Appendix C:
Traction Power Substation

Section C.1:
Traction Power Substation Design Basis Report

Note: This appendix refers to Area A as Area 1 and to Area B as Area 2A, a reflection of previous project nomenclature. Some elements of the Project description are also out of date - please refer to the EPR for the current Project description.

Waterfront Toronto

Queens Quay East 30% PDE

Traction Power Substation Design Basis Report

2 | May 28, 2021

Job number 272263-00

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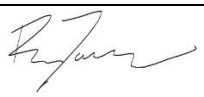
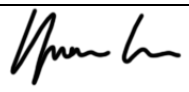
		Signature			
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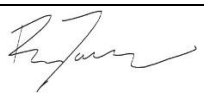
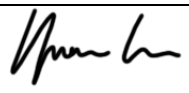
		Signature			
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1 Summary Design Criteria

The following is a summary of high level design criteria required to be accommodated in Quayside Block 2 to house a new traction power substation (TPSS) to support the Queens Quay East streetcar service extensions. The information provided below is as per current understanding from various stakeholders and subject to change upon further design development.

1.1 Location and Site Access

The proposed TPSS is to be located within Quayside Block 2, with the final location to be selected in coordination with Waterfront Toronto during design of the Quayside development. The TPSS is to be separately owned by the TTC with unrestricted access for their ongoing maintenance. The following are design criteria to be considered in siting the substation:

- Locate as close as possible to the streetcar guideway. Location fronting Lakeshore East is preferred from a public realm and development perspective.
- Do not locate along active street frontages, including Queens Quay, Bonnycastle and Small Street.
- Provide a driveway, laneway or on-street layby for vehicular access to the TPSS.
- Two standard vehicle parking stalls to be provided in proximity to the TPSS, to be made exclusive for TTC use. Surface location is preferred.
- Provide direct loading access to the main exterior wall of the TPSS to accommodate a Heavy Single Unit (HSU) truck at grade. Space to be accessible at all times for emergency maintenance.
- An unobstructed path of travel from the fire department vehicle to the primary entrance of the TPSS of 45m or less.
- Access driveway and loading space to be integrated with the public realm design.
- Accommodate an inground duct bank leading from the TPSS to the streetcar guideway on Queens Quay. Exact routing to be identified during design development.

1.2 Building

The footprint of the TPSS is mainly a function of equipment layout and associated access and clearances. Key requirements of the base building design to accommodate the TPSS include:

- Located on ground floor level with a basement for cable pulling.
- TTC has a stated a strong preference for two exterior frontages with direct access to the building exterior, with adequate space for ventilation louvres.
- Overall floor area of 650m^2 at grade with an additional cable pull room in basement beneath the Control Room at minimum. Dimensions of final design may differ subject to meeting all functional requirements.

- Minimum ceiling height of 5m for at grade level.
- Considered as an electrical equipment room in compliance with the Ontario Building Code:
- Group F, Division 3 to be assumed for construction classification of the TPSS
- Meet the requirements of NFPA 13 article 8.15.10.3 in order to permit the space to be unsprinklered as required by the TTC.
- Minimum of 2 egress doorways, sufficiently spaced apart as per OBC requirements. A rated corridor within the base building may be required subject to final design layout.
- Separated from the rest of the building with a 2 hour fire resistance rating.
- Structural design coordinated to suit equipment weights, layouts, and clearances.
- Exterior facades of the TPSS to be architecturally integrated into the base building envelope, with careful consideration of material choice and detailing.

1.3 Services

The TPSS within the base building development will also require the following key service connections:

- Dedicated dual incoming Toronto Hydro services in separate duct banks
- Tie-in connections to the base building for water service
- Dedicated substation grounding system designed to meet OESC and IEEE 80

1.4 Coordination

Further design criteria and functional requirements are provided within this report. Ongoing coordination with the TTC and Waterfront Toronto is expected through future design phases to confirm design requirements and inform construction sequencing and scheduling considerations.

2 Introduction

2.1 Purpose

The purpose of this report is to provide an overview of the design criteria for a new Traction Power Substation (TPSS) required to support the implementation of streetcar service on Queens Quay East. The expansion of at-grade streetcar service on Queens Quay East is part of the Waterfront East LRT Extension (WELRT) project, in conjunction with the expansion of the existing Union LRT Station and Queens Quay LRT Station, currently being designed by others. A baseline design for the TPSS is included in the Queens Quay East 30% Preliminary Design and Engineering scope of work currently being undertaken by this team. The TPSS is proposed to be integrated into a development building to be undertaken by a developer team currently under procurement by Waterfront Toronto, and this report is intended to provide a summary of the functional requirements of the TPSS to inform the developer request for proposal as well as for technical review by the TTC as part of the 30% design submission.

2.2 Project Background

The WELRT project includes three general areas of work:

- Area 1 – expansion of existing Union LRT Station, expansion of existing Queens Quay LRT station, next tunnel connecting to existing streetcar tunnel at the foot of Bay Street, and a new portal structure where the new tunnel emerges west of Yonge Street.
- Area 2A – at-grade portion of the Queens Quay East LRT extension; includes the full reconstruction of Queens Quay within a 38m ROW from Bay Street to the west and Silo Street to the East. Scope of work also includes the implementation of a new TPSS to support the next LRT extension.
- Area 2B – extension of the Queens Quay East LRT from Silo Street to the existing Distillery Loop at Cherry Street north of the rail corridor.

2.2.1 Location Study

A location study was undertaken in October 2020 to determine the ideal location for the proposed TPSS. The following parameters were provided by the TTC through consultation:

- TPSS location shall be 1.5km from the next substations in the transit system.
- Nearest existing substation is at 23 Sumac St. and existing facility at Union Station
- Queens Quay Station substation is expected to be upgraded as part of the Area 1 project
- TPSS shall be located approximately within 50m of guideway

Based on the above parameters, an area around Queens Quay between Small and Silo Street was determined as the optimal zone for locating the TPSS. A load flow analysis is currently being undertaken by the TTC to ensure there will be no service degradation due to low voltages during a substation outage at peak demand periods.

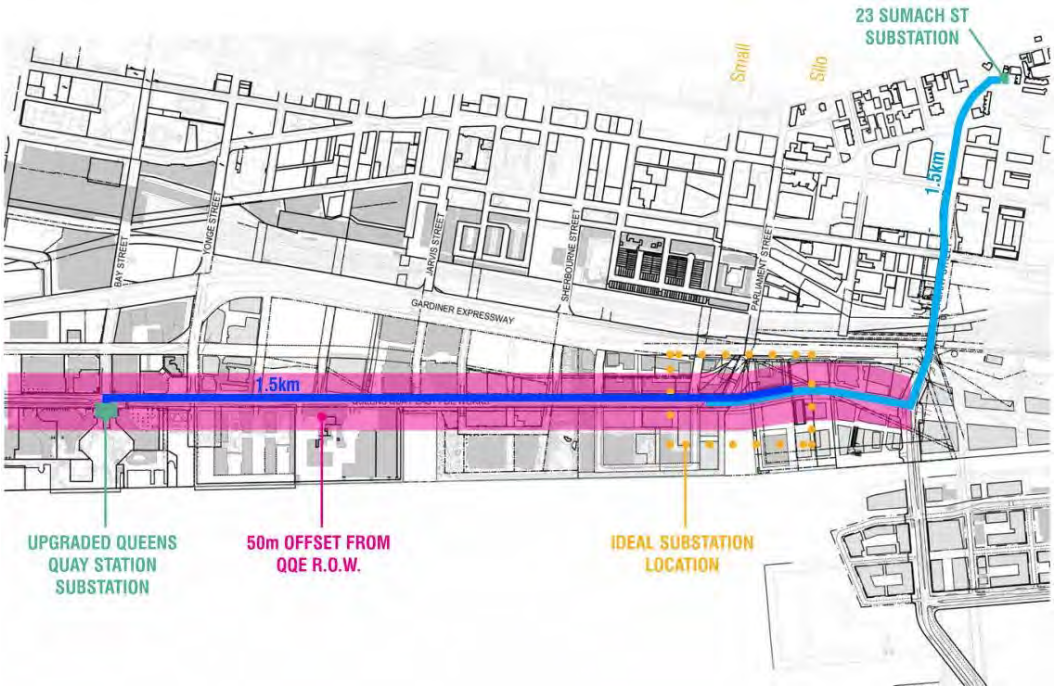

Figure 1 Optimal Zone for Proposed Location

To establish the required footprint of the proposed facility, the design team reviewed the programmatic requirements in the TTC's current Design Manual specifications and standard drawings, which suggested a facility of approximately 730m^2. The footprints of other existing substations within the current system were also reviewed for comparison purposes and were noted to be substantially more compact. Given the extensive redevelopment along the QQE corridor and the limited space within the Queens Quay ROW, an assumed building footprint of 200m^2, based on the dimensions of the Harbourfront substation, was used as a test block for the purposes of the location study. During design discussions, the TTC acknowledged that many of the existing substations do not meet the current design requirements, and a larger footprint is likely required, but it was agreed that the spatial requirements in the Design Manual may be refined and reduced to suit the site constraints and a 2 storey arrangement may be considered.

A number of possible locations were developed and reviewed with Waterfront Toronto, the TTC and the City of Toronto based on the above parameters. Below is a summary of the options considered along with the feedback and assessment by stakeholders:

- Option 1 – Silo Park
- Option 2 – Lakeshore Boulevard
- Option 3 – integration into Quayside Block 2
- Option 4 – standalone building in Quayside Block 3

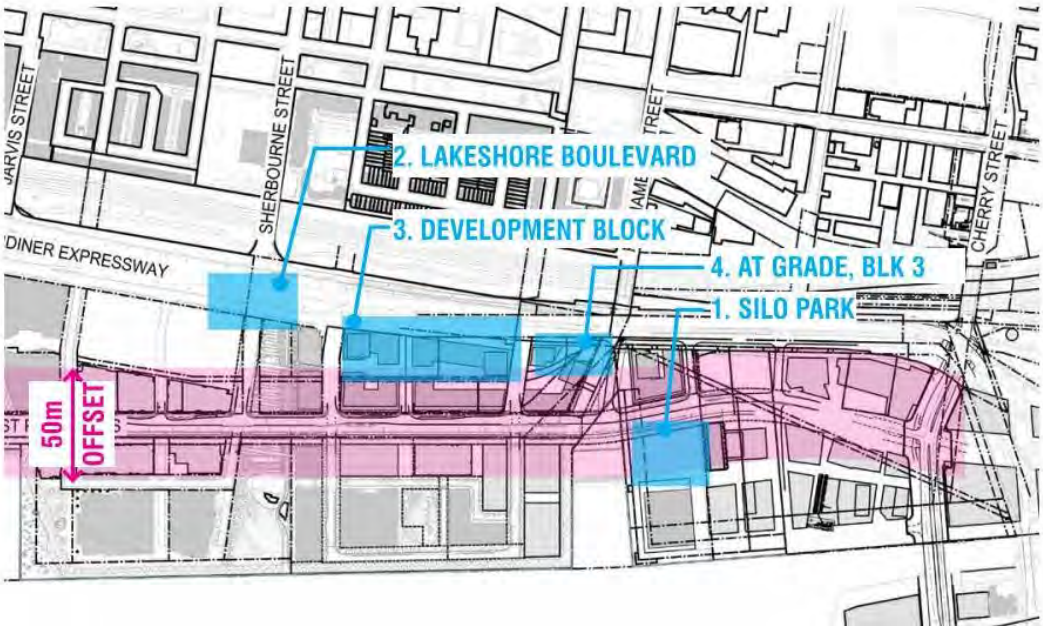

Figure 2 Substation Location Options

Option 1 was deemed unfeasible due to objections to property impacts by City stakeholders. Option 2 was likewise deemed not viable due to TTC concerns with site access and space constraints, and overhead clearance limits of the Gardiner above. Option 4 was originally pursued as the preferred location by all stakeholders. Early concept layouts were developed in consultation with the TTC, however Waterfront Toronto subsequently identified site access constraints due to adjacent property ownership, and this option was abandoned. Option 3, a substation to be integrated into a development building the Quayside development Block 1&2, was identified as the proposed location to be carried forward. The design team was instructed to provide a reference design that would allow for the Quayside developer flexibility to locate the substation as suitable within the development while meeting the technical criteria for the TPSS. This report provides the supporting material to outline the functional requirement to be assumed in the development base building.

This report represents a summary of current understanding based on stakeholder consultation. Changes and refinements can be expected as design development advances.

2.3 Abbreviations

°C	Degree Celsius
ABT	AC Bus Tie Breaker
AC	Alternating Current
ACH	Air Changes per Hour
AHU	Air Handling Unit
CFC	Chlorofluorocarbon
CIRIA	Construction Industry Research and Information Association
CMU	Concrete Masonry Units
CSA	Canadian Standards Association
CT	Current Transformer (metering)

DC	Direct Current
DCW	Domestic Cold Water
DFB	DC Feeder Breaker
DHW	Domestic Hot Water
DX	Direct Expansion Refrigeration
EA	Exhaust Air
EAT	Entering Air Temperature
EF	Exhaust Fan
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
GE	General Exhaust
GHWP	Greenhouse Warming Potential
HVAC	Heating, Ventilation and Air Conditioning
LAT	Leaving Air Temperature
LCB	Load Circuit Breaker
LIS	Load Isolation Switch
MAX	Maximum
MER	Mechanical Equipment Room
MIN	Minimum
NBCC	National Building Code of Canada
OA	Outside Air
OBC	Ontario Building Code
ODP	Ozone Depletion Potential
PT	Potential Transformer (metering)
RA	Return Air
RH	Relative Humidity
SA	Supply Air
SAT	Supply Air Temperature
SE	Sanitary Exhaust
SLD	Single Line Diagram
TPSS	Traction Power Substation
TTC	Toronto Transit Commission (asset owner / operator)
VFD	Variable Frequency

3 Site Access and Parking

3.1 Location and Access Requirements

The TPSS requires vehicular access for purposes of loading equipment during fit-out and for ongoing maintenance. TTC vehicles (standard passenger trucks and vans) will require access on a regular basis, while infrequent loading and unloading functions will be carried out by larger flatbed trucks, such as for the removal of faulty equipment.

A driveway and/or laneway and/or on-street layby must be designed to provide vehicular access to the TPSS and to accommodate the required parking and loading spaces. Access functions can be provided via a common private driveway (e.g. residential building courtyard access, laneway, or fire route), however vehicles accessing the TPSS must be provided parking spaces to park clear of the public roadway and any fire routes.

Emergency access should follow requirements described in Section 3 – Fire and Life Safety. Parking and loading functions must not conflict with emergency access requirements such as fire truck access to standpipe connections, the location of emergency exit points, etc.

Parking spaces for both regular stalls and large vehicle must be accessible 24 hours per day by TTC (i.e. no time of day use restrictions).

The proposed site plan should be developed in agreement with the TTC. Any underground parking proposal must provide unrestricted access for TTC service vehicles.

3.2 Parking Requirements

Two TTC parking stalls for regular vehicles (such as passenger trucks or vans) are required on site and must be located with appropriate adjacency to the TPSS. These two parking stalls are not intended to be used for the loading and unloading of large equipment and do not require immediate adjacency to the TPSS main equipment loading door. The preferred location for the parking spaces is at-grade.

The dimensional requirements for each parking spot as requested by TTC is as follows:

- Length of 7.7 m;
- Width of 4.6 m; and
- Vertical clearance of 4.9 m.

Both stalls must be secured such that they remain for exclusive access by TTC vehicles on a permanent basis. On-street metered parking stalls are not suitable. Methods for securing access may be, but are not limited to the following:

- Lockable folding or retractable bollards; or
- Lockable swing gate.

3.3 Loading Requirements

The TPSS must be accessible by a truck which is required to park within a reasonable distance of its main equipment loading door. An equipment loading zone that accommodates a truck must be provided clear of the public roadway and any fire routes. A Heavy Single Unit (HSU) truck should be used as the design vehicle for sizing the loading zone and assessing vehicle manoeuvrability. Consider the transfer distance for large equipment when siting the TPSS and loading zone to ensure that equipment can be moved efficiently.

The preferred location for the loading space is at-grade. The route between the TPSS main equipment loading door and truck loading area must be unobstructed and be of a clear width sufficient for the movement of required equipment (refer to 9.3.1 for equipment specifications). A hard, non-landscaped surface is required for the route that is weight-resistant to the required equipment (i.e. concrete, asphalt pavement, non-permeable pavers, or other suitable treatment). Building frontage along the exterior doors of the TPSS must be kept clear for equipment access. Loading space to be preserved for TTC access by means of signage and removable bollards or similar method of restricting other uses.

4 Fire and Life Safety

4.1 OBC Compliance Requirements

An outline report detailing the fire protection and life safety requirements of the building code as it relates to the proposed traction power substation in a co-location within a larger building is included as an appendix to this report. The TPSS can be designed either as an electrical equipment room or an electrical equipment vault. The code requirements applicable to both options are detailed in the outline report. Requirements for an electrical vault is more limiting and onerous. Based on the anticipated equipment to be housed in the TPSS, for the purposes of the 30% reference design, the TPSS is being designed as an electrical equipment room. This section summarizes the primary considerations in designing the TPSS and the base building in which it is housed under this option.

4.1.1 Electrical Room

Considered as an electrical equipment room, the TPSS is to be classified as a Group F, Division 3 major occupancy in accordance with the Ontario Building Code. The aggregate area of all Group F, Division 3 spaces in the building should be considered when selecting a construction classification for the base building (or storey) under 3.2.2 of the building code.

In accordance with Article 3.2.2.18, it is anticipated that an automatic sprinkler system will be required for the base building. It is the TTC preference for the TPSS to be designed unsprinklered. Article 8.15.10.3 of NFPA 13 exempts the requirement for sprinklers in electrical equipment rooms where the following conditions are met:

- The room is dedicated to electrical equipment only
- Only dry-type electrical equipment is used
- Equipment is installed in a 2 hour fire resistance enclosure (including protection for penetrations), and
- No combustible storage is permitted to be stored in the room

4.1.2 Fire and Spatial Separation and Exposure Protection

- A 2 hour fire resistance enclosure from the rest of the base building.
- Rated closures for openings in all fire separations to be provided in accordance with 3.1.8.4.
- Doors in required fire separations to be provided with self-closing devices and positive latching mechanism, and will not be permitted to incorporate louvres, grills or other similar unprotected openings.
- Fire dampers are required in ducts penetrating an assembly required to be a fire separation, except where the duct or opening penetrate a fire separation to the outdoors.
- Doors in required fire separations to be provided with self-closing devices and positive latching mechanisms.

- In accordance with NFPA 80-2013, doors required to have a maximum clearance below the bottom of door of 9.5mm where a threshold is provided and 19mm where there is no sill.
- Unprotected openings within the exterior walls (exposing building faces) are to comply with Subsection 3.2.3.

4.1.3 Fire Alarm System

- A single or two-stage fire alarm system will be required for the base building. A standalone fire alarm system with remote communication connection to the TTC's main system, as well as the base building's system.
- Smoke detectors as required, including in air handling systems.
- Manual pull stations to be provided near every required exit from each storey and at the main entrance of the space.
- Portable fire extinguishers to be provided throughout.

4.1.4 Fire Department Access, Egress and Exiting Requirements

- **Fire Department Access:** An unobstructed path of travel of no more than 45m from the fire department vehicle to one entrance of the TPSS is required where access through the base building is not provided and the TPSS is completely cut off from the remainder of the building.
- **Egress:** In accordance with Sentence 3.3.1.5.(1) and Table 3.3.1.5.A, a minimum of two egress doorways will be required to be provided from every room where the area exceeded 200 m^2 and/or egress distance of 25 m. Where two egress doorways are required the doorways are to be located a minimum distance from one another equal to one-third the maximum overall dimension of the room.

  Where there are insufficient exterior walls to place the egress doors sufficiently apart, an egress door connected to the remainder of the building will be required in addition to the exterior doors. Exit stairways and exit corridors serving the TPSS is required to be separated from the adjoining floor area by a smoke-tight fire separation with a 2hr fire-resistance rating. Building code requirements related to the integrity of exits are outlined in the appendix and should be reviewed in designing adjacent or connecting spaces to the exits.
- **Travel distance:** A 30m maximum travel distance to an exit from any point in the floor area of the TPSS is to be provided.
- **Exit and Corridor Widths** - Minimum widths for egress/ exit facilities as follows**:**
  - Corridors / Passageways / Ramps 1100mm
  - Exit Stairs not serving more than 2 storeys above the lowest exit level 900mm
  - Exit Doors 790mm
  - Room Entry / Egress Doors 800mm (clear)
- All exit doors to swing in the direction of exit travel.

4.1.5 Other Requirements

- A single washroom is permitted to serve a maximum occupant load of 10 persons.
- A barrier-free path of travel is not required to extend into service rooms.
- Exit signs to be provided in accordance with the Ontario Fire Code.

5 Architecture

5.1 Ownership

Based on consultation with the TTC, it was understood the preference is for the TPSS to be owned by the TTC in order to allow for:

- Full control on decisions related to maintenance, repairs, upgrades and modifications
- Unrestricted access and maintenance

Easements and land transfers will be required upon construction of the TPSS. Coordination on legal arrangements will be required between Waterfront Toronto, TTC and the future Quayside developer.

5.2 Functional Requirements

The footprint of the TPSS is mainly a function of equipment layout and associated access and clearances, and detailed requirements are outlined in other sections of this report. The concept design of the TPSS takes into account typical floor plate dimensions of a mid to high rise development expected for Quayside Block 2. Variations of the concept plan are included in this document to illustrate possible options in integration with the base building. The following are key spatial requirements:

5.2.1 Street frontage

The TPSS shall be located at grade with direct exterior access. A street level location allows for a more efficient TPSS footprint and ease of accommodating equipment removal, incoming and outgoing feeder routes and risers, ventilation ducts, etc. An at grade location avoids added complexity and constraints to both the base building and TPSS from of potential requirements for equipment elevators, internal corridors, or block out panels.

At least one exterior frontage shall be provided, however poses some limitation on the TPSS spatial arrangement. Two exterior frontages are strongly preferred by the TTC to allow for flexibility for the TPSS internal layout to best accommodate:

- Unrestricted access
- Ease of removing large, heavy, cumbersome equipment
- Access to incoming and outgoing cable routes
- Secondary egress to meet building code requirement
- Ventilation, air circulation and conditioning

Concept plans of both two exterior frontages and a single exterior frontage are included as part of this report to demonstrate their respective spatial requirements. Refer to figures below. The option with two exterior frontages is further developed with supporting architectural, mechanical and electrical concept design drawings. Refer to supporting design drawing package.

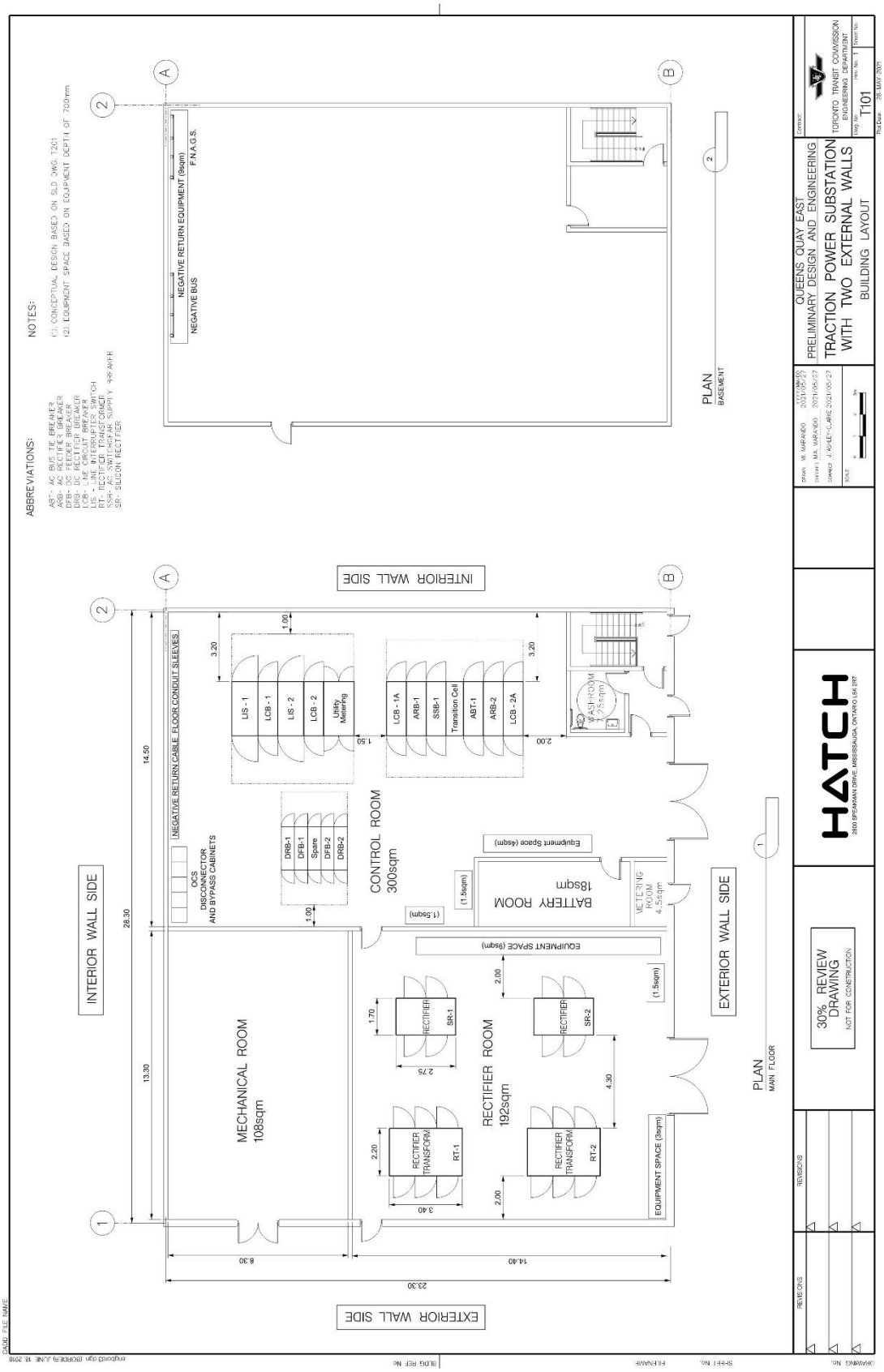

Figure 1 Concept Plan with Two Exterior Frontages

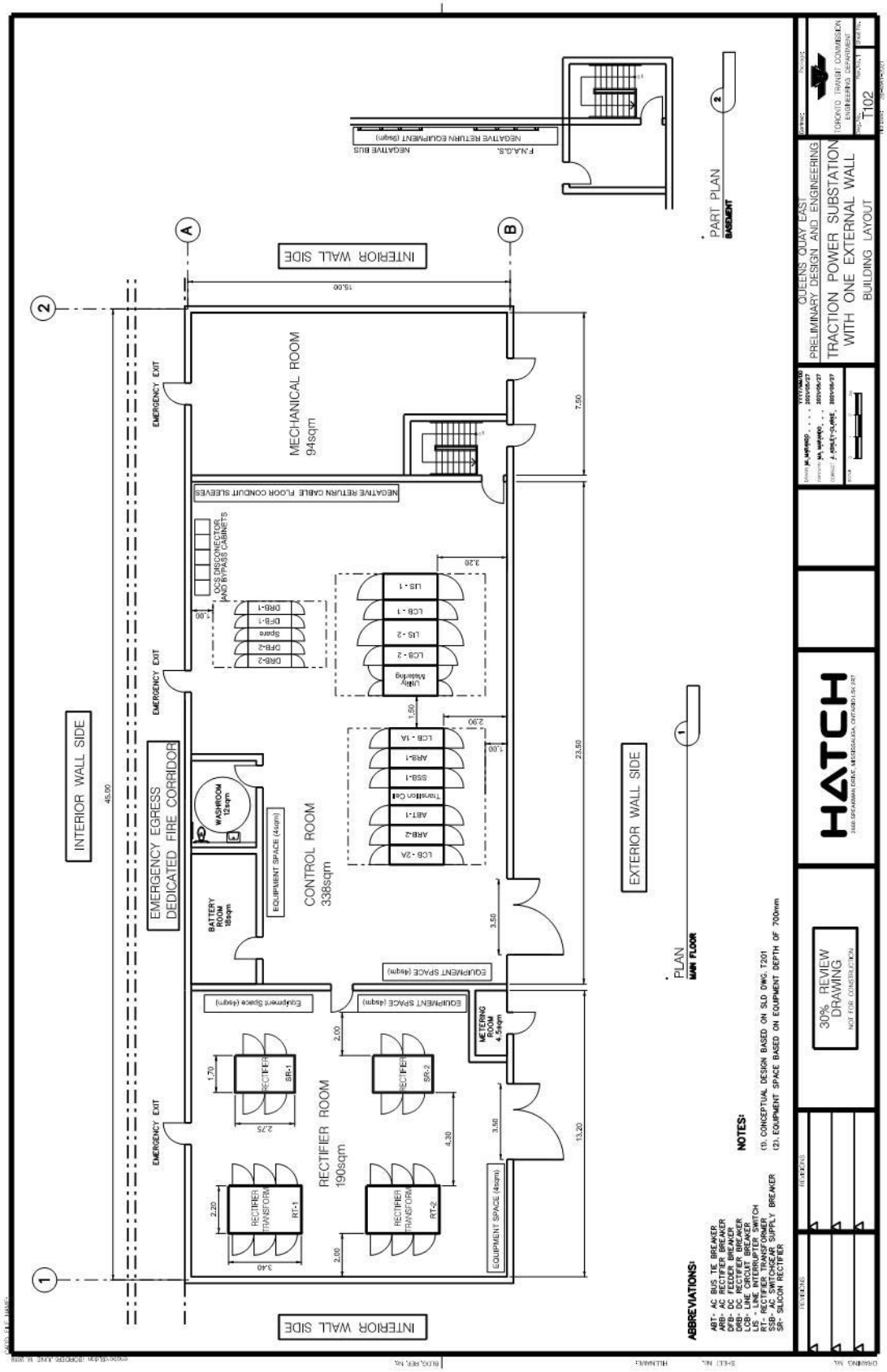

Figure 2 Concept Plan with One Exterior Frontage

5.2.2 Size

The TPSS requires a minimum footprint of 650 m^2 at grade. This footprint is based on:

- Functional electrical configuration;
- Required equipment sizing;
- Clearances defined in the Ontario Electrical Code;
- TTC design manual requirements;
- Ventilation requirements;
- Construction requirements.

Ability to maneuver large components in and out of the space for equipment replacement, off-site maintenance and to withdraw circuit breakers is a necessary consideration when determining the necessary footprint for any electrical component within the space. Sufficient wall space for regulatory and ancillary equipment, as well as cable connections and containment solutions between equipment also need to be factored in on the layout and spatial requirement of the TPSS. In addition, switchgear line-ups arrangement and large component should be positioned such that personnel can safely evacuate during emergencies.

One single staff washroom is required as part of the TPSS. As per the TTC Design Manual, an adult change table is not required, although it is noted as a universal washroom. As such, the staff washroom is designed as a barrier free washroom in the concept plans developed for this stage of design. Requirement should be confirmed during detailed design phases as spatial requirement will differ.

The concept layouts provided within this report demonstrates how these constraints can be met in a general arrangement. Close coordination with the base building design should be undertaken to ensure layout optimized to suit both the internal TPSS layout as well as the base building structure. In addition to the at grade footprint indicated above, a cable pull room is required to be accommodated below grade at the basement level, with a minimum area matching the extents of the control room above. Refer to Section 9.3.8 for technical requirements for the cable pull room.

5.2.3 Ceiling Height

The at grade level of the TPSS shall have a minimum ceiling height of 5m. This requirement allows for electrical clearances above switchgear line-ups; cable connections and raceway designs, air circulation and space allowances for lighting and lighting equipment. The below grade cable pull room can be of a typical floor to ceiling height, and can be designed to match the base building basement level ceiling height for ease of construction.

5.2.4 Construction Assemblies

The key requirement for construction methodology and material selection are based primarily on the fire separation criteria as stated in:

- Ontario Electrical Code;

- Ontario Building Code;

The TPSS shall constructed of non-combustible construction be designed as a separate fire compartment from the rest of the building, see Section 4 for specifics fire and life safety requirements. Proposed adjacent uses in the base building will also determine fire separation requirements and shall be considered during detailed design. Consultation with the Fire department and is recommended. Other functional requirements include:

- Floor construction sufficient to support equipment, refer to section 8 for structural requirements.
- Wall construction capable of supporting wall mounted equipment, refer to section 9 for equipment loading.
- Exterior wall of the TPSS to accommodate ventilation requirements, through mechanical louvres. Refer to section 7 for mechanical requirements.
- Large exterior doors to allow for equipment maintenance and replacement
- Provide a minimum of two (2) points of egress. One of these access points is required to accommodate the largest piece of equipment. Refer to section 9.3.1 for equipment sizes.
- Architectural finishes and specifications as per TTC Design Manual

Refer to the reference architectural plan for assumption on typical construction assemblies.

5.3 Architectural and Urban Design Considerations

Key architectural and urban design considerations include:

- **Plan Location**; The TPSS shall be sited such that required access can be accommodated in a way that minimizes impacts on public realm connectivity through the site. As the functional requirements of the TPSS exterior frontages will likely result in generally solid and blank façades at street level, careful placement of the TPSS within the building footprint shall be considered to minimize negative impacts on primary active street frontages. Priority shall be given to locating TPSS adjacent to other service elements, garage entrances, etc to take advantage of site vehicular access efficiencies.
- **Design Integration**; The exterior façade of the TPSS shall utilize premium, high quality, durable cladding materials, and shall be integrated into the base building architecture in a visually cohesive manner in order to achieve overall consistent visual quality. Detailing, materials and finishes of doors, vents, grilles, exterior lighting and other minor exposed utility components shall be carefully considered to be visually cohesive with the overall architectural design.
- **Loading and Access**; The required exterior loading and access area adjacent to the TPSS shall be designed to seamlessly blend in with the surrounding public realm and landscape design. Access control with bollards or other appropriate landscape treatments shall be considered so the required loading space can be protected for TTC access during emergency maintenance, but can still be integrated into the overall public realm for everyday use. As per TTC requirements, exterior frontages should be clear of vegetations or planters. In-ground access chambers and hatches shall be coordinated and integrated into the landscape design. Alignment for the traction power duct bank should be coordinated with tree planting and public realm elements.

6 Electrical

6.1 Electrical Design Overview

To optimize building size and configuration of the substation, significant considerations have been given to the electrical system to ensure the necessary space, access, and required clearances around the various components will be provided and maintained.

This section aims to provide an overview of the spatial and functional requirements related to the electrical system that have been incorporated in the design of the substation.

The electrical designer's scope for the TPSS includes:

- Auxiliary buildings systems, including lighting, small power (i.e. <600V), and fire alarm
- Incoming service to the TPSS

The traction power and systems design will be provided by the Systems Designer, refer to Systems section of this report.

6.1.1 Applicable Codes and Standards

Calculations and designs are provided in accordance with the TTC Design Manual, Master Specifications and Directive Drawings. Various in-progress electrical sections (DM-07-02 series) of the TTC Design Manual have been provided to the design team for reference and will be reviewed in further detail. In addition to the TTC DM, the following is a list of key codes and standards that govern the electrical design:

- Ontario Building Code
- Ontario Electrical Safety Code
- CSA Z462, Workplace Electrical Safety
- CSA-B72-M87 Installation Code for Lightning Protection Systems
- IEEE 80, IEEE Guide for Safety in AC Substation Grounding
- IESNA Lighting Handbook, 10th Edition
- Toronto Green Standards

All materials and installations associated with the electrical system shall adhere to the requirements of authorities having jurisdiction, as well as the applicable standards from the following organizations:

- ANSI: American National Standards Institute
- ASTM: American Society for Testing and Materials
- CSA: Canadian Standards Association

- EIA: Electronic Industry Association
- IEEE: Institute of Electrical and Electronic Engineers
- NEMA: National Electrical Manufacturers Association
- UL: Underwriters' Laboratories

6.2 Incoming Service

Power to the TPSS will be supplied by two incoming 13.8kV feeders from Toronto Hydro. The redundant feeders will be routed in separate duct banks to ensure that the two sources and electrically and physically separated. Each feeder is fully rated to take the entire electrical load requirement of the TPSS.

A typical incoming supply ductbank from the electrical utility will be buried below the finished grade by at least 750 mm and will comprise of PVC conduits encased in concrete. The actual design of the incoming supply ductbanks will be dependant on the connection agreement and the requirements of the electrical utility but for space allowance purposes, each incoming supply ductbank should be considered to have a section of 1000 mm x 1000 mm. The final duct bank design must follow THESL requirements.

These supplies are independent of power supply requirements / connection agreements associated with the base building. Dedicated incoming supply sub-surface ducts are required directly to the TPSS. The TTC will not accept power from a third-party (for example a sub-feed from the base building). Sizing requirements made within this report make no allowance for the another tenant to receive power from the TPSS.

It is understood from discussions with the TTC and the Toronto Hydro Conditions of Service that the incoming supply electrical utility will not require any additional switchgear from that stated in section 9.2.3. It is the detailed designer's responsibility to confirm final hydro connection requirements with Toronto Hydro.

The design of the high voltage electrical AC system within the TPSS is provided by the Systems Designer, refer to section 9.2.3. A demarcation line of what is and what is not in the scope of this report has been included in the accompanying Single Line Diagram (refer to Drawing T201).

6.3 Auxiliary Power

The design integrates the traction power equipment into the TPSS building, as well as the electrical design of building systems – i.e. lighting, fire alarm, power distribution, conduit routing, and grounding. The building auxiliary systems will be fed by one 600V feeder supplied by the TPSS primary electrical system. Refer to Drawing T201 for TPSS Single Line Diagram.

6.4 Preliminary Load Estimate

The following is a preliminary load estimate for the TPSS auxiliary power.

Load Type	Estimate	Total (W)
Interior Lighting	10W/sq.m.	6,500
Emergency Lighting (EBUs)	-	1,000
HVAC	2 HVAC units, 4 electric heaters	45,000
HVAC (future)	1 HVAC unit	16,000
Fire Alarm		750
Service Receptacles & Miscellaneous		3,000
Total Auxiliary Power		**72,250 W**

Figure 3 Auxiliary Preliminary Load Estimate

6.5 Lighting and Lighting Control

Lighting design within the TPSS is guided by TTC Design Manual DM-0701-05 and Master Specification 26 50 00. The system consists of normal and life-safety lighting that considers the ease of maintenance, minimises power requirements and optimizes energy efficiency. All lighting fixtures will be LED.

TPSS lighting is fed from the TPSS auxiliary (building) power system. Refer to Drawing E201 for TPSS proposed basis of design lighting fixture schedule and interior lighting layout.

Exterior lighting design is expected to be provided by the base building. All exterior fixtures must be Dark Sky Compliant, with aesthetics which complement the building and surrounding area. Pedestrian scale lighting should be considered and provided where appropriate.

Life safety lighting will be provided via emergency battery units with remote heads, as there is no adjacent Station with UPS power available nearby.

The design of the lighting control system will comply with the requirements of ASHRAE 90.1 and Toronto Green Standards. For interior spaces within the TPSS, vacancy sensors will be provided in washroom, stairwell and hallways, and manual on/off controls will be provided in the main equipment rooms.

6.5.1 Target Light Levels

This section will outline the light level requirements as prescribed.

The layout of lighting fixtures will fully coordinate with and equipment, HVAC ducts, cable trays, etc. to ensure that the lux levels prescribed in the TTC Design Manual are maintained. In accordance with the TTC Design Manual, a light loss factor of 0.65 and an Average-to-Minimum uniformity ratio of 3:1 will be used for lighting calculations in the TPSS. The design illumination levels (to be measured at floor level) are summarised in the following table.

Table 1 TPSS Light Level Requirements

Area/Room Name	Average Maintained Illuminance (lx)
Staff Washroom	150
Mechanical Room	150
Control Room	250
Battery Room	250
Rectifier Room	250

Figure 4 TPSS Light Level Requirements

6.6 Fire Alarm System

A standalone fire alarm control panel will be provided to connect the smoke and heat detection devices, speakers, manual pull stations, etc. in the TPSS. The TPSS fire alarm control panel will require remote communications to the TTC main system as well as to the base building fire alarm system. Refer to drawing E501 for Fire Alarm Riser diagram.

6.7 Grounding

The TPSS building will be provided with a grounding system that complies with OESC and IEEE 80 Guide for Safety in AC Substation Grounding. All non-current carrying metallic enclosures or parts of AC equipment are required to be connected to ground. All non-current carrying metallic enclosures and parts of DC equipment are required to be installed insulated from ground and will be connected to grounding provision(s) via a ground fault detection system.

If a grounding grid is utilised as the grounding solution, it shall be constructed from an assembly of bare copper conductors and grounding rods. Grounding rods are required to be located in the corners of any grid to ensure optimum dissipation of fault energy to ground. The grid itself is required to be bonded together at consistent intervals to ensure an equipotential plane. This is to ensure that a predictable voltage gradient exists around the TPSS.

If other grounding solutions are proposed or required, specific design consultation with the TTC would be recommended.

The TTC prefers the substation grounding is standalone from the base building grounding grid. The designer will need to comply with local codes and connect to base building grounding only where required by code.

The final grounding system must be validated and accepted by the TTC before it can be utilised for TPSS grounding. Although not limited to, validation and acceptance is done via:

- Local soil resistivity measurements
- Grounding system resistance measurements
- Touch and step potential calculations

Two ground test wells will be provided within the TPSS building. Electrical rooms inside the TPSS will have a wall mounted perimeter ground bus bar for equipment bonding. Refer to drawing E301 for grounding riser diagram.

For all concrete encased duct banks, a 4/0 AWG bond conductor will be provided along the entire length of the encasement in accordance with TTC standard. A second 4/0 AWG conductor (green, insulated) will be run in a spare duct in the duct bank.

7 Mechanical

7.1 Introduction

The mechanical design will include Heating, Ventilation and Air Conditioning (HVAC), plumbing, drainage, and fire protection. The design will incorporate requirements from the TTC Design Manual and heat dissipation loads from electrical equipment.

7.1.1 Codes and Standards

The installation of mechanical, plumbing, fire protection systems will comply with the current versions of the following codes and standards:

- Ontario Building Code
- Ontario Fire Code
- Ontario Electrical Safety Code
- Ontario Health and Safety Act
- NFPA 10, Standard for Portable Fire Extinguishers
- CSA Standards
- ASHRAE 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings
- ASHRAE 62.1, Ventilation for Acceptable Indoor Air Quality
- ASHRAE Handbooks (2009 through 2012)
- SMACNA Manuals

Calculations and designs are provided in accordance with the TTC Design Manual, Master Specifications and Directive Drawings. The mechanical and plumbing design is provided in accordance with the following relevant TTC Design Guidelines:

- TTC DM-0601-01 Ventilation - General
- TTC DM-0601-02 Ventilation - Design Parameters for Normal Operations
- TTC DM-0602-01 Plumbing and Drainage - General
- TTC DM-0602-02 Plumbing and Drainage - Plumbing
- TTC DM-0602-03 Plumbing and Drainage - Drainage
- TTC DM-0604-01 Vibration Control - General
- TTC DM-0611-01 Equipment Hoists - General

7.1.2 External Design Criteria

The external design conditions used for sizing of the building mechanical systems have been obtained from Table 1.2 Design Data for Selected Locations in Ontario from the Ontario Building Code 2012 Supplementary Bulletin SB-1 for Toronto, ON as follows:

- Heating Design Temperature: -20°C (January 1%)
- Cooling Design Temperature: 31°C Dry Bulb / 24°C Wet Bulb (July 2.5%)

7.1.3 Internal Design Conditions

The indoor temperature will be maintained in accordance with the TTC DM-0601-02 Ventilation – Design Parameters for Normal Operations requirements and as summarized below:

Table 2 Internal Design Conditions

Room	HVAC Operating Mode	Air Temperature (°C DB)	Humidity	Equipment Gains (kW)	Pressurization (Pa)
Rectifier-Transformer Room	Mechanical Ventilation	18 min/40 max	-	29	TBD
Battery Room	Mechanical Ventilation	18 min/40 max	-	TBD	<0
Washroom	Mechanical Ventilation	22 min	-	-	<0
Mechanical Room	Mechanical Ventilation	9 min	-	TBD	TBD

7.2 Heating, Ventilation and Air Conditioning

7.2.1 Cooling and Ventilation

Ventilation is required to dissipate heat generated by primarily by electrical equipment (transformers, rectifiers, etc.), and to provide air changes to prevent hydrogen gas released by batteries from exceeding levels required for combustion.

This TPSS building will be cooled primarily using air handling units located in the Mechanical Room, and thermostats installed in the various equipment rooms. The air handling units will be able to recirculate air mixed with outdoor air to maintain interior temperatures as per TTC design parameters listed in the previous section. Each unit will comprise of a supply fan, a return fan, an electric heating coil, a mixing box and filters. The air handling units will have the capability to provide free cooling during winter months – i.e., when outdoor ambient temperature is suitable, the units will circulate 100% outdoor air throughout the spaces by using motorized dampers.

N+1 redundancy will be implemented as per the TTC guidelines. A total of two (2) air handling units will be installed in the Mechanical Room. Each air handling unit will be sized to deliver approximately 2,835 L/s (6,000 CFM) based on electrical equipment heat load of approximately 29kW and

temperature setpoint requirements per the TTC Design Manual. Space will be allocated in the Mechanical Room for a third air handling unit, which will be installed complete with ductwork, motorized dampers, etc., when the future transformer is installed. The air handling units will be ducted to two louvres, each sized at approximately 4.8m^2, for outdoor intake air and exhaust air, respectively, and accounting for future loads. If installed on the same exterior wall, adequate spacing must be maintained between the louvres to prevent contamination of intake air by exhaust air.

Two (2) dedicated two-speed exhaust fans will be required for the Battery Room to maintain the air change requirement, prevent hydrogen gas accumulation, and to meet N+1 redundancy.

A dedicated inline exhaust fan will be provided for the washroom at an exhaust rate of 50 L/s (100 CFM). Make-up air for the washroom will be transferred from the adjacent room. Supplemental heating will be provided using an electric forced air heater connected to a thermostat, which will operate as required to maintain a minimum room temperature setpoint.

A general exhaust fan will be provided in the Cable Room and Mechanical Room each to provide air circulation, with transfer air coming in from adjacent spaces. Supplemental heating will be provided throughout the building using electric unit heaters and electrical forced air heaters.

7.3 Plumbing and Drainage

The plumbing systems will consist of domestic cold and hot water to serve plumbing fixtures. All domestic cold and hot water piping will be provided with insulation.

The drainage piping system will consist of sanitary drainage piping only.

The Base Building designer must consider the placement of any wet services and the subsequent propensity for water ingress into the TPSS. It is required that:

- No sprinklers or other non-approved fire suppression equipment is permitted within the TPSS.
- Equipment or features requiring drainage shall not be located directly over the TPSS.

7.3.1 Domestic Cold Water

A 50mm domestic cold water (DCW) service connection will be required to serve the washroom in the substation, as well as hose bibs and eyewash station as required by the TTC Design Manual. This connection can be provided in one of the following ways:

1) Provide a DCW service connection from the base building's watermain, complete with a water meter, main isolation valves and a backflow preventer, OR

2) Provide a DCW service connection from the City of Toronto watermain, complete with a municipal water meter in accordance with the City of Toronto Water Meter Guidelines. Main isolation valves and backflow preventer will be provided on the incoming service.

A small mechanical room or enclosed closet will be required to house the water meter and additional equipment for this incoming service connection.

7.3.2 Domestic Hot Water

Domestic hot water for the lavatory and eyewash station will be provided by an electric hot water tank installed in the washroom ceiling plenum.

7.3.3 Sanitary Waste and Vent

Drainage for the washroom, eyewash station and floor drains will be routed via gravity and connected to the base building's sanitary system.

7.4 Fire Protection

The TPSS building will not be sprinklered per the code analysis in Section 4.1, but portable fire extinguishers will be provided.

8 Structural

8.1 Overview

The floor(s) supporting the substation rooms should be designed to the requirements outlined below. The floor(s) should be made of reinforced concrete to minimize the impact of vibration and noise on surrounding occupants.

8.2 Codes and Standards

Design codes and standards shall be as set out in the Toronto Transit Commission Design Manual as well as the codes, standards and guidance references listed below. Refer to the latest editions unless specifically noted otherwise.

Table 3 Codes and standards

Reference	Description
TTC DM	Toronto Transit Commission Design Manual
NBCC	National Building Code of Canada
OBC	Ontario Building Code
CSA A23.1	Concrete Materials and Methods of Concrete Construction
CSA A23.2	Test Methods and Standard Practices for Concrete
CSA A23.3	Design of Concrete Structures
G30.18	Carbon Steel Bars for Concrete Reinforcement
CSA S16	Design of Steel Structures
CFEM	Canadian Foundation Engineering Manual
CSA S478	Guideline for Durability in Buildings

8.3 Materials

8.3.1 Concrete

Concrete shall be normal weight in accordance with CSA-A23.3 Cylinder strengths (f'c) as per Table 4. The specified compressive strength of concrete, f'c, for which each part of the structure is designed shall not be less than 35 MPa nor exceed 40 MPa at 28 days. Design strengths shall be indicated on the detail design drawings. Higher strength concrete structures or portions thereof may be considered in special circumstances and will require detailed analysis and justification. The use of high performance concrete (HPC) requires written approval and specialized quality control (QA & QC) provisions to be included in the project specifications. Submit proposed QA & QC provisions for specifications when obtaining approval for the use of HPC.

Table 4 Concrete strengths

Element	Cylinder Strength (MPa)
All structural elements	35

8.3.2 Concrete Reinforcement

Concrete reinforcing steel shall be minimum 400 MPa yield strength and shall confirm with the following codes:

- ASTM A82
- A185
- A496
- A497
- A775
- CSA G30.18
- W186-M1990

Reinforcement to be welded shall be grade 400, welding in accordance with CSA Standard W186.

Bars for concrete reinforcement shall be deformed bars, with the exception that plain bars may be used for spirals and wire mesh.

8.3.3 Structural Steel

All structural steel, including all rolled sections, fabricated section, and plates, shall be specified as grade 350W and conform to the following codes:

- CAN/CSA-S16-14
- CAN/CSA-G40.20/21
- HSS sections shall conform to CAN/CSA-G40.20/G40.21 Class H

8.4 Loading

8.4.1 Dead Loads

Dead loads from the structure are calculated from element sizes and material densities. Typical material densities used are summarized in Table 5.

Table 5 Material densities

Material	Density (kN/m^3)
Concrete (plain or reinforced)	24

Steel or cast steel	78.5
Glass	25.6
Timber	9.6

8.4.2 Superimposed Dead Loads

A preliminary estimate of the superimposed dead loads is summarized in Table 6. These should be reviewed against the final architectural layouts and finish schedules.

Table 6 Superimposed dead load

Element	**Uniform Load (kN/m^2)**
Floor finishes	2
Ceiling and services	1
Partitions*	3

- *Note – Partition allowance should be reviewed once room layouts are known and locations/concentration of CMU walls known.

8.4.3 Live Loads

Electrical equipment rooms, pump rooms, machinery rooms, storage rooms, service and battery rooms shall be designed for a specified live load of 12 kPa, or the actual equipment load where greater than 12 kPa, applied uniformly over the entire area, or on any portions of the area, whichever produces the most critical effects in the members concerned. The specified live load shall be reduced for structural members supporting large tributary areas in accordance with Ontario Building Code requirements for non-assembly occupancies. A concentrated load of 15 kN applied over an area 750 mm x 750 mm and positioned so as to cause maximum effects shall also be considered. The most critical loading condition shall govern.

Table 7 Live load

Floor Usage	**Uniform Load (kN/m^2)**	**Concentrated Load (kN)**	**Comments**
Equipment room	12	15 (over 750mmx750mm area)	Actual equipment loads should be used where greater.

8.5 Vertical Deflection Limits

To minimize the risk of cracking of non-structural components and lack of fit of cladding elements through excessive deflections, structural elements shall be sized to meet the guidelines given in OBC 2012 and CSA A23.3. These deflection limits are summarized in Table 8.

Table 8 Summary of maximum deflection / span ratios and referenced standards

Building Component	**Type of Member (Reference Document)**			
	Wood (CSA O86)	Concrete (CSA A23.3)	Steel (CSA S16)	Masonry (CSA S304.1)
Floor members not supporting or attached to non-structural elements likely to be damaged by large deflections	1/180b	1/240b or 1/360d	1/300d	1/480a or 20mm max
Roof members not supporting or attached to non-structural elements likely to be damaged by large deflections	1/180b	1/240b or 1/360d	1/300d	-
Roof or floor members supporting or attached to non-structural elements likely to be damaged by large deflections	1/360a or 1/180b	1/480a	1/240b or 1/360d	1/600e
Wall Members	1/180 or 1/360c	-	-	1/240f or 1/360c

Table Notes:

1. That part of the total deflection occurring after the attachment of non-structural elements
2. Immediate deflections under total load
3. When used as structural backing for masonry veneer or brittle finishes or subject to sustained loading
4. Immediate deflection due to specified live or snow load
5. For structural members supporting glass block masonry due to specified loads
6. 1/600 for unreinforced masonry walls or walls acting as structural backing for glass block masonry

8.5.1 Durability

Durability should be considered using the recommendations set out in CSA S478. The following elements should be considered to develop an overall durability strategy:

- Concrete cover
- Concrete mix design
- Steelwork corrosion protection

9 Systems

9.1 Introduction

9.1.1 Purpose

This chapter aims to outline a performance specification for the systems elements that sets out the requirements for a new TTC 570 V DC streetcar traction power substation.

9.1.2 References

This section outlines references, design inputs, meetings and discussions that have occurred that form the basis of the contents of this section.

9.1.2.1 TTC Design Manuals

- The following TTC Design Manuals have been used to create this performance specification:
- DM-0804-01 Traction Power Substation General – 3rd May 2018
- DM-0804-02 High Voltage AC Switchgear – 17th August 2011
- DM-0804-03 DC Switchgear – 17th August 2011
- DM-0804-04 Transformers – 17th August 2011
- DM-0804-05 Metering, Protection Control – 17th August 2011
- DM-0804-06 Electrical Substations, Vaults and Switchgear Rooms – 3rd May 2018
- DM-0804-07 Cables – 17th August 2011
- DM-0804-08 Grounding and Corrosion Control – 17th August 2011
- DM-0804-09 Electrical Supporting Devices – 17th August 2011
- DM-0804-10 Rectifiers – 17th August 2011

9.1.2.2 TTC Design Drawings

The following TTC Design Drawings have been used to create this performance specification:

- 0701-02.01 – SRT & Streetcar Below Grade and Subway Passenger Station Fed from Traction Power Substation
- 0701-02.02 – Passenger Station Fed from Remote Traction Power Substation Single Line Diagram

- 0701-02.03 – Single Line Diagram of Passenger Station Electrical Room Fed by Hydro Utility
- 0701-02.04 – SRT or Streetcar Above Grade Passenger Station Fed from Traction Power Substation
- 0804-01.01 – Ductbank Detail – Typical Arrangement Communication / Control
- 0804-01.02 – Ductbank Section – AC Feeders to Passenger Stations
- 0804-01.03 – Ductbank Section – DC Traction Power Cables
- 0804-01.04 – Ductbank Section – Hydro Feeder Section

9.1.2.3 TTC Communications

Where design requirements differ from those stated in the TTC Design Manuals or where bespoke requirements have been declared, TTC communication dispatches contained hereon-in supersede both TTC Design Manual and TTC Design Drawing content.

- Incoming AC Power Distribution – Two (2) supplies are required in place of the one (1) stated. AC supply will be configured to achieve an independent main-tie-main function in place of what is stated (drawing 0701-02.04).

  Communicated: 31st March 2021 (email / minutes) – Suma Apparao-Das

- Outgoing DC Power Distribution – Two (2) 1500 MCM guideway feeders designated ‘A’ and ‘B’ are required, requiring additional OCS disconnector switches at the TPSS. This requirement although not stated in any TTC Design Manual is based on the Queens Quay West Streetcar upgrade project.

  Communicated: 17th March 2021 (email / minutes) – Richard Vella

- Outgoing DC Power Distribution – Bypass switching is required between OCS disconnector switches. This requirement although not stated in any TTC Design Manual is based on the Queens Quay West Streetcar upgrade project.

  Communicated: 20th May 2021 (design coordination meeting) – Marcus Reis

9.2 Electrical Equipment Configuration

Size requirements for the TTC 570 V DC streetcar TPSS directly correlate to the specified electrical design and the proposed electrical configuration. For this reason, a single line diagram has been proposed. This single line diagram encapsulates the assumptions noted in the Systems design.

Refer to drawing T201 for the reference single line diagram.

9.2.1 Number of Conversion Units

The new TTC 570 V DC streetcar TPSS is sized for two (2) transformer-rectifier pairs. A single rectifier transformer and diode rectifier will be located and space provision for the future equipment has been considered.

Each transformer-rectifier is sized based on a 1.5 MW unit.

9.2.2 Spare Equipment

Upon on requirement of the TTC, one (1) additional DC circuit breaker for future provision is included in the DC switchboard line-up.

9.2.3 AC Switchboard Line-up

A split AC switchboard is proposed for the main AC switchgear to suit the TTC requested incoming service and distribution. The switchboard is split for two reasons:

1. The arrangement is not considered standard and concern exists over whether it is technically possible with buswork to achieve a single AC switchboard line-up.
2. A split AC switchboard requires a greater footprint, thus providing a more conservative size requirement.

With reference to the below figures and the SLD; the split AC switchboard has been configured as a dedicated supply switchboard and a dedicated distribution switchboard. The supply switchboard comprises of five (5) bays; two (2) load isolation switches functioning as a physical disconnect between utility and TTC circuits, two (2) withdrawable circuit breakers for supply trip and one (1) metering cell that contains revenue quality CTs and PTs.

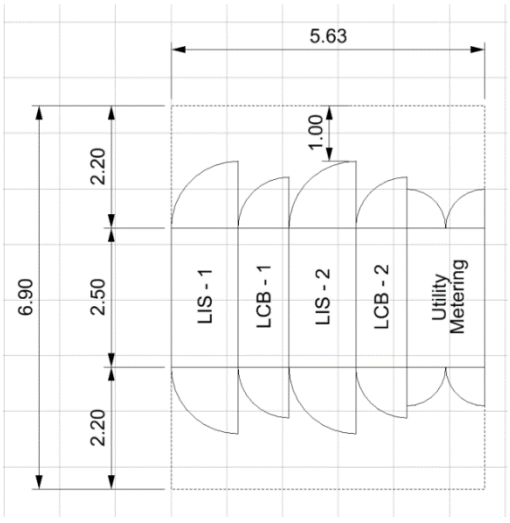

Figure 5 AC Supply Switchboard

The distribution switchboard comprises of seven (7) bays; six (6) bays have been allocated for the following TPSS functionality; a split bus with tie coupler, independently fed buses, independently fed rectifier transformers on each bus and provision for an auxiliary transformer for domestic load

from one of the buses. A transition cell has been allocated to permit tie coupler switchgear flexibility.

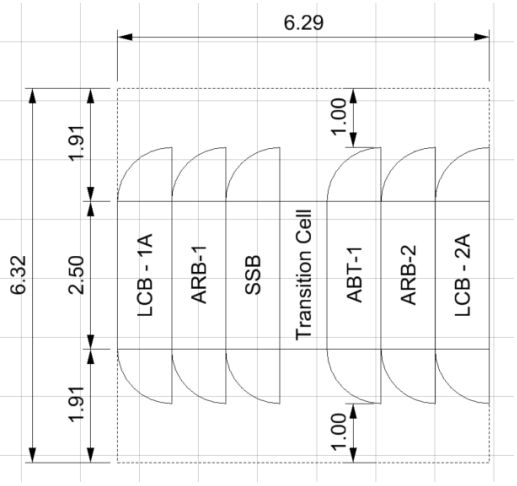

Figure 6 AC Distribution Switchboard

9.2.4 DC Switchboard Line-up

A non-linear DC switchboard is proposed that separates switchgear from associated conversion equipment. This was done for two reasons:

1. A non-linear DC switchboard provides greater TPSS designer flexibility with respect to traction power specific design and component choice.
2. A non-linear DC switchboard requires a greater footprint, thus providing a more conservative size requirement.

With reference to the below figures and the SLD, the DC switchboard comprises of five (5) bays.

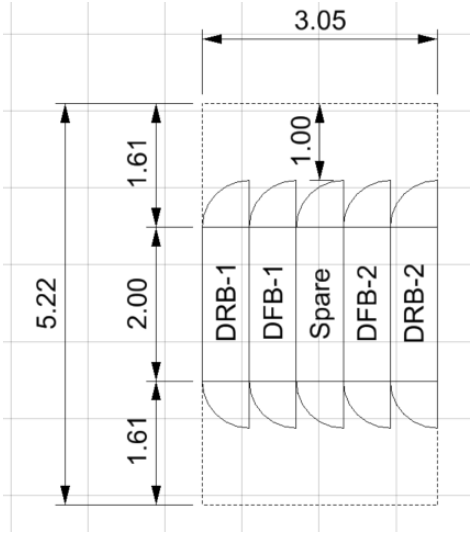

Figure 7 DC Switchboard

9.2.5 OCS Disconnector and Bypass Cabinets

Dedicated OCS disconnector and bypass switching cabinets have been optioneered and accounted for. A cabinet has been sized at 0.7 x .0.7 m and space provision for code compliant access.

9.2.6 Negative Return Equipment

Dedicated wall abutting space of 9 m^2 has been provided for a negative busbar, a grounding busbar, negative grounding switch and negative busbar isolation switches. A requirement for vertically stacked third-party utility (telecoms, water and power) stray current test boxes has also been included.

The TTC has a specific requirement for negative return equipment to be remote and not contained within positive DC switchboard line-ups.

9.2.7 Ancillary Equipment

Consideration has been taken to sure the room and equipment layouts include designated wall space for the mounting, racking or abutting of ancillary equipment cabinets. Respective circuitry, cabling, cable bending radii and associated containment ducts and raceways have to be accommodated for.

Layout plan design concepts T101 and T102 provide at least 24 m^2 of ancillary equipment space. This is based on a provisional depth of 0.8 m for equipment (30 m of available wall space).

Although not limited to, a TPSS is required to contain:

- 120 V AC receptacles
- AC breaker test cabinets
- AC domestic panels
- DC breaker test cabinets
- DC domestic panels
- Emergency trip equipment
- Eyewash stations
- Fire extinguishers
- Fire panels
- Lighting
- Light switches
- SCADA marshalling panels
- SCADA RTU cabinets
- Smoke detectors

9.3 Technical Requirements

This section of the report outlines the functional needs of a new TTC 570 V DC streetcar traction power substation.

9.3.1 Equipment Sizing

The following equipment sizes are used in the design, based on industry averages taken from various North American vendors.

Table 9 Equipment Sizing Assumptions

Equipment	Width (mm)	Depth (mm)	Height (mm)
AC Switchboard			
LIS	1200	2500	2800
LCB	910	2500	2450
Metering	1400	2500	2450
ABT	910	2500	2450
Transition Cell	800	2500	2450
DC Switchboard			
DFB	610	2000	2300
Conversion Equipment			
Rectifier Transformer	2200	3360	2800
Diode Rectifier	1700	2750	2300

9.3.2 Equipment Weights

The Base Building designer should account for the following point loads.

Table 10 Equipment Weight

Equipment	Weight (kg)	Quantity	Comment
Rectifier Transformer	12,000	2	
Diode Rectifier	1500	2	
AC Switchboard	5000 / 7000	2	1000 kg per bay
DC Switchboard	6000	1	1200 kg per bay
Battery Bank	7500	60	2V 500 Ah cells (125kg cells)

The street level floor of the TPSS must be structurally capable of supporting the load of contained equipment. This equipment could be located anywhere within the TPSS and hence the entire floor should be structurally capable.

To not restrict usage of a particular switchgear manufacturer or introduce installation problems the TPSS floor is required to have a floor flatness of ±1 mm / meter.

9.3.3 Equipment Mounting

The Base Building designer is required to provide a TPSS ‘space’ that has walls that are structurally capable of supporting wall-mounted equipment. Table 11 Minimum Wall Loading Requirements has been provided to provide minimum requirements.

Table 11 Minimum Wall Loading Requirements

Equipment	Loading Requirement (kg / m^2)	Comment
Lighting panel boards, relay panels, cross connect panels, AC and DC distribution panel boards, marshalling cabinets and the like.	100	All equipment not specifically mentioned elsewhere.
Battery chargers, distribution transformers, DC negative return equipment and the like.	200	Location specific requirement within TPSS.

Unless specific construction constraints exist, the Base Building designer should consider the worst-case loading so that the TPSS designer is not restricted when designing an internal equipment layout.

9.3.4 Structural Considerations

The key determining factor affecting material and construction methodology is the required fire rating requirements as stated in code requirements. Other considerations include:

- Transformers and batteries are the highest risk components of an electrical substation. Usage of dry type transformers dramatically reduces the combustibility of transformers located within the TPSS. Usage of valve regulated lead acid batteries dramatically reduces the propensity for hydrogen gas release.
- TPSS HVAC design is a key component of achieving the required fire rating and as such has its own specific requirements (section 7).
- Specific Base Building usage may have a direct impact on the required fire rating of the electrical equipment. At time of writing this report, Base Building usage is unknown and not within scope. Consultation with local fire marshals is recommended.
- To not restrict usage of a particular switchgear manufacturer or introduce installation problems the TPSS floor is required to have a floor flatness of ±1 mm / meter.

To not limit the TPSS designer when designing an internal equipment layout, no internal walls or columns should be located within the TPSS space. Where this is not possible or cannot be achieved the TPSS designer should be consulted.

Structural inclusions into the TPSS has a propensity to seriously reduce usable space within a TPSS when equipment size, layout, electrical clearance and accessibility requirements are considered. Structural inclusions into the TPSS space could invalidate sizing requirements in section 5.2.2 leading to a requirement for a large footprint.

With reference to layout plan concepts T101 and T102, a TPSS does have a requirement for internal segregation. The presented plans do not consider structural requirements of the enclosure structure.

9.3.5 Equipment Removal and Replacement

When allocating space provision for the TPSS, the Base Building designer must consider and demonstrate practicable provision for equipment removal and replacement. This provision includes where a vehicle capable of removing the largest piece of equipment in Table 9 can be parked.

This provision does not have to be permanent, but it must be available with unrestricted and unimpeded access.

Rectifier transformers and diode rectifier units are conventionally moved into place using dedicated skidding equipment. Consideration is therefore needed for this skid route – particularly with regards to curbs and steps.

9.3.6 Outgoing DC Feeders

Dedicated 570 V DC feeder cable ducts and separate negative return ducts are required between the TPSS and the guideway. Positive and negative return ducts can be located within the cable ductbank.

The outgoing feeder ductbanks will be buried below grade at least 750mm.

The size of the outgoing DC feeder ductbank will be dependant on cable sizing (and quantity) calculations from the traction power load flow study and will require a dedicated DC manhole for cable marshalling in close proximity to the location of the TPSS within the Base Building.

For the purpose of space provision, the Base Building designer should consider a ductbank of 1500 mm (wide) x 700 mm (depth). This size requirement is based on the assumption of 21 100 mm PVC ducts spaced at 165 mm [a 7 by 3 configuration]. Rationalisation of the ductbank can be done at detailed design when specifics are known.

9.3.6.1 Connections / Routes to the Guideway

When positioning the TPSS with in the Base Building, cognisance of a direct route to Queens Quay must be considered for the outgoing feeder ductbank.

This route should not exceed 100 m, any length will need to accepted by TTC and included in the Queens Quay East load flow study.

Consideration should be made for the access to cable pulling chambers / manholes on the duct route. The Base Building designer should consider an internal bending radius of at least 1500 mm when allocating space for a route between the TPSS and the guideway.

9.3.7 Communication Ductbank

A dedicate communications ductbank is required between the TPSS and the guideway. As per the other ductbanks, this ductbank should be at least 750 mm below finished surface.

Design of communication based systems is very much related to existing infrastructure, technological advancements and the existing connections within the guideway. Since it is not known whether dedicated fibre optic communication transmission systems will be utilised, the Base

Building designer should consider a 1000 mm x 1000 mm section to account for dedicated ducts for fire, comms, SCADA, ETS and telephony.

This dedicated communication ductbank should be located at least 1000mm from the outgoing DC feeder route if it is running parallel for the distance between TPSS and guideway.

9.3.8 Cable Pull Room

The TTC has a strong preference for cable marshalling to be done in a dedicated cable pull room underneath the TPSS footprint. A dedicated cable basement provides operational flexibility for replacing either failed or life expired cables since switch-over can occur at a separate time to the physical installation process.

As a minimum, the cable basement should have the same size footprint as the control room and should be located directly underneath.

9.3.9 Noise

The Base Building designer should account for the following noise levels from the TPSS interior (if noise and vibration is considered a hinderance to the proposed usage).

Noise – up to 100 decibels TBC

These requirements do not include noise and vibration caused by external too TPSS activities. These requirements have been included so that if met there can be no recourse to the TTC. Mitigation once a substation is operational is ongoing, costly and has a limited effectiveness. Recourse considerations are a major decision for an operator when determining the viability of a TPSS site location and assurances will likely be required.

9.3.10 Electromagnetic Compatibility (EMC)

The Base Building designer should account for the following limits (if EMI is considered a hinderance to the proposed usage).

Electromagnetic Noise – up to 0.15-30 MHz

These requirements have been included so that if met there can be no recourse to the TTC. Mitigation once a substation is operational is ongoing, costly and has a limited effectiveness. Recourse considerations are a major decision for an operator when determining the viability of a TPSS site location and assurances will likely be required.

9.3.11 Communications

The Base Building designer needs to consider TPSS communications in and out of the site location.

The TPSS will house a dedicated communications cabinet that will communicate with the TTC owned and operated communications transmission system (CTS) fibre network via dedicated CTS switches and fibre patch panels.

The communications cabinet will contain all internal / external communications equipment related to telephony, intrusion and access control (IAC), CCTV and SCADA RTUs. Respective direct connections will then be made to TPSS located telephone jacks, IAC equipment, CCTV cameras, FDAS equipment and AC and DC switchgear lockout relays.

To permit control of TPSS located systems and equipment a dedicated substation control cabinet will be located on the site. This cabinet contains media converters and network switches, PLCs as well as HMI systems. A dedicated DC media convertor is responsible for status and alarms for substation conversion equipment, ground detection, negative ground switch operation and DC switchgear operation. A dedicated AC media converter is responsible for rectifier transformers, auxiliary transformers and AC switchgear.

PLCs are used to monitor the status of battery charger systems, emergency trip systems, OCS disconnectors and HVAC status and temperature.

Appendix A– Drawings

Refer to drawing set provided separately.

Appendix B– List of Specifications

Specification Number Division	Title	TTC Master
03 10 00	CONCRETE FORMWORK AND FALSEWORK	YES
03 20 00	CONCRETE REINFORCEMENT	YES
03 30 00	CAST-IN-PLACE CONCRETE	YES
03 30 00.01	CONCRETE MIX DESIGN SUBMISSION FORM	YES
03 35 00	CONCRETE FLOOR FINISHING	NO
04 20 00	UNIT MASONRY	YES
05 12 00	STRUCTURAL STEEL	YES
05 31 00	STEEL DECK	YES
05 52 00	METAL RAILINGS	YES
05 50 00	METAL FABRICATIONS	YES
07 14 00	HOT RUBBERIZED ASPHALT FLUID-APPLIED WATERPROOFING	YES
07 21 00	THERMAL INSULATION	YES
07 27 00	AIR AND VAPOUR CONTROL	YES
07 42 43	ALUMINUM COMPOSITE PANEL	YES
08 11 00	METAL DOORS AND FRAMES	YES
08 71 00	FINISH HARDWARE	YES
08 91 19	LOUVRES	YES
09 30 00	TILING	NO
09 66 13	PORTLAND CEMENT TERRAZZO	YES
09 91 00	PAINTING	YES
09 67 00	FLUID-APPLIED FLOORING	NO
10 28 13	WASHROOM ACCESSORIES	YES
20 05 00	MECHANICAL GENERAL REQUIREMENTS	YES
20 05 19	THERMOMETERS AND PRESSURE GAUGES PIPING SYSTEMS	YES
20 05 21	PRESSURE GAUGES AND THERMOMETERS	YES
20 05 23	VALVES	YES
20 05 29	MECHANICAL HANGERS AND SUPPORTS	YES
20 05 48	MECHANICAL VIBRATION CONTROL	YES
20 05 53	MECHANICAL IDENTIFICATION	YES
20 11 12	PRESSURE PIPING	YES

21 25 00	PORTABLE FIRE EXTINGUISHERS	YES
22 07 19	THERMAL INSULATION FOR PIPING	YES
22 11 16	DOMESTIC WATER PIPING	YES
22 16 16	SANITARY AND STORM DRAINAGE AND VENT PIPING	YES
22 16 19	FLOOR AND ROOF DRAINS AND CLEANOUTS	YES
22 33 30	DOMESTIC ELECTRIC WATER HEATER TANKS	YES
22 42 00	PLUMBING FIXTURES AND SPECIALTIES	YES
23 05 16	FLEXIBLE CONNECTIONS AND JOINTS	YES
23 05 93	TESTING, ADJUSTING AND BALANCING (TAB) OF MECHANICAL SYSTEMS	YES
23 07 13	THERMAL INSULATION FOR DUCTWORK	YES
23 09 33	CONTROLS	YES
23 31 14	DUCTS LOW PRESSURE	YES
23 33 00	DUCT ACCESSORIES	YES
23 33 13	DAMPERS	YES
23 33 53	ACOUSTIC DUCT LINING	YES
23 34 16	COMMERCIAL FANS	YES
23 37 13	GRILLES, REGISTERS, AND DIFFUSERS	YES
23 41 13	AIR FILTERS AND FILTER GAUGES	YES
23 82 17	DUCT HEATERS	YES
23 82 40	ELECTRIC HEATERS	YES
25 50 00	BUILDING AUTOMATION AND CONTROLS	YES
25 90 00	BASC SEQUENCE OF OPERATIONS	YES
26 05 00	ELECTRICAL GENERAL REQUIREMENTS	YES
26 05 21	WIRES AND CABLES 0 - 1000 V	YES
26 05 22	CONNECTORS AND TERMINATIONS	YES
26 05 26	GROUNDING AND BONDING	YES
26 05 29	HANGERS AND SUPPORTS	YES
26 05 34	CONDUITS	YES
26 05 36	CABLE TRAYS AND TROUGHS	YES
26 05 41	INSTALLATION OF CABLES IN TRENCHES AND IN DUCTS	YES
26 05 53	ELECTRICAL IDENTIFICATION	YES
26 12 16	DRY TYPE TRANSFORMER	YES

26 13 13	13.8 KV 27.6 KV CIRCUIT BREAKER SWITCHGEAR	YES
26 13 17	FULL LOAD INTERRUPTER SWITCHES TO 15 KV	YES
26 23 00	SECONDARY SWITCHGEAR	YES
26 24 16	PANELBOARD	YES
26 27 26	WIRING DEVICES	YES
26 28 21	MOULDED CASE CIRCUIT BREAKERS	YES
26 28 23	FUSED AND UNFUSED DISCONNECT SWITCHES	YES
26 50 00	LIGHTING EQUIPMENT	YES
28 31 00	FIRE ALARM SYSTEMS	YES
33 71 49	ENCASED DUCT BANKS AND MAINTENANCE HOLES	YES
34 21 19	600 V DC TRACTION POWER SWITCHGEAR	YES
34 21 23	TRACTION POWER RECITIFIER TRANSFOMER-RECTIFIER UNIT	YES
34 21 24	FLOATING NEGATIVE AUTOMATIC GROUNDING SWTICH UNIT (FNAGS)	YES
34 23 20	ELECTRICALLY OPERATED ISOLATING SWITCH	YES

Appendix C– Building Code Outline Report

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FIRE PROTECTION & LIFE SAFETY
BUILDING CODE OUTLINE REPORT

Queens Quay E LRT TPAP
Toronto, Ontario

May 27, 2021

Our File: 20-569

1.0 INTRODUCTION

The following is an outline of the building code concepts for the proposed Queens Quay E LRT TPAP (Project) located in Toronto, Ontario.

The Project includes the construction of a new electrical equipment room (Group F, Division 3) forming part of a greater building to be constructed at the corner of Lakeshore Blvd. and Parliament Street. The electrical equipment room will be two levels, constructed of noncombustible construction and will be approximately 671 m^2 in building area.

In accordance with the Electrical Safety Code adopted under the Electricity Act, 1998, depending on the equipment to be located within the electrical equipment room, this Project is to be designed as an electrical equipment room or an electrical equipment vault. This report set out the 2012 Ontario Building Code requirements applicable to both options.

All reference numbers indicated in this report refer to the 2012 Ontario Building Code (OBC), as amended by O. Reg. 760/20, that is applicable to construction for which a permit has been applied for after December 16, 2020 and prior to January 1, 2022, unless otherwise indicated. This report is based on drawings prepared by West 8 + DTAH received May 5, 2021.

This report was prepared by LMDG Building Code Consultants Ltd. (LMDG) for DTAH. The material provided in this report is based on LMDG's best judgement in light of the information available to LMDG at the time of preparation. Any use of this report by third parties, or any reliance on our decisions to be made based on it are the responsibility of such third parties. LMDG accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

2.0 PROJECT BUILDING CHARACTERISTICS

2.1 Major Occupancy

The proposed electrical equipment room will be classified as containing Group F, Division 3 (Traction Power Sub-station) major occupancy.

In accordance with Sentence 3.2.2.8.(1), in a building in which the aggregate area of all Group F, Division 3 major occupancies are not more than 10% of the floor area of the storey in which they are located, this major occupancy need not be considered as major occupancies for the purposes of Subsection 3.2.2.

3.0 PROVISIONS FOR FIRE FIGHTING

3.1 Fire Department Access

Where this Project is completely cut off from the remainder of the building (building access is not provided), an access route is to be located so that the unobstructed path of travel from the vehicle to one entrance of this Project is not more than 45 m.

4.0 REQUIRED FIRE SEPARATIONS

In accordance with Article 3.1.7.1., a material, assembly of materials, or a structural member required to have a fire-resistance rating will be based on either:

a) an assembly assigned a fire-resistance rating based on tests conforming to CAN/ULC-S101, such as listings from ULC (or an equivalent approved listing agency), or
b) Supplementary Standard SB-2 of the OBC for wall assemblies or ceiling and floor assemblies.

The following sections summarize requirements for other fire separations of the Project.

4.1 Vertical Shafts

In accordance with Sentences 3.4.4.1.(1), 3.5.3.1.(1) and 3.6.3.1.(1), in a building required to have 2-hour floor assemblies, shafts and hoistways are required to be constructed as fire separations having the following fire-resistance ratings (F.R.R.):

Shaft/Hoistway Type	Shaft/Hoistway F.R.R. (Hours)
Exits/Exit Corridors	2
Vertical Service	1

Where the top of a service shaft does not extend through the roof, it will terminate at an assembly having a fire-resistance rating at least equal to the walls of the shaft. Similarly, the bottom of a service shaft will terminate at an assembly having a fire-resistance rating at least equal to the walls of the shaft, except where the shaft extends to the bottom of the building.

4.2 Electrical Equipment Rooms

4.2.1 Electrical Room

In accordance with Sentence 3.6.2.1.(6), electrical equipment that is required to be located

in a service room by a regulation made under the Electricity Act, 1998, will be installed in a service room separated from the remainder of the building by a 1-hour fire separation.

4.2.2 Electrical Equipment Vault

In accordance with Article 3.6.2.7., where an electrical equipment vault is required by the Electrical Safety Code adopted under the Electricity Act, 1998, the electrical equipment vault is required to be totally enclosed by a fire separation of solid masonry or concrete construction having a fire-resistance rating not less than 3 h where the electrical equipment vault is not provided with an automatic fire extinguishing system.

Where a building is required to be sprinklered, the electrical equipment vault need not be sprinklered provided,

a) the vault is designed for no purpose other than to contain the electrical equipment, and
b) a smoke detector is provided in the vault that will actuate the building fire alarm system in the event of a fire in the vault.

An electrical equipment vault, that is part of a building and houses electrical equipment indoors, is required to have,

a) roofs or ceilings consisting of reinforced concrete of adequate strength for the conditions and not less than 150 mm thick, and
b) floors consisting of reinforced concrete of adequate strength for the conditions and not less than 150 mm thick, except that floors that are at excavation level are permitted to be of reinforced concrete not less than 100 mm thick.

Walls, roofs or ceilings, and floors of an electrical vault are required to be adequately anchored together in a manner designed to resist dislodgement by explosion.

Only pipes or ducts necessary for fire protection or the proper operation of the electrical installation are permitted to penetrate the fire separations surrounding the electrical equipment vault.

Ventilation ducts or openings that penetrate a fire separation to the outdoors, need not be protected by a closure at the penetration.

Each door to an electrical equipment vault will be required to be provided with a substantial lock or padlock.

Explosion-relief devices and vents or other protective measures are required to be provided for every electrical equipment vault containing dielectric liquid filled electrical equipment in conformance with Sentence 3.3.1.19.(4) and be provided with a ventilation system designed in conformance with Part 6 to prevent the ambient temperature in the vault from exceeding 40°C.

Where the vault ventilation system is directly from an outdoor area by natural ventilation without the use of ducts, and where the electrical equipment is the principal source of heat, the combined net area of inlet and outlet openings shall be not less than 0.002 m^2/kVa of

electrical equipment capacity with a minimum of 0.093 m^2, except that,

a) where equipment in the power class as described in CAN/CSA-C88-M, "Power Transformers and Reactors" is installed, ventilation requirements are permitted to be based on the actual full-load losses, or
b) where the equipment is installed for emergency purposes only and is not normally energized, it need not be considered in determining the ventilation requirements.

In the vault ventilation system, the inlet for fresh air is required to lead from an outdoor area and shall terminate at a point not more than 1 000 mm above the floor level of the vault.

Where the vault ventilation system is a mechanical system, it is required to be separate from the system for the remainder of the building and is to be designed so that,

a) the vault temperature is thermostatically controlled,
b) the fan is located so that it may be serviced without danger to personnel,
c) a high temperature alarm is provided in the vault,
d) the system is automatically shut off in the event of a fire in the vault, and
e) a filter is provided in the air inlet if there is a possibility of dirt being drawn in.

All ventilation openings are required to be protected in conformance with Sentences 6.2.3.12.(3) and (4) and the protection shall be installed in such a manner that it cannot be removed from the outside by the use of common tools and it is tamperproof.

The floor of the electrical equipment vault is required to be liquid tight and surrounded by liquid tight walls and sills of sufficient height to confine within the vault all of the liquid from the largest item of electrical equipment, but to a height of not less than 100 mm except that the floor of the electrical equipment vault is permitted to be provided with a floor drain connected to a covered sump capable of holding all of the liquid from the largest item of electrical equipment, and the connection shall have a noncombustible trap to prevent the spread of fire from the vault to the sump.

Where the electrical equipment vault is located in a hazardous location classified as Class II, Division 1 in accordance with the Electrical Safety Code made under the Electricity Act, 1998, it is required to have,

a) no vent opening except to the exterior of the building, and
b) suitable pressure-relief openings communicating only with the air outside the building.

Where doors are provided between the vault and the rest of the building the doors are required to have suitable seals such as weatherstripping to minimize the entrance of dust into the vault.

Every electrical equipment vault is required to be provided with,

a) adequate lighting, controlled by one or more switches located near the entrance,

b) luminaires located so that they may be relamped without danger to personnel, and
c) a grounded receptacle located in a convenient location inside the vault, near the entrance.

4.3 Closures (Doors, Glazing and Fire Dampers)

4.3.1 Maximum Size

In accordance with Sentence 3.1.8.6.(1), the size of an opening in an interior fire separation required to be protected with a closure will not exceed 11 m² and will have no dimension greater than 3.7 m where either side of the fire separation is not sprinklered.

4.3.2 Fire Protection Rating

Closures (doors and fire dampers) for openings in all fire separations will be provided with a fire-protection rating in accordance with Article 3.1.8.4. and Table 3.1.8.4., as reproduced in part below:

Fire-Resistance Rating of Fire Separation (Hours)	Required Fire-Protection Rating of Closure (Hours)
1	¾
2	1½
3	2

Doors in required fire separations (including 0-hour fire separations) will be provided with self-closing devices and equipped with positive latching mechanisms designed to hold the door in the closed position after each use. Additionally, doors located in fire separations will not be permitted to incorporate louvres, grills, or other similar types of unprotected openings.

4.3.3 Maximum Temperature Rise/Glass Area Limit in Doors

The maximum temperature rise and area of glazing for closures within required fire separations will be in accordance with Table 3.1.8.15, as reproduced below:

Fire Separation		Min. Closure Fire-protection Rating	Door Max. Temperature Rise	Max. Area of Wired Glass in Doors	Maximum Aggregate Area of Wired Glass & Glass Block not in Door
Type	Rating				
Exits	2-hour	1½ hour	250 °C after 1 hour	0.0645 m²	0.0645 m²
All Others	2-hour	1½-hour	N/A	per listing	individual panes not more than 0.84 m²
	1½-hour	1-hour			
	1-hour	¾-hour			
	¾-hour	¾-hour			

4.3.1 Fire Dampers and Smoke Dampers

In accordance with Article 3.1.8.7., a fire damper having a fire-protection rating conforming to Sentence 3.1.8.4.(2) is required to be installed in conformance with Article 3.1.8.9. in ducts or air-transfer openings that penetrate an assembly required to be a fire separation.

In accordance with Sentence 3.6.2.7.(6), ventilation ducts or openings that penetrate a fire separation to the outdoors, need not be protected by a closure at the penetration.

4.3.2 Self-Closing and Latching Devices

In accordance with Sentence 3.1.8.11.(1), doors in required fire separations will be provided with self-closing devices (closers) designed to return the door to the closed position after each use.

In accordance with Article 3.1.8.13., swing-type doors in fire separations will be equipped with a positive latching mechanism designed to hold the door in the closed position after each use.

4.3.3 Clearances at Door Sills

In accordance with NFPA 80-2013, doors required to provide a fire-protection rating of ¾ to 3-hours will have a maximum clearance below the bottom of the door of 9.5 mm where a noncombustible raised sill (threshold) is provided, and 19 mm where there is no sill (floor).

In accordance with Sentence 3.6.2.7.(17), where doors are provided between the vault and the rest of the building the doors are required to have suitable seals such as weatherstripping to minimize the entrance of dust into the vault.

5.0 FIRE PROTECTION AND LIFE SAFETY SYSTEMS

5.1 Sprinklers

In accordance with Article 3.2.2.18., it is anticipated an automatic sprinkler system will be required for the building.

5.1.1 Electrical Room

In accordance with Sentence 3.2.5.13.(1), the automatic sprinkler system will be required to be designed, constructed, installed and tested in conformance with NFPA 13-2013, “Installation of Sprinkler Systems.”.

In accordance with 8.15.10.3. of NFPA 13, sprinklers are not required in electrical equipment rooms where the following conditions are met:

a) the room is dedicated to electrical equipment only,
b) only dry-type electrical equipment is used,

c) equipment is installed in a 2-hour fire resistance enclosure (including protection for penetrations), and
d) no combustible storage is permitted to be stored in the room.

5.1.2 Electrical Equipment Vault

In accordance with Sentence 3.6.2.7.(1), an electrical equipment vault is not required to be provided with an automatic extinguishing system provided it is separated from the remainder of the building by 3-hour fire separations constructed of concrete or masonry.

5.2 Fire Alarm System

In accordance with Sentence 3.2.4.1.(2) and Clause 3.2.4.3.(1)(e), a single- or two-stage fire alarm system will be required for the building and is to be installed in accordance with CAN/ULC-S524 and verified in conformance with CAN/ULC-S537-13, "Verification of Fire Alarm Systems".

5.2.1 Smoke Detectors

In accordance with Articles 3.2.4.12. and Article 3.2.4.13. and Clause 3.6.2.7.(2)(b), and CAN/ULC-S524, smoke detectors will be installed:
a) at the top of each exit stair shaft, and
b) in ducts where recirculating air handling systems serve more than one storey, and
c) where a building is required to be sprinklered and the electrical equipment vault is not sprinklered, a smoke detector will be provided in the vault that will actuate the building fire alarm system in the event of a fire in the vault.

5.2.2 Manual Pull Stations

In accordance with Article 3.2.4.18., manual pull stations will be provided near every required exit from each storey and at the main entrance of the building, such that it will not be possible to leave the floor area without passing by a pull station.

5.2.3 Zone Configuration

In accordance with Sentence 3.2.4.9.(2), zones will be provided throughout the Project based on the following:
a) air handling systems required to be equipped with smoke detectors, and
b) fire compartments required to be separated by vertical fire separations having a fire-resistance rating not less than 2-hours.

5.2.4 Fire Alarm Signals

In accordance with Article 3.2.4.19., alarm and alert signal devices forming part of the fire alarm system will be installed in the building such that:

a) fire alarm signals are clearly audible throughout all floor areas (with signals being not less than 10 dBA above ambient or 65 dBA minimum), and

b) the alarm signal will follow the temporal pattern required per Sentence 3.2.4.19.(2).

In accordance with Sentence 3.2.4.20.(7), visual signal devices will be installed in floor areas where the ambient noise level is anticipated to be greater than 87 dBA.

5.3 Emergency Lighting & Power

In accordance with Article 3.2.7.3., emergency lighting is required to be provided at an average of 10 lx in the following areas:

a) exits, and
b) principal routes providing access to exit in open floor areas and service rooms,

5.4 Portable Fire Extinguishers

In accordance with Article 3.2.5.17., portable fire extinguishers will be required to be provided throughout the Project in accordance with the Ontario Fire Code.

6.0 SPATIAL SEPARATION AND EXPOSURE PROTECTION

6.1 Building Spatial Separation

In accordance with Sentence 3.6.2.7.(1), the exterior walls of the electrical vault are to be constructed as 3-hour fire separations and, except for ventilation ducts or openings to the outdoors, all openings are to be provided with rated closures. In accordance with Sentence 3.6.2.7.(4), vventilation ducts or openings that penetrate the fire separation to the outdoors are not required be protected by a closure at the penetration.

Unprotected openings (ventilation ducts or openings) within the exposing building face of the electrical vault fire compartment are to comply with Article 3.2.3.1. and Table 3.2.3.1.B. for a fire compartment that is not sprinklered.

7.0 EGRESS/EXITING REQUIREMENTS

Exit systems in this Project used singly or in combination will consist of exterior doors, exit stair enclosures and exit corridors which will discharge at locations having access to public thoroughfares. Exit systems will not re-enter floor areas.

7.1 Egress from Rooms

For rooms and in accordance with Sentence 3.3.1.5.(1) and Table 3.3.1.5.A, a minimum of two egress doorways will be provided from every room or suite intended for an occupant load exceeding 60 persons; or where the following area and/or egress distance limits are exceeded in a floor area that is fully sprinklered:

Occupancy Type	Area	Egress Distance
Group F, Division 3	200 m^2	25 m

In accordance with Sentence 3.3.1.5.(2), where two egress doorways are required the doorways are to be located a minimum distance from one another equal to one-third the maximum overall dimension of the room.

Egress distance is measured from the most remote location within the room or suite to a corridor or an exit, taking into account permanent fixtures which interfere with the most direct egress path.

7.2 Integrity of Exits

In accordance with Sentence 3.4.4.4.(1), exit stairways and exit corridors serving the floor areas for this Project will be separated from the adjoining floor areas by a smoke-tight fire separation having a 2-hour fire-resistance rating.

In accordance with Sentence 3.4.4.4.(1), fire separations that enclose exits will have no openings or penetrations except for:

a) standpipe and sprinkler piping,
b) electrical wires and cables, totally enclosed noncombustible raceways and noncombustible piping that serve only the exit,
c) openings required by the provisions of Subsection 3.2.6.,
d) exit doorways, and
e) wired glass and glass block permitted by Article 3.1.8.14.

7.3 Prohibited Rooms Opening into an Exit

In accordance with Sentences 3.4.4.4.(7), (8) and (9), service rooms, mechanical rooms, electrical rooms, and auxiliary rooms such as storage rooms, washrooms, and janitor's closets which are adjacent to exit shafts will not open directly into an exit.

Where necessary, vestibules will be placed between the prohibited rooms and the exit.

7.4 Location of Exits

In accordance with Clause 3.4.2.5.(1)(c), a 30 m maximum travel distance to an exit will be provided and will be measured from any point in a floor area of the electrical vault.

7.5 Occupant Loads and Exit Capacities

In accordance with Sentence 3.4.3.2.(1), the aggregate required width of exits serving the floor areas of the Project has been determined by multiplying the occupant load of the area served by:

a) 6.1 mm per person for ramps with a gradient of not more than 1 in 8, doorways,

corridors, and passageways,

b) 8.0 mm per person for a stair consisting of steps whose rise is not more than 180 mm and whose run is not less than 280 mm, or

c) 9.2 mm per person for a ramp with a slope less than 1 in 8 or stairs other than those described in sentence (b) above.

The required exit capacities and therefore the widths of the exit stairs for the Project will be based on the occupant loads as designed in accordance with Subclause 3.1.17.1.(1)(c)(i). Approximate exit widths required are indicated in the following tables:

Level	Occupant Load (persons)	Aggregate Width of Exits Required (mm)	Aggregate Width of Exits Provided (mm)
Lower Level	5	1,580 (at doors) 900 (at stairs)	1,820 (at doors) 1,100 (at stairs)
Ground Level	5	1,580 (at doors)	8,830 (at doors)

7.6 Exit and Corridor Widths

In accordance with Subsection 3.3.1. and Sentences 3.4.3.2.(7) and 3.8.3.3.(1), the minimum widths for egress/exit facilities will be as follows:

- Corridors/Passageways/Ramps: 1100 mm
- Exit Stairs not serving more than two storeys above the lowest exit level: 900 mm
- Exit Doors: 790 mm
- Room Entry/Egress Doors: (clear) 800 mm

7.7 Direction of Door Swing

In accordance with Sentence 3.3.1.10.(2), where a room or suite is intended for an occupant load of more than 60 persons, all egress doors from the room or suite will swing on a vertical axis in the direction of exit travel.

All exit doors will swing on a vertical axis in the direction of exit travel, as per Sentence 3.4.6.12.(1).

7.8 Clearance beyond Door Swings

In accordance with Sentence 3.4.3.4.(3), swinging doors in their swing will not reduce the effective width of exit stairs or landings to less than 750 mm. This effective width is measured from the arc of the door swing to the closest portion of the outer face of the dividing wall, or other obstruction. Furthermore, swinging doors in their swing will not reduce the effective width of an access to exit or an exit passageway to less than the minimum required width.

7.9 Door Hardware

Doors and door hardware are to be provided in accordance with Article 3.3.1.12. A door in an access to exit will be readily openable in travelling to an exit without requiring keys, special devices or specialized knowledge of the door opening mechanism.

Door release hardware will be operable by one hand and the door will be openable with not more than one releasing operation. Door release hardware will be installed not more than 1200 mm above the finished floor.

In accordance with Article 3.4.6.16., locking, latching and other fastening devices on every exit door will permit the door to be readily opened from the inside with not more than one releasing operation and without requiring keys, special devices or specialized knowledge of the door opening mechanism. Door hardware will be installed at a height not more than 1200 mm above the finished floor.

In accordance with Article 3.6.2.7., each door to an electrical equipment vault will be required to be provided with a substantial lock or padlock.

7.10 Exit Signs

In accordance with Sentence 3.4.5.1.(1), every exit door will have an illuminated exit sign placed over it. Where illuminated exit signs at exit doors are not visible from open floor areas or corridors used by the public, directional exit signs will be provided to indicate the direction of egress. Specifications for these exit signs will conform to the requirements of Subsection 3.4.5.

In accordance with Sentence 3.4.5.1.(2), exit signs will consist of a green pictogram and white graphic symbol meeting the visibility specifications referred to in ISO 3864-1, “Graphical Symbols- Safety Colours and Safety Signs- Safety Signs Used in Work places and Public Areas” for the following symbols:

a) E001 emergency exit left,
a) E002 emergency exit right,
b) E005 90-degree directional arrow, and
c) E006 45-degree directional arrow.

8.0 HEALTH REQUIREMENTS

8.1 Water Closet Requirements

In accordance with Sentence 3.7.4.9.(2), one water closet is permitted to serve both sexes in an industrial occupancy where the occupant load is not more than 10 persons.

9.0 REQUIREMENTS FOR BARRIER-FREE ACCESSIBILITY

9.1 Applicability

In accordance with Article 3.8.2.1. a barrier-free path of travel is not required to extend into service rooms.

12.0 CONCLUSION

The 2012 Ontario Building Code provides a minimum set of requirements which establishes an acceptable level of fire protection and life safety for buildings. This Building Code Outline Report outlines the various approaches to meet the intent of the applicable requirements with the 2012 Ontario Building Code.

In conclusion, the proposed fire protection and life safety features for the Project, as described in this report, will provide a level of fire protection and life safety which equals or exceeds the minimum acceptable levels established by the requirements of the 2012 Ontario Building Code.

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