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SCHEDULE 15-2
DESIGN AND CONSTRUCTION REQUIREMENTS

PART 2
DESIGN AND CONSTRUCTION REQUIREMENTS − GUIDEWAY

ARTICLE 1 INTRODUCTION

1.1 General Description of the Guideway and Guideway Requirements

(a) The Guideway shall:

(i) Provide for two Tracks for approximately 12.5km from Tunney's Pasture Station in the west to Blair Station in the east; between Train Station and St. Laurent Station provide two tracks that shall branch off the mainline for approximately 0.8km to provide connections to the proposed MSF;

(ii) Generally follow the existing BRT alignment between Tunney's Pasture Station and Blair Station, the exception being for approximately 2.7km through the Downtown Area between Lebreton Station and Campus Station where the Guideway will descend underground and be in a Tunnel below Queen Street, Rideau Street and Waller Street crossing under the Rideau Canal near the National Arts Centre and the Rideau Centre, the Alignment shall be within the right of way of Queen Street from Bronson Avenue to Metcalfe Street; and

(iii) Provide an MSF connection that shall branch off of the mainline west and east of Belfast Road crossing Tremblay Road at the intersection with Belfast Road. The two Tracks shall stay within the Lands of Belfast Road from Tremblay to the Bridge over the VIA railroad, then cross the VIA rail tracks adjacent to the Bridge Structure and connect to the yard Tracks in the MSF.

(b) The Guideway shall consist of:

(i) Track sections built on the existing BRT;

(ii) Track sections built off the existing BRT;

(iii) Track sections on Bridge Structures and Tunnel Structures; and

(iv) Track sections through Stations.

(c) The Guideway shall include components for:

(i) Traction Power;

(ii) OCS;

(iii) Communications ductbanks;

(iv) Signal and control Systems;

(v) Drainage systems and Stormwater Management; and

(vi) Other appurtenances as required by Project Co's design.

(d) The Guideway shall be fenced or otherwise enclosed for security.

(e) The Guideway shall not have continuous lighting. Lighting shall be limited to areas of Passenger interactions with buses and Stations and in other areas requiring lighting for Safety or operational needs.

(f) The property limits for the Guideway are defined as the Lands.

ARTICLE 2 ALIGNMENT AND GEOMETRIC DESIGN CRITERIA

2.1 Horizontal Alignment

(a) General

(i) The horizontal Track Alignment shall be designed in accordance with the requirements of Schedule 15 – Output Specifications, and shall be such that all of the Works is contained within the OLRT Lands.

(ii) The maximum Track design speed for the mainline and the MSF connection shall be 100km/h and 30km/h, respectively. Project Co shall Design the mainline Track so as to maximize the operating speed.

(iii) The horizontal alignment shall be tangent through station platform limits and for a minimum of 15m beyond the end of platforms. If site conditions do not provide sufficient length, then the spiral transition curve may begin closer to the platform provided sufficient running clearances between the selected LRV and Platform are achieved.

(iv) All non-track related construction details shall be related to or dimensioned from the centreline of the eastbound Track, unless otherwise noted.

(b) Track Centres

(i) The typical Track centre spacing is 4500mm. The mainline Track centre spacing may be reduced to an absolute minimum based on the selected LRV dynamic envelope and provided sufficient running clearances and tolerances under all operating conditions are maintained.

(c) Horizontal Curves

(i) Circular curves shall be defined by the arc definition of curvature and specified by their radius in metres to three decimal places.

(ii) For mainline Tracks, the curves shall be designed to maintain the maximum possible operating speed as dictated by existing topography, permanent physical features, property, and Alignment constraints. The absolute minimum radius used shall accommodate the turning capability of the selected LRV.

(d) Reverse Curves

(i) All locations that require a reversal in alignment shall be separated by a tangent.

(ii) The minimum tangent length between reversing curves shall be 25m.

(e) Compound Curves

(i) Compound curves may be used on the mainline Track Design.

(ii) Where two or more circular curves will be connected into a compound curve, the circular curves shall be joined by a spiral curve. The superelevation of each circular curve shall be adjusted to ensure that the maximum permissible speeds for all parts of the compound curve are identical.

(f) Spirals

(i) Spiral transition curves shall be used on all mainline and MSF connection Tracks to connect circular curves to tangents, with the exception that spirals are not required where both actual superelevation is zero and unbalanced superelevation is less than 50mm.

(ii) The minimum length of a spiral transition curve (L, m) shall be calculated using the actual superelevation (Ea, mm), unbalanced superelevation (Eu, mm), and design speed (V, km/h) and shall be determined by selecting the greater value of the following formulas:

A. $L = EaV/108$; and

B. $L = EuV/180$.

(iii) The absolute minimum length of spiral shall be 10m.

(g) Superelevation

(i) Superelevation shall be linearly attained throughout the full length of the spiral curve by raising the rail farthest from the curve centre, while maintaining the top of the inside rail at profile grade.

(ii) For mainline Tracks, the maximum actual superelevation shall be 150mm for ballasted Track and direct fixation or embedded Track. The maximum unbalanced superelevation shall be 115mm. These values may be modified for the selected LRV provided the 0.1g limit that passengers can tolerate comfortably is achieved. The total superelevation (E, mm) shall be based on the design speed (V, km/h) and equivalent radius (R, m), per the formula $E = 11.83V^2/R$.

2.2 Vertical Alignment

(a) General

(i) The vertical Track Alignment shall be set to respect constraints such as clearances over roads and fixed elevations such as at Station Platforms and other adjacent Infrastructure. The vertical Track Alignment shall be designed in accordance with the requirements of this Schedule 15 – Output Specifications. All references

to profile in the vertical Alignment shall represent the top of the low rail for a given Track.

(b) Grades

(i) The maximum allowable grade through Stations shall be 1.5%.

(ii) No changes in grade or vertical curves shall encroach within the limits of Station Platforms.

(iii) A minimum distance of 15m shall be maintained between Platform limits and any point of vertical curvature. If site conditions do not provide sufficient length, then the spiral transition curve may begin closer to the Platform provided sufficient running clearances between the selected LRV and Platform are achieved.

(iv) The maximum grade for mainline and MSF connection Tracks shall be 4.5%, where unachievable the absolute maximum grade for mainline and MSF connection Tracks shall be no greater than 6%.

(c) Vertical Curves

(i) Parabolic vertical curves shall be provided for all grade changes.

(ii) The length of a vertical curve shall be as long as practicable, but no less than shown below.

(iii) The minimum length of vertical curve (LVC, m) for mainline and connection Tracks shall be determined by the following equations:

A. $LVC = 0.005AV^2$, for crest curves; and

B. $LVC = 0.003AV^2$, for sag curves.

2.3 Special Trackwork

(a) Special trackwork shall conform to AREMA requirements.

(b) The horizontal Alignment shall be tangent through special trackwork and for a minimum of 5m ahead of the point of switch and beyond the last long ties. In constrained conditions, the tangent shall extend a minimum of 2m beyond the heel of frog.

(c) For profile Design, all turnouts shall be located on a constant grade that shall extend a minimum of 3m beyond the point of switch and beyond the last long ties.

(d) A minimum tangent length of 20m shall be inserted between the back to back switch points where the turnout arrangement may entail a reverse movement through turnouts.

(e) Special trackwork shall not be located within 15m from the end of the Station Platform and not within a Station Platform.

(f) Special trackwork shall not be located within 50m of the transition between ballasted and direct fixation Track as outlined in the TCRP Light Rail Handbook. Project Co shall provide for special accommodations to mitigate the effects of different Track modulus under various geometric conditions.

2.4 Other Alignment Requirements

(a) Combined horizontal and vertical curvature: Overlapping horizontal and vertical curvature shall be avoided where possible. Where this situation is unavoidable, Project Co shall include justification in its Trackwork Design Report with reference to alignment Safety at the design speed.

2.5 Clearances

(a) Vehicle Clearances

(i) Horizontal clearance dimensions shall always be measured perpendicular to the Track centreline accounting for any superelevation in the Track.

(ii) On tangent Track the typical side clearance shall be a minimum of 1690mm measured perpendicular from the Track centreline. The mainline Track side clearance me be reduced to an absolute minimum based on the selected LRV dynamic envelope and provided sufficient running clearances and tolerances under all operating conditions are maintained.

(iii) Where no walkway is present, a typical minimum side clearance of 1890mm from Track centreline to any physical feature shall be maintained on tangent at-grade and retained cut Track. The mainline Track side clearance may be reduced to an absolute minimum based on the selected LRV dynamic envelope and provided sufficient running clearances and tolerances under all operating conditions are maintained.

(iv) Under cut-and-cover conditions, a typical minimum side clearance of 2150mm shall be provided from Track centreline. The mainline Track side clearance may be reduced to an absolute minimum based on the selected LRV dynamic envelope and provided sufficient running clearances and tolerances under all operating conditions are maintained.

(v) Where emergency walkways are present, tangent Track shall maintain minimum typical side clearances of 2300mm from the Track centreline to an outbound curb, railing fence, or other physical feature. The mainline Track side clearance may be reduced to an absolute minimum based on the selected LRV dynamic envelope and provided sufficient running clearances and tolerances under all operating conditions are maintained.

(vi) Additional clearances shall be provided on the inside of curves due to superelevation effects at the rate of 18mm for every 10mm of superelevation, to provide clearance for tilt-in. On curved Track the Vehicle side clearance shall be

measured perpendicular to the superelevated Track centreline (axis of the Track measured perpendicular to the plan of the top of rails).

(vii) The typical horizontal clearance distance from the centreline of Track to the finished edge of Station Platform shall be 1405mm, or as otherwise required for the selected LRV such that a gap no greater than 75mm is maintained.

(viii) Vertical clearance dimensions shall always be measured in a vertical plane irrespective of any superelevation or profile grade. When superelevation is present, the top of low rail shall be used as the reference elevation when calculating vertical clearance.

(b) Other Clearance Requirements

(i) Signal and trackwork equipment mounted on Track slab along the Alignment shall be kept clear of the under car clearance envelope of the Vehicle.

(ii) Temporary clearance requirements for construction shall be assessed on an individual basis.

ARTICLE 3 TRACKWORK

3.1 Order of Precedence

(a) General

(i) The Design and Construction of trackwork shall be in accordance with the criteria contained in this Article, and all standards, regulations, policies, Applicable Law, guidelines or practices applicable to the Project, including but not limited to each of the following Reference Documents. If the event of a conflict between the criteria, commitments or requirements contained within one document when compared with another, the more stringent shall apply:

A. Requirements of this Article;

B. AREMA Track Standards, or equivalent; and

C. The criteria in TCRP Report 57.

3.2 General Requirements

(a) The scope of the trackwork includes all Works related to the Construction of a complete LRT System as specified herein.

(b) The scope of the special trackwork consists of all Works related to the complete Construction of special trackwork as described in this Schedule 15 – Output Specifications. This includes, but is not limited to, the Design, supply, installation, and testing of special trackwork, including all turnouts, crossover components, adjoining trackwork, fastening components, and all other Track materials.

(c) Project Co shall be responsible for control and any mitigation which may be a result of wheel-rail noise throughout the OLRT System in accordance with Schedule 17-Environmental Obligations.

3.3 Track Types

(a) General

(i) The Track structure shall be built to 1435mm Track gauge. Direct fixation Track shall be used in Tunnels, on aerial structures. Ballasted Track or direct fixation Track shall be permissible through Station Platforms and at all other locations on the Alignment where performance is not compromised and maintenance can be achieved.

(ii) The running rails of all mainline Track, including special trackwork, shall be electrically isolated from the ground.

(b) Ballasted Track

(i) Ballasted Track shall utilize timber or precast concrete crossties with a resilient rail fastening system.

(ii) Crushed stone or other material shall conform to AREMA ballast specifications.

(iii) The particle size requirements shall conform to AREMA requirements in relation to the crushed stone ballast, class number 4A.

(iv) Minimum depth of ballast below the bottom of ties under the running rail shall be 225mm. Shoulder ballast shall extend a minimum of 300mm beyond the ends of ties before sloping at 2:1 to the sub-ballast.

(v) Ballast shall be well drained and shall not contact the running rails for mitigation of stray current and loss of shunting or calibration with signal systems.

(vi) Track bed shall be of sufficient stability to permit operation of track circuits under all climatic conditions.

(c) Direct Fixation Track

(i) Direct Fixation Track

A. Direct fixation Track shall consist of a resilient direct fixation rail fastener system anchored or embedded into a concrete plinth or base slab.

B. The direct fixation Track fastening system shall be designed to support required loading and avoid accumulation of runoff in the rail support areas.

(ii) Track Transition Area

A. Transitions from ballasted Track sections to direct fixation Track shall use a 6m long variable-depth reinforced concrete approach slab to accommodate the change from the solid support of the Track slab to the semi-solid support of the change in Track modulus of the ballast.

3.4 Track Materials

(a) General

(i) Materials identified in the following sections shall be used for all Track Construction.

(b) Rail/115 lb RE

(i) Supply rail that meets:

A. AREMA Volume 1, Chapter 4, Part 2; and

B. ASTM A1.

(ii) Rail Lengths

A. Standard rail lengths shall be used wherever possible.

B. All rail shall be CWR.

(c) Restraining Rails

(i) Project Co shall install restraining rails along the gauge side of the low rail for all mainline horizontal curves with a radius of 145m or less.

(ii) Restraining rail shall be electrically isolated from running rail in order to maintain broken rail protection.

(d) Direct Fixation Fasteners

(i) Project Co shall provide DFF that shall meet the requirements of this Schedule 15 – Output Specification.

(ii) The DFF shall be part of an engineered direct fixation system and shall be designed to meet the required rail loading.

(iii) Project Co shall design the DFF system to resist all slip forces as determined by design.

(iv) The DFF shall:

A. Provide vertical and lateral stability to the rail;

B. Restrain the rail movement during rail break incidents limiting the rail break gap to 50mm;

C. Distribute rail loadings to the concrete support structures;

D. Electrically insulate the rail from the Guideway;

E. Accommodate CWR and structural interface forces;

F. Prevent rail buckling under high temperature conditions; and

G. Provide means for achieving a minimum of 12mm rail lateral adjustment in 3mm maximum increments.

(e) Rail Joints

(i) Project Co shall supply insulated glued joints for 115lb RE rail manufactured to AREMA standards.

(ii) Rail joints shall be electrically tested prior to and after placement in Track.

(f) Rail Bonding

(i) Project Co shall supply and install rail bonds that meet AREMA specifications in Volume 3, Chapter 33, Part 7 and 12.

(ii) Rails shall be welded in continuous lengths and bolted joints shall be electrically bonded.

(iii) At locations requiring insulated joints, the Traction Power direct current continuity of negative rails shall be maintained by use of impedance bonds.

(g) Switch Clearing Device

(i) Switch clearing devices shall be supplied and installed by Project Co at special trackwork locations. Project Co shall also provide conduits and junction boxes and other supporting Infrastructure for these devices.

(ii) Project Co shall provide switch clearing devices that are proven in similar climatic conditions and meet accepted industry standards and do not compromise safety.

(iii) No gas powered switch heaters shall be permitted in tunnels or enclosed areas.

(h) Switch Machines and other Turnout Appliances

(i) Switch machines and other associated equipment shall be provided and installed by Project Co.

(ii) Project Co shall provide for the location of trackside terminal boxes, which shall be located near the switch machine. Terminal boxes shall not be located within a position that would constrict the ability of Maintenance personnel to maintain or manually throw the switch.

(iii) Switch machines shall be able to be manually operated with minimal physical effort, as a backup to powered operation.

(i) End-of-Track Devices (Buffer Stops)

(i) End-of-Track shock-absorbing devices for use at terminal station Tracks shall be included in the Trackwork Design Report and be which shall be submitted as part of the Works Submittals according to Schedule 10 – Review Procedure. These devices shall be mounted near the end of Track on both Station Platform Tracks. Project Co shall procure and install the approved end-of-Track devices as part of the Works.

(j) Rail Expansion Joints

(i) The anticipated rail movement within the full range of rail temperatures shall be handled by the direct fixation assembly.

(k) Noise and Vibration Mitigation

(i) Project Co shall install a site-specific Track structure where it is required to control levels of noise and vibration, as described in Schedule 17 – Environmental Obligations.

3.5 Special Trackwork

(a) General

(i) All special trackwork shall be supplied and installed by Project Co. Special trackwork assemblages include all materials necessary for Construction.

(ii) All special trackwork joints shall be butt welded in-field except where Project Co can demonstrate that space does not permit. At these locations thermite welds performed in accordance with manufacturer's weld procedures are acceptable. Compromise welds shall be considered part of the mainline Track conditions and installation. No holes, for temporary joint installation, or otherwise, shall be permitted within 150mm of the weld location. All thermite welds shall be tested ultrasonically.

(iii) All turnouts shall utilize tangential geometry with curved switch points. All mainline special trackwork shall be configured with 115lb RE rail.

(iv) Special trackwork components shall be based on AREMA specifications for turnout.

(v) All components shall be designed so that the specified tolerances can be maintained throughout the operating life of the special trackwork with minimal Maintenance.

(vi) Crossover locations shall be integrated with signaling and OCS system designs.

(vii) All mainline turnouts and crossovers shall be optimized to meet or exceed the Operations Performance Requirements outlined in Schedule 15-2 Part 1 Article 2.

(viii) Locations for OCS poles shall be provided at all crossover locations.

(ix) Tail Tracks and pocket Tracks shall be maximized to accommodate at least a minimum length consistent with additional length to improve approach speeds where feasible.

(b) Project Co shall undertake the Design of the OLRT Project and systems and shall provide the following minimum required operational Track facilities:

(i) Tail Tracks west of Tunney's Pasture Station sufficient to facilitate the reversing of trains and to maximize approach speeds into the Terminal Station;

(ii) Optimized crossovers adjacent to the MSF west and MSF east connecting tracks that maximize operational flexibility into and out of the yard and minimize operational impacts to mainline revenue operations during loading and unloading of the line;

(iii) Tail Tracks east of Blair Station sufficient to facilitate the reversing of trains and to maximize approach speeds into the Terminal Station; and

(iv) Interlockings and special trackwork at locations necessary to meet or exceed the requirements of the Operations Performance Requirements (Schedule 15-2 Part 1, Article 2).

3.6 Track Construction Tolerances

(a) Verification of the Track installation shall include a Trackstar Geometry Test (or equivalent).

(b) Clearances shall be verified by laser measurement using an L-Kopia vehicle (or equivalent).