OF OPERATIONS

25 90 01

1 GENERAL

1.1 Definitions

- .1 System Start: actions required at system start-up under schedule control or on re-start after power failure.
- .2 Normal Operation: normal control sequence after initial start-up requirements are satisfied.
- .3 Demand Limiting: special operation parameters during normal utility power outages (emergency generator operation)
- .4 System Stop: shut-down of system under schedule control and fail-safe position of system in event of loss of normal power.
- .5 Fire Alarm: action required in the event of a signal from the fire alarm system (FA).
- .6 Schedule: scheduled operation of system
- .7 Alarm: minimum alarm points required.
- .8 Emergency Power: control system elements to be fed from emergency power, refer to electrical drawings.

2 PRODUCTS

2.1 Refer to Sections of Division 25 00 00 BUILDING AUTOMATION SYSTEM

3 EXECUTION

3.1 Sequence of operation and control drawings

- .1 Control sequences that follow describe and detail suggested method of control of systems.
- .2 Control drawings listed for each control sequence illustrate required inputs and outputs for the control and monitoring of systems.
- .3 Review sequence of operation described for each system and allow for additional input and output points to achieve method of control described. Review documents to determine quantity of each piece of equipment or system.

.4 Sequences of Operation

- .1 CS 001 Rooftop Units
- .2 CS 002 Transfer and Exhaust Fans
- .3 CS 003 EF-2
- .4 CS 004 VAV Boxes

END OF SECTION

CS001 – Roof Top Units (RTU)

Reference: Drawing M-601

Sequence:

RTUs shall be monitored and controlled by the Building Automation System (BAS). All setpoints shall be adjustable.

1. System Control:
 - 1.1. Schedule:
 - 1.1.1. The system operates via pre-programmed occupancy time schedule. Coordinate final occupancy schedule with Owner.
 - 1.2. Manual Override:
 - 1.2.1. Override On:
 - 1.2.1.1. The operator's command on BAS shall override the time schedule and revert the system into occupied mode.
 - 1.2.2. Override Off:
 - 1.2.2.1. The operator's command on BAS shall override the time schedule and revert the system into unoccupied mode.
2. Unoccupied Mode:
 - 2.1. RTU fans shall be de-energized and OA damper closed.
 - 2.2. Unoccupied mode:
 - 2.2.1. If there is a call for heating/cooling from the associated VAV zones, the RTU fan shall be enabled. The OA damper shall remain closed.
 - 2.2.2. The supply fan VFD shall modulate to maintain the supply air static pressure setpoint.
 - 2.2.3. The RTU shall enable heating or cooling mode maintain the supply air temperature setpoint.
 - 2.2.4. The system shall revert to unoccupied mode once the unoccupied space temperature setpoint has been met.
3. Occupied Mode:
 - 3.1. Fan Control
 - 3.1.1. RTU fan shall be enabled and run continuously.
 - 3.1.2. The OA damper shall open to it's minimum position.
 - 3.1.3. The supply fan VFD shall modulate to maintain the supply air static pressure setpoint.
 - 3.2. Temperature Control
 - 3.2.1. The system heating mode shall be disabled when the outdoor air temperature rises above 15.5°C.
 - 3.2.2. The system cooling mode shall be disabled when the outdoor air temperature drops below 12.8°C. as set by the global seasonal setpoint.
 - 3.2.3. The system shall modulate the gas heating or stage the DX cooling to maintain the supply air temperature setpoint.
 - 3.2.4. The supply air temperature setpoint shall be as follows:

Return Air Temp (°C)	Supply Air Temp (°C)
24	12.8
18	20
 - 3.3. Economizer Mode
 - 3.3.1. Economizer mode shall be enabled when the OA temperature is below 21°C and the OA enthalpy is less than the RA enthalpy.

- 3.3.2. In economizer mode, the OA damper shall modulate to maintain the supply air temperature setpoint.
- 3.3.3. If the supply air temperature setpoint cannot be achieved via economizer, the DX cooling shall stage on to supplement the cooling.

4. Alarms:

- 1.1. The following points shall alarm at the operator workstation (alarm limits including delays shall be adjustable at OWS web graphics):

Description	Low	High	Time Delay	Action
Mismatch of unit command and fan status feedback	-	-	2 min	Notification
Space temperature	15	25	5 min	Notification
Leak detection	-	-	0 sec	Shut down unit, close CHW valve and notification

CS002 – Exhaust/ Transfer Fans

Reference: Drawing M-601

Sequence:

Exhaust fans shall be monitored and controlled by the Building Automation System (BAS).

1. System Control:
 - 1.1. Schedule:
 - 1.1.1. The system operates via pre-programmed occupancy time schedule. Coordinate final occupancy schedule with Owner.
 - 1.2. Manual Override:
 - 1.2.1. Override On:
 - 1.2.1.1. The operator's command on BAS shall override the time schedule and revert the system into occupied mode.
 - 1.2.2. Override Off:
 - 1.2.2.1. The operator's command on BAS shall override the time schedule and revert the system into unoccupied mode.
2. Unoccupied Mode
 - 2.1. Exhaust fan shall be off and associated damper shall be closed
3. Occupied Mode
 - 3.1. Exhaust fan shall energize and run continuously and associated damper shall be open.
4. Alarms:
 - 1.1. The following points shall alarm at the operator workstation (alarm limits including delays shall be adjustable at OWS web graphics):

Description	Low	High	Time Delay	Action
Mismatch of unit command and fan status feedback	-	-	2 min	Notification

CS002 – Exhaust/ Transfer Fans

Reference: Drawing M-601

Sequence:

Exhaust fans shall be monitored and controlled by the Building Automation System (BAS).

1. System Control:
 - 1.1. Schedule:
 - 1.1.1. The system operates via a manually operated switch.
 - 1.2. Manual Override:
 - 1.2.1. Override On:
 - 1.2.1.1. The operator's command on BAS shall override the time schedule and revert the system into occupied mode.
 - 1.2.2. Override Off:
 - 1.2.2.1. The operator's command on BAS shall override the time schedule and revert the system into unoccupied mode.
2. System Disabled
 - 2.1. Exhaust fan shall be off and associated exhaust fan damper shall be closed. Return air damper to RTU-2 shall be open.
3. System enabled.
 - 3.1. Exhaust fan shall be on and associated exhaust fan damper shall be open. Return air damper to RTU-2 shall be closed.
4. Alarms:
 - 1.1. The following points shall alarm at the operator workstation (alarm limits including delays shall be adjustable at OWS web graphics):

Description	Low	High	Time Delay	Action
Mismatch of unit command and fan status feedback	-	-	2 min	Notification

CS-004 – VAV Boxes

Reference: Drawing M-603

Applicable
System: VAV Boxes

Sequence:

VAV boxes shall be monitored and controlled by the Building Automation System (BAS). All setpoints shall be adjustable.

1. System Control:

1.1. Schedule:

1.1.1. The system operates via pre-programmed occupancy time schedule. Coordinate final occupancy schedule with Owner.

1.2. Manual Override:

1.2.1. Override On:

1.2.1.1. The operator's command on BAS shall override the time schedule and revert the system into occupied mode.

1.2.2. Override Off:

1.2.2.1. The operator's command on BAS shall override the time schedule and revert the system into unoccupied mode.

2. Temperature Control:

2.1. The VAV terminal box controller monitors the space temperature sensor and velocity sensor. The controller shall modulate the cold supply air damper and modulate the electric reheat to maintain the desired room temperature.

2.2. If the space temperature is below its adjustable setpoint, the VAV damper shall modulate to its minimum position.

2.3. On further drop in space temperature below the setpoint, the electric reheat shall modulate to maintain the space temperature setpoint and the VAV damper shall modulate open.

2.4. As the space temperature rises above its setpoint, the electric reheat shall be disabled and the primary damper shall modulate to maintain the space temperature setpoint.

2.5. The supply air volume will be limited by its minimum and maximum supply air volume settings.

2.6. All VAV terminal units shall be addressable from the standalone controllers.

3. Temperature Setpoints:

3.1. Unoccupied Space Temperature set point :

Operation Mode	Set Point
Heating	16°C
Cooling	26°C

3.2. Occupied Space Temperature set point :

Operation Mode	Set Point
Heating	22°C
Cooling	24 °C

4. Alarms:

4.1. The following points shall alarm at the operator workstation:

Description	Low	High	Time Delay
Space temperature	15°C	30.0°C	15 min

Part 1 General

1.1 RELATED REQUIREMENTS

- .1 Division 03 Cast-in-Place Concrete.
- .2 Section 07 21 13.01 - Foundation Board Insulation.
- .3 Section 33 46 17 - Subgrade Drainage Network.
- .4 Division 31 – Earthwork

1.2 REFERENCES

- .1 ASTM International (ASTM)
 - .1 ASTM D698-12e2, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 - .2 ASTM D6506/D6506M-01(2018)e1, Standard Specification for Asphalt Based Protection Board for Below-Grade Waterproofing.
 - .3 ASTM E96/E96M-16, Standard Test Methods for Water Vapor Transmission of Materials.
 - .4 ASTM E154-08a(2019), Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover.
 - .5 ASTM E1643-18a, Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs.
 - .6 ASTM E1745-17, Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs.
 - .7 ASTM E2178-13, Standard Test Method for Air Permeance of Building Materials.
 - .8 ASTM F1249-13, Standard Test Method for Water Vapour Transmission Rate Through Plastic Film and Sheet Using a Modulated Infrared Sensor.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and data sheet for each product specified.
 - .2 Submit manufacturer's installation instructions including joint treatment recommendations.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- .2 Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.
- .3 Store materials in clean, dry area in accordance with manufacturer's instructions.
- .4 Protect materials during handling and application to prevent damage.

Part 2 Products

2.1 VAPOUR RETARDER MATERIAL

- .1 Performance Criteria: Vapour retarder membrane, when tested according to all requirements of ASTM E1745, Class A, shall meet or exceed the following minimum performance requirements:
 - .1 Maximum Water Vapour Permeance (to ASTM E154 Sections 7, 8, 11, 12, 13, by ASTM E96, Method B or to ASTM F1249):
 - .1 As received: ≤ 0.0063 perms.
 - .2 After Wetting and Drying: ≤ 0.0052 perms.
 - .3 Resistance to Plastic Flow and Temperature: ≤ 0.0057 perms.
 - .4 Effect Low Temperature and Flexibility: ≤ 0.0052 perms
 - .5 Resistance to Deterioration from Organisms and Substances in Contacting Soil: ≤ 0.0052 perms.
 - .2 Puncture Resistance (ASTM D1709): $> 3,200$ grams.
 - .3 Tensile Strength ASTM E154, Section 9: ≥ 72 Lb. Force/Inch.
- .2 Vapour Retarder for installation under concrete slabs shall meet or exceed the requirements of ASTM E1745, Class A, minimum 0.38 mm thick (15 mils).
 - .1 Acceptable materials:
 - .1 VaporBlock VB15, by Raven Industries Inc..
 - .2 Moistop Ultra 15 Underslab Vapour Retarder, by Fortifiber Building Systems Group.
 - .3 Florprufe 120 by Grace Construction Products.
 - .4 VapourFLEX 15 by Layfield Geosynthetics & Industrial Fabrics.
 - .5 Viper Vaporcheck II 15 Mil, by Soprema.
 - .6 Perminator 15 mil Underslab Vapour Barrier by W. R. Meadows.

2.2 ACCESSORIES

- .1 Joint sealing tape: air resistant pressure sensitive adhesive tape, cloth fabric duct tape, 100 mm wide for lap joints and perimeter seals, 50 mm wide elsewhere.
- .2 Sealants: Sealant: Asbestos-free non-hardening sealant, compatible with vapour retarder materials, recommended by vapour retarder manufacturer.

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: install products in accordance with manufacturer's printed preparation and installation instructions, technical datasheets, installation illustrations and guide specifications.

3.2 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for vapour retarder installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Consultant.
 - .2 Inform Consultant of unacceptable conditions immediately upon discovery.

- .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

3.1 PREPARATION

- .1 Perform excavating, trenching, and backfilling as indicated, and in accordance with the requirements of Division 31 Earthworks.
- .2 Trim and compact base and subbase to provide firm uniform support throughout footprint of slab and foundations.
 - .1 Level subbase and compact to 100% SPD, to ASTM D698.

3.2 UNDERSLAB VAPOUR RETARDER

- .1 Prepare surfaces in accordance with manufacturer's printed instructions.
- .2 Install continuous vapour retarder around underground ducts in accordance with the Sheet Metal and Air Conditioning Contractors' National Association's (SMACNA) construction standards. Coordinate Work with other trades.
- .3 Install in accordance with manufacturer's printed instructions, and requirements of ASTM E1643.
- .4 Unroll vapour retarder with longest dimension parallel with direction of pour.
- .5 Lap vapour retarder over footings and seal to foundation walls.
- .6 Overlap joints 150 mm and seal with manufacturer's seam tape.
- .7 Seal penetrations (including pipes) with manufacturer's pipe boots.
- .8 No penetration of vapour retarder is permitted, except for permanent utilities, unless approved in writing by Consultant. Seal penetrations as recommended by manufacturer.
- .9 Repair damaged areas by cutting patches of vapour retarder, overlapping damaged area 150 mm, and taping all four sides with tape.

3.3 FIELD QUALITY CONTROL

- .1 Have vapour retarder manufacturer's technical representative or quality control team review the installation when substantially installed together with the Consultant.
- .2 Correct deficiencies at no additional cost to Contract.
- .3 Review does not relieve the Contractor from responsibility to install Work according to Contract and to provide a continuous vapour retarder control layer.
- .4 Testing shall be performed in accordance with the requirements of Section 01 83 00 - Building Enclosure Performance Requirements.

3.4 CLEANING

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 – Cleaning. Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11 - Cleaning. Perform cleaning after installation to remove construction and accumulated environmental dirt.
- .3 Manage and dispose of demolition and construction waste materials in accordance with Section 01 74 19 – Waste Management and Disposal and local requirements.

3.5 PROTECTION

- .1 Protect installed products and components from damage during construction.
- .2 Repair damage to adjacent materials caused by Work of this Section.

3.6 SCHEDULE

- .1 Install vapour barrier under all slab-on-ground locations, maintaining continuity of seal at all transitions and terminations.

END OF SECTION

REFERENCE NOTES SCHEDULE SITE - ROW

SYMBOL	Site Furnishings DESCRIPTION	QTY	DETAIL
	Trash Container - Maglin MLWR1050-HDPE	2	10/L-D1

SYMBOL	Concrete Paving DESCRIPTION	QTY	DETAIL
	Concrete Sidewalk with Soft Boulevard (130mm concrete over 150mm granular A)	317.8 m²	4/L-D1

***GREEN & COOL PAVING:**

- TOTAL NON ROOF HARDSCAPE - 499.8 M²
- HIGH-ALBEDO PAVING AREA - 418.6 M²
- TREE CANOPY SHADE AREA - 20 M²

TOTAL TREATED NON-ROOF HARDSCAPE AREA: 438.6 M²

PERCENTAGE: 87.7%

REFERENCE NOTES SCHEDULE SITE - GROUND

SYMBOL	Site Furnishings DESCRIPTION	QTY	DETAIL
	Bike Rack - Maglin ICONIC MBR 2300-S	5	8/L-D1

SYMBOL	Structures DESCRIPTION	QTY	DETAIL
	Trash Container - Maglin MLWR1050-HDPE	2	10/L-D1

SYMBOL	Structures DESCRIPTION	QTY	DETAIL
	Standard Concrete Filled Metal Bollard	9	5/L-D2
	Removable Steel Bollard	3	6/L-D2

SYMBOL	Concrete Paving DESCRIPTION	QTY	DETAIL
	Concrete Paving with 200mm depth of 19mm Crusher Run Limestone	18.4 m²	5/L-D1

SYMBOL	Unit Paving DESCRIPTION	QTY	DETAIL
	Unilock Eco-Priora Permeable Paver 120 x 240 x 80 - Colour: Opal. Finish: Smooth Premier	386.9 m²	7/L-D1

SYMBOL	Unit Paving DESCRIPTION	QTY	DETAIL
	Unilock Eco-Priora Permeable Paver 120 x 240 x 80 - Colour: Steel Grey Blend. Finish: Smooth Premier	62.8 m²	7/L-D1

SYMBOL	Unit Paving DESCRIPTION	QTY	DETAIL
	Unilock Eco-Priora Permeable Paver 120 x 240 x 80 - Colour: Natural. Finish: Classic	31.7 m²	7/L-D1

SYMBOL	Turf & Grasses DESCRIPTION	QTY	DETAIL
	Sod over 150mm Topsoil	980.3 m²	3/L-D1

***PRIVATE TREE WATERING SCHEDULE:**

- WATER DAILY FOR 1-2 WEEKS AFTER PLANTING
- WATER EVERY 2 TO 3 DAYS IN 3-12 WEEKS AFTER PLANTING
- WATER WEEKLY AFTER 12 WEEKS FOR 44 MONTHS UNTIL ROOTS ARE FULLY ESTABLISHED

WATER WITH BUCKET OR GREEN WATERING BAG

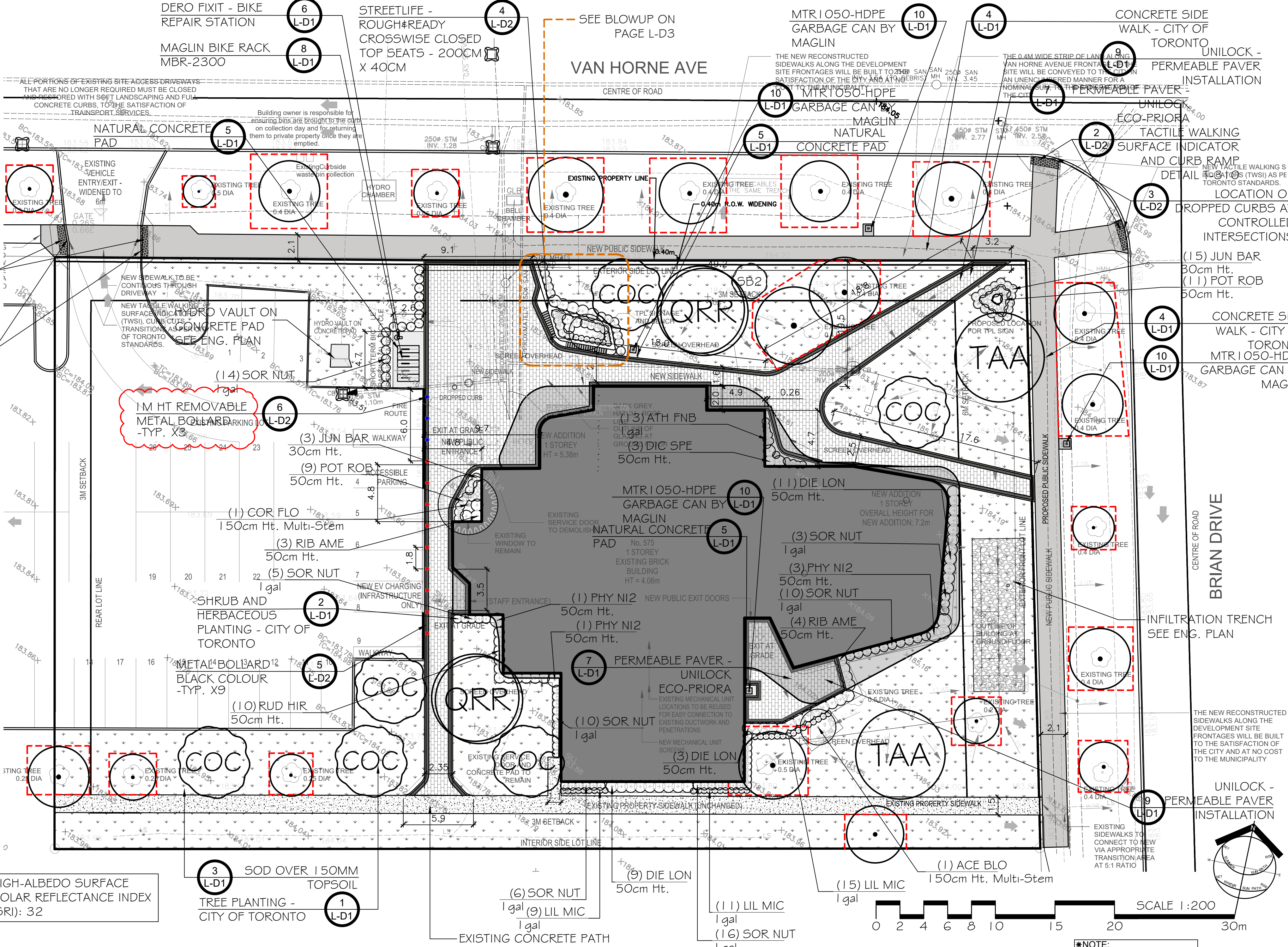
***THE TOTAL OF FOUR(4) YEARS WATERING PROGRAM TO BE PROVIDED FOR PRIVATE TREES**

***PROPOSED PLANTS - TOTAL:**

TOTAL PLANTS IN GROUND LEVEL PLANTING BED: 265

NATIVE: 244 - 92.1%

DROUGHT TOLERANT 246 - 92.8%

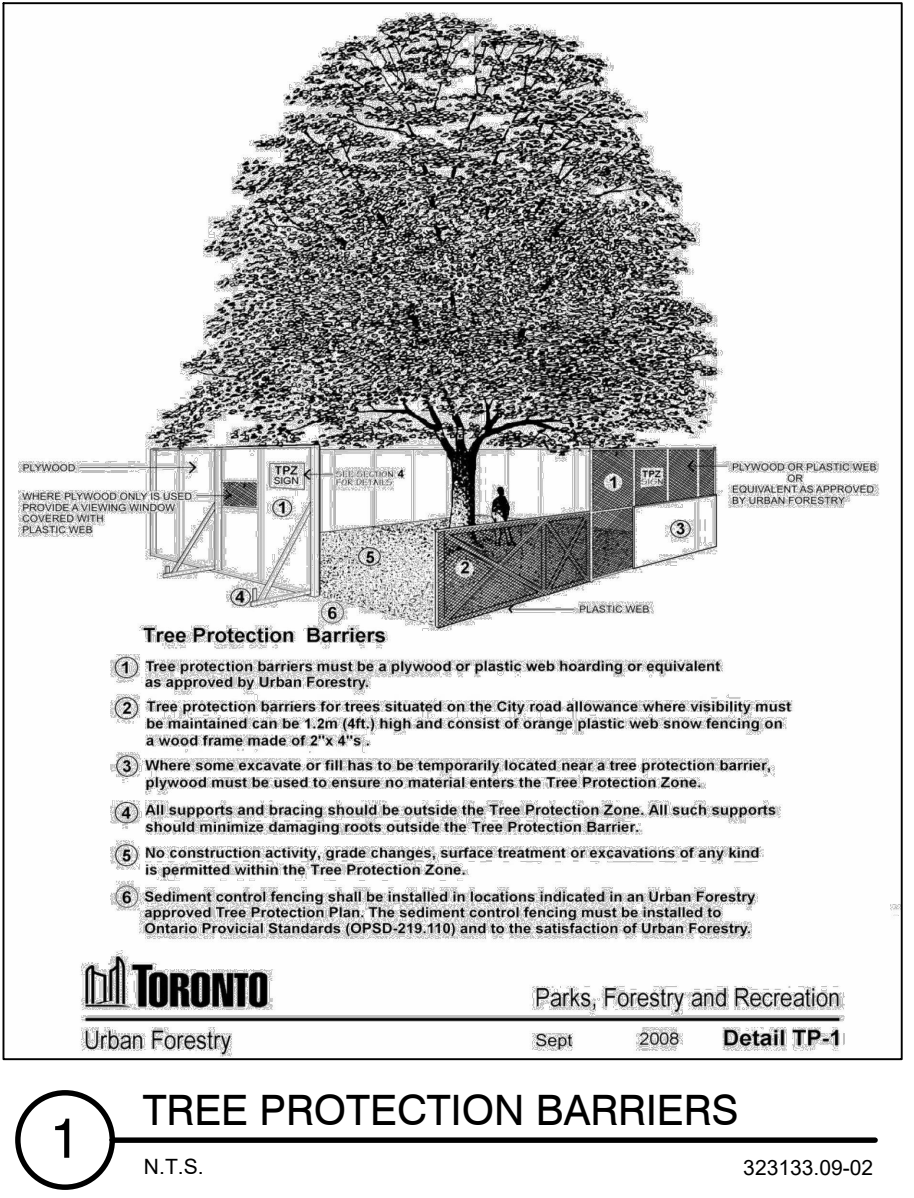


HIGH-ALBEDO SURFACE SOLAR REFLECTANCE INDEX (SRI): 32

HIGH-ALBEDO SURFACE SOLAR REFLECTANCE INDEX (SRI): 34

LEGEND

TREE PROTECTION FENCE



1 TREE PROTECTION BARRIERS

N.T.S. 323133-09-02

PLANT SCHEDULE

CODE	QTY	BOTANICAL NAME	COMMON NAME	SIZE	CONT	REMARKS
TREES						
SB2	1	Amelanchier canadensis	Serviceberry	150cm Ht. Multistem	W.B.	DT/N
COC	6	Celtis occidentalis	Common Hackberry	70mm Cal.	W.B.	DT/N
QRR	2	Quercus rubra	Red Oak	70mm Cal.	W.B.	DT/N
TAA	2	Tilia americana	American Linden	70mm Cal.	W.B.	DT/N
SHRUBS						
ACE BLO	2	Acer palmatum 'Bloodgood'	Bloodgood Japanese Maple	150cm Ht. Multi-Stem	Potted	
ATH FNB	13	Athyrium x 'Branford Beauty'	Ladyfern	1gal	Potted	
COR FLO	1	Cornus florida	Flowering Dogwood	150cm Ht. Multi-Stem	W.B.	N
DIC SPE	3	Dicentra spectabilis	Bleeding Heart	50cm Ht.	Potted	
DIE LON	33	Diervilla lonicera	Bush Honeysuckle	50cm Ht.	Potted	DT/N
JUN BAR	24	Juniperus horizontalis 'Bar Harbor'	Bar Harbor Creeping Juniper	30cm Ht.	Potted	DT/N
LIL MIC	44	Lilium michiganense	Michigan Lily	1gal	Potted	DT/N
PHY N12	5	Physocarpus opulifolius	Ninebark	50cm Ht.	Potted	DT/N
POT ROB	24	Potentilla fruticosa 'Marion'	Red Robin Potentilla	50cm Ht.	Potted	DT/N
RIB AME	12	Ribes americanum	American Black Currant	50cm Ht.	Potted	DT/N
RUD HIR	11	Rudbeckia hirta	Black-eyed Susan	50cm Ht.	Potted	DT/N
SOR NUT	79	Sorghastrum nutans	Indian Grass	1gal	Potted	DT/N
SYR MEY	3	Syringa meyeri 'Palibin'	Dwarf Korean Lilac	50cm Ht.	Potted	DT

PROPOSED PLANTS					
PLANTING TYPE	TOTAL QTY	NATIVE	NATIVE%	DROUGHT TOLERANT	DROUGHT TOLERANT %
TREES	11	11	100%	11	100%
SHRUBS	80	75	93.75%	77	96.25%
HERBACEOUS & GRASSES	174	158	90.80%	158	90.80%

LOCATION MAP



GENERAL NOTES

THE LOCATION OF PROPERTY LINES, ELEVATIONS AND FACILITIES ON THIS PLAN WERE DRAWN ON THE BASIS OF A DIGITAL SITE PLAN OR SURVEY DATA PROVIDED BY OTHER CONSULTANTS.

IT IS THE RESPONSIBILITY OF THE CLIENT AND HIS CONTRACTORS TO CONFIRM THE ACCURACY OF THE SETBACKS, LOCATIONS AND GRADES ETC. ANY VARIATIONS BETWEEN EXISTING CONDITIONS AND THIS PLAN SHOULD BE ADJUSTED ON SITE AND REPORTED TO THE CONSULTING LANDSCAPE ARCHITECT TO DETERMINE THE IMPACT OF THE VARIATIONS ON THE SUITABILITY OF THE PROPOSED DEVELOPMENT.

CONSTRUCTION MUST CONFORM TO ALL CODES AND REQUIREMENTS OF AUTHORITIES HAVING JURISDICTION.

REVISIONS			
NO.	DATE	NOTES	BY
12	2025-09-17	ISSUED FOR ADDENDUM	LZH
11	2025-08-22	ISSUED FOR RE-TENDER	LZH
10	2025-05-15	ISSUED FOR ADDENDUM	LZH
9	2025-04-01	ISSUED FOR TENDER	LZH
8	2024-10-01	ISSUED FOR PERMIT REVIEW	LZH
7	2024-07-26	REVISED PER COMMENTS	LZH
6	2024-05-30	REVISED PER COMMENTS	KT
5	2024-02-05	REVISED PER COMMENTS	YW
4	2023-10-20	REVISED PER COMMENTS	YW
3	2023-05-01	REVISED PER COMMENTS	KT
2	2023-02-09	ISSUED FOR CLASS B COSTING	LZH
1	2022-10-20	ISSUED FOR CLASS C COSTING	LZH

	CONCEPTUAL		TENDER
	PRELIMINARY		CONTRACT
	SITE PLAN		CONSTRUCTION
	PERMIT		AS-BUILT



THESE DRAWINGS ARE INSTRUMENTS OF SERVICE AND THE LANDSCAPE ARCHITECT RETAINS OWNERSHIP OF THESE DRAWINGS. THEY ARE FOR SITE PLAN APPROVAL ONLY AND MAY REQUIRE FURTHER CONSTRUCTION DETAILING AND COORDINATION WITH OTHER ASSOCIATED PROFESSIONAL DESIGN SERVICES BEFORE ACTUAL TENDER AND CONSTRUCTION COMMENCES. DIMENSIONS ARE TO BE VERIFIED PRIOR TO CONSTRUCTION. DRAWINGS ARE NOT TO BE SCALED. IT IS ADVISED THAT CONTRACTORS CONTACT THE LANDSCAPE ARCHITECT PRIOR TO CONSTRUCTION TO ENSURE THE USE OF THE LATEST REVISED DRAWINGS. THE LANDSCAPE ARCHITECT IS NOT LIABLE FOR ERRORS OR OMISSIONS ARISING FROM UTILIZATION OF THESE PLANS BEFORE THE SAID DRAWINGS ARE SEALED, SIGNED AND DATED. AND THE LANDSCAPE ARCHITECT IS CONTRACTED TO PROVIDE CONSTRUCTION ADMINISTRATION AND CERTIFICATION SERVICES BY THE OWNER. ALL APPARENT DISCREPANCIES ARE TO BE REPORTED IN WRITING TO THE LANDSCAPE ARCHITECT BEFORE CONSTRUCTION COMMENCES.

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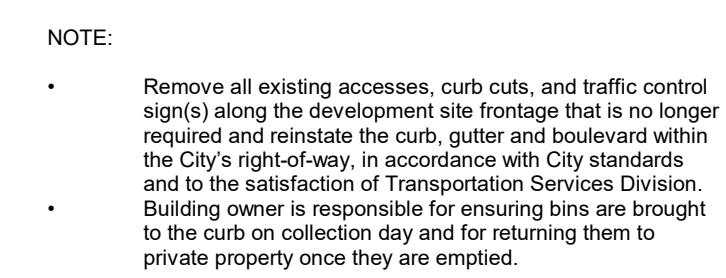
DRAWING: **LANDSCAPE PLAN**

DRAWN BY: LZH
CHECKED BY: KF
JOB NO.: 2022-120

SCALE: 1:200
DATE: OCT. 2022

L-L1
DRAWING 1 of 7

File #2022-120.



GENERAL NOTES - RCP:

1. ALL CEILINGS TO REMAIN EXPOSED UNLESS OTHERWISE NOTED.
2. ALL VISIBLE ELEMENTS AT EXPOSED CEILINGS AND ELEMENTS INCLUDING DUCTWORK, PIPING, CONDUIT ARE TO BE PRIMED AND PAINTED, COLOUR AS PER FINISH SCHEDULE.
3. ALL EXISTING STRUCTURE ABOVE WOOD SLATS TO BE PAINTED, COLOUR AS PER FINISH SCHEDULE.
4. REFER TO FINISH SCHEDULE FOR MATERIAL TYPES WHERE NOTED.
5. REFER TO ELECTRICAL DRAWINGS FOR SWITCHING LOCATIONS.
6. PROVIDE ACCESS PANELS IN THE CEILING AS REQUIRED TO ACCESS EXISTING BUILDING INFRASTRUCTURE. COORDINATE LOCATIONS ON SITE. REF MECHANICAL DRAWINGS FOR ADDITIONAL INFORMATION.
7. REFER TO SHEETS A3.5 AND A3.6 FOR LIGHTING LAYOUTS.

CEILING FINISH LEGEND:

- C1- GWB CEILING
- C2 - ACT ACOUSTIC CEILING TILE
- C3 - WOOD SLAT CEILING WITH PAINTED EXPOSED CEILING ABOVE

CEILING FIXTURE LEGEND:

REF LIGHT FIXTURE SCHEDULE FOR LIGHT FIXTURE INFORMATION

- GENERAL: INDICATES EXISTING TO REMAIN
- GENERAL: INDICATES AREA NOT IN SCOPE
- MILLWORK
- MOTORIZED BLACKOUT SHADES - REF FINISH LEGEND

KEYED NOTES:

- 1 ALL VISIBLE ELEMENTS AT EXPOSED CEILINGS AND ELEMENTS INCLUDING DUCTWORK, PIPING, CONDUIT ARE TO BE PRIMED AND PAINTED, COLOUR AS PER SCHEDULE
- 2 NO CEILING, CONCRETE SOFFIT TO BE FINISHED AS PER FINISH SCHEDULE
- 3 NO CEILING, STRUCTURAL SLAB TO REMAIN EXPOSED
- 4 LINEAR SUPPLY DIFFUSER AS PER MECH
- 5 NEW WSC1 WOOD BAFFLE CEILING TO BE COORDINATED WITH UIS OF CEILING STRUCTURE, MECHANICAL COMPONENTS ETC
- 6 LIGHTS TO BE COORDINATED WITH WSC1 WOOD BAFFLE CEILING
- 7 COORDINATE WSC1 WOOD BAFFLE CEILING TO SEAMLESSLY ALIGN WITH MILLWORK BOOKSHELVES. REFERENCE A9.0 SERIES FOR DETAILS.
- 8 WSC1 CEILING TO MEET ADJACENT C1 CEILING
- 9 REFERENCE ELEVATIONS FOR LIGHTING MOUNTING HEIGHTS

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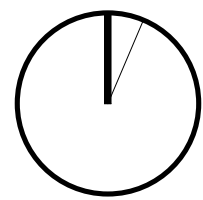
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2 ADDENDUM #01 2025.09.19
1 ISSUE FOR TENDER 2025.08.22

00 ISSUE DATE

FOR TENDER



As indicated @24x36

RCP - LEVEL 01

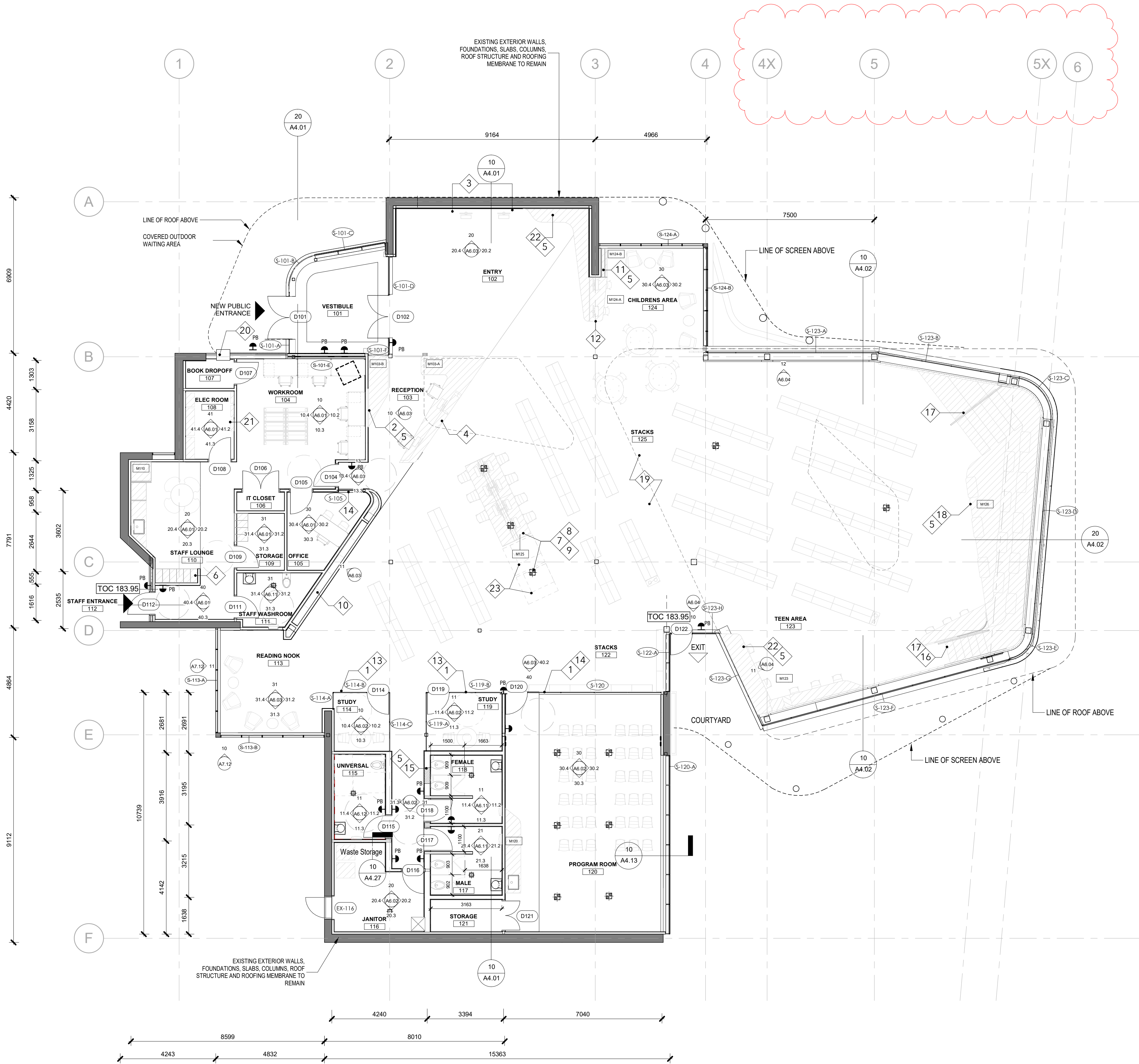
RCP - LEVEL 01

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1 : 100

A2.31

A2.31



GENERAL NOTES - PLANS:

1. WALLS SHOULD EXTEND FROM FLOOR TO UNDERSIDE OF SLAB ABOVE. ANY PENETRATIONS THROUGH WALLS SHOULD BE OVERSIZED, FILLED WITH BATT INSULATION, AND SEALED WITH NON-HARDENING ACOUSTIC CAULK WITH A MIN. MOVEMENT CAPABILITY OF +/-25%. REF TO INTERIOR DETAILS.
2. REFER TO MECHANICAL AND ELECTRICAL DRAWINGS FOR ADDITIONAL REQUIREMENTS.
3. AT LOCATIONS WHERE MECH. DUCTS INTERFERE WITH FULL HEIGHT CONSTRUCTION OF INTERIOR PARTITIONS, OFFSET PARTITION ABOVE CEILING AND BRACE AS REQUIRED. MAINTAIN FIRE SEPARATION/SOUND RATING OF PARTITION. OFFSETTING OF PARTITIONS WILL ONLY BE PERMITTED WHERE DUCTWORK CANNOT BE POSITIONED.
4. ALL DIMENSIONS ARE TAKEN TO FACE OF MASONRY OR CONCRETE AT MASONRY AND CONCRETE WALLS AND PARTITIONS. AT STEEL STUD PARTITIONS, DIMENSIONS ARE TAKEN TO CENTRE OF STUD, UNLESS OTHERWISE NOTED.
5. INCREASE THICKNESS OF WALLS OR FURR OUT WALL THICKNESS AS REQUIRED TO ACCOMMODATE MECHANICAL AND ELECTRICAL PANELS AND SERVICES. MAINTAIN FIRE SEPARATION AROUND BACK OF PANELS WHERE APPLICABLE.
6. MAKE GOOD ALL EXISTING DRYWALL TO REMAIN EXISTING RATING.
7. ALL EXISTING FIRE RATED ASSEMBLIES TO MAINTAIN EXISTING RATING.
8. ALL EXPOSED CONCRETE, COLUMNS, SLABS ETC PIPING CONDUIT, DRAINS TO BE PAINTED P.T. MOUNTED AV. MILLWORK LOCATIONS
9. PROVIDE BLOCKING AS REQUIRED AT ALL WALL MOUNTED AV. MILLWORK LOCATIONS
10. FOR MILLWORK REF. AS SERIES
11. UNLESS OTHERWISE NOTED, DOOR OPENINGS ARE 101mm FROM ADJACENT RETURN WALL.

NOTES:

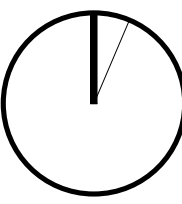
- GENERAL: INDICATES EXISTING TO REMAIN
- GENERAL: INDICATES NEW MILLWORK
- ADD DOOR OPERATOR

- 1. GLAZING TO RECEIVE VINYL FILM GRAPHIC. REFER TO ELEVATIONS, SCHEDULES FOR FURTHER INFORMATION.
- 2. LOCATION OF DIGITAL DISPLAY TV. PROVIDE BLOCKING AS NECESSARY. REFERENCE ELECTRICAL DWGS FOR ADDITIONAL DETAILS
- 3. LOCATION OF SELF CHECKOUT. REFERENCE ELECTRICAL DWGS FOR ADDITIONAL DETAILS
- 4. NEW MILLWORK CIRCULATION DESK
- 5. PROVIDE BLOCKING AT ALL WALL MOUNTED MILLWORK. AV. EQUIPMENT AND PLUMBING FIXTURES AND ACCESSORIES AS REQUIRED. CO-ORDINATE WITH FURNITURE AND ANY OWNER PROVIDED ITEMS
- 6. MANUFACTURED LOCKER UNITS WITH DIGITAL LOCKS
- 7. LOCATION OF 7 COMPUTERS AND PRINTER. REFERENCE ELECTRICAL DWGS FOR DETAILS
- 8. MILLWORK TOP AND FABRIC DIVIDERS TO COVER COMPUTER DESKS. REFERENCE A9.0 SERIES
- 9. CORE DRILLING REQUIRED FOR CONDUITING AND FLOOR BOXES. REFER TO ELECTRICAL AND STRUCTURAL DWGS FOR DETAILS
- 10. SHELVES INSET INTO BUILT OUT WALL
- 11. NEW MILLWORK DISPLAY SHELVES. REFERENCE A9.0 SERIES
- 12. LOCATION OF CHILDREN'S COMPUTER. REFERENCE ELECTRICAL DWGS
- 13. INTERIOR FULL HEIGHT GLAZING
- 14. INTERIOR HALF HEIGHT GLAZING
- 15. BOTTLE FILLER - REFER TO SCHEDULES
- 16. TACTILE ATTENTION INDICATORS AT THE TOP OF STAIRCASES, AND COLOUR CONTRASTING STRIPS ON STAIR TREADS AND ON RAMP LEVEL CHANGES AS REQUIRED BY CSA B651-18.
- 17. NEW FREESTANDING FLATBAR HANDRAIL. ENGINEERED SHOP DRAWINGS REQUIRED. REFERENCE DRAWINGS FOR DETAILS
- 18. MILLWORK BANQUETTE. REFERENCE A9.0 SERIES
- 19. NEW BOOKSHELVES, EXISTING BOOKSHELVES TO BE REFINISHED
- 20. THROUGH WALL MOUNTED BOOK DROP
- 21. ELECTRICAL PANELS. REF ELECTRICAL DWGS FOR DETAILS
- 22. MILLWORK TABLE HEIGHT AND BAR HEIGHT. LAPTOP BAR. REFERENCE A9.0 SERIES
- 23. LOCATION OF PRINTER. COORDINATE WITH ELECTRICAL FOR POWER AND DATA REQUIREMENTS

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2	ADDENDUM #01	2025.09.19
1	ISSUE FOR TENDER	2025.08.22
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FOR TENDER



As indicated @24x36

PLAN - LEVEL 01

PLAN - LEVEL 01

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