WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

WMATA MANUAL OF DESIGN CRITERIA

FOR MAINTAINING AND CONTINUED OPERATION OF

FACILITIES and SYSTEMS

August 2014

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
Department of Transit Infrastructure and Engineering Services
Chief Engineer Infrastructure Services

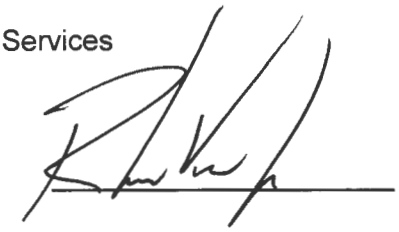
Release 9, revision 2

The Chief Engineer is pleased to endorse this updated version of the WMATA Manual of Design Criteria. This manual establishes the Facilities and Systems engineering design criteria for use to maintain and for safe operation of the Washington Metropolitan Area Transit Authority (WMATA).

Authorized:

Chief Engineer Infrastructure Services

R. Louis Viner, Jr.



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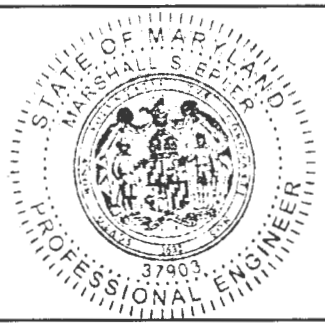
SUMMARY OF CHANGES FOR RELEASE 9, revision 2

RECOMMENDED FOR DEPUTY CHIEF ENGINEER APPROVAL			
Position	Name	Seal / Signature	Date
Deputy Chief Communication & Network Systems	Marshall S. Epler		8/22/2014
Deputy Chief Power Systems Engineering	Ashton W. Robinson		8/22/2014
Deputy Chief Track, Structures and Facilities	Thomas R. Robinson		

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Section	Description	Summary of Changes
6 Bus Facilities	Update based on changes to Sections 14.19, 18, 19 and 21	Section 6 of the Design Criteria Bus Facilities was updated by combining the updated information found in Section 14.19 Mechanical Requirements for Bus Facilities, Section 18 Bus Service Area, Section 19 Bus Maintenance, Bus Storage & Administrative Requirements, and Section 21 Compressed Natural Gas Bus Facility Requirements. These various sections were update with mechanical changes based on the design work of two new WMATA Bus Facilities Shepherd Pkwy and Cinder Bed Road. The design criteria was modified with changes by using the Program Criteria for Shepherd Pkwy and Cinder Bed Rd which was developed for the new bus facilities based on input from Bus Personnel and Engineering. In addition, the criterion was also updated or modified based on the lessons learned during the construction of the Shepherd Pkwy facility. Manufacturer and model numbers were removed from the criteria in order to prevent sole sourcing issues; in addition most of this data was out of date i.e. part numbers no longer valid.

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Section	Description	Summary of Changes
14.3.12 Mechanical	Tunnel Fans	The tunnel ventilation requirements are updated to include a validated computational fluid dynamics quantitative analysis as outlined in NFPA 130. The WMATA predefined fire magnitude remains but is a historical value. Consultation with WMATA for current modeling standards is required. The tunnel fan predefined value of 50,000 CFM is retained for legacy purposes but compliance with NFPA 130 conformance is required for new designs. The requirement for tunnel fans to run to failure in an emergency is now stated. It was previously inferred. Electronically controlled dampers (the preferred method moving forward) are added to the pneumatic control sections (or legacy systems) and the need for desiccant type dryers is explained. Tunnel fan characteristics are updated to reflect compliance with and identify NFPA 130 as the source of these requirements.
14.4.2.3 Mechanical	Battery Rooms	The pre-defined, air changes per hour, has been replaced by the requirement to maintain the hydrogen concentration below 1% (the lower explosive limit is 4%). WMATA stores batteries in the open TPSS rooms. The large volume of the room decreases the chance of concentrating hydrogen. To the extent possible, passive ventilation is recommended. This eliminates maintenance of mechanical systems while insuring safety. Where mechanical ventilation is required, redundant systems are required. This eliminates the need to shut down the battery charger. Concurrence with FM Global, our co-insurer, was obtained. The temperature to start forced ventilation has been lowered to the point where battery performance starts to be de-rated (77F).
14.4.2.4 Mechanical	Train Control, Communications, Dispatch and Trainmen's Rooms	The predefined heat loads for these rooms have been removed and replaced by the requirement to calculate the loads. This is based on the improved efficiency of modern equipment and the increase in the amount of electrically based equipment now used.

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Section	Description	Summary of Changes
14.4.8 Mechanical	Underground Traction Power Substations	Thermostatically controlled heating and ventilation has been replaced with automated controls with remote monitoring. Bag filters have been replaced with pleated type filters. This is the preferred method by PLNT. Change out of pleated filter is cleaner and more efficient. Filter efficiency is equal or better.
14.4.2.9 Mechanical	Aboveground Traction Power Substations	Thermostatically controlled heating and ventilation has been replaced with automated controls with remote monitoring. Fixed ladders have replaced portable ladders for platforms 10 feet and higher.
14.5 Mechanical	Heating	The requirement for resistance type electrical heaters has been removed and replaced with the option for heat pumps where practical. These are available in smaller sizes now and are significantly more efficient.

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Section	Description	Summary of Changes
14.5.2 Mechanical	Design Temperatures	Room temperatures have been standardized for a range of 68F to 72F. Unoccupied rooms maintained at 50F with the ability to raise to 68F with automatic setback to 50. This allows the designers more flexibility to install fewer and more efficient heating and cooling systems. The requirement to heat battery rooms to 77F has been replaced with the criteria above. The de-rating of batteries when they are stored at 50F is minimal and batteries stored above 77F also de-rate minimally as the temperature rises. This decreases the need for additional heaters in battery locations and allows flexibility in heating battery areas with equipment consistent with the rest of the facility. Chilled water plants are now required to be air conditioned to 76F and heated as an un-occupied space. Air conditioning is easily acquired from the chilled water system and is needed due to the electronic controls and heat generating VFDs now used in all chiller plant compressors and pumps. Water chillers are now required to be oil free. This type of compressor is now common in the market place and is characteristic of high efficiency models. It eliminates sump oil heaters and eliminates oil migration into the refrigerant system. Oil migration accounts for a significant loss of efficiency as oil coats the heat transfer surfaces decreasing the ability to transfer heat. Minimum chiller efficiency has been lowered to a level consistent with the high efficiency units on the market today and consistent with oil free compressors. This should also represent an overall savings in maintenance and operating costs to the authority. Water meters have been added to the chiller plant to quantify evaporation. It is anticipated we will use this to deduct our sewage fees for this water that is not being discharged.
14.6 Mechanical	Air Conditioning and Ventilation	Damper controls were identified to reflect the use of electronic actuated dampers (new), pneumatic was identified for legacy (existing). The use of bag filters was changed to pleated filters; pleated filters are less messy and easier to change for maintenance personnel.

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Section	Description	Summary of Changes
14.8.9 Mechanical	Pumping Stations	The criteria have been changed from a submersible station to a wet well and dry well design with submersible pumps. The existing pumping station submarine type designs have flooded resulting in the submarine floating and destroying the pumping station. The wet well and drywell piping, platform grating, equipment mounting, etcetera, have been updated to provide better access to the pits and service of the equipment. The majority of pumps are sized for 500 gallons per minute minimum which is for catastrophic rain/flooding events. However, a majority of the pumping locations only see a constant flow much less than what the pumps are rated for. Therefore, pump motors are to be controlled with Variable Frequency Drives (VFDs) which allow the motors to run at lower more economical speeds and ramp up to higher speeds when the demand arises. Non-slamming check valves have been identified along with the VFDs to help to reduce water hammer or shock in the piping system. Pump controllers are now required to have Human Machine Interface (HMI) with Ethernet communication for remote monitoring.
14.13.3 Mechanical	Fire Protection	The criteria for standpipe design have been updated identifying the latest release of NFPA 14 "Installation of Standpipe and Hose Systems" as the basis of design. The criteria was updated to identify piping as galvanized steel sch. 40, black steel will no longer be used due to corrosion of pipes. The C factor (friction) used in the Hazen Williams formula for calculating pressure loss in standpipes was changed from 100 (black steel) to 120 (galvanized) to reflect the use of galvanized pipes. Fire extinguisher criteria were updated to the latest criteria per the International Fire Code (IFC) and Fire Suppression for the escalators were updated per NFPA 130. Clean Agent Suppression Systems (FM-200) were identified to be used in mission critical electric rooms or rooms where the value of the asset warrants it. In rooms where equipment does not warrant clean agent and no sprinkler is used then a fire detection system shall be used and connected to a centrally monitored fire alarm control panel.

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Section	Description	Summary of Changes
14.14.7 Mechanical	Plumbing	Gallons per minute (GPM) requirements for various identified fixtures were removed and the International Plumbing Code or local code was identified as the source for this data. The Sewage Ejectors section was modified to reflect the two different types of systems in use now; pumps and pneumatics. The pump section was changed from a triplex design to a duplex design. Triplex is used in drainage pumping stations due to their remote location and difficulty of replacing pumps along the roadway. Sewage ejectors are in the stations and easily accessible therefore duplex is adequate. The pneumatic section was updated to require a minimum 50 gallon capacity pot in a dry pit which is served by two air compressors and an air receiver. The minimum discharge rate has been set at 50 gallons per minute. These minimums have been set based on experience with the existing stations. Controls were added for both systems to be a PLC with a HMI interface and capable of remote monitoring.
14.19 Mechanical	Bus Facilities General	The Mechanical Requirements for Bus Facilities were updated based on the design work of two new WMATA Bus Facilities, Shepherd Pkwy, and Cinder Bed Road. Input from Bus Personnel, Engineering, and lessons learned during the construction of the Shepherd facility were incorporated.
14.19.2 Mechanical	Plumbing	The Cold and Hot Water Distribution was updated to reflect the proper, code compliant pipe used in the water distribution system based on material, type, and size. Gas or electric hot water heaters were identified for use in bus facilities, with gas being the most economical identified as the preference. Roof drains were identified to be directed underground to prevent ice and standing water. Floor drains in area where there is vehicular traffic were identified to be H-20 rated and need to be piped to the oil/water separation system. Battery rooms to have no drains (dry sump instead) due to acid. The Mechanical, Electrical, and Compressor Rooms are now required to have at least one drain.

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Section	Description	Summary of Changes
14.19.2.9.4.11 Mechanical	Compressed Air	The Compressed Air System shall consist of a single plant comprised of 2 air compressors based on 100% capacity, which provides redundancy allowing air to be provided to the facility even if one compressor breaks down or needs repair/maintenance. Prior practice was point of use compressors. Regenerative desiccant type dryers will be utilized for drying of the compressed air, helping to eliminate moisture in the pipes and allowing compressed air pipes to be routed underground where required.
14.19.3 Mechanical	HVAC	A number of the areas/rooms were updated with temperature requirements in general 65F or 68F for heating and 75F for Air Conditioning. The Ventilation section requirement for Paint Booths was updated to reflect cross draft style booths with makeup unit mounted on roof for supply air. Filtered intake and exhaust air systems shall be provided with the exhaust being ducted out of facility. Tail pipe exhaust hoses were updated to a 1500F temp requirement to reflect the higher temperature of the new bus exhaust systems. In Battery Rooms, the pre-defined air changes per hour have been replaced by the requirement to maintain the hydrogen concentration below 1% (the lower explosive limit is 4%, see earlier comment concerning battery rooms). Locker Rooms, Restrooms, Office Areas, etcetera, were identified to follow either the guideline identified or Code whichever was more stringent in regards to ventilation. The HVAC Design Guideline Matrix for various rooms and areas was updated to reflect the required Heating (68F) and Cooling (75F).

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18.1 Mechanical	General Design Considerations Design Criteria Section 18 Bus Service Area Change Summary	The Section 18 of the Design Criteria Bus Service Area was update with mechanical changes based on the design work of two new WMATA Bus Facilities Shepherd Pkwy and Cinder Bed Road. The design criteria was modified with changes by using the Program Criteria for Shepherd Pkwy and Cinder Bed Rd which was developed for the new bus facilities based on input from Bus Personnel and Engineering. In addition, the criterion was also updated or modified based on the lessons learned during the construction of the Shepherd Pkwy facility. Manufacturer and model numbers were removed from the criteria in order to prevent sole sourcing issues, in addition most of this data was out of date part numbers no longer valid.
18.1.8 Mechanical	Service Lane Doors	Service lane doors were updated from hydraulic four fold doors to fast actuating rollup doors for service lane entrances and exits. Roll up doors are industry standard and provide both a cost and space savings.
18.4 and 18.4.2.2 Mechanical	Fueling and Maintenance Fluids and Above Ground Storage Tanks	Acceptable manufacturers and part numbers were removed from these sections; callouts for various fluids were standardized.
18.5 Mechanical	Overhead Service Reels	Callouts for fluids were standardized. Overhead service reels was updated with construction of spark resistant alloy, manufacturer and part numbers were removed. Hose requirements with size, length, and pressure rating were added for the various fluids. Pumps for these fluids were identified to be operated below OSHA noise standards.

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18.6 Mechanical	Cleaning	This section was updated to reflect the design criteria for the drive through bus washing system, the original criteria was sufficiently clear and relied on the preferred manufacturer for most info. The manufacturer for the Bus wash system was removed. All equipment located in the wash area to be of corrosion resistant material was added. The automatic controls for the bus wash were updated as none had existed. Controls are to be through an operator HMI panel with screens for diagnostic and analytical purposes and be capable of remote monitoring. Tire guides and skid plates were updated with required sizes and materials along with design requirements. Spray Arch Assembly was modified to include flow and pressure along with various design requirements. The liquid detergent tank was identified to be a 500 gallon poly tank. Oscillating Mop and Vertical Brushes were updated with material requirements along with operating requirements for properly washing all areas of the bus. Bus Wash exit was identified to be designed to reduce or eliminate ice buildup during winter operation. Control for the water reclamation system was identified to be controlled through a HMI panel located in the Water Reclamation Area.
19 Mechanical	General	The Section 19 of the Design Criteria Bus Maintenance, Bus Storage & Administration Requirements was update with mechanical changes based on the design work of two new WMATA Bus Facilities Shepherd Pkwy and Cinder Bed Road. The design criteria was modified with changes by using the Program Criteria for Shepherd Pkwy and Cinder Bed Rd which was developed for the new bus facilities based on input from Bus Personnel and Engineering. In addition, the criteria were also updated or modified based on the lessons learned during the construction of the Shepherd Pkwy facility. Manufacturer and model numbers were removed from the criteria in order to prevent sole sourcing issues.
19..1.3.5 Mechanical	Maintenance Areas	Fall protection was updated to be provided in every maintenance bay, this allows all bays to be used in the same manner.

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19.1.4 Mechanical	Vehicle Lifts	The lift section was updated identifying the three types of lifts used at Bus facilities: portable, drive on parallelogram, and in-ground. Each type of lift criteria section was updated by removing the manufacturer and part number for the specific lift and adding design specific information such as capacity, height to raise the bus, safety features, etc. The changes are extensive and therefore the redline section should be read if more information is required. The overhead service reel section was updated with all of the service fluids required, the nomenclature used to identify various fluids was standardized i.e. anti-freeze fluid was changed to engine coolant. Manufactures names were removed from the criteria section.
19.1.6 Mechanical	Hoist/Cranes	The section was expanded into two sections, Jib Crane and Bridge Crane. Each identifies where in the bus garage these are to be located along with their performance criteria, manufacturer and model numbers were removed.
19.1.7.12 Mechanical	Moveable/Mobile Equipment	High Pressure Hot Water Cleaner and Parts Washers sections were updated with where this equipment is to be located in the Bus Facility and equipment criteria. This equipment along with other miscellaneous equipment all had specific manufacturer and model numbers removed from the criteria.
19.1.9 Mechanical	Paint Preparation Area, Paint Booth and Paint Shop	The paint booth was modified to identify a cross-draft type booth preferred by BUS personnel; no type had been previously identified. Paint shop room location was identified along with heating and ventilation requirements.

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19.1.10 Mechanical	Steam Clean / Chassis Wash Bay	Stainless steel parallelogram lift was identified for use in this bay due to the corrosive environment. Equipment placed in this room was identified to be rated for water and corrosion resistants. Forklift access was identified for the room which impacts drain covers and grating loads.
19.1.11 Mechanical	Parts Storage	Part storage was identified to be in a vertical storage system and the large floor load of this type of system was identified. WMATA Bus facilities have had these storage systems installed and this is the preferred method for storing parts due to the space savings and improved organization.
19.1.12 Mechanical	Tire Storage	Tire storage was updated with Jib crane requirements, this is the crane used to move and install tires. Tire storage was identified to be placed adjacent to the Tire Bay.
21 Mechanical	Compressed Natural Gas Bus Facility Requirements	In section 21 Compressed Natural Gas Bus Facility Requirements the only change was to identify that all electrical components (motors, light fixtures, etc.) located within 18" of the ceiling are to be Class 1, Division 2 rated. The document had originally stated that the ceiling to the top of the lowest Natural Gas Vehicle was to be classified as such.
23 Power	General	Added negative rail potential limits
23 Power	General	Defined voltage drops for normal, abnormal, and emergency outage conditions
23 Power	General	Rail car data revised with addition of new rail car performance curve for simulation
23 Power	General	Clarified DC Switchgear insulation pad coverage
23 Power	General	Removed cross-bonding at TBS
23 Power	General	Removed 40w/lf rating of heat tape
27 Communications	General	Reformat entire section to be consistent with other sections in the manual

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SECTION 1 - GENERAL

1.1 PURPOSE

The primary function of this Manual is to establish criteria to be used in the design of the Washington Metropolitan Area Transit Authority's Facilities. In all cases, the design(s) shall comply with local, state and federal law.

Architectural Design:

- Harry Weese's original architecture with its distinctive, elegant, spacious, underground stations has established a standard for architectural design excellence. Above ground stations, while not as dramatic, are designed with just as much attention given to aesthetics, durability, functionality, and quality. This tradition of architectural design has made the system one of the most beautiful and its stations considered by many to be "exemplary works of Modern Design".

- All new station designs shall follow and build upon this standard for design excellence. All new station designs, whether underground or above ground, shall follow and reinforce this design vision and live up to the view that public architecture in the Nation's Capital shall be dignified and grand.

- While not necessarily duplicating past designs, new station designs shall build upon the tradition of superior architectural design and continue to reinforce a unique Metro image that unifies the system as a whole. New station designs shall have the common range of materials and follow the design principles established by Harry Weese and as outlined in the following criteria.

- In addition to station design, WMATA has a history of and an expectation for architectural design excellence for all its facilities both public and non-public. Other public WMATA structures can include parking structures, pedestrian bridges, customer service facilities, etc. Non-public facilities can include but are not limited to industrial facilities such as rail yard and bus maintenance shop buildings, administrative yard buildings, ancillary rail building, traction power substations, office buildings, etc.

- Architectural consultants providing architectural design services for WMATA facilities shall provide an experienced architectural design staff with proven aesthetic design experience and talent to develop functionally economical as well as aesthetically attractive buildings. Consideration shall be given to creative uses of materials, massing, scale, form, texture, and detailing. Buildings shall be visually attractive, innovative, as well as functional and durable. The overall architecture should impart a sense of pride within the local community, and provide a stimulating and attractive environment for the people who will see, work in, and use the buildings on a daily basis.

1.2 SCOPE

This version of the Design Criteria supersedes all the previously issued Design Criteria and all other standards, and relate to the following elements of design:

1. Architectural
2. Civil
3. Utilities
4. Structural
5. Mechanical
6. Electrical
7. Train Control and Communications Systems including, but not limited to, Train Control, Communications, Trackwork, and Traction Power
8. Automatic Fair Collection

1.3 PROCEDURES

The Designer shall prepare Contract Drawings and Specifications for each project in accordance with the Design Criteria and procedures established in this Manual. WMATA's Safety and Security Certification Program Plan (SSCPP) will be followed when new Metrorail extensions are added, and/or new Metrorail and bus facilities are incorporated into the inventory The Designer shall meet or exceed the Authority's Design Criteria relevant for each element of the work as these represent the minimum standards to be used for design and construction. In addition, WMATA facility designs shall comply with National Highway Standards, Manual of Uniform Traffic Control Devices and other applicable traffic regulatory agencies' standards; private and public utility companies and agencies' published standards; organizational reference standards and specifications including, but not limited to, the National Fire Protection Association (NFPA) Requirements; and current jurisdictional authorities' regulations including, but not limited to, Americans with Disabilities Act Accessibility Guidelines (ADAAG) and international, federal, state and local building, mechanical and electrical codes. The Designer shall note that all WMATA facilities must meet Federal Transit Administration (FTA) ADA requirements, and the Designer's attention is directed to the fact that without exception all WMATA projects are subject to FTA assessment of the facilities as actually built with regard to ADAAG regulations. The Designer shall secure the latest version of these regulations from the FTA. Also, the Designer is urged to acquire the FTA's Accessibility Handbook for Transit Facilities publication for the Designer's use as an information guide. The ADAAG Design Compliance Certification Form attached at the end of Section 01112, DESIGN REQUIREMENTS AND PROGRAM CRITERIA, of the WMATA Standard Specifications addresses design conformance with ADAAG regulations for relevant items reflected in each required level of design completion, and shall be certified by the Designer and accompany each design review submittal as specified in Section 01330, DESIGN AND CONSTRUCTION SUBMITTAL PROCEDURES, of the WMATA Standard Specifications The ADA Facilities Accessibility Checklist Form also attached at the end of Section 01112 shall be completed concurrent with the design of relevant items and shall be submitted along with each required level of design completion review submittal as specified in Section 01330. If any of these laws,

codes, regulations and standards that also control the design and construction of the Project exceed the Authority requirements, then the more stringent shall govern. Deviations may be made to meet the requirements of a particular design problem; however, all deviations shall be referred to WMATA for consideration and approval. It must be emphasized that it is the responsibility of the Designer to justify any deviation from the Design Criteria established and to secure the necessary approvals as the work progresses.

1.4 CHANGES

Changes to the Design Criteria will be authorized as directed by WMATA in accordance with internally established procedures.

1.5 GLOSSARY

Washington Metropolitan Area Transit Authority:

An interstate compact created by Public Law 89-774, 80 Stat. 1324, Nov. 6, 1966, having the responsibility for constructing a rapid rail transit system to serve the National Capital Region. Hereinafter, the Washington Metropolitan Area Transit Authority is referred to as WMATA, or the Authority.

SECTION 2 SITE FACILITIES DESIGN

Prior to Release 8, the design criteria features that were presented in Sections 2.1 through 2.7 and Section 2.9 are now covered in chapter 2 of the 'Station Site and Access Planning Manual' which was developed as an external part of the design criteria. The purpose for having a separate Station Site and Access Planning Manual is to simplify the volume of data an outside party would have to study and absorb when considering a joint development or adjacent construction project that would involve WMATA interests. Architectural, geometric, functional and operational topics are addressed in the Station Site and Access Planning Manual which can be accessed using the following link: http://tsdv/ENGA/2005/PDF/SSAPMMay08.pdf. The information presented below is not covered in the 'Station Site and Access Planning Manual'

2.1 SITE HIGH OCCUPANCY VEHICLES (HOV) FACILITIES

The High Occupancy Vehicle function is designated at specific stations with access to major traffic arteries or limited access highways. It consists of commuter bus/van pool spaces, and may be used to accommodate oversized vehicles such as RV.s. and campers.

- Drop-off lane (10' wide) for A.M. curbside drop-off.
- Storage bays: 12' x 40' for all day bus parking.
- Provide re-circulation path from storage bays to drop-off areas for P.M. curb side pickups.

2.2 SITE PARK & RIDE SURFACE LOTS

2.2.1 Site Park & Ride Surface Lot Vehicular Circulation:

Provide an efficient, clearly defined and safe circulation system, with an emphasis on minimizing pedestrian/vehicular conflicts. Internal parking lot circulation shall encourage use of the entire lot, with a minimum of dead end parking areas. Park & Ride facilities shall be designed with 90° angle parking with two-way circulation. Parking may be designated adjacent to the cross aisles, except where provision of parking will interfere with pedestrian flow between the station entrance and the Park & Ride facility.

Limit the parking lots to areas no larger than 500 cars and orient driving aisles toward the station entrance.

2.2.2 Site Park & Ride Surface Lot Payment System:

The preferred payment system is a pay-on-exit system employing entrance and exit gates at each point of entry and exit. Gates may allow entry only, entry and exit, or exit only, depending on the parking structure design. The number of gates required is calculated as follows:

Minimum gate array for 2-way flow through a single access point is a 2-gate aisle for up to 400 parking stalls (entry and exit with middle gate reversible).

For facilities with more than 400 stalls, provide a minimum of 3-gate aisles, 1-gate aisle for each 250 vehicles projected to peak one-hour period (assuming pay-on-exit). If the garage is designed to be a pay-on-entry facility, provide a 2-gate aisle plus 1-gate aisle for each 250 vehicles projected to enter the facility during the AM peak hour. Where more than a 2-gate array is required, sufficient lane distance on either side of the gates shall be provided for traffic to merge and change lanes safely.

2.2.3 Site Park & Ride Surface Lot Landscaping:

Design landscaping of parking facilities to conform to local jurisdictional requirements and coordinated with WMATA design criteria.

In accordance with WMATA Board of Directors Resolution 1972-27 adopted November 16, 1972, Metro parking areas (for more than five vehicles) shall be effectively screened from surrounding development (on each side which adjoins or faces a residential zone or institutional premises) unless already effectively screened by a natural terrain feature, a railroad track on elevated ground, change in grade or other permanent natural or artificial screen, or (is separated therefrom by) a road whose width of right-of-way is 120 feet or more. Parking lots (containing 500 or more parking spaces) shall be divided into parking areas of not more than 500 cars each and shall be separated by landscaping, changes of grades, buildings or other natural or artificial means. Not less than five percent of the total parking areas of any lot shall be devoted to (such) internal landscaping and interior parking separation areas.

Therefore, provide major landscape buffers of 50 feet minimum width between separate parking areas (with allowance for circulation between areas). See Resolution of the

WMATA Board of Directors, November 16, 1972.

Therefore, provide landscaping equal to 5% of the parking lot. 10-ft. wide landscape areas, located every second parking bay and bordered each side by concrete mowing strips, will satisfy this requirement. Use landscape strips to make grade adjustments in the site.

2.2.4 Site Park & Ride Surface Lot Pedestrian Circulation:

Accommodation of pedestrian movement within and adjacent to the parking lot shall be considered an essential part of the facility's design. Pedestrian route of travel shall be direct, well lit and clearly defined. Pedestrian safety and security shall be given highest priority. The Park & Ride lot shall be laid out according to pedestrian direction of travel, which is assumed to be parallel to car traffic in the driving aisles. In the absence of sidewalks, pedestrians shall be required to walk in the driving aisles.

Collector sidewalks leading to the station shall be located perpendicular to the driving aisles and sized to accommodate the areas they serve.

Landscaped areas shall not be used by pedestrians as part of their travel path. Landscaped areas adjacent to above ground stations shall not have gravel as a surface material.

Accessible spaces required by ADA shall be located in the parking lot as near the station entrance as possible and adjacent to a sidewalk. Where site stairs are required, they shall be located outside the accessible route. Stairs shall be the same width as the walkway, with 12" treads, 6" closed risers, a rounded tread nosing, and continuous handrails on both sides.

2.3 SITE PARKING STRUCTURES

2.3.1 Site Parking Structure Design:

Parking structure design shall be user-friendly, secure, efficient, convenient to use, and designed for minimum maintenance. Interior parking circulation shall be clearly defined with minimum visual obstructions and without dead-end parking areas.

Design facility for self-park operation with pay-on-exit revenue control system.

2.3.2 Site Parking Structure Access Roads and Entrance:

Coordinate with State and local authorities in providing dedicated routes from adjacent municipal roads.

Access drives and revenue access lanes shall be striped with painted lane lines and marked with traffic control signs, signal and control devices as necessary for MUTCD compliance. Provide access and revenue controls as indicated for Park & Ride surface lots.

Where the site allows, utilize the topography to provide multiple level access into the parking structure.

2.3.3 Site Parking Structure Circulation:

Unless constrained by site or access limitations, provide double-threaded helix ramp system if the structure has more than three levels. Provide one set of double-helix ramps for every six bays of structure. Design facility for two-way traffic, with double-loaded aisles and ramps with 90° parking for maximum efficiency. Lay out parking aisles aligned in the same direction as the path to the station.

Parking ramps may not exceed 5% slope. Where parking ramps are not feasible due to the site or other constraints, speed ramps may be provided with 10%-maximum slope if weather protected or 8%-maximum slope if exposed to weather. Provide skid-resistant molded driving surface at all ramps with slopes greater than 5% and restrict from pedestrian traffic.

2.3.4 Site Parking Structure Spaces:

The Authority will provide the Parking Structure Program indicating the minimum number of parking spaces, cashier's booths and access lanes required. Provide minimum 8'-6" wide x 18'-0" long standard parking spaces with a 24-ft. minimum clear drive aisle between rows. Calculate accessible space count and van accessible space count requirements for the disabled in accordance with ADAAG and the governing building codes.

2.3.5 Site Parking Structure Pedestrian Circulation:

Within the structure, pedestrian movement shall be directed along the driving aisles to the primary vertical circulation element(s). Their route of travel shall be direct, clearly defined, and well lit. Where pedestrians must cross vehicular traffic (inside the structure or beyond), clearly defined crosswalks shall be provided, giving right of way to the pedestrians.

Provide an ADA-compliant accessible route from the accessible parking spaces to the elevator lobby. Assure direct access path via sidewalk network, with minimal travel distance across roadways for handicap accessible spaces. Provide a continuous covered walkway or covered pedestrian bridge from the parking structure to the station entrance.

2.3.6 Site Parking Structure Vertical Circulation:

Locate lobby for the elevators and the primary stairs at the nearest point from the parking structure to the station entrance. To facilitate patron use, design primary stair with the maximum width allowed without center rail. Provide minimum 18-foot separation in lobby from the primary stairs to the elevator entrances. Maintain unobstructed pedestrian access for full width of the opening at elevator lobbies and 5-foot minimum unobstructed access to egress stairs using striped markings on decks with properly spaced bollards.

Primary and additional egress stairs shall be designed and located as required by the governing building code. Construct stairs with precast concrete or cast-in-place concrete with aluminum nosing cast in treads. Stair towers and elevator lobbies are to be open to interior spaces and enclosed with glazed aluminum storefront on exposed sides, unless governing codes require rated enclosures. If rated enclosures are required, maintain full visibility of the elevator lobbies from adjacent parking area. Provide natural ventilation with louvers at the bottom and the top of stair towers.

Elevators shall meet ADAAG, local building code, and the WMATA Design Criteria requirements indicated in Section 14 (Mechanical) of this Manual. The requirement for the number of elevators serving a parking structure shall be calculated using the WMATA Elevator Traffic Analysis Guide. Calculating factors determining elevator

counts include maximum wait time, capacity, speed, number of parking spaces, number of levels of parking, parking capacity fill rate and the level from which the access to the station is located. At a minimum, provide two traction elevators serving a parking structure with four or more levels or two hydraulic elevators if serving less than four parking levels. Provide emergency power generator able to operate elevators to designated landing and all emergency lighting circuits and required equipment.

The back of the elevator cab and the back of the hoistway shall be fully glazed for visibility of riders. Orient glazed side of hoistway away from an eastern or western exposure to avoid excessive heat penetration from direct sunlight. Provide ventilation .in accordance with Section 14.17.5.3.

Provide WMATA-approved bomb-resistant trash containers: two at each elevator lobby/main stairway entrance on each level and one at each stair entrance on each level. Provide one ash receptacle at each elevator lobby on each floor.

2.3.7 Site Parking Structure:

The parking structure shall be designed to meet local building codes with local jurisdictional amendments, FTA requirements as applicable, and to the requirements indicated in the Design Criteria Section 15 (Structural) of this Manual. The perimeter of the structure shall be open to the exterior to allow penetration of natural lighting and ventilation into the interior of the structure. Provide light wells to all perimeter areas of the parking structure that are located below grade using architectural cast-in-place or precast-concrete retaining walls.

Parking structures shall be designed for a minimum 50-year life span using the most stringent requirements of the ACI Code, the AASHTO Specifications and the Design Criteria Section 15 (Structural) of this Manual for the design. Generally, design parking structures using a precast, prestressed concrete system unless angled corners are necessary due to the constraints of the site and the schedule would permit using a cast-in-place system. To avoid erection problems during construction, precast, prestressed concrete structures are not permitted to have angled double-tee decks. However, small angles may be used due to site or space constraint, with the approval of the Authority, on a case-by-case basis.

Provide an 8'-2" minimum vertical clearance (plus vertical cure compensation, where

applicable) inside the structure over all parking areas, drive aisles, and at transition slopes on ramps, without intrusions from electrical, plumbing and other systems. Allow 12'-3" minimum floor-to-floor heights with a 48-inch minimum girder depth, and with an inch of construction tolerance. Provide 60-foot wide clear spans minimum for all parking bays with parking located on both sides. For a 60-foot clear span of parking bay, a column grid of approximately 62' long and 45' wide is recommended. However, end bays or bays of 47' width are recommended at the top and bottom of the ramps.

Design and construct parking structures to properly drain water from all surfaces on every parking level. Slope parking decks a minimum of 1.5%, although 2% is recommended, in all directions except at an ADA-accessible route and parking space. Provide drains at all deck low points, slightly oversized to prevent standing water on deck surfaces during storms. The water runoff shall be based on rain fall intensity of 3 inches per hour. Locate expansion joints at the high point of deck where water is less likely to pass over the wash. Slope structure at lobbies to drain away from elevator door openings and stair landings.

For the precast pretensioned prestressed parking structures, the drainage catchment area shall not exceed 2,800 sq. ft. for the roof parking deck and 5,600 sq. ft. for all other level decks. These areas are based on the basic grid module of about 62' long and 45' wide. To achieve proper drainage at the roof level, use of 4-inch thick concrete overlay (see Design Criteria Section 15 (Structural) of this Manual) shall be considered.

Separate elevator and stair towers from the parking structure with an expansion joint. However, on a case-by-case basis, the Authority may allow the use of attached stairs and elevator towers, based on the scheme of the structure.

2.3.8 Site Parking Structure Exterior Precast Spandrels and Panels:

To enhance the appearance of the exterior of the parking structure, fabricate spandrels using architectural precast concrete with finishes indicated or with finishes approved by WMATA. Provide a design for the structure's exterior that compliments the character of the adjacent architecture. Match the finish of the adjacent structure, if the parking structure is an expansion of an existing parking facility. Minimize the depth of spandrels and size of exterior panels to provide a light and open appearance from the structure's exterior and in interior spaces. Do not use metal

railings on top of spandrel panels.

2.3.9 Site Parking Structure Railings and Guardrails:

Design railings and guardrail systems with minimum size steel members to reflect the light and open appearance desired for the structure's exterior. Provide railings and guardrails with finish systems that are highly resistant to corrosion.

2.3.10 Site Parking Structure Security:

Provide parking structure design with passive security measures inside and outside the parking structure. Avoid dead end spaces and dark corners in parking areas. Access to parking structure shall be limited to principle users by restricting access to the interior of the structure from non-principle users with parapets, wire mesh partitions, and/or spiny landscaping materials.

Install Garage Emergency Telephone Systems (GETS) at all stair towers on all levels and at additional points in the structure to provide coverage of a minimum 200 feet of travel distance.

On the lower parking level of the structure, provide a room of area not less than 200 s.f. with a window for the Metropolitan Transit Police Department (MTPD). Finish room with painted walls, tiled floor and an acoustical panel ceiling. Locate MTPD room near a staff restroom. Furnish room with a WMATA phone system telephone, data terminal wired for WMATA-LAN access, heating and air-conditioning, and power for equipment.

Provide CCTV coverage of revenue collection areas and lane control signals, with CCTV images recorded on 4 channel recorders in the Operations Room. Provide CCTV coverage in each elevator cab with feed to station kiosk monitor with display rotation type service. Feed service to existing monitors that are in existing station kiosks.

2.3.11 Site Parking Structure Parking Access and Revenue Controls (PARC):

Provide an Operations Room, of area not less than 250 s.f., with security window

and located in the parking structure to house facility controller and other PARC equipment. Located room within 200 feet from cashier booths and adjacent to a staff uni-sex restroom. Assure direct and exclusive access to Operations Room door from the parking area. Finish room with painted walls, tiled floor and acoustical panel ceiling. Furnish room with a WMATA phone system telephone, data terminal wired for WMATA-LAN access, CCTV equipment, heating and air-conditioning, and power for other equipment.

Furnish Smartrip processing at all revenue access equipment, with each lane separately tracked for all Smartrip activity. Provide ADA-compliant and ballistic-resistant cashier booths that are operated with a fee computer system capable of integrating Smartrip with the fee computer to track transactions by type and amount.

Provide MUTCD overhead lane control signals for all cashier arrays. Signals displays shall be in compliance with the MUTCD. Controls for the signals shall be in the principal cashier booth for each of the arrays.

2.3.12 Site Parking Structure Signage and Graphics:

Provide ADA-compliant signage and graphics packages. Use 12" wide horizontal stripe to color code each floor marking elevator and stair towers in addition to all service and utility rooms. Color code pedestrian directional signs by floor and with colored stripes painted on lobby walls to match signs. Provide special graphics for Smartrip signs and reserved parking. Provide the standard WMATA signs for regulating use of the structure and posting of hours of operation and rates.

2.3.13 Site Parking Structure Fire Protection/Plumbing:

All areas of the parking structure will shall be covered by dry fire department standpipe systems as per NFPA-1A and approved by the jurisdictional Fire Marshall.

2.3.14 Site Parking Structure Lighting:

For all parking areas and pedestrian areas including stairways and elevator towers, use High-Pressure Sodium (HPS) fixtures. Refer to Design Criteria Section 4

(Lighting) Table 4.5.3 of this Manual for "Exterior Spaces" for proper illumination level. Minimum to maximum lighting intensity ratios shall not exceed 1 to 10 measured horizontally and vertically 3 feet above the floor. Average to minimum lighting intensity shall be maintained as 4 to 1. Lighting fixtures are to be specifically designed for parking structures and shall not cause glare for drivers. The light fixture design shall provide for the light bulb source to be shielded from the driver's eye.

20% of the lighting shall be on emergency circuits. Provide separate electrical closet on each floor to house the electrical panel for furnishing power to the light fixtures on the same floor. The electrical closet shall not be installed near the contraction/expansion joint. Provide controls for light fixtures in open glazed stairways to be off during daylight hours, but light fixtures shall remain on where daylight does not reach to at least 50% intensity.

2.3.15 Site Parking Structure Landscaping:

Landscape the perimeter of the parking structure per local codes and WMATA requirements or as required by local jurisdictional Authority. Plant material types and placement shall consider security requirements and maintenance needs including impact of roof top snow removal. Landscape plant materials shall be provided with WMATA standard watering system.

2.3.16 Site Parking Structure Maintenance Considerations:

Provide Storage Room in every parking structure over 500 spaces with a 200 sf space for gasoline/ diesel powered snow removal equipment. Locate Storage Room to avoid loss of any parking spaces below the lowest ramp. Secure space with an electric-operated coiling grille door and concrete masonry walls on all sides. Storage room shall comply with local jurisdictional code.

Install traffic coating over occupied spaces and service rooms to extent required to prevent water penetrations through deck structure and joints in deck.

Design for Architectural, Structural, Electrical and Plumbing systems to eliminate ledges and shelves, as feasible, where birds may roost or nest. Provide angled metal inserts at structural elements that form shelves and other bird control

measures or devices throughout the facility.

Provide steel corner guards at corners of columns where exposed to vehicular traffic and parking areas.

Locate plumbing risers tight to column and walls and protected from vehicular impact with steel guards.

2.3.17 Site Parking Structure Maximum Glass Panel Size:

The maximum glass panel size in stairways and elevator shafts shall not exceed 4 feet by 8 feet.

2.4 SITE AND RIGHT-OF-WAY SIGNAGE AND GRAPHICS

2.4.1 Site and Right-of-Way Signage and Graphics Design Principles:

For standard Site and Right-of-Way Signage and Graphics requirements, refer to the WMATA Manual of Graphics Standards. All new Site and Right-of-way Signage and Graphics shall adhere to the following adopted basic principles of design:

Signs shall be durable and meet the latest standards, regulations and codes.

Traffic and restrictive signs shall conform to the shapes, layouts, colors, letter sizes and typeface as required by the local jurisdictions, National Highway Standards and other applicable traffic regulatory agencies.

Fixed signs located on the Metrorail right-of-way shall conform with Graphics Figures 8 through 22 of the Metrorail Safety Rules and Procedures Handbook.

2.4.2 Site and Right-of-Way Signage and Graphics Design Elements:

When signs are mounted to fire-rated tunnel doors, they shall be mechanically fastened. Adhesive mounting is not acceptable (COG Fire Marshall's have concurred).

Direction signs indicate areas of site use. WMATA standard colors are used.

Signs to be mounted on operating leaves of double doors.

Abbreviate room names on exterior doors of ancillary buildings.

Provide room number only at revenue cart storage rooms.

See the following for WMATA numbering conventions for station service rooms:

	STATION CENTERLINE		
TOWARD	201, 203, etc.	200, 202, etc.	UPPER
⇐ METRO	101,103, etc.	100,102, etc.	MID
CENTER	001,003, etc.	002, 004, etc.	LOWEST LEVEL
	AORA 1	AORA 2	

SECTION 3 STATION DESIGN - Above Ground (At-Grade and Aerial) and Underground

3.1 GENERAL STATION DESIGN CONSIDERATIONS:

Stations shall be designed for a minimum 100-year life span using the Design Criteria Section 15 (Structural) of this Manual.

3.1.1 Station Vertical Circulation:

The Authority determines the program (i.e. quantity and location) for vertical circulation elements in the station facilities, including stairs, escalators, and elevators, as well as for fare collection equipment including faregates, farecard vendors, exit fare vendors and Trip Card Dispensers based on projected passenger demand. Established policy requires that platforms be capable of being cleared as follows:

Design Headway Time	Platform Clearance Time
2-3 Minutes	1.5 Minutes
4-5 Minutes	2.0 Minutes
6-7 Minutes	3.0 Minutes

3.1.2 Station Emergency Exiting Requirements:

The program for vertical circulation elements and faregate aisles may be increased to satisfy emergency exiting requirements as specified by the National Fire Protection Association (NFPA-130) rapid transit standards.

3.1.3 Station Plan and Profile:

The plan and profile of a station and its adjacent track work are determined by WMATA.

3.1.4 Station Piping and Conduits:

Piping and conduits in areas visible to the public shall be concealed as much as

possible.

3.1.5 Station Glazing adjacent to the Trackway:

Glass in areas above or next to the trackway or major roadways must allow for glass replacement from inside the structure, bridge, or station area without having to access the trackway.

3.1.6 Station Glazing Maximum Glass Panel Size:

The maximum glass panel size shall not exceed 4 feet by 8 feet (Typical for all WMATA facilities.)

3.2 STATION ENTRANCE

3.2.1 Station Entrance Design Principles:

The entrance to a station, consisting of the stairs, escalators, elevators, and surrounding space, shall be integrated with its surroundings in such a way as to be compatible with the urban/suburban fabric. The following points shall be observed in its design:

Align the entrance parallel or perpendicular to the major adjacent street, being cognizant of historic and visual axes.

Provide a 20 ft minimum queuing distance at escalator top.

Minimize taking of existing structures where their removal would constitute a disruption of the urban fabric.

Coordinate entrance to not preclude any future joint development, taking care not to preclude access to such development.

Anticipate need for future access points to the Metro System.

Provide an entrance pavilion at above ground stations to distinguish an entrance landmark and provide Metro System information for both rail and bus.

3.2.2 Station Entrance Design Elements: (*Note order change*)

Provide WMATA-approved bomb-resistant trash receptacles. Quantity and location shall be as directed by the Authority.

Two ADA accessible elevators between changes in elevation.

Each escalator wellway shall have a stair plus the required amount of escalators, a minimum of 2 escalators and a stair 10'-0" wide between, from the surface. A straight run is preferred over a scissors type run. The number and combination of escalators and stairs shall be based on passenger circulation requirements or NFPA-130, whichever is greater.

A straight run is preferred over a scissors type run.

Use G-10 and G-15 light fixtures.

Provide a canopy over any exterior open escalator wellway. Typically the canopy is mounted on top of the surrounding granite parapet wall, and typically is the entrance to an underground station at the ground surface level. The form and materials of the canopy shall reflect the standard elements, finishes, lighting fixtures, snow guards, and geometry of WMATA's standard stainless steel and glass canopy as shown on WMATA's design drawings.

Provide a granite parapet surrounding escalator way for an underground station.

Provide a granite apron surrounding the parapet for an underground station.

Provide a 3' x 3' concrete sidewalk grid for an underground station.

Each escalator wellway for underground stations shall have a stair plus the required amount of escalators (a minimum of 2 escalators with a 10'-0" wide stair between them from the surface).

Provide escalator stair pairs between changes in elevation for an above ground station.

3.3 UNDERGROUND STATION ENTRANCE PASSAGEWAYS

3.3.1 Underground Station Entrance Passageway Design Principles:

The station entrance passageway is the connecting element that brings the pedestrian patron from a surface entrance or an adjacent facility to the free area of the mezzanine. In underground stations it resolves horizontally and vertically the inevitable conflict between a logical entrance point within the street grid and the required track alignment (e.g. Judiciary Square). In some stations it allows the pedestrian to pass under a major street or site obstacle (e.g. Wheaton). In some cases, the passageway contain the fare vending equipment.

A minimum distance of 6 ft shall be left between the passageway wall, escalatorway and the nearest property line to accommodate columns of future joint development structures. Bridging the entrance is a common development practice. Provide space adjacent to the structure to allow construction of future air rights structures to be built above the station entrance and passageway.

Minimize the passageway length and number of turns.

Maximize the station manager's visibility; place the kiosk on centerline of the passageway.

Avoid creating dark, obscure recesses.

The passageway slope shall be less than 5%, otherwise it shall be treated as a ramp to meet ADA Requirements, with intermediate landings and handrails.

Locate closure gates at the entrance portal. Gates shall be operable by a single person. Accordion type gates are not recommended.

The surface elevator to the mezzanine for the disabled shall be located on the main entrance passageway with minimum secondary passageway length. The WMATA elevator passageway minimum width = 5'-0" clear, with continuous handrail on one side). All elevator access shall be to the free area, so that access to the platform area shall be only through the faregate array.

Provide a 12 ft. minimum queuing distance for fare vendors including Smartrip Card Dispensers.

3.3.2 Underground Station Entrance Passageway Design Elements:

Curved concrete walls with modular reveals at 8'-0" on center.

Paver tile floor.

Acoustical metal panel ceiling or concrete ceiling with recessed down lights.

Continuous handrail on both sides; bronze where weather-protected, stainless steel where exposed.

Closure gate with drainage detail.

Information/advertising panels.

Farecard vendors and Smartrip Card Dispensers (when not ion mezzanine).

Map case/telephones (one text telephone).

3.4 STATION MEZZANINE

3.4.1 Station Mezzanine Design Principles:

The Authority establishes the program for both the initial and ultimate peak demands. The new or reconstructed mezzanine shall satisfy the ultimate demand.

The layout of the shall reflect the logical sequence that a new patron would follow when first learning to use the system. Circulation flow, leading from one area or function to the next, is the critical issue.

Information panels and fare vending equipment are located on the right of a patron entering the station mezzanine. After the fare vendors and Smartrip Card Dispensers, a telephone booth and map case are located. Next are the faregates.

Adequate queuing distances are absolutely necessary. Insufficient capacity of mezzanine fare equipment may result in faregate queues of such length as to cause passenger back-up to the escalators and platform, or to the farecard vendors and

Smartrip Card Dispensers that would disrupt passenger flows, and possibly compromise safety.

The minimum vertical clearance in the mezzanine shall be 13'-0".

Provide a 20 ft minimum queuing distance for farecard vendors and Smartrip Card Dispensers.

Provide a 25 ft minimum queuing distance for faregates.

Queuing distances for terminal and temporary-terminal station shall be larger than those for a mid-route station. WMATA's projected patronage and recommended clearances to fare equipment shall be considered.

Visibility from the kiosk to the farecard vendors, Smartrip Card Dispensers and faregate equipment is essential. Center the kiosk on passageways and farecard vendor array and faregate equipment. Provide visibility to elevators and escalator ways.

Minimize the duplication of mezzanine fare equipment by locating it at a point common to all entries (either passageways or entrances).

In no case shall direct sunlight reach the farecard vendors, the faregate displays and photo sensors and the Smartrip Card Dispensers, since sunlight will impact the equipment performance and operation.

The free area and paid area shall each have at least two telephones and map cases. One telephone in each location shall be a text telephone.

Provide a minimum of one ADA-accessible elevator to each side platform from the mezzanine, and a minimum of two to a center platform to the mezzanine.

Above ground station mezzanines shall be entirely protected by an entrance pavilion, overhead platform, or vaulted structure. Vertical transparent wind screens shall also be provided for additional protection as required. Design the overhead protection and wind screen so that the mezzanine is adequately protected from driving rain, sleet and snow. Assume a 65^{0} angle from the vertical for roof overhangs . Canopies over mezzanines shall have a continuous linear glazed skylight. Faregates shall be completely protected from rain, sleet, snow, or other

forms of moisture. Fairgates shall be shielded from any direct sunlight.

3.4.2 Station Mezzanine Design Elements:

The size and shape of the mezzanine is directly determined by the programmatic requirements for a station and the number of entrances required. This accounts for the wide diversity of mezzanines throughout the system. However, each contains these elements:

- Kiosk
- Service gate
- Fare gates
- Accessible fare gates
- Farecard vendors and Smartrip Card Dispensers (when not in passageway)
- Exitfare machines
- Bus transfer dispensers
- Escalators and accessible elevators to the surface entrance and to each platform
- Map case
- Telephones (one text telephone)
- Smartrip Card Dispensers (for on-site parking lots only)
- Advertising panels and dioramas
- Metro information panel
- "How to Buy a Farecard" panel
- Paver tile floor

- Precast concrete or stainless steel and glazed parapet
- Lighting
- CCTV
- Signage and graphics
- One single-sided PIDS near the farecard vendors in plain view of patrons purchasing farecards or approaching faregates to enter the system.
- WMATA-Approved Bomb-Resistant Trash Receptacles.

3.4.3 Station Mezzanine Equipment and Queuing:

The program of required equipment, prepared by WMATA, is based on ridership projections. Once the program is known, the minimum areas for queuing determine the size of the mezzanine. Passenger flow shall serve to plan the mezzanine spaces.

3.4.4 Station Mezzanine Faregate Aisles:

The required number of standard faregate aisles is calculated by dividing the projected faregate transactions of the peak minute by the average transactions per minute for one aisle. The calculation employs two important factors: peak load and platform clearance. The peak load concept, or peaking factor, accounts for the uneven distribution of disembarking passenger loads during the peak hour. With respect to platform clearance, it is WMATA policy that platforms be cleared in half the scheduled headway time of the peak train service. Clearance of the platform allows for headway fluctuations, which may occur during peak periods, and assures that the disembarking passenger load shall have unimpeded flow to and through the faregate aisles, without the danger of passenger back-up. The platform clearance factor is assigned only to the number of disembarking passengers.

Spare aisles, a service gate, and at least one ADA accessible faregate aisle are added to the number of standard faregate aisles to establish the total faregate aisle program.

The ADA Aisle shall be located closest to the kiosk, on the side of the kiosk that allows the shortest path from the entrance elevator to the platform elevator.

3.4.5 Station Mezzanine Faregate Aisle Queue:

The queue length is calculated if the number of standard faregate aisles is less than the program requirement. The calculation determines the maximum queue volume, and employs a peak queue factor and interpersonal spacing for Level of Service C pedestrian flow. If the number of standard faregate aisles satisfies the program requirement, then the minimum queue length may be applied.

3.4.6 Station Mezzanine Farecard Vendors:

The required number of farecard vendors is calculated by dividing the projected farecard vendor transactions of the peak minute by the average transactions per minute for one vendor. The calculation employs two factors: peak load and a percentage factor for the number of peak-hour boarding passengers using the vendors. The peak load concept, or peaking factor, accounts for the uneven distribution of passenger loads during the peak hour. Spare vendors are added to the number of farecard vendors to establish the total farecard vendor program. One accessible farecard vendor and one accessible exit fare vendor are required.

The percentage factor varies among the stations, and is highest for those stations that serve passengers unfamiliar with the automatic fare collection system, e.g. tourists and convention attendees.

3.4.7 Station Mezzanine Farecard Vendor Queue:

Calculate the queue length if the number of farecard vendors is less than the program requirement. The calculation determines the maximum queue volume, and employs a peak queue factor and interpersonal spacing for level of service C per pedestrian flow criteria. If the number of farecard vendors satisfies the program requirement, then the minimum queue lengths may be applied.

3.4.8 Station Mezzanine Smartrip Card Dispensers:

The number of Smartrip Card Dispensers shall be based upon the number of parking spaces in the station parking facility. For stations with fewer than 1,000 parking spaces, one Smartrip Card Dispenser shall be installed; between 1,000 and

2,999 parking spaces, two Smartrip Card Dispensers shall be installed; and more than 3,000 parking spaces, three Smartrip Dispensers shall be installed. The Smartrip Card Dispensers shall be located in the free area, and in the general area of the farecard vendors. The queue length minimum for the Smartrip Card Dispensers is equal to queue length calculated for the farecard vendors.

3.4.9 Station Mezzanine Public Information Display System (PIDS):

For each mezzanine, a minimum of one single-sided PIDS shall be installed near the farecard vendor with the PIDS screen in plain view of patrons purchasing farecards or approaching the faregates to enter the system.

3.4.10 WMATA-Approved Bomb-Resistant Trash Receptacles:

Provide WMATA-approved bomb-resistant trash receptacles in quantity and location as directed by the Authority.

3.5 STATION PLATFORM

3.5.1 Station Platform Design Principles:

A clear, unobstructed view of all parts of the station platform, with the minimum number of columns, and equipment, blocking the view, shall be provided.

A center platform is preferred over side or twin platforms.

Where two station entrances are provided, each with its own mezzanine, access from the mezzanines to the platforms shall be located as close to the platform ends as possible, to insure optimum loading and safety.

Above ground station platforms shall be entirely covered. Design the canopy so that the platform is adequately protected from driving rain, sleet and snow. Assume a 65° angle from the vertical for roof overhangs. Canopies over platforms shall have a continuous linear glazed skylight.

3.5.2 Station Platform Design Elements:

All Metro platforms are a minimum of 600 feet long. This corresponds to the length of an 8-car train.

3.6 STATION PLATFORM TYPES

3.6.1 Station Platform Width Design:

Design shall be in accordance with NFPA-130.

3.6.2 Platform Width at Center Platform Station:

The platform width shall be sufficient to accommodate the projected passenger load. However, the minimum platform width shall be 30'-0½" with a clear distance between the platform edge and the nearest obstruction (e.g. escalators) being a minimum of 9'-3" where possible. Area adjacent to trackway below platform over hang to remain open for emergency refuge.

3.6.3 Platform Width at Side Platform Station:

Minimum platform width shall be 15'-0" to the face of the parapet wall if vertical circulation elements are located within the limits of the platform, with a clear distance between the platform edge and the nearest obstruction (e.g. escalators) being a minimum of 9'-3" where possible. Minimum platform width may be reduced if vertical circulation elements are located outside the platform limits. Area adjacent to trackway below platform over hang to remain open for emergency refuge.

3.6.4 Platform Width at Dual Chamber Station:

Minimum platform width shall be 13' 5-7/8" to the face of the parapet wall. The clear distance between the platform edge and the nearest obstruction (e.g. escalators) shall be a minimum of 9'-3" where possible. Employ where dual chambers are excavated for the station train room (e.g. Wheaton and Forest Glen Stations). Area adjacent to trackway below platform over hang to remain open for emergency refuge.

3.6.5 Twin Platform Width at Triple Track Station:

Minimum platform width shall be 24'-3". The clear distance between the platform edge and the nearest obstruction (e.g. escalators) shall be a minimum of 9'-3" where possible. Employ where center pocket track is located in the station (e.g. National Airport and West Falls Church Stations). Area adjacent to trackway below platform

over hang to remain open for emergency refuge.

3.6.6 Station Track Stationing and Elevations:

The location of a station platform is precisely fixed by its "stationing" (the distance normally measured from Metro Center (or another base reference if necessary) in 100 feet lengths along the track alignment) and by its top of rail (T/R) elevations on the profile, denoted as follows (in this example, Anacostia Station):

Begin Platform	Sta. 182+37.00
(inbound end)	T/R EL.+2.57'
End Platform	Sta. 188+37.00
(outbound end)	T/R EL.+0.47'

The numerical difference between the beginning station at the in-bound end of the platform and the end stations of the platform is always a minimum of 600 feet; the difference between T/R elevations may vary from 1.2 ft, which represents a 0.2% slope (the minimum for an at-grade station) to 2.1 ft, which represents a maximum slope of 0.35% required for underground and aerial stations and the maximum for at-grade stations. The platform and ancillary rooms slope correspondingly.

3.7 STATION PLATFORM AND TRAINROOM ELEMENTS

3.7.1 Station Platform and Trainroom Items:

The following items are to be included on all WMATA Platforms either underground, or above ground(at grade or aerial):

- Granite edge with flashing lights
- 2-ft. strip of ADA detectable tiles inboard and next to the granite edge
- Paver tile floor
- Telephones
- Map cases

- Advertising panels and dioramas
- Escalators and accessible elevators to the mezzanine
- Precast concrete or stainless steel and glazed parapet
- Lighting
- CCTV
- Signage and graphics
- Double-sided PIDS for all Station platform types with display screens visible from a maximum distance of 150 feet measured along any platform edge
- Granite benches
- Glazed shelters (above ground stations only)
- Mechanical and Lighting Pylons (underground stations only)
- WMATA-Approved Bomb-Resistant Trash Receptacles

3.7.2 Station Platform and Trainroom Item Modulations:

The platform and train room are modulated by the following dimensions:

ITEMS TO BE SPACED	MODULE DIMENSION	NUMBER OF MODULES
Blinking lights on platform edge	**4'-2"**	**144**
Vault ribs/coffers/beams and columns	**8' - 4"**	**72**
Public address speakers	**16' - 8"** **25'-0"**	**36** **24**
Granite benches A/C pylons	**33'-4"**	**18**
Closed circuit TV cameras	**150'-0"**	**4**
Manholes, fire standpipes, emergency call stations, electric, convenience outlets	**200'-0"**	**3**

PIDS	**300' - 0",**	**2 min (starting at no further than 150'-0" from ends of Platform)**
Approved Bomb - Resistant Trash Receptacles	**Location as directed**	**Quantity as directed**

3.7.3 Glazed Windscreen Shelters (above ground stations only)

- Shelter Architecture shall be developed to be compatible with the station architecture and reflect an excellence in functional design and aesthetic appearance.
- Shelters shall consist of framing constructed of non-corrosive materials, such as heavy duty anodized aluminum or stainless steel.
- Shelters shall have transparent glass inserts constructed of tempered glass or laminated safety glazing, light fixtures providing appropriate illumination levels (all wiring shall be concealed within the framing) and a bench.
- Shelters not protected by a station canopy shall have roofs with skylights and a gutter system for drainage.
- Shelters in new stations shall be made of stainless steel and incorporate a pay phone and a stainless steel map case with an illuminated system map or neighborhood map with a horizontal station ahead lists above the maps. Center platforms are to have double sided maps with a system map on one side and a neighborhood map on the other.
- Shelters in older stations shall also incorporate non-illuminated horizontal station ahead lists mounted on the shelter.

3.8 STATION ESCALATORS

3.8.1 Station Escalator Design Principles:

Information on the Design Criteria for escalators is contained in Section 14 (Mechanical) of this Manual.

3.8.2 Station Escalator Design Elements:

All escalators are designed on a standard 30° angle of inclination. "Working points" (upper and lower) are intersections of this line with the finish floor elevations of the two levels.

The quantity and location of escalator in each station are based in part on the policy program for vertical circulation.

Cladding panels on the outside of escalators shall have plumb vertical joints.

3.9 STATION ELEVATORS

3.9.1 Station Elevator Design Principles:

Information on the Design Criteria for elevators is contained in Section 14 (Mechanical) of this Manual.

3.9.2 Station Elevator Design Elements:

Elevator Types: The following types of elevators are used in the system:

- Hydraulic (types I-IV):
- Vertical rise up to 50'-0".
- Machine room may be remote from elevator if necessary.
- Traction (Types VI-VIII):
- Vertical rise over 50'-0".
- Machine room shall be adjacent to elevator.
- Dual street elevator access and dual center platform elevators shall be provided a minimum of one elevator per mezzanine or two per station, whichever is greater.

Elevator Hoistway and Cab Walls and Doors Glazing: Provide clear glazing for viewing into and out of the interior for safety and security on elevator hoistway walls and doors and on cab walls and doors. Glazing is to be laminated tempered safety glass. Where hoistway wall glazing is not possible, glazing is still required on the elevator hoistway doors and cab doors for unobstructed viewing into and out of the cab.

3.10 STATION SERVICE ROOMS:

The Service Room Schedule is a list of all the required ancillary rooms for a station. The numbering system is consistent throughout all General Plans; therefore, if a room is not required in a particular station, its name and number are simply omitted from the list. In other words, 8 always refers to the Fire Equipment Cabinet. This list is inserted into the General Plans and Sections showing the service rooms and the corresponding numbers are placed in the room plans and sections. All required rooms are listed on one sheet, with reference to this schedule being made on subsequent sheets.

3.10.1 Station Service Room Schedule:

1	Mechanical Room	15	Bus Drivers' Washroom
2	A.C. Switchboard Room	16	Terminal Supervisor's Room
3	Battery Room	17	Train Operator' Room(w/potable water)
4	Communications Room	18	Train Operators' Washroom (2)

5 Train Control Room
6 Operations Room
7 Telephone Room
8 Fire Equipment Cabinet
9 Cleaners' Room
10 Cleaners' Room with Ejector
11 Women's Washroom
12 Men's Washroom
13 Water Service Room
14 D.C. Tie Breaker Room
19 Maintenance Room
20 Train Operators' Locker Room
21 Transformer Room
22 Elevator Machine Room
23 Sewage Ejector Room
24 Cart Storage
25 Electrical Cabinet Room
26 Police Service Room
27 Emergency Tunnel Excavation Cart Storage Room

3.10.2 Station HVAC Mechanical Rooms:

All mechanical rooms are denoted as #1, with their specific function labeled on the plans.

For room sizes and other dimensions, refer to the Design & Standard Drawings.

#1 Mechanical Equipment Room

Center Platform Stations
Two rooms, one located at each end of platform; or
Four rooms, two at each end of platform, stacked vertically.

Side Platform Stations
Four rooms, located at each end of both platforms; or
Eight rooms, stacked vertically at each end of both platforms.

The Mechanical Equipment Room provides air conditioning for platform area and under platform exhaust:

- Each room needs 6'-0" x 8'-0" high double doors and a knockout panel adjacent to tracks for equipment access.
- No personnel access to these rooms via Electrical Rooms; entrance shall be off of a corridor leading to an exit.
- Ductwork runs from these rooms under platform and under any service rooms located between the station end wall and the Mechanical Room; center ductwork under platforms.
- Provide two means of egress, diagonally opposite from each other.

Fan Room (ventilates the A.C. Switchboard Room)

- Locate adjacent to AC Switchboard Room.
- Fresh air intake and exhaust required.
- 6' x 8' double doors.
- 9'-0" minimum ceiling height.
- Access not through Electrical Room.

Chiller Plant (for underground stations; may serve more than one station)

- 10' x 10' double door.
- 3' x 3' access hatch to cooling tower (unless cooling tower is remote).

Cooling Tower

- Provide one for each Chiller.
- May be remote from Chiller Plant, but chilled water lines connect the two rooms, so minimize distance.
- Needs exposure to fresh air.

Fan Room at Mezzanine (to ventilate and cool kiosk)

- Room required unless fans can be placed above kiosk to exhaust at grade.

3.10.3 Station Electrical Rooms:

All electrical rooms are denoted as #2, #3, #14 and #25 with their specific function labeled on the plans.

#2 A.C. Switchboard Room

- 2 rooms -- used where 2 entrances to the station are remote from each other, generating two sets of service rooms.
- Combined -- used when there is a centrally located mezzanine and all the service rooms are located together.
- All AC rooms shall have 2 means of egress.
- 6' x 8' double door and access hatch for equipment.

#3 Battery Room

- Requires adjacency to each A.C. Switchboard Room.
- 3' x 7' door on short side of room.

#25 Electrical Cabinet Room

- Required when service rooms are remotely located from A.C. switchboard room; enables electrical service to be brought into service rooms.

#14 D.C. Tie Breaker Room

- Required when there is no substation located at a crossover.
- Door at platform level

3.10.4 Station Systems Rooms:

All systems rooms are denoted as #4, #5, #6, #7, #8, #16, #17, #24, #26 and #25 with their specific function labeled on the plans.

#4 Communications Room This room is preferred to be located at the platform level.

#5 Train Control Room This room varies according to the track conditions. All Train Control Rooms shall have two means of egress. Platform level is optimum.

#6 Operations Room Locate at platform level; may be combined with the train operator's room #17 to form one large room (see requirements for #17).

#7 Telephone Room Located at mezzanine level or platform level, one at each end of station.

#8 Fire Equipment Cabinet Locate at each end of platform and in every mezzanine. Platform cabinets shall be immediately adjacent to end of platform.

#16 Dispatcher Room Located only at terminal or temporary-terminal stations, for dispatching of trains. Located at inbound end of platform with a window for clear visibility of trains in the station.

#17 Train Operator's Room Located next to dispatcher room with a Dutch door between the two rooms May be combined with the operations room #6. Functions as a place for train operators to report to work, eat lunch, use toilet facilities, etc. Provide lockers.

#24 Cart Storage Room Size may vary according to number of carts programmed per station. The room shall be located at inbound end of platform (unless revenue collection is remote). Provide easy access to elevator for transporting carts to/from mezzanine (2'-6" minimum corridor width).

#26 Police Service Room: Equipped with in-house telephone, locate at mezzanine level, in a place where an injured or arrested person can be taken, where reports can be filed by Metro Police, and where VIPS can gather for a briefing.

#27 Emergency Tunnel Evacuation Cart Storage Room: Locate at inbound end of platform.

3.10.5 Station Plumbing and Maintenance Rooms:

All plumbing and maintenance rooms are denoted as #9, #11-12, #13, #18 and #19 with their specific function labeled on the plans.

#9 Cleaner's Room: For grade or above grade stations.

#11-#12 Women's and Men's Washrooms/Bus Driver's Washrooms Shall comply with ADAAG guidelines for accessible restrooms. Provide men's and women's washrooms at each mezzanine and in terminal station operators' room on platform level. Provide bus driver's washrooms as required by WMATA.

#13 Water Heater Service Room Located at mezzanine level near existing utility service.

#18 Train Operators' Washrooms (men's and women's) Shall comply with ADAAG guidelines for accessible restrooms and be adjacent to the Train Operators' room (#17).

#19 Maintenance Room One per station, usually at platform level, shall have minimum dimensions of 12' X 12'.

3.10.6 Station Tunnel Doors:

Reference Design Criteria Section 15 (Structural) of this Manual: Metro Underground Structures Design for Air Pressure Caused by Running Trains.

3.10.7 Station Exit Stair Doors:

All doors in a tunnel leading to exit stairs serving as a path of egress shall be a swing-type door, 4 ft. wide by 7 ft. 2 in. high. Door assembly, including the hardware, must shall be corrosion resistant, meet the air pressure criteria and shall meet NFPA Codes 80, 101 and 130.

3.10.8 Station Roof Design Criteria:

Roof Design shall meet or exceed the strictest requirements of international, national, regional, and local building codes for wind, weather, and fire resistance with appropriate regard for safety of persons and property. Roof designs shall follow a “system approach” utilizing approved products of a single source recognized leading manufacturer to the greatest extent possible. Approved roofing designs shall incorporate quality detailing and materials for appropriateness, appearance, weatherability, ease of maintenance, protection of persons and facilities, and economy of construction.

Roof designs shall incorporate details for ease of maintenance accessibility for roofing and roof-mounted equipment while providing maximum security protection from vandalism or unauthorized entry. Particular attention shall be paid to equipment supports, equipment fluid overflow pans, roof access doors, and

pedestrian traffic areas. Roofs bounded by parapet walls or curbs are preferred to control blow off of rain and snow during periods of inclement weather. Locate roof drains away from walls, curbs, parapets, penetrations, or other obstructions. Provide watershed and overflow designs, drains, scuppers, or gutters and downspouts to eliminate ponding and standing water on roof surfaces.

Avoid the use of volatile organic compounds or products, and all material subject to attack by rodents, vermin, birds, and all other pests. Provide a standing seam metal roofing system with a curved or gabled profile for sloped For low-sloped and flat roof applications either a multi-ply or a single ply membrane system may be used. These shall be fully adhered systems. If single-ply membrane system is used it shall have a minimum thickness of 1.5 millimeters and shall incorporate pedestrian access paths to all rooftop equipment. Use either pressure-treated or fire-retardant treated lumber for blocking and nailers as dictated by code.

All roofing systems shall have a minimum 15-year manufacturer's warranty.

3.11 STATION SIGNAGE AND GRAPHICS:

3.11.1 Station Signage Design Principles:

WMATA standard signage requirements are outlined in the "WMATA Manual of Graphics Standards". Station signage shall meet all current ADA requirements, and all new station signage shall adhere to the WMATA Board of Directors' Resolution 2004-34 adopted July 15, 2004 that stated the nine basic principles of design for station signage. The nine principles are as follows and samples of some of these principles are attached at the end of Section 3:

- Principle #1: Pylons shall not be used for displaying directional signage.
- Principle #2: Place signage overhead in the path of travel where possible.
- Principle #3: Display the train destination and line color/s below the Station Name (See Principle #3 Signage Example of train destination and line color/s for Side Platform Station and Principle #3 Signage Example of train destination and line color/s for Center Platform Station of Attachment - Signage Examples at end of Section 3).
- Principle #4: On side platform stations, mount horizontal station ahead lists on the wall.
- Principle #5: Distinguish between train information and station exits (See Principle #5 Example of train information and station exits of Attachment - Signage Examples at end of Section 3).
- Principle #6: On center platform stations, mount wayfinding signs overhead, parallel with, and centered on the platform; mount signs on side walls for side platform stations.
- Principle #7: On underground center platform stations, mount horizontal station ahead lists on top of the dioramas; on above ground center platform stations, mount horizontal station ahead lists in windscreen map cases.
- Principle #8: Use illuminated signs at key decision making points (See Principle

#8 Example of illuminated signs above an escalator of Attachment - Signage Examples at end of Section 3).

- Principle #9: On side platform stations, use vertical station ahead lists at the top of escalators at the mezzanine (See Principle #9 Example of vertical station ahead lists of Attachment - Signage Examples at end of Section 3).

3.11.2 Station Signage Design Elements:

All static signs are to use the Helvetica Medium typeface.

All structural signage attachments shall be designed and stamped by a structural engineer licensed in the jurisdiction where the signage is to be installed.

Illuminated signs shall use standard bulb sizes and lamps as directed by WMATA.

Access to lamps in illuminated signs shall be from a piano-hinged front panel/s with hold-opens so relamping can be done by one person.

Map cases shall use tamper proof screws instead of keyed locks for access.

3.11.3 Station Passenger Information Display System (PIDS):

The Passenger Information Display System (PIDS) shall be a network of electronic signs displaying dynamic, multiple LED display text messages on all Metrorail platforms and mezzanines. The PIDS shall convey basic information to customers such as date, time of day, safety messages, the number of minutes until the next train arrives, and the number of cars in the next train. The PIDS shall also communicate special information such as delays, holiday schedules, Metro marketing promotions, etc.

Housings: The PIDS electronic screens shall be housed in rectangular metal boxes. Displays on PIDS can be single-sided or double-sided depending on location, but the housing for both shall be the same dimensional size. The housing finish and color shall be compatible with the Station design.

Mountings: The PIDS may be suspended from ceilings or cantilevered from walls, column supports or pylons. To facilitate the servicing of platform PIDS, the mountings shall permit the housings to be rotated 90 degrees to a position parallel to the track.

Mounting Height: The PIDS shall be mounted at heights that optimize viewing of displays by patrons standing at a maximum distance of 150 feet away. As much as possible at all locations, the PIDS housing shall be mounted out of the public's reach. However, the PIDS shall be mounted high enough for patrons to safely walk under, with a minimum ADA requirement of eighty (80) inches vertical clearance.

Displays: Single lines of large text or multiple lines of small text may be displayed. The minimum text height permitted is three (3) inches. Use of all capital letters is preferred. Also, simple pictorial graphics may be displayed.

Power supply: Load and electrical power supply requirements for PIDS are defined in Design Criteria Section 13 (ELECTRICAL) of this Manual.

SIGNAGE EXAMPLES OF WMATA BOARD OF DIRECTORS' RESOLUTION 2004-34

Principle #3 (example of train destination and linecolor/s for Side Platform Station)

Principle #3 (example of train destination and line color/s for Center Platform Station)

Principle #5 (example of train information and station exits

Principle #8 (example of illuminated signs above an escalator)

Principle #9 (example of vertical station ahead lists)

SECTION 4 SITE AND STATION LIGHTING

4.1 GENERAL SITE AND STATION LIGHTING DESIGN CONSIDERATIONS

4.1.1 Site and Station Lighting Design:

The lighting design of the Metrorail system is an integral part of the architectural concept, to provide comfort, safety and accessibility to patrons, as well as lighting system reliability and efficiency. Visual coherence and integrity have dictated color compatibility between different light fixtures, and freedom from visual noise, such as disorderly light patterns or overly bright lamps. Minimum maintained illumination levels have been based on the locations and functions of the various areas in and around the stations. Maintenance and accessibility of installed fixture is required.

Lighting design and installation shall be closely coordinated with the following:

- Landscaping
- Safety & Security Requirements
- Maintenance
- ADA Regulations
- CCTV Systems

WMATA Lighting Poles by Location:

• Station entrance	• G-10 & G-15 Poles
• Bus platform	• G-10 & G-15 Poles
• Walkways	• G-15 Poles
• Roads (incl. bus loops)	• G-25 Poles
• Parking Lots (P&R, K&R)	• G-25 & G-40 Poles

4.1.2 Underground Station Lighting:

To achieve a comfortable ambiance, an indirect (and direct, where shown in the General Plans) lighting system shall be used. Wherever possible, the lighting shall be integrated with the structure and furnishings to conceal the light sources. The indirect lighting is intended to minimize "visual noise" from discordant sources and patterns. It is especially important to light the trainroom vaults, because the perception of a space is dependent upon its illumination, and the perception of light itself is based on the brightness of surfaces in the visual field. Even if the platform is well lighted, dark walls will give the trainroom a gloomy appearance.

In passageways and mezzanines, light shall be added to the ambient illumination where specific activities take place, e.g. farecard vendors, Smartrip Card Dispensers and faregates.

4.1.3 Above Ground Station Lighting:

Because of the limited areas of vertical surfaces, direct light sources shall be used to illuminate and define the shape and extent of the platform and canopies. The light sources shall be consistent with the architectural elements, and shall not compete with the building definition. Disturbance of the neighborhood through glare and light spillage shall be avoided.

Mezzanines and entrances shall be highlighted to indicate the way into the station. Where possible, walls shall be washed with light to prevent a dark, gloomy appearance.

4.1.4 Exterior Space Site Lighting:

The lighting for parking lots, kiss-and-ride areas, bus loading areas, pedestrian walkways, station entrances and other supporting facilities shall provide for amenity and safety of the user. The arrangement of the lighting shall make both pedestrians and drivers aware of the organization of the station by providing visual information for maximum clarity. The lighting shall be arranged as a lead-in to the station entrance. As the organizational focus, the entrance area shall be well-lit within a 30-ft. radius from the entrance or the parapet wall of the stair/escalator well per Table 4.5.1. Disturbance of the neighborhood through glare and light spillage shall be avoided. The sense of security in a parking lot is increased when the perimeter is well lighted; therefore all perimeter conditions shall be continuously lighted, in addition to the minimum interior illumination of each lot. The maximum-to-minimum lighting level ratio shall be low to avoid overly bright spots, which make the overall average illumination appear darker. Close coordination is required between the outdoor lighting and landscaping disciplines, to avoid problems such as conflicting layouts of luminaries and trees, and tree shadows over parking spaces and drives.

4.2 UNDERGROUND STATION LIGHTING – Design Elements & Application

4.2.1 Side-Platform Underground Station Lighting:

The vault shall be illuminated by super-high-output warm-white fluorescent lamps (or a similar light source arranged to provide continuous illumination) located behind the platform parapets and in the louvered trough under the safety walk between the tracks. Incandescent lamps shall be used for the recessed platform-edge lights.

4.2.2 Center-Platform Underground Station Lighting:

The vault shall be illuminated by super-high-output warm-white fluorescent lamps (or a similar light source arranged to provide continuous illumination) located in the louvered trough under the safety walks along the sides of the station, and by 1,000 watt metal-halide lamps in ANSI Type III optical systems mounted in the pylons. To help achieve that level, recessed compact fluorescent lamps shall be located in the soffit under the mezzanine. Incandescent lamps shall be used for the recessed platform-edge lights.

4.2.3 Underground Station Mezzanine Lighting:

The vault shall be illuminated by metal-halide lamps (or a similar light source) in pendant fixtures suspended from the transverse ribs. These lamps shall have a 20% direct downlight component with a translucent lens.

4.2.4 Underground Station Kiosk Lighting:

Compact fluorescent lights shall provide a minimum maintained illumination level of 15 foot-candles on the work counter for reading instruments and writing, with minimum disturbance by glare and specular reflections. Kiosk lighting shall be controlled by a dimmer.

4.2.5 Underground Station Passageway Lighting:

All passageways shall be illuminated by recessed compact fluorescent or metal halide lamps. Farecard vendors and Smartrip Card Dispensers shall be lighted with recessed wall washers

4.2.6 Underground Station Stair, Escalator Way and Station Entrance Lighting:

Walls and ceilings below ground, and enclosing walls above ground, shall be illuminated by super-high-output fluorescent lamps (or by a similar light source arranged to provide a continuous illumination) on a controlled circuit, concealed in the balustrades of the two outer escalators. Escalators shall have continuous fluorescent step lights on both sides. All stairs except emergency exit stairs shall have a continuous fluorescent light integrated in the handrail, pointing downward to illuminate the treads.

The area within a 30-ft. radius of the stair/escalator well, or the at-grade station entrance, shall be illuminated by ambient street light and/or WMATA luminaries.

4.2.7 Underground Station Elevator Lighting:

Elevators shall be lighted by warm-white fluorescent lamps, concealed in a cove in the soffit or ceiling.

4.2.8 Underground Station Emergency Lighting:

The emergency lighting level shall comply with local codes, but in no instance shall be less than 20% of the average lighting level, distributed evenly throughout the facility. Station lights shall be controlled by time clock to go off during non-revenue hours, with the exception of the emergency lights as noted above.

4.2.9 Underground Station Lighting Controls:

All lighting controls shall be located in the AC Rooms for interface with the Energy Management System.

4.2.10 Underground Station CCTV Surveillance Lighting:

For normal monitoring requirements, the lighting as outlined in this Design Criteria Section 4-Lighting will suffice.

4.2.11 Underground Station Ancillary Space Lighting:

Illuminating Engineering Society, I.E.S. standards shall be adhered to.

4.3 ABOVE GROUND STATION LIGHTING - Design Elements & Application

4.3.1 Above Ground Station Platform Lighting:

The illumination of the platform section under the canopy shall be by recessed or surface-mounted lamps as indicated on the General Plans. For any uncovered

section of the platform, the same fixtures shall be used, mounted on free-standing columns. Lighting of the platform edge shall be the same as in underground stations.

4.3.2 Above Ground Station Mezzanine Lighting:

Illumination shall be provided by recessed or surface-mounted lamps as indicated on the General Plans. Faregate, farecard vendor, Smartrip Card Dispenser, kiosk, passageway, elevator, stair and escalator lighting criteria shall be the same as for underground stations.

4.3.3 Above Ground Station Emergency Lighting:

The emergency lighting level shall comply with local codes, but in no instance shall be less than 20% of the average lighting level, distributed evenly throughout the facility. Station lights shall be controlled by time clock to go off during non-revenue hours, with the exception of the emergency lights as noted above.

4.4 EXTERIOR SPACE SITE LIGHTING – Design Elements & Application

4.4.1 Parking Lot Site Lighting:

The parking lots shall be lighted by H.I.D. lamps of the type, configuration and combination of wastage and pole heights indicated in the General Plans. A combination of G-25 and G-40 light poles shall provide a minimum maintained illumination. The pole layout and laminar photometric performances shall provide lot illumination with average-to-minimum illumination ratio of 4:1, and maximum-to-minimum illumination ratio of 8:1. All the luminaries in a station's parking areas shall be by the same manufacturer. G-25 luminaries shall be used at the perimeter of lots and along driveways; G-40 luminaries shall be used for lot interiors.

4.4.2 Parking Structure Site Lighting:

See Design Criteria Section 2 of this Manual for lighting requirements in Parking Structures.

4.4.3 Pedestrian Walkway Site Lighting:

Some illumination shall be provided by low-wattage H.I.D. lamps with reflectors, in clear globes mounted on 10 ft. poles. The primary purpose of the globes is to provide direction and orientation, and to delineate access to the station entrance. G-15 luminaries shall be used for perimeter pedestrian walkways.

4.4.4 Bus Platform Site Lighting:

Bus shelters shall be internally lighted by 50W high-pressure sodium wall packs. These shall provide a minimum maintained illumination level per Table 4.5.3, measured horizontally @3 ft. above pavement. Platforms shall be lighted by G-15 luminaries providing a minimum maintained illumination level per Table 4.5.3. Depending on site conditions, bus roadways may be supplemented with G-25 luminaries.

4.4.5 Kiss & Ride Area, Access & Bus Roadway Site Lighting:

These areas shall be lighted by G-25 luminaries providing a minimum maintained

illumination level per Table 4.5.3.

4.4.6 Structured Bus and Kiss & Ride Area Site Lighting:

If Bus Bays or Kiss & Ride areas are inside a parking structure, they shall be lighted by surface or pendant-mounted H.I.D., low-brightness cylindrical downlight, providing a minimum maintained illumination level of 10 foot-candles, measured horizontally @3 ft. above pavement. The fixtures shall be laid out so that buses do not cast shadows on the platforms. Signage shall be illuminated to insure easy readability.

4.4.7 Site Lighting Controls:

All exterior lighting shall be controlled by a combination of NEMA-type photocell and time clock. The photocell shall turn on all lighting when north sky luminance falls below 5 foot-lamberts. The time clock shall turn off 80% of the lighting during non-revenue hours. The remaining 20% of site luminaries, on a separate control and evenly distributed throughout the site, shall remain on all night for security. The security lights shall be turned off by the photocell when north sky luminance rises above 5 foot-lamberts. The photocell shall be mounted on a G-40 pole in the middle of a lot with an unobstructed view to the north sky.

Lighting system controls shall be compatible with the Automated Energy Management System (AEMS).

4.4.8 Site Lighting Retrofit:

When retrofitting site lighting in for existing stations, lamps shall be replaced as follows, depending on location and specific circumstances:

1. Incandescent lamps:	Replace with compact fluorescent or tungsten halogen
2. Mercury Vapor:	Replace with metal halide or high-pressure sodium

4.5 LIGHTING CRITERIA TABLES

4.5.1 Underground Stations Lighting Criteria:

STATION AREA	AVERAGE ILLUMINATION LEVEL		MINIMUM ILLUMINATION LEVEL	
	MAINTAINED	INITIAL	MAINTAINED	INITIAL
Platform Open to Vault Above	10 FC	18 FC	3 FC	5 FC
	Average Luminance of Vault: 10 Foot lamberts			
Platform Under Mezzanine	10 FC	18 FC	3 FC	5 FC
Mezzanine	10 FC	18 FC	3 FC	5 FC

STATION AREA	AVERAGE ILLUMINATION LEVEL		MINIMUM ILLUMINATION LEVEL	
	MAINTAINED	INITIAL	MAINTAINED	INITIAL
	Average Luminance of Vault: 10 Foot lamberts			
Kiosk	30 FC	43 FC	15 FC	21 FC
Passageways	10 FC	18 FC	3 FC	5 FC
Stairs Landings, Escalator compatible	10 FC	14 FC	5 FC	7 FC
Stair and Escalator Treads	10 FC	14 FC	5 FC	10 FC
Station Entrance Within 30-ft. of the Entrance or Parapet Wall	3 FC	4.3 FC	1 FC	1.4 FC
Faregates	20 FC	28 FC	10 FC	14 FC
Farecard Vendors and Smartrip Card Dispensers	20 FC (Vertical)	28 FC	10 FC (Vertical)	14 FC

4.5.2 Above Ground Station Lighting Criteria:

STATION AREA	AVERAGE ILLUMINATION LEVEL		MINIMUM ILLUMINATION LEVEL	
	MAINTAINED	INITIAL	MAINTAINED	INITIAL
Platform -- Under Canopy	10 FC	14 FC	3 FC	4 FC
Platform -- Outside Canopy	10 FC	14 FC	3 FC	4 FC
Mezzanine	10 FC	14 FC	3 FC	4 FC
Platform Edge, Kiosk Passageways, Stairs, Escalators, Faregates, Farecard Vendors and Smartrip Card Dispensers, Ancillary Spaces			See Table 4.5.1	

4.5.3 Exterior Space Site Lighting Criteria:

STATION AREA	AVERAGE ILLUMINATION LEVEL		MINIMUM ILLUMINATION LEVEL	
	MAINTAINED	INITIAL	MAINTAINED	INITIAL
Parking Lots	3 FC	4.3 FC	1 FC	1.4 FC
Pedestrian Walkways	3 FC	4.3 FC	1 FC	1.4 FC
Bus Platforms	3 FC	4.3 FC	1 FC	1.4 FC
Bus Shelters	20 FC	29 FC	10 FC	14 FC
Kiss & Ride	3 FC	4.3 FC	1 F.C.	1.4 FC
Parking Structures: Stairs & Vestibules Ramps and Corner	10 FC	14 FC	5 FC	7.1 FC
Parking Structures: Covered Decks	5 FC (50 FC daytime at vehicle entrance/exit area)	7.1 FC	3 FC	4.3 FC
Parking Structures: Roof Decks	3 FC	4.3 FC	1 FC	1.4 FC
Structured Bus and Kiss & Ride Areas	5 FC	7.1 FC	3 FC	4.3 FC

4.6 LIGHTING SUMMARY:

Minimum maintained illumination levels shall be measured horizontally @3 ft. above the floor or ground, and at stair & escalator treads.

4.6.1 Station and Site Lighting Maintenance Factors:

Direct lighting	0.70
Indirect Lighting	0.55
Site & Parking Structure Lighting	0.64

SECTION 5 (NOT USED)

SECTION 6 BUS FACILITIES

6.1 Facility Types

6.1.1 A modern bus maintenance facility is classified as a Level I, II, or III, depending on the kind of maintenance and servicing provided:

6.1.1.1 Level I. A primary service facility providing running maintenance and storage. Activities include fueling, washing, fare collection, light-bulb replacement, wiper-blade replacement, fuel-level checks, etc.

6.1.1.2 Level II. A secondary maintenance facility, sometimes called an inspection garage for light maintenance, i.e., engine tune-ups, lubrications, inspections, tire changing, brake repair, and minor body work, as well as unit change out.

6.1.1.3 Level III. A tertiary maintenance garage that is basically a full maintenance garage. Activities include engine and transmission rebuilding, testing, major body repairs, painting, etc.

6.1.2 Most modern bus maintenance facilities are a combination of Levels I, II, and III. A typical large city or regional bus transportation system generally has a large central Level III shop served by satellite combination Level I and II garages. The central shop provides major component repair and overhaul of units shipped to it from the satellite garages. The secondary garages provide all Level I and II operations as well as unit replacement, but no major repairs. On the other hand, a small local transit company is most efficiently served by a Level I or II garage, with major maintenance sent out to contract garages.

6.1.3 This criteria is primarily for a Level II facility servicing diesel fuel buses. Section 21 addresses compressed natural gas (CNG) vehicles.

6.2 Bus Service Area

6.2.1 General Design Considerations

6.2.1.1 Bus servicing is performed as a daily routine that includes fare removal, refueling, interior and exterior cleaning and some minor maintenance/fluid checks. Smooth operation of the bus servicing facilities is one of the most important functions of the entire maintenance facility because it has a direct impact on time and schedules. Service lanes must facilitate as quick a turnaround time as possible. The location and layout of all items within the service area is critical in accomplishing this goal. The following section will provide general guidelines toward that end, with the understanding they should be customized as required by the unique aspects of the specific maintenance facility under consideration.

6.2.1.2 The service lanes should be flexible enough to handle all the different models and sizes of buses in the existing fleet, as well as what is anticipated for the future. It is imperative to obtain and understand this information before designing the service area.

6.2.1.3 The service lanes should be immediately accessible upon entering the maintenance facility. The order of operation is:

6.2.1.3.1 Queuing
6.2.1.3.2 Fare removal
6.2.1.3.3 Exterior cleaning
6.2.1.3.4 Interior cleaning (usually done at the same time as fueling service)

6.2.1.3.5 Fueling and minor maintenance/fluid checks

6.2.1.4 Since fueling and washing take approximately the same amount of time, a linear (inline) design configuration provides the greatest efficiency of operation. In this design, buses can be refueled while the previous bus is being washed. The linear configuration is WMATA's preferred design for service lanes.

6.2.1.5 While WMATA's preferred standard facility houses the service lanes and maintenance area in the same building, the linear design allows for the entire servicing lane operation to be housed in a separate building from the maintenance operation if, because of site issues, that juxtaposition is deemed appropriate. Another variation used by some transit operations is to completely segregate washing from the other service lane activities. In the linear configuration, service lanes can act like wind-tunnels. Spray from washers can blow back through the servicing area, making an unpleasant working environment in cooler weather. Serious consideration should be given as to which of these variations is appropriate dependent upon wind and weather conditions, the specific site configuration and the specific operational requirements of the individual facility under design.

6.2.1.6 The number of service lanes required is determined by a combination of the total number of buses serviced by the facility and the amount of time allocated to this activity. To assist in this determination, it should be noted that based upon an operational average of six (6) minutes to wash a bus, ten (10) buses in one lane can be washed in one (1) hour. As a general planning rule, one (1) service lane can service one hundred (100) buses per day. Additionally, one (1) "spare" service lane shall be provided for each facility. This "spare" lane will be used for fare removal, fueling, fluid checks, and interior cleaning. The "spare" lane shall also be provided with adequate utility services to accommodate a future bus wash system.

6.2.1.7 Consideration should be given to providing an exterior by-pass lane that by-passes the service lane when servicing is not necessary.

6.2.1.8 Fast actuating rollup doors shall be used for service lane entrance and exit doors.

6.3 Interdependencies

6.3.1 The interdependencies necessary in a bus maintenance facility are based on the basic systems evident in a garage and how they relate to one another.

6.3.2 The three basic systems, illustrated in Figure 6.1, are as follows:

6.3.2.1 System A: Fueling / cleaning / bus storage.
6.3.2.2 System B: Maintenance / parts / bus storage
6.3.2.3 System C: Administration / drivers / bus storage.

6.3.3 **System A** consists of the fueling of a bus, a level check of oil and other fluid levels, i.e. windshield-washing fluid, engine coolant, air, etc., and interior and exterior visual checks for defects. In addition, the bus is cleaned both inside and out and then sent to a storage area. It is in this phase that vehicle fare receipts are removed from the bus and into a coin room or vault pulling area, and also where brake inspections are often made. If an electronic fluid management system is present, data from the bus

is entered into that system.

6.3.4 **System B** is the maintenance area and, for a Level II facility, can be in the same building as the other systems or in its own separate building. Maintenance is either programmed maintenance based on the vehicle miles or breakdown maintenance because of vehicle failure. In either case, the need is identified in the servicing area of System A and the bus is then sent to a storage area to await maintenance. The maintenance area is the heart of any well-run transit operation. It is here that building design can affect great savings in time. A maintenance area consists of parking bays, some with work pits, others with lifts and some flat bays for doing maintenance work. Specialized areas are devoted to tires, air conditioning, de-greasing, upholstering, body work, painting, machine shop, carpentry, electronic fare boxes, batteries, testing, etc. The maintenance areas must be readily accessible to the parts area because the mechanics are constantly working with the parts department; much efficiency is lost if ready accessibility is not provided. Finally, the maintenance area must also be convenient to the storage area, both for retrieving buses to work on as well as returning repaired vehicles to service.

6.3.5 **System C** deals with the administration of the garage and the drivers who operate the buses on the road. This system has the most interrelationship with the other systems because of the need to know and control the activities in the other systems. This is particularly true of the money removed from the buses in the servicing system and, because of the large financial investment, of parts inventory associated with the maintenance area. Typically, drivers pick up their route and bus assignments in this area or relax between routes.

6.3.6 In reviewing the three systems, it is important to note the juxtaposition of key elements as well as the elements common to more than one system. For example, the receipts, although removed in System A, are controlled by System C. On the other hand, the storage area is common to all three systems. Figure 6.1 illustrates basic relationships:

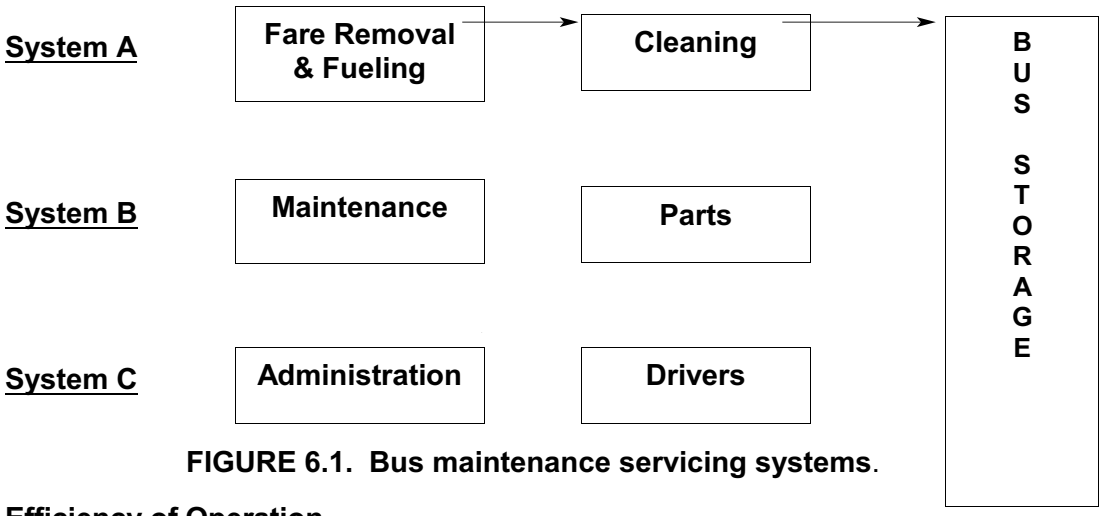

FIGURE 6.1. Bus maintenance servicing systems.

6.4 Efficiency of Operation

6.4.1 Efficiency of the operation is of paramount importance in the design of a bus maintenance facility since many of the operations are repetitive and are done time after time, day after day. Small savings in time and/or distance can have dramatic savings over the life of a facility.

6.4.2 Critical adjacencies among spaces are shown in Section 19, Figure 19.3. However, of equal importance is to design around a repair philosophy that results in having a crippled bus "down" for as little time as possible. The sooner it is back into revenue operation, the more advantageous it is to the operator.

6.4.3 Figure 6.2 shows, diagrammatically, the assembly line component repair that reflects this philosophy. The crippled bus arrives at location 1.0 and the damaged part is removed. Subsequently in 2.0 to 4.0 the part is disassembled, cleaned and sorted. A damaged, unusable part is either discarded in 4.3 or, if still under warranty, returned to the manufacturer for a new part. A serviceable part is either repaired in 5.0 or rebuilt in 6.0, and then tested in 7.0. The inventory and storage area, as a result, is critical to this operation since parts waiting for an assembly, parts replaceable under warranty, or tested assemblies waiting to be used, are constantly going back and forth.

6.4.3.1 The overall goal, in 8.0, is to have the crippled bus that arrived in 1.0, receive a new assembly in 8.0 and be back on the street as expeditiously are possible, without having to wait long periods of time to receive the proper part or assembly.

6.4.3.2 Upon adoption of this philosophy and subsequent design of a facility with this in mind, an efficient operation results.

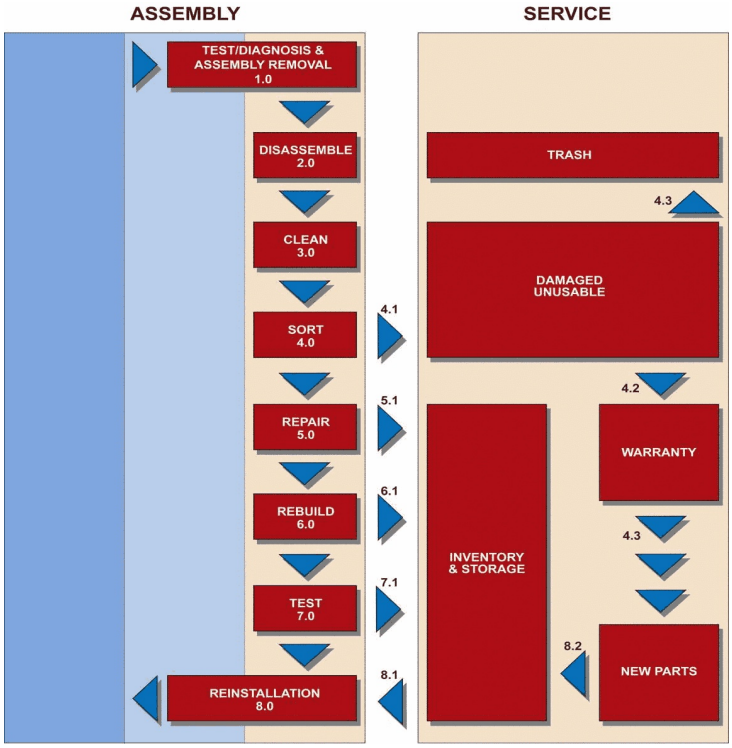

FIGURE 6.2 Component repair process.

6.5 Climatic Considerations

6.5.1 It is important to recognize that difficulties may arise when a modern diesel engine is stored in air temperatures below 40°F (4°C). As a result, special precautions must be taken for buses that operate in cold climates. Storage should be inside at

controlled temperatures of 50-55°°F (10-13◦°C), otherwise electric engine block heaters must be utilized or extraordinary means taken during cold weather, like running the buses during the night. For optimum performance, inside storage is preferable.

6.5.2 Warm-weather operations, on the other hand, are significantly different. Circulation patterns can be outside, and many of the system elements are often in separate buildings. One building might be for servicing and another for maintenance and administration. Also, the bus storage elements are generally outside. In this case, the need for shading and protecting the buses is of concern. A bus parked in the sun heats up and requires substantial running time of the engine and the air-conditioning unit to cool it before placing it in service. Bus-shading elements reduce the cool-down time and associated fuel usage.

6.5.3 WMATA is located in a “border line” area. While some cold, inclement days occur they are not, generally, enough to require an indoor bus storage area. For the occasional occurrence of less than 40◦°F weather, the engines may be leftrunning. On the other hand, there are enough hot, sunny days to require shading. As a result these standards will focus on a facility that provides outdoor storage, outdoor circulation, and shading for the parked vehicles.

6.6 Vehicle Configurations

6.6.1 In the following figures 6.3, 6.4 and 6.5 the profile and dimensions of typical buses that will use this facility and provide the design standards to be shown. It is important, however, to review the actual buses that will be using the garage, paying particular attention to the vehicle mix as well as any new bus innovations. In 1999, the first “low floor” buses were introduced and they had a major impact on some garages. See Standard Drawings ST-BUS-01 through ST-BUS-05.

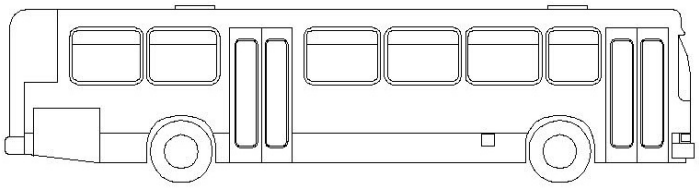

Figure 6.3

Standard Low Floor Transit Bus
Length 43'-3"
Width 11'-0"
Height 11'-5"
Outside Turning Radius 48'-0"
Inside Turning Radius 25'-0"

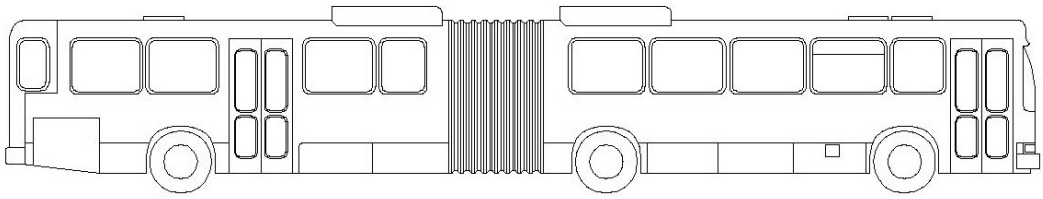

Figure 6.4

Articulated Low Floor Transit Bus
Length 66'-0"
Width 11'-0"
Height 11'-5"
Outside Turning Radius 45'-0"
Inside Turning Radius 23'-0"

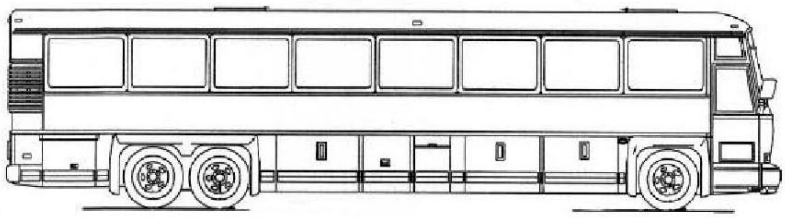

Figure 6.5

Intercity Coach Bus
Length 45’5”
Width 11'-0"
Height 11'-5"
Outside Turning Radius48'-0"
Inside Turning Radius 25'-0"

6.7 Criteria

6.7.1 Operational efficiency is the first and single most important factor in locating a bus maintenance facility. In doing so, the minimizing of deadhead time and miles is of critical importance. The time and miles necessary to reach the first stop and return from the last stop of a revenue-producing run is defined as deadheading. In the lifetime of a facility, these costs will dominate from an annual operating cost perspective.

6.7.2 To evaluate the deadhead time and miles it is first necessary to calculate, for a particular facility, the Center of Bus Operations (CBO). The CBO takes into account the number of buses and the routes they travel. The CBO is a hypothetical point which, if every bus started and finished at that point, would result in the generation of zero deadhead miles (non-revenue miles). Minimizing deadhead miles is an important factor in reducing operating costs. These reduced annual costs, can potentially offset initial adverse site development costs.

6.7.3 Site Size: The site should have a minimum area of 2.1 times the required combined area of the building, automobile parking and revenue vehicle parking. Also, it should

ideally be rectangular with a 2 to 1 ratio of sides.

6.7.4 Traffic: Volume of traffic on fronting streets and adjacent intersections should not be adversely affected by the buses. Sight distances for buses entering and exiting the site should be generous.

6.7.5 Circulation: Bus circulation on the site should be predominately counter-clockwise and provide an opportunity to separate vehicles by type (i.e. buses from cars from deliveries etc.). Sufficient space must be provided for turning of articulated buses. The maintenance area should be designed with a “drive through” traffic pattern to minimize the need for backing buses.

6.7.6 Utilities: Adequate utilities should be approximate to the facility and should also not have to be relocated.

6.7.7 Topography: The site should be relatively flat but still have adequate drainage.

6.7.8 Neighborhood: Zoning and land use should be appropriate and sites adjacent to residential areas, schools and churches should be avoided. The following chart on the next page illustrates zoning requirements for the areas in which WMATA operates. Local jurisdictions are to be consulted to verify zoning designation and proper land use regulations.

6.7.9 Site Contamination: Sites requiring extraordinary environmental remediation could impose substantial additional costs; on the other hand, they should not be considered “deal breakers”, since government aid may be available for clean up of sites termed “brownfields”, and, in many cases, development of such sites has proven satisfactory.

Zoning Requirements for Bus Maintenance Facilities						
County	Alexandria, VA	Arlington, VA	Fairfax, VA	Montgomery, MD	Prince George's, MD	DC
County Website	www.ci.alexandria.va.us	www.co.arlington.va.us	www.co.fairfax.va.us	www.co.mo.md.us	www.co.pg.md.us	www.dcra.dc.gov.org
Land Use Designation	UT	Vehicle Repair & Overhaul	WMATA Facilities	Vehicle Repair & Service	Vehicle Repair & Vehicle Storage Yard	2302 Repair Garage & 2302 Parking Lot
Where Permitted	UT	CM, M1, M2	PDH, PDC, PRC	C-2, C-3 I-1, I-4	I-1, I-2	All
Where Permitted with Special Exception			R-E, R-1, I-2 - 1-6, R-2, R-MHP, C-1, C-9, I-1			

6.8 Criteria Weighing

6.8.1 After site selection criteria are known, it is important for each facility under consideration to "weight" the importance of the criteria. The weighing objectives reflect the assessment of the relative importance of each criterion with respect to other criterion. For example, Operation Costs, which continue over the life of the building, will be given more weight than Construction Costs, which occur only at the beginning of the facility's life cycle. The weight given to zoning on the other hand may reflect the individual importance on a specific site. The resulting weighing of objectives is the second factor that the sites under consideration should be evaluated against.

6.8.2 Deal Breakers" in a site selection process are always present; however, they always include operational efficiency and size. A site in the wrong location, particularly with respect to deadhead cost, will have a very high annual operating cost. A site that is too small will certainly cause major compromises.

6.9 Service Lane Queuing

6.9.1 Storage

Bus servicing can be initiated in one of two ways. The way chosen is both an operational decision and a design decision. The first way is retrieval of a bus by a hostler (facility personnel who are responsible to retrieve buses for servicing and maintenance operations and then return them to their designated parking storage locations) from a parking space where it was left by an operator at the end of his

work shift. This parking space may be in the storage bays or an exterior staging area. The buses are then systematically serviced during off-peak hours. No bus awaiting service in this arrangement should extend into a street.

6.9.2 Immediate Queuing

The second way for bus servicing to be initiated is the bus operator bringing the bus directly to the maintenance facility for immediate servicing at the end of his work shift instead of to a parking area. This requires more queuing space directly on-site than retrieving buses from parking areas for servicing during off-peak hours. This space shall be exterior to the building, and should be of sufficient space to allow for peak-hour queuing.

6.10 Bus Facility Administrative and Operational Requirements

6.10.1 General Description

The Administrative & Operations Area consists of functions required for the smooth day to day operations of the facility. These include offices for administrators and facilities for bus operators and their supervisory personnel. This area is separated from the maintenance area, with particular attention given to relationships between dispatchers, bus driver's day room, bus parking, employee parking and locker room facilities.

6.10.2 Functional Space Descriptions

Space requirements for this area are dependent on the fleet size and level of management at the particular facility. Refer to Section 18 for further elaboration in this regard. In general adequate space for the following shall be provided:

6.10.2.1 Dispatcher Room: The daily routines of the bus system are conducted by the dispatcher. These include the dispatching of bus drivers, route schedules and record keeping. The dispatch room shall have direct visual contact with buses entering / leaving the facility and the bus storage area.

6.10.2.2 Day Room: This room is the place where the bus drivers report for duty, spend off time between runs, prepare necessary reports and have meals. Typically it is divided between an active area and a more quiet space. Allocation of 15 sq. ft. per person for this area is adequate. In addition, space for kitchenette and vending machines shall be planned. The Day Room is adjacent to the dispatcher, separated by a pass thru window. The dispatcher should also be able to view the entire space. There should be easy access from employee parking, bus parking, locker and toilet facilities.

6.10.2.3 Supervisor Room: Shall be located convenient to their area of supervision and their office shall include some degree of privacy for consultation purposes.

6.10.2.4 Lockers and Toilet Facilities: Separate facilities for male and female management and male and female hourly employees are required. Female facilities shall be designed for expandability to a 50/50 male/female ratio, where initial requirements are for less than this ratio.

6.10.2.5 Training / Conference: These spaces may or may not be combined depending on the facility size, larger facilities tending to have separate spaces. The rooms should be sized at 15 SF per person. Acoustical and climate control within the room shall be carefully considered and acoustical

separation from adjoining rooms is essential. Lighting of the room shall be designed to function for the type of presentations intended. Within the training room considerations for bus simulation equipment may be necessary.

6.10.2.6 Facility Manager's Office: Office shall be adequately sized to provide space for the necessary furnishings. Should provide for closed door private conversations. Offices for general managers shall be designed to provide space for small meetings within the room.

6.10.2.7 General Office: This space is sized according to the level of management of the facility. The Administrative and Clerical Personnel are the space users and should be located conveniently to all upper management.

6.10.2.8 Storage: Rooms and areas for storage shall be carefully considered for size and conveniently located according to need.

6.10.2.9 Furniture Requirements: The following chart represents the types of furnishings that are normally found in the different types of spaces. Quantities and specific types need to be decided during program development of the specific facility.

Equipment	SPACE TYPE										Remarks
	Manager Office	General Office	Dispatcher	Day Room	Supervisor	Conference Room	Training Room	Storage	Drivers Locker Room	Management Locker Room	
Staff Desks	..	..	..		..						
Desk Chair	..	..	..		..						
Side Chairs	..	..			..	..	..				
File Cabinets	..	..	..		..						
Shelving	..						..	..	..		May be fixed or movable
Wastebasket	..	..	..	..	..	..	..		..	..	
Large Lockers					..						
1/ 2 Height Lockers									..	..	
Benches									..	..	
Lunch Tables				..							
Café Seating				..							
Tackboards	..	..	..	..	..	..	..		..	..	
Chalkboards			..			..	..				
Projection Screen						..	..				

Figure 6.6 - Furniture Requirements

6.11 FARE REMOVAL

6.11.1 WMATA System: The WMATA system for fare collection is:

6.11.1.1 To have the fare removal as the first step of the service lane operation and,

6.11.1.2 To have the fare box removed from the bus and placed inside a fare box collection unit, the money is removed, the empty fare box is immediately replaced in the bus, and the bus continues on for service.

6.11.1.3 2 CCTV camera/vault.

6.11.2 Fare Box Maintenance Area (Electrical Shop): A Fare Box Maintenance Room, shall be located parallel to the fuel dispensing station. The Fare Box Maintenance Room shall be a secured minimum 20' x 20' space and shall be separated with a masonry wall for security reasons. All windows in the Fare Box Maintenance Room shall have bullet-resistant glass and should be alarmed. Access doors should also be alarmed for security reasons. The room shall be provided with sufficient work benches, electrical power for computers, security camera, lighting, HVAC, electrical resistance heaters and test equipment.

6.11.2.1 Fare box collection equipment will be purchased and installed per WMATA requirements as the bus maintenance facility is constructed. Adequate space, power service and data service shall be provided. Coordinate specific requirements with WMATA.

6.12 FUELING AND MAINTENANCE FLUIDS/UTILITIES

6.12.1 Fueling: Each service lane shall have it's own diesel fuel dispensing system, which shall be connected to the fluid monitoring system.

6.12.1.1 The fuel dispenser in the service lane shall not be located further than 50 feet from the building entrance, per NFPA 30A.

6.12.1.2 Fueling Hose and Nozzle (Revenue Vehicles): ~~Acceptable Products are the FF-619TR Hose and FF-642-TR Posi/Lock 105 Nozzle by FFS Inc. or equivalent. This is a~~ A flexible 1 inch hose and fueling nozzle with swivel feature, which operates only when connected to an adapter on the vehicle, eliminating spills and reducing odors. Include hose rest hooks to accommodate extra length hose. Nozzles shall be 8 inches long.

6.12.1.3 Overhead Tramway Fueling System: ~~Acceptable Products are Model FF-2000-TS by FFS Inc. or equivalent.~~ This system is an overhead suspended fueling hose and post mounted support system which allows all fleet vehicles to be refueled with one nozzle within a 20'-0" fueling envelope length, and with spill-proof separation feature in the event the refueling vehicle moves away from the fuel island with the nozzle still attached. Install with 12'-0" minimum clear height and 4'-0" from edge of fueling lane, unless otherwise indicated. Included with the system shall be one (1) stainless steel 24" desk top, which is mounted on one of the support posts.

6.12.1.4 Fuel Dispensing Pump: ~~Acceptable products shall be Model 9140 by Gasboy International Inc. or equivalent.~~ This is a traditional mechanical registration type dispenser, and accommodates twin hoses as required by WMATA. One for revenue vehicles and one for non-revenue vehicles, which shall be fitted with a standard fueling nozzle. Include provisions for connection to fluid management system, filter and vapor recovery.

6.12.1.5 Controls: The transfer of diesel fuel from storage tanks to the dispensers shall be regulated from one of two control cabinets. The main control cabinet shall be located as directed by WMATA. A remote control cabinet shall be located in the fueling area. This cabinet shall include a "mushroom" panic button to shut down the system in case of emergency. Level indication should be here also.

6.12.1.5.1 The main control panel shall be self contained and shall include the following:

6.12.1.5.1.1 Starters and circuit breakers

6.12.1.5.1.2 H-O-A switches for each pump

6.12.1.5.1.3 Test switches

6.12.1.5.1.4 Running lights – indicators for each pump

6.12.1.5.1.5 Required switches for the remote control panel

6.12.1.5.2 The remote control panel shall include running light indicators, selector switch and low tank level indicators.

6.13 FUELING AND MAINTENANCE FLUIDS/UTILITIES

6.13.1 Fueling: Each service lane shall have it's own diesel fuel dispensing system, which shall be connected to the fluid monitoring system.

6.13.1.1 The fuel dispenser in the service lane shall not be located further than 50 feet from the building entrance, per NFPA 30A.

6.13.1.2 Fueling Hose and Nozzle (Revenue Vehicles): ~~Acceptable Products are the FF-619TR Hose and FF-642-TR Posi/Lock 105 Nozzle by FFS Inc. or equivalent. This is a~~ A flexible 1 inch hose and fueling nozzle with swivel feature, which operates only when connected to an adapter on the vehicle, eliminating spills and reducing odors. Include hose rest hooks to accommodate extra length hose. Nozzles shall be 8 inches long.

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6.13.1.5.1.2 H-O-A switches for each pump

6.13.1.5.1.3 Test switches

6.13.1.5.1.4 Running lights – indicators for each pump

6.13.1.5.1.5 Required switches for the remote control panel

6.13.1.5.2 The remote control panel shall include running light indicators, selector switch and low tank level indicators.

6.13.2 Storage Tanks

6.13.2.1 Underground Storage Tanks

6.13.2.1.1 The diesel gasoline and other fluid systems shall conform to the latest requirements of the N.F.P.A., the EPA, CENF, and all state and local codes, including the District of Columbia Fire Department. All underground fuel and fluid storage tanks shall be located outside the building. While an underground location is preferable from a safety and security perspective, the environmental implications must be considered. WMATA'S facilities typically utilize underground tanks for all fuel and fluids except, where possible, above ground storage tanks are used.

6.13.2.1.2 Gasoline fuel is prohibited by N.F.P.A. from being stored or dispensed inside the building.

6.13.2.1.3 A popular storage capacity in the past was 150 – 200 gallons per bus which would be equivalent to four to six days of normal operation for buses realizing 5 miles per gallon. Economics and today's fuel situation has altered that parameter. The following are average storage capacities for a 150 bus maintenance facility:

6.13.2.1.3.1	Diesel Fuel	2 – 20,000 Gallon Storage Tanks
6.13.2.1.3.2	Engine ~~Motor~~ Oil	2 – 3,000 Gallon Storage Tanks

6.13.2.1.3.3	Automatic Transmission Fluid	1 – 6,000 Gallon Storage Tank
6.13.2.1.3.4	Engine Coolant ~~Antifreeze~~	1– 6,000 Gallon Storage Tank
6.13.2.1.3.5	Gasoline (Non-Revenue Vehicles)	1 – 8,000 Gallon Storage Tank

6.13.2.1.4 All fuel and fluid storage tanks shall be constructed of double-wall fiberglass in accordance with UL 1316, and shall be connected to the fluid monitoring system (See Section 18.7.). All piping shall enter the tank through a man way. Each tank shall be provided with the following:

6.13.2.1.4.1 Two watertight man ways

6.13.2.1.4.2 Mechanical high level cut-off valve

6.13.2.1.4.3 Interstitial and man way leak detection

6.13.2.1.4.4 Positive displacement flow meter.

6.13.2.1.4.5 Inventory control and high level alarm systems

6.13.2.1.4.6 Fill cap with 15 gallon, below grade catchment basin vent connections

6.13.2.1.4.7 Overfill prevention (fill limiter valve and audible alarm)

6.13.2.1.4.8 Individual service access for all functions.

6.13.2.1.5 Roadway manhole covers over the man ways shall be constructed of fiberglass and have an H-20 rating. The covers shall be configured to prevent water entry.

6.13.2.1.6 The leak detection system shall be connected to an audio visual alarm at a 24-hour manned location. The over-fill alarm shall be connected to an audio visual alarm mounted near, and in sight of, the fill box.

6.13.2.1.7 Buried tanks containing petroleum products (diesel, gasoline, oil, etc.) shall be within a structure that prevents any transfer of surface loads to the fiberglass tanks. The District of Columbia Fire Department or other authorities outside of the District shall approve the design and inspect the installation.

6.13.2.1.8 Underground storage tanks containing flammable or combustible liquids shall be buried not less than 2 feet below grade. Underground storage tanks shall be located a sufficient distance from the facility per applicable code, Fire Marshall and Insurance carrier requirements.

6.13.2.1.9 The underground storage tanks shall be vented separately to the exterior. The vent shall discharge not less than 12 feet above the adjacent ground level and terminate with a vent cap to minimize the effect of weather and air borne dirt. The vent discharge point shall not be closer than 15 feet from any operable building opening or outside air intake.

6.13.2.1.10 All underground piping shall be double-wall fiberglass, sloped toward the tank. Piping that cannot be sloped shall be provided with a point type or long line leak detection system. Fill lines shall be provided with flow meters and spill containment with a hinged roadway cover. The flow meter shall have remote readout mounted in the Superintendent's office.

6.13.2.1.11 Underground storage tank areas shall be paved over so delivery trucks have easier access and do not block bus circulation.

6.13.2.1.12 Pumping System: One submersible pump shall be provided with each storage tank. The diesel fuel pumps shall be manifolded and shall be connected and valved so that each pump may feed any or all of the diesel fuel dispensers. A filtration system consisting of dual filters and a water separator shall be provided in each fuel dispenser line. An emergency, mushroom style, shunt-trip switch shall be located on the facility wall such that in the case of an emergency power will be cut to all underground storage systems. The emergency shut-off switch will be located not greater than 75 feet from the dispensers. The diesel pumps shall have a capacity of 50 GPM and the gasoline pump (if required) shall have a capacity of 10 GPM.

6.13.2.2 Above Ground Storage Tanks.

6.13.2.2.1 If above ground storage tanks are used for maintenance fluids (not including diesel fuel), and are located within the building, they shall be located in a 2-hour rated lubrication room. The amount of fluid stored in this room shall not exceed 10 gallons per square foot. This room shall not exceed 500 square feet in area and shall have the floor slab depressed a minimum of 4" from the surrounding floor slab. All joints in this room must be fluid-tight. In lieu of a 2-hour room, 2-hour rated tanks, UL rated 2085, may be used, if allowed or if required by the local fire Marshall and code officials.

6.13.2.2.2 All above ground fuel and fluid dispensing piping shall be schedule #40, black steel. Fitting and valve classification shall be as appropriate for the pump discharge pressure plus 25% but in no case less than class 150. All above ground fuel and fluid dispensing piping shall be painted in accordance with WMATA's standard color code. The fuel and fluid dispensing piping shall be further identified with plastic pipe markers, which will also indicate the direction of fluid flow.

6.13.2.2.3 Maintenance fluids typically stored in the building in above ground tanks would be ~~antifreeze solution~~ engine coolant, automatic transmission fluid, new ~~motor~~ engine oil and used ~~motor~~ engine oil. These tanks would be connected to the overhead service reels. The remaining maintenance fluids would typically be stored in multiple 55-gallon drums on spill-pallets. These would be chassis grease, gear oil ~~lubricant~~, windshield washer fluid, and wheelchair oil. These drums would be connected to the overhead service reels.

6.13.2.2.4 Used oil recovered from the buses shall be stored in an above ground used oil storage tank of minimum 2000 gallon capacity~~, equivalent to Safe Waste Aboveground Storage Systems Model FRSW 1000 by Containment Solutions~~. The tank shall be double wall steel with a corrosion resistant coating and a 2 hour fire rating (UL 2085). The tank unit shall include primary tank, secondary containment chamber, leak

detection system, vent, pump, suction tube, discharge hose and shall be furnished with roll collection caddys. The tank and fittings shall conform with NFPA 30, 30A and UL requirements.

6.14 OVERHEAD SERVICE REELS

6.14.1 The following maintenance fluids and utilities shall be provided by means of properly labeled overhead service reels at each fueling station in the service lane:

6.14.1.1 Engine coolant (EC) ~~Antifreeze~~

6.14.1.2 Automatic transmission fluid (ATF)

6.14.1.3 Compressed air (CA)

6.14.1.4 Engine ~~Motor~~ oil (EO)

6.14.1.5 Water

6.14.1.6 Chassis grease (CG)

6.14.1.7 Gear oil (GO)

6.14.1.8 Windshield washer fluid (WWF)

6.14.2 Overhead service reels shall be of heavy duty double pedestal frame design, spring powered and self-retracting constructed from non-sparking alloy for use in fueling environments~~;~~. ~~with double pedestal arm design adjustable to 360 degrees~~. ~~Manufacturers shall be Graco, Sampson Corp. or equivalent.~~

6.14.3 Hose

6.14.3.1 CA & WWF - 65' x 3/8" ID 300 psi pressure rating
6.14.3.2 GO, ATF & EC - 50' x ½" ID 2000 psi pressure rating
6.14.3.3 CG - 50' x 3/8" ID 4000 psi pressure rating

6.14.4 All piping shall be as described previously in Section 18.4.2.2 for above-ground storage tanks.

6.14.5 All fluid transfer pumps for overhead service reels shall be air driven, self-priming positive displacement pneumatically operated pumps. Provide pumps capable of mounting on top of 55 gallon drums where used. Provide controls to automatically start and stop pumps when fluid is required at the overhead service reels. All pumps to operated below OSHA noise standards.

6.15 CLEANING

6.15.1 Bus Interior Cleaning

6.15.1.1 Methods / Equipment

6.15.1.1.1 In the linear (in-line) service lane design, the interior cleaning of the buses is done as part of the service lane operation. This interior

cleaning is done by means of a 4" diameter hose vacuuming system, and is done at the same time the bus is being fueled.

6.15.1.1.2 Portable air blowers are used by the workman to sweep the seats and floor to dislodge dirt, papers and other debris which will be drawn into the vacuum hose and deposited into a portable dumpster. The transportation air then passes thru a secondary filter to remove particulate matter prior to its return to the building space.

6.15.1.1.3 The Vacuum shall be designed to provide for the collection of debris in dry form and discharge after compaction of same into a loading dumpster of the type presently used. Provisions shall be made for minimizing the exhaust of dust inside the building through double filtration. 100% of the air input shall be returned to the garage area.

6.15.2 Bus Exterior Cleaning

6.15.2.1 Methods and Equipment Options

6.15.2.1.1 Bus washing is the final element of the service cycle prior to parking the bus in its storage space. Preferably there is one bus washer unit per service lane. One washer unit may serve more than one service lane, but adequate space must be provided to by-pass or line up a bus for the washer. If fewer washers than service lanes are provided, the lanes without washers should be provided with piping and wiring to accommodate the addition of a future washer unit.

6.15.2.1.2 Provide the bus washer as part of the service lane operation and to provide one washer unit per individual service lane.

6.15.2.1.3 There are several alternatives available in regard to type and operation of bus washers. Minimum Automatic Washers have a rotating brush and water spray side-washing capability. Complete automatic washers have additional front and rear capability with rotating brushes that move across the front and rear as the bus progresses through the device. The roof washer is usually a wet mop, however, a rotating brush is available. Wheel washers consisting of a high pressure water spray are sometimes used.

6.15.2.1.4 There are two types of automatic bus washer systems commonly available, the Drive Thru type and the Gantry type. The Drive Thru System is the type generally used at a service island. Following fuel servicing and vacuum cleaning, the bus is driven slowly thru the washer. Upon leaving the washer, if a stripper has been made part of the system, it will dry off the bus with high velocity air prior to the bus being parked.

6.15.2.1.5 When a Gantry System is employed, generally for fleets with 35 buses or less, the bus is driven to the Gantry location and parked between guide rails. Adjacent to the guide rails is tracks on which the Gantry travels. Adjacent to the tracks is usually a wall on which a traveling umbilical is mounted which supplies air, electric and water to the Gantry. The Gantry contains side and top brushes. When the start button is pushed, the top brush lowers itself to a position a few inches above the floor and the machine moves toward the vehicle traveling along the tracks. The Gantry moves along the length of the vehicle with the vertical brushes cleaning the sides and the top brush cleaning the front, roof and back of the vehicle. During this cycle water and soap are

sprayed on all surfaces. On its return pass the vehicle is rinsed with fresh water while the brushes counter-rotate. At the end of the rinse cycle all brushes automatically move aside to allow the vehicle to be drive away.

6.15.2.2 Drive Through Bus Washing System and Equipment: The drive thru type with a blower/dryer assembly and water reclamation system shall be as follows**:**

6.15.2.2.1 Operations: Washer components shall be automatically actuated in sequence by vehicles, primarily transit buses, driven in centered path between tire guides, at a nominal speed of 1.0 to 1.5 feet per second through wash washing stage without stopping. Entry shall be through a pumped pre-wetting/detergent application cycle, progressing through a brush washing cycle which shall effectively scrub all vertical body surfaces of front, sides and rear of vehicles including windshield and windows, using a minimum of four vertical rotary brushes, each equipped with detergent spray applicators. Effective washing of the horizontal and curved portions of the vehicle roof shall be by a full width oscillating mop augmented by a detergent spray applicator. Final rinse of the front, roof, sides, rear and wheels shall be by a canted rinse spray assembly. All equipment including piping, conduits, support devices, etc contained in this area or routed through this area to be of corrosion resistant material.

6.15.2.2.2 Major Components: Complete system shall include the following major components.

6.15.2.2.3 Automatic Controls: Vehicle actuated switch gear including prewired electric control panel and manual override controls. The bus wash shall be operated through an operator interface touch panel (HMI). The panel shall be connected to the WMATA Local Area Network for remote monitoring, alarm notification, and connectivity to the building information system. The HMI shall contain screens for diagnostic and analytical purposes to include but not limited to: all elements that automatically stop the operation of the system, pump or equipment run times for each pump, rotating brush etc., total number of succesfull wash cycles and number of incomplete cycles, number of successful cycles per day, gallons of water used and gallons of water discharged, gallons of detergent used, alarms or warnings for filter and backwashing status, event manager logs for every input.

6.15.2.2.4 Tire Guides: Full length, one pair min. 4" dia. tubular galvanized steel with capped ends and no breaks or edges which could damage tire sidewalls.

6.15.2.2.5 Skid Plates: One pair, flat 3/16" stainless steel mounted flush to slab. Angled entry section of tire guide shall minimize tire sidewall damage caused by resistance to lateral movement resulting from misaligned entry to vehicle washer. Plates to be nominally 3 feet wide tapering with tire guide angled to 2 feet wide at entrance to straight section of tire guides.

6.15.2.2.6 Pre-wetting/Detergent Spray Arch Assembly: Automatic, frame mounted, freestanding unit, positioned to provide optimum detergent penetration before brush wash cycle begins. Side nozzle pipe assemblies shall be canted away from approaching bus to provide sequential application of detergent starting at bottom and progressing to top of bus. Nozzle total output to be 20 gallons per minute at 40 psig and shall be of the quick disconnect type for easy removal for cleaning and replacement. Lowest point on each pipe to be fitted with valve to allow pipes to be fully drained during freezing conditions. Liquid detergent shall be stored in a 500 gal. poly tank.

6.15.2.2.7 Oscillating Mop: Roof mop assemblies shall be suspended from two separate frames supporting three mops each. Mops to be mildew resistant Ozite type carpet hung from galvanized steel frame. Each frame shall be hung by 2 pieces of Goodyear four ply conveyor belting (12000 lb combined pull strength). Sprays shall supply 20 gallons per minute at 100 psig lowest point to be fitted with valve for draining. High pressure spray at 90 gpm and 200 psig shall be angled to hit the fronts, hoods, wheels and windshields of the vehicles ~~Full width with integral detergent spray assembly~~.

6.15.2.2.8 Vertical Brushes: Washing of bus vertical surfaces shall be by four electrically driven rotary brushes with integral detergent spray and supporting frame assembly. The brush yoke arm shall be curved to allow clearance for the extreme corners of the bus during the washing motion. All brush shaft and brush yoke bearings shall be protected from moisture. Movement of brush arm shall be by pneumatic cyclinders, brush yokes shall retract when power is off, permitting unobstructed vehicle passage through wash lane ~~Four rotary brushes with integral detergent spray and supporting frame assembly~~.

6.15.2.2.9 Rinse Spray Arch: Automatic frame mounted, free standing, fresh water unit.

6.15.2.2.10 Washer Equipment Miscellaneous: Brush yokes, support structure, columns, base plates, anchor bolts, pump, detergent storage tanks and detergent distribution system.

6.15.2.2.11 Radiant heated concrete floor slab from end of bus wash equipment to exit door. Exit shall be designed in order to reduce or eliminate ice build up on slab.

6.15.2.2.12 Water Reclamation System: As follows:

6.15.2.2.12.1 Waste water run-off from the bus washer is collected in a reticulent drain, under and parallel to the bus, and is directed to a sump-well in which grit settles out of the liquid. A pump transfers this liquid to a separate adjacent storage-well through a filter that removes most of the suspended impurities. This clarified water is then pumped back to the bus washer by a separate hi-pressure pump for reuse in the wash cycle. Fresh water make-up is provided by the final rinse arch. Also, additional fresh water is added to the clarified water in the storage well to account for water lost by evaporation and carried away by the vehicle. A separate storage-well and pump system is provided for the wheel washer system. Provide closed tanks and water recirculation to control odor accumulation.

6.15.2.2.12.2 The bus washes and water reclamation system shall be controlled through a central HMI panel located in the Water Reclamation Area. Bus wash shall be part of the building monitoring system.

6.16 FLUID MONITORING SYSTEM.

6.16.1 The bus garage will be furnished with a fluid monitoring and leak detection system. The System shall monitor all storage tank levels and fluid usage. The monitoring system shall be computer based capable of providing but not limited to high and low level alarming, leak detection alarming, vehicle usage and mileage reports, vehicle bar code identification, pump/meter usage reports, product reports, time and date reports, inventory, inventory reconciliation and tank levels, and fleet reports. The system shall also be capable of providing remote access to allow the downloading of all the reports.

6.16.2 The system design shall be based on the Veeder Root TLS-PC system and supporting monitoring consoles and software. In addition to the level and metering devices the system shall be furnished with a personal computer, modem, report printer, Windows® based software and a stand alone monitoring consoles. All of the computer related devices and software shall be the most recent technology and releases.

6.17 Paint Preparation Area, Paint Booth and Paint Shop

6.17.1.1 Provide a paint preparation area large enough for an articulated bus to be cleaned, sanded, filled and otherwise prepared to receive new paint in the paint booth. Provide adequate space all around the bus for mechanics, materials, tools and equipment. Refer to Section 14.19 for ventilation and exhaust requirements.

6.17.1.2 Paint Booth: Provide a fully enclosed, prefabricated pressurized cross-draft type vehicle paint room (booth) for spray painting of buses and large trucks.~~; equivalent to Dry Arrestor Truck and Large Equipment Booth by JBI Inc.~~ Booth shall be large enough to accommodate articulated buses and shall be provided complete with fluorescent lighting, heavy duty exhaust with totally enclosed fan cooled motor, personnel access doors, product doors, manometer (draft gauge), man lift, intake and exhaust filters with grids, and all necessary hardware. Construction shall be heavy duty, of minimum 18 gauge sheet steel panels, fabricated to provide a smooth interior surface. Refer to Section 14.19 for breathing air system and further ventilation requirements.

6.17.1.3 Provide a Paint Shop Room adjacent to the paint booth for storage, mixing and containerizing of paints. Provide a Paint Shop Room adjacent to the paint booth for storage, mixing and containerizing of paints. Room to be ventilated and heated and contain a flammable material cabinet.

6.18 Steam Clean / Chassis Wash Bay

Provide one fully enclosed area for steam cleaning of buses, preferably located adjacent to the lift bays and arranged for the same drive-forward-and-through-access as previously discussed. The bay shall be provided with a stainless steel parallelogram lift .Provide high pressure hot water cleaners specified above in this area. Equipment for this area to be located in

adjacent area if possible in order to protected against water/corrosion. If equipment is located in bay then equipment should be shielded in order to protect it from water. This area to be provide with a hose bibb and compressed air (disconnects on wall located per detailed design). Equipment located in this area to be rated for water environment (waterproof and watertight) and constructed of corrosion resistant material. Forklift access to this area will be required.

6.19 Parts Storage

Parts storage shall be provided in vertical carousel part storage systems, similar to a Kardex Remstar system. This system has a large floor load ensure that the floor slab is properly rated. Provide a secure room for parts storage, for the dispensing of replacement parts for buses and for replacement parts for maintenance equipment. This room shall contain a Paint Storage System, large parts shelving, large parts storage cabinets and small parts drawer storage . Include a service door for parts deliveries.

6.20 Tire Storage

Provide a room for tire storage with enough height to accommodate vertical storage of tires and a jib crane and other tire handling equipment. Provide tire storage racks constructed of steel with typical construction as shown in Figure 6.8 below. Tire storage to be located adjacent to Tire Bay.

6.21 Secured Tool Storage

Provide an area room enclosed by a wire mesh partition with locking door, for secure storage of tools. Size of room shall be 15 by 25 feet minimum.

6.22 HVAC Repair Shop

Provide an enclosed room, temperature and humidity controlled, for repairs to HVAC equipment. Size of room shall be 15 by 25 feet minimum.

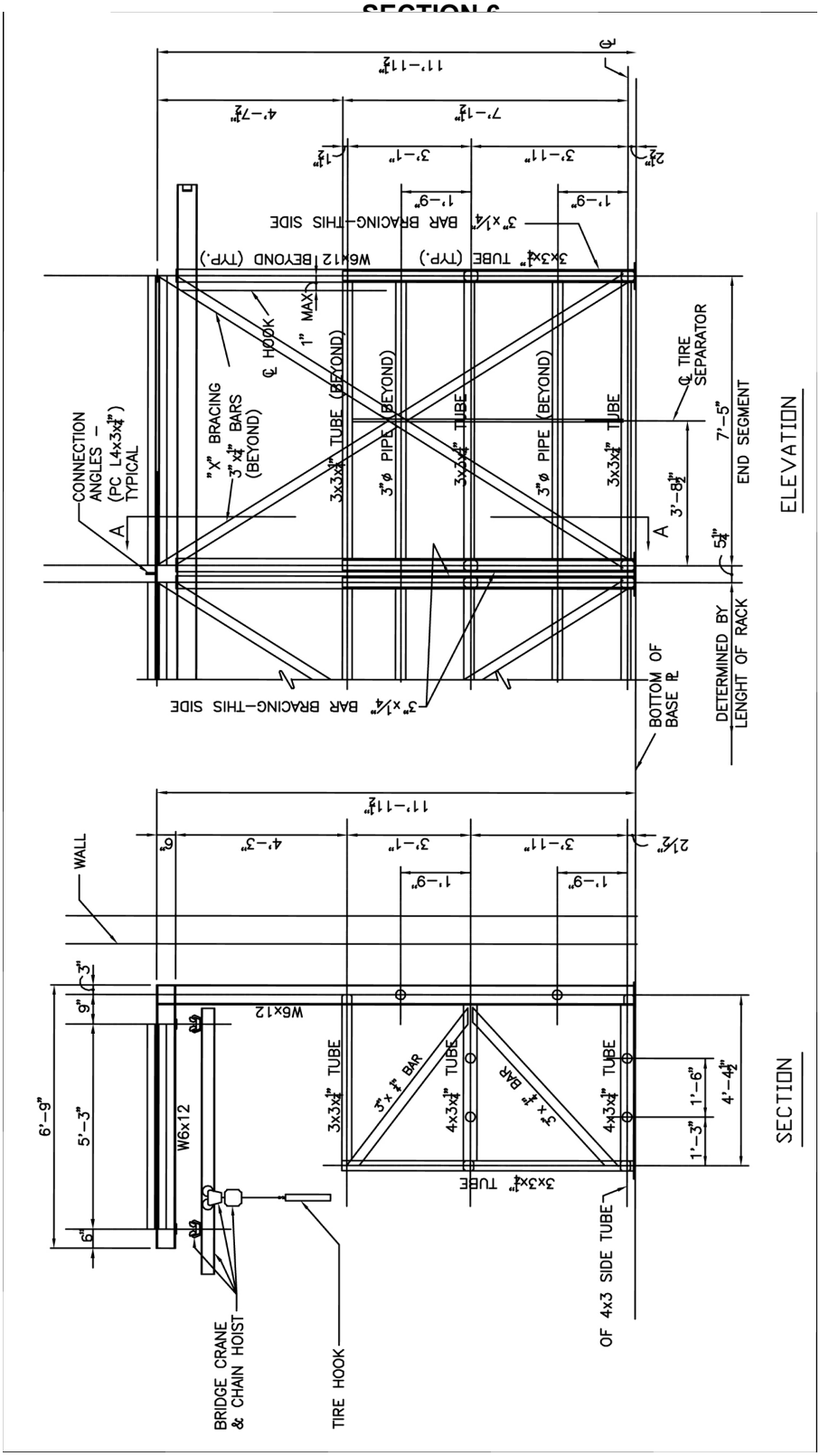


FIGURE 6.8 - Tire Storage Rack Details

6.23 TYPICAL SERVICE LANE DESIGN

6.23.1 Typical Plan Layout With Critical Dimensions: Refer to Figure 6.9 .

6.23.1.1 Design Considerations

6.23.1.1.1 Dimensional Criteria

6.23.1.1.1.1 Drive Lane Between Curbs: 12'-0" Minimum.

6.23.1.1.1.2 Width of island between drive lanes if only fueling equipment is located on it: 6'-0" minimum.

6.23.1.1.1.3 Width of island between drive lanes for fueling equipment and bus vacuuming system located on it: 8'-0" minimum.

6.23.1.1.1.4 Width of island between drive lanes if fueling equipment is located on it and each drive lane has it's own bus wash unit: 12'-0" minimum.

6.23.1.1.1.5 Width of end island in service lane: 3'-0" minimum.

6.23.1.1.1.6 Width of entrance door into fueling area for a single drive lane: 15'-0" clear, minimum.

6.23.1.1.1.7 Width of single entrance door into fueling area for two drive lanes which share one bus wash unit: 30'-6" clear, minimum.

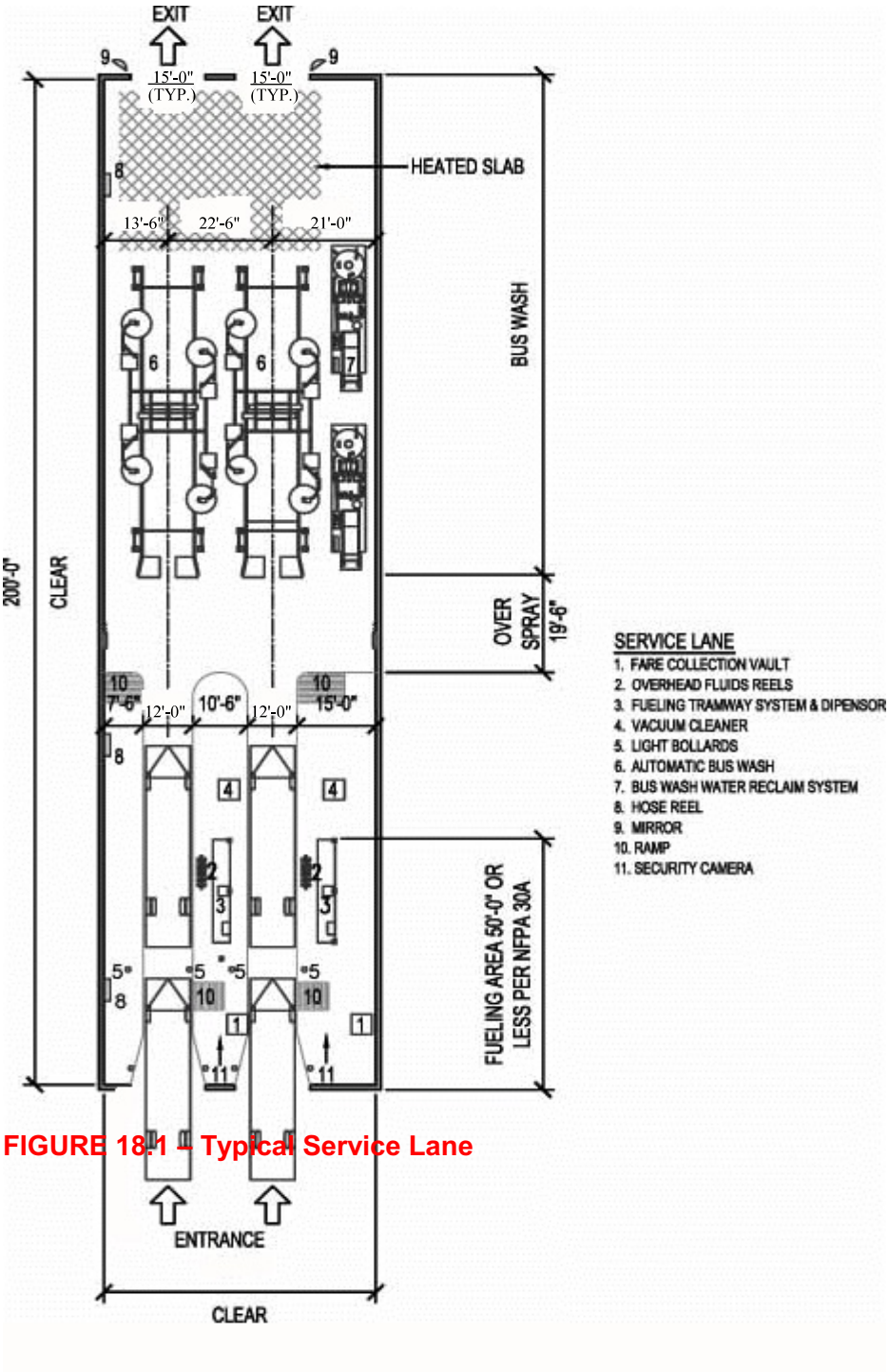


FIGURE 18.1 – Typical Service Lane

6.23.1.1.1.8 Width of entrance doors into fueling area for more than two drive lanes, each of which have it's own bus wash unit: Recommend 1 door per drive lane, each one 15'-0" clear, minimum.

6.23.1.1.1.9 Height of entrance doors: 15'-0" clear, minimum.

6.23.1.1.1.10 Minimum clear height required from the finish floor to the underside of any structure:

6.23.1.1.1.10.1	Service Lane	16'-0" clear
6.23.1.1.1.10.2	Maintenance Lift Area	20'-0" clear
6.23.1.1.1.10.3	Bus Storage Area (Shading)	15'-0" clear
6.23.1.1.1.10.4	Bus Parts Storeroom	10'-0" clear
6.23.1.1.1.10.5	Paint Booth	21'-0" clear
6.23.1.1.1.10.6	Boiler Room	16'-0" clear
6.23.1.1.1.10.7	Electrical Distribution Room	16'-0" clear
6.23.1.1.1.10.8	Communications Equipment Room	10'-0" clear
6.23.1.1.1.10.9	Office Areas	8'-0" clear
6.23.1.1.1.10.10	Repair Shops	12'-0" clear

6.23.1.1.1.11 Dispensing Equipment: The fuel dispensing system in the service lane can not be located no further than 50 feet from the building entrance.

6.23.1.1.2 Other Design Considerations

6.23.1.1.2.1 If an exterior apron is provided for exterior queuing of buses, it should be made of concrete and be sloped away from the building.

6.23.1.1.2.2 Queuing for buses in the service lanes should be planned and laid out to insure that there is no backup into a street when buses return at their peak rate.

6.23.1.1.2.3 One service lane will service approximately 100 buses per day.

6.23.1.1.2.4 If the fleet size requires only one service lane, consider providing two service lanes for fare collection, fueling and interior cleaning with a shared bus wash unit so that the fueling operation is not shut down due to equipment failure.

6.23.1.1.2.5 Consider a by-pass lane for buses not going through the wash cycle.

6.23.1.1.2.6 Consider a direct access from the service lanes to the maintenance area, located in the area between servicing and washing.

6.23.1.1.2.7 Verify that fueling hoses on a tramway are long enough to reach all filler-neck locations, especially where interior cleaning systems may fix the location of the buses front door in the service lane operation.

6.23.1.1.2.8 All fuel and fluids used in the service lane should be connected to the fluid monitoring system.

6.23.1.1.2.9 The service area should have a non-skid surface on the floor slab. Refer to Room Finish Schedule in DD Drawings (DD-A-SC-003 thru DD-A-SC-007).

6.23.1.1.2.10 Service islands should be elevated at least 4" above the floor slab. This dimension needs to be coordinated with requirements for low-floor buses.

6.23.1.1.2.11 Provide pipe bollards filled with concrete for protection of all service islands and service lane equipment.

6.23.1.1.2.12 Provide pipe bollards with flood lighting mounted on top or drop lighting suspended from the structure above to illuminate the engine compartment when the bus is located in the fueling/interior cleaning position.

6.23.1.1.2.13 Equipment on the service islands should be placed so that it clears the projecting rear-view mirrors on the bus as it passes the equipment.

6.23.1.1.2.14 Depending on the exiting configuration of the service lane, consider placing mirrors on the exterior of the building to facilitate the driver's vision and provide safe exiting from the service lane.

6.23.1.1.2.15 Vacuum system could be a central unit serving multiple service lanes or individual units for each service lane.

6.23.1.1.2.16 Consider preheating exterior buses during the fueling operation in cold weather so water does not freeze on the buses during the wash cycle.

6.23.1.1.2.17 Gasoline storage or dispensing is not allowed in the building.

6.23.1.1.2.18 Entrance door operation for the service lanes shall be high speed doors rollup fast actuating type.

6.23.1.1.2.19 Modify service lane design as required if articulated buses are to be serviced.

6.23.1.1.2.20 Sufficient distances between service and washing equipment should be provided to prevent water misting from the bus wash unit from drifting into the service area.

6.23.1.1.2.21 Provide a continuous trench drain from the beginning of the bus wash unit to the end of the blower dryer assembly. Connect drain to water reclamation system.

6.23.1.1.2.22 The plumbing system for the floor drainage shall include an oil/water separator as a part of the design.

6.23.1.1.2.23 Slope the slab on grade to the floor drains.

6.23.1.1.2.24 Provide a men's and women's toilet room and utility closet near the service lane for use of the service lane personnel. The toilet rooms shall be accessible. In the men's room, provide a water closet, urinal, lavatory, toilet paper dispenser, paper towel dispenser and soap dispenser. The women's room shall have two (2) water

closets, a lavatory, toilet paper dispenser, paper towel dispenser and soap dispenser. The utility closet shall have a service sink and have shelving to stock toilet room supplies.

6.23.1.1.2.25 Light fixtures, motors, etc. are to be water tight.

6.23.1.1.2.26 Proper lighting should be provided, both in regard to location and color-correction, in order to read the gauges of the fluid levels.

6.23.1.1.2.27 All electrical devices in the service lane area shall be specified as waterproof devices.

6.23.1.1.2.28 Provide overhead service reels in the service lane.

6.24 MAINTENANCE AREA

6.24.1 Introduction

This section describes circulation, spatial and equipment requirements for the maintenance area, which is the area provided for the servicing and repair of buses with specific maladies which are outside the realm of the service lanes. Servicing and repair includes, but is not limited to tune-ups, lubrication, parts replacement, tire repair and replacement, and body repairs and painting.

6.24.2 Vehicular Traffic Pattern

6.24.2.1 Pull-In and Drive Through Service: WMATA requires that buses requiring maintenance drive forward through an entrance service door, through interior circulation space, into the required maintenance bay and then drive forward through interior circulation space to an exit service door when the required maintenance is completed. This is much easier and more efficient than a pull-in and back-out traffic pattern. Service doors remain open for a short period of time, thus conserving energy, and maintenance staff spend less time directing buses out of the maintenance area, thus providing a more efficient operation. Refer to Figure 19.3 below for an illustration of desired maintenance area circulation.

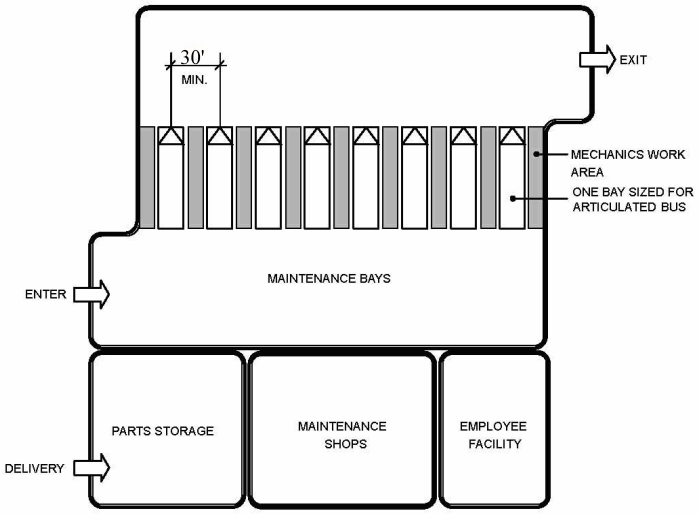


FIGURE 19.3 - Maintenance Area Diagram

6.24.2.2 Service Door Quantities: WMATA requires / desires that there be only one service door entrance and one service door exit for buses in the maintenance area. Although this arrangement requires more interior circulation space, it also conserves a great deal of energy and increases worker comfort, especially during cold weather months. Refer to DD Drawings (DD-A-SC-008 thru DD-A-SC-011) for material and design requirements for exterior service doors.

6.24.3 Maintenance Bays:

6.24.3.1 Design maintenance bays with enough space at front, rear and sides of each space for circulation and access for mechanics, as well as tool and equipment storage bins. Refer to Figure 19.3 above for an illustration of desired maintenance bay spacing.

6.24.3.2 Quantity and Type: Provide one maintenance bay for every 10 buses stationed at the facility. Of these bays, one bay each shall be provided for the following:

6.24.3.2.1 Steam clean bay (enclosed).

6.24.3.2.2 Tire changing bay.

6.24.3.2.3 HVAC repair bay.

6.24.3.2.4 Handicapped lift repair bay.

6.24.3.2.5 Articulated bus and intercity coach bus repair bay.

6.24.3.2.6 Paint booth and prep area for 40 ft. bus.

6.24.3.3 In addition to the quantity and types of maintenance bays above, provide two inspection bays with below-grade pits. Each below-grade pit shall be provided with two sets of stairs for exiting, a safety net and a rolling oil pan.

6.24.3.4 Provide maintenance bays with skylights for additional day lighting and with ceiling fans for additional ventilation.

6.24.3.5 Provide fall protection in every bay ~~safety line system for hooking up to maintenance personnel when working on top of buses~~.

6.24.4 Vehicle Lifts:

WMATA bus facilities use three lift types; portable lifts, drive on parallelogram lifts and in-ground lifts. The distribution of lift type shall be based on optimizing the facility's current requirements and allowing for future expansion ~~,requires a mixture of 30% portable lifts, 30% drive-on parallelogram lifts and 40% in-ground electric screw type lifts be incorporated into the maintenance bays~~. Hydraulic lifts with in-ground plunger-cylinder units are not allowed. The following are WMATA requirements for lift types~~,~~ and capacities ~~and manufacturers~~:

6.24.4.1 Portable Lifts: Hydraulic mobile lifts specifically designed to elevate large buses, ~~Electro-mechanical mobile lifts specifically designed to elevate large buses, equivalent to SEFAC Model 1200M65 BL, 15~~ 18,000 lb. capacity each, 4 lifts per bus minimum.

6.24.4.2 Drive-On Parallelogram Lifts: Heavy duty recess mounted parallelogram platform lift with non-skid surface, electro-hydraulic operation, automatic wheel chocks front and rear and a total of two rolling jacks. . Platform to raise a min. of 63" above finish floor at a min. rate of 50" per minute with a min. of 10 lock stops. Safety locks will ensure a min. amount of travel in a hydraulic failure and maintain the lift at that height in this situation. Lift sizes to be 50,000 lb. capacity and 32 ft. and 75,000 lb capacity and 48 ~~ft Minimum capacity 36,000 lbs. Acceptable manufacturers are SEFAC, Rotary, and Stertil-Koni/OMER.~~ Waterproof model is to be installed in Chassis Wash Bay.

6.24.4.2.1 Adjustable Axle Lift 2 and 3 Post Modular: Lifts shall consist of two or three individual lifting assemblies in line with the longitudinal axis of the vehicle, each lifting assembly equipped to engage the axle and suspension. Lift to be housed in a totally contained environmentally safe housing, post to be equipped with shutter plate covers which move with the post to cover the trench at all times. Lift to be electro-hydraulically operated and contain a variable equalized control system. Lift locks shall be rated for same capacity as jack unit and lock in 18 positions on 3 inch increments.

6.24.4.2.2 Axle Lift 2 Post: rated for 60,000 lbs

6.24.4.2.3 Axle Lift 3 Post: rated for 90,000 lbs

6.24.4.3 In-ground Lifts:

6.24.4.3.1 In ground lifts to have integral sump and sump pump to pump out any water than accumulates in bottom of lift pit, shop floors are routinely cleaned with a water hose. Pumps to be serviceable from above the pit, entry into the pit should not be required. Pumps to be minimal emulsifying type and be capable of passing ¼" solids.

6.24.4.3.2 Lift controls shall contain Modbus RTU communication for remote monitoring and connected to the building automation sytem. Lifts shall not be capable of remote control. The intent is to monitor the lifts for the following conditions: lift out of service, high water level in sump, number of cycles and any other maintenance indicators.

6.24.5 Overhead Service Reels:

6.24.5.1 Provide one overhead service reel for each two maintenance bays. Construction shall be of heavy duty design, spring powered and self-retracting, with double pedestal arm design adjustable to 360 degrees. Services on reel to include ~~compressed air,~~ water (W), ~~motor~~ engine oil (EO), electric power, automatic transmission fluid (ATF), chassis grease (CG), gear oil (GO) ~~lubricant~~, window wash fluid (WWF)~~;~~ and engine coolant (EC) ~~anti-freeze fluid~~. In addition, at the handicapped lift repair bay, provide separate wheelchair lift oil supply. ~~Manufacturers: Graco, Samson Corp or equivalent.~~

6.24.5.2 Refer to Section 14.19 for piping to reels and pumps to propel fluids to reels.

6.24.6 Hoists / Cranes:

~~Provide one jib crane for every four lift bays. Provide bridge crane with electric chain hoist at tire storage area.~~

6.24.6.1 Jib Cranes: Provide a one jib crane for every four lift bays. Provide bridge crane with electric chain hoist at with a 1 ton capacity and a 12 foot reach in the tire storage area. The jib crane is to swing approximately 180 degrees with stops to prevent any portion of the boom, hoist, or tagline system from coming in contact with building walls or structure. ~~Equivalent to Model H93040-15 Electric Chain Hoist (4000 lb capacity) with Model H311-4-12 Jib Crane Wall Bracket by Global Industrial Equipment.~~

6.24.6.2 Bridge Crane ~~and Chain Hoist~~: Provide a self supporting monorail bridge crane with electric chain hoist rated for 1 ton, in one of the articulated repair bays. Crane to run the entire length of the bay and be interlocked with the bus lift to ensure the hoist is at the end of the lift prior to the bus lift operation. This will ensure that buses are not lifted into the hoist damaging either the hoist or bus. ~~Equivalent to Light Load Self Align Bridge Crane with MBC-500-2 end truck trolley at one end and SAC-500-2 self-aligning truck trolley at opposite end by Unified Industries Inc.; and Model VHK 4341 1000 lb capacity electric chain hoist by Little Mule (formerly Yale Industrial Products).~~

6.24.7 Miscellaneous Maintenance Equipment

6.24.7.1 High Pressure Hot Water Cleaner: Provide heavy duty high pressure hot water cleaner to be located outside Steam / Chassis Wash Bay. If unit is located in Bay unit to be shielded from water spray to protect against corrosion and grime/grease ruining unit. Preferred fuel is natural gas, if abailable. Provide heavy duty high pressure hot water cleaner with 7 to 8 gpm discharge, 3000 psi operating pressure~~, equivalent to Model 991 by Hotsy Corporation~~, with adjustable spray pattern nozzle, extra hose lengths, hose reel, wand extensions, quick couples, downstream detergent injectors, rotating brush, and foam applicator.

6.24.7.2 Parts Washers: Provide a small parts washer and a large parts washer. Washers to be vented to outside of building if this is not possible than locate

washers in Chassis Wash Area. If located in Chassis Wash Area ensure units are shielded from pressure washer spray in order to protect unit from corrosion and grease/grime.

6.24.7.2.1 Small Parts Washer: Provide industrial jet washer ~~equivalent to Impulse by Better Engineering Mfg. Inc~~. Washer shall be top loading, hot water and detergent automatic parts washer, with floating oil removal, sludge removal, and subsequent recycling of wash water. Weight capacity shall be ~~1~~ 500 lbs of parts.

6.24.7.2.2 Large Parts Washer: Provide industrial jet washer ~~equivalent to Purifier Model F-3000-PZX by Better Engineering Mfg. Inc~~. Washer shall be front loading turntable type, hot water and detergent automatic washer, with two parts baskets, one removable, for extra parts cleaning capacity. Turntable diameter shall be 30 inches minimum, with weight capacity of ~~7~~ 1500 lbs ~~for turntable and 150 lbs for upper basket~~. Include filtration system to trap particles and sediment for removal, oil skimming system to remove floating oils and subsequent recycling of wash water. Include water level control and steam exhaust features.

6.24.7.3 Bearing Presses: Provide 50 ton hydraulic bearing press ~~equivalent to Model 78055A Shop Press by Norco~~. Includes manually operated two speed pump, liquid filled gauge to measure ram force in pounds and tons, safety oil bypass and overload system, hand operated winch to raise / lower press bed, and self-retracting ram moving laterally on head channel.

6.24.7.4 Brake Drum Lathe: Provide heavy duty, double spindle lathe designed to cut heavy duty drums up to 16 inches deep and 24 inches in diameter, and simultaneously turn brake lining to the exact diameter of the newly refaced drum~~, equivalent to Model 53-D8 Transfermatic Brake Drum Lathe by Star Machine & Tool Co.~~ Drum spindle housing shall extend to support the largest transit dual wheel assemblies without additional support. Include lubrication system, hood enclosure, and portable chip collector. Spindle speeds shall be variable from 20 to 90 rpm.

6.24.7.5 Work Bench With Vise: Provide heavy duty work bench with vise ~~equivalent to Premier Work Bench by Edsal with Utility Vise No. N244839 by Winton~~.

6.24.7.5.1 Work Bench: Heavy duty design with heavy gauge adjustable height steel legs and maple butcher block top with protective oil finish.

6.24.7.5.2 Vise: Maximum opening 6-1/2 inches with a 6 1/4" throat depth replacable main and pipe jaws facings , ~~built-in pipe jaws~~, steel top jaws, built-in anvil, 360° locking swivel base, keyed round slide bar with sealed lubrication.

6.24.7.6 Large Parts Shelving & Storage:

6.24.7.6.1 Large Parts Shelving: Provide heavy duty shelving units ~~equivalent to 6700 Series Bulk Storage Rack by Lyon Metal Products~~. Provide units with minimum 14 gauge steel uprights, beams and columns; and 5/8 inch thick particle board decking. Units to have load capacity of 1650 - 3300 lbs per pair of beams and 20,000 lbs per upright assembly. Shelving shall be adjustable on 1-1/2 inch centers. For pallet storage, provide shelving units equivalent to Lyon Pallett Rack by Lyon Metal Products, with same construction as above bulk storage rack, but without particle board deck and with load capacity of 4100 - 9900 lbs per pair of beams and 17,200 -

30,200 lbs per upright assembly, and with shelving beams adjustable on 2 inch centers.

6.24.7.6.2 Large Parts Storage Cabinets: Provide storage cabinets ~~equivalent to All Welded Extra Heavy Duty Storage Cabinet by Lyon Metal Products~~. Provide units of all welded, minimum 14 gauge steel construction, with padlock hasp and heavy duty brass pin hinges on doors, 1450 lb load capacity per shelf, and shelves adjustable on 3 inch centers.

6.24.7.7 Small Parts Storage: Provide steel drawer cabinets for small parts storage ~~equivalent to Platinum 240 Series Modular Drawer Cabinets by Lyon Metal Products~~. Provide units with 400 lb load capacity per drawer, variable drawer heights, and variable interior drawer layout kits as required.

6.24.7.8 Flammable Liquids Storage Cabinet: Provide heavy duty cabinets ~~equivalent to 5400 Series Flammable Liquids Safety Storage Cabinets by Lyon Metal Products~~. Provide units constructed of minimum 18 gauge steel with reinforced double walls, leak-proof pan bottom, heavy gauge adjustable shelves with 350 lb load capacity, doors with built-in key lock, grounding wire connectors, dual vents with fire baffle and cap, large warning labels and adjustable leveling.

6.24.7.9 Brake Tester: Provide portable computerized electronic brake tester ~~equivalent to Bowmonk 2000 Electronic Brake Tester by Bowmonk Ltd.~~ Unit measures vehicle speed at braking and distance traveled, brake effort, and can also be used to test acceleration. Accuracy shall be +/- 2 percent. Unit shall be completely self-contained, portable, and shall include keyboard, LCD display and printer. Unit shall display step by step instructions for each procedure, and shall be suitable for testing service and hand brakes on all types of vehicles.

6.24.7.10 Wheel Alignment Tester: Provide computerized wheel alignment tester for heavy duty vehicles ~~equivalent to Model SS100T Sideslip Tester by Hunter Engineering~~. System shall include drive-on plate in floor, computer console and printer. As each axle is tested, results are displayed on the computer console and hard copy automatically printed. Capacity 30,000 lbs each single axle, 44,000 lbs each tandem axle.

6.24.7.11 Wheel Alignment Adjuster: Provide computerized wheel alignment system for heavy duty vehicles ~~equivalent to Model 611T Wheel Alignment System by Hunter Engineering~~. System shall include computer console with keyboard, 27 inch color monitor and printer, and cordless sensors with self-centering wheel adapters. System provides on-screen, step-by-step instruction for sensor placement, measurement and adjustment for a wide variety of axle configurations.

6.24.7.12 Moveable / Mobile Equipment:

6.24.7.12.1 a. Forklifts / Snow Removal Equipment: Provide standard counterbalance truck type upright forklifts ~~as manufactured by Clark Material Handling Equipment Company, Yale Industrial Trucks or equivalent~~. Include seat deck mounted hydraulic levers, stop lights, headlights, back-up lights, strobe lights, audible back-up alarm, and rear turn signals. Provide size and capacity of forklifts to suit each facility. Provide forklift storage area and areas for snow removal equipment.

6.24.7.12.2 Floor Scrubbers: ~~Provide riding motorized floor scrubber equivalent to Hydro-Retriever 260BI ID by Advance Machine Company.~~ Floor scrubber to be battery powered walk behind unit designed for use on rough textured floors. Unit to have recycling system which recycles the solution allowing 3 hours of contiuous runtime and leave the floor virtually dry. Brushes shall be attached using spring clip system requiring no tools for changes. Squeegee to be of parabolic breakaway design the assembly shall be free floating swing type constructed of stainless steel and aluminum with no tools required for change out. Sscrubber shall have a minimum 36 inch scrubbing path, minimum aisle turn of 67 ½ inches max, squeegee width of 45 ½ inches, solution tank of 30 gallons, and a 40 gallon recovery tank. The scrubber shall have a forward speed of 0 to 3 mph. Provides storage area for floor scrubbers. ~~Provide scrubber with minimum 26 inch cleaning path, cleaning rate of minimum 24,000 square feet per hour, battery powered 1 HP brush motor and 3 /4 HP vacuum motor, forward and reverse gears.~~

6.24.7.12.3 Parking Lot Scrubbers: Provide riding, motorized floor scrubber ~~equivalent to Model 7760 Riding Sweeper/Scrubber by Alto American-Lincoln~~. Provide scrubber with minimum 54 inch wide scrub path, 60 inch wide sweep path, 100 gallon solution and recovery tanks, and power steering.

6.24.7.12.4 Wheel & Brake Dollies: Provide wheeled dollies ~~equivalent to Back Buddy by Safe Shop Tools~~. Provide dollies specifically designed to lift and carry all hub and drum assemblies, with lift and tilt controls and removable drip tray.

6.24.7.13 Battery Charging Bench: ~~Equivalent to Model SSC 2040 by Service Scaffold Inc.~~ All-welded steel frame bench with 2" hardwood rollers on top, five rollers per bank of rollers. Capacity 200 lbs per linear foot. Acid-resistant black finish on steel.

6.24.7.14 ~~Battery Charger: Equivalent to Hitran Model 3SCRF012-200SP. Input 208 volts, 23 amps, 60 Hertz. Output 12 volts, 200 amps.~~Unit shall be capable of charging 1 to 36, 12 VDC batteries. Unit shall be provided with Bus bar set with fiberglass backboard assembly with connecting cables, insulated clamp storage bar and 10 pair of 10 gauge, 300 amp rated charging leads 36 inches long premounted at bus bar end with vinyl insulated safety clamps on other end. Three foot 4 AWG cables shall allow connection to charger or additional bus bar. Room to have ventilation, see Section 14.4.2.3 for air exchange rates. Provide dry sump, floor slope to sump to capture any spills.

6.24.7.15 Rolling Oil Pan: Provide heavy duty rolling pit drain pan designed to run on rails or angles along edge of pit ~~equivalent to Model 1356 Hook Up Kit by Samson Equipment Capacity 34 gallons. Include attachment for vacuum.~~

6.24.8 Dust Collection / Exhaust Collection

Refer to Section 14.19 , WMATA Manual of Design Criteria Facilities, for ventilation requirements for hood exhaust requirements at lathe, welding, cutting and grinding areas, and for tailpipe exhaust collection requirements.

6.25 BUS STORAGE

One of the principle functions of any bus maintenance facility is bus storage. Efficient bus parking configurations on a garage site are essential for smooth operations within the site.

The WMATA buses will be stored outside since there are not enough nights when the temperature is below 40 degrees F to warrant building large indoor bus storage areas. Buses will be parked such that they do not have to back up, either to enter the parking space or leave it.

6.25.1 CIRCULATION AND PARKING PATTERNS

6.25.1.1 Access to the parking area should be as straightforward as possible with the minimum number of turns. Circulation into and through the bus storage area should be counter-clockwise, that provides for a left-hand circulation pattern. This provides the driver with an unrestricted travel view and minimizes the chance of damage to vehicles and buildings.

6.25.1.2 When planning the bus storage area, the turning radius of the buses is the most important factor. Although the area should be planned to house the buses used in that particular fleet, there should be some part of the area that could handle larger, intercity and articulated buses, even if they are not part of the existing fleet.

6.25.1.3 There are several parking configurations that can be used, depending on the size of the site and the transit operations. Refer to Figure 19.2. The first is parking the buses head to tail in rows, double rows or in-line (stacked) patterns. This is the most efficient in terms of land use but it means that the first bus in line must always be the first to leave and all others must follow in order.

6.25.1.4 The second configuration is the single pull-through, usually in an angled or double angled pattern. A herringbone pattern is another option, but requires backing out. This configuration is WMATA's preference as it offers the maximum flexibility for bus pull out as any bus can enter or leave independently. These patterns consume much more space as there needs to be an aisle wide enough for the bus to turn into a parking stall. This aisle is shared by the row behind as an exit row. A double row is a variation of the single row, with resulting loss of some flexibility.

6.25.1.5 The choice of parking pattern for a particular application is influenced by site and circulation constraints. Conventional stacked parking is only selected when the site is small. If possible, modern facilities are constructed on sites large enough to permit parking patterns that allows access to every vehicle at all times. Direct access greatly simplifies maintenance access, pull-outs and pull-ins.

6.25.2 PAVING

6.25.2.1 The bus areas are to be paved with concrete in order to withstand the constant starting, stopping and turning of heavy vehicles. Refer to Section 2 and Section12 for concrete pavement design requirements. The storage area should be sloped a minimum of 1/4" per foot to drain well, but should not exceed a 4% slope, except in rare cases.

6.25.2.2 Automobile parking areas are to be paved with asphalt, refer to Sections 2 and 12 for design requirements.

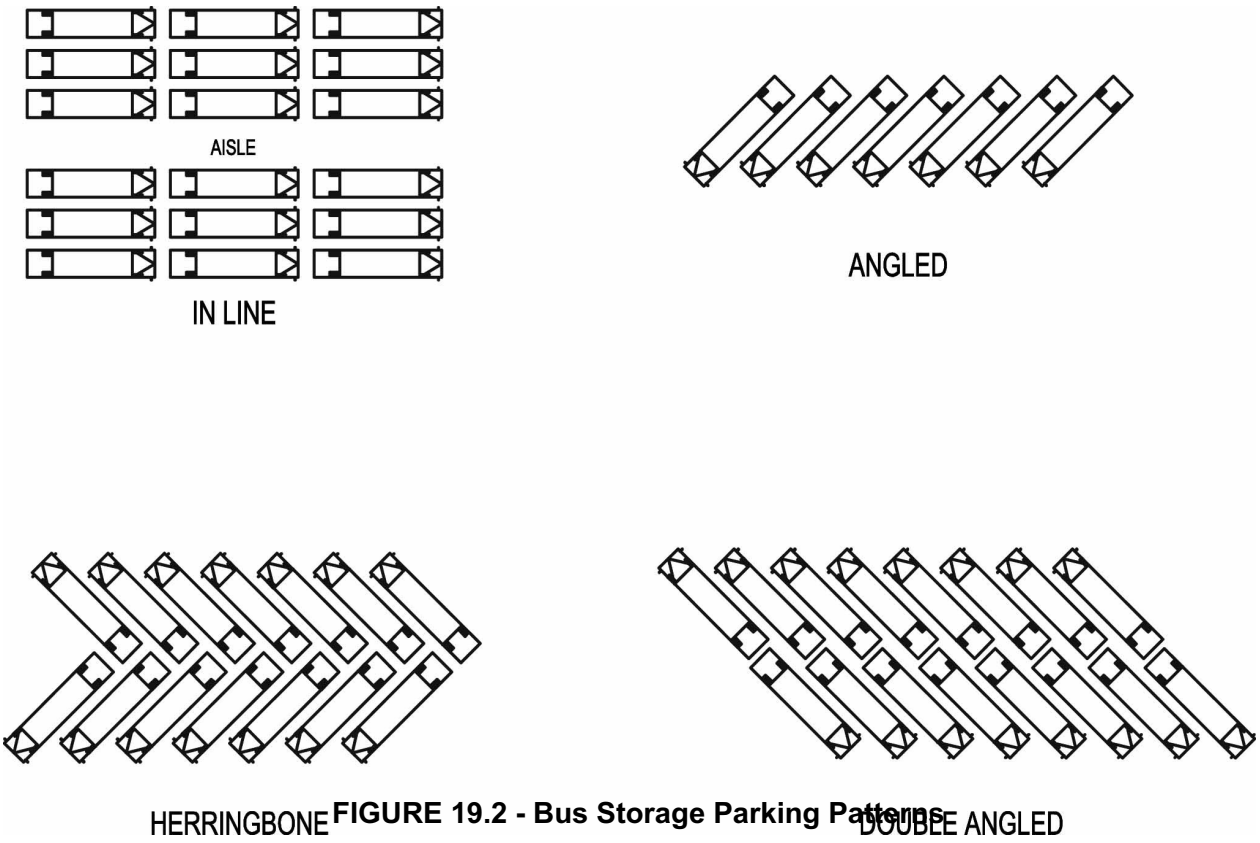


FIGURE 19.2 - Bus Storage Parking Patterns

6.25.3 SERVICES

6.25.3.1 A canopy for shading the buses reduces the build up of heat in the bus and the consequent time needed to let the bus air conditioning run to cool it down. This saves not only on fuel, but also on time that the bus is running but not in service earning revenue. There is also a reduction in air pollution. Canopies also reduce snow accumulation on buses, reducing time for snow removal. Canopies shall be included as an optional design element for cost comparison.

6.25.3.2 Site lighting is required for driver safety but it is important that the light is directed onto the site without spillover onto neighboring properties. Canopies can provide shielding for light patterns, where lighting is mounted under canopy roofs. Electrical and compressed air outlets should be located on light standards or canopy columns and shall be spaced throughout the parking area. Depending on the size of the parking area, a dedicated air compressor may be used, but, in any case, air drying is important to prevent line freezes in cold weather.

6.26 MECHANICAL REQUIREMENTS FOR BUS FACILITIES

6.26.1 Fire Protection

6.26.1.1 General

6.26.1.1.1 The fire protection systems shall be designed per all local and state codes as is appropriate for the project site. In addition, the systems shall be designed in accordance with the latest versions of the NFPA as they apply to the space and/or application being served. Where the NFPA and, local and state codes differ, the design shall follow the most stringent requirements.

6.26.1.1.2 Coordinate building systems and services with the Fire Protection and Alarm such that there shall be, where appropriate, automatic shutdown of the affected system(s) or service(s) should any of the fire protection systems be activated. (e.g. fuel dispensing system shutdown where the associated fire protection system is activated.)

6.26.1.1.3 Coordinate fire protection requirements with WMATA's fire protection underwriter.

6.26.1.2 Wet Sprinkler Systems

6.26.1.2.1 The building sprinkler systems shall be designed in accordance with NFPA 13, other appropriate NFPA sections, and the local and state building code requirements. The system shall be designed under the direct supervision of an engineer experienced in the design of such system and shall be licensed within the state or district where the building will be located ~~reside~~.

6.26.1.2.2 All areas of the building shall be protected by a wet sprinkler system, except as allowed below. The system shall be separately connected to the local municipal water main with connections being in accordance with the water purveyors connection and back-flow prevention requirements.

6.26.1.2.3 The system shall be completely hydraulically designed to meet the density and flow requirements set-forth in NFPA 13 and 30. Unless otherwise indicated in the NFPA requirement, the areas of the building shall generally fall into the following Hazard Classifications:

6.26.1.2.3.1	General Areas	Ordinary hazard
6.26.1.2.3.2	Office Areas	Light hazard
6.26.1.2.3.3	Fuel Dispensing Areas	Ordinary hazard
6.26.1.2.3.4	Paint Spray Booth	Extra hazard

6.26.1.2.4 The sprinkler head selection shall be made according to the hazard classification and specific requirement of the areas served in accordance with the applicable NFPA standards. The sprinkler system shall be provided with test fittings, inspector test valves and drainage fittings. Test fitting, inspector test valves and drainage fittings shall be provided for in each fire zone. The test fittings and drainage fittings shall be discharged to the exterior of the building so as to avoid water damage. The sprinkler heads shall be the upright type except where ceilings or other obstructions prohibit their use.

6.26.1.2.5 The sprinkler piping system shall be designed with Schedule 40, black steel pipe. The fittings shall be screwed type joist for sizes below 2 ½" and either screwed or mechanical type for sizes 2 ½" and larger. The building sprinkler piping system shall be designed with sprinkler risers to meet the

NFPA 13 area requirements. Each riser shall be provided with appropriate riser trim and a seismic connection and check valve. Coordinate the connection requirements with the local fire department and WMATA's insurance carrier requirements. Each fire zone shall be designed with a manual shutoff valve (with tamper switch) and flow-indicating device. The tamper switches and flow indicating devices shall be tied into the Fire Alarm System. All fittings, valves and devices shall be FM approved. The sprinkler piping system shall be supported in accordance with NFPA 13 requirements.

6.26.1.3 Foam Systems:

In areas within the building where fuel is dispensed or in Class I, II and III Liquid Storage Rooms, foam-water sprinkler systems ~~shall~~ may be used. In addition to observance of the local and state building codes, these systems shall be designed in accordance with NFPA 30, 30A and other appropriate NFPA sections regard these types of systems. The system shall be designed under the direct supervision of an engineer experienced in the design of such systems and shall be licensed within the state or district where the building will be located ~~reside~~.

6.26.1.4 System Testing:

After the system has been installed, a pre-test and final acceptance test shall be performed. The testing shall be in accordance with the requirements of the appropriate NFPA sections and local and state requirements.

6.26.1.5 Fire Protection Guidelines:

Provide types of fire protection for specific areas as indicated below.

Occupancy	Suppression
Battery Storage	FE
Electrical Equipment Areas	FE
Fuel Dispensing	HH
Maintenance and Service Areas	WS
Mechanical Equip. Rooms	WS
Boiler Rooms WS(165°F heads)	
Elevators	WS
Office Areas	WS
Storage: Hazardous	HH
General	WS
Paint Booth	HH

ABBREVIATIONS:

WS	Wet Sprinklers
HH	High Hazard Wet Sprinklers
FE	Fire Extinguishers

6.26.2 Plumbing / Drainage

6.26.2.1 General: The plumbing systems shall be designed per ~~all~~ the International Building Code and local and state codes as are appropriate for the project site. The system shall be designed under the direct supervision of an engineer

experienced in the design of such systems and shall be licensed within the state or district where the building will be located ~~reside~~.

6.26.2.2 Municipal Water Service: The plumbing system will be served by a separate municipal water service. The water service shall be separated from the domestic water system by a Reduced Pressure Zone type backflow preventer.

6.26.2.3 Fixtures: The plumbing fixtures shall be designed in accordance with ADA requirements, where applicable. All fixtures shall be provided with removable handle type stops. The Urinals and Water Closets shall be wall-hung type with flush valves. The locker room areas shall be furnished with stainless steel wash fountains for hand washing. Individual Restrooms shall be designed with wall hung lavatories utilizing single lever faucets. Electric water coolers shall be provided in locker rooms, the maintenance areas, service area, and outside of grouped restrooms. Provide stainless steel kitchen sink(s) with disposal(s) in breakroom(s) or otherwise as requested by WMATA. ~~and~~ Janitor and costodial rooms shall have ~~provide~~ mop service basins with bucket holding supported spout fixture and a short flexible hose connection. ~~in janitor's closets~~

6.26.2.4 Plumbing Specialties

6.26.2.4.1 The plumbing system shall include emergency eyewashes and combination eye wash and shower units. These shall be tied to a tempered water loop that shall provide water at the proper volume and temperature, and for the duration necessary to meet OSHA requirements. Combination units will be located in the Shop Areas, Maintenance Repair Bays ~~Area~~, Chasses Wash, Lube/Compressor Room, Pant Booth Area, Service Lane, and the Battery Charging/Storage Area. Provide eyewash units in ~~the Flammable Liquid Storage Room,~~ rooms where hydraulic lift pumps are located and other areas where the potential for eye damage exists and as required to meet local, state and federal requirements.

6.26.2.4.2 The system shall include shock absorbers, on the cold and hot water distribution system, where the action of quick operating valves could result in a water hammer condition. Provide dielectric fittings at connections of dissimilar metals.

6.26.2.4.3 Hose bibbs shall be provided, on the exterior of the buildings and in the interior, and as required by WMATA. Hose reels with 50 feet of 1" hose shall be provided every third bay in the maintenance area, at the beginning and end of the washbays, in the tire bay and in the paint booth area. Freeze proof wall hydrants shall be provided every 100 feet around the perimeter of the building.

6.26.2.5 Cold and Hot Water

6.26.2.5.1 The cold and hot water distribution system shall be designed as predominately flush valve systems. The distribution system will serve both the domestic water load and the bus wash system requirements. ~~The domestic hot and cold water flows shall be determined using Hunter's Curve.~~ The Flow required for the bus washer(s) shall be considered a constant demand and be added to the domestics water flow.

6.26.2.5.2 The water distribution system shall be ~~shall be~~ constructed of the following: ~~type "M" copper piping for sizes up to 2 ½" and of Sch. #40, Black Steel for sizes greater than 2 ½".~~

2 1/2" and smaller - aboveground ASTM B 88 Type L drawn-temper copper tubing with soldered joints or press fit. Below grade or within slabs ASTM B88 Type K annealed-temper copper tubing with soldered joints. 3" and larger - Provide ASTM A53/A53M, type S Grade A or B, sch. 40 galvanized.
The water supplies to the bus washer(s) shall be protected from the backflow of wash water by Reduced Pressure Zone backflow preventer.

6.26.2.5.3 The design shall include a gas or electric ~~central dual fuel~~ water heater (gas preferred) . The heater will operate on natural gas or electric ~~and No. 2 fuel oil~~. It will be sized to meet the demanded of the domestic hot water load along with any building core area loads resulting from cleaning equipment or wash down requirements. Remote hand sink or similar hot water loads will be met through ~~the~~ point of use ~~of~~ or small tank type electric or gas water heater. Provide cleanouts at the base of risers and wall cleanouts at gang toilets.

6.26.2.6 Sanitary and Vent System

6.26.2.6.1 All above grade sanitary piping shall be No-Hub service weight cast iron. All below grade sanitary piping shall be Hub and Spigot service weight cast iron. Provide cleanouts at all changes in direction of 45° or greater, every 50 feet on piping 4" and less, and every 100 feet for piping over 4".

6.26.2.6.2 The vent system shall be: 2 ½" and smaller above ground DWV copper tube with soldered joints ~~up to 2 ½" and No-Hub service weight cast iron above 2 ½"~~. 3" and larger above ground: Copper DMW tube with soldered joint or Cast-Iron soil piping, stainless steel or cast iron couplings.

6.26.2.6.3 All below ground pipe shall be cast iron with gasket and gasket joints.

6.26.2.7 Storm Piping: All above grade storm piping shall be No-Hub service weight cast iron or stainless (304) couplings. All below grade storm piping shall be Hub and Spigot service weight cast iron with gasketed joints. Provide cleanouts at all changes in direction of 45° or greater, every 50 feet on piping 4" and less, and every 100 feet for piping over 4".

6.26.2.8 Roof Drainage: Unless otherwise stated by local or state code, the roof drainage system shall be designed based on the maximum local hourly rainfall intensity. Provide system with both roof drainage and overflow drainage systems. Direct all downspouts in parking and sidewalk areas underground to storm water to prevent ice and standing water.

6.26.2.9 Interior Floor Drainage: All floor drainage from the maintenance and Fuel and wash lanes area which have vehicular traffic shall be piped to the oilwater separation system. Provide floor drains at all equipment having condensate drains. Mechanical/Electrical and Compressor Rooms shall all have a minimum of one floor drain. Do not provide drains in shop and parts storage areas due to misc parts getting trapped in drain system, floor scrubber to clean these areas. Provide additional floor drains where required to eliminate horizontal drainage piping from equipment exceeding 10 feet. Battery storage rooms to have no floor drain, floor to be sloped to dry sump. All gratings used to cover trench drains, catch basins, etc shall be hot dip galvanized H-20 load rating. Gratings which are greater than 30 lbs shall be accessible by forklift in order for removal (removal by chain and forklift).

6.26.2.9.1 Bus Wash Area: A longitudinal trench drain shall be located along the entire length of the bus washers, including the blower/dryer assembly, and shall be centered in the bus wash lane. Each trench drain shall be pitched to accommodate the Wash Water Reclamation System and shall terminate with a sediment trap. The trench drains shall be sloped at not less than 1/8" per foot. The overflow from the Reclamation System shall be directed to the Sanitary Sewer System if permitted by local discharge limits.

6.26.2.9.2 Maintenance Area and Service Lane

6.26.2.9.2.1 Trench drains shall be run across the entrance to these areas and be located within 2'~~approximate 5'~~ from the face of the overhead doors. A trench drain shall also be located in the steam clean bay. The trench drains shall be pitched to allow efficient flow of water and terminate with a sediment trap. The trench drains shall be not less than 12" wide to allow cleaning with a shovel and the grating shall accommodate H-20 loading.

6.26.2.9.2.2 An oil water separator shall be designed as part of the drainage system serving the vehicle entrances described above. The oil water separator shall be capable of removing the petroleum product typically seen in similar applications. The separator shall be designed based on American Petroleum Institute (API) standards, a maximum horizontal velocity of 3 fpm, a maximum depth-to-width ratio of 0.5, and continuous flow operation. The separator shall be additionally designed based on local, state and federal requirements. The local sewer district should be contacted to determine if there are specific requirements and discharge limits.

6.26.2.9.2.3 The oil water separator shall be designed with: a sediment trap; integral holding tank; a top capable of H-20 loading; and applicable features necessary for the use and installation requirement where it will be installed.

6.26.2.9.2.4 A catch basin will be installed just upstream of the oil water separator described above. The catch basin shall be not less than 36" in diameter and be used for initial sedimentation of the floor drainage. The outlet of the catch basin shall consist of a vertically oriented tee with a 12" open drop leg and capped top. The bottom of the catch basin will have an invert 24" below the bottom of the open drop leg. The catch basin shall be provided with a manhole cover capable of H-20 loading.

6.26.2.9.3 Waste water from floor scrubbers and parking lot scrubbers shall be handled in one of the following ways, depending on a cost/benefit analysis, local requirements and WMATA requirements:

6.26.2.9.3.1 Storage on-site in an above ~~below~~ grade holding tank or floor sump, size to be determined by WMATA, prior to removal by a licensed disposal contractor.

6.26.2.9.3.2 Pre-treatment on-site prior to discharge into the sanitary sewer system.

6.26.2.9.4 Oil Separation / Pretreatment System

6.26.2.9.4.1 The following system description is provided for information only. Final design criteria and requirements shall be confirmed during design and shall:

6.26.2.9.4.1.1 Meet local discharge requirements.
6.26.2.9.4.1.2 Meet WMATA requirements.
6.26.2.9.4.1.3 Meet all other applicable requirements.

6.26.2.9.4.2 Provide one (1) collection manhole for every three (3) maintenance bays. The collection manholes shall be 24" long, 18" wide and 36" deep (all inside dimensions). Provide the manholes with heavy duty fiberglass grates with an opening to allow a suction pipe installation. Each of the manholes will be accompanied by a air driven double diaphragm pump capable of delivering 25 gpm at the calculated pressure differential.

6.26.2.9.4.3 The pretreatment system generally consists of ~~a collection~~ manholes, transfer pumps (both from the manholes to settling tank and from settlement tank to the oil separator, filter, membrane filter, holding tank, and automatic chemical treatment system. ~~Refer to appendix B for the system description, P&ID, and components.~~

6.26.2.9.4.4 The system shall be capable of treating 1000 gallons of solution per day. It shall be capable of maintaining a discharge having a ph of between 5 and 10, oil and grease less than 100 parts per million and filtration to 25 microns.

6.26.2.9.4.5 The settlement tank shall be installed in the floor. It shall have a 2000 gallon volume and have an invert not deeper than four (4) feet below the floor surface. Provide the settlement tank with a fully removable, heavy duty, steel cover such that each section can be removed by a single individual.

6.26.2.9.4.6 Above ground transfer piping shall be treaded or mechanical joint, schedule 40 black steel. Provide cleanout at all changes in direct of greater than 45° or at straight runs of pipe greater than 50 feet.

6.26.2.9.4.7 A 25 gpm double diaphragm pump will transfer the effluent for the settlement tank to and above ground oil/water separator. The oil/water separator shall be sized as described above but in no case have a capacity of less than 20 gpm.

6.26.2.9.4.8 After passing through the oil/water separator effluent will flow by gravity to a "zero gravity" filter. Backwash from the filter should be returned to the settlement tank.

6.26.2.9.4.9 Effluent from the filter will flow by gravity to a 25 micron ~~membrane~~ filter and on to final holding tank where the effluent will be chemically treated prior to flowing to the municipal sewer.

6.26.2.9.4.10 Natural Gas Piping

6.26.2.9.4.10.1 The natural gas piping shall be designed in accordance with NFPA 54 and the local gas provider's requirements. ~~The gas pressure within the building shall be limited to less than 11" of water column (w.c.) with the piping being sized based on a pressure drop of 0.3" w.c. per 100' of pipe.~~

6.26.2.9.4.10.2 The natural gas piping shall be constructed of Sch. #40, Black Steel pipe. Piping 2 ½" and below shall utilize threaded fittings and piping greater than 2 ½" shall be welded steel fittings. Gas shutoff valves and drip legs shall be provided up stream of all gas consumers.

6.26.2.9.4.11 Compressed Air System

6.26.2.9.4.11.1 The compressed air system shall be furnished with two (2) air compressors, each ~~to be~~ sized for 100% capacity based on a 50% diversity factor at 100 psig. The compressors will have soft starts with cross connectable independent air dryers, preferably regenerative desicant type capable of delivering compressed air at a dew point of 28°F. ~~The compressors shall be furnished with intake filtration, cylinder unloading, automatic blow-down, and after cooler.~~ The sizing of the compressor shall be based on the following:

Impact Hammer:	40 SCFM
Blow Gun:	3 SCFM
Paint Spray:	20 SCFM
Drill:	50 SCFM
Rotary Sander:	30 SCFM
Tire Changer:	2 SCFM
Engine Cleaner:	5 SCFM

~~**14.19.2.9.4.11.2** A mechanical compressed air dryer shall be furnished to meet 100% of the anticipated load. The dryer shall be capable of delivering compressed air with a dew point of 28 F.~~

6.26.2.9.4.11.2 The overhead compressed air piping system shall be designed based on a working pressure of 150 psig. All valves and fitting shall be class 150. The piping shall be not less than schedule #40 black steel with the branch piping being not less than 3/4" diameter. The size of the branch piping shall be based on most demanding device being served. Each branch shall be furnished with a filter/regulator/dryer and a isolation valve at the branch/main takeoff. Filter/regulator/dryer assemblies shall be per WMATA's standard requirements. Confirm standards prior to installation.

~~**14.19.2.9.4.11.3** The compressed air mains shall be sized based on a 50% diversity factor.~~

6.26.2.9.4.11.3 See Sections 18 and 19 for system components downstream of the filter / regulator / dryer.

6.26.2.9.4.11.4 Provide quick disconnects, at air outlets, to meet WMATA's standard tool requirements.

6.26.2.9.4.11.5 Provide general air outlets every 50 feet along the perimeter of the wash bays, maintenance and service bays. Provide two (2) air outlets in the Tire Service bay and four (4) in the Paint Booth bay.

6.26.3 HVAC

6.26.3.1 General

6.26.3.1.1 The HVAC systems shall be designed per ~~all~~ the International Building Code, local and state codes as are appropriate for the project site. In addition the systems shall be designed in accordance with the latest versions of the ASHRAE, NFPA, SMACNA, ASME and UL standards as they apply to the systems utilized for the facility. In addition, any generally accepted standards which are recognized or generally accepted within the local engineering community for similar projects and/or systems shall apply.

6.26.3.1.2 The system shall be designed under the direct supervision of an engineer experienced in the design of similar systems and shall be licensed in the state or district where the building will be located ~~reside~~.

6.26.3.1.3 The facility shall be designed in accordance with the latest version of NFPA 30A and 88B, as they apply to the specific areas of the facility.

6.26.3.2 Heating: The primary heating system shall be a hot water design. The heating system will be zoned to provide for the varying load requirements of each area.

6.26.3.2.1 Boilers

6.26.3.2.1.1 The boilers shall be fire tube type, each design sized to meet 80% of the design day heating load. Design heating load will be based on ASHRAE Winter Design Dry Bulb 95% and 80% of maximum building ventilation load.

6.26.3.2.1.2 The boilers shall be equipped with duel fuel, modulating type power assisted burners that shall be capable of operation on natural gas and No. 2 fuel oil. The burners shall be designed to swing out allowing full burner face access without having to disconnect fuel piping or wiring. The burners shall have full IRI gas and oil trains and be provided with a combined burner management and flame safeguard system. The burner management system shall be capable of providing lead/lag changeover and fuel selection functions.

6.26.3.2.1.3 No. 2 fuel oil shall be pumped to the boilers from an exterior underground oil tank capable of storing one (1) month's oil at fully loaded boiler operation. The tank shall be dual wall fiberglass design and be provided with leak detection system. Ancillary tank equipment such as oil fill boxes, vents, manholes, oil level indicators, anti-syphon valves, and alarms shall be provided. The fuel oil transfer pumps shall be skid mounted duplex type each

being capable of providing sufficient oil for both boilers operating 100% loaded.

6.26.3.2.1.4 The boiler flue venting shall be accomplished through a pre-manufactured stainless steel flue system. The flue system shall be designed in accordance with NFPA requirements. Design shall include make-up air to the boiler room to provide for boiler combustion and ventilation requirements.

6.26.3.2.2 Area Heating Requirements

6.26.3.2.2.1 Entrances and Exits: Heated air curtains shall be provided at all vehicle entrances and exits. Heated air curtains shall be installed at all service area entrances. All air curtains shall be designed for the local winter wind velocity as identified in the latest version of the ASHRAE fundamentals.

6.26.3.2.2.2 Bus Maintenance Areas: The bus maintenance areas heating requirements shall be served by air handling units that will be located on elevated mezzanines. The unit shall be designed to maintain a space temperature of 65° F through the use of a hot water heating coil. (see Ventilation below for further related requirements)

6.26.3.2.2.3 Parts Storage Rooms: The Parts Storage Room shall be ~~served by its own air-handling unit. Space temperature shall be~~ maintained at 65 ~~70~~° F. The hazardous storage rooms shall be designed to Class I, Division 2 requirements (NFPA 30). Space temperature shall be maintained at 65° F.

6.26.3.2.2.4 Bus Wash Area: The Bus Wash Area shall be designed unitizing a combination of space air handling and high intensity, infrared, gas fire unit heaters. The system shall be designed to maintain a space temperature of 65° F.

6.26.3.2.2.5 Offices, Locker Rooms, Training Rooms, Operators Areas: Maintained at 68 ~~70~~° F by the central heating system.

6.26.3.2.3 Air Conditioning: The Offices, Locker Rooms, Toilet Rooms, Training/Conference Rooms, Day Rooms and other similar areas in the administration and operations areas shall be air-conditioned, maintained at 75°F. The air conditioning of these spaces shall be accomplished through roof top direct expansion air conditioners which will utilize water coils for heating. Consideration should be made for the used of a packaged Variable Air Volume to maintain zone control.

6.26.3.2.4 Ventilation

6.26.3.2.4.1 Due to the nature of the operation of these facilities, significant amounts of make-up and exhaust air are required. In addition to local and state requirements the ventilation system shall be designed to meet both NFPA and ASHRAE standards. Where any of the requirements and standards differ, the design shall be in accordance with the most stringent.

6.26.3.2.4.2 Air handling units servicing the maintenance areas shall be mounted on elevated mezzanines. The supply air shall be ducted,

with the ductwork being fabricated of materials appropriate for the environment they are serving. Where air is to be distributed in high bay areas (20'+) the use of high velocity drum type diffusers shall be considered. The ductwork shall be constructed in accordance with SMACNA standards as appropriate for the pressure class of the system and units being served.

6.26.3.2.4.3 The maintenance area air handling units shall be equipped with variable frequency drives (VFD). The supply fan shall operate at minimum speed and maintain minimum make-up air volume based on the space use. As the space exhaust air demand increases the VFD will increase supply fan speed to maintain space pressurization. The space pressurization shall be monitored through the use of space pressure sensors. The air handling units shall be designed for 100% of the ~~of the~~ heat recovery exhaust fan and 50% of the roof top centrifugal exhaust fan volumes.

6.26.3.2.4.4 The maintenance area general exhaust shall be accomplished through a combination of heat recovery exhaust fans and roof top centrifugal exhaust fans. The heat recovery exhaust fans shall be sized to handle the minimum ventilation rate of 4 air changes per hour. The roof top centrifugal exhaust fans shall be sized such that their total exhaust volume will provide 8 ~~86~~ air changes per hour. The ductwork from the heat recovery exhaust fans shall be such that 50% of the exhaust air is taken from 6" above the finished floor. The ductwork that is run down to the floor level intakes shall be attached and run down walls or columns to protect them from being hit by the buses.

6.26.3.2.4.5 As a result of the large make-up air and exhaust requirements, heat recovery shall be used wherever the exhaust stream allows for its use. The type and application of the heat recovery system selected shall be appropriate for the quality of heat available from and the nature of the exhaust stream.

6.26.3.2.4.6 Specific Area Ventilation Requirements

6.26.3.2.4.6.1 Service Lanes - Fuel Dispensing Area: Provide 10 air changes per hour at low speed and 12 air changes per hour at high speed. Provide two exhaust intakes at 6" above finished floor for each fuel island.

6.26.3.2.4.6.2 Service Lanes - Bus Wash Area: Provide 4 air changes per hour on low speed and ~~8~~ 6 air changes per hour at high speed.

6.26.3.2.4.6.3 Air Compressor and Electrical Distribution Rooms: A mechanical ventilation system shall provide supply and exhaust air to maintain space temperature below 95° F.

6.26.3.2.4.6.4 Paint Booth Area: The paint booth will be a cross draft style pre-manufactured system to be erected at the site. The booth walls shall be capable of supporting a three axis manlift capable of traveling the length of the booth. Booth air shall be supplied through the use of a makeup unit, which is mounted on the roof of the building. A fully filtered intake and exhaust air system shall be provided, with exhaust being removed from system and facility by ductwork and plenums. Fall protection

for maintanence of fans. ~~The system shall be provided with an exhaust fans and a 80/20 style direct fired make-up air unit. The make-up air unit shall be mounted on the roof of the building. The make-up air unit shall be sized that the total volume is 10025% of the exhaust volume.~~ A low pressure breathing air system shall be provided complete with air compressor, purification system controls and alarms, distribution system with not less than two (2) hook-up stations, portable hoses, vortex air coolers and masks. The system shall be capable of allowing two (2) people to use it simultaneously.

6.26.3.2.4.6.5 Tail Pipe Exhaust: The tail pipe exhaust system shall be designed to provide 600 cfm per connection with a 50% diversity factor. . The exhaust hoses shall be rated for a temperature of 1500°F. Each maintenance bay will be provided with an overhead, pull down hose reel which will automatically start the exhaust fan when the hose is extended for connection to the bus exhaust. The main header will be design per SMACNA standards with the hose and ductwork being as appropriate for the suction pressure generated at the "dead head" condition. The tail pipe connection shall be attached to the tail pipe through the use of an inflatable rubber bellows. The bellows shall utilize compressed air to inflate. Provide an end switch that automatically deflates the bellows should the bus be moved prior to disconnecting.

6.26.3.2.4.6.6 Battery Charging/Storage Room: To the extent practicable ventilation design shall take advantage of passive ventilation to maintain the hydrogen concentration level below 1% and comply with applicable code requirements. Where passive ventilation is not applicable, mechanical ventilation shall be used to maintain the concentration level below 1%. Redundant ventilation shall be provided. Battery Chargers shall be interlocked with the ventilation system, preventing their operation should the ventilation system not be in operation. Rooms to be mechanically ventilated at temperatures above 77°F. Battery rooms dependent on mechanical ventilation require remote monitoring per code. Hydrogen monitoring is not preferred because it requires regular sensor calibration and replacement. ~~The ventilation system shall be sized to 15 air changes per hour. The supply air to the space should be at 90% of the exhaust rate to prevent vapors from exiting the space. An exhaust hood shall be designed that will extend over the batteries being charged to exhaust any hydrogen produced by battery charging. The space electrical equipment and exhaust fan shall be designed per Class I, Division 1 with the chargers being interlocked with the ventilation system, preventing their operation should the ventilation system not be in operation.~~

6.26.3.2.4.6.7 Locker Rooms / Restroom: Each Locker Room or Restroom shall be designed with a supply air and exhaust system. The space exhaust air shall be designed for 2 cfm per square foot or the sum of 75 cfm per water closet and urinal; 50 cfm per shower; and 15 cfm per locker, which ever is greater. The supply/make-up air shall be design at 90% of the exhaust

volume to provide a pressure differential between the Locker/Restroom and the surrounding area. These guidelines or code regulations, whichever requires more cfm, shall be followed.

6.26.3.2.4.6.8 Office/Training/Operators Areas: The Office, Training and Operators Areas shall be designed to provide a minimum of 15 cfm per person of outdoor air. The spaces shall be zoned such that space with similar use and occupancy are on the same air-handling unit (see Air Conditioning above for further requirements). These areas should be designed to provide a positive pressure relationship as compared to surrounding areas. This will be done to reduce infiltration from the outside and maintenance areas. These guidelines or code regulations, whichever requires more cfm, shall be followed.

6.26.3.2.4.7 Hood Exhaust: Specific exhaust systems will be provided in the welding shop and for the individual brake lathes and grinders. Movable direct capture hoods will be provided at the welding bench and at each grinding and cutting device. Hoods shall be designed to provide a capture velocity of not less than 150 feet per minute over the cross sectional area. Each hood shall be provided with a blast gate to allow balancing and shutoff. The exhaust duct system shall be designed to the SMACNA pressure class which the suction of the exhaust fan will generate at the "dead head" condition but in no case less than 5" w.g.

6.26.3.2.5 HVAC Controls

6.26.3.2.5.1 The control system shall be based on a distributive type Direct Digital Control (DDC), Building Management System (BMS). The system shall be capable of peer to peer communication on a primary or primary/secondary, BACnet ~~or Lontalk,~~ open protocol network. Access to the network shall be available through; a local workstation; a portable personal computer able to be plugged into the system devises; or remotely through the use of the Internet.

6.26.3.2.5.2 The Internet access shall be made possible through the creation of a building specific Web Site. The control system shall be furnished with all software, programming, hardware and start-up services necessary for the implementation of the Web Site. The Web Site access shall all full BMS control form a remote personal computer without the need for additional software.

6.26.3.2.5.3 All microprocessor controlled HVAC equipment shall be furnished with all necessary interface equipment and software necessary for full control and monitoring. This equipment would include but not be limited to boilers, chillers, variable frequency drives, air compressors and rooftop air conditioners.

6.26.3.2.5.4 It is the intent that insomuch as possible the entire BMS will be electronic. All sensors and controls devises should be electronic. ~~Where torque requirements do not allow for the use of electronic actuators, electric actuators shall be used.~~

6.26.3.2.5.5 In all areas where bus maintenance or service is to take place electronic diesel specific carbon monoxide (CO) monitoring shall

be provided. The monitoring system shall directly initiate high fan speed operation of the space exhaust fans, initiate a local audio/visual alarm, and alarm the HVAC control system should a high CO level be sensed. The monitoring system shall be an aspirated type unless approved by engineering. The intent is to eliminate the need to access sensors at the ceiling and to provide for calibration of the sensors by replacement with pre-calibrated units. All maintenance items in the aspirated type units are at ground level.

6.26.3.2.5.6 A hydrogen gas detection system shall be provided in the Battery Storage Room. The system shall initiate an audio/visual alarm and send an alarm signal to the BMS.

6.26.3.2.5.7 A CNG detection system shall be provided in the Bus Garage and shall be connected into the BMS system.

6.26.3.2.6 HVAC Design Guidelines: As follows:

SUMMARY OF HVAC CRITERIA				
SPACE	**HVAC SYSTEM**	**HEATING DESIGN CRITERIA**	**COOLING DESIGN CRITERIA**	**AIR CIRCULATION AND OUTSIDE AIR**
General office	HWH, RTAC	68 ~~70~~°F	75 ~~78~~°F/50%RH	1.0 CFM/SF circ. 20 CFM/person OA
Operations and Training Areas	HWH, RTAC	68 ~~70~~°F	75 ~~78~~°F/50%RH	1.0 CFM/SF circ. 20 CFM/person
Corridors (in general areas)	HWH, RTAC	68 ~~70~~°F	75 ~~78~~°F/50%RH	0.5CFM/SF circ. 0.1CFM/person OA
Electrical Shop	HWH, RTAC	68 ~~70~~°F	75 ~~78~~°F/50%RH	0.5CFM/SF circ. 0.1CFM/person OA
Locker Rooms	HWH, RTAC	68 ~~70~~°F	75 ~~78~~°F/50%RH	(see Section 14.19.3.2.4.6.7)
Air Conditioning	HWH, RTAC	68 ~~70~~°F	75 ~~78~~°F/50%RH	(see ASHRAE)
Service Lanes & Maintenance Areas	HWH, ADH	65°F	N/A	4 ACH general OA 8 ACH rooftop exhaust
Storage Rooms	HWH	65°F	N/A	6 ACH exhaust
Air Compressor and Electrical Room.	HWH	65°F	N/A	Maintain below 90°F
Battery Charge Room	HWH	65°F	N/A	15 ACH exhaust
Boiler Room	HWH	65°F	N/A	10 CFM/boiler HP
Break Lathe				Industrial ventilation handbook
Welding Room				Industrial ventilation handbook
Paint Booth				100FPM across the cross sectional area
Repair Shop				Std. 15
Tail Pipe Exhaust				600 cfm per connection

ABBREVIATION LIST

HWH	Hot Water Heat
RTAC	Rooftop Air Conditioning
ADH	Above Door Heater (Hot Water)

RH	Relative Humidity
CIRC	Circulation
OA	Outside Air
ACH	Air Change Per Hour
HP	Horse Power
N/A	Not Applicable
CFM	Cubic Feet Per Minute
SQ. FT.	Square Foot
FPM	Feet Per Minute

6.27 COMPRESSED NATURAL GAS (CNG) BUS FACILITY REQUIREMENTS ~~VEHICLE FUELING INFRASTRUCTURE~~

6.28 Introduction

This section will provide basic criteria and guidelines for the design and implementation of a Compressed Natural Gas (CNG) Vehicle fueling system, for WMATA transit bus fleet(s). Some of the CNG infrastructure design issues that will be outlined ~~in this report~~ include; efficient vehicle fueling, reliability, safety, local, state, and national codes, and equipment service and maintenance. In addition, vehicle storage and maintenance facility design impacts will be identified. Specific facility system effects include mechanical and electric systems.

6.29 CNG Fueling System

6.29.1 Site Layout

6.29.1.1 Compressor Package Location: There are several issues to be evaluated in selecting the location of a fast-fill (typically 5 to 15 minutes fueling period per vehicle), CNG fueling station. [Slow-fill stations will typically not provide the fueling rates required by a transit fleet.] These issues include, but are not limited to the following:

6.29.1.1.1 The system location should meet International Building Code, local, state, and national code requirements, specifically NFPA 52 - Compressed Natural Gas (CNG) Vehicular Fuel Systems Code. Refer to the "Code Compliance and Industry Standards" Section 6.29.3.5.

6.29.1.1.2 The system should meet local, state, and national code requirements for distance from property line, sidewalk, and street (minimum of 10 feet per NFPA 52).

6.29.1.1.3 Appropriate distance from adjacent businesses or homes where compressor noise would be an annoyance.

6.29.1.1.4 Distance from railroad tracks (minimum of 50 feet per NFPA 52, consult RR Company for specific RR requirements).

6.29.1.1.5 Location relevant to overhead and underground utilities (contact local utilities for specific distances and requirements). Do not install a CNG fueling station below overhead power lines or above underground utilities.

6.29.1.1.6 To reduce installation and equipment costs, location should be as close to natural gas and electrical utility services as reasonably possible.

6.29.1.1.7 Allow service and maintenance clearance around the CNG fueling equipment as recommended by the manufacturer.

6.29.1.1.8 CNG storage vessels should be kept as close to the compressor package as possible.

6.29.1.1.9 Distance between compressor package and dispenser should not be greater than 100 feet.

6.29.1.1.10 Distance from adjacent facility air intakes, doors, and windows (recommend minimum of 20 feet).

6.29.1.1.11 Select location that will not disturb site aesthetics, and/or allow space for a landscaped earth berm.

6.29.1.1.12 Location that would allow the installation of proper site drainage, and not allow flooding or ponding. Perform a topography survey.

6.29.1.1.13 Location should allow for safe, efficient snow removal.

6.29.1.1.14 Perform soil boring tests to establish the soil composition for construction, and the requirements of a retention wall (if required).

6.29.1.1.15 Allow appropriate space for future expansion.

6.29.1.2 **Fueling Location**: The location of the fueling dispenser is critical for efficient CNG fueling and operator safety.

6.29.1.2.1 The dispensing system location should meet local, state, and national code requirements, specifically NFPA 52. Verify the NFPA edition adopted by the authorities having jurisdiction, and the local Fire Marshall. Refer to the "Code Compliance and Industry Standards" Section 6.29.3.5

~~21.2.1.2.2 The system should meet local, state, and national code requirements for distance from property line, sidewalk, and street (minimum of 10 feet per NFPA 52).~~

6.29.1.2.2 It is recommended in most applications to install the CNG dispenser outside of the building, adjacent to or in front of the service lanes. This arrangement allows for an efficient fueling arrangement and increases valuable site space for other uses. The installation of the CNG dispenser near the service lanes will typically increase construction costs due to the increased length of CNG tubing and utilities, in addition to increased facility construction costs to meet codes, regulations, and guidelines.

6.29.1.2.3 Per NFPA 52, the fueling island location should easily provide access to a remote, manual ESD (emergency shut-down device). A second ESD is required is be within "view" from the fueling location and a minimum of 5 feet from the CNG dispenser.

6.29.1.2.4 The fueling island location should be designed to account for the following CNG related issues:

6.29.1.2.4.1 Vehicle turning radii - design for greatest possible vehicle turning radius.

6.29.1.2.4.2 The fueling point location on the vehicle(s) (typically the curbside rear corner on CNG transit buses).

6.29.2 Fueling Station, Compressor and Gas Storage

6.29.2.1 Utility Services: Utility services are one of the most critical elements required for the operation of a CNG fueling station, and often have a substantial impact on installation and operational costs. Natural gas and electric utility feeds should be "take offs" from the facility's main utility services, unless it is more economical to install a dedicated service for the CNG fueling station. The CNG fueling station loads should be included in the sizing of the utility services, and coordinated with the local utility companies (refer to Section 12, Section 13 and Section 14).

6.29.2.2 Utility Trenches: Natural gas piping, electrical conduit, and communication cable, shall share a common utility trench. Each utility line shall be separated by a minimum of 12 inches of compacted earth. Electrical conduit shall be the uppermost buried utility, with a minimum of 36 inches cover in traffic areas.

6.29.2.3 Natural Gas Service: Below is a list of the key design issues that should be evaluated during design, and investigated with the local gas utility.

6.29.2.3.1 Gas piping and tubing: Supply piping shall be steel pipe, ASTM A 53, Type E or S, Grade B, Schedule 40, black, welded joints. CNG tubing shall be seamless, stainless steel, annealed SA 213, Type 316, ASTM A269, with maximum working pressure of 5,000 psig.

6.29.2.3.2 Location of gas main serving facility: The closer the service is to the proposed site, the less expensive gas piping costs will be.

6.29.2.3.3 Gas main pressure: The higher the available gas pressure, the less gas compressor equipment purchase and operational costs will be.

6.29.2.3.4 Gas quality, should be of "pipeline quality" gas and meet or exceed NFPA 52 and SAE J1616. Supply gas should not contain greater than 7 lbs. water vapor per mm scf. Carbon dioxide concentrations should not be greater that 2%, otherwise corrosion may occur in piping when mixed with water vapor.

6.29.2.3.5 Gas regulator: A natural gas regulator should be provided on the CNG fueling station gas supply line. The regulator shall be set for a pressure in accordance with manufacturer's recommendations, for the specific equipment to be installed.

6.29.2.3.6 Gas submeter: A natural gas submeter should be provided downstream of the CNG fueling station gas supply line. This will enable the owner to record and analyze gas usage.

6.29.2.3.7 Gas service and contract: Provide the gas utility with the fueling station's maximum gas load in SCFM, and periods of peak load (greatly impacted by the selection of an electric driven compressor vs. a natural gas driven compressor). Determine the rate tariff or negotiate a gas service term contract with a specific rate per cf (Ccf or MCF) for delivery. Determine whether the tariff would be an interruptible or non-interruptible gas service.

6.29.2.4 Electric Power Service: Below are key issues that should be evaluated during design, and discussed with the local electric utility.

6.29.2.4.1 Electrical wire shall be encased in rigid, schedule 40 PVC pipe, with properly sealed joints. All materials and equipment to conform to UL requirements, and be listed by UL, FM, or nationally recognized testing laboratory (NRTL).

6.29.2.4.2 Location of electrical panelboards in facility: The closer the panelboard is to the proposed site, the less expensive electrical conduit and wire costs will be, as it relates to the installation of a CNG fueling station.

6.29.2.4.3 Electrical service voltage and capacity should be determined by a system load calculation and information provided by the equipment manufacturer (greatly impacted by the selection of an electric driven compressor vs. a natural gas driven compressor). Typical voltage is 480v, 3 phase for electric driven compressor and 120v, single phase for associated system controls.

6.29.2.4.4 **Emergency Power System:** the CNG vehicle fueling system's electrical load and requirements shall be included in the design and sizing of the emergency power system. The emergency power system shall enable complete and full operation of the CNG fueling system.

6.29.2.5 **Natural Gas Dryer:** The purpose of a natural gas dryer is to eliminate moisture from the gas supply, and to maintain a minimum level of moisture vapor entering the gas compressor. Special attention is required in determining dryer specifications as they relate to outside air temperature in various geographic locations.

6.29.2.5.1 A manually activated, closed loop, heat regenerative twin tower dryer, with a molecular sieve 3A low pressure gas dryer shall be supplied. The dryer shall dry the gas before it is compressed so that the pressurized dew point (measured at 5,000 psi) will not allow moisture to condense at design ambient -10 deg. F. to 95 deg. F. Have special molecular sieve for minimal effect on natural gas odor.

6.29.2.5.2 The natural gas dryer shall be designed, constructed, and tested in conformance with the following:

6.29.2.5.2.1 Compressed Natural Gas Vehicular Fuel Systems (NFPA 52)

6.29.2.5.2.2 National Electric Code (NEC), NFPA 70

6.29.2.5.2.3 American Gas Association (AGA)

6.29.2.5.2.4 Underwriters Laboratories (UL)

6.29.2.5.2.5 Society of Automotive Engineers (SAE)

6.29.2.5.2.6 American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code

6.29.2.6 **Compressor:** Two types of prime mover compressor systems are currently available. They include electric driven and natural gas driven compressor systems.

6.29.2.6.1 Electric Driven: Drive motors shall be three phase, AC induction motors, soft start, TEFC type, NEC Div. 2 rated, premium efficiency rated, including starter, starter housing, motor protection circuit.

6.29.2.6.2 Natural Gas Driven: Gas engine shall consist of an industrial (heavy duty), four stroke, spark ignited internal combustion engine. Associated engine components shall include; lubrication systems, cooling systems, temperature and pressure switches and gauges. Gas engines are available in naturally aspirated or turbo-charged options.

6.29.2.6.3 Compressor (package) performance and conformance specifications:

6.29.2.6.3.1 Piston rings: Minimum design life of 4,000 hours lubricated or 2,000 hours non-lubricated.

6.29.2.6.3.2 Piston rod packing: Leakage rate of no greater than 0.5% of throughput. Minimum design life of 4,000 hours lubricated or 2,000 non-lubricated.

6.29.2.6.3.3 Lubricated oil consumption: No greater than 0.5 pounds of oil per mmscf. Oil recycling capability - blowdown tank to crankcase.

6.29.2.6.3.4 Synthetic oil lubricated.

6.29.2.6.3.5 Interstage separators: Centrifugal separator or coalescing filter required after each pressure lubricated stage.

6.29.2.6.3.6 Discharge filter: Only single coalescing filter for non-lubricated, pre-coalescing and coalescing filter required for lubricated.

6.29.2.6.3.7 Automatic gas recycling system.

6.29.2.6.3.8 Controls: PLC

6.29.2.6.3.9 Codes and regulations: NEC and NFPA 52 compatible. All components UL listed, FM approved or otherwise approved by a NRTL.

6.29.2.6.3.10 Enclosure: Maximum noise emission level of 85 dbA at 15 feet, or local noise ordinances as applicable. Unit shall include heat, light, and gas detection.

6.29.2.6.3.11 Lifting and rigging mounts and supports.

6.29.2.6.4 The selection of an electric vs. natural gas prime mover is very complicated. Each application requires a technical and economic analysis, to determine the most feasible and cost effective option. Refer to Table 21.1 below for summary of key comparison issues between electric and natural gas prime movers.

6.29.2.7 Storage: Cascade, fast-fill CNG fueling system applications utilize vessels to store CNG until required by the dispensing system. A slow-fill CNG fueling system does not utilize storage to enable complete vehicle fueling in a short period of time. Storage of CNG enables the system to fuel vehicles during high demand periods. Unlike the transfer of a liquid fuel, natural gas flows from storage to the vehicle due to a pressure difference. Natural gas flows from high pressure (storage) to low pressure (CNG Vehicle). As a result of this, it

is impossible to utilize the entire storage volume. Typically, 30% to 40% of the storage volume is used to "fill" a CNG Vehicle, the remaining 60% to 70% is provided by the operation of the compressor.

Performance Issue	Gas Engine	Electric Motor
Energy (fuel) Cost	Low compared to motor, price of natural gas fairly uniform across U.S. Only minimal electrical service needed for station, 3 phase power not necessarily required for station.	High compared to engine, local electrical costs vary considerably across U.S. Expensive electrical service upgrades often required for motor operation.
Maintenance Cost	Regular maintenance required, moderate cost involved.	Virtually no maintenance required.
Reliability	Good, however lower than Motor reliability.	Very high, seldom any problems.
Operating Emissions	Some unburnt methane, CO, CO_2, NOx, and H_20. Little evidence of emissions on site.	No emissions with exception of those produced at site of electrical power generation.
Noise Pollution	Considerable noise generated in comparison to motor.	Very little noise generated, virtually undetectable when adjacent to reciprocating compressor.
Capital Cost	Several times more than an equivalent electric motor.	Much less expensive than a gas engine.
Control System	More elaborate controls required: starting, warming-up, idle, full speed, shut down etc.	Controls relatively simple in comparison to those required for engine. Soft-start, run, shutdown.
Packaging	Requires more space, stronger mounting, additional parts, increased compressed air requirements and an exhaust system.	More compact, lighter and less complex than engine.
Other	Power output affected by altitude and temperature.	Power output virtually independent of ambient conditions.

Table 21.1 Summary Comparison between Gas Engine and Electric Motor Driven CNG Compressors

6.29.2.7.1 Storage (Skid) Performance Specifications:

6.29.2.7.1.1 Compressed Natural Gas (CNG) ASME 3-Vessel storage tank assembly.

6.29.2.7.1.2 Manufactured to ASME UPV Code Section VIII Division 1 App. 22.

6.29.2.7.1.3 Safety factor rating of 3:1 for dry gas, non-corrosive service.

6.29.2.7.1.4 5,500 psi design pressure, 5,000 psi operating pressure.

6.29.2.7.1.5 Total storage volume of product at 5,000 psi (to be determined based on NGV fleet requirements).

6.29.2.7.1.6 Skid footprint no greater than 2' wide x 12' long.

6.29.2.7.1.7 Full port stainless steel (½") ball valves on front and rear of each vessel.

6.29.2.7.1.8 Safety relief valves on each vessel.

6.29.2.7.1.9 Dome outlet drain valves on each vessel.

6.29.2.7.1.10 Saddle mount frames for horizontal mounting of vessels.

6.29.2.7.1.11 Lifting and rigging mounts and supports.

6.29.2.7.1.12 Complete priming and painting of storage skid and assembly.

6.29.2.7.2 The volume, arrangement, and type of each CNG fueling system's storage package varies with the fleet. Proper fueling rates and capacities need to be calculated and evaluated for each fleet fueling application.

6.29.3 Fueling Island - Dispensing System

6.29.3.1 **Components:** The fueling island should contain several components including, but not limited to; CNG dispenser, fuel management system, equipment and driver protection, safety devices, proper signage, fueling hoses, and an emergency shut down system. The function of a dispenser is to act as the interface between the CNG fueling station and the CNG vehicle, including authorizing fueling, metering, recording, and displaying of fueling data for each transaction.

6.29.3.2 Fueling Island

6.29.3.2.1 Stainless steel island form, 4 feet wide x 14 feet long, full round ends, double wall side. Fill with concrete, rebar enforced, slope at 1%.

6.29.3.2.2 Provide schedule 80 steel bollards, 8 inch diameter x 8 ft. long. Fill with concrete, round top.

6.29.3.2.3 Provide site lighting meeting hazardous area classification, Class 1, Division 1.

6.29.3.2.4 Provide fire extinguisher with 20-B:C rating, mounting post and accessories.

6.29.3.2.5 Provide placard stating the name and address of the CNG fueling location, and the name and phone number of the nearest Fire Company.

6.29.3.3 Dispenser Performance Requirements:

6.29.3.3.1 Maximum delivery pressure of CNG shall be controlled for 3,000/3,600 psi vehicle fueling requirements affording optimal vehicle fills. Maximum storage pressure of the gas, after compression, is to be maintained at not more than 5,000 psi compensated at 70°F ambient temperature for outdoor installations.

6.29.3.3.2 All components shall be assembled, piped, wired and interconnected, so as to provide an operable system requiring minimal field construction and installation.

6.29.3.3.3 System design pressure shall be 5,000 psi with operating pressures to be 3,000/3,600 psi as specified.

6.29.3.3.4 Dispensing equipment shall be designed for outdoor use and equipped with means to protect all operating controls and electrical wiring from climatic conditions. Exposure to normal weather conditions shall not interfere with the performance and safety of the equipment supplied.

6.29.3.3.5 Dispensing system to provide site specific number of dispensing hoses (TBD), and be capable of fueling site specific number of NGVs simultaneously (TBD).

6.29.3.3.6 The dispensing system shall be able to operate independently from compression equipment.

6.29.3.3.7 Vehicle fuel cylinders shall be protected by pressure relief valves set at or below the designated maximum allowable vehicle filling pressure. Pressure relief valves shall comply with Section VII, Division 1 of the ASME Boiler and Pressure Valve code.

6.29.3.3.8 Dispenser fueling hose shall be conductive type designed for CNG service and appropriately marked. Each hose shall incorporate a breakaway connection to prevent loss of CNG and minimize damage to the dispenser in the event the fueling hose is pulled away from dispenser.

6.29.3.3.9 Minimum fuel flow rating of the dispenser shall be determined by fleet requirements.

6.29.3.3.10 Each hose shall be:

6.29.3.3.10.1 15 feet long if connected to upper part of dispensing unit or, 12'-6" long if connected to side of dispensing unit

6.29.3.3.10.2 electrically conductive and constructed with a non-metallic braid

6.29.3.3.10.3 rated for 5,000 psi, SAE 100R8

6.29.3.3.10.4 equipped with a stainless steel breakaway connector that limits breakaway to hose not greater than 150 lbs.

6.29.3.3.11 Dispenser shall operate on 120 Volt single phase power supply.

6.29.3.3.12 In line filters of not greater than 25 micron shall be provided for each line of fuel supply. Filters shall be incorporated into the dispenser cabinet.

6.29.3.3.13 Dispenser shall provide LCD display to indicate the quantity in GGE of fuel dispensed.

6.29.3.3.14 Dispenser shall not utilize pressure gauge indication of vehicle fueling status but instead shall indicate LCD "Percent of Fill" status.

6.29.3.3.15 Fueling nozzles shall be at a minimum, ANSI/AGA NGV 1, Type 1 of the appropriate pressure rating for the identified filling pressure requirements. All nozzles shall provide capture of disconnect gas for safe venting away from vehicle connection point.

6.29.3.3.16 Dispensers supplied for this application shall incorporate only electronically controlled temperature compensated fuel control systems, which shall include the following:

6.29.3.3.16.1 Algorithm based software to provide vehicle filling control that calculates the vehicle's required fuel capacity compensating for ambient temperature, heat of compression and vehicle cylinder temperature rise so as to provide accurate fills to within 93-98% of vehicle rated capacity.

6.29.3.3.16.2 Computer based adjustable control of sequential set points for low, mid and high banks of storage with full low flow cut off.

6.29.3.3.17 Dispenser fuel metering shall be accomplished through the use of a coriolis mass flow meter consisting of a sensor and an electronic control module that measures the mass of the gas flow independent of density, pressure or temperature. An independent coriolis metering system, Micro Motion DH038 or equivalent, for each fueling hose of the dispenser. Certified metering accuracy of +/- 1.5%.

6.29.3.3.18 High Flow Cut Off - provides shutoff of fuel flow if gas is dispensed at a rate determined by fleet requirements.

6.29.3.3.19 Pressure Drop Cut Off - provides shutoff of fuel flow if there is a sudden pressure drop during fueling process.

6.29.3.3.20 Pressure Rise Cut Off - provides shutoff of fuel flow if the fueling pressure does not rise in accordance with the mass of gas dispensed.

6.29.3.3.21 ESD Interlock - Closes the fuel system's ESD valves when the dispenser is not in use. Closes the fuel system's ESD valves if the dispenser control system senses a fault with a control component.

6.29.3.3.22 A pit frame shall be provided for dispenser mounting that can be installed at installation site.

6.29.3.3.23 Fueling dispenser shall be designed, constructed, and tested in conformance with the following:

6.29.3.3.23.1 American Gas Association (AGA).

6.29.3.3.23.2 American National Standards Institute (ANSI).

6.29.3.3.23.3 American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code, Section VIII, Division 1.

6.29.3.3.23.4 Compressed Gas Association (CGA).

6.29.3.3.23.5 Underwriters Laboratories (UL).

6.29.3.3.23.6 Nationally Recognized Testing Laboratory (NRTL).

6.29.3.3.23.7 Factory Mutual Research Association (FM).

6.29.3.3.23.8 National Electrical Manufacturers Association (NEMA).

6.29.3.3.23.9 National Fire Protection Association (NFPA) NFPA70 National Electric Code NEC.

6.29.3.3.23.10 National Fire Protection Association (NFPA), NFPA52.

6.29.3.3.23.11 National Pipe Threads (NPT)

6.29.3.3.23.12 Uniform Fire Code (UFC)

6.29.3.3.23.13 Occupational Safety and Health Administration (OSHA)

6.29.3.4 Fuel Management System

6.29.3.4.1 Components: A fuel management system should include a card reader, software, and communication equipment necessary for an owner to monitor and evaluate fuel usage data. Typical fuel management systems provide fueling transaction data such as; vehicle number, operator name, vehicle mileage, quantity of fuel, date, and time. The complexity of a CNG fuel management system can vary greatly depending on the application and owner requirements.

6.29.3.4.2 Fuel Management System Performance Requirements:

6.29.3.4.2.1 System to be a fully automated fuel dispensing system and capable of providing inventory and transactions data without the need for a fuel station attendant.

6.29.3.4.2.2 System must be capable of selective card lockout, computing pump totalizer reading for inventory control, telephone modem hookup from remote sites to the existing central system.

6.29.3.4.2.3 System to be capable of controlling and relaying information to a remote computer system.

6.29.3.4.2.4 System components to be FCC and UL listed.

6.29.3.4.2.5 Island Card Reader: Island card reader to be island (base) mounted, two key system, with a weatherproof enclosure, built-in diagnostic system, capable of controlling a minimum of two hoses simultaneously, and including an emergency stop button. Suitable for Class 1, Division 2 areas. Illuminated system faceplate, LCD display and keypad suitable for all weather installation with back lighting or display suitable for viewing in lighted nighttime island setting. Capable of being activated and de-activated by the owner's fuel management system terminal. Must be compatible with owner's fuel management system, and provide vehicle and fueling data as required.

6.29.3.4.2.6 Voltage Regulator: Provide a UL listed voltage regulator to give voltage regulation, transient suppression and common mode protection for the island card reader, pump control units, site controller and phone modem.

6.29.3.5 Code Compliance and Industry Standards

6.29.3.5.1 NFPA 30A -

6.29.3.5.2 NFPA 52 - Compressed Natural Gas (CNG) Vehicular Fuel Systems: NFPA 52 is the encompassing standard that should (typically) be used in the design of a CNG fueling station. The intent of this standard, as written, is to serve as a minimum guideline, not a specification. NFPA 52 is not universally adopted throughout the United States. Fueling station design should conform to the NFPA 52 version that has been adopted by the authorities having jurisdiction, and the local Fire Marshall. NFPA 52 versions vary significantly, specifically as they pertain to electrical requirements. It should also be stressed that NFPA 52 may not be the encompassing design standard if the site's local Fire Marshall has not adopted NFPA 52 as a code. Regional codes may augment and/or supersede NFPA 52.

6.29.3.5.3 NFPA 70 - National Electric Code (NEC): NFPA 70, Chapter 5 - Special Occupancies, contains several sections relating to hazardous locations that apply to CNG fueling stations. NFPA 52 defines where each of the hazardous electrical areas are located, but does not define what type of electrical equipment is required, or how it is to be wired and installed. As with NFPA 52, NFPA 70 - NEC needs to be verified as the applying code by the local authorities having jurisdiction.

6.29.3.5.3.1 Article 500, 501, 504, 511 - Hazardous Locations: NFPA codes classify hazardous areas according to the likelihood of the particular hazardous or flammable material being present in a given location. Often the most unclear and confusing code requirement issues involve determining the electrical "Classes" and "Divisions" as they apply to hazardous area equipment. The following description should help to generally understand this issue.

6.29.3.5.3.1.1 Class 1, Division 1, Group D: A location where natural gas is present all of the time, or where it may be present as the result of faulty equipment operation or gas relief.

6.29.3.5.3.1.2 Class 1, Division 2, Group D: A location where natural gas is normally contained in a gas vessel or pipe, and can only escape as the result of equipment failure or abnormal circumstance.

6.29.3.5.3.1.3 NFPA 37 - Stationary Combustion Engines and Gas Turbines: This code outlines the necessary instrumentation, mechanical, and electrical requirements, for the installation of a natural gas engine. This code would only apply for the installation of a natural gas prime mover CNG fueling station.

6.29.3.5.3.1.4 NFPA 497 -

6.29.3.5.3.1.5 Uniform Fire Code (UFC): The main issue in this code is the equipment separation requirements as outlined in sections 5201 and 5204 in the 1994 edition.

6.29.3.5.3.1.6 National Electrical Manufacturers Association (NEMA): A CNG fueling station designer should be familiar with NEMA electrical equipment ratings. NEMA provides a method of rating electrical enclosures for the environment and applications they can be installed.

6.30 CNG SERVICE, MAINTENANCE AND STORAGE AREAS

This Section is written only as a general guideline, as no encompassing code covers the indoor storage and service of CNG vehicles, and as a result, design practices are determined on a case by case and application basis. Facility design should include careful consideration of the vehicles and the facility's systems, and should be coordinated with local fire and safety officials follow codes and standards described in Section 21.2.3.5.

6.30.1 Mechanical Systems and Equipment

6.30.1.1 Ventilation System - Service and Maintenance Areas

6.30.1.1.1 Ventilation system shall provide 4 ACH continuously (as required by OSHA and NFPA 88B). Powered ventilation system shall be spark resistant, centrifugal, roof exhaust fans, with Class 1, Division 2, explosion proof motor

and power accessories. OA shall be introduced to the space at ground level. Design shall ensure that all areas of the ceiling are ventilated, regardless of ceiling geometry.

6.30.1.1.2 Emergency ventilation system shall provide a total of 8 ACH, and shall be automatically activated by the gas detection system, as well as a manual emergency button.

6.30.1.1.3 Where possible, ventilation fans shall be located directly above CNG service bays.

6.30.1.2 Ventilation System - Storage Areas

6.30.1.2.1 Ventilation system shall provide 1 cfm per square foot of floor space, continuously during normal business hours. Powered ventilation system shall be spark resistant, centrifugal, roof exhaust fans, with Class 1, Division 2, explosion proof motor and power accessories. OA shall be introduced to the space at ground level. Design shall ensure that all areas of the ceiling are ventilated, regardless of ceiling geometry.

6.30.1.2.2 Emergency ventilation system shall provide a total of 8 ACH, and shall be automatically activated by the gas detection system, as well as a manual emergency button.

6.30.1.3 Space Heating System

6.30.1.3.1 Heating devices within the hazardous area (facility) shall be hot water or indirect (sealed combustion), Class 1, Division 2 rated (per NFPA 30A and 88B). All combustion air is to be supplied from outside the facility.

6.30.1.3.2 Electrical Systems and Equipment

6.30.1.3.2.1 Panelboards and sub-panelboards should not be installed in hazardous areas. Panelboards should be located outside of CNG service and storage areas, or in a dedicated electrical room, without the possibility of gas infiltration by natural or mechanical means.

6.30.1.3.2.2 Equipment - (Motors, Light Fixtures, etc.)

6.30.1.3.2.2.1 All electrical equipment, components, and accessories - located 18" down from the underside of the roof deck ~~from the top of the lowest NGV, to the ceiling~~ - shall be Class 1, Division 2 rated.

6.30.1.3.3 Specialty Service Equipment

6.30.1.3.3.1 Welding and Grinding

6.30.1.3.3.1.1 Welding, grinding, other spark or open flame related work - work area to be a minimum of 50 feet from CNG service or storage areas. Work area shall contain a spark/vapor curtain.

6.30.1.3.3.1.2 NGVs to be serviced by a welding or grinding activity shall be "de-fueled" to at least half of rated tank pressure, and NGV fuel tank and manifold isolation valves closed. NGV engine shall be turned-over to burn residual gas.

6.30.1.3.3.2 Hand Tools

6.30.1.3.3.2.1 Hand held lighting and electrical tools shall be appropriate and listed for Class 1, Division 2 rated areas.

6.30.1.3.3.2.2 Hand held methane detectors should be provided to inspect CNG Vehicle fueling lines and storage tanks, prior to commencing service work.

6.30.1.3.4 Facility Design - Coordination Issues

6.30.1.3.4.1 Roof trusses shall be of open design, and not allow gas to be "trapped" in ceiling spaces, design shall allow for through ventilation.

6.30.1.3.4.2 Facility indoor partitions should be continuous from floor to ceiling, securely anchored, and have a minimum of 2 hour fire resistance.

6.30.1.3.4.3 CNG service bays shall be located directly under any necessary "high points" in ceiling design.

6.30.1.3.4.4 Deflagration panels may be designed into exterior facility walls where highly hazardous areas are considered.

6.30.1.3.5 Gas Detection System

6.30.1.3.5.1 Complete gas (methane) detection system and accessories including; infrared gas detector transmitter and receiver assembly with reflector panel, gas personality modules and mounting brackets, explosion proof insulating power supplies. Control system to include; dual channel control card with independent digital displays, site specific programmable alarm levels per channel, power and fault diagnostics indicators, test/reset and alarm inhibit switches, system enclosure, mounting brackets, power supply, audio/visual alarm devices, remote zone alarm indicator, PDT relays, termination assembly, 115v AC power operation.

6.30.1.3.5.2 The gas detection system shall open outside doors, start emergency ventilation fans, sound alarms, and disable certain equipment.

6.30.1.3.6 Code Compliance and Industry Standards: It should be made clear that existing codes lack emphasis and clarity on significant CNG issues. The following codes and guides should be referenced when designing a CNG service, maintenance, or storage facility, but common sense and experience should prevail. The use of an experienced Architect and Engineer is recommended.

6.30.1.3.6.1 NFPA 30A and 88BA - Parking Structures and NFPA 88B - Repair Garages: These codes provides requirements for flammable and combustible liquids (NFPA 30), and liquefied petroleum gas (NFPA 58), which in vapor form are heavier than air, and will collect along the facility floor. Natural gas is lighter than air, and will travel from the source, to the facility ceiling. Natural gas under pressure will tend to flow in the direction of leaking force, then rise to the ceiling. These codes basically describe that the requirements on/along the floor for diesel fuel vapors, should be applied to the ceiling area for natural gas. The Class 1, Division 2 zone in the maintenance area shall be 18" down from the underside of roof deck.

6.30.1.3.6.2 Federal Transit Administration (FTA) - Garage Guidelines for Alternative Fuels: This document provides a general description of CNG service, maintenance, and storage hazards, however it does not provide specific design requirements or equipment ratings.

6.30.1.3.6.3 IBC - International Building Code: These codes mainly provide minimum standards for building design and construction. Most sections dealing with hazardous materials and how they impact system design and construction, refer the reader to NFPA. This code does however, identify building "group" classifications based upon the intended use of a building or area, and/or the hazards which may be stored in a particular building or area. Design and construction shall meet all IBC ~~IBOCA~~ requirements, specifically chapter 3, sections 307, 309, and 311.

6.31 GLOSSARY OF ABBREVIATED TERMS

AGA - American Gas Association
ANSI - American National Standards Institute
ACH - Air Changes per Hour
ASME - American Society of Mechanical Engineers
ASTM - American Society Testing Materials
BOCA - Building Officials and Code Administrators International, Inc.
CGA - Compressed Gas Association
CF - Cubic Feet
CFM - Cubic Feet per Minute
CNG - Compressed Natural Gas
dbA - Decibel Absolute
FCC - Federal Communication Commission
FM - Factory Mutual Research Association
GGE - Gasoline Gallon Equivalent
IBC - International Building Code
LCD - Liquid Crystal Display
NEMA - National Electrical Manufacturers Association
NFPA - National Fire Protection Association
NPT - National Pipe Threads
NGV 1 - Natural Gas Vehicle Standard
NEC - National Electric Code
NRTL - Nationally Recognized Testing Laboratory
OA - Outside Air
OSHA - Occupational Safety and Health Administration
PLC - Programmable Logic Controller
PSIG - Pounds per Square Inch Gauge
SAE - Society of Automotive Engineers
SCF - Standard Cubic Feet
SCFM - Standard Cubic Feet per Minute
TEFC - Totally Enclosed Fan Cooled
UFC - Uniform Fire Code
UL - Underwriters Laboratories

6.32 REFERENCES

International Building Code (IBC) published by the International Code Council
Building Officials and Code Administrators International, Inc. (BOCA) - National Building Code
Federal Transit Administration (FTA) - Garage Guidelines for Alternative Fuels
National Electrical Manufacturers Association (NEMA) Standards
NFPA 30A
National Fire Protection Association (NFPA) 37 - Stationary Combustion Engines and Gas Turbines
National Fire Protection Association (NFPA) 52 - Compressed Natural Gas (CNG) Vehicular Fuel Systems
National Fire Protection Association (NFPA) 70 - National Electric Code (NEC)
National Fire Protection Association (NFPA) 88A - Parking Structures
National Fire Protection Association (NFPA) 88B - Repair Garages
NFPA 497
Natural Gas Vehicle (NGV) Institute - Certification Training Program Manual
Uniform Fire Code (UFC)

SECTION 7 LIGHT RAIL

7.1 (FUTURE)

SECTION 8 DESIGN POLICIES FOR THE OPERATING METRORAIL SYSTEM

8 .1 GENERAL

The following design criteria in sequence first establishes the criteria for the Metro Design Vehicle and then provides the criteria for the facilities required for the safe operation of the Metro Design Vehicle in the Metrorail System.

To facilitate operations in a single-track mode to by-pass emergencies, maintenance and repair, all tunnels and aerial guide-ways shall be separate single track structures, except where necessary for special trackwork. Double track structures may be considered when approved by WMATA.

8 .2 DESIGN VEHICLE

System rolling stock will be designed and operated in two car multiple units. Multiple car trains in lengths of two, four, six and eight cars will be scheduled for revenue service. The maximum train consist is eight cars or 600 feet. Moving a bad order train will result in a maximum train length of 1200 feet.

WMATA cars will be high performance, lightweight, electrified vehicles having the following characteristics:

8 .2.1 Dimensions

Length over coupler faces, maximum		75' - 0"
Approximate length over anti-climbers		74' - 9"
Width, maximum		10' - 1¾"
Height at centerline above top of rail, maximum		10' - 10"
Floor height, above top of rail		3' - 4"
Truck Spacing		52' - 0"
Truck Wheel Base,	minimum	6' - 6"
	maximum	8' - 6"
Wheel Gage		4' - 7 11/16"
Basic Track Gage		4' - 8 ¼"
Wheel Diameter		28"
Roll Angle (AREA Static Lean Test)		1° 30' max.

8 .3 CLEARANCE ENVELOPE

The Rohr, Breda, CAF and Alstom Cars also have design characteristics that differ slightly from the WMATA Car. The clearance envelope shown on Standard Drawing ST-C-2 incorporates all of the these different car characteristics. The final design must allow for the car outline found on ST-C-2 which is described as follows: The **clearance envelope** is defined as the space occupied by the dynamic outline of the 10'-1¾" wide design vehicle plus an additional allowance of 2" around the dynamic outline. The following factors have been considered in developing the clearance envelope:

8 .3.1 Dynamic Outline

The dynamic outline of the design vehicle includes the following car body movements:

8 .3.2 Vertical Upward Displacement

Track construction tolerance	0.250"
Car construction tolerance	0.500"
Car body camber	0.500"
Bounce against stops	1.500"
Vertical track curvature	0.375"
Total	3.125"

8 .3.3 Vertical Downward Displacement

Wheel wear	0.750"*
Rail wear	0.750"*
Air springs against stops	1.500"
Primary springs against stops	1.500"*
Vertical track curvature	0.375"
Total	4.875"
* Total - Truck Parts Only	3.000"

8 .3.4 Lateral Displacement

Lateral of wheels	0.406"*
Car body against stops	1.500"
Car construction tolerance	0.125"
Track construction tolerance	0.250"*
Truck assembly tolerance	0.125"*
Wheel wear	0.250"*
Rail wear	0.500"*
Total	3.156"
* Total - Truck Parts Only	1.531"

8 .3.5 Roll

3½ degree roll occurring after 1½ inches of lateral movement. The combined effect of these factors is shown on Fig. 11.29 as the dynamic outline. For clearances at Station Platforms only, the following car body movements have been used:

Vertical Downward	3.00"
Lateral Movement	2.625"
Roll, after 1½" lateral movement	2.00°

8 .4 Passenger Capacities and Car Loadings and Weights

Passenger Capacity Loadings	
Seating Capacity per car	81
Passenger Capacity per car, seated plus standees:	
Normal Loading	130
Normal Maximum	160
"Crush" Loading	220

Weights per Car with Different Loadings	
Lightweight, including air conditioning	82,000 lbs.
Normal Maximum Loading	106,000 lbs
"Crush" Loading	115,000 lbs
Absolute Maximum Loading	132,000 lbs

8 .5 Performance Characteristics

8 .5.1 Design Velocity

The design vehicle maximum velocity is 75 mph. The minimum desirable design velocity is 40 mph. The train control system limits the operational running speeds to ten preset values.

8 .5.2 Normal Acceleration

Fig. 11.32 has been prepared to illustrate a typical Speed-Time-Distance curve for normal acceleration of the design vehicle from a standing stop to the maximum speed attainable of 75 mph on level, tangent track.

8 .5.3 Normal loading of 130 passengers per car was assumed in curve development.

The acceleration rate is non-linear, tapering from a maximum of 3.0 mphps at the start of acceleration to balancing speed.

8 .5.4 Normal Deceleration

Fig.11.33 illustrates a typical Speed-Time-Distance curve for normal deceleration from a maximum speed of 75 mph to a stop on level, tangent track. Crush loading of 220 passengers per car was assumed in curve development. The following tapered braking rates were assumed:

75 mph to 50 mph - 2.25 mphps increasing uniformly to 3.0 mphps
50 mph to 0 mph - 3.0 mphps

8 .6 AUTOMATIC TRAIN CONTROL - ATC

The WMATA Automatic Train Control uses stepped code speeds for operating vehicles on the main line tracks. The code speeds are: 15, 22, 28, 35, 40, 45, 50, 55, 65, 75. The design of a curve for a faster speed than one of the coded speeds will result in the ATC operating the train through the curve and spirals at code speed which is below the rated design speed of the curve/spiral. For example a curve designed for 44.5 miles per hour will be limited to 40.0 mph in Metrorail operation. The determination of maximum design speed through a curve for areas of limited space should recognize this limitation in design flexibility in the design of actual curve superelevation.

8 .7 TURNOUTS

The maximum horizontal limits of the design vehicle dynamic outline of the standard design vehicle as it moves through a turnout has been established for WMATA No. 6, 8, 10 and 15 turnouts.

8 .8 ACOUSTICAL TREATMENT ALLOWANCE

Critical clearance dimensions are not increased to allow for the application of acoustical treatment. However, this will not preclude the use of acoustical treatment in areas not critically affected by car clearance requirements.

8 .9 CONTROL OF ACCESS

8 .9.1 General

The rapid transit right-of-way shall be protected in such a manner as to prohibit public vehicular or pedestrian traffic from the right-of-way, except at points of passenger ingress and egress, such as stations and parking areas.

8 .9.2 Crossings

All crossings of the right-of-way shall be grade separated.

8 .9.3 Right-of-Way Barriers

Along the system, security barriers shall be provided to prevent the public from gaining access to the tracks.

8 .9.4 Pedestrian Barriers

Forms of pedestrian barriers include fences, walls, and structural elevation differences. A deterrent in the form of barbed wire or equal physical obstruction must be mounted on the top of the barrier where illustrated in WMATA Manual of Design Criteria Facilities, Section 11, Figure 11.70 to Figure 11.72.

8 .9.5 Fencing at Surface Routes

Minimum 6' high chain link security fence with extension arms and 3 strands of barbed wire shall be provided with 4'-0" wide sliding emergency access gates at approximately 800 foot intervals on both sides of the right-of-way to coincide with the trip station lights.

Where the transit right-of-way is crossed by a pedestrian walkway, the barrier on the walkway should effectively prevent objects being dropped or thrown on the transit right-of-way.

8 .9.6 Vehicular Barriers

Acceptable vehicular barriers include highway guard rails, barrier curbs, structural walls or earth embankments. In each case, where vehicular access to areas adjacent to the transit right-of-way is possible, individual circumstances must be evaluated including the possibility of accidental entry by runaway vehicles.

8 .9.7 Safety Railings

Where elevation differences alone constitute a sufficient pedestrian or vehicular barrier, safety railings must be provided both for the protection of the public and the rapid transit personnel.

8 .10 Service Roads

Service roads as shown on the trackwork designing and standard drawings shall be provided for Metro construction at grade on exclusive right-of-way wherever land use permits and wherever real estate and construction costs make their inclusion economically feasible. The decision to include or exclude a service road shall be made by the Authority upon receipt of the Designer's evaluation of cost and feasibility.

Service roads need not be continuous although this is desirable. A means of access shall be provided for each section of service road. A cul-de-sac shall be provided at the end of a service road where a direct connection to a public road is not possible or feasible. Furthermore, it is not necessary that the service road always be on the same side of the tracks.

For minimum clearances required between the design vehicle dynamic outline and service road structures or installations, refer to Standard Drawing ST-TW-RR-005

Maintain uniform roadway alignment calculations, referencing service roads to track alignment whenever possible. Maintain records of computer output of calculations with clearly referenced sketches and definitions of computer output codes.

8 .11 MAINTAINABILITY

The Metrorail System shall be designed to attain the optimum degree of maintainability consistent with established Metrorail architectural and engineering design criteria

contained in this Manual. Maintainability is determined by the characteristics of Metrorail structures, finishes, fixtures and installed equipment which make it possible to operate a safe and efficient system with the most economical expenditure of maintenance resources.

Maintenance resources include manpower, equipment, materials and support facilities. Emphasis shall be applied to those maintainability considerations which determine the frequency, rapidity and ease of maintenance operations.

Maintenance operations consist of inspection, adjustment, cleaning, servicing, testing, repair and replacement. Particular attention shall be placed on providing accessibility for performance of maintenance (service hatches, stairs, ladders, lifting equipment, catwalks, structural openings, space, layout and fixture/equipment location). Full consideration shall be given to economic factors, e.g., life cycle costs, in determining the extent to which maintainability is incorporated. Where the principle of maintainability is in conflict with criteria in this Manual or the General Plans, such conflicts, with recommended action, shall be brought to the attention of the Authority.

8 .12 CONTRACT DRAWING STANDARDS

8 .12.1 GENERAL

8 .12.1.1 Drawings

Drawings shall be created using CAD procedures that are defined in the August 2004 version of the WMATA CAD Manual . Drawings shall be submitted in hardcopy, AutoCAD and pdf formats.

Drawing presentation, size, symbols and details must be standardized as much as possible to facilitate reading and filing by the Authority and contractors. Standardization within each individual contract and throughout the large number of contracts for the rapid transit system is essential.

All contract drawings shall be produced on a 22"x34" - 0.003" thick polyester sheet, matte both sides, identical in format to the sample supplied by the Authority.

DRAWING SEQUENCE FOR CONTRACTS - Design drawings provided for construction contracts shall organize the drawings in the following sequence:

Cover Sheet
General Site Plan
Index of Drawings
Cross Index
Project Signs
Civil Abbreviations, Symbols and Notes (including curve geometry)
Horizontal and Vertical Controls
Survey Plots (including boring locations)
Geotechnical Symbols, Abbreviations and Notes
Boring Logs
Right-of-Way
Plan and Profile (including structural key plans and other key plans if it can be done without loss of clarity)
Alignment Data (coordinate tabulation)
Typical Section (composite)
Construction Staging

Grading Plans (as required)
Paving and Restoration
Standard Barricades
Sediment Control Plans
Utility Symbol and Abbreviation Standard
Composite Utility Plans
Separate Utility Plans (as required)
Utility Profiles (separated by type)
Utility Details (separated by type)
Structural Abbreviations and General Notes
Structural Plans (by structural unit)
Structural Details
Structural Pay Limits
Architectural Symbols, Abbreviations and Notes
Architectural Drawings
Mechanical Key Plans (if not on Plan and Profile)
Mechanical Symbols, Abbreviations and Notes
Mechanical Drawings
a. Plumbing
b. HVAC
Electrical and Train Control Key Plan
Electrical and Train Control Symbols, Abbreviations and Notes
Electrical Drawings
Train Control Drawings
Communication Drawings

CONTENT AND ORGANIZATION OF CONTRACT DRAWINGS

The drawing format for the general construction site plan shall utilize a full size sheet which shall be placed immediately after the cover sheet. It shall include the information pertinent to the general construction site.

The contract title must be specific. Identify major elements such as stations, parking lots, substation, etc., in the title.

The survey plot drawings should show soil boring locations and Metro horizontal and vertical control monuments. Small sketches showing the monument reference ties should be included on individual sheets. Tabulations of boring coordinates and monumentation data should also be shown on unused portions of the survey plot sheets.

The horizontal and vertical control (plan and profile) sheet should show the schematic ties between monuments and alignment control points (PIs, POTs, etc.) and other pertinent control information.

The standard horizontal curve geometry sheet should be expanded to include all civil abbreviations and symbols. The datum conversion table should be included on this sheet.

The use of a separate sheet as a drawing key plan is not required. Instead, a small schematic of the site should be inserted on each sheet where appropriate, with the area of the site covered by the particular sheet highlighted on the schematic.

Information currently shown on the structural and mechanical (drainage) key plans may also be included on the PP drawings. However, care must be

taken not to overcrowd the PP drawings. The PP drawings should be the central reference plans for the major components of the section, thereby facilitating design review and encouraging coordination among disciplines during design and construction.

The plan and profile drawings should be supplemented by typical cross sections at reasonable scales (on separate sheets, if needed) taken at critical locations, such as curves, crossover areas, and transitions between different types of construction (i.e., tunnel to cut-and-cover). The cross sections should show fire lines, electrical cables (embedded or attached to channel inserts) handrails, panel boxes, lighting, etc. Care must be taken to indicate items as N.I.C. where appropriate. These sections would minimize the need for separate sections showing items pertaining to each discipline throughout the set of plans.

Alignment coordinates may be removed from the PP sheets and tabulated on a separate sheet.

Information shown, in addition to the current alignment data, should include:

Structural unit designation, stations, and IB & OB T/R elevations at the construction joints (if separate structural key plans are not provided).

Location of the safety walk.

Station location of the beginning and ending of structure widening with centerline track to wall dimensions. Where dimensions vary (on spirals) dimensions at start and ending of variation should be shown.

Major electrical system elements could be indicated, such as trip stations, divisions of AC power, tie breaker stations and substations. Provide separate key plans for electrical and train control items.

Screened topographic mapping is required for the plan and profile drawings.

Special trackwork designation and P.S. stations, floating slab limits, etc.

Separate structural plans need not be drawn for each unit when a typical plan may serve to define a number of units.

Contract drawings shall be prepared on electronic media files in accordance with the following requirements:

(1) The Section Designer is required to (or as specified by the Authority) provide all final drawing documents in Latest Release of AutoCAD drawing file. WMATA will specify prior to delivery which medium the Section Designer shall use to provide this information. The digital medium shall be provided by the Section Designer and become the property of WMATA.

(2) The Section Designer is required to comply with the UMTA metric conversion plans as directed by the WMATA Project Manager which may require use of metric units of measure in all documents provided under the terms of this contract.

These drawings are to be photographically reduced and offset printed to half-size for binding into contract books and subsequent distribution to bidders. Other than signatures, no free-hand entries are permitted. Letters and numbers on the body of the drawing shall not be less than one-eighth of an inch high. In drawings where a subdued background is required, the background shall be screened to a 50 percent density at 80 to 85 lines per inch.

Entries in pencil are not permitted for the final submitted drawings. Final entries must be in ink.

Figures 8 .1 and 8.2 illustrate the types and weights of lines, north points and section arrows which shall be used on contract drawings. Figure 8.3 explains title block and scale requirements.

Completed drawings shall become the property of the Authority. These drawings shall be complete with all revisions and shall represent, as closely as practicable, the complete system facilities.

Drawings modified by amendments prior to construction or by revision during construction shall be clearly marked to identify the detail changed. Amendment and revision numbers shall be noted and dated in the title block. Amendment numbers shall be placed in a 1/4 inch square e.g., A/1 2 and immediately adjacent to the detail modified and to the top and right borders of the drawing. These squares shall be opposite the amendment or revision square in the detail modified.

The crossover alignment, including curve control points and curve data, is to be shown on the PP drawings.

The project coordinate system or a baseline and offset system should be used to locate and define curb lines and profile grade lines. Baseline shown for layout geometry may not necessarily be considered construction baseline. That should be left to the option of the construction contractor.

All curb lines except small islands should have a top of curb or flowline included. Rigid mathematization of all profiles may not be consistent with construction practice. "Spline" profiles may be used.

Symbols used on the construction staging plans shall be uniform. These would include:

a. Precast concrete barrier (single and double)
b. Other standard barricades
c. Metro construction - current stage
d. Metro construction - completed in previous stages
e. Decking - current and completed
f. Temporary pavement

Show survey baseline on the survey plot drawings . Tie the cross sections on the plan to the alignment of the outbound track. Tie cross section to the survey baseline only if it is not practical to tie them to the centerline of the outbound track.

8 .12.2 Drawing Numbering System

8 .12.2.1 Route and Contract Numbers

Figure 8.4 indicates the general location of each route.

There are eleven routes in the regional rapid transit system with the following designations:

A - Shady Grove
B - Glenmont Route
C - Huntington Route
D - New Carrollton Route
E - Greenbelt Route
F - Branch Route
G - Addison Route
H/J - Franconia/Springfield Route
K - Vienna Route
L - L'Enfant - Pentagon River Crossing

Each of these routes has been subdivided into specific contracts. The contract number shall be shown on each drawing in the lower right corner in the box above the title block. Information drawings in each bid package shall also include the contract number. Contracts of each route have been stationed consecutively starting at the 0+00 system reference point for the particular route. The first digits of all contract drawing number shall indicate the route and contract number and will include the letter designation of the subsection (example: K7i). The contract number for a finish contract for this same design section will be preceded by the letter 'F" (example: FK7i). The Main heading in the title block of each drawing shall indicate the name of the route of which the particular contract is a part.

8 .12.2.2 Drawing Type Designations

Drawing types will vary from contract to contract, and will include the following types of drawings, among others. The middle digit of the contract drawing number shall indicate the drawing type:

G - General Information
C - Horizontal and Vertical Control
SP - Survey Plots
SO - Soils & Geotechnical Information
R - Right-of-Way
PP - Plan and Profile
GR - Grading
X - Cross Sections
SC - Soil Erosion and Sediment Control
U - Utilities
P - Paving and Restoration
TM - Maintenance of Traffic
S - Structural
A - Architectural
LA - Landscape Architecture
M - Mechanical
E - Electrical
TC - Train Control
CM - Communications

Other digits as required.

Drawings shall appear in the contract book in the sequence as set forth in Section II, Item R.

8 .12.2.3 Drawing and Sheet Numbers

The last digits of the drawing number shall indicate the sequence in which the drawings were actually produced. When the drawings are assembled in the contract book, the drawing numbers need not appear in consecutive order throughout any one group of drawings. Order in the book shall be established by numbering each sheet in the sequence desired, with the sheet number preceded by a file number supplied by the Authority. This is the final step in contract book preparation.

8 .12.3 Cover Sheets

The cover sheets for the contract drawings shall include the following information in a format as indicated in Figure 8.15:

Information	Example
a. IFB Number	IFB-C-509
b. Design Section Designation	Section K-5c
c. Route Name	Vienna Route
d. Title of Project	North 25th Street Tie Breaker Station
e. Contract Number	1KOO53
f. Date of Advertisement	November 1, 1981
g. Designer	Polytech, Inc.

8 .12.4 Standard Drawings

Information and details which are of a standard nature and are to be repeated on successive contracts have been detailed by the General Consultants on Standard Drawings. These drawings are numbered as follows:

Civil	ST-C-
Utilities	ST-U-
Structural	ST-S-
Mechanical	ST-M-
Electrical	ST-E-
Train Control	ST-TC-
Communications	ST-CM-
Architectural	ST-A-

Full-size photographic reproductions of standard drawings will be furnished to Designers at the pre-final review stage, upon request, for inclusion in the contract drawing books at the end of the appropriate section of drawings. Standard Drawings are not to be modified. If a portion is not needed, it may be crossed out.

8 .12.5 Coordination and Review of Contract Drawings

8 .12.5.1 Coordination

The WMATA Project Engineer will coordinate the work of all Designers. Information from one Designer which affects other Designers will be

coordinated between the Designers with copies to the Project Engineer. In order to facilitate coordination and review of the work, periodic submissions of contract drawing prints are to be made by the Designers to the General Consultants. It should be stressed that review by the General Consultants shall not relieve the Designer of responsibility for accuracy of the design and adequacy of the drawings.

The Designer shall direct technical questions, correspondence and prints for review to the Project Engineer who will be responsible for expediting a response to questions by the Designers and for the review of drawings and submittals.

Designers will require certain information regarding inserts, slots, sleeves, recess and duct locations, etc., for traction power, supervisory control, train control and other system contracts being developed by others. This information will .be forwarded by the General Engineering Consultant. Provision for these details shall be made on the contract drawings.

8 .12.5.2 Reviews

Prints of all contract drawings produced by the Designer shall be submitted to the General Consultants each month. These prints will serve as a record of progress. Review submittals are defined in the Scope of Services for each particular contract. Monthly submittals shall be half-size prints and consist of all drawings. Review submittals shall be half-size prints and consist of all contract drawings produced by the Designer.

8 .12.6 Approvals

Upon completion of the contract drawings, each drawing shall be sealed and signed by the Professional Engineer, Surveyor or Architect under whose direction the drawings were produced and who assumes full responsibility for all aspects of the design. The Professional Engineer, Surveyor or Architect shall be licensed in the jurisdiction where the work will be constructed.

Mylar drawings, signed and sealed as indicated above, shall be delivered to the Authority at the completion of the design.

8 .12.7 Types of Contracts

There are a number of types of contracts for which contract documents will be required. In general, structural contract should include the construction work performed by the heavy construction trades while finish contract should include the work performed by the building trades.

8 .13 STRUCTURAL CONTRACTS

The following drawings shall be produced for a structural contract. Other drawings shall be included as required. The scales to be used and information to be shown on each type of drawings are listed below:

All rapid transit routes have been stationed from a preselected reference point, 0+00 at Metro Center and 0+00 on 7th Street, N.W., at Gallery Place Station.

For ease in orientation, drawings for contracts of the Shady Grove (A), Huntington ©), Vienna (K), Franconia/Springfield (H/J), and L'Enfant Pentagon River Crossing (L) Routes

shall be drawing with stationing increasing from right to left on each sheet. Drawings for contracts of the Glenmont (B), Greenbelt (E), New Carrollton (D), Addison (G) and Branch (F) Routes shall have stationing increasing from left to right on each sheet.

The drawings shall appear in order of increasing stationing.

8 .13.1 General Information

Scale: As required

General Information drawings shall be prepared for the following items:

8 .13.1.1 Key Plan of System **The base for this drawing will be furnished by the General Engineering Consultant.**

8 .13.1.2 General Construction Site Plan

Scale: Appropriate to allow the construction site to fit on one sheet. If possible, the site plan and key plan of the system shall be shown on the same sheet.

8 .13.1.3 Traffic and Construction Staging

Scale: Horizontal - As required

Information shown:

Traffic Staging, coordinated with and approved by local authorities

Traffic Detours, coordinated with and approved by local authorities

Construction Staging

Possible construction ramp and storage sites

Street and sidewalk areas to be decked for duration of construction.

8 .13.1.4 General Notes and Abbreviations

8 .13.1.5 Index of Drawings

A complete index of drawing shall be included with the set of contract plans. The index shall include drawing numbers, titles and sheet numbers. A cross index by drawing number shall also be included.

8 .13.1.6 Payment Limits

Drawings delineating payment limits shall be included as required.

8 .13.2 Horizontal and Vertical Control

Scale: Horizontal 1" = 200'
Vertical 1" = 40'
Information shown:

Structural alignment and outline in relation to street system
Control line ties to track alignment
Coordinate system
Location of control points and benchmark
Top of rail profile and structure outline
Ground surface
Contract limits and type of construction
Benchmark, ties to horizontal control points and control point coordinates
Control Survey Marker Detail (See Figure 8.17).

8 .13.3 Right-of-Way

Scale: Horizontal 1" = 40'
Information shown:
Right-of-Way lines with distances and bearings
Centerline of tracks
Outline of transit structure
Track centerline stationing and station equations
Relationship of right-of-way to property lines, street systems and where properties will be affected by construction
Reference ties by distance and bearing from the right-of-way to copper corners in the District of Columbia and other monuments in Maryland and Virginia.
Right-of-Way widths, both existing and proposed
Curve data of right-of-way curves
Parcel numbers, lot numbers, square numbers, subdivision names and patent or survey names
Names of property owners
Design section limits
Affected and adjacent vaults with their disposition
Construction fencing
All existing easements on the property
Total area of parcel or lot affected
Area of taking
Coordinates
a. coppers
b. sufficient to re-establish right-of-way
c. PC and PT of curves

Parcel, lot, square and track boundary lines of affected properties with distances and bearings shown
Distances and bearings around proposed takings
Names and widths of abutting streets and highways
Encroachments on, over and across land to be purchased
PC and PT of right-of-way curves
Show outbound track centerline at intersections with property block or square lines
If land is part of larger tract, show larger tract
Note in the property disposition table buildings to be demolished.
Where one lot has two or more easements of same type, note areas of each on plan, and sum in property disposition table.
Legend
Coordinate Grid
Pavement limits, curb lines.

8 .13.4 Survey Plots

8 .13.4.1 Scale: 1" = 40'

8 .13.4.2 General information to be shown:

All planimetric features of the entire area affected by Metro construction.

8 .13.4.2.1 Streets and Railways - describe all surface elements.

8 .13.4.2.2 Buildings - describe material of construction, height, and street number of buildings adjacent to construction.

8 .13.4.2.3 Proposed Metro alignment and facilities - indicate by phantom outline.

8 .13.4.2.4 Trees - species, size and location in accordance with the following guidelines:

8 .13.4.2.4.1 It is the Authority's policy to remove as few trees as possible and to design surface features to allow as many natural features as possible to remain while screening the Metro facilities from the adjacent property owners.

8 .13.4.2.4.2 Preparation of the Survey Plot sheets shall be undertaken to provide a record for restoration after construction and of preservation during design. If the trees are to be destroyed during construction and not replaced, their location on the drawings can be indicated graphically, either individually in clusters or in molts. In the event an area is to be partially cleared, the Designer shall attempt to save as much as possible of the natural growth worth saving, designing the Authority's structures and facilities in accordance with the location and Metro guidelines for landscaping, using not only the advice and counsel of the location jurisdictions, but also that of trained professionals.

8 .13.4.2.4.3 The extent of the identification and location of trees necessary to satisfy the Contract shall be determined by the Designer and reviewed by the GEC, based upon an evaluation of the trees, their location, the requirements of Metro, the overall area, and anticipated public interest in the trees.

8 .13.4.2.4.4 Soil boring locations

8 .13.4.3 Topographic Data to be shown

8 .13.4.3.1 Accuracy of elevations

8 .13.4.3.1.1 Paved areas ± 0.01'

8 .13.4.3.1.2 Unpaved areas ±0.1'

8 .13.4.3.2 Cut-and-Cover Construction and Excavations - Provide ground elevation on a 50' (maximum) grid with supplementary elevations of all abrupt breaks in grade (i.e., top and bottom of curbs, etc.) over entire area affected by construction.

8 .13.4.3.3 Tunnel Construction - Provide a minimum of five ground elevations at 50' intervals along centerline of construction. These elevations will be

oriented perpendicular or radial to centerline of construction and shall be located as follows:

One midway between tunnel(s)	1
One at each centerline track	2
One 20' outside each centerline track	2
Total	5

One midway between tunnel(s)	(1)
One at each centerline track	(2)
One 20' outside each centerline track	(2)

8 .13.4.3.4 At-Grade & Aerial Construction

Provide one-foot contour interval supplemented with spot elevations at critical points throughout all areas affected by construction.

8 .13.5 Plan and Profile

Scale: Horizontal 1" = 40'
Vertical 1" = 20'
Information shown: (See below)

Horizontal and vertical alignment superimposed on street system and existing ground profile.

Outline of structure in plan and profile.

Horizontal and vertical alignment data.

Buildings, structures and other prominent physical features.

The preceding five sections of drawings comprise the Civil drawings. Abbreviations and legends shall conform to those given on Figures 8.5 and 8.6. If required, additional abbreviations may be used with approval of the General Engineering Consultant.

8 .13.6 Utilities

Composite plans of all utilities shall be prepared to show the interrelationship of all existing and proposed utilities rearrangements and Metro structures in the contract area. Where utility facilities are above the proposed Metro tunnel and the intention is that they be maintained in place, a separate plan and profile is not required but pertinent information such as material or a typical cross-section showing proximity to the tunnel should be included in the composite plans. In addition to the composite plan, in areas affected by construction, separate utilities plans and profiles must be prepared for:

Water Mains

Sanitary Sewers
Storm Sewers
Gas
Electric
Telephone

Utilities that are not congested may be combined in one drawing if it is acceptable by the approving agency.

In the interests of clarity and if impractical to do otherwise, separate utility plans shall also be prepared for the following:

Fire and Police Alarm Systems
Parks
U.S. Capitol Grounds
Street and Traffic Lights
Parking Meters
U.S. Steam Tunnels and Pipes

The structural outline on Composite and Detail Utility drawings shall be delineated with a shading medium (AutoCAD hatching).

All openings to the surface, such as vent shafts and dome reliefs, and all ancillary spaces, service areas, etc. shall be clearly shown and identified on the plans and profiles.

Refer to Utility Standard Drawing ST-U-14 for abbreviations, symbols and general notes to be used on these drawings.

In the preparation of composite and separate utility drawings, the Designer shall make a field survey to locate all visible utilities which shall, among other things, determine the following insofar as they may affect Metro design:

Location of all manholes, valve boxes, vaults, street and traffic signals and appurtenances, trees and other improvements.

Size and invert elevations of all pipes in sewer manholes.

Size, internal dimensions, cover and headroom of all manholes on duct lines belonging to electric, telephone and telegraph companies and governmental agencies. The Designer shall not remove the covers nor enter any manholes without the prior approval of the owner, and in company with the owner's representative.

Overall dimensions and conformation of all duct lines in manholes on electric, telephone and other similar facilities. Depths, position in walls of manholes and the location of cables at manholes shall be determined for all affected duct lines.

Which cables, if any, are owned by AT&T, governmental agencies or are coaxial TV lines.

Interior dimensions, depth, cover, elevations and type of material of private vaults.

Should test pits be required, the Designer shall submit recommendation and estimate of cost for such work to the Authority for approval.

On composite plans, all utilities shall be designated as existing, proposed, previously abandoned, to be abandoned, to be maintained complete in place, etc., using the symbols shown on Standard Drawing ST-U-14. The size and type of each utility shall be indicated (S 12", E 6", etc.) by the use of the appropriate abbreviation shown on the Standard Drawing. These drawings are not to be dimensioned but shall be drawn accurately to scale. The centerline of the utility will be used for scale reference.

Separate utility plans and profiles shall include information for all lines (existing, proposed, to be abandoned, etc.) of the particular facility, using the symbols on Standard Drawing ST-U-14.

Abbreviations on these drawings shall clearly indicate size, type, material of all lines (G 6" CI, W 12" CIPC, T 12 MTD (4x3), W 12" DILM) and pertinent data concerning facilities in manholes. The drawings shall be dimensioned to indicate depth and location of facility from curb, building line, or centerline of street and to demonstrate clearances with other utilities and structures. The center point of all new manholes shall be located from baseline approximately at right angles to each other. Similar information shall be included for existing manholes in areas affected by Metro that are to be retained in service. Designers shall consult, and coordinate at all stages of planning and design with the appropriate utilities and governmental agencies, and shall reach agreement with the respective owners before detailing drawings. Where designs are prepared by owners, the Designer shall ascertain that work is compatible with Metro and shall include the work on Metro plans appropriately labeled. The Underground Construction Office, Department of Highways and Traffic for the District of Columbia and appropriate agencies in adjoining jurisdictions, shall be apprised of proposals for handling utilities as they are developed. The Designer shall cooperate with these offices and owners to assure fully coordinated utilities rearrangements.

It is essential, particularly for cut-and-cover construction, that preparation of composite and separate utility drawings be started promptly. Necessary consultations with utility owners shall be initiated and work scheduled and prosecuted to assure that completion of the overall project is not delayed by poor utility planning.

It is the responsibility of Designers to submit plans and specifications at various stages of completion for review of the respective utility owners, including government agencies, and to secure and file with the Authority, letters of acceptance and approval by the owners. Upon completing design, the Designer shall submit a statement listing betterments and shall secure from each affected owner a firm estimate of work to be undertaken by the utility. After formal approval of plans, two sets of full-size prints shall be made available to each utility owner.

Insofar as applicable, all utility work shall conform to the standards of each utility owner and to the policies established, or as may be established by the Authority.

In the preparation of designs, the Designer shall consider the various ways in which utilities may be handled and the effect of these on the overall cost or other aspects of the project.

In lightly developed areas, where utilities are spaced intermittently along the Metro route, drawings shall include a key map showing areas in which utilities are located along the route and an index to composite and detail drawings in the concerned areas.

For those portions of Metro to be constructed in tunnel, or where utilities are sparse, composite drawings may suffice. Detail drawings may be omitted only if approved by the Authority.

Designs shall take into account and make allowance for subway decking and trench bracing systems.

To the fullest extent practicable and economical, existing utilities shall be maintained complete in place. All facilities maintained in place, restored and new are to be supported on compacted backfill. When circumstances justify, utilities may be permanently supported on concrete posts bearing on the roof of the Metro structure. Each posting, however, must be separately considered and approved by the Authority.

Preferred scales are shown herein for each type of utilities drawing. However, in areas of congested utilities and cut-and-cover construction, 1" = 10' or larger scale may be required for clarity. In areas of tunnel construction, 1" = 40' scale may suffice, with larger scale details at locations of fan shafts, vent shafts, station entrances and other similar features.

In addition to building and curb lines, subway structures, vaults and trees, plan sheets of detail drawings shall show only the pipes, ducts, etc., pertaining to the particular facility. Profiles shall show all utilities and interferences as well as Metro structures; they shall show depths below surface and the top and bottom envelope or cross section of all utilities, all drawn to scale.

When work shown on the drawings is "to be done by others," the plans shall indicate if it is to be executed before, during or after Metro construction and if it is to be supported during construction.

8 .13.6.1 Utilities - Composite Plan

Scale: 1" = 40'-0"
Information shown:

All utilities, abandoned (when of record), existing, to be abandoned, maintained, supported, restored, diverted and proposed.

Structure outline, building lines, sidewalks, curbs, trees, poles, public and private vaults, pipelines, tunnels, other surface and subsurface features.

Abandoned street car tracks, as shown in Figure 8.7, may still be in place and in some instances covered with bituminous pavement. A typical detail of these tracks shall be shown on the contract drawings and their location shown in street cross sections. Plan shall note clearly the existence of all tracks, defining their limits including crossovers and switches and shall indicate payment limits of any removal.

Service lines between utilities and adjoining properties must be investigated for maintenance of service but need not be indicated on the drawings unless required by the owner of utility to which service is connected. It should be noted on the drawings that service connections must be maintained by the Contractor.

Detailed dimensions and elevations of roof and floor of vaults affected by construction shall be shown on an appropriate utility plan.

The drawings shall not include utility work beyond the immediate vicinity of construction. As soon as the need for any such work is developed, such as in the case of rerouting, the matter shall be discussed with the General Engineering Consultant. Major utility work beyond the limits of construction will, unless directed otherwise by the Authority, be handled by the utility company concerned.

8 .13.6.1.1 Water Mains, Sewers and Drainage Facilities

Scale: Horizontal 1" = 40'
Vertical 1" = 10'
Information shown:

Plan, profile and cross sections shall clearly indicate water mains, sewers, drainage lines, catch basins and appurtenances affected by construction, including facilities to be maintained, relocated, proposed, abandoned, etc.

Details of non-standard manholes or other facilities shall be included on these drawings or on separate sheets.

Indicate and identify any related work to be designed and constructed by others.

8 .13.6.2 Gas

The Washington Gas Company (WGCO) will prepare plans for any abandonment of gas mains, for the construction of any new or temporary mains and services, and for any connection or re-connections of gas mains and service. All such construction work will be normally performed by the WGCO, although some temporary relocation work may be performed by the Metro Contractor upon specific agreement with WGCO. Designs prepared by WGCO shall be placed on Metro drawings and marked "work to be done by others." The line symbols and abbreviations shall be made to conform with the standards shown on Utility Standard Drawing ST-U-14. Plans shall indicate staging of construction and clearly indicate which shall be "maintained complete in place" during Metro construction.

The Designer shall consult, as required, with WGCO to assure that proposed facilities are compatible with other existing and proposed utilities on Metro installations.

The transit system construction contractor will be required to excavate certain abandoned gas mains and to protect and support other lines. This work may be indicated on the drawings prepared by WGCO or on separate sheets, whichever is most practicable.

Scheduling of construction shall recognize the obligation of WGCO to provide uninterrupted service during the winter heating season.

8 .13.6.3 Electric

Scale: Horizontal 1" = 40'
Vertical 1" = 10'
Information shown:

Construction of duct and vault structures may be performed by the owner or Metro, depending on the approval of the utility owner for each section. Installation and connection of cables will always be performed by the owner.

Plan, profile and cross sections shall clearly indicate electric conduits, high voltage pipes, manholes and transformer manholes affected by construction. Indicate facilities to be "maintained complete in place," temporary wooden manholes to be constructed and maintained during construction, temporary wooden troughs to be provided and supported, abandoned ducts and manholes to be removed, special backfill for pipe conduit carrying high voltage cable, all by the Metro contractor.

All new ducts and manholes, removal of ducts and manholes on hot lines, transfer of cables to temporary troughs (see above) and other work by the owner shall be indicated.

Details of all non-standard manholes shall be included on plan drawings or on separate sheets. Each plan sheet shall include on that sheet a schedule of information concerning existing manholes and ducts (see above) and as shown by Figure 8.8.

Plans shall indicate which lines to be constructed by the owner will be completed prior to Metro construction as well as those installed at other designated stages.

When circumstances justify, proposed, maintained and restored utilities may be permanently supported on concrete posts tied to the roof of the Metro structure. Each posting, however, must be separately approved by the Authority.

Any work involving street lights and traffic signals and appurtenances may be included on these drawings (See Section 8.13.6.8).

8 .13.6.4 Telephone, Telegraph and CATV

Scale: Horizontal 1" = 40'
Vertical 1" = 10'
Information shown:

Plan, profile and cross sections shall clearly indicate telephone, telegraph and cable television lines affected by transit construction and indicate facilities to be maintained, relocated, proposed, abandoned, etc.

Details of non-standard manholes or other facilities shall be included on these drawings or on separate sheets.

Indicate any related work to be performed by others.

Each plan sheet shall include on that sheet a schedule of information concerning manholes and ducts as shown by Fig. 8.8.

Where new ducts are installed, all cables will be pulled and changeovers made by the affected telephone, telegraph, or cable television company.

Indicate which ducts, if any, may be maintained in place during construction and then permanently supported on compacted backfill or those temporarily

supported in troughs during construction, then restored and permanently supported on compacted backfill. The method adopted shall be at the Contractor's option.

When circumstances justify, new, maintained and restored utilities may be permanently supported on concrete posts tied to the roof of the Metro structure. Each posting must be separately approved by the Authority.

Designers shall ascertain if telephone, telegraph or cable TV cables are affected and, after consultation with the owners, shall include the necessary work in the Metro design.

Work involving police and fire alarm systems may be included on these or separate drawings (See Section 8.13.6.5).

8 .13.6.5 Fire and Police Alarm Systems

Scale: Horizontal 1" = 40'
Vertical 1" =10'
Information shown:

Location of alarm boxes and cable runs thereto.

Show facilities to be removed, temporarily relocated and restored and cables to be supported.

Each plan sheet shall include information concerning existing manholes and ducts as shown by Figure 8.8.

Construction work affecting alarm boxes and the restoration of cable runs in the District of Columbia will be handled by District forces at no expense to the Contractor unless otherwise indicated on the drawings and/or specifications.

Suburban communities do not operate fire and police alarm systems.

Affected facilities may be indicated on Telephone, Telegraph and CATV drawings or on separate sheets, with the notation that the specific work item is to be performed by others.

8 .13.6.6 Parks and Other Government Controlled Areas

Scale: Horizontal 1" = 40'
Vertical 1" =10'
Information shown:

Separate plans for each utility, as stipulated in the first paragraph of Section 8.13.6 shall be prepared where Metro crosses parks and other government controlled areas.

Plan, profile and cross sections shall indicate all facilities to be affected by Metro construction. Indicate facilities to be maintained, relocated, proposed, abandoned, etc. Drawings shall clearly identify facilities belonging to the controlling agency and those on the property owned by utility corporations and agencies normally operating in areas beyond limits of property. Work involving facilities of the controlling agency shall be in accordance with requirements for similar facilities beyond limits of controlled areas. Details of

non-standard facilities shall be included on these drawings or on separate sheets.

8 .13.6.7 U.S. Capitol Grounds

Scale: Horizontal 1" = 40'
Vertical 1" =10'
Information shown:

Separate plans for each utility, as stipulated in Section 8.13.6 shall be prepared where Metro crosses the U.S. Capitol Grounds.

Plan, profile and cross-sections shall indicate all facilities to be affected by Metro construction. Indicate facilities to be maintained, relocated, proposed, abandoned, etc. Drawings shall clearly identify facilities belonging to the Capitol and to utility corporations and other agencies normally operating in areas beyond the limits of the Capitol Grounds.

Work involving Capitol facilities shall be in accordance with requirements for similar facilities beyond limits of the Capitol Grounds.

Details of non-standard facilities shall be included on these drawings or on separate sheets.

8 .13.6.8 Street Lights and Traffic Signals

Scale: Horizontal 1" = 40'
Vertical 1" = 10'
Information shown:

Plans shall show all street lights and traffic signals in the affected area: those maintained in service, to be temporarily relocated and restored, temporary installations and new installations; also cable and duct runs, as well as control appurtenances.

Generally all such work will be performed by governmental agencies with their own contract or power company forces, at no cost to the Contractor.

The Contractor shall be responsible for and handle any work involving lights owned by private parties. These may be located on either public or private property.

8 .13.6.9 U.S. Steam Tunnels & Pipes

Scale: Horizontal 1" = 40'
Vertical 1" = 10'
Information shown:

Plan, profile and cross sections shall clearly indicate steam tunnels and pipe lines affected by Metro construction including facilities to be maintained, relocated, abandoned, constructed, etc. Profiles, sections and details of any special structures shall be included.

Details of any permanent supports shall be included. Plans and construction schedule shall take into account the need to supply steam to U.S. Government buildings, including the Pentagon, at all times.

8 .13.6.10 Parking Meters

Scale: Horizontal 1" = 40'
Information shown:

Drawings shall indicate parking meters affected by Metro construction and disposition to be made by the District of Columbia, or other local jurisdictions. The Contractor is to remove, store and reinstall posts; the meter heads will be removed and replaced by the local jurisdictions without cost to the contractor.

8 .13.7 Paving and Restoration

Scale: Horizontal 1" = 40'
Vertical 1" = 10' (if required)
Information shown:

Plan shall show structure outline, street lines, sidewalks, curbs, alleys, catch basins, vaults, and other surface features affected by Metro construction. Typical sections, existing and proposed elevations, cross sections or cross section information, type of pavement, curbs and other details for areas to be repaved or restored shall be shown. Elevations of street surfaces to be matched shall be indicated. The pay limits of areas to be constructed or restored shall be clearly defined. They shall include a reasonable area outside the limits of excavation, approximately 15 feet, and also any areas damaged by utility relocation. A note should be added to the effect that the final limits of restoration shall be determined by the extent of damage to existing surfaces. Provide interface details as required to maintain integrity.

When restoration does not extend beyond roadway limits and does not involve any restoration or replacement of curbs, plans shall include centerline profile and elevations at intervals of 50' and breaks in grade, shall show original and proposed elevations at point on profile and at edge of restoration. Existing elevations at flow line shall be included.

When restoration involves replacement of curbs, plans shall include centerline profile, as well as profiles at each curb line showing flow line or top of curb.

When restoration includes adjoining sidewalk with or without curb, plans shall show areaways, window wells, doorways, Metro gratings and other pertinent surface features together with existing and proposed elevations in sufficient detail to clearly indicate slope and warping of sidewalk to assure that areas are properly drained.

Show rates of grade for the flow lines with control elevations at the tangent points of the street corners or fillets, and at points to be matched.

Breaks in grade in excess of 0.50% require a vertical curve. Both breaks in grade and vertical curves should be properly noted.

Show pavement marking and striping, and provide details.

When existing catch basins located in curb returns and their connecting pipes are to be removed and replaced or replaced and maintained, it is preferable that they

be relocated on the tangent a minimum of 5'-0" off the PCs or PTs of the curb returns, provided no extra cost is involved.

Locate and note trees to be removed by the Contractor.

Unless notified to the contrary by the General Engineering Consultant, disturbed areas shall be restored to rough grade to match the adjoining properties, alleys and streets.

Unless otherwise shown, all work shall conform to conditions existing at the start of construction and to applicable local standards.

Street lights, traffic signals, and police and fire alarm facilities affected shall be indicated. Restoration will be handled by others as set forth in Section 8.13.7 (this section) and shall be noted on drawings. Restoration of all areas within the construction right-of-way and adjoining properties shall be indicated. Details of restoration for each property will be dependent upon the terms of the acquisition agreements.

Contraction and construction joints shall be prepared for both rigid pavement and sidewalk.

Drawings shall include plans showing pavement and surface restoration in park areas and the grounds of the U.S. Capitol.

8 .13.8 Soils and Geotechnical Information

Scale: Horizontal 1" = 40'
Vertical 1" = 10'
Information shown:

Boreholes shall be located on the survey plot drawings and numbered according to the soils report prepared by the Authority's General Engineering Consultant. Reference shall be made to separate soils drawings upon which should be reproduced without alteration, the borehole logs are presented by the General Engineering Consultant. Reference shall also be made to more complete information contained in soils reports.

8 .13.9 Structural

8 .13.9.1 Key Plan of Structure

Scale: Horizontal 1" = 40'
Vertical 1" = 10'
Information shown:

The plan and profile drawings should be used as the key plan unless separate structural key plans are required to avoid loss of clarity. The number of each structural unit shall be given along with the number of the first drawing upon which it is detailed. The station at each contraction joint between structural units shall be given. The position of the safety walk shall be clearly shown.

In plan, for open cut or cut-and-cover construction, controls for maximum vertical distance between points of support for excavation shall be shown over the length of the project. Critical areas for excavation support shall be noted. See Standard Specification Section

In profile, the ground surface at the centerline of structure, the outline of structure, and the track profile grade line shall be shown. If the profile grade lines of adjacent tracks are not the same, separate profiles of each track shall be shown. The elevation shall be shown to the nearest one-hundredth of a foot for top of low rail at each contraction joint. Grades and vertical curves shall be indicated.

8 .13.9.2 Detail Drawings

Scale: ¼" = 1'-0" (general)
Information shown:

Each structural unit shall be completely detailed in plan and elevation and shall show adequate details for construction and for the detailing of reinforcing steel by the Contractor. Where possible, a unit shall be complete on one drawing.

It is preferred that not more than one unit be detailed on one drawing; however, where dissimilarities between units are minor, varying dimensions may be tabulated.

The Designer shall include in the structural drawings loading diagrams and design criteria for the design of temporary retaining and deck structures. Horizontal soil pressures and allowable bearing values shall be recommended by the Designer and coordinated with the General Engineering Consultant.

8 .13.9.3 Numbering of Structural Units

Units shall be numbered according to line and station. The number shall be based upon the approximate station to the centerline of the unit. The number need only be based on station to the nearest 10 feet. For example, a typical 50' long structural unit on the Rockville Route having stations of 16+00 and 16+50 at contraction joints would be numbered A162. Similarly, a unit between stations 238+45 and 238+95 would be numbered A2387.

Drawings of structural units shall be arranged in the contract drawing book in numerical order by unit number. When a station is reached, the architectural functional plans prepared by the Designer shall be inserted for the general information of the contractor preceding details of structural units in station.

8 .13.9.4 Underpinning Plans

Reference should be made to the subsection relating to "Support of Existing Structures" in Section V of these criteria.

The scale of underpinning drawings shall be selected to suit the particular building being underpinned. Drawings shall be complete in detail and shall clearly describe and indicate the method of underpinning to be used.

8 .13.10 Architectural

8 .13.10.1 General Plan Drawings and Design Drawings

Scale: 1" = 20', 1/8" = 1', ½" = 1', 1-½" = 1'
Information Shown:

The General Architectural Consultant will prepare General Plan Drawings and Design Drawings for all stations. General Plans for each station will include configuration of all spaces, materials and finishes. The drawings will include dimensioned plans, control elevations, sections and details. Design Drawings will include standard details to be used as shown on the General Plan drawings. These General Plans will be furnished to the Designer as a guide to development of the architectural drawings for the construction contracts. Applicable standard details from the architectural Design Drawings shall be included on the Designer's plans utilizing the nomenclature or standard reference as shown on the architectural designs.

8 .13.10.2 Detail Drawings

Scale: Site Plans: 1" = 40'
Plans and Sections: 1/8" = l'
Details: ½" = 1', 1½" = 1', 3" = 1'

Overall plans, sections showing all exits, mezzanines and key surface features on one drawing: 1" = 20'

Information Shown:

The Designer shall prepare for each station construction bid documents based upon the General Plan drawings and Design Drawings. These bid documents shall include all information required for the structural contract, the subsequent application of architectural finish elements and electrical and mechanical items in a separate finish contract. Drawings shall fully coordinate all aspects of the structural contract with architectural finishes, and stage contract items.

8 .13.11 Mechanical

The following minimum of mechanical items are required in the structural contract drawings:

8 .13.11.1 Key Plan of Drainage, Plumbing, Ventilation and Air Conditioning

Scale: Horizontal 1" = 40'
Vertical 1" = 20'
Information Shown:

The plan and profile drawings should be used as the key plan unless separate mechanical key plans are required to avoid loss of clarity. Locations of escalators and elevators, water supply entrances to structures, drainage discharge from structures, fan shafts, emergency access shafts, vent shafts, manholes, track drains, ejector pits, and recesses in ceilings of train tunnels for jet fans and piping crossovers shall be indicated. Provisions for chilled water and control air piping to enter structures shall be included. Structural unit numbers shall be indicated. The drainage profile shall be shown; indicate top of rail elevations, stations at manholes and drainage pipe invert elevations at manholes.

8 .13.11.2 Detail Drawings

Scale: 1/8" = 1' (General)
Information Shown:

8 .13.11.2.1 Details of drainage pump installations.

8 .13.11.2.2 Details of drainage installations in the tunnels and structural units.

8 .13.11.2.3 Temporary drainage pumps (where used) and their installation in wet wells.

8 .13.11.2.4 Details shall include, both in plan and elevation, all buried or other piping and ductwork inaccessible to the finish contractor.

8 .13.11.2.5 All pipe and ductwork (or air passages) to grade or connected to utilities from structures.

8 .13.11.2.6 Details in plan and elevation of all pipe sleeves, duct sleeves, and other openings in walls, floors and ceilings required in the finish contract.

8 .13.11.2.7 All necessary inserts and support points for equipment, ductwork, piping and pipe anchors.

8 .13.11.2.8 All necessary access openings, panels, doors and hatches in structural work so as to facilitate installation and servicing of all elements.

8 .13.11.2.9 Vent shafts, fan shafts and emergency access shafts shall be designed and detailed to accommodate future dampers, and fans, which will be included in the finish contract. Frames and gratings at grade shall be shown in the structural drawings.

8 .13.11.2.10 Floor drains, condensate drains, etc., encased in structure.

8 .13.11.2.11 All ductwork and pipework, constructed in the structural contract shall be terminated at points where continuation under the finish contract is feasible. The limit of such work shall be clearly shown and identified.

8 .13.11.2.12 Terminations of all pipe work and ductwork shall be adequately capped to prevent entry of water, dirt, and vermin.

8 .13.11.2.13 Details in plan and elevation of all escalator support structures, clearances and necessary service access provisions in structural work.

8 .13.11.2.14 Jet fan installations, including mounting details.

8 .13.11.2.15 All other details determined by the Designer to be necessary for the structural contractor.

8 .13.12 Electrical, Communications and Train Control

The following Electrical, Communications and Train Control drawings will be prepared for inclusion in the structural or combined contracts. All structural requirements to provide for the installation of Electrical, Communications and Train Control equipment shall be shown on these drawings.

Symbols and General Notes Drawing

Key Plan and Schedule of embedded items.

Detail drawings with section views and expanded plans of congested areas

Conduit Schedule

Standard Plans

These plans divide the task into two general areas. The Key Plans and Schedule shall define all requirements between stations while the Detail Drawings and Conduit Schedule shall illustrate structural requirements in all remaining areas such as stations, ancillary rooms, power substations, vent and fan shafts, and tie breaker stations.

8 .13.12.1 Symbols and General Notes Drawing

Information shown:

All abbreviations and symbols employed as well as all notes of a general nature shall be shown. Abbreviations and symbols shall agree with those presented in Figures 8.9 through 8.12. Should additional symbols or abbreviations be necessary the Designer shall include them. Such symbols shall conform to NEMA, IEEE, EIA and AAR standards.

8 .13.12.2 Key Plan and Schedule

Scale: 1" = 40'
Information shown:

A plan view of the structure divided into numbered structural units shall be shown. The plan shall indicate the type of structure and location of walkway with sufficient stationing points shown for reference.

A schedule indicating locations of recesses, slots, sleeves and embedded conduit for all electrical, train control and communications equipment between stations shall be shown on each key plan. This schedule shall be divided into the following subsections:

8 .13.12.2.1 Item No. (items shall be sequentially numbered)
8 .13.12.2.2 Unit No. and Description (each item shall have a code number and description name).
8 .13.12.2.3 Structural Unit No. (each item shall be specifically located by the Structural unit number).
8 .13.12.2.4 Stationing (each item located within a structural unit shall be further **located by the actual stationing of the item).**
8 .13.12.2.5 Drawing No. (a drawing number shall indicate where the details of the item may be found).
8 .13.12.2.6 Detail (the detail letter shall indicate the specific detail of the above-mentioned drawing that applies to the item).
8 .13.12.2.7 Track (indicates track location).
8 .13.12.2.8 Outbound Track (indicates track location).
8 .13.12.2.9 Note (indicates number of note if special information is required.)

Section views and details necessary to clearly define all items listed on said schedule shall be shown on the Detail Drawings and shall be adequately cross-referenced. All information to be included on the schedule not under the control of the Designer will be provided by the Authority.

The Designer shall furnish the Authority with three prints and one sepia of Key Plans for marking of embedded items. One print so marked will be returned to the Designer for his use in including these items on his plans.

8 .13.13 Detail Drawings

Scale: 1/8" = 1'
Information Shown:

Architectural drawings of the station areas, traction power substations, tie breaker stations, ancillary rooms and all other structural areas not covered in the Key Plans shall be used to show the location of all embedded conduits or raceways, recesses, slots, sleeves, and channels. The requirements for Electrical, lighting and power systems shall be shown on separate drawings. The requirements for Fire and Intrusion Alarm, Communications and Train Control shall be shown on the same drawings. Section views and details shall be added by the Designer to clearly illustrate all areas of conduit congestion, or to define details necessary for installations. Locations of communication equipment marked by the Authority will be given to the Designer for his use in including this information on his plans.

8 .13.14 Conduit Schedule

A schedule separating the conduit requirements for Electrical, Fire and Intrusion, Communications and Train Control facilities shall be included with each set of drawings and shall be divided into the following sections:

8 .13.14.1 Conduit Number (Each conduit shall be sequentially numbered and prefixed in a manner to clearly distinguish between Electrical, Train Control and Communications conduits).
8 .13.14.2 Drawing Number (The number of the plan on which conduit is shown shall be listed).
8 .13.14.3 Size and Type (The size and material type of conduit shall be specified).
8 .13.14.4 End Points (The two points connected by the conduit shall be specified and listed in "FROM", "TO" columns).
8 .13.14.5 Type of Service (The type of service for which the conduit is required shall be specified, i.e., A.C., including voltage: CCTV, P.A. SYSTEM).
8 .13.14.6 Remarks (List here any special information required).

Information relating to items not under the control of the Designer will be provided by the Authority.

8 .13.15 Standard Plans

The Authority will provide standard drawings to define certain repetitive items required throughout the system. Additional standard drawings as necessary to facilitate installation within the area of a section shall be produced by the Designer. All standard drawings applicable to the contract section shall be included with the contract drawings.

8 .14 COMBINED CONTRACTS

The Combined Contracts will provide for the execution of all work usually associated with the buildings trades and will include architectural construction, finishes, mechanical and electrical work. In some instances light structural work may be included. The work will generally be applied to structures constructed by others in previous construction

contracts, The following drawings will prepared for a finish and combined contracts. Other drawings shall be included as required.

8 .14.1 General Information

Scale: As Required

General information drawings shall be prepared for the following items:

8 .14.1.1 Key Plan of System

The base for this drawing will be furnished by the Authority.

8 .14.1.2 General Construction Site Plan

Scale: Appropriate to fit on one sheet. If possible the site plan and key plan shall be shown on the same sheet.

8 .14.1.3 Key Plan of Structure - The key plan of structure drawings from the structural contract shall be reproduced and included in the finish contract drawings, with titles, notes, and other information revised as necessary.

8 .14.1.4 Index of Drawings - A complete index of drawings shall be included with the set of contract plans. The index sheet shall include drawing numbers, titles and sheet numbers, and shall be arranged in sections by sheet numbers. A cross index by drawing number shall also be included.

8 .14.1.5 General Notes and Abbreviations

8 .14.2 Architectural

Scales:
Site Plans : 1" = 40' or as required
Overall Station Plans: 1" = 20'
Plans and Sections: 1/8" = 1"
Details: ½" = 1', 1½" = 1', 3" = 1'

The Designer shall prepare a complete set of architectural drawings, including the following types of drawings:

8 .14.2.1 Master Key Plan, identifying rooms and areas, with finish schedule, showing the full extent and limits of the finish contract
8 .14.2.2 Station Plans, showing separate levels on individual sheets, at 1" = 20'
8 .14.2.3 Tunnel Plans, where work is required in tunnel areas, at 1/8" = 1"-0'.
8 .14.2.4 Service Room Plans and Elevations, showing floor plan, reflected ceiling plans, elevations, at 1/8" = 1' or ¼" = 1'. A small key plan identifying the general location of the room shall be shown on each service room sheet.
8 .14.2.5 Platform Plans, at 1/8" = 1'
8 .14.2.6 Mezzanine Plans, at 1/8" = 1'
8 .14.2.7 Train Room Plans and Elevations
8 .14.2.8 Entrance Plans and Elevations
8 .14.2.9 Passageway Plans
8 .14.2.10 Detail and Schedule Sheets, showing flooring and wall finishes, tile details, stonework, doors, folding gates, railings, registers, gratings, fixtures

The following architectural items are stage contract items and shall be furnished and installed in separate construction contracts which will be prepared by others.

8 .14.2.11 Kiosk
8 .14.2.12 Fare Collection Facilities
8 .14.2.13 Graphics
8 .14.2.14 Escalators
8 .14.2.15 Public Address System
8 .14.2.16 Closed Circuit Television System

Provisions are to be included in the finish contract for installation of these items by others.

8 .14.3 Mechanical

8 .14.3.1 Key Plan of Drainage, Plumbing, Ventilation, Air Conditioning and Escalators

Scale: Horizontal 1" = 40'
Vertical 1" = 20'
Information shown:

The key plan of mechanical drawings from the structural contract shall be reproduced and revised as necessary to include: locations of escalators and elevators, water supply entrances to structures, drainage discharges from structures, primary ventilating fans, vent shafts, sewage ejectors and manholes. Locations of chilled water piping, control of air piping and water supply piping (if any) in train tunnels. Structural unit numbers shall be indicated. The drainage profile shall indicate top of rail elevations, stations at manholes and drainage pipe invert elevations at manholes. All work completed in structural contract shall be indicated as existing by symbols and/or notes.

8 .14.3.2 Detail Drawings

Minimum Scale: 1/8" = 1'-0"

Information Shown:

8 .14.3.2.1 Details of factory packaged drainage pumps.

8 .14.3.2.2 Non-typical drainage installations in the tunnels and structural units and connections to wet wells and effluent channels or piping.

8 .14.3.2.3 Details in plan and in elevation of all piping for the following services:

8 .14.3.2.3.1 Drainage, sanitary
8 .14.3.2.3.2 Drainage, other than sanitary
8 .14.3.2.3.3 Water supply, hot and cold
8 .14.3.2.3.4 Chilled water
8 .14.3.2.3.5 Condensate piping
8 .14.3.2.3.6 Condenser water piping

8 .14.3.2.3.7 Fire protection
8 .14.3.2.3.8 Control air

Line drawings in diagrammatic perspective form shall be submitted for illustration.

8 .14.3.2.4 Details of all plumbing fixtures together with all connections to services.

8 .14.3.2.5 Details in plan and in elevation of all ductwork, air shafts and air tunnels, for the following services:

8 .14.3.2.5.1 Primary ventilation
8 .14.3.2.5.2 Secondary ventilation
8 .14.3.2.5.3 Air conditioning
8 .14.3.2.5.4 Heating
8 .14.3.2.5.5 Exhaust air

8 .14.3.2.6 Details in plan and in elevation of all equipment, appurtenances and controls for the following services:

8 .14.3.2.6.1 Drainage, sanitary
8 .14.3.2.6.2 Drainage, other than sanitary
8 .14.3.2.6.3 Water heating
8 .14.3.2.6.4 Air conditioning
8 .14.3.2.6.5 Heating, electric resistance
8 .14.3.2.6.6 Primary ventilation
8 .14.3.2.6.7 Secondary ventilation
8 .14.3.2.6.8 Control air
8 .14.3.2.6.9 Fire protection
8 .14.3.2.6.10 Escalators
8 .14.3.2.6.11 Ladders for fan shafts, vent shafts, emergency access shafts and pumping station access shafts
8 .14.3.2.6.12 Grating and miscellaneous metals

8 .14.3.2.7 All other mechanical details necessary to complete the finish or combined contracts.

8 .14.4 Electrical

Installation requirements of Electrical wiring and equipment for finish or combined design shall be shown on the following set of plans:

8 .14.4.1 Symbols and General Notes Drawing
8 .14.4.2 Running Structure Plans, including section views and details
8 .14.4.3 Detail Drawings, including section views, expanded plans, and one-line diagrams
8 .14.4.4 Panelboard Schedules
8 .14.4.5 Standard and Design Plans

These plans divide the electrical finish design task into two general areas. The running structure plans shall define electrical requirements for trackside areas between stations while the detail drawings shall illustrate the requirements in all remaining areas such as stations, traction substations, tie breaker stations, ancillary rooms, fan and vent shafts, and pumping stations.

8 .14.4.6 Symbols and General Notes Drawing

Information shown:

All abbreviations and symbols employed as well as all notes of a general nature shall be shown. Abbreviations and symbols shall agree with those presented in Figures 8.9 through 8.12. Should additional symbols or abbreviations be necessary the Designer shall include them. These symbols and abbreviations shall conform to NEMA and IEEE standards.

8 .14.4.7 Running Structure Plans

Scale: 1" = 40'

Information shown:

A plan view of the structure including at-grade areas, with sufficient stationing points to locate between station platforms, all track side normal and emergency lighting fixtures, associated wiring, junction boxes and circuitry details shall be shown.

A similar plan view of the structure with sufficient stationing points to locate all other finish design electrical facilities between station platforms shall also be shown. Said facilities shall include emergency trip boxes including blue light and receptacle, electrical receptacles, combination transformer and panel boxes, and all associated wiring, junction boxes and circuitry details.

Section views, tabulations and details necessary to clearly define any item presented on either of the running structure plans shall also be shown and shall be adequately referenced.

8 .14.4.8 Detail Drawings

Scale: 1/8" = 1'-0"

Information shown:

Architectural drawings of the station areas, traction power substations, tie breaker stations, ancillary rooms and any other structural areas not covered in the running structure plans shall be used to show the location of all finish design electrical facilities. Said facilities shall include all switchboards, panelboards, junction boxes, cable raceways, normal and emergency lighting fixtures, signs, switches, receptacles, transformers, control or disconnect equipment, and grounding facilities, as well as all feeds for heating, ventilating, and pumping equipment, escalators, ticket vending and collection equipment, communications and train control equipment.

The detail drawings shall identify each room or space and show the calculated foot candle level for each such room or space, as well as the location of all ductwork sufficient for train control and communication facilities. The detail drawings shall also include a one-line diagram of facilities from the incoming power service through all subpanel boards.

Section views and details shall be added by the Designer to clearly illustrate all features of the electrical facilities in a manner to permit installation of a complete, coordinated, electrical lighting, power, and wiring system within the limits of the contract.

8 .14.4.9 Panelboard Schedule

Information Shown:

A panelboard schedule showing all main and subpanel boards shall include the following information.

8 .14.4.9.1 Panel designation
8 .14.4.9.2 Panel mounting, either surface of flush
8 .14.4.9.3 Size and type of mains
8 .14.4.9.4 Voltage
8 .14.4.9.5 Complete feeder circuit breaker information
8 .14.4.9.6 Circuit designations or description
8 .14.4.9.7 Wire or cable information as necessary to provide fully detailed installation data

8 .14.4.10 Standard and Design Plans

The Authority will provide Standard and Design Drawings to define certain repetitive items required throughout the system. Additional or modified standard drawings as necessary to facilitate installations within the area of a section shall be produced by the Designer. All standard drawings applicable to the contract section shall be included with the contract drawings.

8 .14.5 Other Drawings

The Designer shall prepare drawings additional to those listed herein as required to complete the design work.

8 .15 INFORMATION TO BE SUPPLIED BY THE AUTHORITY

Each Designer will receive from the Authority copies of each of the following:
Manual of Design Criteria
Guide Specifications
General Plans (Half-size)
Design Drawings (Half-size)
Standard Drawings (Half-size)
Additional information listed in the Designer Scope of Services.
In addition, each Designer will be supplied with a comprehensive soils report

8 .15.1 General Plans

Two sets of half-size general plans will be furnished by the GEC. The Designer shall utilize these in accordance with the requirements of his specific contract. In all cases the information shown on the General Plans shall be verified by the Designer before using the information on contract drawings. General Plans are considered preliminary drawings subject to further study by the Designer.

8 .15.2 Design Drawings

Design drawings are sample solutions and shall be adapted by the Designer to fit the specific design circumstances. Not all design problems are shown on the Design Drawings.

Included in the Design Drawings are Architectural Standard Details which shall be incorporated into the work by the Designer as applicable.

8 .15.3 Standard Drawings

Standard Drawings are system wide standards which are to be inserted into the contract documents by the Designer as appropriate. The half-size books include copies of all Standard Drawings; the Designer shall select from this book those standards appropriate to the section and request full-size reproducibles of these from WMATA, at the prefinal submittal stage. The Designer shall include the full-size reproducibles with the final submittal of contract documents.

8 .15.4 Additional Information

8 .15.4.1 One reproducible set of 1" = 40' scale planimetric survey manuscripts will be made available to the Designer. For areas designed after 1989, digital copies of the topography (in AutoCAD format) may also be available. The data on these surveys must be verified and supplemented by field surveys carried out by the Designer as required.

8 .15.4.2 Other information as listed in the Scope of Services for each particular contract.

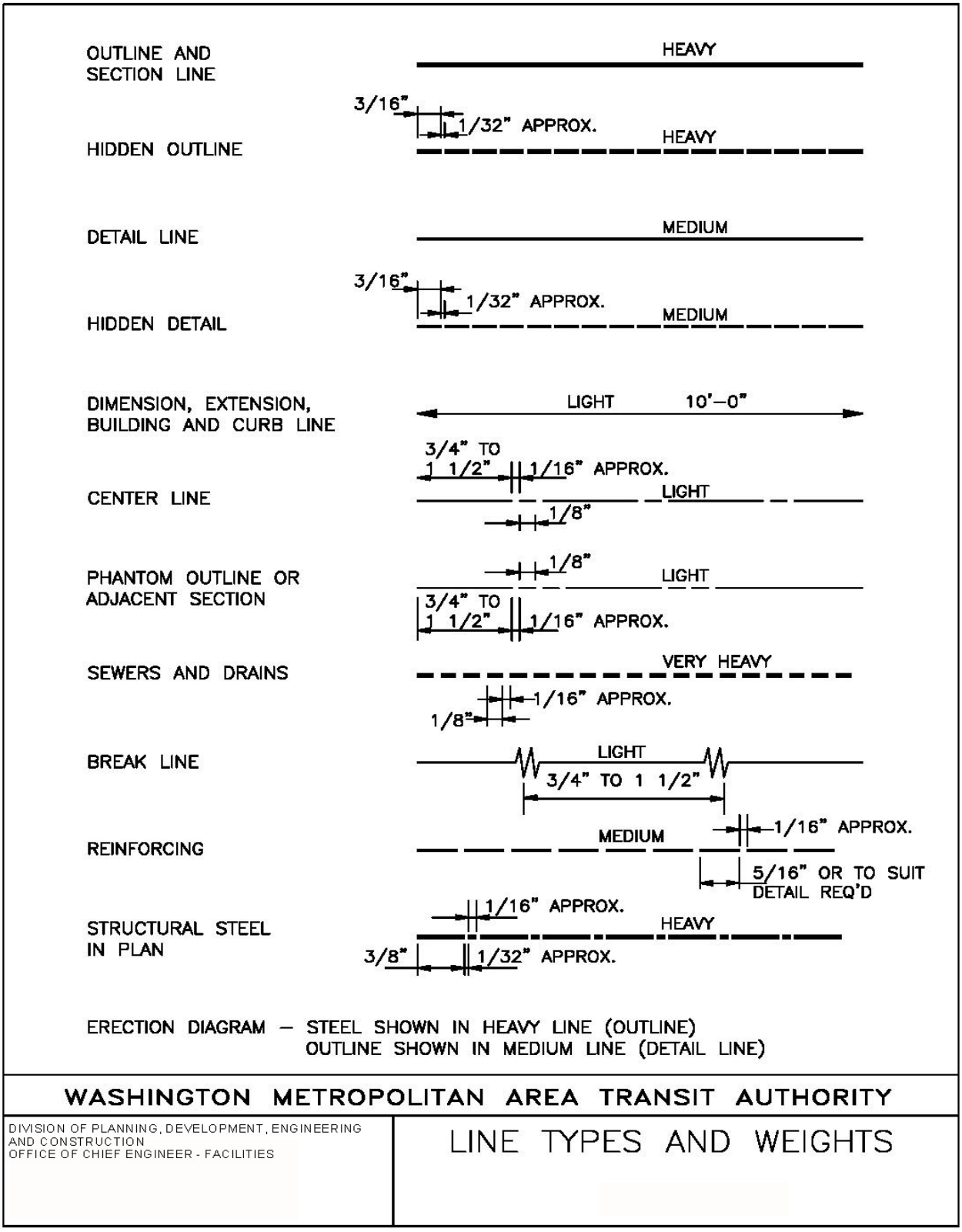

OUTLINE AND SECTION LINE
HEAVY
3/16"
1/32" APPROX.
HIDDEN OUTLINE
HEAVY
DETAIL LINE
MEDIUM
3/16"
1/32" APPROX.
HIDDEN DETAIL
MEDIUM
DIMENSION, EXTENSION, BUILDING AND CURB LINE
LIGHT
10'-0"
3/4" TO 1 1/2"
1/16" APPROX.
CENTER LINE
LIGHT
1/8"
1/8"
PHANTOM OUTLINE OR ADJACENT SECTION
LIGHT
3/4" TO 1 1/2"
1/16" APPROX.
SEWERS AND DRAINS
VERY HEAVY
1/16" APPROX.
1/8"
BREAK LINE
LIGHT
3/4" TO 1 1/2"
REINFORCING
MEDIUM
1/16" APPROX.
5/16" OR TO SUIT DETAIL REQ'D
STRUCTURAL STEEL IN PLAN
1/16" APPROX.
HEAVY
3/8"
1/32" APPROX.
ERECTION DIAGRAM – STEEL SHOWN IN HEAVY LINE (OUTLINE)
OUTLINE SHOWN IN MEDIUM LINE (DETAIL LINE)
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
DIVISION OF PLANNING, DEVELOPMENT, ENGINEERING AND CONSTRUCTION
OFFICE OF CHIEF ENGINEER - FACILITIES
LINE TYPES AND WEIGHTS

FIGURE 8.1

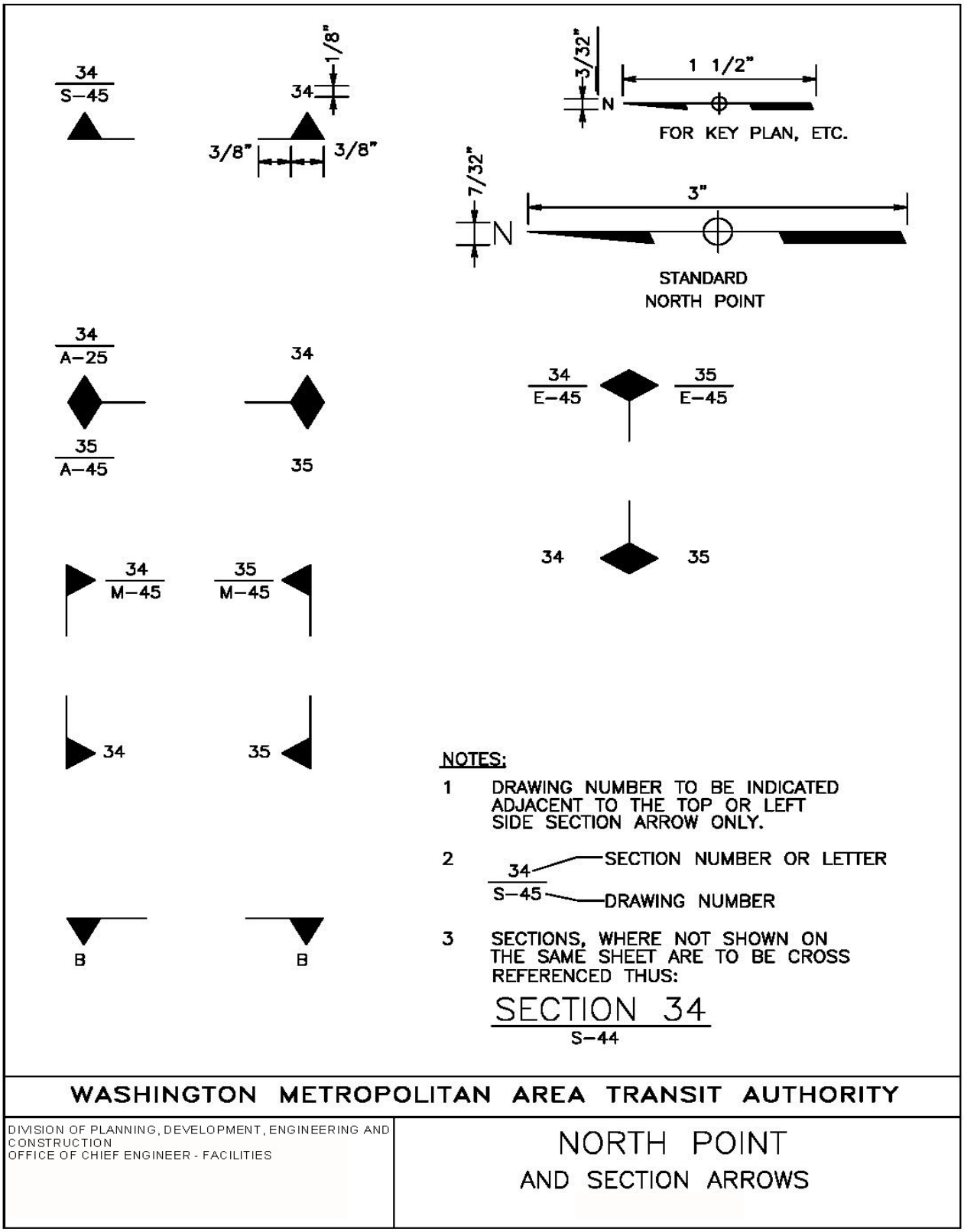
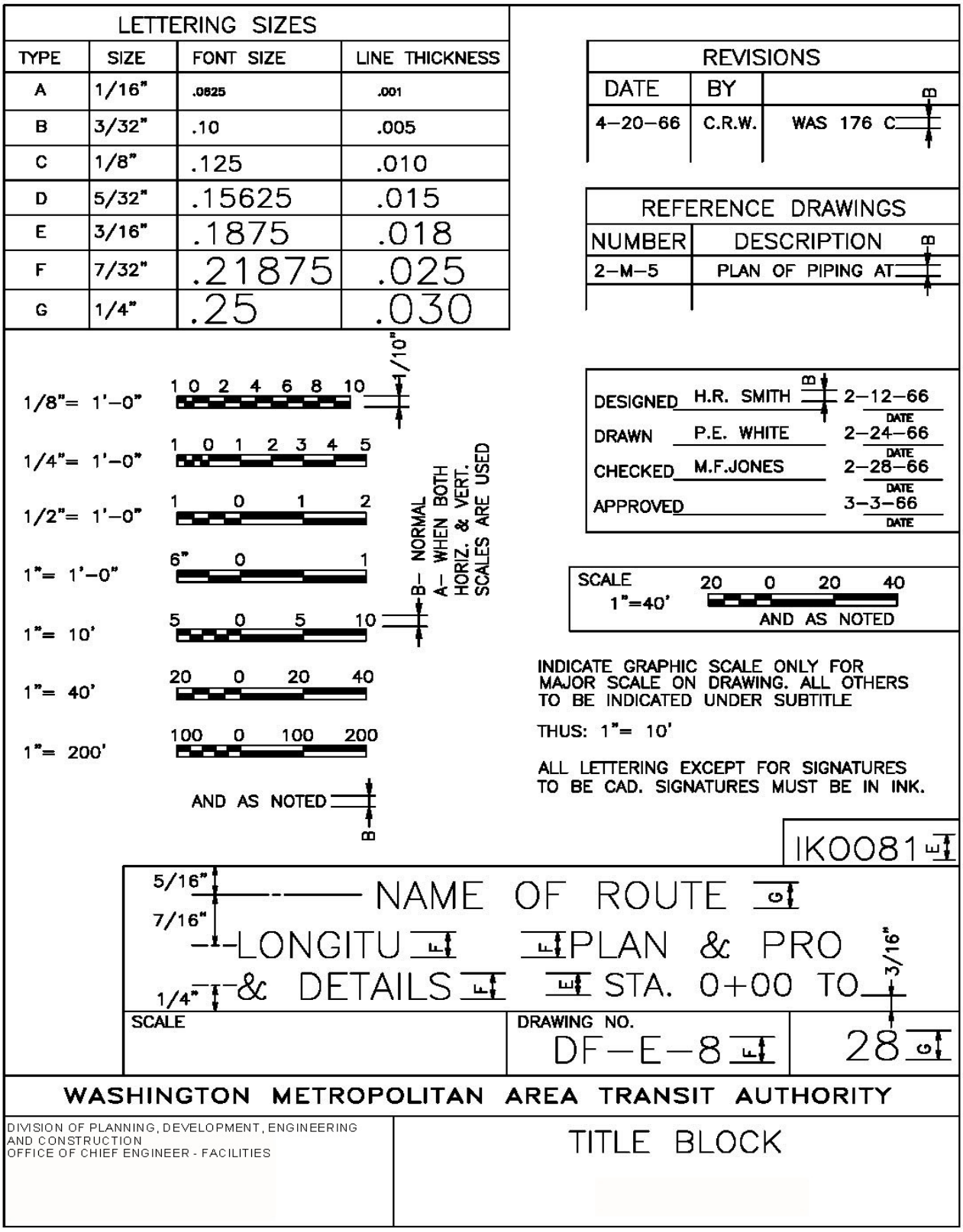

34
S-45
1/8"
34
3/8"
3/8"
3/32"
1 1/2"
N
FOR KEY PLAN, ETC.
7/32"
3"
N
STANDARD
NORTH POINT
34
A-25
35
A-45
34
35
34
E-45
35
E-45
34
35
34
M-45
35
M-45
34
35
B
B
NOTES:
1 DRAWING NUMBER TO BE INDICATED ADJACENT TO THE TOP OR LEFT SIDE SECTION ARROW ONLY.
2 34 SECTION NUMBER OR LETTER
S-45 DRAWING NUMBER
3 SECTIONS, WHERE NOT SHOWN ON THE SAME SHEET ARE TO BE CROSS REFERENCED THUS:
SECTION 34
S-44
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
DIVISION OF PLANNING, DEVELOPMENT, ENGINEERING AND CONSTRUCTION
OFFICE OF CHIEF ENGINEER - FACILITIES
NORTH POINT
AND SECTION ARROWS

FIGURE 8.2


LETTERING SIZES
TYPE | SIZE | FONT SIZE | LINE THICKNESS
A | 1/16" | .0825 | .001
B | 3/32" | .10 | .005
C | 1/8" | .125 | .010
D | 5/32" | .15625 | .015
E | 3/16" | .1875 | .018
F | 7/32" | .21875 | .025
G | 1/4" | .25 | .030
REVISIONS
DATE | BY
4-20-66 | C.R.W. | WAS 176 C
REFERENCE DRAWINGS
NUMBER | DESCRIPTION
2-M-5 | PLAN OF PIPING AT
1/8"= 1'-0"
1/4"= 1'-0"
1/2"= 1'-0"
1"= 1'-0"
1"= 10'
1"= 40'
1"= 200'
AND AS NOTED
B- NORMAL
A- WHEN BOTH HORIZ. & VERT. SCALES ARE USED
DESIGNED H.R. SMITH 2-12-66
DRAWN P.E. WHITE 2-24-66
CHECKED M.F.JONES 2-28-66
APPROVED 3-3-66
DATE
SCALE 1"=40' AND AS NOTED
INDICATE GRAPHIC SCALE ONLY FOR MAJOR SCALE ON DRAWING. ALL OTHERS TO BE INDICATED UNDER SUBTITLE
THUS: 1"= 10'
ALL LETTERING EXCEPT FOR SIGNATURES TO BE CAD. SIGNATURES MUST BE IN INK.
IK0081
NAME OF ROUTE
LONGITU PLAN & PRO
& DETAILS STA. 0+00 TO
SCALE
DRAWING NO.
DF-E-8
28
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OFFICE OF CHIEF ENGINEER - FACILITIES
TITLE BLOCK

FIGURE 8.3

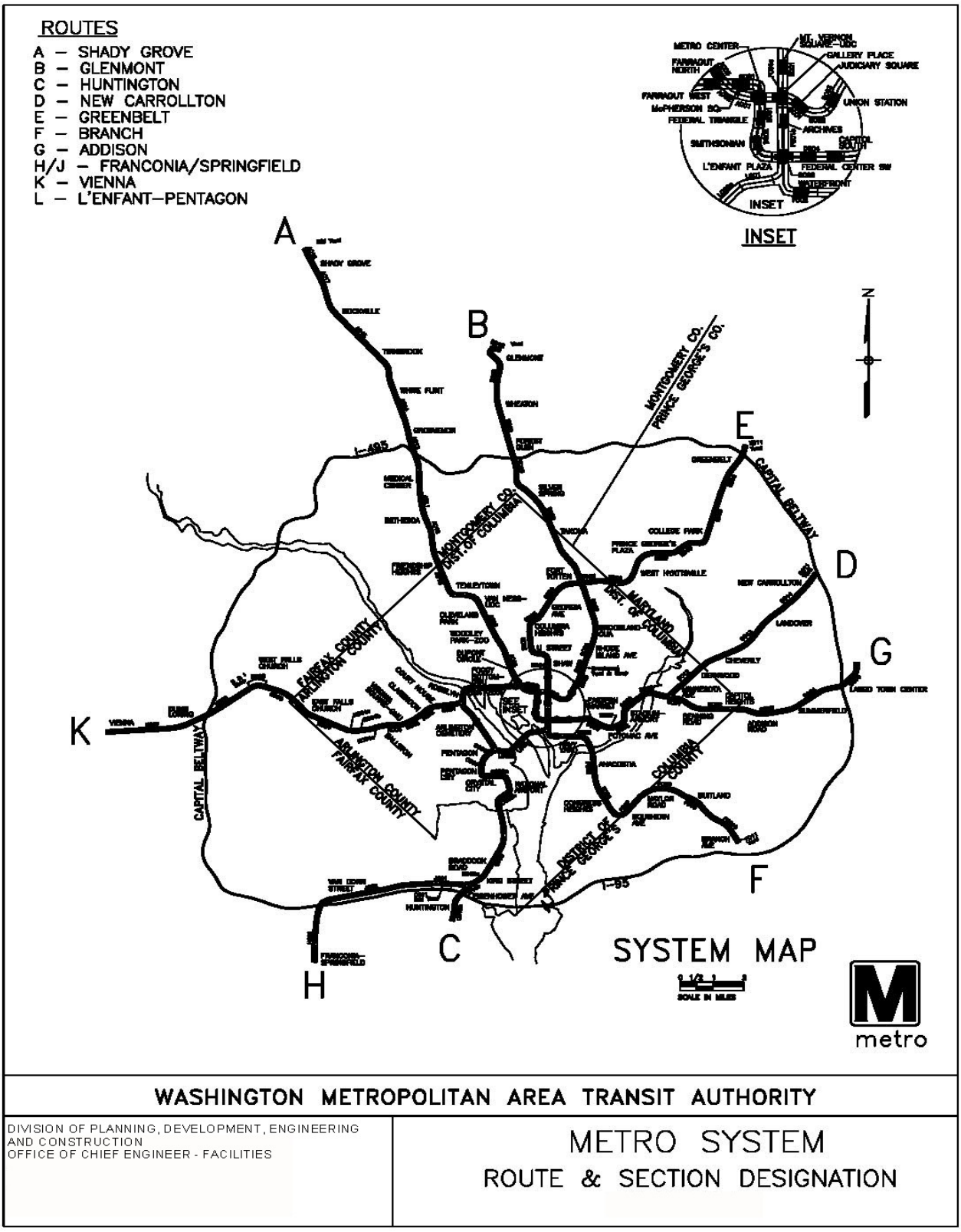
ROUTES
A – SHADY GROVE
B – GLENMONT
C – HUNTINGTON
D – NEW CARROLLTON
E – GREENBELT
F – BRANCH
G – ADDISON
H/J – FRANCONIA/SPRINGFIELD
K – VIENNA
L – L'ENFANT–PENTAGON
INSET
METRO CENTER
FARRAGUT NORTH
FARRAGUT WEST
McPHERSON SQ.
FEDERAL TRIANGLE
SMITHSONIAN
L'ENFANT PLAZA
MT. VERNON SQUARE–UDC
GALLERY PLACE
JUDICIARY SQUARE
UNION STATION
ARCHIVES
CAPITOL SOUTH
FEDERAL CENTER SW
WATERFRONT
A
B
C
D
E
F
G
H
K
I-495
I-95
CAPITAL BELTWAY
MONTGOMERY CO.
DIST. OF COLUMBIA
MONTGOMERY CO.
PRINCE GEORGE'S CO.
DIST. OF COLUMBIA
MARYLAND
FAIRFAX COUNTY
ARLINGTON COUNTY
ARLINGTON COUNTY
FAIRFAX COUNTY
COLUMBIA COUNTY
DISTRICT OF COLUMBIA
PRINCE GEORGE'S
SYSTEM MAP
SCALE IN MILES
metro
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
DIVISION OF PLANNING, DEVELOPMENT, ENGINEERING AND CONSTRUCTION
OFFICE OF CHIEF ENGINEER - FACILITIES
METRO SYSTEM
ROUTE & SECTION DESIGNATION

FIGURE 8.4

AHD.	AHEAD
A.R.E.A.	AMERICAN RAILWAY ENGINEERING ASSOCIATION
A.R.E.M.A.	AMERICAN RAILWAY ENGINEERING AND MAINTENANCE–OF–WAY ASSOCIATION (FORMERLY A.R.E.A.)
BK.	BACK
B.&O.	BALTIMORE AND OHIO
℄	BASELINE
B.M.	BENCH MARK
℄	CENTERLINE
CONST.	CONSTRUCTION
EL.	ELEVATION
EQN.	STATIONING EQUATION
5 STY.	FIVE STORY
G.P.S.	GLOBAL POSITIONING SURVEY
H.F.	HEEL OF FROG
HORIZ.	HORIZONTAL
INV.	INVERT
MEZZ.	MEZZANINE
M.O.	MID ORDINATE
M.P.H.	MILES PER HOUR
N.G.S.	NATIONAL GEODETIC SURVEY
P.C.C.	POINT OF COMPOUND CURVE
P.O.C.	POINT ON CURVE
P.I.T.O.	POINT OF INTERSECTION OF TURNOUT
P.R.C.	POINT OF REVERSE CURVE
P.S.	POINT OF SWITCH
P.O.T.	POINT ON TANGENT
P.V.C.	POINT OF VERTICAL CURVE
P.V.I.	POINT OF VERTICAL INTERSECTION
P.V.T.	POINT OF VERTICAL TANGENT
PROP.	PROPOSED
R.O.W.	RIGHT OF WAY
RTE.	ROUTE
STD.	STANDARD
STA.	STATION
ST.	STREET
TAN.	TANGENT
T/R	TOP OF RAIL
VERT.	VERTICAL
V.C.	VERTICAL CURVE

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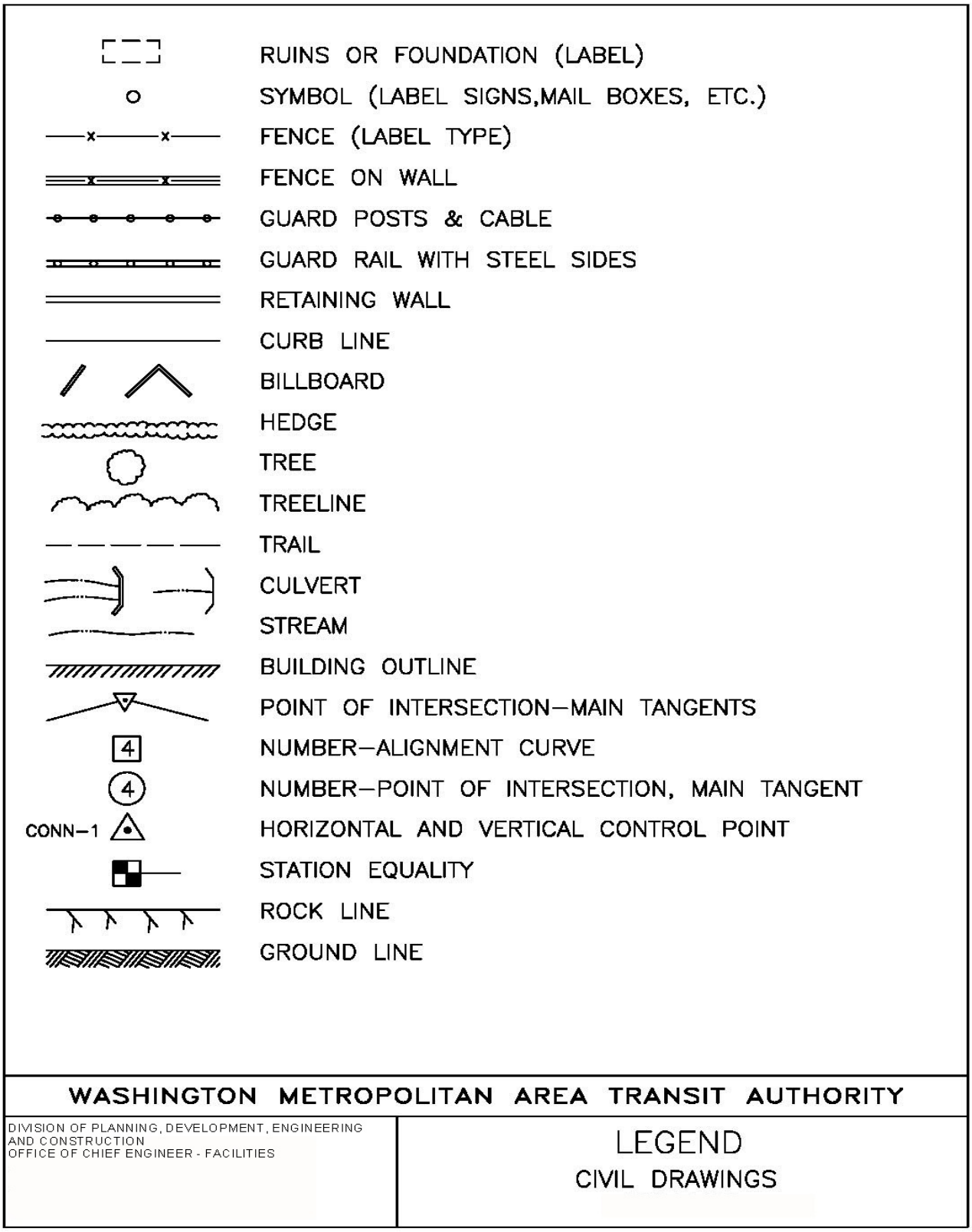
ABBREVIATIONS
CIVIL DRAWINGS

FIGURE 8.5


RUINS OR FOUNDATION (LABEL)
SYMBOL (LABEL SIGNS,MAIL BOXES, ETC.)
FENCE (LABEL TYPE)
FENCE ON WALL
GUARD POSTS & CABLE
GUARD RAIL WITH STEEL SIDES
RETAINING WALL
CURB LINE
BILLBOARD
HEDGE
TREE
TREELINE
TRAIL
CULVERT
STREAM
BUILDING OUTLINE
POINT OF INTERSECTION—MAIN TANGENTS
4
NUMBER—ALIGNMENT CURVE
4
NUMBER—POINT OF INTERSECTION, MAIN TANGENT
CONN-1
HORIZONTAL AND VERTICAL CONTROL POINT
STATION EQUALITY
ROCK LINE
GROUND LINE
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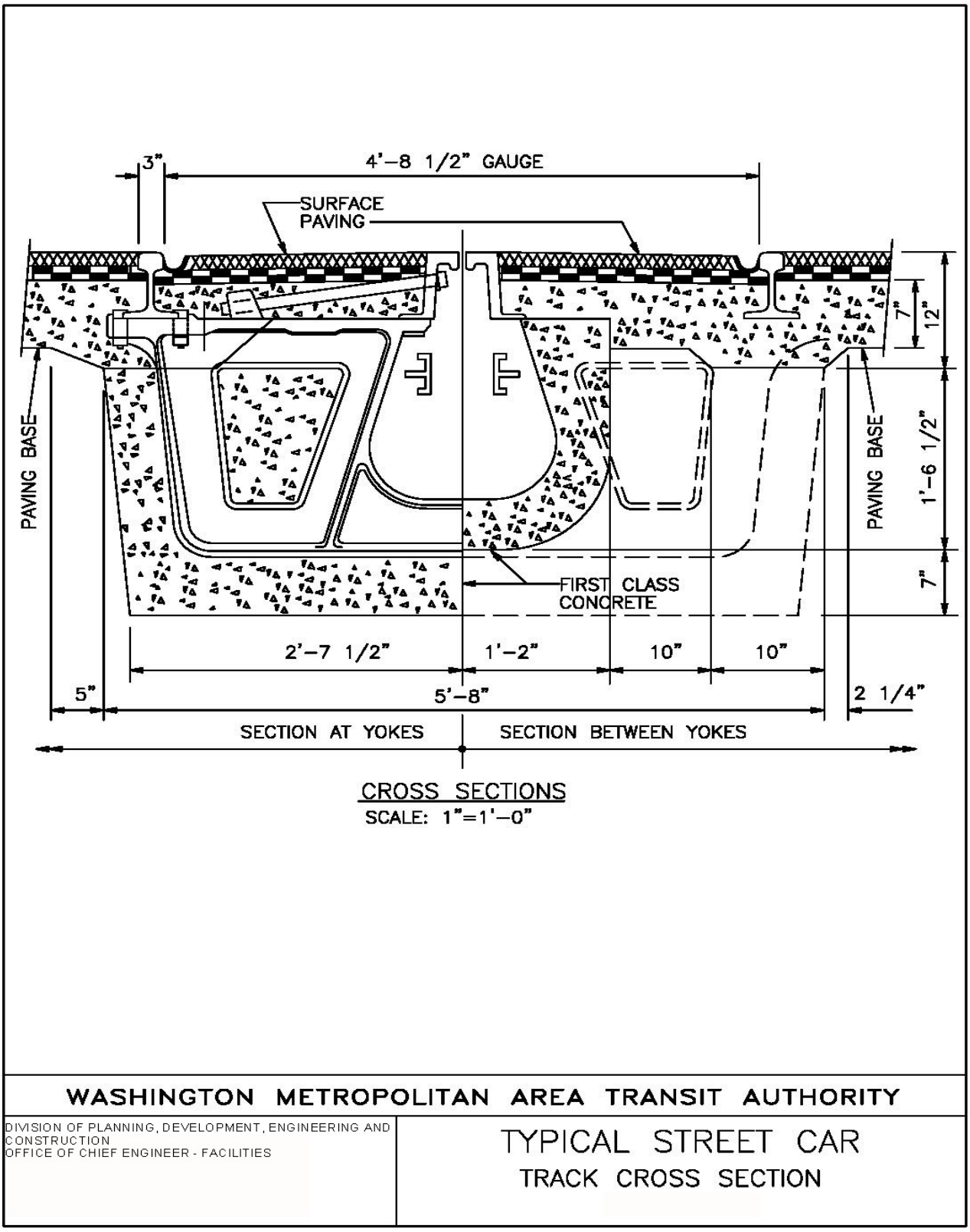
OFFICE OF CHIEF ENGINEER - FACILITIES
LEGEND
CIVIL DRAWINGS

FIGURE 8.6


3"
4'–8 1/2" GAUGE
SURFACE PAVING
7"
12"
PAVING BASE
PAVING BASE
1'–6 1/2"
7"
FIRST CLASS CONCRETE
2'–7 1/2"
1'–2"
10"
10"
5"
5'–8"
2 1/4"
SECTION AT YOKES
SECTION BETWEEN YOKES
CROSS SECTIONS
SCALE: 1"=1'–0"
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
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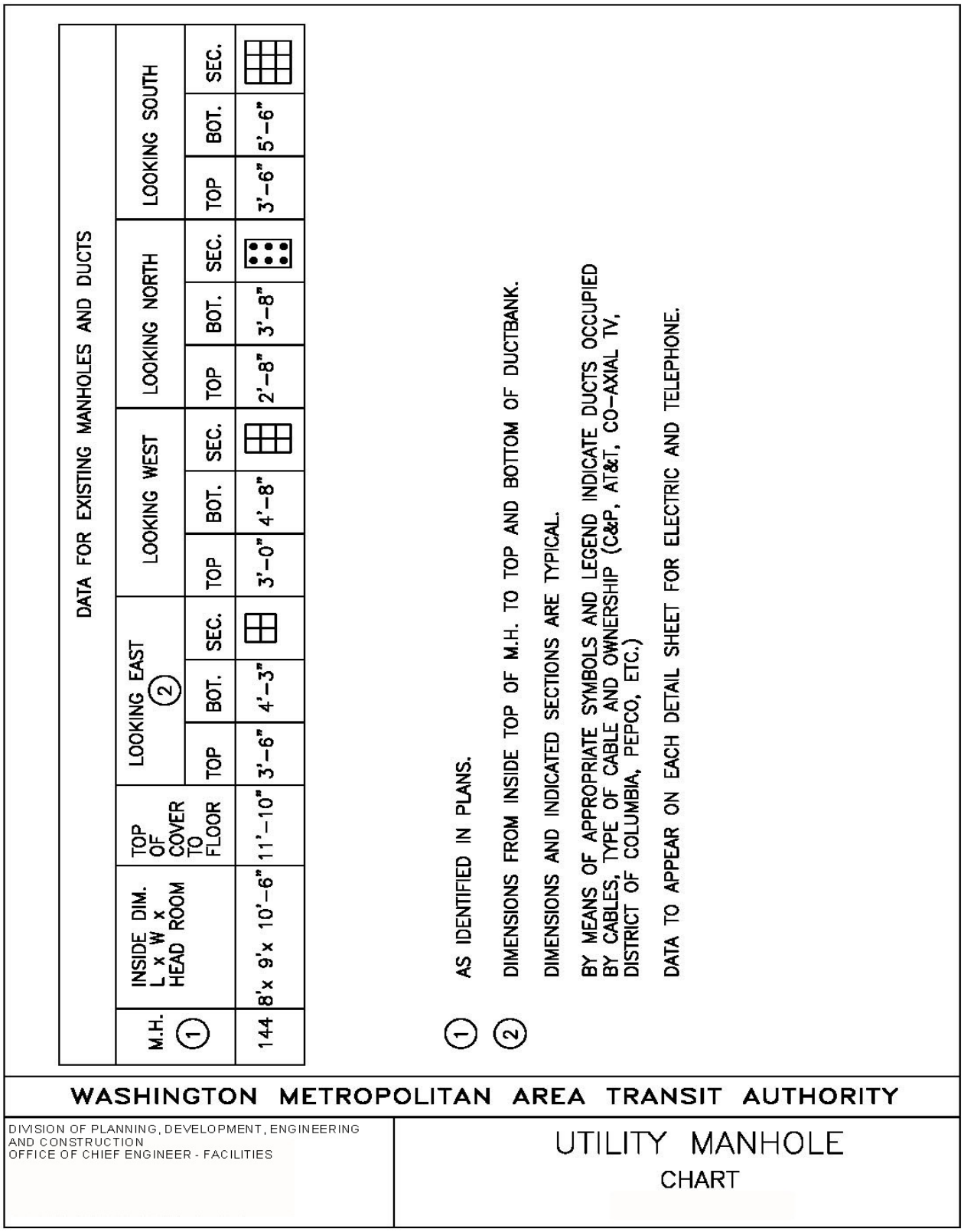
TYPICAL STREET CAR
TRACK CROSS SECTION

FIGURE 8.7


DATA FOR EXISTING MANHOLES AND DUCTS
M.H. ①
INSIDE DIM. L x W x HEAD ROOM
TOP OF COVER TO FLOOR
LOOKING EAST ②
LOOKING WEST
LOOKING NORTH
LOOKING SOUTH
TOP
BOT.
SEC.
144
8'x 9'x 10'-6"
11'-10"
3'-6"
4'-3"
3'-0"
4'-8"
2'-8"
3'-8"
3'-6"
5'-6"
① AS IDENTIFIED IN PLANS.
② DIMENSIONS FROM INSIDE TOP OF M.H. TO TOP AND BOTTOM OF DUCTBANK.
DIMENSIONS AND INDICATED SECTIONS ARE TYPICAL.
BY MEANS OF APPROPRIATE SYMBOLS AND LEGEND INDICATE DUCTS OCCUPIED BY CABLES, TYPE OF CABLE AND OWNERSHIP (C&P, AT&T, CO-AXIAL TV, DISTRICT OF COLUMBIA, PEPCO, ETC.)
DATA TO APPEAR ON EACH DETAIL SHEET FOR ELECTRIC AND TELEPHONE.
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UTILITY MANHOLE
CHART

FIGURE 8.8

CONDUIT OR CABLE TURNING AWAY OR DOWN	
CONDUIT OR CABLE TURNING UPWARD	
CONDUIT CAPPED OR CABLE DEAD ENDED	
JUNCTION OR PULL BOX	JB
TOGGLE SWITCH, 1 POLE	S_1
TOGGLE SWITCH, 2 POLE	S_2
TOGGLE SWITCH, 3 WAY	S_3
SWITCH, SPECIAL (NOTE REQUIRED)	S
DUPLEX FLUSH RECPTACLE 25A 125V WITH WEATHERPROOF SPRING COVER	C
PUSH BUTTON AS FOR MOTOR CONTROL	PB
DUPLEX FLUSH RECEPTACLE 15A 125V	
SINGLE HEAVY DUTY FLUSH RECEPTACLE 125V WEATHERPROOF SPRING COVER	
EMERGENCY BLUE LIGHT, INCANDESCENT	B
EMERGENCY WHITE LIGHT, (TUNNEL), INCANDESCENT	E
EMERGENCY EXIT LIGHT INCANDESCENT	X
INDICATES NUMBER AND SIZE OF WIRES, SIZE CONDUIT HOME RUN TO PANEL AND BREAKER DESIGNATION	#10–3/4 NP_1
SURFACE CONDUIT OR CABLE	
BURIED OR CONCEALED CONDUIT	

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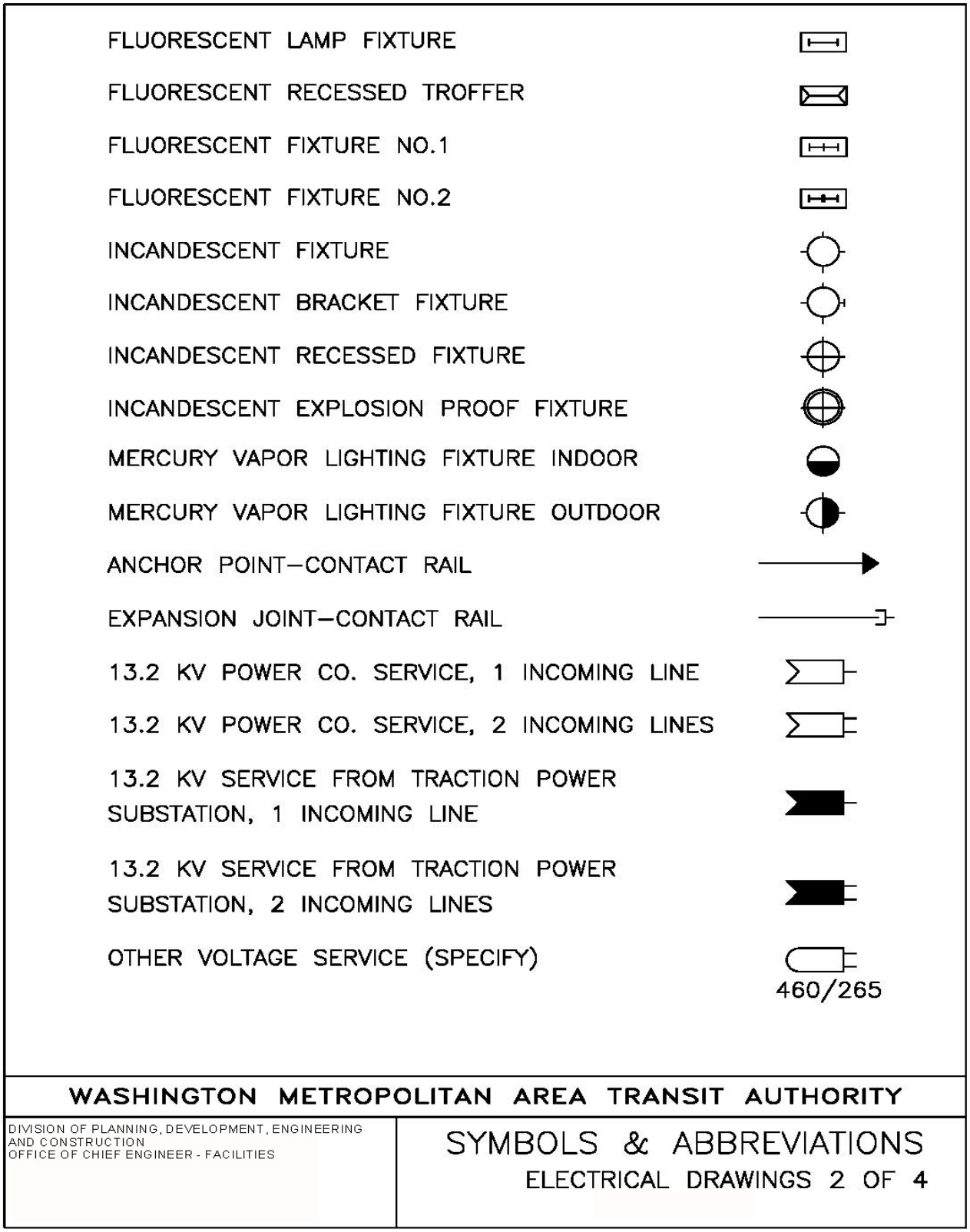
SYMBOLS & ABBREVIATIONS
ELECTRICAL DRAWINGS 1 OF 4

FIGURE 8.9


FLUORESCENT LAMP FIXTURE
FLUORESCENT RECESSED TROFFER
FLUORESCENT FIXTURE NO.1
FLUORESCENT FIXTURE NO.2
INCANDESCENT FIXTURE
INCANDESCENT BRACKET FIXTURE
INCANDESCENT RECESSED FIXTURE
INCANDESCENT EXPLOSION PROOF FIXTURE
MERCURY VAPOR LIGHTING FIXTURE INDOOR
MERCURY VAPOR LIGHTING FIXTURE OUTDOOR
ANCHOR POINT—CONTACT RAIL
EXPANSION JOINT—CONTACT RAIL
13.2 KV POWER CO. SERVICE, 1 INCOMING LINE
13.2 KV POWER CO. SERVICE, 2 INCOMING LINES
13.2 KV SERVICE FROM TRACTION POWER SUBSTATION, 1 INCOMING LINE
13.2 KV SERVICE FROM TRACTION POWER SUBSTATION, 2 INCOMING LINES
OTHER VOLTAGE SERVICE (SPECIFY)
460/265
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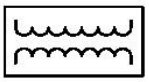
SYMBOLS & ABBREVIATIONS
ELECTRICAL DRAWINGS 2 OF 4

FIGURE 8.10

TIE BREAKER STATION	B
BREAKER, A.C.	⊠
BREAKER–STARTER COMBINATION–A.C.	⊠
PANEL, DISTRIBUTION "NP"	◢
RELAY OR CONTACTOR–REQUIRES NOTE	R
STARTER, MOTOR	⊠
SWITCHBOARD, A.C.	■
SWITCH–WALL, LOCK–TYPE	S,L
TRANSFORMER, DRY–(CAP & VOLTS AS SHOWN)	
EMERGENCY TRIP SWITCH	◥
SWITCH, SAFETY	□
SWITCH, PHASE SELECTOR	⊘
AMMETER	A
VOLTMETER	V
WATTHOUR METER	WH
POTENTIAL TRANSFORMER	PT
CURRENT TRANFORMER	CT
SWITCH, TEST	TS

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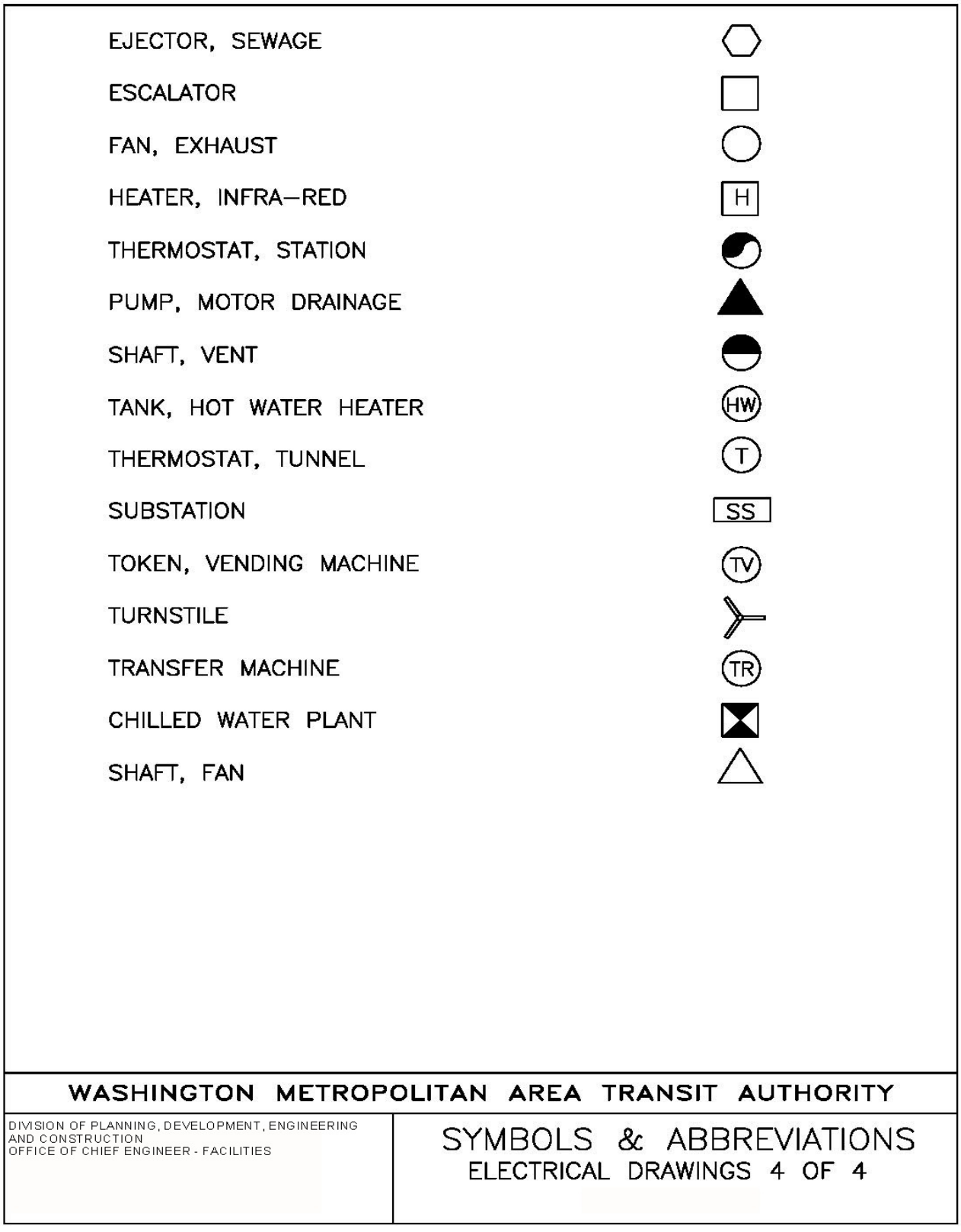
OFFICE OF CHIEF ENGINEER - FACILITIES

SYMBOLS & ABBREVIATIONS
ELECTRICAL DRAWINGS 3 OF 4

FIGURE 8.11


EJECTOR, SEWAGE
ESCALATOR
FAN, EXHAUST
HEATER, INFRA–RED
H
THERMOSTAT, STATION
PUMP, MOTOR DRAINAGE
SHAFT, VENT
TANK, HOT WATER HEATER
HW
THERMOSTAT, TUNNEL
T
SUBSTATION
SS
TOKEN, VENDING MACHINE
TV
TURNSTILE
TRANSFER MACHINE
TR
CHILLED WATER PLANT
SHAFT, FAN
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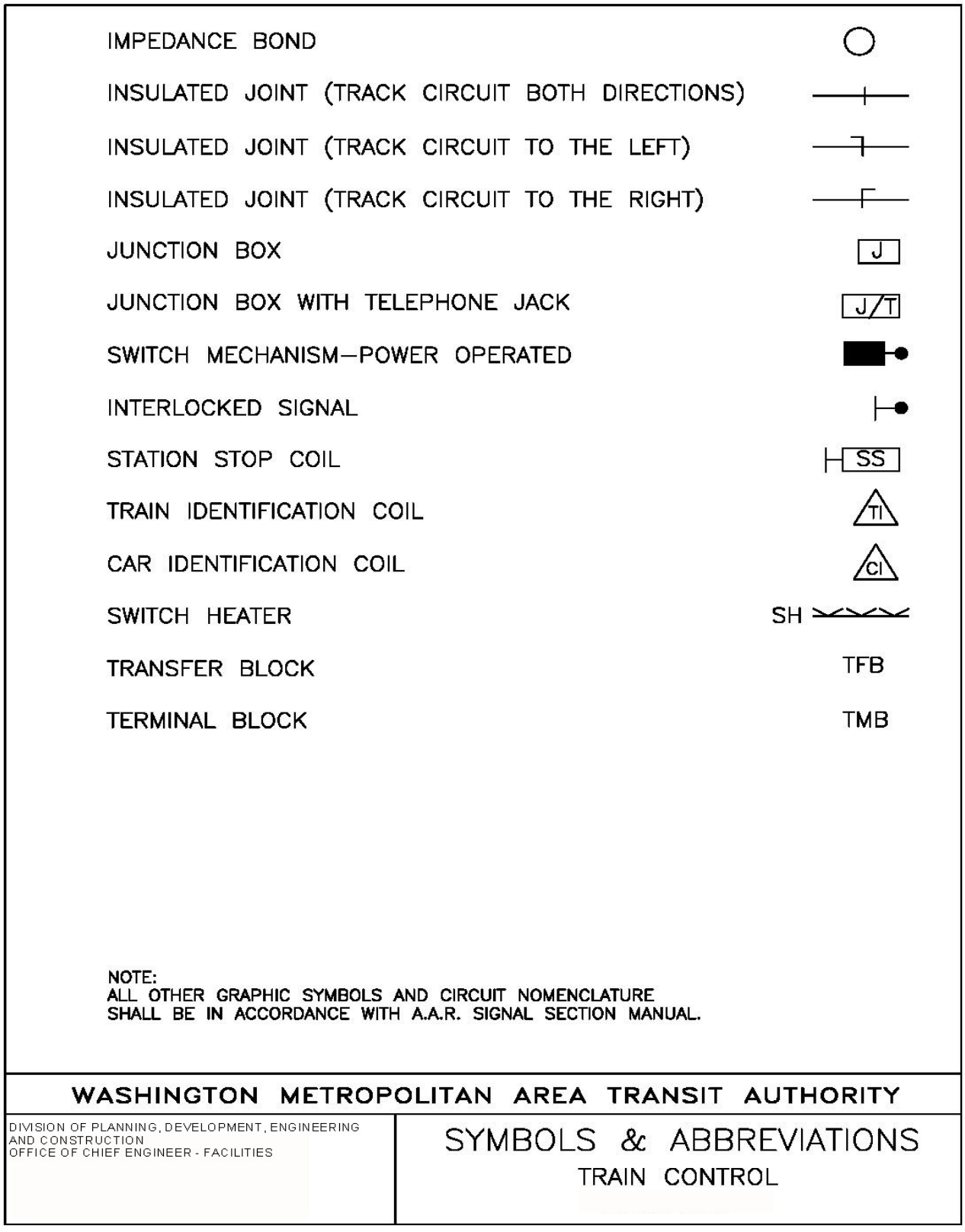
AND CONSTRUCTION
OFFICE OF CHIEF ENGINEER - FACILITIES
SYMBOLS & ABBREVIATIONS
ELECTRICAL DRAWINGS 4 OF 4

FIGURE 8.12


IMPEDANCE BOND
INSULATED JOINT (TRACK CIRCUIT BOTH DIRECTIONS)
INSULATED JOINT (TRACK CIRCUIT TO THE LEFT)
INSULATED JOINT (TRACK CIRCUIT TO THE RIGHT)
JUNCTION BOX
J
JUNCTION BOX WITH TELEPHONE JACK
J/T
SWITCH MECHANISM—POWER OPERATED
INTERLOCKED SIGNAL
STATION STOP COIL
SS
TRAIN IDENTIFICATION COIL
TI
CAR IDENTIFICATION COIL
CI
SWITCH HEATER
SH
TRANSFER BLOCK
TFB
TERMINAL BLOCK
TMB
NOTE:
ALL OTHER GRAPHIC SYMBOLS AND CIRCUIT NOMENCLATURE
SHALL BE IN ACCORDANCE WITH A.A.R. SIGNAL SECTION MANUAL.
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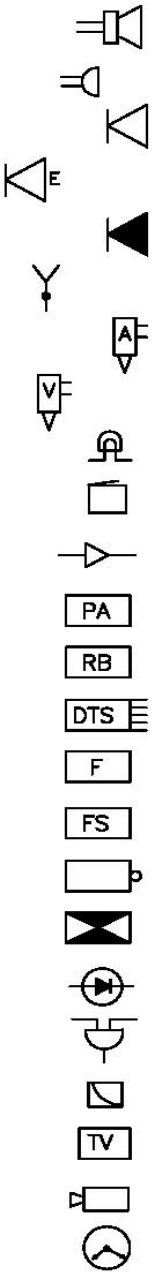
DIVISION OF PLANNING, DEVELOPMENT, ENGINEERING
AND CONSTRUCTION
OFFICE OF CHIEF ENGINEER - FACILITIES
SYMBOLS & ABBREVIATIONS
TRAIN CONTROL

FIGURE 8.13

LOUDSPEAKER
MICROPHONE
TELEPHONE, PRIVATE AUTOMATIC BRANCH EXCHANGE (PABX)
TELEPHONE, EMERGENCY
TELEPHONE, PUBLIC
TELEPHONE, MAINTENANCE, JACK
RECORDER–AUDIO
RECORDER–VIDEO
LAMP
BUZZER
AMPLIFIER
PA SYSTEM
RADIO BASE STATION
DIGITAL TRANSMISSION SYSTEM REMOTE TERMINAL
FIRE ALARM STATION, MANUAL
FIRE ALARM DEVICE, AUTOMATIC
FIRE ALARM BELL
CITY FIRE ALARM STATION
BURGLAR ALARM DEVICE
2–WAY POWER SPLITTER
LOW PASS FILTER
CLOSED CIRCUIT TELEVISION (CCTV) MONITOR
CLOSED CIRCUIT TELEVISION (CCTV) CAMERA
STANDARD TIME DISTRIBUTION SYSTEM DEVICE



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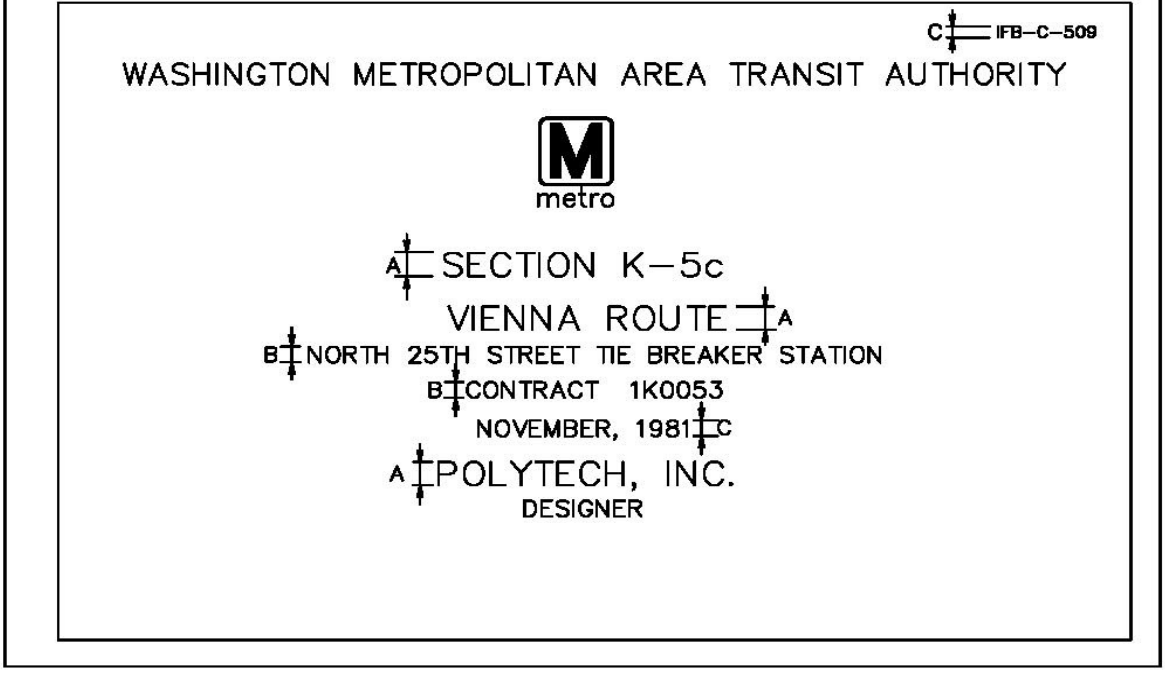
OFFICE OF CHIEF ENGINEER - FACILITIES

SYMBOLS & ABBREVIATIONS
COMMUNICATIONS

FIGURE 8.14



TYPICAL EXAMPLE

DESIGNATION	FONT SIZE	FONT STYLE
A	.72"	
B	.425"	
C	.35"	

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OFFICE OF CHIEF ENGINEER - FACILITIES

FORMAT FOR CONTRACT DRAWING COVER SHEET

FIGURE 8.15

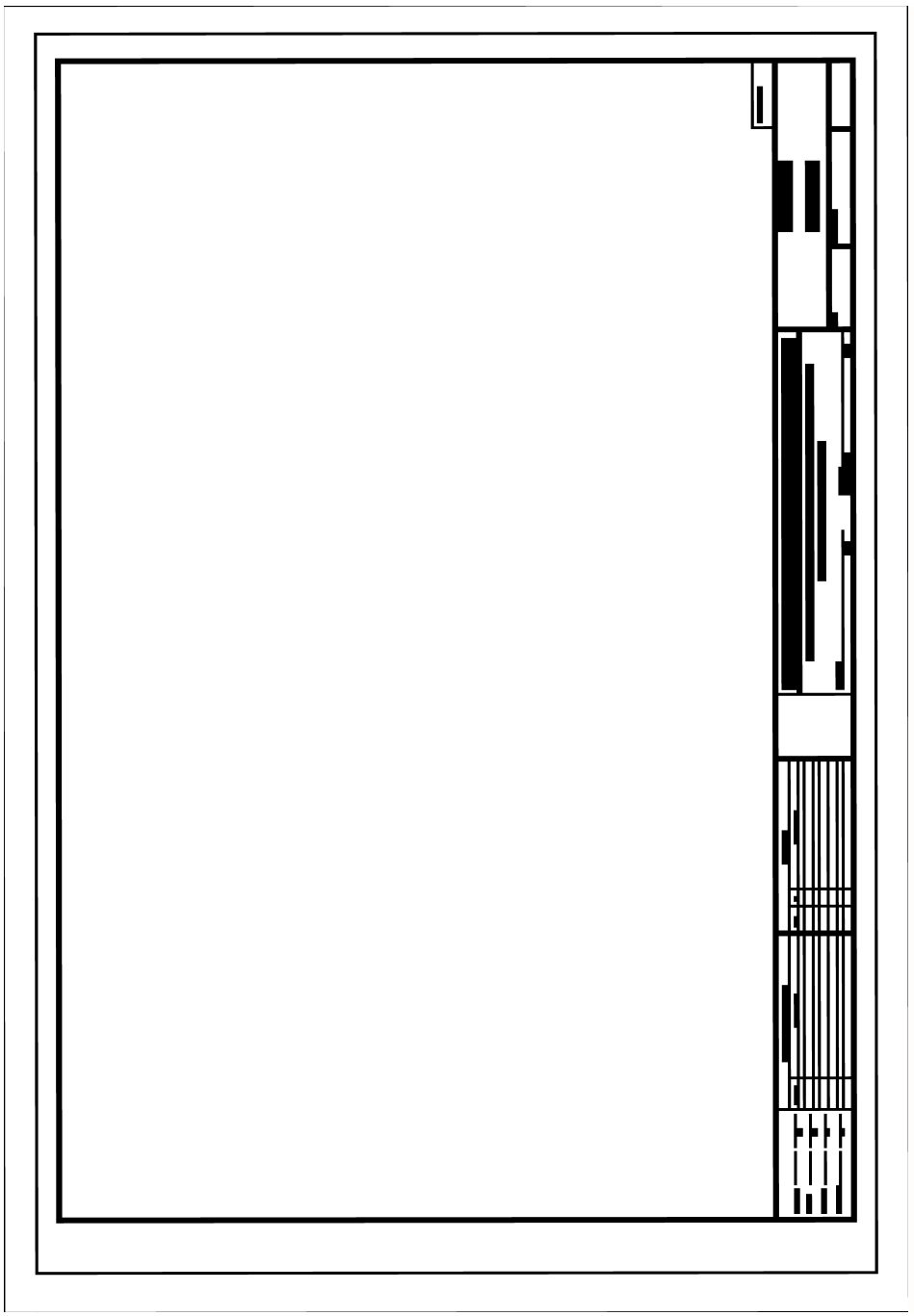
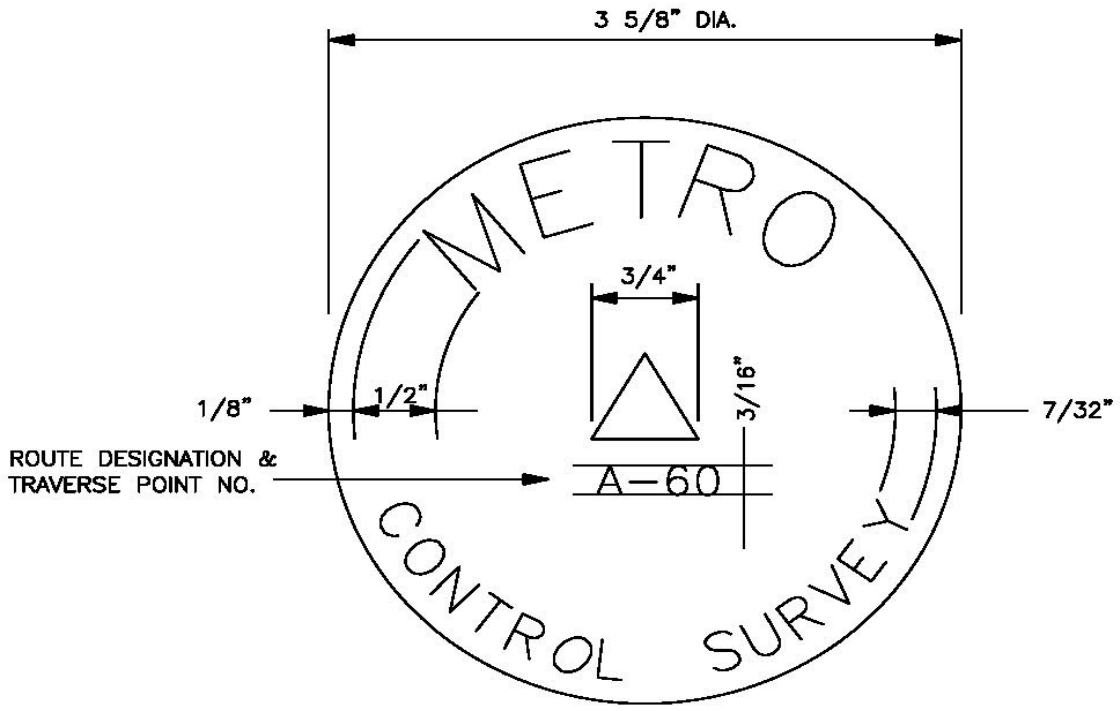

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
DIVISION OF PLANNING, DEVELOPMENT, ENGINEERING AND CONSTRUCTION
OFFICE OF CHIEF ENGINEER - FACILITIES
DRAWING BORDER

FIGURE 8.16



WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DIVISION OF PLANNING, DEVELOPMENT, ENGINEERING AND CONSTRUCTION
OFFICE OF CHIEF ENGINEER - FACILITIES

CONTROL SURVEY MARKER

FIGURE 8.17

SECTION 9 RIGHT-OF-WAY

9.1 GENERAL

9.1.1 Policy

Right-of-way is defined as the composite or total requirement of all real property interests and uses, both temporary and permanent, needed to construct, maintain, protect, and operate the Metro system.

WMATA's policy is to certify for acquisition the minimum right-of-way sufficient to construct, operate, and maintain the bus and rail transit system. The right-of-way plans approved by the WMATA Office of Chief Engineer Facilities (CENF) are used by the WMATA Office of Property Development and Management (LAND) as a basis for acquisition of property interests. LAND will make the final determination of the quantum of the estate in the land to be acquired.

For permanent easements, the Section Designer shall determine a right-of-way envelope which encompasses all permanent construction, drainage, future maintenance requirements, access roads, fire protection, utilities, rock bolts and any other permanent improvements or projections necessary for the construction, operation and maintenance of the system. In developing a right-of-way envelope, the cost of the land to be acquired should be factored into the proposed easement acquired.

The acquisition envelope is influenced by the topography, drainage, ditches, retaining walls, service roads, utilities, the nature of the structure and the slopes required. The limit of right-of-way shall be shown as an unbroken line which delineates the right-of-way with simple curves and connecting tangents. Chords may be used in lieu of large radius curves.

9.2 Right-of-way Staging

The Section Designer shall identify the minimum limits of the right-of-way during the design of the first or "structural" contract developed for a design section. Any subsequent contracts should not identify additional or new right-of-way required for that contract.

The first contract should identify the land that will be available for the first contract, the land that will be made available for any sequential contracts, and when in the construction cycle one contractor will make the land available for another contractor.

The contract drawings for the second contract, need only identify the work areas that the second contractor will have available. The complete set of right-of-way drawings need not be inserted in subsequent contract drawing sets.

9.3 DEFINITIONS OF RIGHT-OF-WAY EASEMENTS

9.3.1 Permanent Surface Easement

A permanent surface easement shall provide sufficient space for the construction, operation, protection and maintenance of the Metro facility at the ground surface. The recommended easement width must incorporate basic track width, drainage, supporting slopes and utilities. Typical examples of permanent surface easements are sites for stations, traction power substations, chiller plants, vent and fan shafts, and other at-grade structures, in addition to at-grade tracks.

9.3.2 Permanent Surface Easement with an Upper Limit

A permanent surface easement with an upper limit shall provide space for the transit structures and for their future maintenance. This easement is applicable where structures such as a railroad or highway pass over Metro facilities. The easement shall have definite upper and lateral limits. A lower limit shall be described only when required.

9.3.3 Permanent Underground Easement

A permanent underground easement shall encompass the total Metro facility located beneath the surface of the ground. It shall have definite upper and lateral limits. Lower limits shall be described only where special limiting features exist.

9.3.4 Permanent Aerial Easement

A permanent aerial easement shall completely envelop the aerial portion of the Metro facility, with lower and lateral limits. An upper limit shall be described only where special limiting features exist.

9.3.5 Utility Easement

A utility easement shall provide space for the relocation of existing utilities or the installation and maintenance of required or relocated utilities.

9.3.6 Construction Easement

A construction easement is a temporary easement or short term lease that provides sufficient space to allow for the temporary use of property by the Contractor during construction.

9.3.7 Slope Easement

A slope easement is a permanent surface easement for a cut or fill side slope to the tracks. A slope easement can be made revertible to the adjacent property owner if acceptable provisions are made for future support of the slope.

9.3.8 Drainage Easement

A drainage easement is a permanent surface easement for drainage of water along a prepared course.

9.3.9 Electric Grounding Grid Easement

The electric grounding grid at substations and tie breaker stations should be designed to be located in any permanent surface easements at the station. If such an arrangement is unworkable, then the grounding grid shall be located in an identifiable grounding grid easement. The grounding grid location should be monumented.

9.3.10 Access Easement

9.4 DRAWING DETAILS

Right-of-way drawings shall be 1" = 40' scale showing the relationship of the right-of-way to the street system and properties affected by construction. All existing topographic features shall be screened on the base sheets.

Show property lines and delineate affected parcel ownership along the right-of-way. When a property appears on more than one sheet of the right of-way plans, the total area of the easement required shall be shown in the Property Disposition Table on the first sheet on which the property appears. The property shall be listed in the property disposition table on each sheet on which it appears and shall be cross referenced to the sheet which delineates the area of the easement.

The right-of-way drawings shall have a designated grid system and north arrow reflecting the appropriate datum of WMATA's project grid or related USC&GS datum as appropriate for the area concerned.

9.4.1 Format

All right-of-way plans shall conform to the format established in the most current WMATA Right-of-way Design Drawings and Contract Drawing Standards.

9.4.2 Graphic Symbols

Graphic symbols used to describe easements shall be uniform and shall conform to the standard right-of-way legend (see FIGURE 9.I). Each sheet shall contain a legend describing only the symbols used on that sheet. The edge of each easement shall be marked with a neat line to mark the limit of the easement and to aid in distinguishing it from existing facilities or other easement symbols. The street system shall be clearly shown and identified by street names as well as Federal, State and/or County route numbers.

9.4.3 Centerline

The right-of-way plans shall show the centerline of the tracks and the outline of the structure, in addition to the limits of right-of-way which describes the right-of-way envelope. Stationing and station equations shall be shown in addition to contract limits. The beginning and ending points for curves and spirals on the centerline of both tracks shall be shown, as well as the dimension between tangent track center-lines. Show the outbound centerline stationing at property lines.

9.4.4 Contractors' Work Areas

Delineate on the drawings the property required for the contractors' use and show the limits of any additional easements, temporary or permanent, that are required to accommodate access, temporary roads, drainage and utilities. Show all structures that require razing prior to construction. Show temporary fencing or barriers around contractors' work areas. Determine the property owners of record affected by the above limits and show the property dispositions in table form with areas involved by type easement required.

Coordinate all of the requirements for the contractors' work areas at each end of the design section. The contractor's work areas for one design section shall not cross over into the adjacent section. If construction staging allows the use of an area in an adjacent design section, its use must be coordinated with WMATA and the adjacent section designer to avoid contractor confusion and claims.

9.4.5 Property Surveys in the District of Columbia

In the District of Columbia, the right-of-way envelope shall be dimensionally tied to existing copper corners. Copper corners, which are generally offset from the square corners or property lines, can only be established by the D.C. Surveyor, or a surveyor registered in D.C. After establishing a copper, the surveyor then prepares and records a plat showing the relationship between the established copper and the property line. Ties from the proposed limit of right-of-way to the property lines are also required.

The following procedure is to be followed when requesting copper corners:

9.4.5.1 The General Plans shall be reviewed by the Section Designer to determine the location of the copper corners needed to complete the design.

9.4.5.2 A search of the District of Columbia's survey records shall be conducted to determine the exact field location of each existing copper in the affected area.

9.4.5.3 A field check shall be made to determine the accuracy of all coppers located based on the copper locations taken from the D.C. survey records.

9.4.5.4 Coppers located and verified by the field check may be used in the design.

9.4.5.5 If additional copper corners are required to complete the right-of-way design, the Section Designer will provide a list of the desired corners to WMATA-CENF. WMATA shall request the D.C. Surveyor to mark the corners. WMATA shall monitor the D.C. Surveyor's progress.

9.4.5.6 WMATA shall establish the location of the coppers with respect to the Metro grid and place the coordinate values on the plats prepared and signed by the D.C. Surveyor. Plats with the coordinated copper corners shall be used in the design and the coordinated values of the copper corners shall be shown on the right-of-way plans. (It is emphasized that copper corners be requested as early as possible to avoid delay in design.) When calculating areas of required rights-of-way, each square affected by the right-of-way envelope must be considered separately.

9.4.5.7 Written descriptions shall be in the D. C. meridian.

9.4.6 Property Surveys in Maryland and Virginia

- The WMATA right-of-way envelope on the plans shall be described by bearings and distances, ensuring that the pertinent portions of all tracts, subdivisions, U. S. lands, parcels, and other areas which are affected by the envelope are similarly described. Coordinates and elevations further describing the right-of-way limits and existing property corners shall be shown on the plans. Coordinates shall be provided for all angle and curve points along the limits of right-of-way. Properties that are affected by WMATA's right-of-way shall be shown in their entirety. Smaller scale (e.g. 1" = 200') drawings may be used.

- The Section Designer shall prepare plats of survey for recordation in accordance with the requirements found in Section 9.4.7 and the minimum technical standards of the appropriate jurisdiction. The final plats shall comply with the requirements of the jurisdiction in which the property is situated. It is required in Arlington County (and strongly recommended for other jurisdictions) that the Section Designer submit the plats to the County (or City) having jurisdiction for their approval and comments. The plats shall be coordinated with WMATA prior to their submittal to the County (or City). Final plats shall be certified by a Land Surveyor registered in the applicable jurisdiction.

- In 1974, the National Geodetic Survey (formerly the United States Coast and Geodetic Survey) adjusted the values of the horizontal control coordinates of all first order Triangulation Stations in Maryland and Virginia. WMATA mapping and control was generally based on the NAD27 1971 field geographic positions and coordinate values of these stations. One small section of WMATA's mapping and control (A-14 to A-17) was based upon NAD27 1974 adjustment. In either case, the Section Designers shall include on the right-of-way plans, and on the plats of recordation, a note that describes the coordinate datum and adjusted values which are the basis for the coordinates shown. Survey consultants performing surveys for WMATA shall endeavor to use the NAD27 1971 and 1974 positions where historically these positions have been used in the past. NAD83 1991 positions shall be used for all extensions beyond the 103 Mile System. Adjustment of existing control shall be limited to avoid complications due to the differences of accuracy, and its relationship to previously set rail centerline control points and right-of-way monuments.

9.4.7 Plat of Survey Requirements

9.4.7.1 A surveyor performing any boundary survey for WMATA shall follow the minimum technical jurisdictional requirements and the WMATA technical standards during the performance of the work. Deviation from these requirements shall require WMATA approval.

9.4.7.2 All original plats of boundary surveys shall be provided on durable reproducible film, drawn at a jurisdictionally approved suitable scale clearly indicating the compiled results of the field work, computations, research, and record information.

9.4.7.3 All plats shall be submitted to WMATA in the latest AutoCAD® digital file format. All legal descriptions shall be submitted to WMATA in the latest WordPerfect® digital file format.

9.4.7.4 All plats and legal descriptions shall be signed and sealed by the record surveyor.

9.4.7.5 Plats may not be smaller than 8 ½ x 11 inches. Plats shall be prepared in multiples of 8 ½ x 11 inches or 8½ x 14 inches. Tic marks shall be placed on the plat to indicate the corners of the multiple rectangles. The scale of the plat shall be 1 inch = 100 feet or smaller. Excess blank space shall be avoided.

9.4.7.6 Dimensions, bearings, or angles, including sufficient data to define curves, shall be neatly and legibly shown with respect to each property boundary line. Tables of dimensions, bearings and angles shall be avoided.

9.4.7.7 All bearings shall be shown in a clockwise direction.

9.4.7.8 Building street address numbers, as displayed on the premises, or so noted if no numbers are displayed.

9.4.7.9 Markers shall be labeled as "found" or "set", with a brief description of the marker and relevant reference markers, if any, along with their positions in relation to the corner.

9.4.7.10 Natural or artificial features, where relevant, such as water courses, streets, curb lines, pavement lines and visible utilities, shall be labeled, dimensioned, and referenced to the nearest property boundary line or represented by a symbol on the plat in its proper location. Each symbol shall clearly indicate what is represented or shall be labeled for identification either individually or in a separate key of symbols or legend.

9.4.7.11 A statement indicating the origin and method of determination of the bearings shall be made on each plat, and the origin of the bearings shall include a reference to the WMATA approved local coordinate system with the controlling station names listed along with coordinate values.

9.4.7.12 Separate intricate details, blowups, or inserts may be used for clarity. They shall be properly referenced to the portion of the plat where they apply, particularly in areas where lines of occupation do not conform to the deed lines, and or where a comparison of adjoining deeds indicates the existence of a gap or overlap.

9.4.7.13 When record bearings or angles or distances differ from measured bearings, angles or distances, both the record and measured bearings, angles, and distances shall be clearly indicated. If the record description fails to form a mathematically closed figure, the surveyor shall so indicate.

9.4.7.14 Cemeteries and burial grounds found by the surveyor within the premises being surveyed shall be noted on the plat.

9.4.7.15 All evidence of monuments found beyond the subject tract, on which establishment of the corners of the subject tract are dependent, along with their application related to the survey shall be indicated.

9.4.7.16 Different line weights or delineating letters or numbers shall be used to clearly show the limits of the survey.

9.4.7.17 Easements and other physical encumbrances shown on the title shall be included on each plat along with all data necessary to establish or reestablish

the location of the lines and the area of a strip or parcel of land designated on a tract of land for the specific use and benefit of others.

9.4.7.18 Upper and lower easement elevations and geometric delineation of easements required shall be shown on all plats.

9.4.7.19 WMATA structure lines and WMATA right-of-way lines shall be shown on all corresponding plats.

9.4.7.20 Permanent property interests required by WMATA shall be plainly and precisely identified on all corresponding plats.

9.4.7.21 The character of any and all evidence of possession shall be stated and the location of such evidence carefully given in relation to both the measured boundary lines and those established by the record. An absence of notation on the survey shall be presumptive of no observable evidence of possession.

9.4.7.22 Flood zone designation with proper annotation based on Federal Emergency Management Agency Flood Insurance Rate Maps or the state or local equivalent, by scaled map location and graphic plotting only shall be shown on each plat.

9.4.7.23 The name of owner(s) of record and deed book reference where the acquisition was recorded shall be shown on all plats.

9.4.7.24 Adjoining properties will be shown and shall include record owner name(s), square number, block & lot number, parcel number, section number, and name of subdivision, as appropriate, or if not in a subdivision, Town/City and County. In addition, tax identification number and deed book & page shall also be shown on each plat.

9.4.7.25 Names and widths of streets and highways abutting the property surveyed and widths of right of way shall be shown on the plat. Distance to nearest intersection, based upon record data. If not available from record data, distance to nearest intersection may be determined from best available data, and so qualified.

9.4.7.26 Improvements such as any fixed permanent features including buildings, sheds, detached garages, structures, and fences shall be shown on each plat. The type of building construction shall be noted as brick, frame, steel, concrete, etc. All improvements shall be dimensioned (including number of stories and projections into public space) and shown on the plat. If no buildings exist a note shall be placed on the plat stating "No buildings".

9.4.7.27 Driveways and alleys on or crossing the property shall be shown. Where there is evidence of use by other than the occupants of the property, the surveyor must so indicate on the plat or map. Where driveways or alleys on adjoining properties encroach, in whole or in part, on the property being surveyed, the surveyor must so indicate on the plat or map with appropriate measurements.

9.4.7.28 A statement as to whether or not a current title report has been furnished to the surveyor along with title report number.

9.4.7.29 Building restriction line(s) per restrictive covenant, if shown on the record subdivision plat.

9.4.7.30 All measured and record boundary line distances of parcels surveyed shall be shown.

9.4.7.31 Date of plat certification (signing & sealing)

9.4.7.32 Path & filename (digital)

9.4.7.33 Survey contractor's project filename & number

9.4.7.34 WMATA survey request number (if applicable)

9.4.7.35 WMATA task order number (if applicable)

9.4.7.36 WMATA line & section number (if applicable)

9.4.7.37 CENF parcel number

9.4.7.38 LAND parcel number

9.4.7.39 QA review by signature block

9.4.7.40 Date of field survey

9.4.7.41 Revision date(s)

9.4.7.42 Name of surveyor

9.4.7.43 Survey company name

9.4.7.44 Survey company address and the phone number

9.4.7.45 Client's name (survey prepared for)

9.4.7.46 Title of survey

9.4.7.47 Title report reference

9.4.7.48 Classification of the survey (urban, suburban, rural, mountain and marshland)

9.4.7.49 Scale of drawing

9.4.7.50 Basis of bearings

9.4.7.51 Datum (NAD83 or other datum approved by WMATA)

9.4.7.52 Gridlines / grid ticks

9.4.7.53 Coordinate station names

9.4.7.54 Coordinate station values for base control

9.4.7.55 Coordinate station scale factor(s)

9.4.7.56 North arrow

9.4.7.57 Legend

9.4.7.58 Signature, seal, printed license number of the surveyor & date block

9.4.7.59 Property description & location

9.4.7.60 Vicinity map

9.4.7.61 Land area for each parcel (acreage)

9.4.7.62 **Point** of commencement/point of beginning

9.4.8 Deliverables

9.4.8.1 In addition to the right-of-way drawings, plats of survey and written metes and bounds descriptions of the proposed permanent easements shall be prepared by the Section Designer. Digital and hard copies shall be submitted to WMATA. The plats shall show both the record and the measured distances and bearings. Area closure sheets shall also be submitted.

9.4.8.2 Fee interests are normally taken from railroad companies, in lieu of permanent surface easement. Therefore, plats of railroad property where WMATA will require permanent surface easement shall be prepared to show fee takings. (The right-of-way plans shall still show permanent surface easement in the railroad properties.)

9.4.9 Curve Data

The Section Designer shall reduce all spirals to circular curves at the limit of right-of-way. Circular curves are the only type of curves acceptable for recording purposes. Curve data shall be shown on the right-of-way plan sheet on which the curve appears in a table of curve data. Tangent sections shall be used in lieu of curves to show the limits of the right-of-way when curves are extremely flat.

9.4.10 Right-of-way for Aerial Structures

9.4.10.1 In determining right-of-way needs when dealing with aerial structures the Section Designer may use as a guide a horizontal distance of twenty-five feet (25'-0") from the centerline of the nearest track to the right-of-way line. This should provide sufficient space for fire protection and maintenance. Consideration shall be given to the location of adjoining buildings and property limits which could govern the extent of the right-of-way limits.

9.4.10.2 The upper elevation of an aerial easement shall be a plane parallel with the datum, the upper elevation controlled by the highest point of the Metro structure. The upper elevation plane shall be stepped as necessary to prevent excessive takings. The steps shall be co-located with property lines, or other land features acceptable in land description practice. A lower limit will be required in most cases. Typical examples are a railroad passing under the WMATA facilities, or where the Metro passes over Federal Aid Highways, parking lots, or other facilities. Future requirements of access for maintenance

purposes from ground elevation shall be considered in designing aerial rights-of-way.

9.4.10.3 Within the aerial easement area the following rights are obtained as a minimum:

9.4.10.3.1 Support rights for foundations, piers and other structural members.

9.4.10.3.2 The right of unobstructed and unimpaired use of the aerial envelope.

9.4.10.3.3 The right to prevent the transfer of loads to any part of the structure or foundations.

9.4.10.3.4 Access rights for periodic inspection and maintenance of the structure and footings.

9.4.10.3.5 The right to prevent the storage of flammables, explosives or other hazardous materials under the aerial envelope.

9.4.10.3.6 The right to install utilities beneath the surface of the ground within the easement area.

9.4.10.3.7 The right to use the area of the aerial easement as a contractor's work area during construction.

9.4.10.4 In property owned by the National Park Service (NPS) or by the General Services Administration (GSA), the areas for all easements required below the aerial easement shall be defined in the normal way.

9.4.10.5 In designing the WMATA right-of-way, the Section Designer shall take the above criteria into consideration and any existing local, state and Federal requirements.

9.4.11 Continuous Right-of-way

Even though WMATA may not require acquisition of public space, all plans shall show the right-of-way envelope as being continuous crossing public as well as private space.

9.4.12 Isolated Right-of-way

The easement areas supporting all new construction such as fan and vent shafts, substations, escalators, and chiller plants shall be geometrically delineated as is the right-of-way envelope, with ties shown where the location is not contiguous to the right-of-way.

9.4.13 Underground Vaults

Underground vaults (found mainly in the District of Columbia) that will be influenced by WMATA construction shall be shown and their disposition noted. The vaults shall be labeled in accordance with the following categories:

9.4.13.1 Category "A" are those vaults which must be physically removed during construction.

9.4.13.2 Category "B" are those vaults which lie within the influence line of construction, but may not require physical removal.

9.4.13.3 The influence line may generally be considered to project upwardly on a 1:1 slope from a point two feet (2') below the lowest point of excavation nearest the property line. Vaults not in Category "A" but within the influence line could experience cracking and utility lines may be subject to rupture. The owner may be required to abandon use of vaults designated Category "B" during construction.

9.4.14 Multilevel Easements

Multilevel easements may be required by WMATA at station entrances located in buildings. In such instances the Section Designer shall prepare a separate detail drawing showing the interests on each floor level. The following points shall be adhered to:

9.4.14.1 Each floor level affected by the WMATA facility shall be so noted and separately illustrated. The area required on each level should be shown on each level of the detail, with the sum of the areas shown in the property disposition table for that property.

9.4.14.2 Each type of easement on a floor level shall be properly dimensioned and symbolized. All footing and column locations shall be shown.

9.4.14.3 The elevations of each floor easement shall be given and referenced to the project datum. Elevations shall normally be from the underside of the floor structure to the underside of the next higher floor structure.

9.4.14.4 Access to each level of the easements must also be included in the design.

9.4.15 Explanatory Notes

Explanatory notes shall be used, where applicable, to aid in clarification of right-of-way takings.

9.4.16 Construction Easements

9.4.16.1 Construction easements are temporary easements that are normally required only during construction. These easements do not need the detailed definition of permanent easements, as an agreement (lease) is normally entered into with the property owner. It is essential, however, that the Contractor be able to accurately locate the extent of the easement in the field. Thus, distances and ties to existing features are important.

9.4.16.2 If the proposed easement is isolated from the WMATA right-of-way, ties or coordinates sufficient to locate the easement in the field should be shown on the plans.

9.4.16.3 Where WMATA facilities will be built by cut-and-cover construction, a construction easement is required over the permanent underground easement

that will envelope the structure. The area of the construction easement is to be noted in the property disposition table with an asterisk, which refers to a note of explanation: "* INCLUDES AREA ABOVE PERMANENT UNDERGROUND EASEMENT", placed above the Property Disposition Table. Plats are not required for construction easements, except in the event of condemnation. Plats used for condemnation are required to show construction easements by bearings and distances.

9.5 RIGHT-OF-WAY LIMITS

The Section Designer shall concurrently evaluate the right-of-way requirements for access, drainage, utilities, embankments, grades, alignments, and interfaces. The following criteria are provided as a guide for establishing the right-of-way limits. All right-of-way limits shall be defined as horizontal or vertical planes. The dimensions given herein are for general conditions and are to be modified where good sense, engineering, physical limitations, or real estate requirements dictate. The right-of-way limits will not always be concentric or parallel with the centerline of the tracks. Special attention shall be given to property takings, with the intent of avoiding takings where it is possible without adversely affecting the composite requirements of the Metro system. This may be accomplished by reducing or increasing the distance from the centerline of the tracks to the right-of-way limits or by stepping the limits around a certain property. The Section Designer shall establish the right-of-way limit to include the security fence and its support structure. Right-of-way limits should be developed which will allow minor adjustments as the design is refined.

The following distances are offered as a guide in establishing the final right-of-way requirements early in the design. Right-of-way widths at stations are based on 40'-6" track centers. Use of wider track centers will require additional right-of-way widths.

9.5.1 At-Grade Structure (See Figure 9.2)

Upper Limit: Normally, an upper limit is not required. When an upper limit is required, the limit shall be described by the elevation of horizontal planes, stepped as required, locating the steps at existing property lines or prominent topographical features. The minimum distance from the top of the high rail to the horizontal plane is eighteen feet (18').

Lateral Limits: The Section Designer shall establish the right-of-way limits taking into account all requirements that apply to the alignment. The following distances shall be used as a guide:

9.5.1.1 Normal at-grade section, five feet (5') from the toe or top of slope.

9.5.1.2 Normal at-grade section with a drainage interceptor ditch, five feet (5') from the outside edge of the interceptor ditch.

9.5.1.3 Restrictive and retained sections as approved by CENF.

Lower Limit: When required, the lower limit shall be defined in a manner similar to the upper limit, using a minimum distance of fifteen feet (15') below the top of low rail or fifteen feet (15') below the lowest flow line of adjacent drainage channels, whichever is lower.

9.5.2 Aerial Structure (See Figure 9.2, Figure 9.10 and Figure 9.11)

Lateral Limit: Single track minimum fifty feet (50') total; double track on fourteen feet (14') centers, sixty four feet (64'). A lateral distance of twenty five feet (25') from the centerline of each track is to be maintained on wider track centers.

Lower Limit: A lower limit will normally be required under the aerial structure. The limit will vary from 1' to 4' below the bottom of the structure. The limit is delineated by elevations of horizontal planes, stepped as required, locating the steps at existing property lines or prominent suitable topographical features. For clearance requirements see Section 11.11.

Upper Limit: An upper limit is generally not required; however, if required, the upper limit should be set at eighteen feet (18') above the top of the high rail.

9.5.3 Rock Tunnel (See Figure 9.2, Figure 9.7, Figure 9.8 and Figure 9.9)

Dimensions given in the aforementioned figures and following paragraphs are minimum distances. Actual dimensions may increase due to the conditions of the rock.

Upper Limit: The limit of the right-of-way is described by elevations of horizontal planes, stepped as required, locating the steps at existing property lines or prominent suitable topographical features. As a guide, a horizontal plane shall be used that is thirty five feet (35') above the top of the high rail for single track, forty feet (40') for double track, and seventy feet (70') at stations.

Lateral Limit: Vertical planes shall be used that are thirty feet (30') from the centerline of the nearest track. In station areas, use sixty feet (60') from the centerline of the station.

Lower Limit: Lower limits are normally not prescribed for rock tunnels. Where used, the lower limit shall be configured in a like manner to the upper limit, using a distance of fifteen feet (15') below the low rail.

9.5.4 Earth Tunnel (See Figure 9.2 and Figure 9.6)

Upper Limit: The limit of the right-of-way is described by elevations of horizontal planes, stepped as required, locating the steps at existing property lines or prominent suitable topographical features. As a guide, a horizontal plane twenty five feet (25') above the top of the high rail shall be used.

Lateral Limit: Fifteen feet (15') from the centerline of the nearest track.

Lower Limit: Where required by local jurisdictions or field conditions, a lower limit shall be configured in a manner similar to the upper limit using a distance of fifteen feet (15') below the top of the low rail.

9.5.5 Cut and Cover (See Figure 9.2, Figure 9.3, Figure 9.4 and Figure 9.5)

Upper Limit: Twenty five feet (25') above the top of the high rail for single track, double track or triple track, and forty feet (40') at stations. The limit is delineated by

elevations of horizontal planes, stepped as required, locating the steps at existing property lines or prominent suitable topographical features.

Lateral Limit: Fifteen feet (15') from the centerline of the nearest track. In station areas, forty feet (40') from the centerline of the stations.

Lower Limit: Where required by local jurisdiction or conditions.

9.5.6 Storm Drainage

Local requirements shall be adhered to where applicable. If there are no applicable local requirements, then the following shall apply:

9.5.6.1 Open Ditches

A minimum strip ten feet (10') wide is required for ditches where the design requires surface drainage. (See standard drawings for other ditch dimensions and slopes.) A two foot (2') wide clean-out shelf is required where the ditch is unpaved.

Back and Front Slopes: In soils, a maximum back or front slope of 21/2:1 shall be used. Where soil conditions would require excessive maintenance of a 21/2:1 slope, use a suitable flatter slope.

9.5.6.2 Underground Drainage

Widths of public easements for underground drainage systems shall be approved by the local approving agency.

9.5.7 Stations

All station platforms are 600' long, with ancillary rooms as an additional requirement. Station platforms shall be shown on the plans with stationing at each end of the platform. Right-of-way dimensions are delineated in paragraphs 9.5.1, 9.5.2,9.5.3, 9.5.4, and 9.5.5.

9.5.8 Projections in Public Space or Public Street Right-of-way

The Section Designer shall submit to WMATA a written list of projections into public space which must be removed to accommodate the construction of the metro facilities. This list should be submitted as soon as possible, but no later than the intermediate review submittal.

The projections list shall identify the type of projection, the location of the projection by square and lot number or by the tax assessor's designations, the street address, and the owner's name and address. Types of projections include vaults, fire escapes, signs, display windows, footings, foundations, and stairways.

9.5.9 Escalator Requirements

In addition to the structural, mechanical and electrical requirements for escalator space, the requirements for pedestrian circulation space to and from the escalators must be satisfied. A fifteen feet (15') wide longitudinal walking strip on either side of the finished escalator portal is required. A twenty feet (20') distance from the newels must also be preserved for pedestrian circulation. Exterior escalators require overhead protection from the elements. See standard canopy design drawings DD-A-CP-001 though DD-A-CP-008. Provide a minimum 15'-0" maintenance easement above the top of the canopy structure. The minimum head room above the escalator is twelve feet (12'-0") for escalator truss removal.

9.5.10 Substations

At-grade substations require an access road that is a minimum of eighteen feet (18') wide, with a twenty feet (20') long parking area and a turnaround sufficient for a WB-50 vehicle. The requirement for land will vary with the type of substation. The substation area should be contiguous to the limit of right-of-way for the transit way, where possible, with a five feet (5') maintenance space between the limit of right-of-way and the face of the substation structure.

Underground substations require an underground easement extending out ten feet (10') from the outside face of the structure.

Provision shall be made for permanent right-of-way for the electrical and communications cable ducts between the substation and the tracks.

The electric grounding grid at substations shall be located within the permanent surface easement at the substation. If such an arrangement is unworkable, then the grounding grid shall be located in an identifiable grounding grid easement. The grounding grid location should be monumented.

9.5.11 Tie Breaker Stations

At-grade tie breaker stations require an access road that is a minimum of eighteen feet (18') wide, with a twenty feet (20') long parking area and a turnaround sufficient for a WB-50 vehicle. The requirement for land varies with the type of tie breaker station. The tie breaker area should be contiguous to the limit of right-of-way for the transit way, where possible, with a five feet (5') maintenance space between the limit of right-of-way and the face of the tie breaker structure.

Underground tie breaker stations require an underground easement extending out ten feet (10') from the outside face of the structure.

Provision shall be made for permanent right-of-way for the electrical and communications cable ducts between the tie breaker station and the tracks.

The electric grounding grid at tie breaker stations shall be located within the permanent surface easement at the tie breaker station. If such an arrangement is unworkable, then the grounding grid shall be located in an identifiable grounding grid easement. The grounding grid location shall be monumented.

9.5.12 Vent and Fan Shafts

Vent and fan shafts shall be located in public space where possible. The gratings shall not exceed forty percent (40%) of the sidewalk width. When located on private property, the limit of right-of-way shall be five feet (5') from the outside face of the structure. Access to the shaft is required from the public street right-of-way.

9.5.13 Chiller Plants

At-grade chiller plants require five feet (5') from the face of the structure to the limit of the right-of-way. Suitable access is required.

Chiller plants require additional space for the cooling tower when the cooling tower is located beside the mechanical plant instead of on top of the plant building. When chiller plants are located on existing buildings, a pipe and conduit chase shall be provided and required easements delineated on the right-of-way plans.

9.5.14 Fencing

All construction sites and contractor's areas shall have temporary fencing and suitable barricades where required to protect pedestrians and vehicles. It shall be noted on the plans that the contractor is required to fence only the area he will need to conduct his operations. The fencing will generally follow the limit of a construction easement. Contractor work areas in public space will be indicated by the limit of the construction fence. Dimensions of fencing may be scaled.

9.5.15 Monumentation

9.5.15.1 The objective of WMATA's monumentation is to provide a broad network of survey control, right-of-way and boundary monuments from which WMATA's real property interests can accurately be identified.

9.5.15.2 Definitions

9.5.15.2.1 Survey control monument

A Metro monument consisting of a brass or bronze disc inscribed "METRO-CONTROL SURVEY", as shown on Standard Drawings ST-C-3 and ST-C-19. These are geodetically established, geo-referenced monuments placed within Metrorail corridors. This is the primary survey control used to design and construct the Metrorail system.

9.5.15.2.2 Right-of-way monument

A Metro monument consisting of a brass or bronze disc inscribed "METRO-RIGHT-OF-WAY", as shown on Standard Drawings ST-C-3 and ST-C-19. These are geo-referenced monuments which document the boundary as determined by a registered surveyor.

9.5.15.2.3 Boundary monument

A steel rebar rod with aluminum cap inscribed "Metro - Property Monument," as shown on Standard Drawings, ST-C-3 and ST-C-19, are to be used to mark a corner or point on a boundary line. The

registered surveyor setting the monument is to inscribe the cap with their registration number, WMATA Real Estate parcel number and point number, and comply with all jurisdictional regulations.

9.5.15.2.4 Witness post

A fiberglass flexible post about six feet in length (one and one-half to two foot burial depth) used to mark a survey control, right-of-way or boundary monument located in open space, and provide an easily visible identifying reference to the monument. Witness posts may also be used to locate points on property lines when the line is not readily identifiable. See Standard Drawings ST-C-3 and ST-C-19 for details of the decal that is to be applied to all witness posts.

9.5.15.3 Local Regulations

9.5.15.3.1 Right-of-way monuments shall be installed at property corners to mark the WMATA right-of-way when jurisdictional regulations require it.

9.5.15.3.2 Where jurisdictional regulations require a boundary monument to mark property acquisitions or divisions in property, the local regulations shall govern. If jurisdictional regulations do not require monuments to be set, then WMATA policies shall apply. Refer to Section 9.5.15.4.

9.5.15.3.3 The monumentation for the right-of-way of WMATA facilities shall be accomplished in such a manner that the right-of-way lines can be readily re-established by a registered surveyor.

9.5.15.4 Design Considerations

9.5.15.4.1 It is WMATA policy to monument all Metro right-of-way in such a manner that the right-of-way line can be readily re-established on the ground by a registered surveyor currently licensed to practice in the appropriate jurisdiction. In order to have consistency among the many surveys made, or that will be made in the future, the Metro control survey network shall be considered the basis for all Metro right-of-way monumentation.

9.5.15.4.2 Right-of-way monuments shall be installed at property corners to mark the WMATA right-of-way. Right-of-way monuments shall be installed at all station entrances, on property lines adjacent to public spaces, and on property lines considered to be sensitive, as directed by WMATA. Setting the WMATA right-of-way lines shall be accomplished only after careful consideration has been given to adjacent property lines.

9.5.15.4.3 Coordinate values on boundary survey plats are to be shown in the applicable state plane system. Coordinate values on right-of-way plans are to be based on the project coordinate system in District of Columbia and Maryland and for part of the Huntington Route in Virginia. Coordinates in Virginia, except for part of the Huntington Route, are to be based on the Virginia State Plane Coordinate System, North Zone. State plane NAD83, 1991 coordinate values shall be utilized for various parts of the E-Route and the extension of the Outer G-Route.

9.5.15.5 Location of Monuments and Markers

9.5.15.5.1 It is WMATA's policy to set all property corners and to mark all underground utilities within the Metrorail right-of-way.

9.5.15.5.2 WMATA's control survey network shall be considered the basis for WMATA's right-of-way monumentation. Right-of-way monuments shall be set at angle points, at the beginning and ends of curves, and at intermediate points at intervals of not greater than 1000 feet.

9.5.15.5.3 Right-of-way monuments shall be placed where they would not normally be disturbed by WMATA maintenance operations, private grass cutting, future construction, and where their use would not create a hazard for the public or surveyors.

9.5.15.5.4 Boundary monuments shall be set in accordance with local laws, ordinances and regulations. Boundary monuments will not be set in the District of Columbia as this is the prerogative of the Surveyor, D.C..

9.5.15.5.5 Right-of-way monuments shall be set at Metrorail station entrances to define the limits of the WMATA surface property interests. Brass or other disks shall be used to mark the corners.

9.5.15.5.6 Control survey monuments shall be set following construction of WMATA concrete structures.

9.5.15.6 Monumentation of surface, underground, aerial and utility rights-of-ways

9.5.15.6.1 Surface right-of-way:

Right-of-way monuments shall be located outside of the WMATA security fence.

9.5.15.6.2 Underground right-of-way:

Right-of-way monuments shall not normally be used to mark WMATA underground occupancy of public space. On WMATA property, survey control monuments shall be set in readily accessible places such as entrances, dome relief curbs, elevator openings, and fan and vent shafts' concrete structures.

9.5.15.6.3 Aerial right-of-way:

Right-of-way monuments shall not normally be used to mark these rights-of-way.

9.5.15.6.4 Utility right-of-way:

All underground utility lines will be marked in accordance with Standard Drawing ST-U-66.

9.5.16 Underpinning Construction Easements

The Section Designer shall provide detailed plans of the right-of-way necessary for the underpinning required by the design. Separate drawings showing the easements required for the construction contractor shall be prepared and

referenced in the Property Disposition Table under "Remarks". The underpinning detail shall show the dimensions of the easements and tie the easements to the WMATA right-of-way, the property line, and the supporting columns of the structures. All footing and column locations shall be shown. Proposed access to the work areas through the building and location of dust walls shall be shown (see Section 15.7).

9.5.17 Street Closings

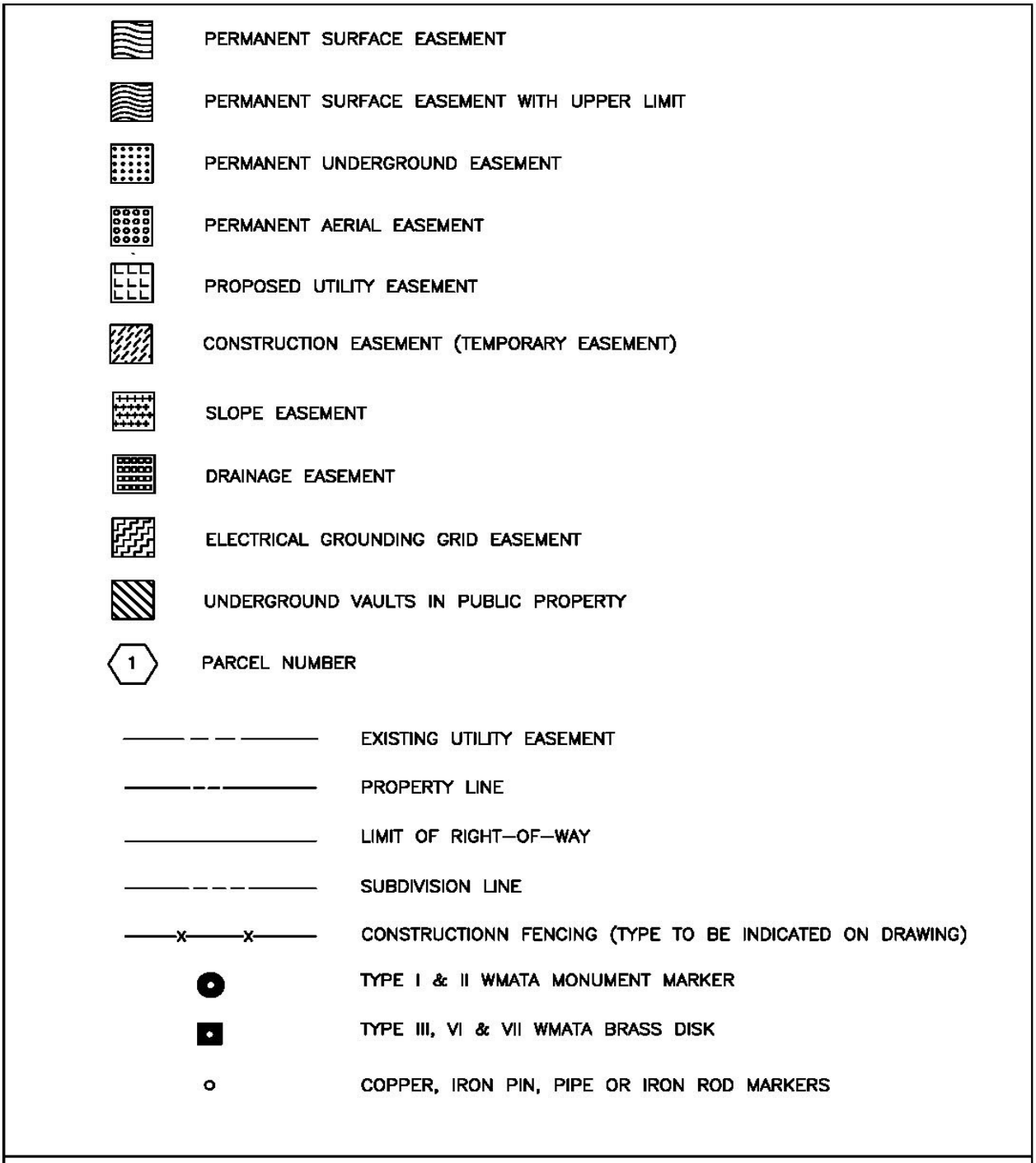
Provide separate drawings showing the areas of public property to be closed and utilized for WMATA. These drawings shall be prepared in accordance with all local requirements. The local plat requirements generally conform to the requirements for subdivision plats.

9.5.18 Utility Easements

Utility easements shall be treated as rights-of-way. Bearings and distances along the centerline shall be shown as well as the lengths and widths of the easements, and ties to the limits of right-of-way. All easements and clearances shall be in accordance with the Federal, State, local, and utility regulations and policies. All easements for new or relocated utilities shall be described by a metes and bounds description based upon the required plat.

9.5.19 Elevators

Provide direct access from elevators to public space. The access shall be a minimum of fifteen feet (15') wide, in addition to the space required for the queuing area. Provide for access to machine rooms, hoistways, elevator pits, etc., as required by the applicable code. Right-of-way for required utility services to the elevators shall be provided in accordance with the local jurisdiction requirements.


PERMANENT SURFACE EASEMENT
PERMANENT SURFACE EASEMENT WITH UPPER LIMIT
PERMANENT UNDERGROUND EASEMENT
PERMANENT AERIAL EASEMENT
PROPOSED UTILITY EASEMENT
CONSTRUCTION EASEMENT (TEMPORARY EASEMENT)
SLOPE EASEMENT
DRAINAGE EASEMENT
ELECTRICAL GROUNDING GRID EASEMENT
UNDERGROUND VAULTS IN PUBLIC PROPERTY
1
PARCEL NUMBER
EXISTING UTILITY EASEMENT
PROPERTY LINE
LIMIT OF RIGHT—OF—WAY
SUBDIVISION LINE
CONSTRUCTIONN FENCING (TYPE TO BE INDICATED ON DRAWING)
TYPE I & II WMATA MONUMENT MARKER
TYPE III, VI & VII WMATA BRASS DISK
COPPER, IRON PIN, PIPE OR IRON ROD MARKERS
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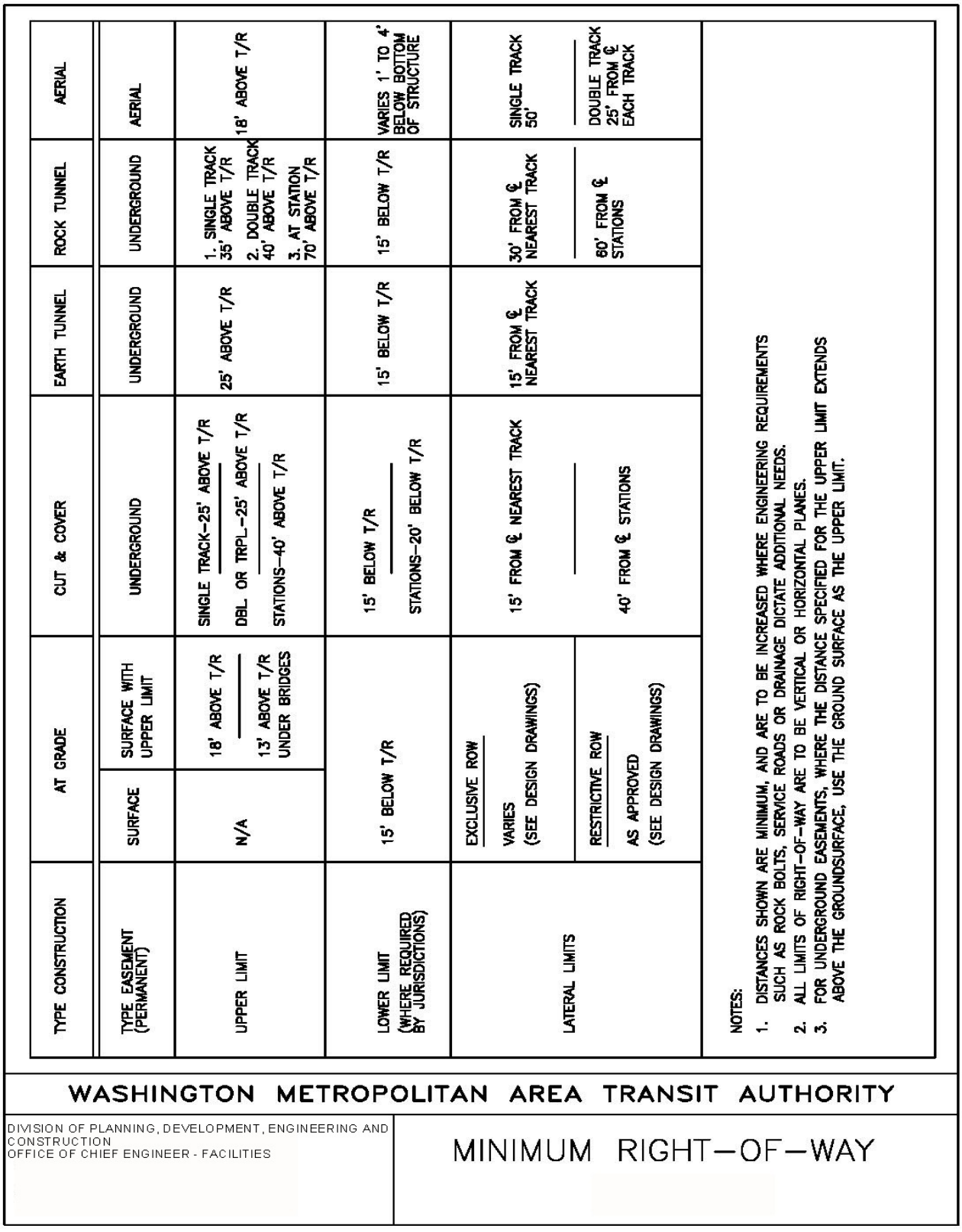
DIVISION OF PLANNING, DEVELOPMENT, ENGINEERING AND CONSTRUCTION
OFFICE OF CHIEF ENGINEER - FACILITIES
LEGEND
RIGHT—OF—WAY

FIGURE 9.1


TYPE CONSTRUCTION
AT GRADE
SURFACE
SURFACE WITH UPPER LIMIT
CUT & COVER
UNDERGROUND
EARTH TUNNEL
UNDERGROUND
ROCK TUNNEL
UNDERGROUND
AERIAL
AERIAL
TYPE EASEMENT (PERMANENT)
UPPER LIMIT
N/A
18' ABOVE T/R
13' ABOVE T/R UNDER BRIDGES
SINGLE TRACK-25' ABOVE T/R
DBL OR TRPL-25' ABOVE T/R
STATIONS-40' ABOVE T/R
25' ABOVE T/R
1. SINGLE TRACK 35' ABOVE T/R
2. DOUBLE TRACK 40' ABOVE T/R
3. AT STATION 70' ABOVE T/R
18' ABOVE T/R
LOWER LIMIT (WHERE REQUIRED BY JURISDICTIONS)
15' BELOW T/R
15' BELOW T/R
STATIONS-20' BELOW T/R
15' BELOW T/R
15' BELOW T/R
VARIES 1' TO 4' BELOW BOTTOM OF STRUCTURE
LATERAL LIMITS
EXCLUSIVE ROW
VARIES (SEE DESIGN DRAWINGS)
15' FROM ℄ NEAREST TRACK
15' FROM ℄ NEAREST TRACK
30' FROM ℄ NEAREST TRACK
SINGLE TRACK 50'
RESTRICTIVE ROW
AS APPROVED (SEE DESIGN DRAWINGS)
40' FROM ℄ STATIONS
60' FROM ℄ STATIONS
DOUBLE TRACK 25' FROM ℄ EACH TRACK
NOTES:
1. DISTANCES SHOWN ARE MINIMUM, AND ARE TO BE INCREASED WHERE ENGINEERING REQUIREMENTS SUCH AS ROCK BOLTS, SERVICE ROADS OR DRAINAGE DICTATE ADDITIONAL NEEDS.
2. ALL LIMITS OF RIGHT-OF-WAY ARE TO BE VERTICAL OR HORIZONTAL PLANES.
3. FOR UNDERGROUND EASEMENTS, WHERE THE DISTANCE SPECIFIED FOR THE UPPER LIMIT EXTENDS ABOVE THE GROUNDSURFACE, USE THE GROUND SURFACE AS THE UPPER LIMIT.
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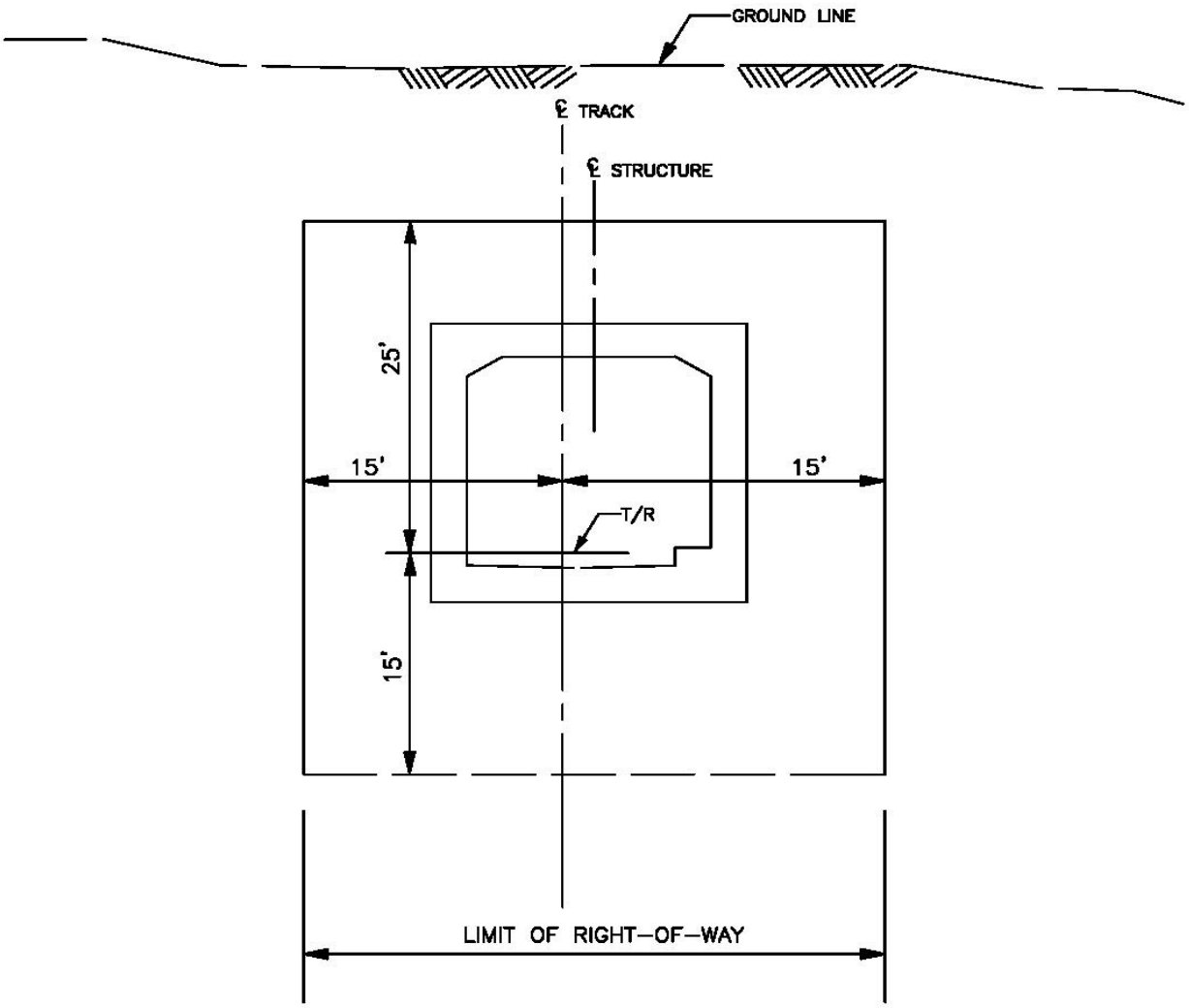
OFFICE OF CHIEF ENGINEER - FACILITIES
MINIMUM RIGHT-OF-WAY

FIGURE 9.2



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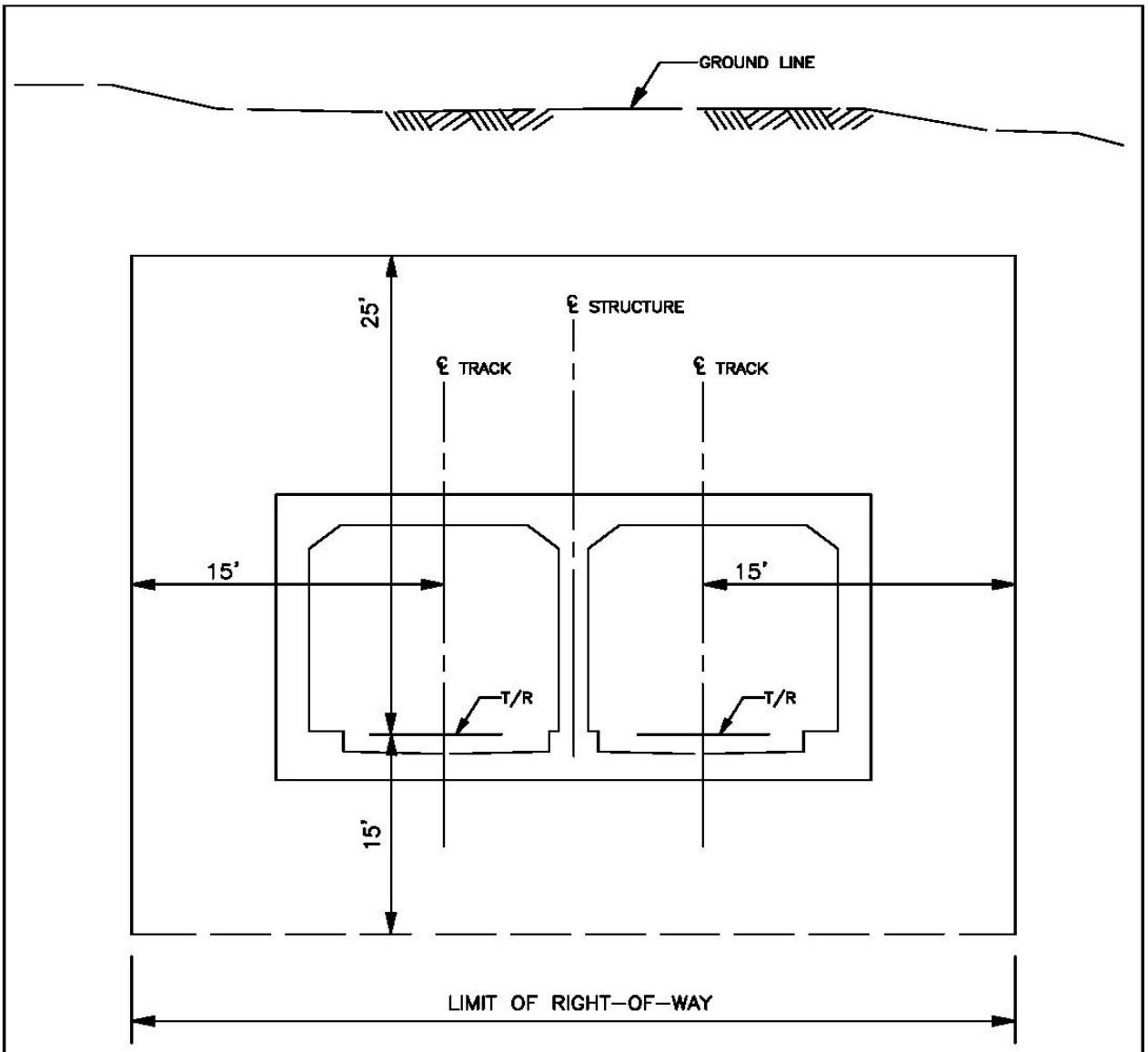
TYPICAL ROW
CUT & COVER – SINGLE TRACK

FIGURE 9.3



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AND CONSTRUCTION
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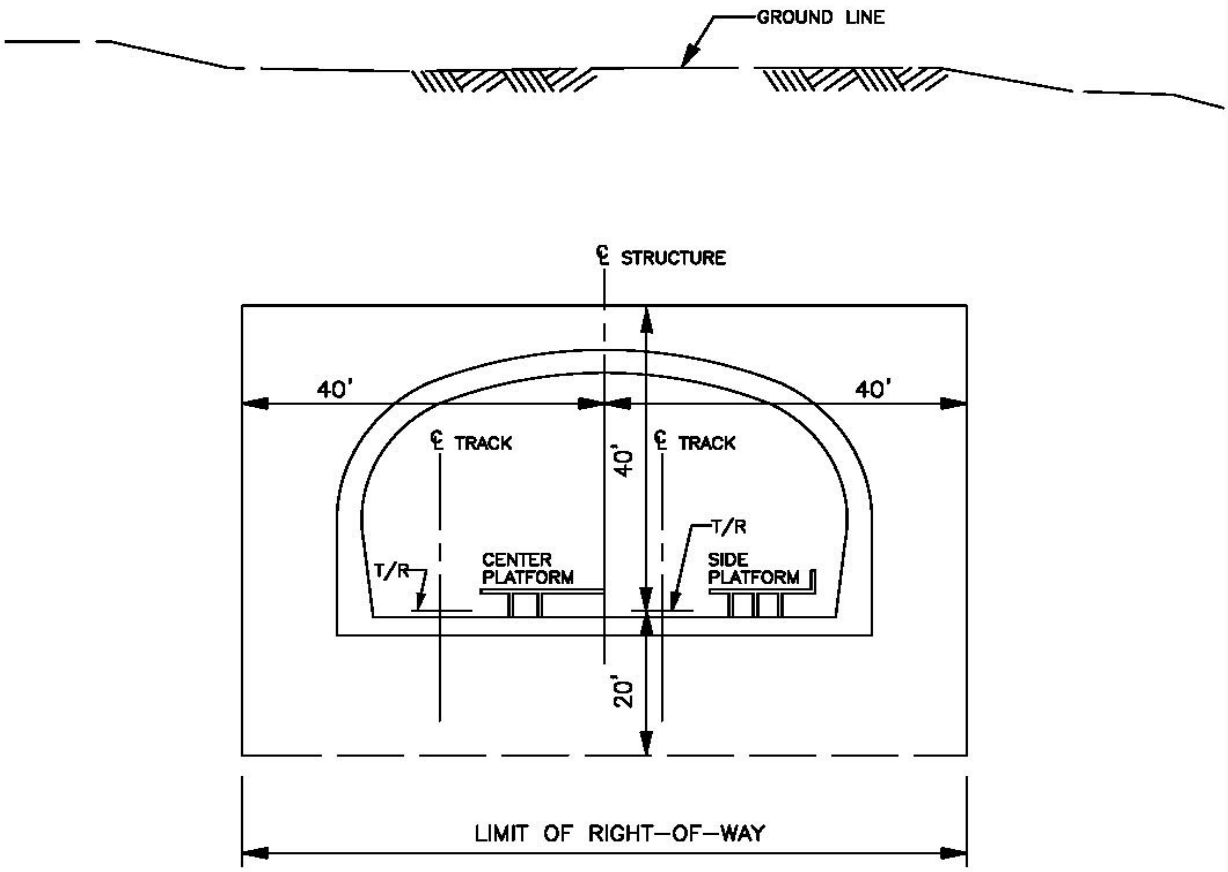
TYPICAL ROW
CUT & COVER – DOUBLE TRACK

FIGURE 9.4



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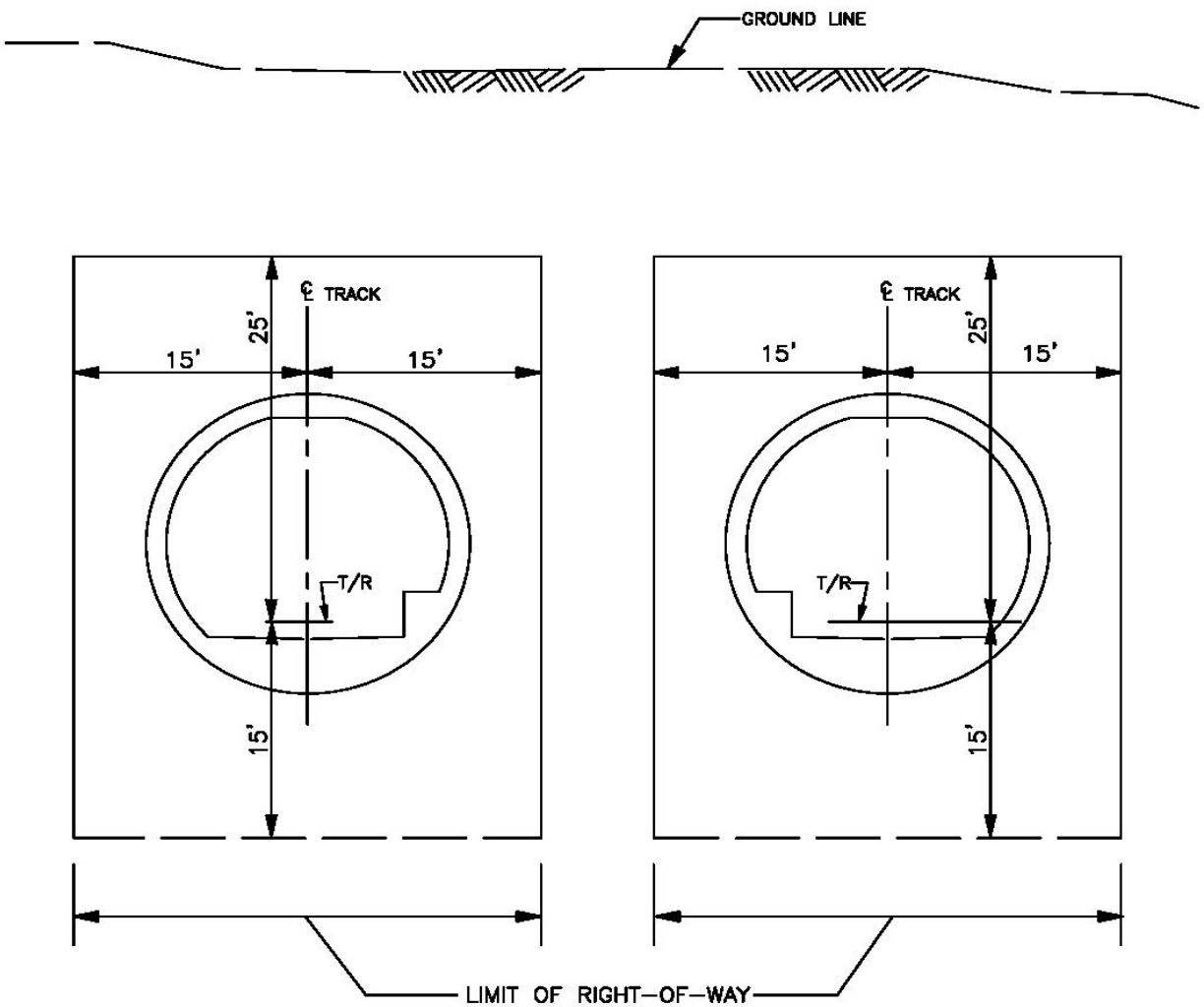
TYPICAL ROW
CUT & COVER – STATION

FIGURE 9.5



NOTE: WHERE CENTERLINES OF TRACKS ARE 35 FEET OR LESS, OR R.O.W. LIMITS BETWEEN TUNNELS OVERLAP, THE R.O.W. LIMIT BETWEEN TUNNELS NEED NOT BE DEFINED.

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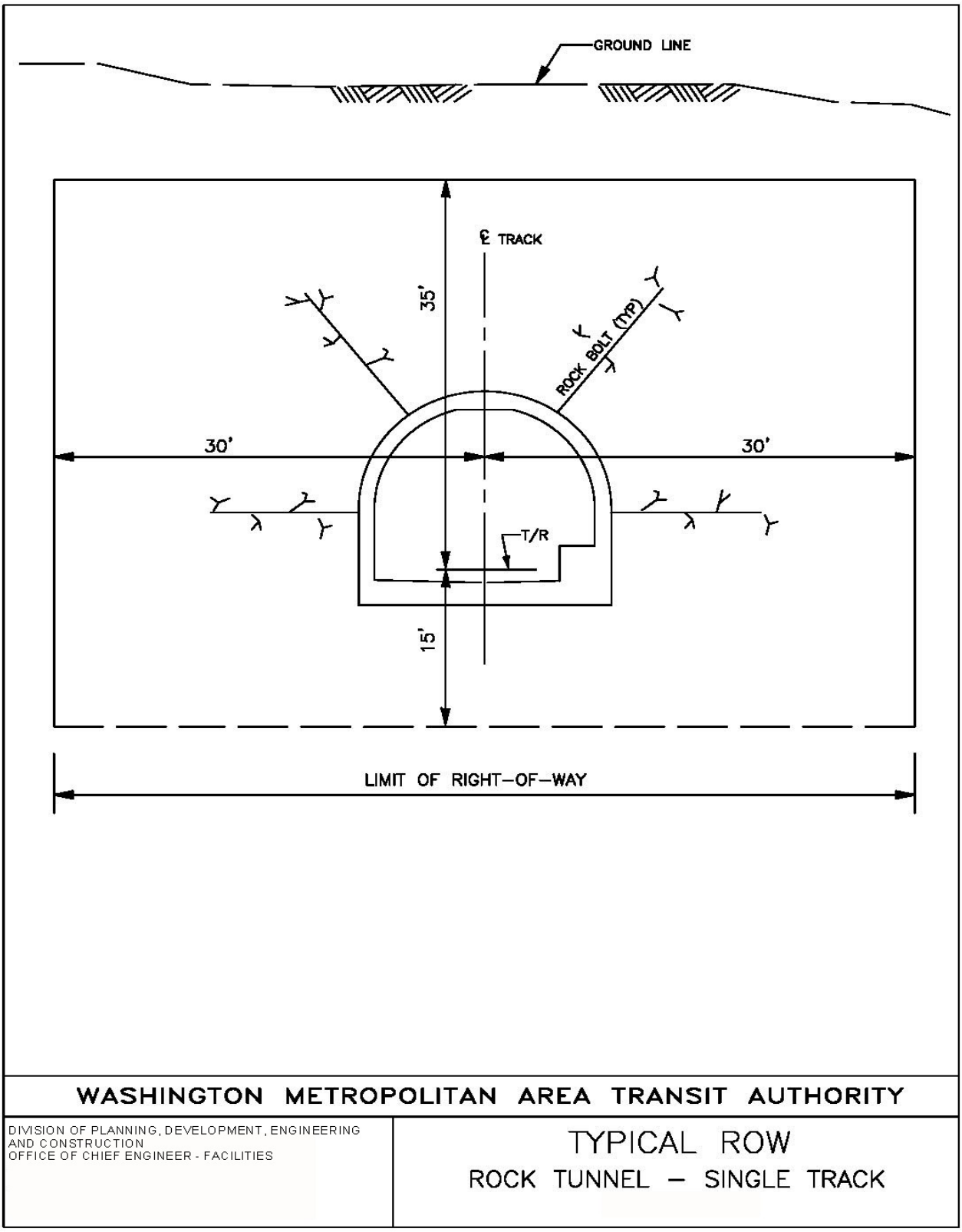
TYPICAL ROW
EARTH TUNNEL

FIGURE 9.6


GROUND LINE
℄ TRACK
35'
ROCK BOLT (TYP)
30'
30'
T/R
15'
LIMIT OF RIGHT-OF-WAY
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
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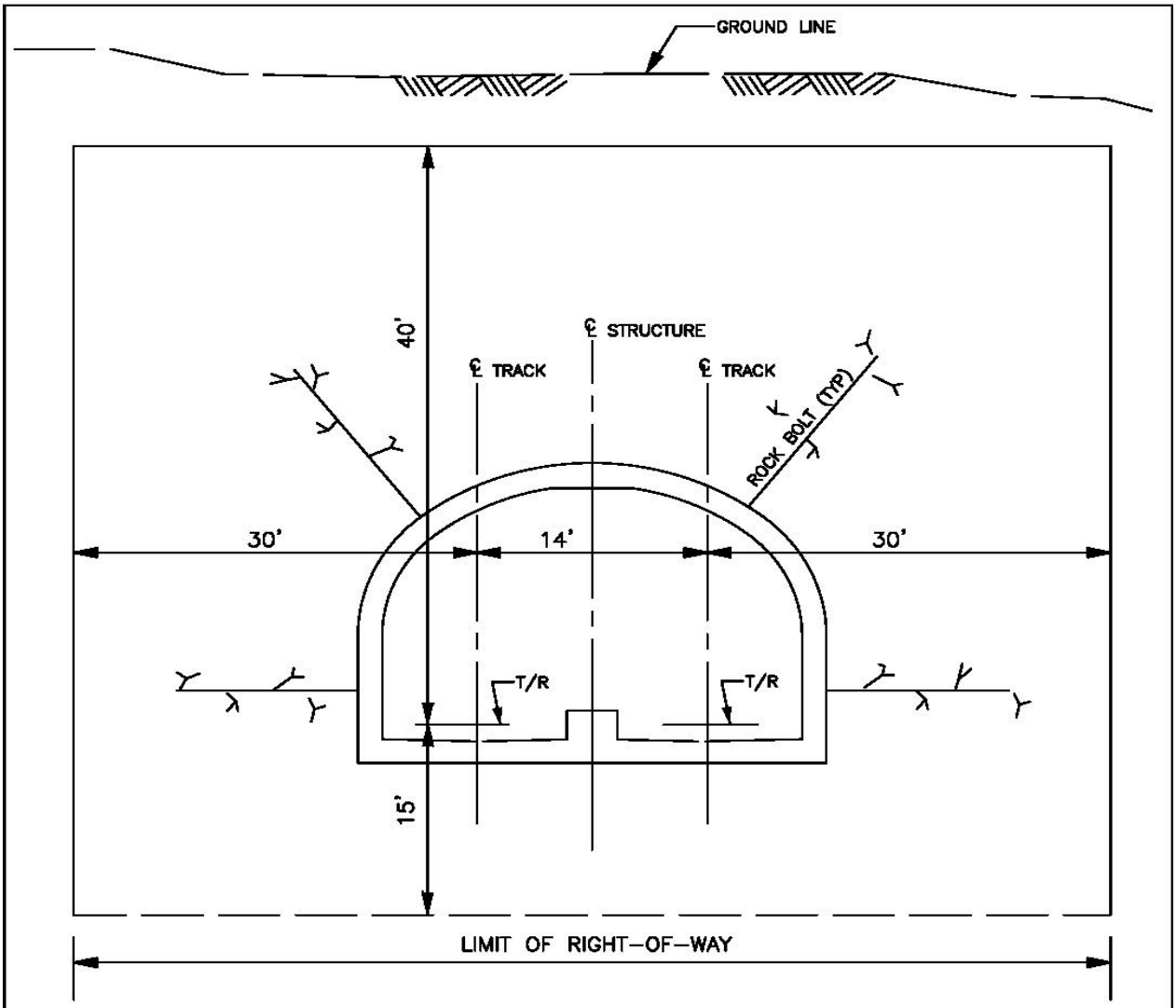
OFFICE OF CHIEF ENGINEER - FACILITIES
TYPICAL ROW
ROCK TUNNEL – SINGLE TRACK

FIGURE 9.7



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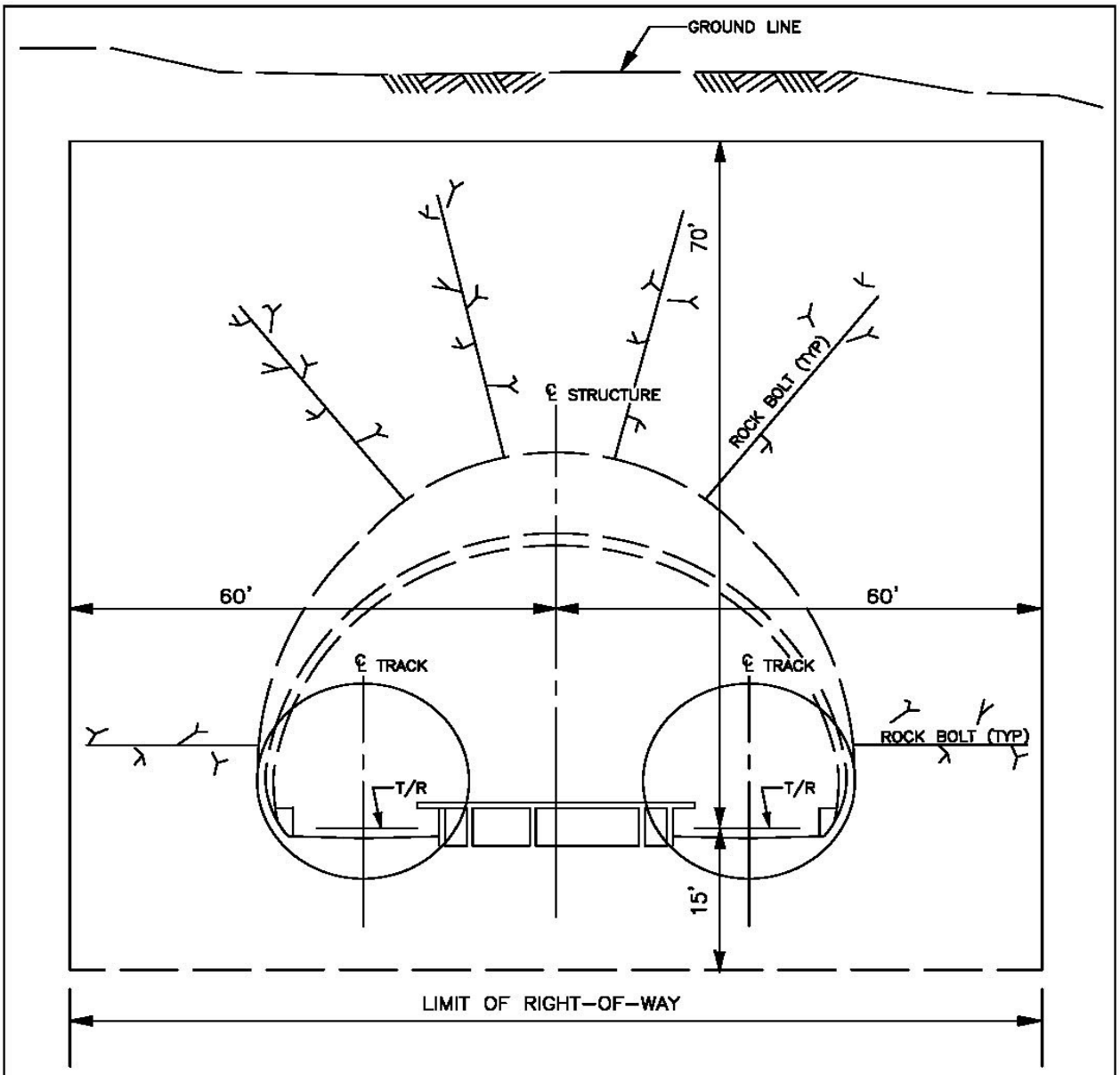
TYPICAL ROW
ROCK TUNNEL – DOUBLE TRACK

FIGURE 9.8



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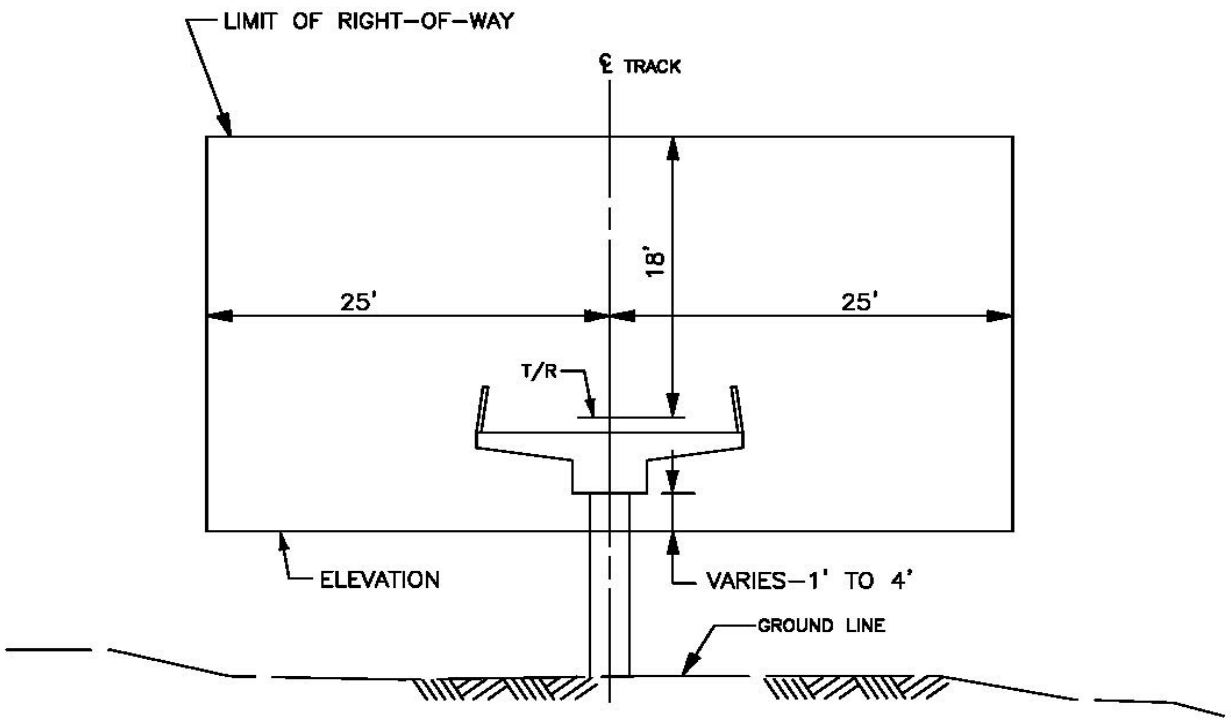
TYPICAL ROW
ROCK TUNNEL–STATION

FIGURE 9.9



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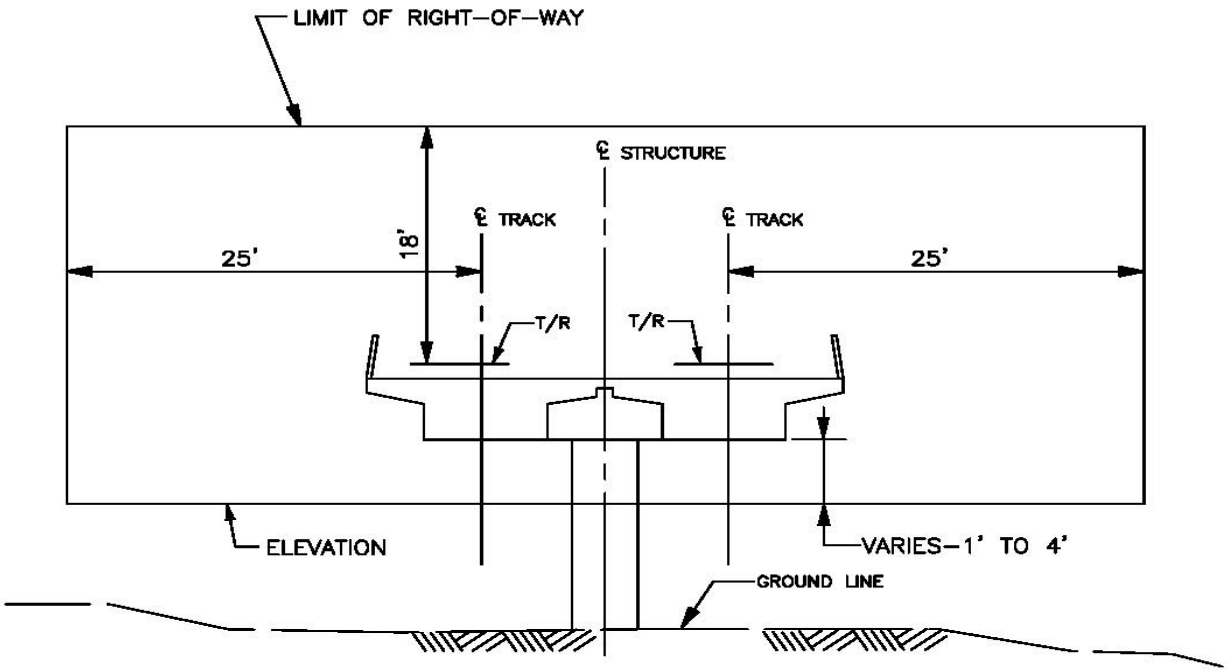
TYPICAL ROW
AERIAL-SINGLE TRACK

FIGURE 9.10



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TYPICAL ROW
AERIAL–DOUBLE TRACK

FIGURE 9.11

SECTION 10 (NOT USED)

WMATA MANUAL OF DESIGN CRITERIA
SECTION 10

CIVIL

11 .1 GENERAL

This section establishes the basic design criteria for geometrics, trackwork, and clearances for the Washington Rail Rapid Transit System. Determination of riding comfort relative to superelevation is based on the AREMA ride index scale. The index factor used in these criteria varies from 0.0, desirable, to a maximum of 1.5, as defined in the Proceedings of the American Railway Engineering Association Joint Committee Report, "Passenger Ride Comfort on Curved Track" published in the proceedings of the Fifty-Fourth Annual Convention of the Area, Volume 56, 1955.

11 .2 SURVEY CONTROL

11 .2.1 Horizontal Control

It shall be the responsibility of WMATA CENF to direct the appropriate base control for use in establishing all future WMATA control points to be used for design or construction purposes.

In general, all new horizontal control points established will be related to the new North American Datum of 1983, as defined by the National Geodetic Survey. Where applicable and or required, local jurisdiction coordinate systems shall prevail. Global Positioning System, GPS, based control may be implemented where applicable. All finalized control must be approved and sealed by a registered land surveyor registered in the appropriate jurisdiction.

Project survey control points were established from U.S.C. & G.S. Triangulation Stations. In April, 1974, the National Geodetic Survey (formerly U.S.C. & G.S.) announced that all triangulation stations in the United States, except Washington, D. C., were readjusted. Since there are significant changes in the final values, a note shall be affixed to the final design plans stating, "The Grid Coordinates and Horizontal Control Values are based on U.S.C. & G.S. 1971 Field Geographic Positions and Coordinate Values." This provision applies to design plans not using GPS based coordinates.

The horizontal control for all alignments shall be based on survey control points established under the direction of the WMATA as follows:

District of Columbia and Maryland Coordinates for control points in the District of Columbia and Maryland and for part of the Huntington Route in Virginia are generally based on the Maryland State Plane Coordinate System, adjusted for scale and elevation to project grid, herein referred to as Project Coordinates.

Virginia Coordinates for control points in the Commonwealth of Virginia, with the exception of part of the Huntington Route, shall be based on the appropriate version of the Virginia State Plane System, as dictated by the Virginia Department of Transportation (VDOT) and/or any governing agency.

The method for coordinate conversion is as follows:

To convert project coordinates to Maryland state plane coordinates, multiply the project coordinates by 0.9999430.

To convert project coordinates to Virginia state plane coordinates, then convert project coordinates to Maryland state plane coordinates, convert Maryland state plane coordinates to geographical position (latitude and longitude) as outlined in U.S. Dept. of Commerce Coast and Geodetic Survey Manual of Plane Coordinate Projection

Tables for Maryland, Special Publication No. 292, last, convert geographical position to Virginia state plane coordinates as shown in U.S. Department of Commerce Coast and Geodetic Survey Manual of Plane Coordinate Projection Tables for Virginia, Special Publication No. 293.

For map showing designation of various coordinate systems by Metro Route see Figure 11.1.

Traverses in the project coordinate system shall be connected to traverses in the Virginia state plane coordinate system as follows:

Huntington (C) Route shall be connected to the existing Pentagon traverse as shown on Figure 11.2.

Vienna (K) Route shall be connected to the existing Pentagon traverse as shown on Figure 11.3.

11 .2.2 Vertical Control

All bench marks established shall contain a minimum of one deep bench per half mile of vertical control to be used for construction. The relationship between U.S.C. & G.S. datum and the various datum planes common to the Washington Metropolitan area are as shown on Figure 11.4.

District of Columbia. The vertical control for the District of Columbia is related to the U.S. Coast and Geodetic Survey Mean Sea Level Datum, 1929 General Adjustment. Refer to Figure 11.4 for the relationship between District of Columbia and WMATA vertical datums. Coordination shall be made with the D.C. Surveyor's Office.

Virginia and Maryland Bench marks for the lines in Virginia and Maryland will be based upon the U.S. Coast and Geodetic Survey Mean Sea Level Datum, 1929 General Adjustment.

11 .2.3 Horizontal and Vertical Control Adjustments

All new control shall conform to the latest version of Standards and Specifications for Geodetic Control Networks published by the Federal Geodetic Control Committee.

Horizontal closures for control traverses shall have a relative accuracy ratio of not less than 1:100,000 (distance accuracy standard) if using GPS.

Secondary control traverses used to establish centerline geometry shall have a relative accuracy ratio of not less than 1:50,000.

When connecting new GPS based control to the existing control, some modifications may be made to the requirements with consent of WMATA and other governing authorities involved with the project.

Computations for all control (horizontal and vertical) shall be prepared under the direction of a professional land surveyor registered in the appropriate jurisdiction and sealed prior to submission to WMATA. Computations will show results in both the U.S. survey foot and in the metric system, for incorporation into the existing WMATA system, and to meet the new requirements of WMATA and other agencies.

11 .3 DESIGN PROCEDURES FOR ALIGNMENT

Development of alignment for a rail corridor is a procedure of successive refinements. The location of new alignments is often dependent on the availability of a corridor for the proposed alignment or the need to locate a station at a particular location for access or concentration of population. Planning the location of the centerline in the proposed alignment is the initial step in the design process.

When the general location of the alignment is decided and topography is available for vertical alignment, the tangents representing the track centerline are laid out. Assume a curve avoiding physical restrictions between tangents. Avoid cemeteries, schools, parks, wetlands and other sensitive areas. The first assumptions should be made as follows:

Lay out the centerline tangents. Keep the central angle of the curve as small as possible.
Assume a design speed of 75 miles per hour.
Calculate the minimum radius for a curve for a design speed of 75 miles per hour. Use spiral lengths of 300 feet for at-grade or aerial structures and 200 feet for tunnels or cut and cover structures as a point of beginning.
Calculate minimum spiral, curve and superelevation. Compare superelevation with comfort levels and re-calculate as necessary.
Reduce design speed if necessary, and recalculate allowable.
Check alignment clearances of tunnel, at grade or aerial cross section.
Reduce R and V to obtain clearances as required.
Redefine the calculations as required.
List and justify criteria deviations.

11 .4 HORIZONTAL ALIGNMENT

The main line horizontal alignment will consist of tangents joined to circular curves by spiral transition curves. All curves on the main line tracks will use spirals for entering and exiting the curve.

Curvature and superelevation shall be related to design speed, considering the acceleration and deceleration characteristics of the design vehicle as presented in Section 8 of this Manual. Every attempt shall be made to maintain a minimum design speed of 40 miles per hour. Wherever possible, the geometrics shall accommodate the maximum design speed up to 75 miles per hour, considering the locations of curves, station stop spacings, and the performance characteristics of the design vehicle. The maximum design speed shall not be limited to the available speed settings. Design speeds other than available speed settings may be used to allow for acceleration and deceleration through curves.

All routes shall be stationed radially from reference points; 0+00 at Metro Center Station for the Red, Blue, and Orange lines; and 0+00 on 7th Street, N.W., at Gallery Place Station for the Green and Yellow lines. Stationing for routes originating at junction points shall be equated to the base route stationing at the junction points.

Stationing and geometrics shall generally be denoted for the centerline of the outbound track; however, independent track stationing and geometrics shall be required in the following cases:

Where widened track centers are required for clearance requirements,
When tracks are not concentric or parallel, or
When the inbound and outbound tracks are in separate structures.

11 .4.1 Drawing Format

The outbound and inbound vertical alignment must be defined on the profile drawings. Where both inbound and outbound alignments are parallel, the Outbound T/R should be drawn.

Label the Top of Rail as "OB T/R ONLY" (Outbound Top of Rail ONLY) or "OB AND IB T/R," (Outbound and Inbound Top of Rail) as applicable. Show vertical curve data (PVI, PVC, PVT, STA., Elev., and LVC) for both IB and OB tracks. The profile grade should be shown for both IB and OB. For example: “4.00% IB AND OB” or “4.00% OB, 3.87% IB.”

The locations of station equations should be in the following format:

Apply a station equation at the point where non-parallel tracks become parallel. Locate station equations at an ST, either IB or OB, opposite a POT on the adjacent track.

The OB stationing should, in general, be continuous. The station equation should be of the form:

STA XXX IB BACK =
STA XXX OB & IB AHD

Under special circumstances, it could be of the form:

STA XXX IB BACK =
STA XXX OB BACK =
STA XXX OB & IB AHD

The maximum horizontal limits of the design vehicle dynamic outline as it moves through the standard WMATA crossovers at the various design track centers is shown on Figures 11.73 through 11.77

11 .4.2 Tangent Lengths

The desirable minimum tangent length shall be 200 feet. In special circumstances the minimum tangents the minimum tangent shall be 75 feet. At rapid transit stations the horizontal alignment shall be tangent throughout the 600-foot platform length; the tangent shall extend a minimum distance of 65 feet beyond each end of the station platform for a total tangent of 730'. Deviation from these lengths shall require approval by the Authority.

Within crossover tracks, the minimum tangent length may be less than 75 feet.

11 .5 CURVATURE

11 .5.1 Circular Curves

Circular curves shall be defined by the arc definition of curvature, and specified by their radii. The length of curve is defined by the equation:

$$L = 100 * \Delta / D$$

Where: L = Length of curve, feet
Δ = Central angle of curve, degrees
D = Degree of curvature, degrees

For mainline running track the minimum desirable radius of circular curves is 1000 feet.The absolute minimum radius of circular curves in mainline track is 755 feet.

The absolute minimum radius of curvature for yard and secondary track is 300 feet.

The desirable minimum length of circular curve is 100 feet. However, if physical conditions prohibit this minimum curve length and is approved by the Authority, circular curve length may be less than 100 feet but should be kept as long as possible.

Refer to Figure 11.5 for circular curve functions and abbreviations.

11 .5.2 Spiral Transition Curves

Spiral transition curves shall be used to connect all circular curves and tangents, except in yard and secondary track. The spiral used shall be the Barnett spiral. Spiral curve functions and abbreviations are shown on Figure 11.6.

The minimum length of spiral shall be the greater of the lengths as determined by formulae (1), (2) and (3):

(1) $L_s = 50 * E_a$

Where: Ls = Minimum length of spiral, feet
Ea = Actual superelevation of rail, inches

(2) $L_s = 1.22 * E_u * V$

Where: Ls = Minimum length of spiral, feet
Eu = Unbalanced superelevation on curve, inches
Unbalanced superelevation is defined as the difference between the equilibrium superelevation, Ee, and the actual superelevation, Ea.
V = Design velocity at the circular curve, mph.

(3) $Ls = 100' minimum$

The relationship between superelevation and spiral length is shown on Figure 11.7.

11 .5.3 Compound Curves

Where compound circular curves are required, a spiral of sufficient length to satisfy the requirements of Spiral Transition Curves, shall be inserted between the circular curves. The controlling formulae for Spiral Transition Curves shall apply, modified as follows:

(4) $Ls = 50 * (Ea_2 - Ea_1)$

Where:Ls = Minimum length of spiral, feet
Ea_1 = Actual superelevation of rail on the first circular curve, inches.
Ea_2 = Actual superelevation of rail on the second circular curve, inches.

(5) $Ls = 1.22 * (Eu_2 - Eu_1) * V$

Where:Ls = Minimum length of spiral, feet
Eu_1 = Unbalanced superelevation on the first circular curve, inches.
Eu_2 = Unbalanced superelevation on the second circular curve, inches.
V = Design velocity at the circular curves, mph.

(6) $Ls = 100' minimum$

11 .6 SUPERELEVATION

11 .6.1 Method of Attaining Superelevation

Superelevation will be attained and removed linearly throughout the full length of the spiral transition curve, by raising the rail farthest from the curve center while maintaining the top of the inside rail at the profile grade. The superelevation will be maintained as a constant throughout the circular curve between the two spiral transitions.

11 .6.2 Balanced Superelevation

Balanced superelevation is defined as the state of the rail car in motion along a curved track such that the downward force perpendicular to the floor of the car, acts through the car center of gravity and the passengers feel no centrifugal force. When the force through the car center of gravity is not perpendicular to the floor of the rail car then the total superelevation Ee necessary to bring the car into equilibrium and the downward force perpendicular to the car floor is the sum of the actual and the unbalanced superelevation.

11 .6.3 Unbalanced Superelevation

Unbalanced superelevation is defined as the deficiency of superelevation when a vehicle operates on a curve above equilibrium speed. It is expressed in inches and is directly related to centrifugal force acting on the vehicle and passengers. The unbalanced superelevation also allow the cars to transit the curve at a higher design speed.

The length of spiral should be such that the introduction of actual superelevation and unbalanced superelevation on the track will not be uncomfortable to passengers. With average roll tendency of rail cars operated on the track, the rate of change of the unbalanced lateral acceleration should not exceed 0.04 g per sec. Equation (1) and (2) or (7) then applies:

(7) $Ea = (4.011 * V^2 / R) - Eu$

11 .6.4 Maximum Superelevation

The maximum actual superelevation for curves in the system shall be as follows:

For curves in tunnels or in cut and cover structures, Ea = 4 inches.
For curves at grade or on elevated structures, Ea = 6 inches.

11 .6.5 Amount of Superelevation

Superelevation shall be determined by the formula:

(8) $Ea = (0.0007 * V^2 * D) - Eu$

Where: Ea = Actual superelevation, inches.
When Eu = 0, then Ea = equilibrium or balanced superelevation.
V = Velocity, mph.
D = Degree of curve, degrees.
Eu = Unbalanced superelevation, inches.

Expressed in terms of radius of curvature, this becomes:

$$(9) \qquad Ea = (4.011 * V^2/R) - Eu$$

Where Ea, Eu and V are as above, and
R = Radius of circular curve, feet

The relationship between superelevation, curvature and design speed is shown on Figure 11.8.

Unbalanced superelevation shall vary from 0 inches (desirable) to 4 ½" inches (maximum) in the following manner:

For Ea = 4 inches maximum, the unbalanced superelevation, Eu, shall equal 0 inches until Ea = 4 inches is reached. Actual super elevation, Ea, will then be maintained at 4 inches until the total Ea+ Eu is equal to 8 ½inches. At this point, a limit is placed on design speed of operation.

For Ea = 6 inches maximum, the unbalanced superelevation, Eu, shall equal 0 inches until Ea = 6 inches is reached. Actual superelevation, Ea, will then be maintained at 6 inches until the total Ea+ Eu is equal to 10 ½inches. At this point, a limit is placed on design speed of operation.

Introduction of unbalanced superelevation before Ea maximum is achieved shall require approval of the Authority.

Calculated values of actual superelevation, Ea, shall be rounded to the nearest one-quarter inch. For a calculated superelevation of ½ inch or less, no superelevation need be applied.

Yard and secondary track will be superelevated in accordance with the Yard & Shop Criteria, Section 17.

11 .7 VERTICAL ALIGNMENT

Profile grade shall represent the elevation of the top of low rail. When only one track profile is given for curved alignment, the profile of the second track shall be adjusted uniformly to accommodate the difference in length through the curve.

11 .7.1 Mainline Grades

The desirable maximum for mainline running track shall be 4.0 percent. In exceptional circumstances, such as split-level junctions and other isolated cases, the maximum grade may be increased to 5.0 percent, on down grades only. The minimum grade in underground and aerial structures shall be 0.35 percent to accommodate drainage runoff. Except at stations, there is no minimum grade for at-grade construction; in this case drainage ditches shall be sloped as necessary to accommodate runoff. A desirable grade of 0.35 percent shall be held through underground and aerial stations. Any constant grade from 0.35 percent to 0.20 percent is acceptable for at-grade stations. Under exceptional circumstances, grades through stations may be increased with approval of the Authority and the General Consultants.

11 .7.2 Yard and Secondary Track Areas

In yard and secondary tracks, the maximum grade shall be 1.0 percent. The minimum desirable grade shall be 0.20 percent. For storage tracks, desirable grade shall be 0.20 percent, except at tracks adjacent to stations, where a 0.35% grade is preferable.

11 .7.3 Miscellaneous

Permanent stub end tracks should be sloped away (down) from the turnout using gravity to insure that the transit vehicle remains at rest in the stub track. For the same reason, through storage tracks or sidings, should have a sag in their profiles, if possible.

11 .7.4 Vertical Curvature

All changes in grades shall be connected by parabolic vertical curves. The minimum length of vertical curve shall be determined by the formula:

$$L=(G_1-G_2)*100$$

Where: L = Length of vertical curve, feet

(G_1-G_2) Algebraic difference of grades connected by the vertical curve, percent.

The designer should be liberal when establishing length of vertical curve, allowing up to twice the minimum if possible.

The absolute minimum length of vertical curve shall be 200 feet.

11 .7.5 Minimum Length of Grade

The desirable minimum length of constant profile grade between vertical curves shall be 100 feet. Compound vertical curves are preferable to broken-back curves provided all other criteria are met.

11 .7.6 Compensation

No compensation of grades is required for horizontal curvature.

11 .8 TRACKWORK

Metro track materials and special trackwork shall comply with the Design Drawings, Design Criteria and Standard Drawings of WMATA which are based on the current American Railway Engineering and Maintenance-of-Way Association (AREMA) "Manual for Railway Engineering" and “Portfolio of Trackwork Plans”.

Railroad trackwork shall comply with current plans and specifications.

11 .8.1 Direct Fixation Track Fastening

Running track and special trackwork shall be fastened directly to the concrete trackbed of underground and non-ballasted aerial structures. Second-pour plinth

concrete (top-down) construction may be used as an alternative where physical clearances permit use of this installation.

Special trackwork throughout the system shall be fabricated and installed on special steel base plates. In the underground and non-ballasted aerial portions of the system, these base plates shall be installed on elastomer pads to reduce the transmission of noise and vibrations. The rail fasteners required beyond the limits of the steel base plates in the special trackwork units shall be the same basic rail fastener used in running track construction.

11 .8.2 Gauge

Metrorail track gauge for wood tie track shall comply with Table 11.1:

TABLE 11.1

HORIZONTAL TRACK ALIGNMENT	Track Gauge	
	Main Tracks	Yard and Secondary Tracks
Tangent Track	4'-8 1/4"	4'-8 ½"
Curve of Radius ≥ 1425'	4'-8 1/4"	4'-8 ½"
Curve of Radius between 1425' and 350'	4'-8 ½"	4'-8 ½"
Curve of Radius <350'	N/A	4'-9"
Curve of Radius <350' with restraining rail	N/A	4'-9 1/4"

These gauges apply only with standard AAR wheel Gages of 4'-7 11/16" and vehicle axle spacing of 7'-0" and 8'-6" inclusive.

For concrete tie installation, track gauge shall conform to Table 11.1, except that main track tangent alignment and curves above 350' radius shall have 4'-81/2" gauge.

For every 1/4" change in track gauge, the transition in gauge shall be made in a length of track not less than 31" nor more than 62".

Basic track gauge for special trackwork shall conform to WMATA Standard Trackwork Plans.

11 .8.3 Rail

Running rail shall be 115 RE section, welded in continuous lengths, with insulated joints at interlocking locations. All main track rail shall conform to the sections below confirming to in-line head hardened running rail, in accordance with AREMA specifications.

11 .8.3.1 Head Hardened Running Rail

Head hardened rails shall conform to AREMA specifications for head hardened (high strength) running rail, in accordance with WMATA Design Drawings and Standard Drawings.

11 .8.3.2 Use of Control Cooled Rail

Control cooled rail conforming to AREMA specifications shall be used in yard and storage tracks, except at turnouts where head hardened rail shall be used.

11 .8.4 Special Trackwork

Crossovers and turnouts shall be located on horizontal and vertical tangent track. Location of turnouts on horizontal curves without superelevation is possible in special cases with approval of the Authority.

Crossovers are to be located to allow emergency single track operations on either track, in both directions, with a sustained 10-minute headway in each direction, where economically practical. Crossovers shall be located at the first station beyond a diverging route.

Double crossovers shall be used in the underground and non-ballasted aerial portions of the system to reduce the overall length of special structure. Double crossovers shall be located on parallel tracks only. Single crossovers shall be used in the at-grade portion of the system unless space limitations are prohibitive. Special trackwork shall not be located within 200 feet of a transition between direct fixation and ballasted track construction. The desired tangent length between a point of switch and the end of a station platform shall be 80 feet. The location of special trackwork requires coordination with train control equipment requirements and transit system operations criteria.

The minimum horizontal and vertical tangent distance preceding a point of switch shall be 40 feet on ballasted track or 10 feet on direct fixation track.

The placement of special trackwork on non-ballasted aerial structures shall be avoided wherever possible in order to eliminate a costly special design of the structure and track. The special design would be required to prevent misalignment of the special trackwork due to the thermal stresses in the aerial structure and track.

The switch unit is to be located where there is minimum relative movement between rail and structure (see Section 15.5.1.2.10, Rail/Structure Interaction Force). The special steel base plates for frogs and diamonds should be designed to accept relative movement between rail and structure while minimizing the interaction force.

11 .8.5 Maximum Speeds

The maximum speeds for the design vehicle through the various turnouts designated for use on Metro are shown on Table 11.2. For design purposes, the normal operating speed shall be used.

TABLE 11.2

OPERATING SPEEDS THROUGH TURNOUTS

Turnout Number	Switch Rail Length	Switch Type	Speed Through Turnout-MPH		
			Normal Operating Speed[1]	Maximum Operating Speed (Eu = 4.5")	Critical Speed (Eu = 6")
6 (Old MOW[2] Track Standard)	11'-0"	Straight	15	17.2	19.8
6 Guarded (Yard Storage Tracks)	16'-6"	Curved	15	17.9	20.6
6 Equilateral Guarded (Storage Turnaround Tracks)	16'-6"	Curved	22	25.3	29.2
8 (MOW Tracks)	16'-6"	Straight	22	22.8	26.3
8 Guarded	26'-0"	Curved	22	23.9	27.6
10	22'-0"	Curved	28	30.2	34.9
15	26'-0"	Curved	40	46.3	53.5

11 .8.6 Standard Turnout and Crossovers

Special trackwork shall comply with the criteria and WMATA Standard Drawings:

[1]The normal operating speed in Table 11.2 is the nearest Automatic Train Control (ATC) speed command below the maximum operating speed. The maximum operating speed is based upon the value of Unbalanced superelevation equal to 4 ½inches and is determined using the lead radius and the switch radius or theoretical switch radius with the most restrictive speed governing. The critical speed is based upon the unbalanced superelevation being equal to six (6") inches and is the safe maximum speed.

[2] MOW stands for Maintenance-of-Way

Center storage (pocket) tracks on underground and non-ballasted aerial structures: No. 6 guarded equilateral turnouts.

Center storage tracks at-grade: No. 8 guarded curved switch.

Yards: No. 8 guardedpreferred, No. 6 guarded turnouts where approved by the Authority. Crossovers shall be No. 10 turrnouts.

Main track emergency crossovers and yard and secondary track connections to main track: Guarded No. 8 or No. 10 turnouts.

Permanent turnback crossovers located near the end of a station platform: No. 10 turnouts.

Junction of main line routes: No. 15 turnouts.

11 .8.7 Special Trackwork Limiting Factors

Limiting factors to be considered in designing the horizontal and vertical alignment adjacent to special trackwork units are:

Table 11.3

Turnout No.	Type of Track Construction	Minimum Length of Turnouts		
		Absolute Minimum from Point of Switch to *T.S. or P.C.	Distance from Point of Switch to *P.V.C.	Minimum Distance from Point of Switch to the End of Turnout Unit and TS or Point of Curve
6 Eql. Guarded	Direct Fixation	57'	57'	70'
6 Eql. Guarded	Ballasted	57'	71'	71'
6	Ballasted	57'	71'	71'
6 Guarded	Ballasted	70'	82'	82'
8	Direct Fixation	81'	81'	87'
8	Ballasted	81'	98'	98'
8 Guarded	Direct Fixation	81'	81'	91'
8 Guarded	Ballasted	94'	110'	110'
10	Direct Fixation	97'	97'	102'
10	Ballasted	97'	116'	116'
15	Direct Fixation	140'	140'	147'
15	Ballasted	140'	165'	165'

* These are the absolute minimum values that may be used. The desired minimum values are those listed in the "End of Turnout Units" column. Absolute minimum values shall be used only with prior approval of the Authority.

The limits of any design or construction contract shall not be located within a special trackwork unit.

11 .9 CONTACT RAIL

Contact (third) rail shall consist of composite steel rail and aluminum fishplate cladding as shown in the Design Drawings.

The Contact Rail End Approach is defined as the vertical transition at each end of the contact rail to allow for smooth shoe contact of the third rail. End approach rails come in several lengths.

During design the location of the third rail in the relation to the turnout is controlled by the separation distances required between the point of switch of adjacent switches. Various combinations of switches and their directions in relation to each other are shown in Figures 11.22 through 11.27. These tables provide the distances between point of switch A and point of switch B.

The contact rail end approaches shall be used as follows: 11'-0" end approaches on mainline track; 5'-6" end approaches on yard and secondary tracks and storage tracks; 3'-0" end approaches on kicker rail on No. 8 double crossovers at 14'-0" track centers. See Design Drawings for typical details of the composite rail end approaches.

The location of the third rail shall be opposite the safety walk, opposite station platforms including access to service rooms off the platform, and opposite personnel access points.

11 .10 ADDITIONAL TRACKWORK - Ties, Derails, Bumping Posts

11 .10.1 Derails

Derails shall be installed on yard and secondary track normally used for the storage of unattended vehicles if this track is directly connected to the main track and its prevailing grade is descending to the main track.

Derails shall be located as follows:

At the downgrade end of the yard and secondary track,
To derail equipment away from the main track, if possible, and
To derail equipment away from the contact rail.

The location of derails in relation to turnouts shall be as shown on Figure 11.18 to Figure 11.20 and shall be coordinated with the Authority.

11 .10.2 Tie Spacing

Concrete ties will be used for new construction in ballasted track. Either wood or concrete ties will be used in ballasted track for replacement ties to match existing tie conditions. Wood ties shall be spaced 27 inches center-to-center in main track and 30 inches center-to-center in yard and secondary track. Concrete ties shall be spaced 30 inches center-to-center in main track and 33 inches center-to-center in yard and secondary track. Yard and secondary tracks which are used at speeds greater than 15 mph shall use mainline tie spacing. Yard and secondary tracks with radii less than 350 feet shall use 24 inch tie spacing. Only wood ties shall be used in ballasted special trackwork units and they shall be spaced in accordance with the trackwork Standard Drawings. Except in special trackwork units, every fourth tie shall be a contact rail tie.

11 .10.3 Direct Fixation Rail Fastener Spacing

Concrete trackbed reinforcing steel shall be designed to provide the anchorage clearance envelopes shown on the Design Drawings and in such manner as to permit the following direct fixation rail fastener spacing:

30 inches in main track
33 inches in yard and secondary track

11 .10.4 Bumping Posts

A bumping post shall be installed at the end of each stub end track. The minimum distance between the face of bumping post when un-compressed and the end of track shall be 14'-6".

11 .10.5 Approach Slabs

An approach slab shall be provided at all transitions between direct fixation and ballasted track construction.

11 .10.6 Emergency Guard Rail

Emergency guard rail shall be installed on all main track ballasted bridges and direct fixation aerial structures. On all single track structures, two emergency guard rails shall be installed, one inside of each running rail.

Emergency guard rail shall be fabricated from 6 inch x 6 inch x ¾ inch structural angle and installed with the outside face of the vertical leg 15 inches from the gauge line of the running rail. The horizontal leg shall extend toward the center of the track. The 16 foot long end approaches shall be fabricated from the same size structural angle. The end approach shall be installed with the one end at the center of the track and the other at a point 15 inches from the gauge line of the running rail and shall be welded to the emergency guard rail. Emergency guard rail shall be continuously welded except for expansion gaps where required. A minimum of two gaps per guard rail are required. Gaps in ballasted track shall be not more than 100 feet apart.

On multiple track structures where tracks are supported on the same deck or on separate decks having less than 4½ inches opening between decks, each exterior track shall have one guard rail installed to the inside of the running rail farthest from the edge of the structure. On multiple track structures where tracks are supported on separate decks having 4½ inches or more opening between decks, each track shall have two guard rails, one rail to the inside of each running rail.

No emergency guard rail shall be installed within the limits of special trackwork.

Emergency guard rails shall extend 60 feet ahead of the abutment face on the approach end and 26 feet beyond the abutment face on the departure end of each structure. The above lengths do not include the emergency guard rail end approach sections which shall be 16 feet long at each end of every emergency guard rail installation.

Emergency guard rail shall be fastened to every second tie in ballasted track. In direct fixation track the guard rail anchorages shall be not more than 5 feet on centers.

11 .10.7 Restraining Rail

Restraining rail shall be installed on all main track with curves of radius less than 800 feet, and on yard and storage tracks with curves of radius less than 500 feet.

It shall consist of 132 RE jointed rail mounted vertically with spacer blocks with the top of the restraining rail no more than 3/4 inch above the top of the plane of running rails. The base of the restraining rail shall be planed and the fasteners and joints designed so that no portion of the installation extends more than 8-7/16 inches above the base of the running rail. The flange way between the restraining rail and the running rail shall be 1- 7/8 inches wide and not less than 1-7/8 inches deep. The restraining rail separator block assemblies shall be adjustable laterally to compensate for rail wear. Restraining rail separator blocks shall be spaced not more than 5 feet on centers.

11 .10.8 Constructibility and Maintainability of Trackwork

All trackwork design shall be performed with the objective of obtaining an optimum degree of constructibility and maintainability. Alternative analyses of major cost items of trackwork shall be made using life cycle and other analytic procedures which address the following principles:

Selection of materials, configurations, and tolerances (manufacturing and construction) shall be based on lowest life cycle cost which meets the level of quality established by Metro standards, good engineering practice, and the level of service intended, with consideration of constructibility and maintainability. Key components shall be standardized to provide interchangeability and reduce maintenance stockpiles.

Constructibility shall be considered from initial design development to final detailing. Packaging and scheduling of trackwork procurement and installation contracts shall seek to minimize brokering, periods of inactivity, excessive storage time, re-handling of materials, and interference with other contractors. Installation contracts shall be staged to maximize trackbed availability, access, and continuity of work. Special consideration should be given to handling of continuous welded rail. Contractors should be provided with convenient, adequate staging and storage sites. Selection of materials and configuration of materials should give consideration to the site conditions, and contractor's skill levels and plant capacity for their affect on the ease of handling and installing materials and the tolerances to be met.

Maintainability encompasses the selection of materials and configurations that result in highly durable, easily accessible and easily repaired or replaced components and systems. Durability is achieved by materials which resist wear, fatigue and deterioration due to environmental conditions. Accessibility is achieved by configuring materials, particularly fasteners, and clearances to permit inspection, adjustment, repair and replacement with minimum disturbance to other components. Maximum accessibility should be provided to these components requiring most frequent maintenance. Repair ability is achieved by providing materials and configurations which require minimum quality control effort in the field to inspect, adjust, repair or replace by avoiding complex sequences of steps to mix, place, cure, tighten, finish, or adjust and which require minimum tolerance to be acceptable.

Where a conflict between constructibility and maintainability occurs, preference shall be given to maintainability. Within maintainability, preference shall be given to durability over accessibility and repair ability.

11 .11 CLEARANCES

Clearances between obstructions and the rail car are determined from the dynamic outline of the. The clearance envelope is shown on Design Drawing DD-C-1 “WMATA Rapid Transit Car Clearance Envelope.” The clearance envelope is developed from the rail car

dynamic outline, and is a composite of the WMATA Design Vehicle, the Rohr Car and the Breda Car. Each of the extreme dimensions of each car have been taken into account in the development of the Clearance Envelope.

The Clearance Envelope is equal to the Dynamic Outline plus 2" (inches). The design of tunnel structures, surface sections and aerial structures must accommodate the dynamic outline of the rail car for safe operations.

11 .11.1 Clearance Definitions

11 .11.1.1 DW Dynamic Width - Maximum horizontal width of dynamic outline or superelevated track, exclusive of M.O. and E.O. and equal to DW_A + DW_T

11 .11.1.2 DW_A Dynamic Width Away - Maximum horizontal distance from the centerline of track to the dynamic outline, exclusive of M.O., on the side of the rail car away from the curve center.

11 .11.1.3 DW_T Dynamic Width Toward - Maximum horizontal distance from the centerline of track to the dynamic outline, exclusive of M.O., on the side of the rail car toward the curve center.

11 .11.1.4 M.O. Mid Ordinate - Distance from the centerline of a curved track to the centerline of the rail car at a point midway between the trucks.

11 .11.1.5 E.O. End Overhang - Distance from the centerline of a curved track to centerline of car at each end of the car measured normal to the centerline of the track.

11 .11.1.6 A_C Allowance Corded Construction - Measured horizontally.

11 .11.1.7 C.T. Construction Tolerance Allowance.

11 .11.1.8 SW Safety Walk

11 .11.1.9 X_A Structure Centerline Offset - Away from Curve Center

11 .11.1.10 X_T Structure Centerline Offset - Toward the Curve Center

11 .11.1.11 Offset Offset is measured from centerline of track in all cases except in double track rock tunnel where it is measured from the centerline of the safety walk.

11 .11.1.12 Y Difference in elevation from top of low rail to working point of tunnel.

11 .11.1.13 P.G. Profile Grade Elevation at top of low rail.

11 .11.1.14 M_A & M_T In arched roof section, the distance from the centerline of track to the vertical wall with provision from a minimum of 6" clearance at the arch and a minimum of 8 inch clearance at the vertical wall between the dynamic outline and the structure. This distance is the equivalent to 4 inches clearance at the arch and 6 inches clearance at the vertical wall between the clearance envelope and the structure.

11 .11.1.15 Structure Size Factors used in sizing the structure but not included in the clearance envelope are allowances for corded

construction, construction tolerances and clearances to walls specified by type of cross-section.

11 .11.2 Safety Walks

The safety walk spaces are defined as a minimum 3'-0" distance between vertical lines through the edges of the dynamic outlines for a center safety walk on aerial structures, and a minimum 2'-0" distance for outside safety walks on aerial structures. In tunnels and at grade sections the safety walk is a minimum of 2'-0", measured as above. The dynamic outline shall not intrude into the safety walk area. Figures 11.10 through 11.60 provide minimum clearance details for various types of construction.

11 .11.3 Construction Tolerance

All walls and roof slabs shall have a horizontal and vertical construction tolerance allowance of 1". Fences, piers, columns, light standards and miscellaneous structures shall have a horizontal construction tolerance of ±1".

11 .11.4 Middle Ordinate Displacement

Is the horizontal displacement of the center of the side of the design vehicle toward the center of the curve, as it transits a curve of a specific radius. The Middle Ordinate can be calculated for any radius from the formula $M.O. = R - (R^2 - 676)^n$ where R = radius in feet and n = ½. For design purposes, the end overhang and middle ordinate of the vehicle are considered equal. The formula is based on a 75'-0" long vehicle with 52'-0" truck centers. Rounding at car corners has not been considered. The centerline radius of the curve should be reduced by half of the width of the car plus the dynamic outline.

11 .11.5 Chorded Construction

Walls for Cut and Cover Rectangular Sections shall be constructed in chords whose length shall be measured along the inside face of the wall nearest the curve center. Single Track Rock Tunnel Sections. Circular Tunnel Sections may be constructed in chords whose length shall be measured along the inside face of the wall nearest the curve center Maximum lengths of chord for certain radii are:

Radii 2500 feet or greater	50 feet
Radii less than 2500 feet	25 feet

Values to be used for the allowance for chorded construction in clearance calculations on the inside face of the wall shall be calculated in accordance with the formula for Middle Ordinate Displacement.

11 .11.6 Effect of Superelevation

The effect of superelevation is considered independently in determining the clearance envelope and has been taken into account in establishing the dimensional clearances for the various construction sections. The width of the design vehicle dynamic outline on superelevated track, exclusive of values for mid-ordinate and end overhang, is called the dynamic width. This width includes the dynamic width toward the curve center, (DW_T) shown on Fig 11.30, and the dynamic width away from the curve center, (DW_A) shown on Fig.11. 31. These

values are measured horizontally from the centerline of track to the widest point on the design vehicle dynamic outline.

Each such restriction is to be considered independently and submitted for approval.

11 .11.7 Minimum Clearances from the Dynamic Outline

The design vehicle dynamic outline shall be located to satisfy the following criteria:

Table 11.4	
Minimum Clearances from the Dynamic Outline Description of Location (*)	**Clearance Distance**
Between the face of wall and the clearance envelope outline	6"
Between the roof surface and the clearance envelope outline	4"
Between any fixed installation (e.g., pipes, pipe hangers, pipe supports, signals, lighting fixtures, air conditioning units, etc.) and the design vehicle dynamic outline.	2"
Between light standards and the design vehicle dynamic outline.	4"
Between existing adjacent intermittent columns and existing point restrictions, and the clearance envelope	6"
Between new adjacent intermittent columns and new point restrictions, and the clearance envelope	2'-0"
Between top of low rail to the under-clearance point of overhead structure.	13'-0"
Between track centers.	14'-0"
Between top of rail and bottom of new bridges spanning the right-of-way	15'-0"
The design vehicle dynamic outline shall not encroach into the safety walk space defined by a vertical line through the edge of the safety walk	0"
Additional allowance for finish on exterior walls at stations	0'-6"

(*) These clearances are defined by the clearance envelope. However, installations shall be so dimensioned and located that maximal distances are obtained between these and the clearance envelope along tangent and curved alignments.

11 .11.8 Clearances Diagrams

The clearance requirements for surface track sections are indicated in Figure 11.54. Figures 11.34 and 11.35 indicate the clearance requirements for cut and cover sections. The walls of all structures shall be designed to clear design vehicle dynamic outline and to satisfy the following additional clearance criteria:

11 .11.9 Structure Width

The structure width is determined by the factors shown on the various Figures that relate to the applicable designtype of tunnel structure . In chorded construction, the horizontal dimensions from centerline of track to inside face of wall and the dimension from the top of low rail to the inside face of roof slab shall be measured at the breakpoint location of the chorded elements.

11 .11.10 Tunnel Turnout Clearances

The horizontal offsets from centerline of track to the design vehicle dynamic outline as shown on Figures 11.63 to 11.66 have been determined graphically from a plan drawn at a scale of 1" = 1'-0". In developing these offsets it has been assumed that the design vehicle is on a tangent track as it approaches the turnout and as it leaves the turnout. It is also assumed that the vehicle is operating on track that is not superelevated. If the turnout is from a curved or superelevated track, the values shown on Figures 11.63 to 11.66 must be adjusted to compensate for additional clearance required for curvature and superelevation.

11 .11.11 Design Tables

The tabulated values for the horizontal dimensions A, T, A_s, and T_s, measured from centerline of track to inside face of wall, are shown in the Figures for each typical section . These values shall be used for sizing sections. Linear interpolation is to be used for values of radii and superelevation intermediate to those shown in the tables

11 .11.12 Widening Track Centers on Curves

Track centers on circular curves must be widened geometrically to accommodate the clearance requirements. The total clearance required and the changes in the curves to accommodate the clearance must be checked by the Designer when producing structural details.

Values shown in the tables for width of structure on a circular curve shall be applied and removed linearly over a length equal to the spiral length, beginning at a point on the tangent 25 feet prior to the T.S. Full width required on the circular curve shall be reached at a point on the spiral 25 feet before the S.C. and maintained 25 feet after the C.S.

11 .11.13 Design Tables

Tabulated values for track center spacing are shown in Figure 11.56. These values allow for installation of a 10 inch" light standard or similar pole structure between the tracks.

11 .11.14 Continuous Fence Clearance

The horizontal clearance distance from centerline of track to continuous fence shall be:

1. For track between railroad mains and along side railroad mains:

   10'-6" minimum (13'-0" desirable) and 11'-0" minimum (13'-0" desirable) on outside of curve when track superelevation exceeds 3 3/4";

2. For tangent track in highway median:

   10'-9" minimum (13'-0" desirable)

3. For superelevated track in highway median:

10'-9" minimum for superelevation less than 3 3/4", 11'-0" minimum for superelevation greater than 3 3/4" (13'-0" desirable) on the high side and;

10-9" minimum (13'-0" desirable) on the low side.

For absolute minimum clearances to fences use A_s and T_s values in Figures 11.56 to 11.59 These absolute minimum dimensions are to be used only in special circumstances when approved by WMATA.

The tabulated values for the horizontal dimensions A and T, measured from centerline of track to face of columns or point restrictions and for A_s and T_s, measured from centerline of track to face of parallel bridge abutments and piers, are shown in Figures 11.56 to 11.59.

Widening on Curves

Track centers on circular curves in surface sections must be widened geometrically to maintain the 1'-8" minimum space reserved for installation of light standards and similar structures. Values shown in the tables for distance from centerline of track to intermittent columns and point restrictions shall be interpolated linearly for points which fall on the spiral.

11 .12 AERIAL TRACK STRUCTURES

11 .12.1 General

Double track aerial structures shall have an independent girder for each track with the safety walks located between, and outside of each track on opposite side of contact rail. On curved track, each girder shall be superelevated as required by the track geometry. If not constructed concentric with the centerline of track, the proper corrections for chorded construction must be made. Where light standards are required, they shall be located between the tracks.

Figure 11.67 indicates the clearance requirements for double track aerial structures. The design vehicle dynamic outline shall be located to satisfy the following criteria:

Allowance is to be made for installation of a 10 inch wide light standard or similar pole structure between tracks..

11 .12.2 Design Tables

Tabulated values for track center spacing are shown in Figure 11.68. The horizontal dimensions A and T measured from centerline of track to adjacent columns and point restrictions are shown in design tables for Surface Track Section, Figure 11.56 to Figure 11.59.

Linear interpolation is to be used for values of radii and superelevation intermediate to those shown in the tables.

11 .12.3 Horizontal Track Clearances:

Minimum horizontal clearances measured from centerline of track on tangent alignment shall be as follows:

Converging Tracks: Clearance distances for two converging tracks are determined from the transit clearance envelope and, where appropriate, include the allowances for middle ordinate and end overhang of the transit car.

Two converging tracks, the absolute minimum clearances between track centers with respect to vehicles only are shown on Figure 11.18 to Figure 11.20. The dimensions shown must be increased for structures, structural clearances, safety walks, and other installations as noted in Section 8 of this criteria. Track capacity will be determined from the location of the insulated joint farthest from the clearance point as shown on Figure 11.18 to Figure 11.20. Insulated joint locations will be coordinated WMATA.

11 .12.4 Fixed Structure in Open

Intermittent columns and point restrictions: 7′–6 5/8″ preferred. Refer to Figure 11.54.

Continuous restrictions: 8′–6″ .

Fences parallel with track: 10′–6″ . Varies with situation.

For clearance in tunnels and in cut-and-cover structures on tangent tracks, see Figures 11.10 to 11.17. For clearances on curved alignment, see Section 11.11.

11 .12.5 Station Clearances

The following are platform minimum widths. Additional width shall be added to accommodate projected platform passenger load.

Center platform width: 30′–0 1/2″ minimum,

Side platform width: 13′–6″ minimum,

Edge of platform to centerline of track: 5′–2 3/4″ (+1/4″, –0″)

11 .13 RAILROAD CLEARANCES

Railroad clearances for each jurisdiction shall satisfy the requirements for that jurisdiction in the latest edition of the following publications:

The Designer shall establish minimum requirements acceptable to the railroad in each instance, and will report thereon to the Authority. In the course of consultation with the railroad existing clearances and conditions shall be considered in order to achieve a Metro alignment at minimum construction and acquisition costs. The study and report to the Authority shall contain cost comparisons and plans illustrating alignment, construction types and acquisition alternatives to enable the Authority to comprehensively review the alternatives prior to negotiating agreement with the railroad. Railroad requirements are subject to approval by the Authority.

11 .13.1 In the District of Columbia

"Safety Standards, Rules and Regulations for Railroad Clearances," published by the Minimum Wage and Industrial Safety Board of the District of Columbia.

11 .13.2 In Maryland

Orders of the Public Service Commission

11 .13.3 In Virginia

Regulations of the State Corporation Commission

11 .14 HIGHWAY AND OTHER CLEARANCES

Vertical clearance, rapid transit structure over highway

The above vertical clearances, in addition to horizontal clearance requirements, shall be verified by the Designer with the appropriate authorities at the time of final design. For structures under the jurisdiction of agencies other than those listed above, the Designer shall coordinate his design with the appropriate owner.

11 .14.1 District of Columbia

Each overpass will be evaluated individually by the Department of Public Works of Washington, D.C.

Minimum vertical clearance 14′–6″

11 .14.2 Maryland

On roadways under Maryland State Highway Administration jurisdiction

Minimum vertical clearance 16′–9″

On roadways under Montgomery County Department of Public Works and Transportation jurisdiction

Minimum vertical clearance 16′–9″

On roadways under Prince George's County Department of Public Works and Transportation jurisdiction

Minimum vertical clearance 15′–0″
Desirable vertical clearance 16″–9″

11 .14.3 Virginia

On roadway under Virginia Department of Transportation jurisdiction

Minimum vertical clearance 16′–6″

On roadways under Arlington County Department of Transportation jurisdiction

Minimum vertical clearance 16′–0″
Desirable vertical clearance 16′–6″

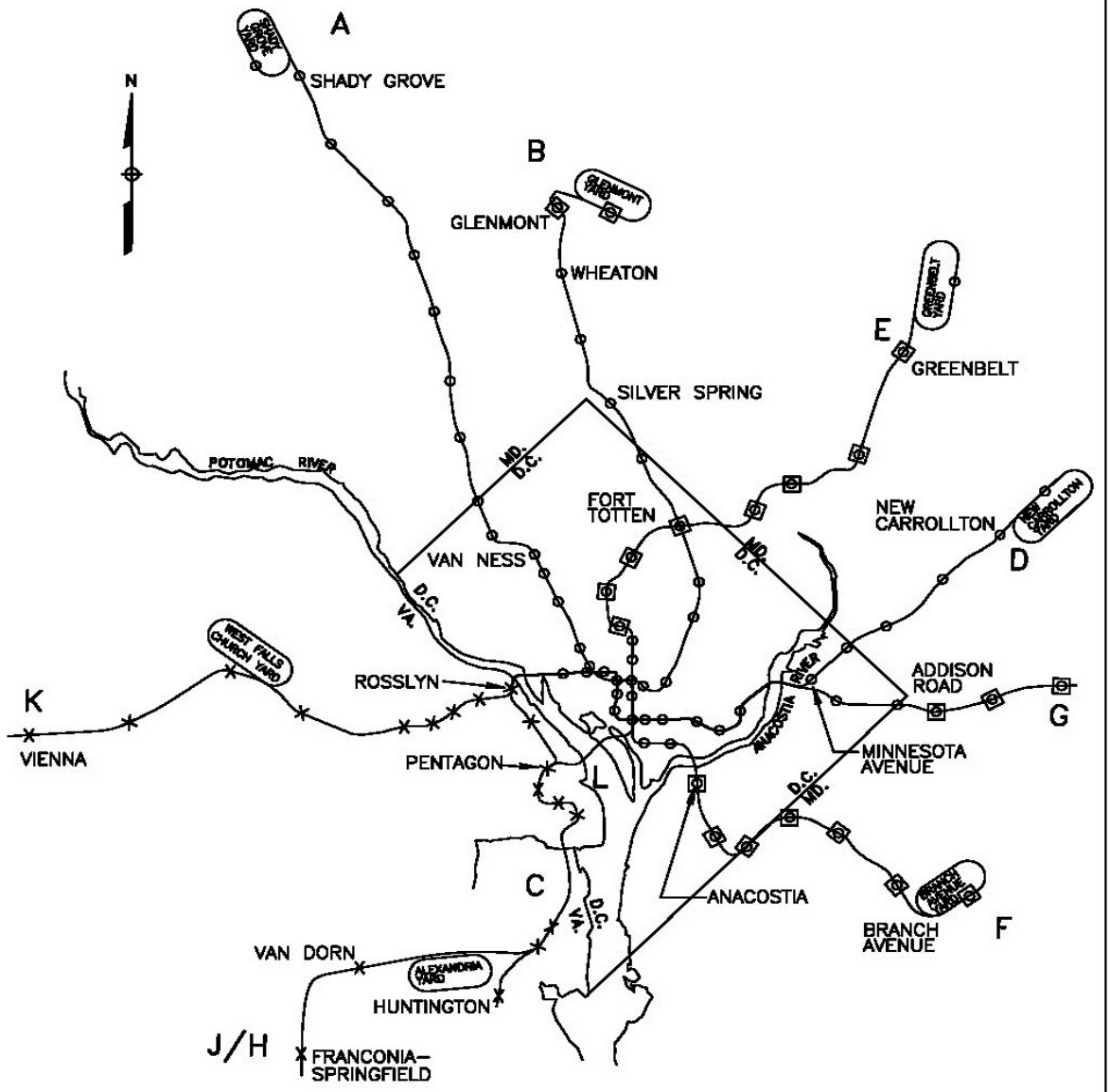
On roadways under Alexandria City jurisdiction

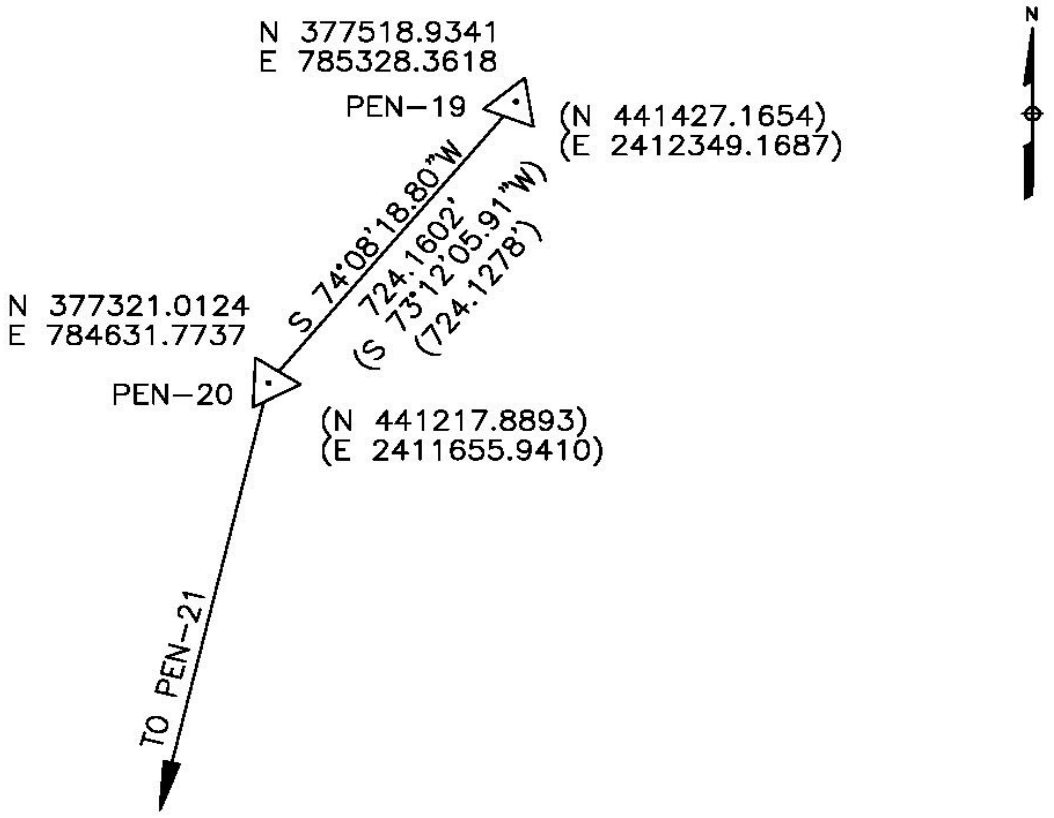
Minimum vertical clearance 14′–6″
Desirable vertical clearance 16′–6″

On roadway under Fairfax County Department of Transportation Planning jurisdiction

Minimum vertical clearance 16′–6″

FIGURE
11.1


A
SHADY GROVE
N
B
GLENMONT
WHEATON
E
GREENBELT
SILVER SPRING
POTOMAC RIVER
MD.
D.C.
FORT
TOTTEN
NEW
CARROLLTON
D
VAN NESS
D.C.
VA.
K
ROSSLYN
ADDISON
ROAD
G
VIENNA
PENTAGON
L
ANACOSTIA RIVER
MINNESOTA
AVENUE
C
ANACOSTIA
BRANCH
AVENUE
F
VAN DORN
HUNTINGTON
J/H
FRANCONIA–
SPRINGFIELD
PORTION OF ROUTES UNDER PROJECT COORDINATE SYSTEM.
PORTION OF ROUTES UNDER VIRGINIA STATE PLANE COORDINATE SYSTEM.
GPS BASED CONTROL
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
DIVISION OF PLANNING
DEVELOPMENT ENGINEERING &
CONSTRUCTION
OFFICE OF THE CHIEF ENGINEER -
FACILITIES
DESIGNATION OF COORDINATE
SYSTEMS



NOTES:

1. ALL COORDINATES, BEARINGS & DISTANCES ARE SHOWN IN PROJECT COORDINATE SYSTEM.
2. FIGURES SHOWN IN PARENTHESES ARE IN VIRGINIA NORTH ZONE NAD27, STATE PLANE COORDINATE SYSTEM AND ARE TO BE USED TO EXTEND TRAVERSE LINES IN DIRECTION SHOWN. PLEASE REFER TO THE STATION MONUMENT RECORD SHEET FOR UPDATED OR REVISED COORDINATES.

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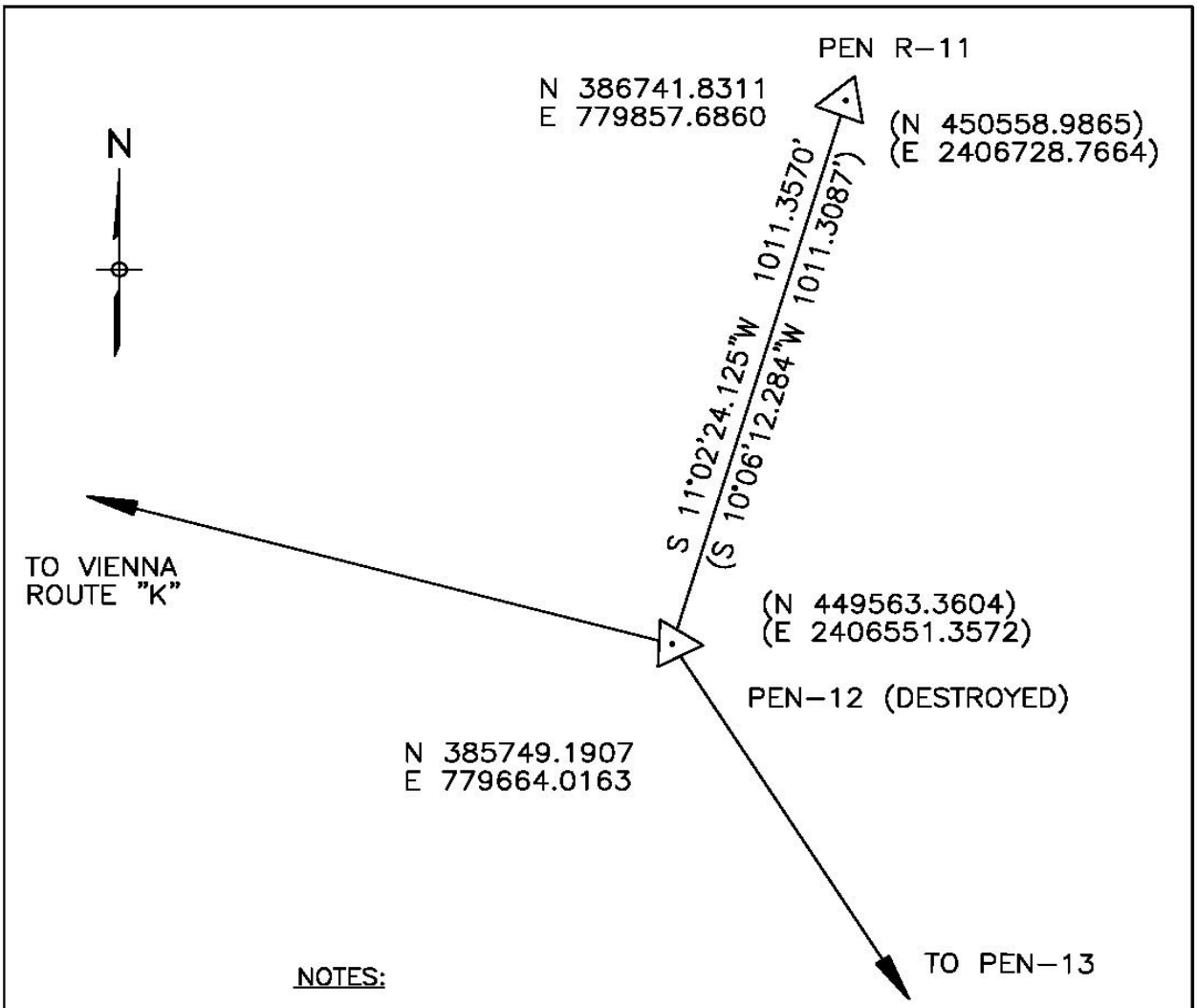
HUNTINGTON ROUTE
TRAVERSE BEGINNING

FIGURE 11.2



NOTES:

1. ALL COORDINATES, BEARINGS & DISTANCES ARE SHOWN IN PROJECT COORDINATE SYSTEM.
2. FIGURES SHOWN IN PARENTHESES ARE IN VIRGINIA NORTH ZONE NAD27, STATE PLANE COORDINATE SYSTEM AND ARE TO BE USED TO EXTEND TRAVERSE LINES IN DIRECTION SHOWN. PLEASE REFER TO THE STATION MONUMENT RECORD SHEET FOR UPDATED OR REVISED COORDINATES.
3. VIENNA ROUTE TRAVERSE STATIONS TO BE MARKED WITH LETTER PREFIX "K" ; SUCH AS K–1, K–2, ETC.

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VIENNA ROUTE
TRAVERSE BEGINNING

FIGURE 11.3

DATUM PLANES – WASHINGTON METROPOLITAN AREA

	ELEVATION RELATIVE TO PROJECT DATUM (FEET)	DATUM
ABOVE PROJECT DATUM	0.94	WASHINGTON AQUEDUCT AND FILTRATION PLANTS (W.A.D.)
	0.70	DISTRICT OF COLUMBIA ENGINEERING DEPARTMENT Potomac Electric Power Company Washington Gas Company C. & P. Telephone Company D. C. Engineering Departments
	0.57	PENNSYLVANIA RAILROAD
	0.00	PROJECT DATUM = SEA LEVEL DATUM (NGVD 1929 GENERAL ADJUSTMENT) U.S. Coast & Geodetic Survey U.S. Geological Survey Naval Research Laboratory (Bellevue) R. F. & P. Railroad B. & O. Railroad (Alexandria Branch) Arlington County
BELOW PROJECT DATUM	0.15	SEA LEVEL DATUM (1912 GENERAL ADJUSTMENT) * Washington Suburban Sanitary Commission * Montgomery County
	1.41	LOW WATER DATUM – WASHINGTON HARBOR (L.W.D.) Baltimore District, Corps of Engineers (Except Washington Aqueduct) National Park Service Public Roads Administration Washington National Airport
	1.63	BOLLING AIR FORCE BASE
	4.50	NAVAL GUN FACTORY
	4.70	ANACOSTIA NAVAL AIR STATION

* Note: The Washington Suburan Sanitary Commission and Montgomery County also use sea level datum (1929 general adjustment) in some areas.

EXAMPLE:

CAPITOL BENCH MARK – APEX OF BRONZE BOLT SET IN EAST WINDOW SILL OF THE SOUTH SIDE OF THE SENATE WING OF THE U.S. CAPITOL. IT WAS PLACED IN POSITION IN JUNE 1894 AND IS INSCRIBED "CAPITOL B.M."

DISTRICT OF COLUMBIA ENGINEERING DEPARTMENT	89.840
PENNSYLVANIA RAILROAD	89.970
PROJECT DATUM = SEA LEVEL DATUM (1929 GEN. ADJ.)	90.540

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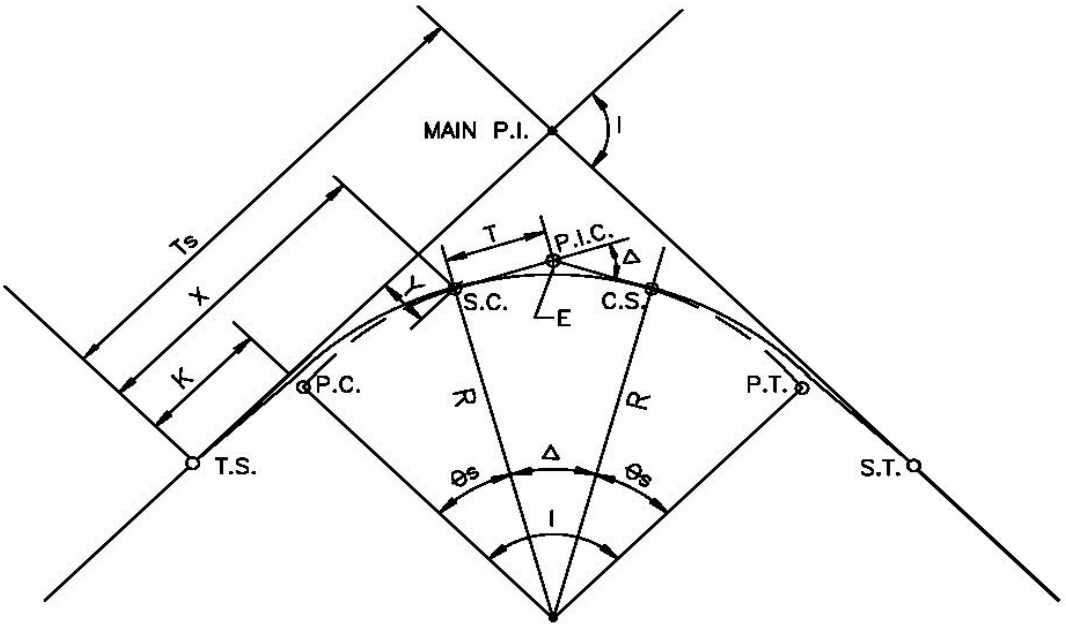
DATUM PLANES
WASHINGTON METROPOLITAN AREA

FIGURE 11.4



I = TOTAL INTERSECTION ANGLE
Θs = SPIRAL ANGLE = $\frac{LsDc}{200}$
Δ = CENTRAL ANGLE OF CIRCULAR CURVE = I−2 Θs
R = RADIUS OF CIRCULAR CURVE
T = TANGENT LENGTH OF CIRCULAR CURVE = R TAN Δ/2
L = LENGTH OF CIRCULAR CURVE = $\frac{\Delta \pi R}{180}$
E = EXTERNAL DISTANCE = R EXSEC Δ/2
Ts = TANGENT LENGTH FROM T.S. TO MAIN P.I. = (R+P) TAN I/2 +K
P.C. = POINT OF CURVATURE
P.T. = POINT OF TANGENCY
T.S. = TANGENT TO SPIRAL
S.C. = SPIRAL TO CURVE
C.S. = CURVE TO SPIRAL
S.T. = SPIRAL TO TANGENT
P.I. = POINT OF INTERSECTION

NOTE:
SEE FIG. III.6 FOR SPIRAL CURVE FUNCTIONS & ABBREVIATIONS.

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CIRCULAR CURVES
FUNCTIONS & ABBREVIATIONS

FIGURE 11.5

Ls = LENGTH OF SPIRAL (BARNETT SPIRAL)

$\Theta s = \frac{LsDc}{200}$

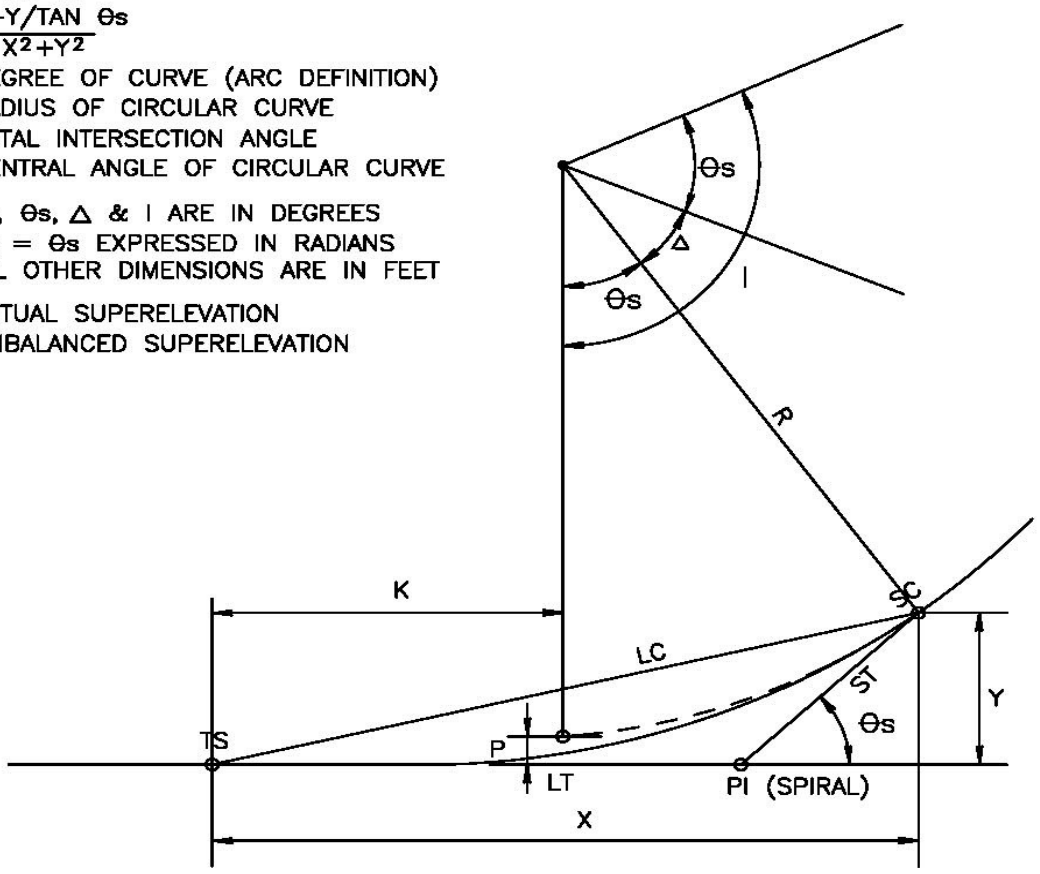
$$X = Ls\left(1 - \frac{\delta s^2}{10} + \frac{\delta s^4}{216} - \frac{\delta s^6}{9360} + \frac{\delta s^8}{685440} - \frac{\delta s^{10}}{76204800} + \frac{\delta s^{12}}{11975040000}\right)$$

$$Y = Ls\left(\frac{\delta s}{3} - \frac{\delta s^3}{42} + \frac{\delta s^5}{1320} - \frac{\delta s^7}{75600} + \frac{\delta s^9}{6894720} - \frac{\delta s^{11}}{91808640} + \frac{\delta s^{13}}{168129561600}\right)$$

Ts = TANGENT LENGTH FROM T.S. TO MAIN P.I. = (R+P) TAN I/2 + K
P = Y−R (1−COS Θs)
K = X−R SIN Θs
ST = Y/SIN Θs
LT = X−Y/TAN Θs
LC = $\sqrt{X^2+Y^2}$
Dc = DEGREE OF CURVE (ARC DEFINITION)
R = RADIUS OF CIRCULAR CURVE
I = TOTAL INTERSECTION ANGLE
Δ = CENTRAL ANGLE OF CIRCULAR CURVE

Dc, Θs, Δ & I ARE IN DEGREES
δs = Θs EXPRESSED IN RADIANS
ALL OTHER DIMENSIONS ARE IN FEET

Ea = ACTUAL SUPERELEVATION
Eu = UNBALANCED SUPERELEVATION



NOTES:
1. ACTUAL SUPERELEVATION (Ea) WILL START AT THE TS AND BE PRORATED LINEARLY THROUGHOUT THE FULL LENGTH OF THE SPIRAL TRANSITION CURVE TO FULL SUPERELEVATION AT THE SC.
2. SEE FIG. III.5 FOR CIRCULAR CURVE FUNCTIONS & ABBREVIATIONS.

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SPIRAL CURVES
FUNCTIONS & ABBREVIATIONS

FIGURE 11.6

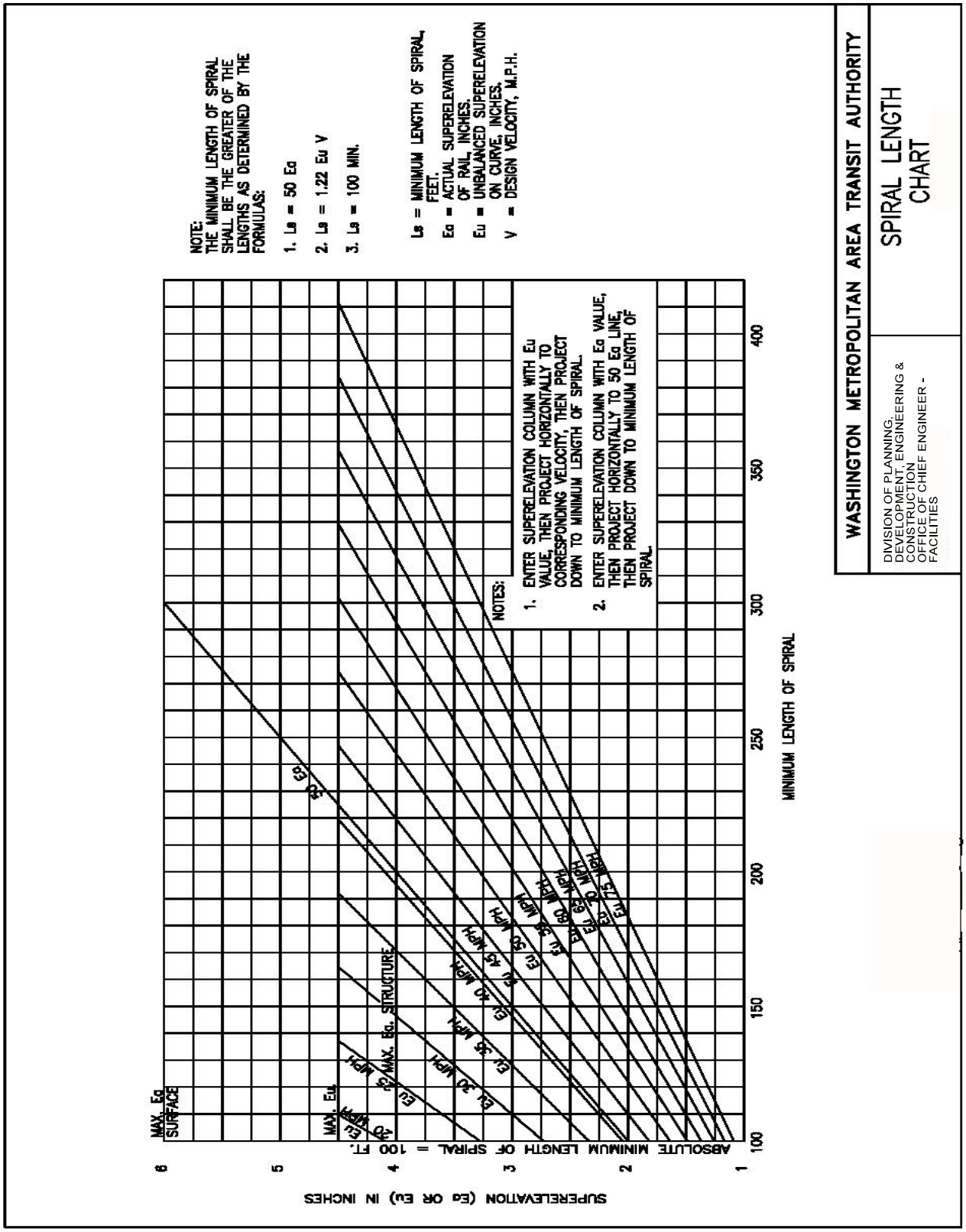
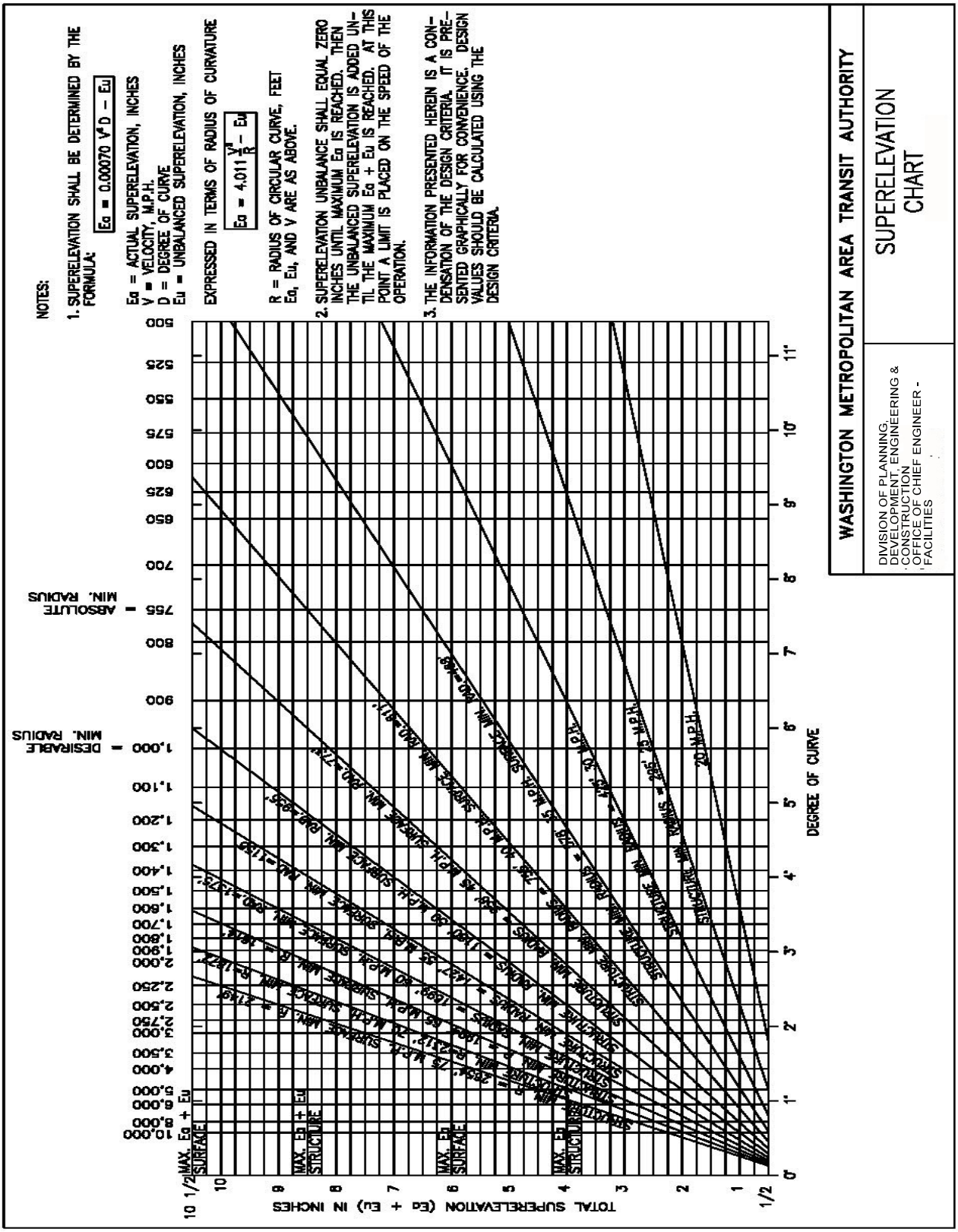

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
SPIRAL LENGTH CHART
DIVISION OF PLANNING, DEVELOPMENT, ENGINEERING & CONSTRUCTION
OFFICE OF CHIEF ENGINEER - FACILITIES
NOTE:
THE MINIMUM LENGTH OF SPIRAL SHALL BE THE GREATER OF THE LENGTHS AS DETERMINED BY THE FORMULAS:
1. Ls = 50 Ea
2. Ls = 1.22 Eu V
3. Ls = 100 MIN.
Ls = MINIMUM LENGTH OF SPIRAL, FEET.
Ea = ACTUAL SUPERELEVATION OF RAIL, INCHES.
Eu = UNBALANCED SUPERELEVATION ON CURVE, INCHES.
V = DESIGN VELOCITY, M.P.H.
NOTES:
1. ENTER SUPERELEVATION COLUMN WITH Eu VALUE, THEN PROJECT HORIZONTALLY TO CORRESPONDING VELOCITY, THEN PROJECT DOWN TO MINIMUM LENGTH OF SPIRAL.
2. ENTER SUPERELEVATION COLUMN WITH Ea VALUE, THEN PROJECT HORIZONTALLY TO 50 Ea LINE, THEN PROJECT DOWN TO MINIMUM LENGTH OF SPIRAL.
MAX. Ea SURFACE
MAX. Ea STRUCTURE
MAX. Eu
SUPERELEVATION (Ea OR Eu) IN INCHES
ABSOLUTE MINIMUM LENGTH OF SPIRAL = 100 FT.
MINIMUM LENGTH OF SPIRAL
100
150
200
250
300
350
400
1
2
3
4
5
6

FIGURE 11.7


NOTES:
1. SUPERELEVATION SHALL BE DETERMINED BY THE FORMULA: Ea = 0.00070 V² D − Eu
Ea = ACTUAL SUPERELEVATION, INCHES
V = VELOCITY, M.P.H.
D = DEGREE OF CURVE
Eu = UNBALANCED SUPERELEVATION, INCHES
EXPRESSED IN TERMS OF RADIUS OF CURVATURE Ea = 4.011 V²/R − Eu
R = RADIUS OF CIRCULAR CURVE, FEET
Ea, Eu, AND V ARE AS ABOVE.
2. SUPERELEVATION UNBALANCE SHALL EQUAL ZERO INCHES UNTIL MAXIMUM Ea IS REACHED. THEN THE UNBALANCED SUPERELEVATION IS ADDED UNTIL THE MAXIMUM Ea + Eu IS REACHED. AT THIS POINT A LIMIT IS PLACED ON THE SPEED OF THE OPERATION.
3. THE INFORMATION PRESENTED HEREIN IS A CONDENSATION OF THE DESIGN CRITERIA. IT IS PRESENTED GRAPHICALLY FOR CONVENIENCE. DESIGN VALUES SHOULD BE CALCULATED USING THE DESIGN CRITERIA.
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OFFICE OF CHIEF ENGINEER - FACILITIES
SUPERELEVATION CHART
TOTAL SUPERELEVATION (Ea + Eu) IN INCHES
DEGREE OF CURVE
MAX. Ea + Eu SURFACE
MAX. Ea + Eu STRUCTURE
MAX. Ea SURFACE
MAX. Ea STRUCTURE
DESIRABLE MIN. RADIUS
ABSOLUTE MIN. RADIUS
70 M.P.H.

FIGURE 11.8

HORIZONTAL TRACK ALIGNMENT	TRACK GAUGE	
	MAIN	YARD AND SECONDARY
TANGENT TRACK	4'–8 1/4"	4'–8 1/2"
CURVE OF RADIUS ≧ 1425'	4'–8 1/4"	4'–8 1/2"
CURVE OF 1425' > RADIUS ≧ 755'	4'–8 3/4"	4'–8 3/4"
CURVE OF 755' > RADIUS ≧ 500'	4'–8 3/4"	4'–8 3/4"
CURVE OF 500' > RADIUS ≧ 400'	N/A	4'–9"
CURVE OF 400' > RADIUS ≧ 300' *	N/A	4'–9 1/4"

* MINIMUM RADUIS IN YARDS & SECONDARY TRACKS.

NOTES:

1 THESE GAUGES APPLY ONLY WITH STANDARD AAR WHEEL GAUGES OF 4'–7 11/16" AND VEHICLE AXLE SPACING 7'–0" AND 8'–6" INCLUSIVE.

2 FOR EVERY 1/4" CHANGE IN TRACK GAUGE, THE TRANSITION SHALL BE MADE IN A LENGTH OF NOT LESS THAN 31' NOR MORE THAN 62'.

3 BASIC TRACK GAUGE FOR SPECIAL TRACKWORK SHALL CONFORM TO AREA PORTFOLIO OF TRACKWORK PLANS AND SPECIFICATIONS.

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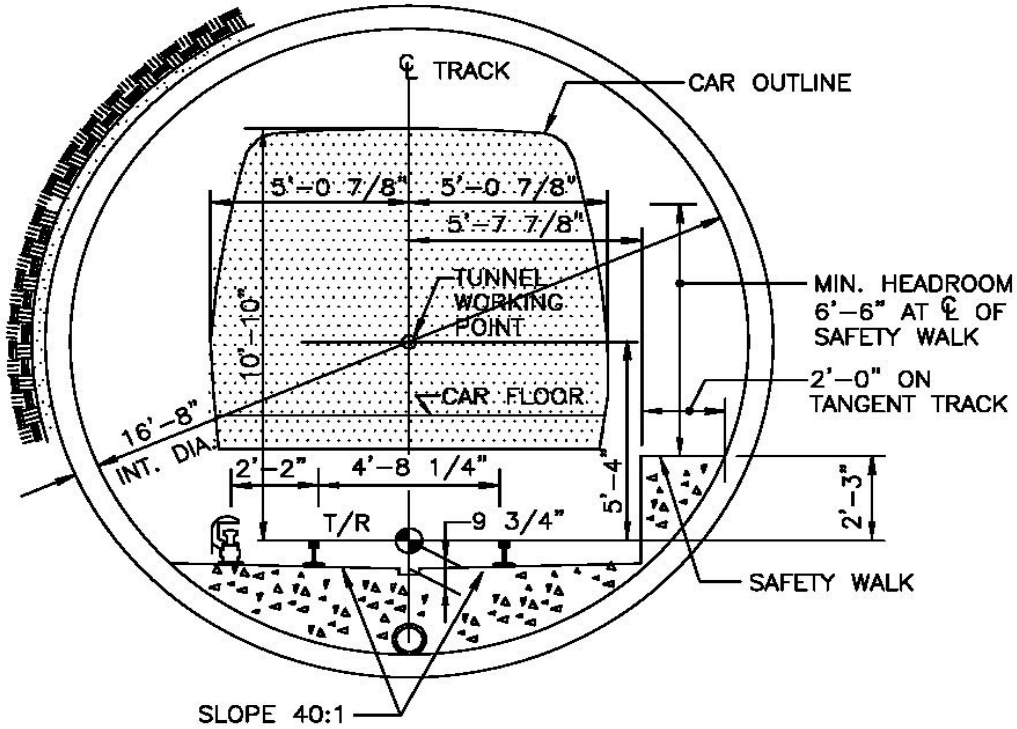
FACILITIES

METRO TRACK GAUGE

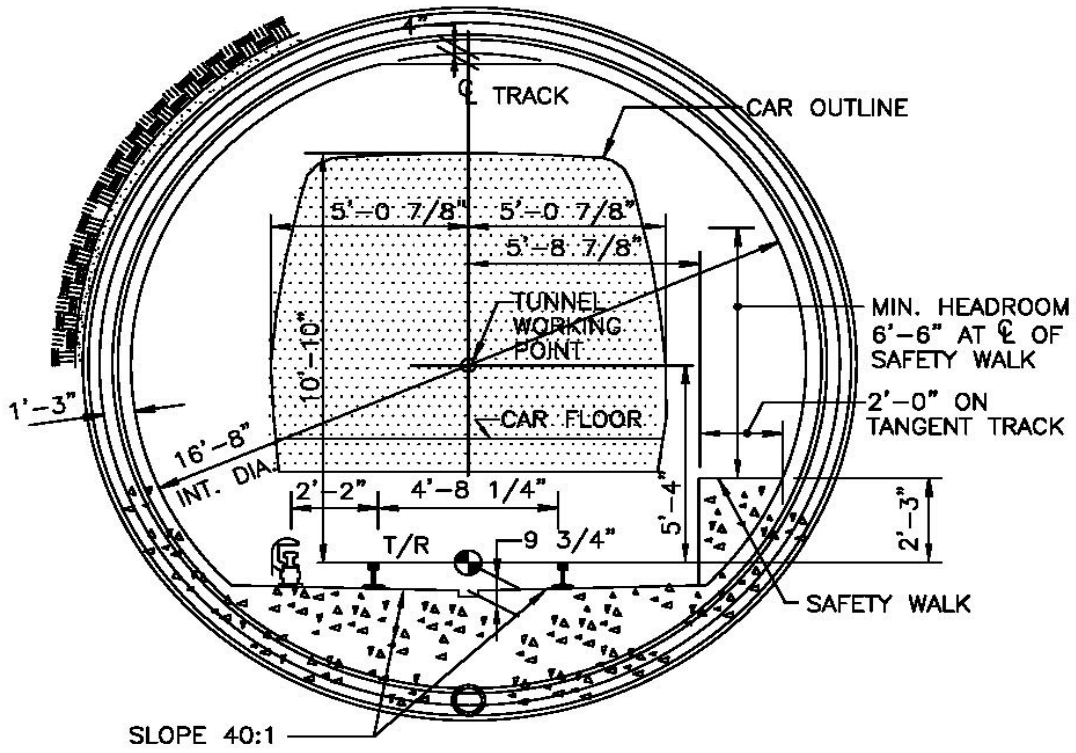
FIGURE 11.9



NOTES:
1. THIS SECTION APPLIES TO TUNNELS IN EARTH.
2. THE STANDARD 16'-8" DIAMETER TUNNEL CAN BE USED FOR RADII EQUAL TO OR GREATER THAN 700'. THE LOCATION OF THE TUNNEL WORKING POINT VARIES WITH THE HORIZONTAL CURVATURE. SEE FIGURES II.22 AND II.23.
3. CAR OUTLINE IS INDICATED, DYNAMIC OUTLINE IS NOT SHOWN.

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY	
DIVISION OF PLANNING DEVELOPMENT ENGINEERING & CONSTRUCTION OFFICE OF THE CHIEF ENGINEER - FACILITIES	CIRCULAR SEGMENTAL TUNNEL SECTION TANGENT TRACK

FIGURE 11.10



NOTES:
1. THIS SECTION APPLIES TO TUNNELS IN EARTH.
2. THE STANDARD 16'-8" DIAMETER TUNNEL CAN BE USED FOR RADII EQUAL TO OR GREATER THAN 700'. THE LOCATION OF THE TUNNEL WORKING POINT VARIES WITH THE HORIZONTAL CURVATURE. SEE FIGURES III.50 AND III.51.
3. CAR OUTLINE IS INDICATED, DYNAMIC OUTLINE IS NOT SHOWN.

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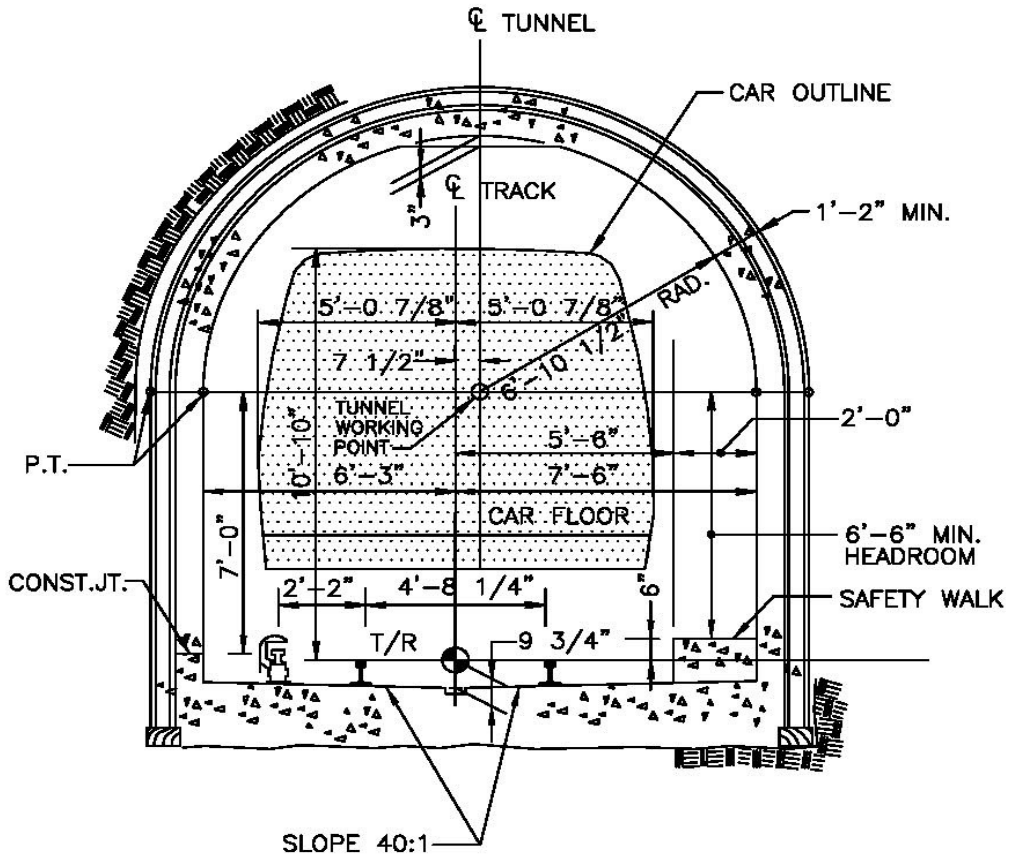
DIVISION OF PLANNING DEVELOPMENT ENGINEERING & CONSTRUCTION OFFICE OF THE CHIEF ENGINEER - FACILITIES	CIRCULAR CAST-IN-PLACE TUNNEL SECTION TANGENT TRACK

FIGURE 11.11

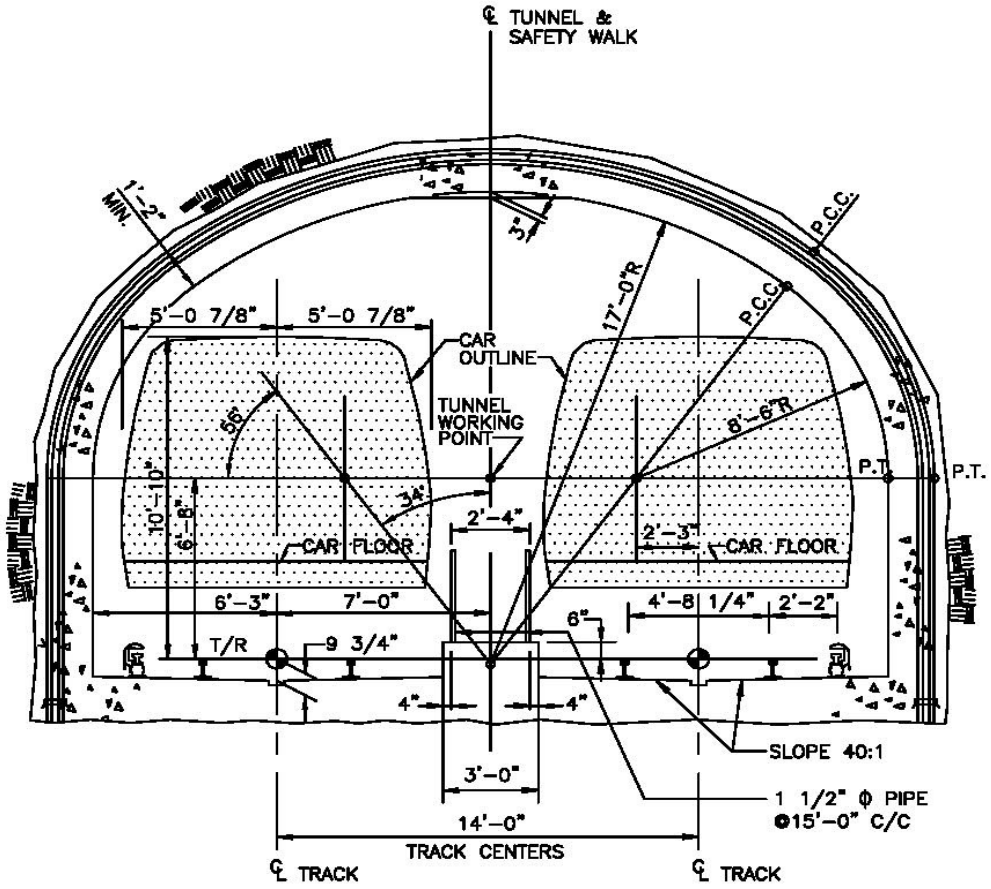


NOTES:

1. THIS SECTION APPLIES ONLY TO TANGENT TUNNEL IN ROCK.
2. THE OUTSIDE DIMENSIONS ARE SUBJECT TO LOCAL CONDITIONS.
3. CAR OUTLINE IS INDICATED, DYNAMIC OUTLINE IS NOT SHOWN.

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY	
DIVISION OF PLANNING DEVELOPMENT ENGINEERING & CONSTRUCTION OFFICE OF THE CHIEF ENGINEER - FACILITIES	SINGLE TRACK ROCK TUNNEL SECTION TANGENT TRACK

FIGURE 11.12

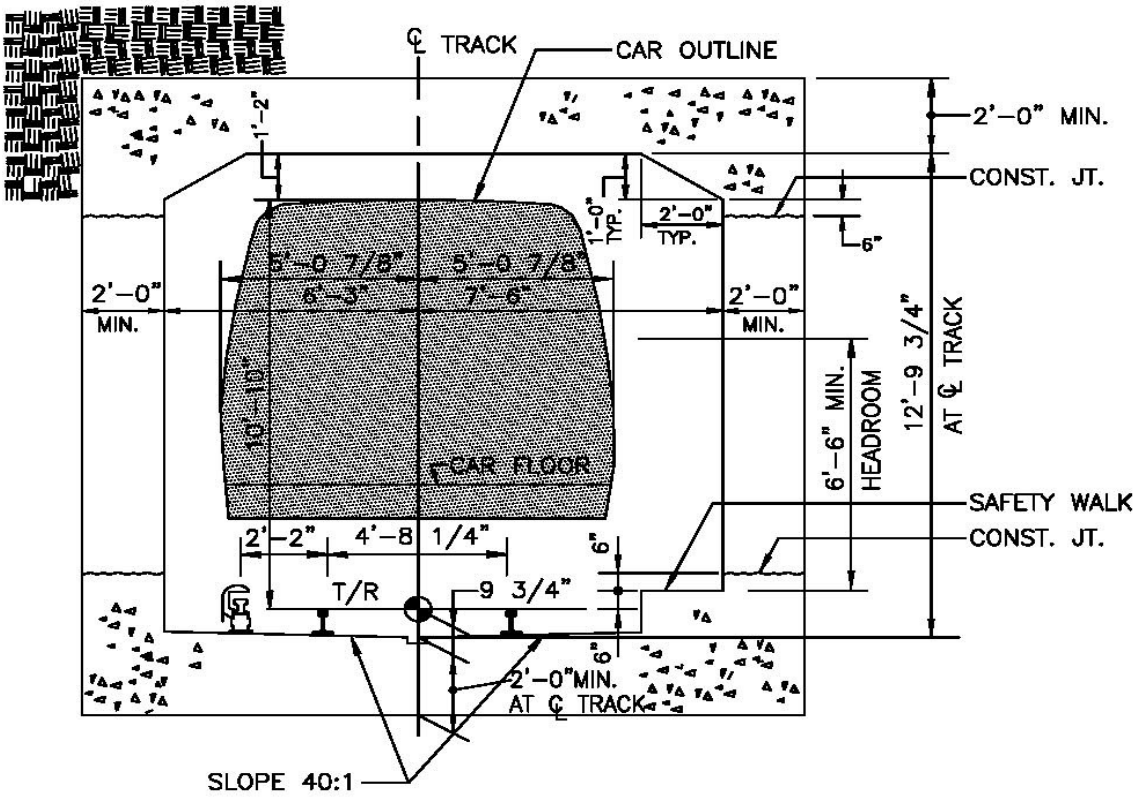


NOTES:

1. THIS SECTION APPLIES ONLY TO TANGENT TUNNEL IN ROCK.
2. THE OUTSIDE DIMENSIONS ARE SUBJECT TO LOCAL CONDITIONS.
3. CAR OUTLINES ARE INDICATED, DYNAMIC OUTLINES ARE NOT SHOWN.

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY	
DIVISION OF PLANNING DEVELOPMENT ENGINEERING & CONSTRUCTION OFFICE OF THE CHIEF ENGINEER - FACILITIES	DOUBLE TRACK ROCK TUNNEL SECTION TANGENT TRACK

FIGURE 11.13



NOTES:

1. THIS SECTION APPLIES TO CUT AND COVER CONSTRUCTION.
2. THE INTERIOR DIMENSIONS OF THE BOX SECTION VARY WITH THE HORIZONTAL CURVATURE. SEE FIGURES III.34 & III.35.
3. CAR OUTLINE IS INDICATED, DYNAMIC OUTLINE IS NOT SHOWN.

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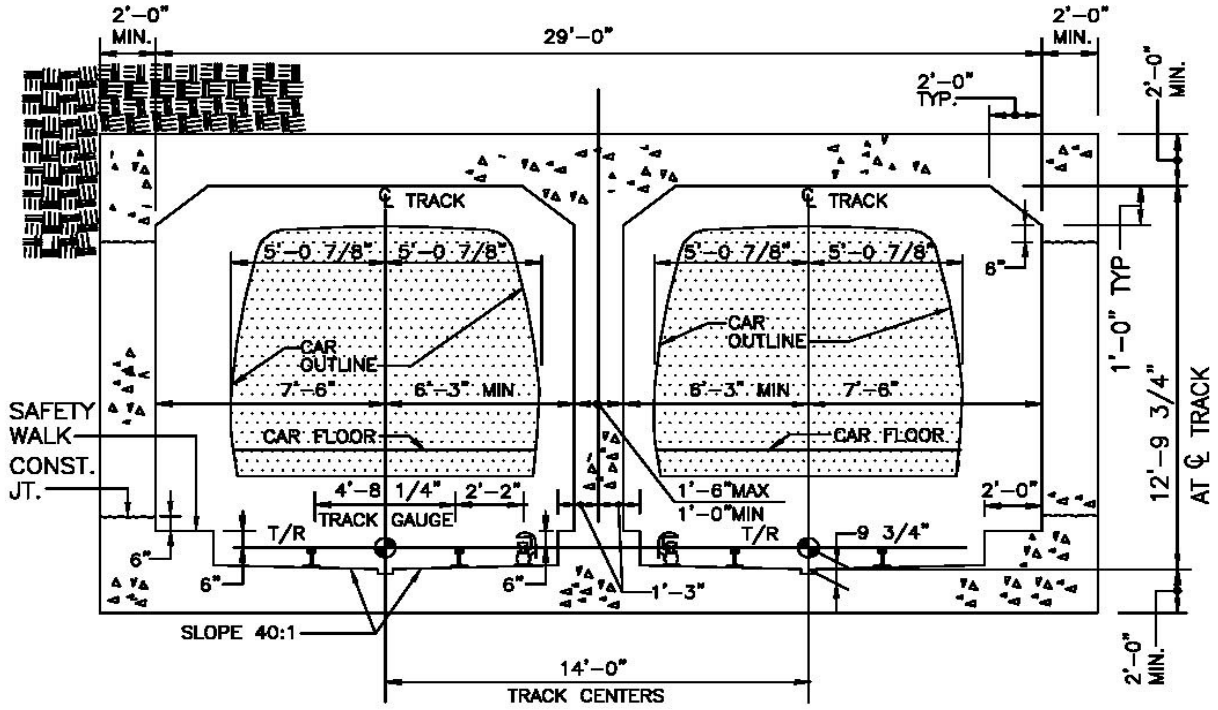
DIVISION OF PLANNING
DEVELOPMENT ENGINEERING & CONSTRUCTION
OFFICE OF THE CHIEF ENGINEER - FACILITIES

SINGLE BOX SECTION
TANGENT TRACK

FIGURE 11.14



NOTES:

1. THIS SECTION APPLIES TO CUT AND COVER CONSTRUCTION.
2. THE INTERIOR DIMENSIONS OF THE BOX SECTION VARY WITH THE HORIZONTAL CURVATURE. SEE FIGURES III.34 & III.35.
3. CAR OUTLINES ARE INDICATED, DYNAMIC OUTLINES ARE NOT SHOWN.

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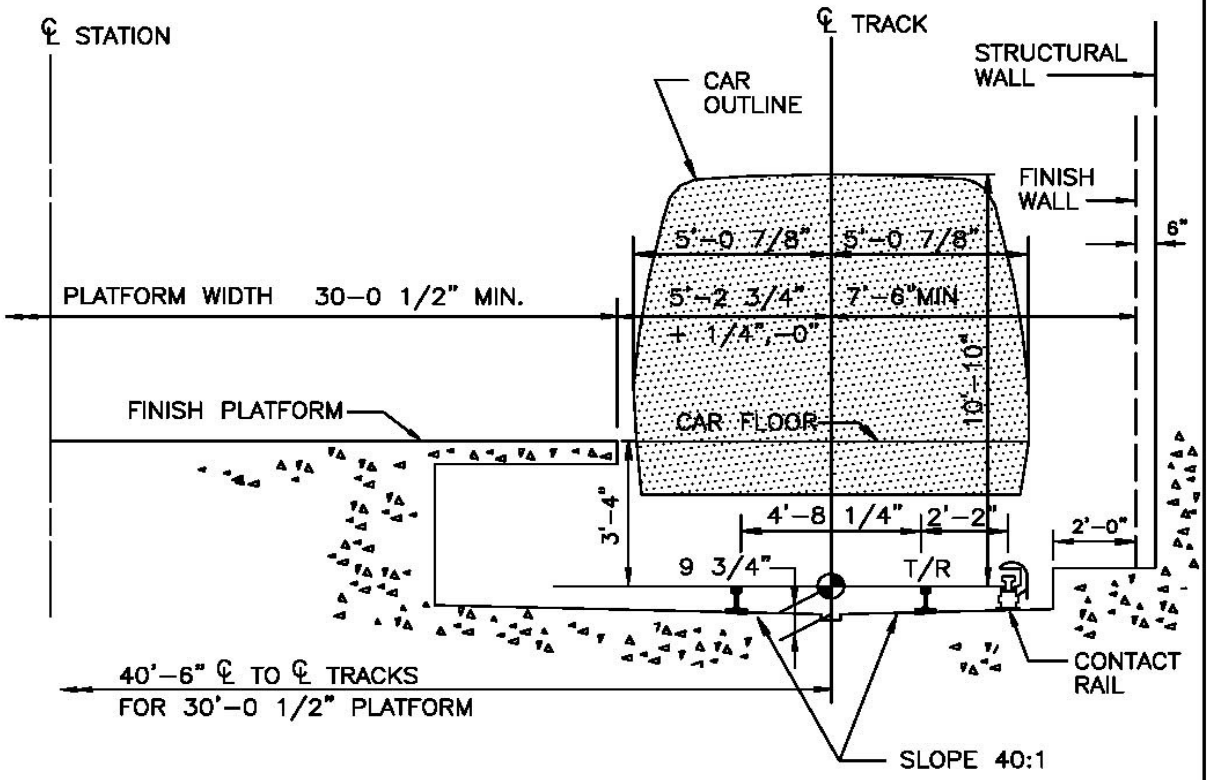
DIVISION OF PLANNING
DEVELOPMENT ENGINEERING & CONSTRUCTION
OFFICE OF THE CHIEF ENGINEER - FACILITIES

DOUBLE BOX SECTION
TANGENT TRACK

FIGURE 11.15



NOTES:

1. PLATFORM WIDTH: 30'-0 1/2" MINIMUM OR AS NECESSARY TO ACCOMMODATE PROJECTED PLATFORM PASSENGER LOADS.
2. CAR OUTLINE IS INDICATED, DYNAMIC OUTLINE IS NOT SHOWN.
3. ELECTRICAL CONTACT RAIL TO BE LOCATED ON SIDE OF TRACK OPPOSITE THE PLATFORM.

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DIVISION OF PLANNING
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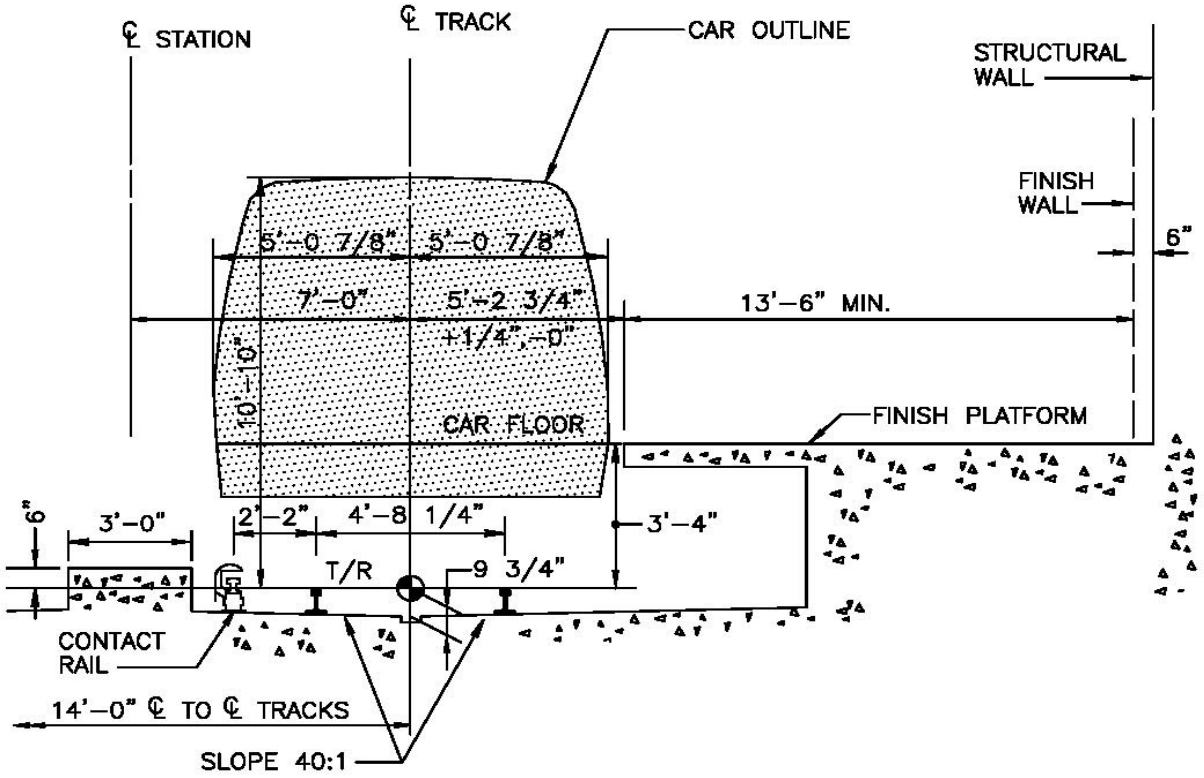
STATION CLEARANCES
CENTER PLATFORM STATION

FIGURE 11.16



NOTES:

1. PLATFORM WIDTH: 13'-6" MINIMUM OR AS NECESSARY TO ACCOMMODATE PROJECTED PLATFORM PASSENGER LOADS.
2. CAR OUTLINE IS INDICATED, DYNAMIC OUTLINE IS NOT SHOWN.
3. ELECTRICAL CONTACT RAIL TO BE LOCATED ON SIDE OF TRACK OPPOSITE THE PLATFORM.

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DIVISION OF PLANNING
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OFFICE OF THE CHIEF ENGINEER - FACILITIES

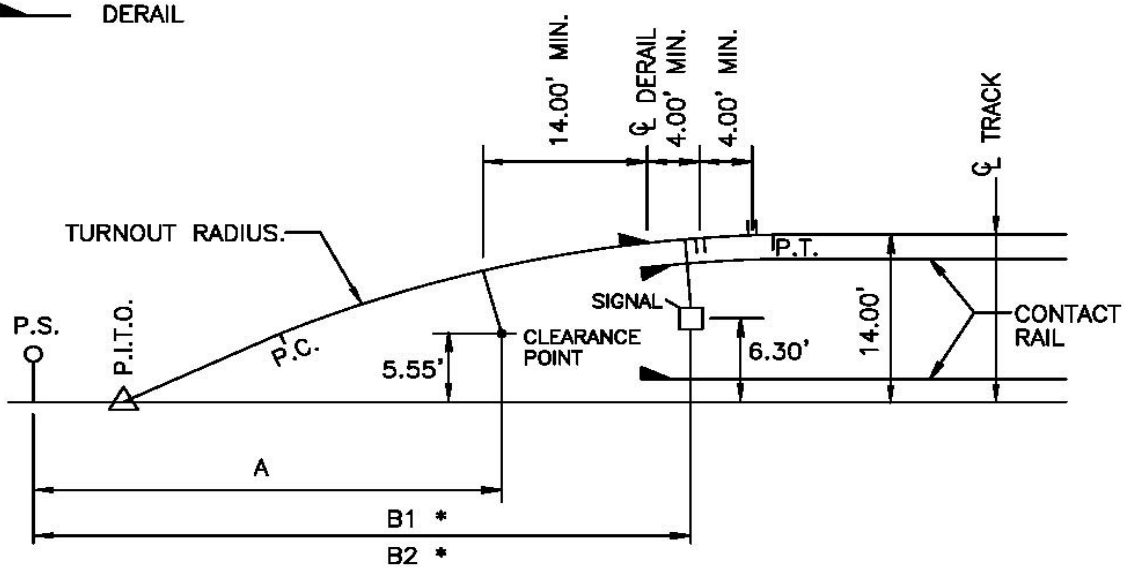
STATION CLEARANCES
SIDE PLATFORM STATION

FIGURE 11.17

LEGEND:

INSULATED JOINT

DERAIL



SIGNAL IS LOCATED WITH MINIMUM CLEARANCE AND A 1 FOOT WIDE SIGNAL HEAD.

T.O. NO.	A	B1 (Min.)	B2 (Min.)
6	102'	111'	111'
8	137'	150'	150'
10	158'	175'	175'
15	221'	247'	250'

* IF EITHER CONTACT RAIL IS TO THE INSIDE (AS SHOWN) THEN B2 APPLIES.

NOTE:

IF DERAIL IS NOT REQUIRED, THE INSULATED JOINT NEAREST THE P.S. SHALL BE LOCATED NOT LESS THAN 14.00' BEHIND THE CLEARANCE POINT. THE SECOND INSULATED JOINT, IF REQUIRED, SHALL BE LOCATED IN THE OPPOSITE RAIL 4.00' BEHIND THE FIRST INSULATED JOINT.

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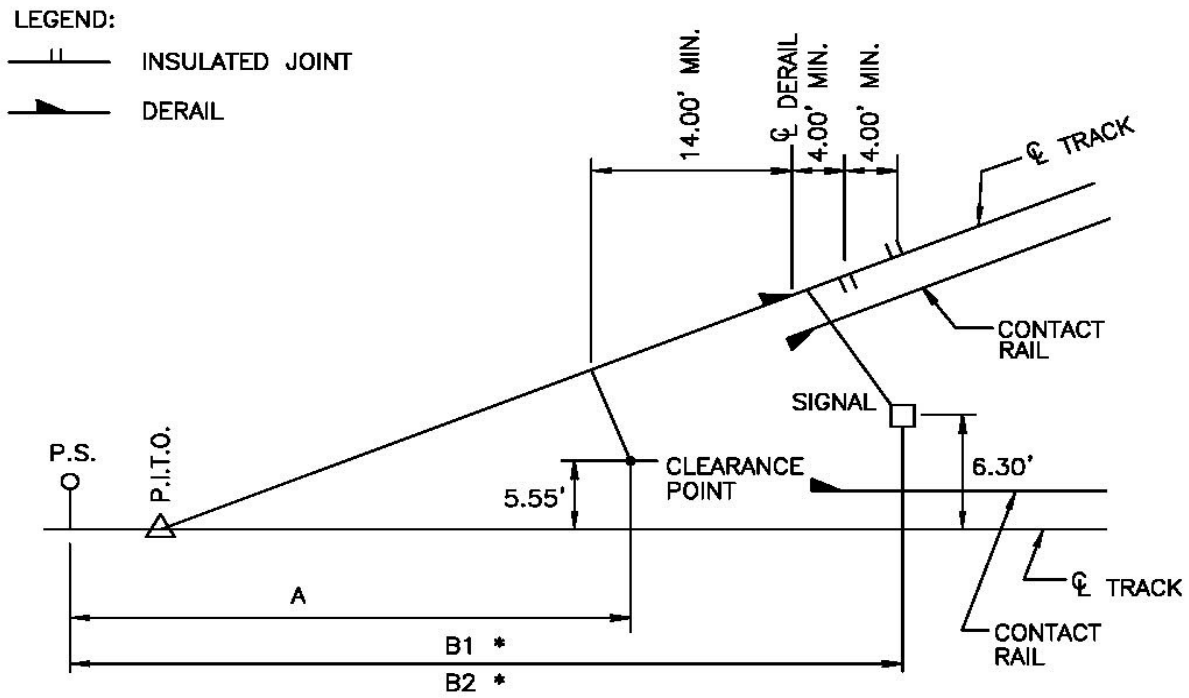
OFFICE OF THE CHIEF ENGINEER - FACILITIES

CLEARANCE FOR TURNOUTS TO PARALLEL SIDINGS ON 14 FOOT TRACK CENTERS

FIGURE 11.18



SIGNAL IS LOCATED WITH MINIMUM CLEARANCE AND A 1 FOOT WIDE SIGNAL HEAD.

T.O. NO.	A	B1 (Min.)	B2 (Min.)
6	85'	94'	110'
8	118'	130'	140' YARD 150' M/L
10	141'	155'	175'
15	204'	224'	250'

* IF EITHER CONTACT RAIL IS TO THE INSIDE (AS SHOWN) THEN B2 APPLIES.

NOTE:

IF DERAIL IS NOT REQUIRED, THE INSULATED JOINT NEAREST THE P.S. SHALL BE LOCATED NOT LESS THAN 14.00' BEHIND THE CLEARANCE POINT. THE SECOND INSULATED JOINT, IF REQUIRED, SHALL BE LOCATED IN THE OPPOSITE RAIL 4.00' BEHIND THE FIRST INSULATED JOINT.

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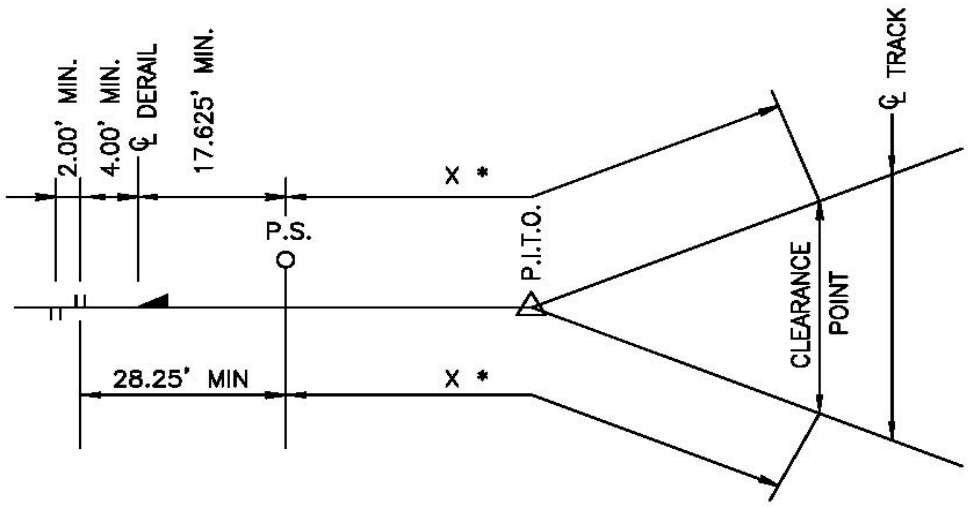
CLEARANCE FOR TURNOUTS WITH TANGENT TRACKS BEYOND THE FROG

FIGURE 11.19



LEGEND:

INSULATED JOINT

DERAIL

T.O. NO.	X
4–Y	75'
6–Y	99'

X * IS MEASURED ALONG THE CENTERLINE OF TRACK FROM P.S. TO P.I.T.O. AND THENCE TO THE CLEARANCE POINT.

NOTE:

IF THE DERAIL IS NOT REQUIRED, THE FIRST INSULATED JOINT SHALL BE 5.75' FROM THE P.S. AND THE SECOND INSULATED JOINT SHALL BE LOCATED IN THE OPPOSITE RAIL 2.00' BEHIND THE FIRST INSULATED JOINT.

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CLEARANCE FOR EQUILATERAL TURNOUTS WITH TANGENT TRACKS BEYOND THE FROG

FIGURE 11.20

NO. OF TURNOUT	SWITCH RAIL LENGTH	TYPE OF SWITCH	SPEED THROUGH TURNOUT		
			NORMAL OPERATING SPEED	MAXIMUM OPERATING SPEED	CRITICAL SPEED
NO. 4–Y	11'–0"	EQUILATERAL	15	16	18.5
NO. 6	11'–0"	STRAIGHT	15	16.5	19.0
NO. 6–Y	13'–0"	EQUILATERAL	22	25.6	29.6
NO. 8	16'–6"	STRAIGHT	22	22.7	26.3
NO. 10	19'–6"	CURVED	28	30.0	34.7
NO. 15	26'–0"	CURVED	40	45.8	52.9

NOTES:
1. NORMAL OPERATING SPEED IS THE NEAREST ATC SPEED COMMAND BELOW MAXIMUM OPERATING SPEED.

2. MAXIMUM OPERATING SPEED IS BASED ON Eu= 4 1/2" AND IS DETERMINED USING THE LEAD RADIUS AND THE SWITCH RADIUS (FOR CURVED SWITCHES) OR THEORETICAL SWITCH RADIUS (FOR STRAIGHT SWITCHES) WITH THE MOST RESTRICTIVE SPEED GOVERNING.

3. CRITICAL SPEED IS BASED ON Eu= 6" AND IS THE MAXIMUM SAFE SPEED.

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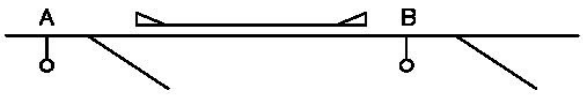
SPEED THROUGH TURNOUTS

FIGURE 11.21

BACK–TO–POINT TURNOUTS OF SAME HAND

TURNOUT & HAND		11'–0" END APPROACH	5'–6" END APPROACH
A	B		
6R	6R	N.A.	84.58'
6L	6L	"	"
6R	8R	"	"
6L	8L	"	"
6R	10R	"	"
6L	10L	"	"
6R	15R	"	"
6L	15L	"	"
8R	8R	112.44'	112.44'
8L	8L	"	"
8R	10R	"	"
8L	10L	"	"
8R	15R	"	"
8L	15L	"	"
10R	10R	140.35'	140.35'
10L	10L	"	"
10R	15R	"	"
10L	15L	"	"
15R	15R	210.23'	210.35'
15L	15L	"	"



NOTE: CONTACT RAIL IS REQUIRED IN ALL THE ABOVE CASES.

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

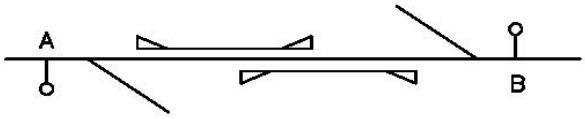
DIVISION OF PLANNING
DEVELOPMENT ENGINEERING & CONSTRUCTION
OFFICE OF THE CHIEF ENGINEER - FACILITIES

REQUIRED DISTANCES BETWEEN SWITCH POINTS–I

FIGURE 11.22

BACK–TO–POINT TURNOUTS OF SAME HAND

TURNOUT & HAND		11'–0" END APPROACH	5'–6" END APPROACH
A	B		
6R	6R	N.A.	168.0'
6L	6L	"	"
6R	8R	"	194.0'
6L	8L	"	"
6R	10R	"	224.0'
6L	10L	"	"
6R	15R	"	284.0'
6L	15L	"	"
8R	8R	220.0'	220.0'
8L	8L	"	"
8R	10R	250.0'	250.0'
8L	10L	"	"
8R	15R	310.0'	310.0'
8L	15L	"	"
10R	10R	280.0'	280.0'
10L	10L	"	"
10R	15R	340.0'	340.0'
10L	15L	"	"
15R	15R	400.0'	400.0'
15L	15L	"	"



NOTE: CONTACT RAIL IS REQUIRED IN ALL THE ABOVE CASES.

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DIVISION OF PLANNING
DEVELOPMENT ENGINEERING & CONSTRUCTION
OFFICE OF THE CHIEF ENGINEER - FACILITIES

REQUIRED DISTANCES BETWEEN SWITCH POINTS–II

FIGURE 11.23

BACK–TO–POINT TURNOUTS OF OPPOSITE HAND
(LARGER FROG ANGLE LEADING)

TURNOUT & HAND		11'–0" END APPROACH		5'–6" END APPROACH	
A	B	MINIMUM	DESIRED	MINIMUM	DESIRED
6R	6L	N.A.	N.A.	81.71'	82.00'
6L	6R	"	"	"	"
6R	8L	"	"	85.00'*	85.00'*
6L	8R	"	"	"	"
6R	10L	"	"	81.58'	81.88'
6L	10R	"	"	"	"
6R	15L	"	"	"	91.33'
6L	15R	"	"	"	"
8R	8L	104.08'	109.00'	104.08'	109.00'
8L	8R	"	"	"	"
8R	10L	"	"	"	"
8L	10R	"	"	"	"
8R	15L	"	118.46'	"	118.46'
8L	15R	"	"	"	"
10R	10L	116.92'	127.44'	116.92'	127.44'
10L	10R	"	"	"	"
10R	15L	"	136.90'	"	136.90'
10L	15R	"	"	"	"
15R	15L	154.23'	183.13'	154.23'	183.13'
15L	15R	"	"	"	"

NOTE: CONTACT RAIL IS REQUIRED IN ALL THE ABOVE CASES.
* CONTACT RAIL REQUIREMENTS GOVERN.

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DIVISION OF PLANNING
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OFFICE OF THE CHIEF ENGINEER - FACILITIES

REQUIRED DISTANCES BETWEEN SWITCH POINTS–III

FIGURE 11.24