16 .1.9.2.6 UST piping, including vent piping underground, shall be double-walled fiberglass. Piping material shall be compatible with the substance to be distributed. Piping must slope to a sump located on top of the tank that is connected to a tank monitoring system.

16 .1.9.2.7 Fill ports shall be located directly over the tank and shall be fitted with locking caps; remote fills are not acceptable. UST shall have below-grade spill containment sump with a minimum 15-gallon capacity. Fill port drop tube shall have overfill prevention valve that incorporates two-stage shutoff (first stage reduced flow by 90% and second stage shuts off flow).

16 .1.9.2.8 Gasoline UST shall have below-grade spill containment sump at Stage I vapor recovery riser.

16 .1.9.2.9 All underground metal pipe risers shall be wrapped and coated to prevent corrosion.

16 .1.9.2.10 Pipe riser for interstitial monitor shall be constructed of PVC.

16 .1.9.2.11 UST shall have watertight, fiberglass sumps that are integral to the tank.

16 .1.9.2.11.1 Penetration through fiberglass sumps shall be accomplished using fiberglass bulkhead fittings, not rubber boots.

16 .1.9.2.11.2 All tank sumps shall be fiberglass, except the following: spill containment sump and gasoline vapor recovery.

16 .1.9.2.11.3 All tank sump covers shall be fiberglass press-on type with O-ring seal. No metal connections/clamps shall be used.

16 .1.9.2.12 UST manholes shall be H-20 rated and shall be the following minimum diameters:

STP sump:	42 inch
Inventory probe:	18 inch
Interstitial probe:	18 inch
Manual stick port:	12 inch

16 .1.9.2.13 Pour reinforced concrete pad over USTs. Pad shall be a minimum of 12 inches thick and shall be reinforced using two layers of No. 4 rebar installed 12 inches OCEW. Additional reinforcement shall be provided at manholes in accordance with manufacturer's recommendations.

16 .1.9.2.14 Fueling facility UST vents shall be located outside the distances indicated by NFPA/NEC that require explosion-proof fixtures within the fueling facility kiosk.

16 .1.9.2.15 Each tank fill port manhole and vent pipe shall be painted to identify product stored in the tank in accordance with WMATA color codes.

16 .1.9.2.16 Install metal tag clamped to each fill port riser that identifies the tank product and capacity.

16 .1.9.2.17 Underground conduit for UST systems shall be PVC-coated, rigid steel, min. 3/4" diameter.

16 .1.9.2.18 Install a minimum of two observation wells/pipes within the backfill of each underground storage tank field. When required by state of local jurisdiction, install additional monitoring wells/pipes.

16 .1.9.2.19 All heating oil systems shall include a day tank to enable CSLD for the UST.

16 .1.9.2.20 Install signage near each tank field to identify the following: 1) WMATA color codes; and 2) tank product and capacity.

16 .1.9.3 Tank Monitoring Systems:

16 .1.9.3.1 All tank systems (except glycol ASTs at Rail Yards) shall have tank monitoring system to be Veeder-Root TLS 350R. Heating oil systems and all AST's may be V-R TLS 350.

16 .1.9.3.2 Tank monitoring system console shall be located in an area that can be maintained within the operational range of the unit (i.e., a conditioned space) and does not require explosion-proof electrical accessories.

16 .1.9.3.3 Monitoring systems shall provide leak detection for UST systems that meet local jurisdiction requirements.

16 .1.9.3.4 Monitoring systems shall include inventory probe, interstitial sensors, tank sump sensors, dispenser sump sensors, and overfill alarm and acknowledgment switch.

16 .1.9.3.4.1 Tank monitoring system shall perform monthly CSLD testing and monthly reconciliation. All system programming shall be completed by the Contractor at the time of installation.

16 .1.9.3.4.2 For pressurized line systems, all sump sensors shall be interlocked with pumps such that pumps will be disabled if any liquid is present in any tank sump.

16 .1.9.3.4.3 Provide audible alarm and strobe adjacent to the V-R console with signage that indicates alarm conditions.

16 .1.9.3.5 Wiring for V-R systems shall be shielded cable with individually shielded pairs.

16 .1.9.3.6 Tank monitoring systems shall have remote communication capabilities. At a minimum, provide Ethernet connection, ethernet board, and SiteFax modem and telephone line connected to each system console. Telephone line shall be an in-house analog line.

16 .1.9.3.7 All pressurized systems must be monitored by electronic line leak detection that is compatible with, and certified by, V-R tank monitoring system.

16 .1.9.4 Fuel Dispensing Systems:

16 .1.9.4.1 Dispensing areas shall incorporate a gravity oil/water separator capable of holding 100 gallons of fuel.

16 .1.9.4.2 Diesel dispensing systems for revenue vehicles (i.e., buses) shall be capable of delivering fuel at a rate of 40 gpm at the nozzle. Dispensing system shall include overhead tramway fueling system.

16 .1.9.4.3 Each bus service lane shall include a pedestal diesel dispenser (Pump Measure Control Inc. Model MSH-62, or equal) with Posi-Lock stow coupling and liquid control flow meter with mechanical registration and pulse unit. Liquid control flow meter (M-5-1, or equal) shall be capable of delivering fuel at a rate of 5-60 gpm at 150 psi. Dispensing system shall be compatible with V-R tank monitoring system.

16 .1.9.4.4 Diesel and gasoline dispensing systems for non-revenue vehicles shall be capable of delivering fuel at a rate of 22 gpm at the nozzle.

16 .1.9.4.5 Where product piping enters gasoline and diesel dispensers underground, dispensers shall have below-grade dispenser sumps constructed of fiberglass with sensors connected to the tank monitoring system.

16 .1.9.4.6 Rail yards shall include a diesel dispenser to fuel CTEM equipment in the right-of-way. Locate dispenser immediately adjacent to track so that dispenser hose is not placed across track when in use.

16 .1.9.4.7 Each fueling area shall include an emergency shut-off (mushroom) switch located to comply with NFPA requirements. Label each switch using a minimum 2" high text.

16 .2 NOISE AND VIBRATION

16 .2.1 GENERAL INTRODUCTION

This document is intended to provide design criteria for all community related noise and vibration control problems relating to the construction and operations of the WMATA Metro System, excluding the transit vehicle noise and vibration control specifications. It is an update of previous versions of the WMATA Noise and Vibration Design Criteria and is consistent with WMATA's on going noise and vibration control program which has been in existence since 1970.

Design of maintenance projects at existing facilities, including major renovations, shall conform to the design criteria in existence when the facility was constructed. The construction activity for maintenance shall comply with the construction criteria shown below.

The basic goals of these design criteria are to:

Minimize the adverse impact of system operations and construction on the community by preventing excessive noise and vibration levels from being created and controlling transmission of noise and vibration to adjacent properties.

Provide noise and vibration control consistent with economic constraints and appropriate technology.

Community acceptance of a rail transit system requires control of airborne noise from transit train operations, transit ancillary areas and facilities such as yard operations, fan and vent shafts of the ventilation system, electrical substations, and emergency service buildings. The design should also provide for control of ground borne noise and vibration from transit train operations.

Community acceptance of construction noise and vibration requires that the contractors follow published guidelines by the American Public Transit Association (APTA) and use machinery, equipment and construction methods with efficient noise and vibration suppression devices and that other noise and vibration abatement measures be used for protection of both employees and the public.

The criteria presented are based upon scales that most closely correlate with the subjective evaluation of noise: For most typical noise sources, it has been found that the A-weighted sound level provides excellent correlation with the subjective response to noise. Thus, the A-weighted sound level, which can be read directly from a sound level meter, has been selected for evaluating the response of people to the noise created by transit system construction and operations. However, evaluation of ground-borne noise, with associated low frequency sound pressure levels, requires octave band analyses and C-weighted measurements for effective evaluation.

These criteria are consistent with the earlier versions of the WMATA Noise and Vibration Design Criteria developed in 1970 and 1976. These criteria are also consistent with those contained in (APTA) publication, "Guidelines for Design of Rapid Transit Facilities".

NOTE: Definitions of many of the terms used in Section 16 are found in Section 16.11.

16 .2.2 MEASUREMENT PROCEDURES AND ASSUMPTIONS

16 .2.3 General

Unless otherwise indicated, all noise levels are expressed in decibels (dB) referenced to 20 x 10^{-6} Pascals (20 µPa) as measured with the A-weighting network of a standard sound level meter, abbreviated dBA. All noise levels or measurements refer to the use of A-weighting and "slow" response of an instrument complying, at a minimum, with the Type 2 requirements of the latest revision of American National Standard (ANSI) S 1.4, "Specification for Sound Level Meters".

Vibration levels are expressed in decibels (dB) in terms of vibration velocity level referenced to 10^{6} in/sec (1.0 µin/sec) as measured with a velocity transducer or accelerometer with suitably integrated output. Vibration decibels are usually expressed as VdB so as not to confuse the measurement with sound decibels.

16 .2.4 Transit System Wayside Noise and Vibration Measurements

The WMATA Metro wayside noise criteria are based on measurements taken at appropriate distances and performed in essentially a free-field or open space environment away from reflective or shielding surfaces. Unless otherwise indicated, the vibration criteria are based on measurements of vibration in the vertical direction from building floors.

16 .2.5 Construction Noise and Vibration Measurements

Construction noise shall be measured in accordance with Section 16.4.1. All impulsive or impact noise levels or measurements refer to use of an impulsive sound level meter complying with the criteria of IEC 179 for impulse sound level meters. As an alternative procedure, a Type .2 General Purpose sound level meter on C-weighting and "fast" response may be used to estimate peak values of impulsive or impact noises.

Noise levels near buildings affected acoustically by the Contractor's operations refer to measurements at points between 3 ft and 6 ft from building facades or building setback lines.

Vibration at buildings affected by construction operations refers to vibration in any direction on the ground surface outside the affected building.

16 .3 COMMUNITY CATEGORIES AND RELATION TO CRITERIA FOR WAYSIDE NOISE AND VIBRATION

A wayside community noise design criterion provides a basis from which to determine the type and extent of noise attenuation and reduction measures necessary to avoid annoyance in the community. The wayside noise criteria must be related to the type of activity taking place in the building or community and the ambient noise levels in the absence of transit system noise. Obviously, a noise level of a given magnitude is more objectionable in a quiet residential area at night than in a busy commercial area during the day.

Existing ambient or background noise and vibration can vary significantly for different communities. Therefore, it is necessary to evaluate the nature of the community in which the transit system is to be located before determining the appropriate criterion for allowable noise or vibration levels from the transit system in the community.

Table 1 indicates the five generalized categories of wayside areas into which the communities along transit system corridors can be categorized for the purpose of assigning appropriate noise and vibration criteria. The table indicates the description of the areas and the normal expected range of ambient noise levels. These categories and noise levels are based in part, on the information developed from studies of rail transit corridor environments along with the extensive data presented in the 1974 U. S. Environmental Protection Agency (EPA) document, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of safety, usually referred to as the "Levels Document", and other field noise measurement data obtained in many community areas throughout the United States.

Table 1 General Categories of Communities Along WMATA Metro System Corridors

Area Category	Area Description	Typical Ambient Noise Levels dBA (Average or L_{50}*)	Typical Day/Night Exposure Levels L_{dn}**
I	Low Density urban residential, open space park, suburban residential or quiet recreation area. No nearby highways or boulevards.	40-50 (day) 35-45 (night)	Below 55

II	**Average urban residential, quiet apartments and hotels, open space, suburban residential, or occupied outdoor areas near busy streets.**	**45-55 (day) 40-50 (night)**	**50-60**
III	**High Density urban residential, average semi-residential/ commercial areas, urban parks, museum, and non-commercial public building areas.**	**50-60 (day) 45-55 (night)**	**55-65**
IV	**Commercial areas with office buildings, retail stores, etc., primarily daytime occupancy. Central Business Districts.**	**60-70**	**Over 60**
V	**Industrial areas or Freeway and Highway Corridors**	**Over 60**	**Over 65**

*** - L_{50} is the long-term statistical median noise level.**
**** - L_{dn} is the day-night sound level.**

The categories defined in Table 1 are used in determining appropriate noise and vibration design criteria. The land use or area categories presented above are similar to those used in the 1970 WMATA Design Criteria and are the same as the categories used in the 1976 WMATA Design Criteria and in the APTA Publication, "Guidelines for Design of Rapid Transit Facilities". In most cases, experience with the newer systems now in operation and specifically with the WMATA Metro System has indicated that these categories and the associated criteria provide for adequate results. Most neighbors of the transit facility find the noise and vibration levels acceptable.

16 .4 WAYSIDE NOISE AND VIBRATION DUE TO TRANSIT TRAIN OPERATIONS

16 .4.1 Airborne Noise from Above-Ground Train Operations

Table 2 presents design criteria for single pass by maximum noise levels for airborne noise from transit,'trains for various types of buildings in each of the land use area categories listed in Table 1. These criteria are generally applied to nighttime operations because sensitivity to noise is greater at night than during the daytime. The maximum levels are based on the maximum level that will not cause significant intrusion or alteration of the pre-existing noise environment and represent noise levels which are considered acceptable for the type of land use in each area. The criteria presented in Tables 2 and 3 are generally applicable outdoors at the nearside of the nearest occupied building or area under consideration, but not less than 50 ft from track centerline.

Table 2 Criteria for Maximum Airborne Noise from Train Operations

		Maximum Pass by Noise Level		
Community Area Category		**Single Family Dwellings**	**Multi** Family Dwellings	Commercial Buildings
I	Low Density Residential	70 dBA	75 dBA	80 dBA
II	Average Residential	75	75	80
III	High Density Residential	75	80	85
IV	Commercial	80	80	85
V	Industrial/Highway	80	85	85

For some types of buildings or occupancies maximum noise level limits should be applied regardless of the community area category. The design should reflect careful consideration of noise control when the transit line is near these specific type of buildings or areas. Table 3 presents design criteria for maximum airborne noise from transit operations near these specific types of buildings.

Table 3 Criteria for Maximum Airborne Noise from Train Operations Near Specific Types of Buildings or Areas

Building or Occupancy Type	Maximum Pass by Noise Level (dBA)
Outdoor Amphitheaters or Concert Pavilions	65
"Quiet" Outdoor Recreation Areas	70
Concert Halls, Radio and TV Studios, Auditoriums	70
Churches, Theaters, Schools, Hospitals, Museums, Libraries	70

16 .4.2 Ground borne Noise from Train Operations

Table 4 presents criteria for maximum ground borne noise due to transit train operations for various types of residential communities. Ground-borne noise and ground borne vibration are directly correlated with each other . Ground-borne vibration describes waves in the ground which can be measured using vibration pickups mounted on the sidewalk, foundations, building floors, or stakes in the ground and which can be perceived as mechanical motion. Ground borne noise describes sound generated when the same waves in the ground reach room surfaces in buildings, causing them to vibrate and radiate sound waves in the room.

Wayside impact due to the operation of transit trains in subway is normally described in terms of ground borne noise because in most situations, the noise produced by the vibration of room surfaces is audible at ground borne vibration levels below those which are perceptible to tactile senses. Thus, in most cases, a criterion limiting audible noise levels will provide adequate protection against tactile ground borne vibration levels.

In most cases for surface or aerial transit train operations, the airborne noise is significantly louder than the ground borne noise, and ground borne noise is not perceived separately from the airborne noise. Thus, assessment of the acoustic noise level due to vibration instead of ground vibration levels facilitates comparison with expected interior airborne noise.

TABLE 4 Criteria for Maximum Ground borne Noise from Train Operations for Buildings with Sleeping Areas

		Maximum Pass by Ground borne Noise Level		
	Community Area Category	**Single Family Dwellings (dBA)**	**Multi-Family Dwellings (dBA)**	**Hotel/ Motel Dwellings (dBA)**
I	Low Density Residential	30	35	40
II	Average Residential	35	40	45
III	High Density Residential	35	40	45
IV	Commercial	40	45	45
V	Industrial/Highway	40	45	50

As with airborne noise, there are some types of buildings for which specific design criteria should be applied, regardless of area category. Table 5 presents design criteria for generally acceptable levels of transient ground borne noise levels in occupied spaces of various types of buildings and occupancies. The table is not intended to be all inclusive, but may be a convenient general guide.

TABLE 5 Criteria for Maximum Ground borne Noise for Train Operations Near Specific Types of Buildings

Type of Building or Room	Maximum Pass by Ground borne Noise Level (dBA)
Concert Halls and TV Studios	25
Auditoriums and Music Rooms	30
Churches and Theaters	30-35
Hospital Sleeping Rooms	35-40
Courtrooms	35
Schools and Libraries	35-40
University Buildings	35-40.
Offices	35-40
Commercial Buildings	45-55

Ground-borne noise that achieves the design criteria listed above will be discernable in most cases , however, the level will be sufficiently low with little significant intrusion or annoyance . In most cases, noise from street traffic, other occupants of a building, or other sources, which will create noise intrusion that is equivalent to or greater in level than the noise from transit trains.

A range of the maximum ground-borne noise limit is given in some cases to permit an adjustment of the design criterion to be suitable for the environment and location of the building. For example, at office in a quiet, landscaped office park area, the limit should be at the low end of the range, 35 dBA. For offices located at a busy intersection or in a busy central business district the limit can be at the upper end of the range, 45 dBA.

16 .4.3 Ground borne Vibration from Train Operations

Table 6 presents the appropriate ground borne vibration criteria for maximum ground borne vibration for various types of residential buildings. The criteria apply to measurements of vertical vibration of floor surfaces within the buildings.

TABLE 6 Criteria for Maximum Ground borne Vibration from Train Operations for Buildings with Sleeping Areas

Community Area Category		Maximum Passby Ground borne Vibration Velocity Level (dB re 10^{-6} in/sec)		
		Single Family Dwellings	Multi Family Dwellings	Hotel/Motel Buildings
I	Low Density Residential	72	72	72
II	Average Residential	72	72	75
III	High Density Residential	72	75	75
IV	Commercial	72	75	75
V	Industrial/Highway	75	75	75

As with ground borne noise, there are some types of buildings for which specific design criteria for ground borne vibration should be applied, regardless of area category. Table 7 presents design criteria for transient ground borne vibration levels in occupied spaces of various types of buildings and occupancies. This table is not intended to be all inclusive.

TABLE 7 Criteria for Maximum Ground borne Vibration from Train Operations Near Specific Types of Buildings

Type of Building or Room	Maximum Passby Ground-borne Vibration Velocity Level (dB re 10.6 in/sec)
Vibration Sensitive Industrial or Research Laboratory	**60-70**
Concert Halls and TV Studios	**65**
Auditoriums and Music Rooms	**70**
Churches and Theaters	**70**
Hospital Sleeping Rooms	**70**
Courtrooms	**70**
Schools and Libraries	**75**

Type of Building or Room	Maximum Passby Ground-borne Vibration Velocity Level (dB re 10.6 in/sec)
University Buildings	**75-80**
Offices	**75-80**
Commercial and Industrial Buildings	**75-80**

Ground borne vibration that achieves the design criteria listed above will not be imperceptible in all cases; however, the level will be sufficiently low so that no significant intrusion or annoyance should occur. In most cases, there will be vibration from street traffic, other occupants of a building, or other sources, that will create intrusion that is equal or greater in level than the vibration from the transit trains.

16 .5 AIRBORNE NOISE FROM TRANSIT ANCILLARY FACILITIES

16 .5.1 Introduction

There are sources of community noise from a transit system other than trains. The two basic types of airborne noise from ancillary facilities are transient and continuous. For example, transient noise occurs during train passbys and this noise is transmitted from vent shaft openings. Power substations and fan noise may be characterized as continuous ancillary equipment noise. These noises can be obtrusive due to their tonal and continuous nature. The appropriate noise level design criterion depends on the activities of occupants as well as the background noise in the area. The acceptable levels of transient and continuous noises are different. Transient noises are acceptable at higher levels than continuous noises, particularly continuous noises containing pure tones.

Table 8 presents the design criteria for transit system ancillary facility noises in each of the community are categories defined in Table 1.

Table 8 Criteria for Noise from Transit System Ancillary Facilities

Community Area Category		Maximum Noise Level - dBA	
		Transient Noises	Continuous Noises
I	Low Density Residential	50	40
II	Average Residential	55	45
III	High Density Residential	60	50
IV	Commercial	65	55
V	Industrial / Highway	75	65

The criteria in Table 8 should be applied at a distance of 50 ft from the shaft outlet or other ancillary facility or should be applied at the setback line of the nearest buildings or occupied area, whichever is closer.

As previously stated, transient noise design criteria apply to short time duration events such as train passby noise transmitted from vent shaft openings. Continuous noise criteria apply to noises such as fans, cooling towers, or other long duration noises except electrical transformer hum. The criteria for transformer noise, or other noise sources with tonal components, should be 5 dBA less than given in Table 8.

16 .5.2 Fan and Vent Shafts

For fan and vent shafts with surface gratings or openings the noise shall be limited in accordance with the criteria for exterior noise from ancillary facilities presented in Table 8.

Vent shaft noise reduction shall be achieved by acoustical absorption treatment in the shafts applied to the walls and ceilings. Fan shaft noise reduction shall be achieved by use of standard duct attenuators in shafts where the fans are near the surface gratings. For shafts with fans located remotely from the grating the noise reduction shall be achieved by the use of standard attenuators and sound absorption treatment applied to the fan room and shaft walls and ceilings with the combination to achieve the total attenuation required. Where absorption treatment is necessary, the treatment shall have a minimum sound absorption coefficient of 0.6 at 250 Hz and 0.8 at 500 Hz.

16 .5.3 Substations and Emergency Power Generation

Substation and emergency power generation equipment noise shall be limited to 5 dBA less than the sound level than listed for continuous noise in Table 8. Reduction of noise from these sources shall be achieved by barriers, enclosures, sound absorption materials and mufflers, as applicable to the individual facility or unit design.

16 .5.4 VIBRATION ISOLATION OF TRANSIT STRUCTURES

16 .5.4.1 Scope

Vibration isolation shall be provided at any point where a subway, aerial structure column, aerial structure girder or other structure is in direct contact with, supported on, or supporting a building structure), or at any point where a subway structure, station structure or other transit structure is in very' lose proximity or directly against a building structure or building foundation element.

16 .5.4.2 General Considerations

Vibration isolation in the form of a resilient element shall be provided between the transit structure elements and building structure elements to prevent direct transmission of noise and vibration to buildings.

16 .5.4.3 Isolation Elements

For underground transit structures near or at buildings, the resilient element between the two structures shall consist of intervening soil of at least 2 ft thickness or depth. If the separation between the two structures is less than 2 ft, then an elastomer pad plus the intervening soil shall be the resilient element between the transit structure and building. the elastomer pad shall be a 1 in to 2 in thick closed-cell expanded neoprene, selected to give proper support of hydraulic or structural loads with deflection of the elastomer pad not exceeding 10% to 20% of pad thickness.

For aerial structure columns or girders, the transit structures should be separately founded from buildings and resilient bearing pads or elastomer separation elements provided between the transit structures and the building. There shall be no rigid connection between the building elements and the transit structure elements.

16 .6 WAYSIDE NOISE FROM SERVICE AND INSPECTION YARDS

The principal noises that have been found to create annoyance in communities near S & I yards are the noise from the transit cars, including:

The wheel squeal which results when the cars move on short radius curves entering the yard or on loop tracks

The noise from auxiliary equipment on the cars

The noise from car propulsion systems and the wheel and rail interaction when the cars are moving on the track, and

The pings, clicks and bangs that occur as wheels pass over frogs and joints in the special trackwork included in the yard.

These sources produce randomly occurring noises which are of considerably different character than typical community background noise and if of sufficient level can be noticeable and intrusive. Table 9 presents design criteria for noise control at S & I Yards applicable to residential areas, again using the community categories defined in Table 1. The criteria presented should be applied at the nearest affec$_t$ed residential properties. If necessary to be compatible with existing noise ordinances, the criteria should apply at the

S & I Yard property line or the boundary line dividing the industrial/commercial and residential zones.

TABLE 9 Criteria for Maximum Airborne Noise from Metro Train Operations at Service and Inspection Yards Adjacent to Residential Areas

	Community Area Category	Maximum Noise Level - dBA
I	Low Density Residential	55
II	Average Residential	55
III	High Density Residential	65
IV	Commercial	65
V	Industrial/Highway	70

16 .7 CONSTRUCTION NOISE AND VIBRATION CONTROL

16 .7.1 General

The requirements of this Section are intended to provide general guidelines to minimize construction noise and vibration and may not be applicable in all situations. More detailed noise and vibration control specifications may be necessary for certain construction contracts. These specifications should be reviewed by a competent acoustical consultant.

Perform construction operations in a manner to minimize noise and vibration. Provide working machinery and equipment with efficient noise suppression devices and employ other noise and vibration abatement measures necessary for protection of both employees and the public. In addition, restrict working hours and schedule operations in a manner that will minimize to the greatest extent feasible the disturbance to the public in areas adjacent to the work and to occupants of buildings in the vicinity of the work. Protect employees and the public against noise exposure in accordance with the requirements of the Occupational Safety and Health Act of 1970 and the current statutory noise limits set by the Occupational Safety and Health Administration, specifically 29 CFR 1910.95 (Occupational Noise Control). Compliance with the requirements of this Section will not relieve the Contractor from responsibility for compliance with state and local ordinances, regulations, and other Sections of this criteria document.

16 .7.2 Special Requirements

Compliance with the requirements of this Section will require the use of machines with effective mufflers or enclosures and selections of quieter alternative procedures. Compliance may also require the use of completely or partially closed enclosures (tongue and groove plywood or sheathing) around work sites or a combination of closed boarding and effective mufflers or enclosures. It will also be necessary to arrange haul routes to minimize noise and vibration at residential

sites and it may be necessary to place operating limitations on machines and trucks. Shop drawings of work sites and haul routes showing provisions for control of construction noise shall be submitted to the Engineer for approval. Calculations of effective noise dampening and attenuation, via noise absorption and transmission data and calculations, shall be evaluated by an Acoustical Engineer.

16 .7.3 Monitoring

Monitor noise and vibration levels of work operations to assure compliance with the noise and vibration limitations contained herein and retain records of noise and vibration measurements for inspection by the Engineer. Promptly inform the Engineer of any complaints received from the public regarding noise and vibration. Describe the action proposed and the schedule for implementation and subsequently inform the Engineer of the results of the action.

16 .7.4 Definitions

Daytime/Nighttime - Daytime refers to the period from 7 a.m. to 7 p.m. local time daily except Sundays and legal holidays. Nighttime, refers to all other times including all day Sunday and legal holidays.

Construction Limits - Construction Limits are defined for the purpose of these noise and vibration control requirements as the Right-of-Way lines, Construction Easement Boundary or property lines as indicated on the drawings.

Special Zones or Special Construction Sites - There are two types of Special Zones. The first is that designated at the request of the contractor. These may be designated outside of the construction site by the agency having jurisdiction where the construction site is located. These specially designated zones shall be treated by the contractor as if they were within the construction limits.

The second type of Special Zone is that designated by the local agency having jurisdiction and may have specific noise level and working tome restrictions.

16 .7.4.1 Noise Level Restrictions

Noise Level Restrictions in All Areas. In no case expose the public to construction noise levels exceeding 90 dBA (slow) or to impulsive noise levels with a peak sound pressure level exceeding140 dBA as measured on an impulse sound level meter or 125 dBA maximum transient level as measured on a general purpose sound level meter on "fast" meter response.

Noise Level Restrictions at Affected Structures. Conduct construction activities in such a manner that the noise levels 200 ft from the Construction Limits or at the nearest affected building, whichever is closer, do not exceed the levels listed in Tables 10 and 11.

Continuous Noise. Prevent noises from stationary sources, parked mobile sources or any sources or combination of sources producing repetitive or long-term noise lasting more than two hours from exceeding the limits of Table 10.

TABLE 10 LIMITS FOR CONTINUOUS CONSTRUCTION NOISE

Affected Structure or Area	Maximum Allowable Continuous Noise Level	
	Daytime dBA	Nighttime dBA
Residential		
Single family residential areas, not along a major arterial	**60**	**50**
Along an arterial or in multi-family residential areas, including hospitals	**65**	**65**
In semi-residential/commercial areas, including hotels	**70**	**60**
Commercial		
In semi-residential/commercial areas, including schools	**70**	**65**
In Commercial areas with no nighttime residency	**75**	**70**
Industrial		
All locations	**80**	**80**

Intermittent Noise - Prevent noises from non-stationary mobile equipment operated by a driver or from any source of non-scheduled, intermittent, non-repetitive, short-term noises not lasting more than two hours from exceeding the limits of Table 11.

TABLE 11 LIMITS FOR INTERMITTENT CONSTRUCTION NOISE

Affected Structure or Area	Maximum Allowable Continuous Noise Level	
	Daytime dBA	Nighttime dBA
Residential		
Single family residential areas, not along a major arterial	**75**	**60**
Along an arterial or in multi-family residential areas, including hospitals	**75**	**65**
In semi-residential/commercial areas, including hotels	**80**	**70**

Commercial		
In semi-residential/commercial areas, including schools	**80**	**80**
In Commercial areas with no nighttime residency	**85**	**85**
Industrial		
All locations	**90**	**90**

Special Zone or Special Construction Site. In areas outside of Construction Limits but for which the Contractor has obtained designation as a Special Zone or Special Construction Site from agency having jurisdiction, the noise limitations for buildings in industrial areas apply.

In zones designated by the local agency having jurisdiction as a special zone or special premise or special facilities, such as hospital zones, the noise level and working time restrictions imposed by the agency shall apply. These zones and work hour restrictions shall be obtained by the Contractor from the local agency.

More Than One Limit Applicable - Where more than one noise limit is applicable, use the more restrictive requirement of determining compliance.

16 .7.5 Noise Emission Restrictions

Use only equipment meeting the noise emission limits listed in Table 12, as measured at a distance of 50 feet from the equipment in substantial conformity with provisions of the latest revisions of SAE J366b, SAE J88 and SAE J952b or in accordance with the measurement procedures specified herein.

TABLE 12 NOISE EMISSIONS ON CONSTRUCTION NOISE

Type of Equipment	Maximum Noise Limit Date Equipment was Acquired	
	Before 01/01/1990 dBA	On or After 01/01/1990 dBA
All equipment other than highway trucks; including hand tools and heavy equipment	**90**	**85**
Highway trucks in any operating mode or location	**83**	**80**

16 .7.6 Vibration Level Restrictions

Vibration Limits in all areas: In order to minimize annoyance or interference to occupants of affected buildings, the contractor shall conduct construction activities in such a manner that ground vibration at the nearest occupied building do not exceed the following peak particle velocity (PPV) magnitudes in any direction.

	Vibration Velocity Magnitude - in/sec (PPV)
Sustained(≥ 1 hr/day)	0.03
Intermittent(< 1 hr/day)	0.07
Intermittent(< 10 min/day)	0.10

To avoid physical damage to buildings, the contractor shall conduct construction activities in such a manner that the maximum ground vibration magnitude at all times does not exceed 0.2 in/sec(PPV) in any direction for buildings which are in generally sound condition.

For buildings or historical monuments that are considered particularly fragile (as determined by a competent structural engineer) due either to the method of construction or a weakened condition resulting from the age of the structure, the contractor shall conduct construction activities in such a manner that the maximum ground vibration magnitude at all times does not exceed 0.12 in/sec (PPV) in any direction.

Special Zones. In zones designated by the local agency having jurisdiction as a special zone or special premise or special facilities, the vibration level and working time restrictions imposed by the agency shall apply. These zones and work hour restrictions shall be obtained by the contractor from the local agency.

16 .7.7 Noise and Vibration Control Requirements

Notwithstanding the specific noise and vibration level limitations specified herein, utilize the noise and vibration control measures listed below to minimize to the greatest extent feasible the noise and vibration levels in all areas outside the Construction Limits.

Utilize shields, impervious fences or other physical sound barriers to inhibit transmission of noise.

Utilize sound retardant housings or enclosures around noise producing equipment.

Utilize effective intake and exhaust mufflers on internal combustion engines and compressors.

Line or cover hoppers, storage bins and chutes with sound deadening material:

Do not use air or gasoline driven saws.

Conduct truck loading, unloading and hauling operations so that noise and vibration is kept to a minimum.

Route construction equipment and vehicles carrying spoil, concrete or other materials over streets and routes that will cause the least disturbance to residents in the vicinity of the work. Advise the Engineer in writing of the proposed haul routes prior to securing a permit from the local government.

Site stationary equipment to minimize noise and vibration impact on the community, subject to approval of the Engineer.

Use vibratory pile drivers or auguring for setting piles in lieu of impact pile drivers. If impact pile drivers must be used, their use is restricted to the hours from 8 a.m. to 5 p.m. weekdays in residential and in semi-residential/commercial areas.

16 .8 Glossary of Terms

16 .8.1 A-Weighted Sound Level (dBA):

The sound pressure level in decibels as measured on a sound level meter using the internationally standardized A-weighting filter or as computed from sound spectral data to which A-weighting adjustments have been made. A-weighting de-emphasizes the low and very high frequency components of the sound in a manner similar to the response of the average human ear. A-weighted sound levels correlate well with subjective reactions of people to noise and are universally used for community noise evaluations.

16 .8.2 Accelerometer:

A vibration sensitive transducer that responds to the vibration acceleration of a surface to which it is attached. The electronic signal generated by an accelerometer is directly proportional to the surface acceleration.

16 .8.3 Acceleration Level:

Also referred to as "vibration acceleration level". Vibration acceleration is the rate of change of speed and direction of a vibration. An accelerometer generates an electronic signal that is proportional to the vibration acceleration of the surface to which it is attached. The acceleration level is 20 times the logarithm to the base 10 of the ratio of the RMS value of the acceleration to a reference acceleration. The generally accepted reference vibration acceleration is 10-6 g (10-5 m/sec).

16 .8.4 Ambient Noise:

The prevailing general noise existing at a location or in a space, which usually consists of a composite of sounds from many sources near and far.

16 .8.5 Background Noise:

The general composite non-recognizable noise from all distant sources, not including nearby sources or the source of interest. Generally background noise consists of a large number of distant noise sources and can be characterized by L90 or L99.

16 .8.6 Community Noise Equivalent Level (CNEL):

The Leq of the A-weighted noise level over a 24-hour period with a 5 dB penalty applied to noise levels between 7 p.m. and 10 p.m. and a 10 dB penalty applied to noise levels between 10 p.m. and 7 a.m.

16 .8.7 Day-Night Sound Level (Ldn):

The Leq of the A-weighted noise level over a 24-hour period with a 10 dB penalty applied to noise levels between 10 p.m. and 7 a.m.

16 .8.8 Decibel (dB):

The decibel is a measure on a logarithmic scale of the magnitude of a particular quantity (such as sound pressure, sound power, sound intensity) with respect to a standardized quantity.

A dimensionless unit relating the logarithm of the ratio of the threshold of sound perception to the threshold of pain from sound. The decibel scale of 1 - 140 describes this extremely large range from 20 micropascals to 200,000,000 micropascals.

16 .8.9 Energy Equivalent Level (Leq):

The level of a steady noise which would have the same energy as the fluctuating noise level integrated over the time period of interest. Leq is widely used as a single-number descriptor of environmental noise. Leq is based on the logarithmic or energy summation and it places more emphasis on high noise level periods than does L50 or a straight arithmetic average of noise level over time. This energy average is not the same as the average of sound pressure levels over the period of interest, but must be computed by a procedure involving summation or mathematical integration.

16 .8.10 Frequency (Hz):

The number of oscillations per second of a periodic noise (or vibration) expressed in Hertz (abbreviated Hz). Frequency in Hertz is the same as cycles per second.

16 .8.11 L1, L10, L50, L90 and L99:

The noise (or vibration) levels that are exceeded 1%, 10%, 50%, 90% and 99% of a specified time period, respectively. Environmental noise and vibration data are often described in these terms.

16 .8.12 Noise Criterion Curves (NC Curves):

A series of curves which specify the maximum sound pressure level in each octave band between 63 Hz and 8,000 Hz used to characterize the noisiness of steady sounds in an occupied indoor space.

16 .8.13 Noise Exposure Level (NEL):

Noise Exposure Level (NEL), also referred to as Sound Exposure Level (SEL), is a time integrated metric which quantifies the total energy in A-weighted noise (sound) level measured during a particular event referenced to a duration of 1 second.

16 .8.14 Noise Reduction (NR):

Noise reduction, also referred to as noise level reduction (NLR) is the overall difference between the exterior and interior sound levels of a building space, taking into account the sound transmission loss of all structural elements (walls,

roofs, doors, windows, etc.) and the interior sound absorptive characteristics of the space.

16 .8.15 Noise Reduction Coefficient (NRC):

Noise reduction coefficient is a measure of the acoustical absorption performance of a material, calculated by averaging its sound absorption coefficients at 250 Hz, 500 Hz, 1000 Hz and 2000 Hz.

16 .8.16 Octave Band - 1/3 Octave Band:

One octave is an interval between two sound frequencies that have a ratio of two. For example, the frequency range of 200 Hz to 400 Hz is one octave, as is the frequency range of 2000 Hz to 4000 Hz. An octave band is a frequency range that is one octave wide. A standard series of octaves is used in acoustics, and they are specified by their center frequencies. In acoustics, to increase resolution, the frequency content of a sound or vibration is often analyzed in terms of 1/3 octave bands, where each octave is divided into three 1/3 octave bands.

16 .8.17 Reverberant Field:

The region in a room where the reflected sound dominates, as opposed to the region close to the noise source, where the direct sound dominates.

16 .8.18 Reverberation:

The continuation of sound reflections within an enclosed space after the sound source has stopped.

16 .8.19 Reverberation Time (RT):

The time taken for the sound pressure level in a room to decrease to one-millionth (60 dB) of its steady-state value after the source of sound energy is suddenly interrupted. It is a measure of the persistence of a sound in a room and of the amount of acoustical absorption present inside the room.

16 .8.20 Sound Absorption Coefficient (α):

The absorption coefficient of a material is the ratio of the sound absorbed by the material to that absorbed by an equivalent area of open window. The absorption coefficient of a perfectly absorbing surface would be 1.0 while that for concrete or marble slate is approximately 0.01 (a perfect reflector would have an absorption of 0.00).

16 .8.21 Sound Exposure Level (SEL):

See definition of Noise Exposure Level

16 .8.22 Sound Pressure Level (SPL):

The sound pressure level of sound in decibels is 20 times the logarithm to the base of 10 of the ratio of the RMS (root-mean square) value of the sound pressure to the RMS value of a reference sound pressure. The standard reference sound pressure is 20 micro-pascals as indicated in ANSI S1.8-1969, "Preferred Reference Quantities for Acoustical Levels".

16 .8.23 Sound Transmission Class (STC):

STC is a single number rating, specified by the American Society for Testing and Materials (ASTM), which is used for comparing the sound transmission characteristics (in decibels) of building elements. It is widely used for rating sound insulation characteristics of buildings materials and products for sources such as speech, radio, television and similar sounds within buildings.

16 .8.24 Velocity Level:

Also referred to as the "vibration velocity level". Vibration velocity is the rate of change of displacement of a vibration. The velocity level is 20 times the logarithm to the base 10 of the ratio of the RMS value of the velocity to the reference velocity. In this report the reported vibration velocity levels are all referenced to 10-6 in/sec. Above approximately 10 Hz, human response to vibration is more closely correlated to the velocity level than the acceleration level.

16 .8.25 Weighted Velocity Level:

The vibration velocity level to which a weighting factor has been added. The weighting de-emphasizes the low frequencies in a manner similar to human response to vibration.

16 .8.26 Statistical Distribution Terms

- L99 and L90 are descriptors of the typical minimum or "residual" background noise (or vibration) levels observed during a measurement period, normally made up of the summation of a large number of sound sources distant from the measurement position and not usually recognizable as individual noise sources. The prevalent source of this residual noise is distant street traffic. L99 and L90 are not strongly influenced by occasional local motor vehicle passbys. However, they can be influenced by stationary sources such as air conditioning equipment.

- L50 represents a long-term statistical median noise level over the measurement period and does reveal the long-term influence of local traffic.

- L10 describes typical levels or average for the maximum noise levels occurring, for example, during nearby passbys of trains, trucks, buses and automobiles, when there is relatively steady traffic. Thus, while L10 does not necessarily describe the typical maximum noise levels observed at a point, it is strongly influenced by the momentary maximum noise level occurring during vehicle passbys at most locations.

- L1, the noise level exceeded for 1% of the time is representative of the occasional, isolated maximum or peak level which occurs in an area. L1 is usually strongly influenced by the maximum short-duration noise level events which occur during the measurement time period and are often determined by aircraft or large vehicle passbys.

SECTION 17 RAIL YARDS AND RAIL SHOPS

17.1 GENERAL

This design criteria include design requirements for yards and shops for the Washington Metropolitan Area Transit Authority Metro Rail System. The yards will store the rapid transit trains, provide a storage area for the system maintenance and support the shops. The shops will perform repair, maintenance, and inspection services for the individual transit cars. Car cleaning will be performed in the yards.

17.2 SHOPS

17 .2.1 Transit Car Maintenance Philosophy

Efficient operation of the Metro Rail System requires the availability of a completely reliable service fleet of revenue cars sufficient to maintain scheduled service, while minimizing the total number of cars required. In order to accomplish this goal, maintenance operations will be divided into routine maintenance and major repair operations.

Routine maintenance, sometimes referred to as preventative maintenance involves the detection and resolution of minor maintenance problems before the malfunction either necessitates major overhaul of the transit car or causes a breakdown in service. Running repairs also are to be included in routine maintenance.

Major repair operations, sometimes referred to as heavy or specialized maintenance, involves complete rebuilding of cars, change out of major components, and major repairs. Modifications and retrofitting of new cars are to be included also.

The diverse natures of equipment and manpower requirements for these two types of maintenance make it desirable to separate the shop facilities at which these operations are performed. Routine maintenance work will be performed at Service and Inspection Shops, referred to hereafter as S&I Shops, and heavy or specialized maintenance work will be performed at a Major Repair Shop. The design of the shops shall be coordinated with the design of the yards to insure the various functions and yard layout requirements are provided.

The following comparisons of work items and equipment illustrate some of the differences in the maintenance activities of the two shops:

SERVICE AND INSPECTION SHOP

a. Cars are handled as married pairs.

b. Unit parts and components are replaced.

c. Running repairs are made when major disassembly of parts is not involved. Truck work may been an exception to this item.

MAJOR REPAIR SHOP

d. Portable hand tools are the workman's primary aid with few machine tools.

e. Majority of work is on-car requiring relatively small work support areas.

f. Complete cars are rapidly cycled.

g. Lubricants are replenished during servicing procedure.

a. Cars may be handled as single units.

b. Unit parts and components are rebuilt or repaired.

c. Major repairs are made when disassembly of unit pairs or major components are involved.

d. Extensive use is made of machine tools.

e. Majority of work is on major components requiring a relatively large support area.

f. Components are methodically routed through rebuilding process.

g. Lubricants are completely replaced during rebuilding procedure.

17 .2.2 Service and Inspection Shops

The shop shall be designed to facilitate the performance of scheduled inspection, minor repair, interior/exterior car cleaning, major truck repair, body repair and painting. The shop layout shall provide for segregation of work functions into designated areas to minimize interference with other functions and time lost in material handling. Aisles shall be kept clear of fixed equipment to allow free flow of materials. The layout shall be based on servicing 75 foot transit cars coupled into 150 ft. married pairs.

17 .2.3 Major Repair Shop

The System has two major repair shops, designed to accommodate the following functions:

17.2.3.1 Complete car overhaul, including body repair and painting.

17.2.3.2 Exchange of trucks.

17.2.3.3 Replacement, repair, overhaul and testing of car system components and sub-assemblies.

17.2.3.4 Extensive modifications.

17.2.3.5 Wheel truing.

17.2.3.6 Repair of miscellaneous system equipment.

17.2.3.7 New car acceptance and preparation.

17.2.3.8 Spare parts storage.

These tasks are oriented toward the rebuilding of complete cars or replacement of entire components and as such will require extensive periods of time. Consequently, the Major Repair Shop will be designed to service individual car operating units rather than complete trains. Accommodations to service at least 5% of the total system car fleet simultaneously are to be provided.

To accommodate staged construction of the WMATA transit system, the major repair shops were designed to incorporate a service and inspection a shop which shall accommodate three two-car units per inspection track.

17.3 YARDS

Yards for the Metro system shall satisfy two basic functions: Storage of trains for operations and support of the shops. Basic to the design of train storage facilities are the desires to minimize reverse movements and non-revenue car mileage, to optimize introduction to and removal of trains from revenue service, and to facilitate changes in train consists during different operating periods. In the design of yard layouts consideration shall be given to the maintenance facilities and equipment required in each yard and to the operation of each yard as it fits into the operating program of its division. Adequate visual and acoustical protection for the area surrounding the yard shall be developed during the design of the yard.

17 .3.1 General

Yards are divided into two types according to the functions which are to be performed. These are Storage Yards, and Service and Inspection Yards.

The following criteria shall be met in the design of all yards:

17.3.1.1 The length of car storage tracks shall be designed in multiples of two car modules with the desirable minimum capacity of eight cars.

17.3.1.2 A facility shall be provided for supervisory and yard and train operating personnel. This facility shall have a reporting and dispatching area and locker space.

17.3.1.3 Listed below is a summary of horizontal and vertical track alignment and turnout data for use in yards.

17 .3.1.3.1 All curves are to be simple curves, not requiring spiral transitions.

17 .3.1.3.2 The absolute minimum radius of a curve shall be 300 feet and the desirable minimum radius of a curve shall be 350 feet.

17 .3.1.3.3 1" superelevation is desirable in curves with a radius approaching the minimum radius for frequently used tracks, such as the yard entrance tracks and the yard loop tracks. Superelevation transition is to be accomplished in the first 50 feet and last 50 feet of the curve.

17 .3.1.3.4 Single ended storage tracks shall be sloped downward from the yard throat to the bumping post.

17 .3.1.3.5 Double ended storage tracks shall have a sag in their profile to prevent transit cars from rolling to either end.

17 .3.1.3.6 All tracks connecting with the mainline shall slope downward from the mainline unless otherwise approved by the Authority.

17 .3.1.3.7 Yard and secondary tracks shall have a maximum grade of 1.0 percent, and a minimum grade of 0.35 percent, except the desirable maximum grade on storage tracks shall be 0.2 percent downward towards the bumping post.

17 .3.1.3.8 Separate car wash buildings shall have a 0.35% gradient upward in the direction of washing.

17 .3.1.3.9 A flat gradient shall be used for S&I Shop Building and its lead tracks.

17 .3.1.3.10 Connections from main track to yard and secondary track shall be by No. 10 turnout.

17 .3.1.3.11 Connections between the yard, secondary and storage tracks shall be No. 6 Guarded turnouts, No. 8 turnouts and No. 10 Crossovers.

17 .3.1.3.12 It is desirable for storage and transfer tracks to be on tangent alignment. Curve alignment of the storage or transfer tracks shall require approval of the Authority.

17 .3.2 Storage Yards

The principal function of a storage yard is to store trains for operations with facilities provided for exterior and interior car cleaning. Secondary functions of a storage of maintenance equipment and possibly for developing a building which can be used for the performance of system maintenance services.

In addition to the general yard criteria, the following are specific requirements that pertain to storage yard layouts:

17.3.2.1 Yards shall be designed to allow eight-car trains to enter and exit under automatic train operation through the use of transfer tracks.

17.3.2.2 The transfer check shall have direct access to the mainline and shall be segregated from but provided direct access to the storage tracks. To simplify interface with ATO the special trackwork involving both yard and central control should be minimized. The transfer zone shall be a minimum of 650 feet long with a preferred length of 700 feet.

17.3.2.3 The storage tracks shall be constructed at alternating track centers of 14 feet minimum and 18 feet to permit access to cars by personnel and equipment. Each storage track's third rail shall have the capability of being independently electrically isolated. Limited air rights facilities can be accommodated with these track centers.

17.3.2.4 There shall be a Yard Operations Building of sufficient size to accommodate the following:

17 .3.2.4.1 Yard Office and first aid room.

17 .3.2.4.2 Reporting and dispatching area for operating personnel.

17 .3.2.4.3 Building mechanical equipment room.

17 .3.2.4.4 Lunchroom.

17 .3.2.4.5 Locker and wash rooms for operating personnel. Additional facilities shall be provided for car cleaning personnel when the building is located in the end of the car storage tracks.

17 .3.2.4.6 Shower rooms.

17 .3.2.4.7 Communications equipment room.

17 .3.2.4.8 Train control equipment room.

17 .3.2.4.9 Electrical equipment room.

17 .3.2.4.10 Small parts storage for transit cars.

17.3.2.5 There shall be a Yard Control Building of sufficient size to accommodate the following:

17 .3.2.5.1 Yard Control Tower.

17 .3.2.5.2 Train control equipment room.

17 .3.2.5.3 Communications equipment room.

17 .3.2.5.4 Electrical equipment room.

17 .3.2.5.5 Building mechanical equipment room.

17 .3.2.5.6 Technician's shop and tool room.

The Yard Control Building shall be placed in such a location as to provide the Control Tower maximum visual contact with the Yard Throat and storage tracks and to minimize the lengths of train control cable required in the yard.

17.3.2.6 A maintenance and storage area shall be provide to facilitate the performance of system maintenance services.

17.3.2.7 A sufficient parking area(s) shall be provided to accommodate employee and maintenance vehicles.

17.3.2.8 An emergency repair track of eight car lengths shall be provided for emergency repair of transit cars, with provisions to remove power from the third rail.

17.3.2.9 A double ended 400-foot track or two 200-foot stub-end tracks shall be provided for storage of maintenance equipment. This track is to be equipped with a third rail and a switch to remove power.

17.3.2.10 A substation building shall be located near the throat of the yard to minimize the length of traction power cable required.

17.3.2.11 Tie breaker stations shall be located near the special trackwork as required.

17.3.2.12 A platform at car floor height shall be placed across the end of the stub-end storage tracks with fingers extending between alternate tracks to allow entry into the first side doorway of the first car to facilitate daily interior cleaning.

A canopy shall be constructed over the platform and the fingers. An enclosed storage facility accessible to the platform shall be provided for transit car cleaning equipment. Steps shall extend from the platform to walkways between all tracks.

17.3.2.13 An enclosed building of approximately 30 feet by 350 feet shall be provided. The building shall accommodate an exterior car washing facility and a 160 foot open inspection pit for making emergency inspections and repairs of rapid transit cars. The exterior car wash shall have access from the transfer tracks to the storage yards without requiring a reverse movement of rapid transit trains. A minimum clear lead distance of 650 feet on each end of the exterior car wash building is desirable so that the exterior washing operation will not interfere with other operations of the yard. The building shall be located on tangent track. There shall be provision to remove power from the third rail section through the building which shall be controllable from within building.

17 .3.3 Service and Inspection Yards

A Service and Inspection Yard shall be made up of a Service and Inspection (S&I) Shop and a storage facility for rapid transit cars. The Service and Inspection Yard requirements are similar to those of the Storage Yard except that the building enclosing the exterior car washing facility and inspection pit and the eight-car emergency repair track are to be deleted since these operations will be performed within the S&I Shop. Equipment rooms for the Yard Control Building, listed in 2.e., may be consolidated with similar S&I Shop facilities.

Some additional requirements for an S&I Yard are as follows:

17.3.3.1 Direct access to S&I Shop entrance from the transfer tracks shall be provided so that transit cars can be moved directly into the shop for exterior washing, inspections and running repairs.

17.3.3.2 The car capacity of the shop entrance and exit lead tracks shall be as shown in Figure 17.1.

17.3.3.3 The shop exit tracks shall have access to car storage tracks and to transfer tracks without interfering with normal shop operations. This will assure an efficient flow of cars out of the S&I Shop.

17.3.3.4 A bypass track shall be provided to facilitate easy access to either end of the S&I Shop and to minimize interference of yard operation with shop operation.

17.3.3.5 Entrance to the S&I Shop from the storage yard shall be designed with a minimum of necessary reverse movements of the transit cars.

17 .3.4 On-Line Emergency Storage

On-Line Emergency Storage will provide a short-term emergency storage facility for malfunctioning cars.

On-Line Emergency Storage shall be designed to mainline alignment and grade standards, with the desirable minimum capacity of eight cars per track. At terminal stations where emergency storage tracks are to be provided the storage tracks shall be located beyond the point of safe braking distance so that automatic train operation can be maintained. The emergency storage tracks shall be sloped downward from the station platform.

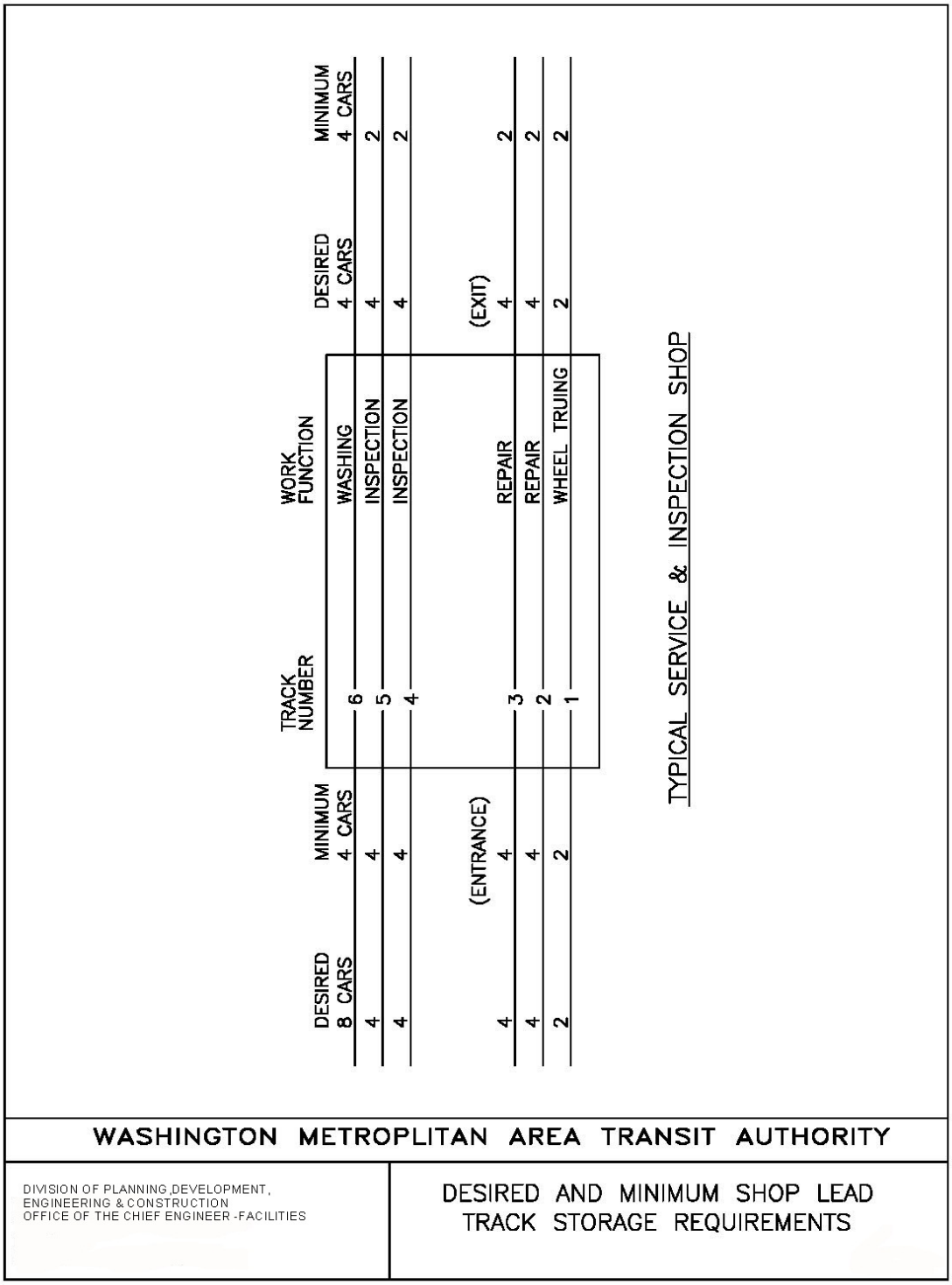
TYPICAL SERVICE & INSPECTION SHOP
DESIRED 8 CARS
MINIMUM 4 CARS
(ENTRANCE)
TRACK NUMBER
WORK FUNCTION
DESIRED 4 CARS
MINIMUM 4 CARS
(EXIT)
6
WASHING
4 4
4 4
5
INSPECTION
4 4
4 2
4
INSPECTION
4 4
4 2
3
REPAIR
4 4
4 2
2
REPAIR
4 4
4 2
1
WHEEL TRUING
2 2
2 2
WASHINGTON METROPLITAN AREA TRANSIT AUTHORITY
DIVISION OF PLANNING,DEVELOPMENT,
ENGINEERING & CONSTRUCTION
OFFICE OF THE CHIEF ENGINEER -FACILITIES
DESIRED AND MINIMUM SHOP LEAD
TRACK STORAGE REQUIREMENTS

FIGURE 17.1

SECTION 18 BUS SERVICE AREA

18.1 GENERAL DESIGN CONSIDERATIONS

18.1.1 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.

18.1.2 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.

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

18.1.3.1 Queuing
18.1.3.2 Fare removal
18.1.3.3 Fueling and minor maintenance/fluid checks
18.1.3.4 Interior cleaning (usually done at the same time as fueling service)
18.1.3.5 Exterior cleaning

18.1.4 Since fueling and washing take approximately the same amount of time, a linear (in-line) 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.

18.1.5 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.

18.1.6 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 (~~8~~ 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.

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

18.1.8 Fast actuating rollup doors should be used for service lane entrance and exit doors. ~~Due to their low maintenance and fast speed of operation, hydraulic four-fold (biparting bi-fold) doors should be used for the service lane entrance and exit doors. These shall be steel doors equal to model 46 as manufactured by Electric Power Door (522 West 27th Street, Hibbing, MN 55746, 1-800-346-5760) or equivalent. Hydraulic four-fold doors typically have significantly more opening and closing cycles before needing maintenance, repair or replacement than traditional overhead doors. With an opening speed of 2-feet per second, these doors are also significantly faster in operation, thereby conserving energy costs and increasing the efficiency of the operation.~~

~~**18.1.9** Refer to Figure 18.1 for a typical service lane layout.~~

18.2 SERVICE LANE QUEUING

18.2.1 From 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.

18.2.2 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. No bus awaiting service in this arrangement should extend into a street.

18.3 FARE REMOVAL

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

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

18.3.1.2 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.

18.3.1.3 2 CCTV camera/vault.

18.3.2 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.

18.3.2.1 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.

18.4 FUELING AND MAINTENANCE FLUIDS/UTILITIES

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

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

18.4.1.2 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.

18.4.1.3 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.

18.4.1.4 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.

18.4.1.5 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.

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

18.4.1.5.1.1 Starters and circuit breakers

18.4.1.5.1.2 H-O-A switches for each pump

18.4.1.5.1.3 Test switches

18.4.1.5.1.4 Running lights – indicators for each pump

18.4.1.5.1.5 Required switches for the remote control panel

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

18.4.2 Storage Tanks

18.4.2.1 Underground Storage Tanks

18.4.2.1.1 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.

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

18.4.2.1.3 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:

18.4.2.1.3.1	Diesel Fuel	2 – 20,000 Gallon Storage Tanks
18.4.2.1.3.2	Engine ~~Motor~~ Oil	2 – 3,000 Gallon Storage Tanks
18.4.2.1.3.3	Automatic Transmission Fluid	1 – 6,000 Gallon Storage Tank
18.4.2.1.3.4	Engine Coolant ~~Antifreeze~~	1– 6,000 Gallon Storage Tank
18.4.2.1.3.5	Gasoline (Non-Revenue Vehicles)	1 – 8,000 Gallon Storage Tank

18.4.2.1.4 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:

18.4.2.1.4.1 Two watertight man ways

18.4.2.1.4.2 Mechanical high level cut-off valve

18.4.2.1.4.3 Interstitial and man way leak detection

18.4.2.1.4.4 Positive displacement flow meter.

18.4.2.1.4.5 Inventory control and high level alarm systems

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

18.4.2.1.4.7 Overfill prevention (fill limiter valve and audible alarm)

18.4.2.1.4.8 Individual service access for all functions.

18.4.2.1.5 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.

18.4.2.1.6 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.

18.4.2.1.7 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.

18.4.2.1.8 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.

18.4.2.1.9 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.

18.4.2.1.10 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.

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

18.4.2.1.12 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.

18.4.2.2 Above Ground Storage Tanks.

18.4.2.2.1 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.

18.4.2.2.2 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.

18.4.2.2.3 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.

18.4.2.2.4 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.

18.5 OVERHEAD SERVICE REELS

18.5.1 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:

18.5.1.1 Engine coolant (EC) ~~Antifreeze~~

18.5.1.2 Automatic transmission fluid (ATF)

18.5.1.3 Compressed air (CA)

18.5.1.4 Engine ~~Motor~~ oil (EO)

18.5.1.5 Water

18.5.1.6 Chassis grease (CG)

18.5.1.7 Gear oil (GO)

18.5.1.8 Windshield washer fluid (WWF)

18.5.2 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.~~

18.5.3 Hose

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

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

18.5.5 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.

18.6 CLEANING

18.6.1 Bus Interior Cleaning

18.6.1.1 Methods / Equipment

18.6.1.1.1 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.

18.6.1.1.2 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.

18.6.1.1.3 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.

18.6.2 Bus Exterior Cleaning

18.6.2.1 Methods and Equipment Options

18.6.2.1.1 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.

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

18.6.2.1.3 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.

18.6.2.1.4 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.

18.6.2.1.5 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.

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

~~**18.6.2.2.1** Manufacturers: Ross & White Company, N/S Corporation, SSI Corporation or equivalent.~~

18.6.2.2.1 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.

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

18.6.2.2.3 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.

18.6.2.2.4 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.

18.6.2.2.5 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.

18.6.2.2.6 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.

18.6.2.2.7 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~~.

18.6.2.2.8 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~~.

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

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

18.6.2.2.11 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.

18.6.2.2.12 Water Reclamation System: As follows:

18.6.2.2.12.1 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.

18.6.2.2.12.2 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.

18.7 FLUID MONITORING SYSTEM.

18.7.1 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.

18.7.2 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.

18.8 TYPICAL SERVICE LANE DESIGN

18.8.1 Typical Plan Layout With Critical Dimensions: Refer to Figure 18.1 .

18.8.1.1 Design Considerations

18.8.1.1.1 Dimensional Criteria

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

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

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

18.8.1.1.1.4 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.

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

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

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

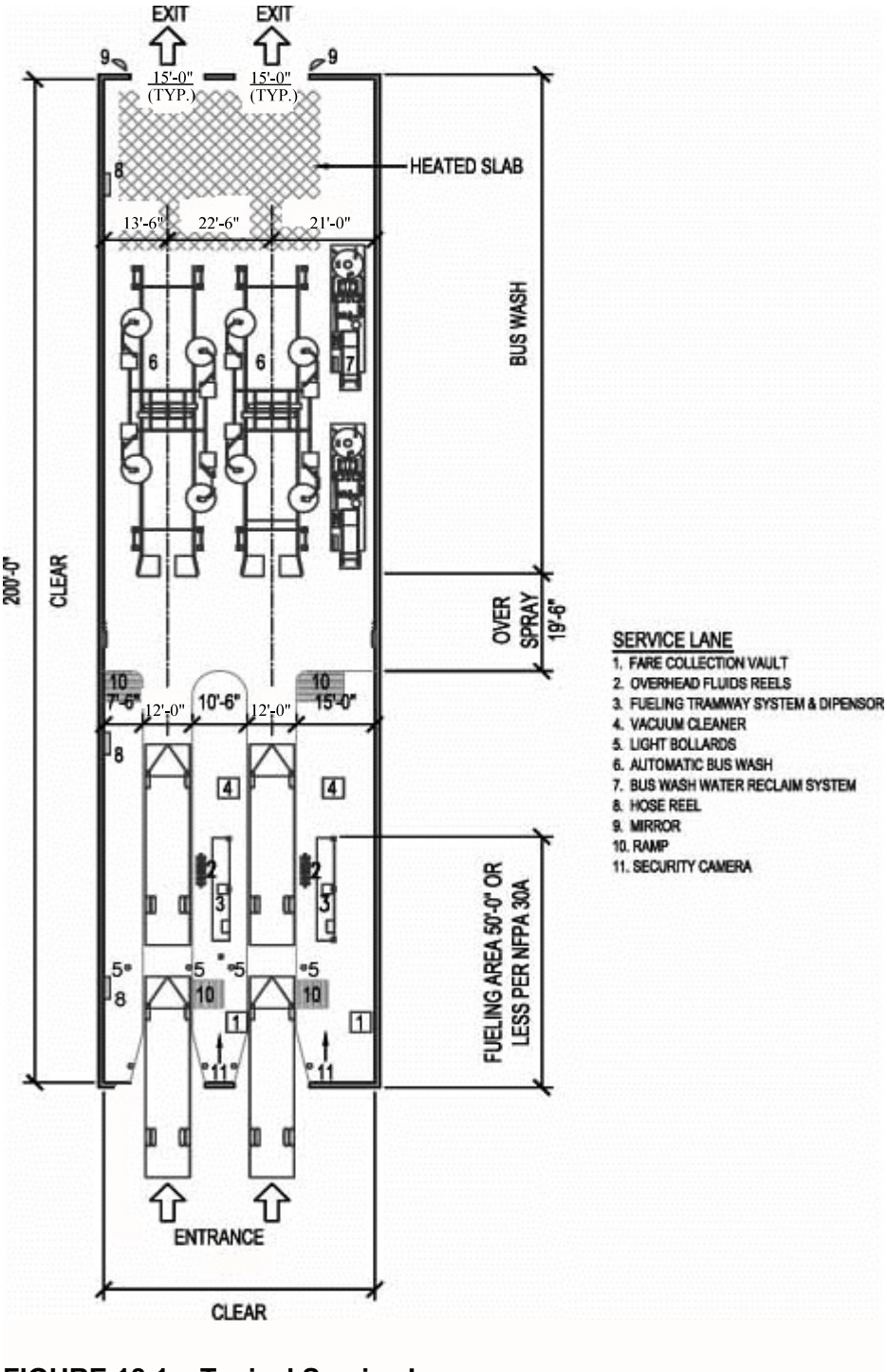

FIGURE 18.1 – Typical Service Lane

18.8.1.1.1.8 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.

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

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

18.8.1.1.1.10.1	Service Lane	16'-0" clear
18.8.1.1.1.10.2	Maintenance Lift Area	20'-0" clear
18.8.1.1.1.10.3	Bus Storage Area (Shading)	15'-0" clear
18.8.1.1.1.10.4	Bus Parts Storeroom	10'-0" clear
18.8.1.1.1.10.5	Paint Booth	21'-0" clear
18.8.1.1.1.10.6	Boiler Room	16'-0" clear
18.8.1.1.1.10.7	Electrical Distribution Room	16'-0" clear
18.8.1.1.1.10.8	Communications Equipment Room	10'-0" clear
18.8.1.1.1.10.9	Office Areas	8'-0" clear
18.8.1.1.1.10.10	Repair Shops	12'-0" clear

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

18.8.1.1.2 Other Design Considerations

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

18.8.1.1.2.2 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.

18.8.1.1.2.3 One service lane will service approximately ~~8~~ 100 buses per day.

18.8.1.1.2.4 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.

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

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

18.8.1.1.2.7 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.

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

18.8.1.1.2.9 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).

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

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

18.8.1.1.2.12 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.

18.8.1.1.2.13 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.

18.8.1.1.2.14 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.

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

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

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

18.8.1.1.2.18 Entrance door operation for the service lanes shall be ~~hydraulic four-fold, high speed doors~~ rollup fast actuating type.

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

18.8.1.1.2.20 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.

18.8.1.1.2.21 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.

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

18.8.1.1.2.23 Slope the slab on grade to the floor drains.

18.8.1.1.2.24 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.

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

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

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

18.8.1.1.2.28 Provide overhead service reels in the service lane.

SECTION 19 BUS MAINTENANCE, BUS STORAGE & ADMINISTRATIVE REQUIREMENTS

19.1 MAINTENANCE AREA

19.1.1 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. Such servicing and repair includes, but is not limited to tune-ups, lubrication, parts replacement, tire repair and replacement, and body repairs and painting.

19.1.2 Vehicular Traffic Pattern

19.1.2.1 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.

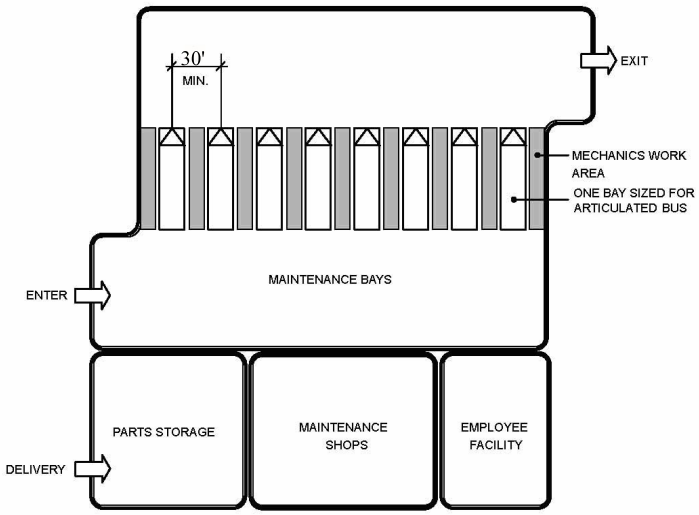

FIGURE 19.3 - Maintenance Area Diagram

19.1.2.2 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.

19.1.3 Maintenance Bays:

19.1.3.1 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.

19.1.3.2 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:

19.1.3.2.1 Steam clean bay (enclosed).

19.1.3.2.2 Tire changing bay.

19.1.3.2.3 HVAC repair bay.

19.1.3.2.4 Handicapped lift repair bay.

19.1.3.2.5 Articulated bus and intercity coach bus repair bay.

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

19.1.3.3 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.

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

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

19.1.4 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~~:

19.1.4.1 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.

19.1.4.2 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.

19.1.4.2.1 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.

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

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

19.1.4.3 In-ground Lifts:

19.1.4.3.1 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.

19.1.4.3.2 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.

19.1.5 Overhead Service Reels:

19.1.5.1 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.~~

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

19.1.6 Hoists / Cranes:

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

19.1.6.1 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.~~

19.1.6.2 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).~~

19.1.7 Miscellaneous Maintenance Equipment

19.1.7.1 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.

19.1.7.2 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.

19.1.7.2.1 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.

19.1.7.2.2 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.

19.1.7.3 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.

19.1.7.4 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.

19.1.7.5 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~~.

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

19.1.7.5.2 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.

19.1.7.6 Large Parts Shelving & Storage:

19.1.7.6.1 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.

19.1.7.6.2 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.

19.1.7.7 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.

19.1.7.8 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.

19.1.7.9 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.

19.1.7.10 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.

19.1.7.11 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.

19.1.7.12 Moveable / Mobile Equipment:

19.1.7.12.1 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.

19.1.7.12.2 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.~~

19.1.7.12.3 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.

19.1.7.12.4 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.

19.1.7.13 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.

19.1.7.14 ~~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.

19.1.7.15 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.~~

19.1.8 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.

19.1.9 Paint Preparation Area, Paint Booth and Paint Shop

19.1.9.1 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.

19.1.9.2 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.

19.1.9.3 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.

19.1.10 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.

19.1.11 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 ~~Rotomax~~ Paint Storage System, large parts shelving, large parts storage cabinets and small parts drawer storage ~~cabinets as specified above a Rotomax Paint Storage System~~. Include a service door for parts deliveries.

19.1.12 Tire Storage

Provide a room for tire storage with enough height to accommodate vertical storage of tires and a ~~bridge~~ jib crane and other tire handling equipment ~~with chain hoist as specified above~~. Provide tire storage racks constructed of steel with typical construction as shown in Figure 19.1 below. Tire storage to be located adjacent to Tire Bay.

19.1.13 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.

19.1.14 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.

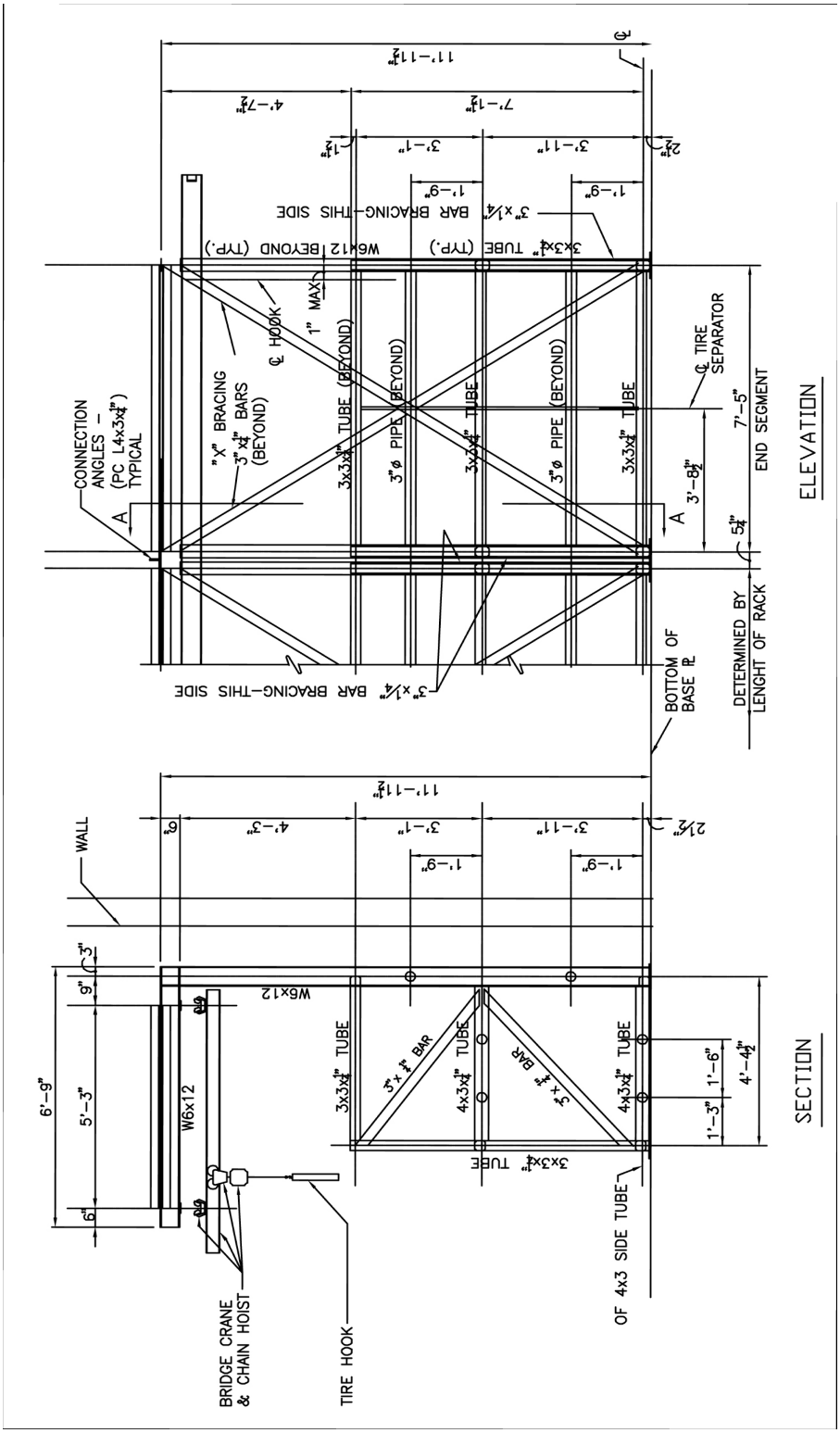

FIGURE 19.1 - Tire Storage Rack Details

19.2 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.

19.2.1 CIRCULATION AND PARKING PATTERNS

19.2.1.1 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.

19.2.1.2 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.

19.2.1.3 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.

19.2.1.4 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.

19.2.1.5 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.

19.2.2 PAVING

19.2.2.1 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.

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

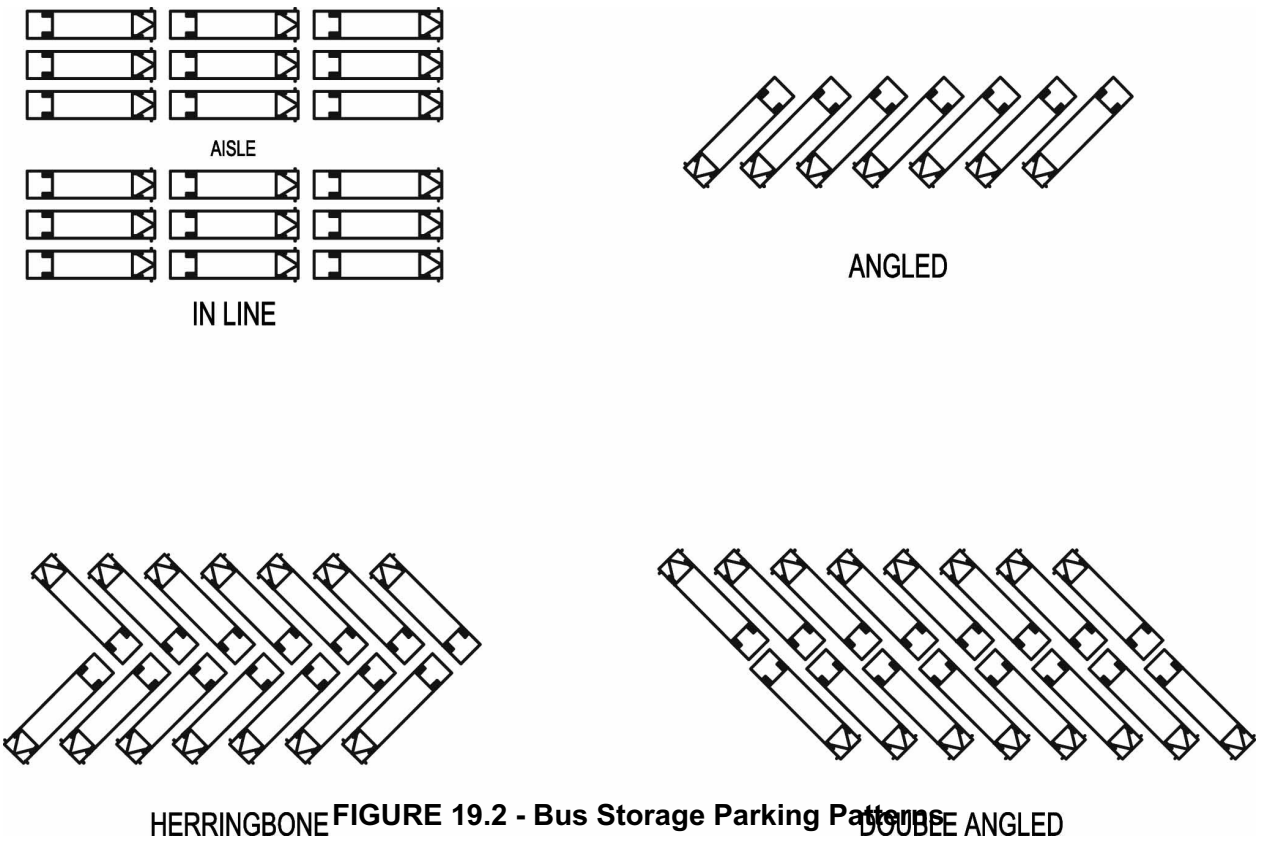

FIGURE 19.2 - Bus Storage Parking Patterns

19.2.3 SERVICES

19.2.3.1 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.

19.2.3.2 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.

19.2.4 SECURITY

19.2.4.1 Land use, zoning, and neighborhood characteristics must all be considered when designing perimeter security. Controlled access to the facility is necessary, not only for protection of vehicles and equipment, but for protection of personnel. There are two types of facilities to secure; those built to the property line and those that are set back. Lot line structures can usually be secured through prudent location of windows and doors, minimizing street level access. The setback facility involves more complex issues. While wire mesh fencing with razor ribbon will deter most intruders, it may not be compatible with the community. Concealment of razor ribbon and other obstacles is prohibited.

19.2.4.2 Building security shall involve control of unauthorized access to the facility as well as internal property protection. Supervisors shall have clear views of work and storage areas for safety as well as security. Where this is not possible, electronic surveillance, including closed circuit television (CCTV), shall be provided. See WMATA Manual of Design Criteria - Systems for electrical and electronic security system requirements.

19.2.4.3 Security Booth

19.2.4.3.1 An insulated, weatherproof, minimum 8'-0" by 12'-0" booth shall be provided for 24-hour direct and remote monitoring of site access, revenue areas and fire alarms. The booth shall be located at the main security gate for setback facilities, or at the service lane entrance for lot-line structures. The booth may be elevated above grade, where prudent, to enhance surveillance, but shall allow observation of vehicle occupants from inside.

19.2.4.3.2 The unit shall be shipped completely assembled and ready to set in place on foundations on the site. Fluorescent lighting fixtures shall be ceiling mounted. In addition, required wiring, duplex outlets, electrical heater (including thermostat), air conditioner, exhaust fan and circuit breaker box shall be provided.

19.2.4.3.3 Wall assembly shall be welded, galvanized steel construction with 14 gauge steel panels and tubing on the exterior and 18 gauge panels on the interior. Floor shall be constructed of 12 gauge galvanized steel, 4-way safety plate. All exposed interior and exterior steel surfaces shall be electrostatically painted. Walls and roof to be fully insulated.

19.2.4.3.4 Door shall be weatherstripped, of hollow metal steel construction and provided with a vision panel. Sliding windows shall be aluminum frame construction with glass and screens included. Clear, tempered safety glass (1/8" minimum thickness) shall be used for door glazed vision panel and windows.

19.2.4.3.5 Unit to be furnished with personnel lockers (48" high), writing counter, one standard desk chair and one small filing cabinet. An exterior writing stand with light shall be provided on the facility entrance side of the booth.

19.2.4.3.6 The booth security equipment shall include:

19.2.4.3.6.1 An Alarm Monitoring System for security and fire.

19.2.4.3.6.2 Monitors for Closed Circuit Television System and Video Motion Detectors.

19.2.4.3.7 Yard Lighting: All yards shall be illuminated per design requirements in Section 4, WMATA Manual of Design Criteria Facilities.

19.2.4.3.8 Fencing: Front, rear and side yards shall be secured with eight-foot high chain link fencing. The fence shall be constructed of a 9 gauge, 1" x 1" galvanized steel mesh fabric. Fence posts shall be set in concrete footings and shall be spaced in a maximum of 8 feet apart. The top of the fence shall be capped with 3 strands of barbed wire. Refer to WMATA's standard Fence Detail Drawings.

19.3 ADMINISTRATIVE AND OPERATIONS REQUIREMENTS

19.3.1 General Description

19.3.1.1 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.

19.3.2 Functional Space Descriptions

19.3.2.1 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:

19.3.2.1.1 Dispatcher: 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.

19.3.2.1.2 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 SF 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.

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

19.3.2.1.4 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.

19.3.2.1.5 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.

19.3.2.1.6 Facility Manager's Office: Shall be adequately sized 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.

19.3.2.1.7 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.

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

19.3.3 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 19.4 - Furniture Requirements

SECTION 20 (NOT USED)

SECTION 21 COMPRESSED NATURAL GAS (CNG) BUS FACILITY REQUIREMENTS ~~VEHICLE FUELING INFRASTRUCTURE~~

21 .1 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.

21 .2 CNG Fueling System

21 .2.1 Site Layout

21.2.1.1 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:

21 .2.1.1.1 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 21.2.3.5.

21 .2.1.1.2 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).

21 .2.1.1.3 Appropriate distance from adjacent businesses or homes where compressor noise would be an annoyance.

21 .2.1.1.4 Distance from railroad tracks (minimum of 50 feet per NFPA 52, consult RR Company for specific RR requirements).

21 .2.1.1.5 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.

21 .2.1.1.6 To reduce installation and equipment costs, location should be as close to natural gas and electrical utility services as reasonably possible.

21 .2.1.1.7 Allow service and maintenance clearance around the CNG fueling equipment as recommended by the manufacturer.

21 .2.1.1.8 CNG storage vessels should be kept as close to the compressor package as possible.

21 .2.1.1.9 Distance between compressor package and dispenser should not be greater than 100 feet.

21 .2.1.1.10 Distance from adjacent facility air intakes, doors, and windows (recommend minimum of 20 feet).

21 .2.1.1.11 Select location that will not disturb site aesthetics, and/or allow space for a landscaped earth berm.

21 .2.1.1.12 Location that would allow the installation of proper site drainage, and not allow flooding or ponding. Perform a topography survey.

21 .2.1.1.13 Location should allow for safe, efficient snow removal.

21 .2.1.1.14 Perform soil boring tests to establish the soil composition for construction, and the requirements of a retention wall (if required).

21 .2.1.1.15 Allow appropriate space for future expansion.

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

21 .2.1.2.1 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 21.2.3.5

~~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).~~

21 .2.1.2.2 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.

21 .2.1.2.3 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.

21 .2.1.2.4 The fueling island location should be designed to account for the following CNG related issues:

21 .2.1.2.4.1 Vehicle turning radii - design for greatest possible vehicle turning radius.

21 .2.1.2.4.2 The fueling point location on the vehicle(s) (typically the curbside rear corner on CNG transit buses).

21 .2.2 Fueling Station, Compressor and Gas Storage

21.2.2.1 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).

21.2.2.2 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.

21.2.2.3 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.

21 .2.2.3.1 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.

21 .2.2.3.2 Location of gas main serving facility: The closer the service is to the proposed site, the less expensive gas piping costs will be.

21 .2.2.3.3 Gas main pressure: The higher the available gas pressure, the less gas compressor equipment purchase and operational costs will be.

21 .2.2.3.4 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.

21 .2.2.3.5 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.

21 .2.2.3.6 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.

21 .2.2.3.7 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.

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

21 .2.2.4.1 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).

21 .2.2.4.2 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.

21 .2.2.4.3 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.

21 .2.2.4.4 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.

21.2.2.5 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.

21 .2.2.5.1 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.

21 .2.2.5.2 The natural gas dryer shall be designed, constructed, and tested in conformance with the following:

21 .2.2.5.2.1 Compressed Natural Gas Vehicular Fuel Systems (NFPA 52)

21 .2.2.5.2.2 National Electric Code (NEC), NFPA 70

21 .2.2.5.2.3 American Gas Association (AGA)

21 .2.2.5.2.4 Underwriters Laboratories (UL)

21 .2.2.5.2.5 Society of Automotive Engineers (SAE)

21 .2.2.5.2.6 American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code

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

21 .2.2.6.1 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.

21 .2.2.6.2 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.

21 .2.2.6.3 Compressor (package) performance and conformance specifications:

21 .2.2.6.3.1 Piston rings: Minimum design life of 4,000 hours lubricated or 2,000 hours non-lubricated.

21 .2.2.6.3.2 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.

21 .2.2.6.3.3 Lubricated oil consumption: No greater than 0.5 pounds of oil per mmscf. Oil recycling capability - blowdown tank to crankcase.

21 .2.2.6.3.4 Synthetic oil lubricated.

21 .2.2.6.3.5 Interstage separators: Centrifugal separator or coalescing filter required after each pressure lubricated stage.

21 .2.2.6.3.6 Discharge filter: Only single coalescing filter for non-lubricated, pre-coalescing and coalescing filter required for lubricated.

21 .2.2.6.3.7 Automatic gas recycling system.

21 .2.2.6.3.8 Controls: PLC

21 .2.2.6.3.9 Codes and regulations: NEC and NFPA 52 compatible. All components UL listed, FM approved or otherwise approved by a NRTL.

21 .2.2.6.3.10 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.

21 .2.2.6.3.11 Lifting and rigging mounts and supports.

21 .2.2.6.4 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.

21.2.2.7 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

21 .2.2.7.1 Storage (Skid) Performance Specifications:

21 .2.2.7.1.1 Compressed Natural Gas (CNG) ASME 3-Vessel storage tank assembly.

21 .2.2.7.1.2 Manufactured to ASME UPV Code Section VIII Division 1 App. 22.

21 .2.2.7.1.3 Safety factor rating of 3:1 for dry gas, non-corrosive service.

21 .2.2.7.1.4 5,500 psi design pressure, 5,000 psi operating pressure.

21 .2.2.7.1.5 Total storage volume of product at 5,000 psi (to be determined based on NGV fleet requirements).

21 .2.2.7.1.6 Skid footprint no greater than 2' wide x 12' long.

21 .2.2.7.1.7 Full port stainless steel (½") ball valves on front and rear of each vessel.

21 .2.2.7.1.8 Safety relief valves on each vessel.

21 .2.2.7.1.9 Dome outlet drain valves on each vessel.

21 .2.2.7.1.10 Saddle mount frames for horizontal mounting of vessels.

21 .2.2.7.1.11 Lifting and rigging mounts and supports.

21 .2.2.7.1.12 Complete priming and painting of storage skid and assembly.

21 .2.2.7.2 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.

21 .2.3 Fueling Island - Dispensing System

21.2.3.1 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.

21.2.3.2 Fueling Island

21 .2.3.2.1 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%.

21 .2.3.2.2 Provide schedule 80 steel bollards, 8 inch diameter x 8 ft. long. Fill with concrete, round top.

21 .2.3.2.3 Provide site lighting meeting hazardous area classification, Class 1, Division 1.

21 .2.3.2.4 Provide fire extinguisher with 20-B:C rating, mounting post and accessories.

21 .2.3.2.5 Provide placard stating the name and address of the CNG fueling location, and the name and phone number of the nearest Fire Company.

21.2.3.3 Dispenser Performance Requirements:

21 .2.3.3.1 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.

21 .2.3.3.2 All components shall be assembled, piped, wired and interconnected, so as to provide an operable system requiring minimal field construction and installation.

21 .2.3.3.3 System design pressure shall be 5,000 psi with operating pressures to be 3,000/3,600 psi as specified.

21 .2.3.3.4 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.

21 .2.3.3.5 Dispensing system to provide site specific number of dispensing hoses (TBD), and be capable of fueling site specific number of NGVs simultaneously (TBD).

21 .2.3.3.6 The dispensing system shall be able to operate independently from compression equipment.

21 .2.3.3.7 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.

21 .2.3.3.8 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.

21 .2.3.3.9 Minimum fuel flow rating of the dispenser shall be determined by fleet requirements.

21 .2.3.3.10 Each hose shall be:

21 .2.3.3.10.1 15 feet long if connected to upper part of dispensing unit or, 12'-6" long if connected to side of dispensing unit

21 .2.3.3.10.2 electrically conductive and constructed with a non-metallic braid

21 .2.3.3.10.3 rated for 5,000 psi, SAE 100R8

21 .2.3.3.10.4 equipped with a stainless steel breakaway connector that limits breakaway to hose not greater than 150 lbs.

21 .2.3.3.11 Dispenser shall operate on 120 Volt single phase power supply.

21 .2.3.3.12 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.

21 .2.3.3.13 Dispenser shall provide LCD display to indicate the quantity in GGE of fuel dispensed.

21 .2.3.3.14 Dispenser shall not utilize pressure gauge indication of vehicle fueling status but instead shall indicate LCD "Percent of Fill" status.

21 .2.3.3.15 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.

21 .2.3.3.16 Dispensers supplied for this application shall incorporate only electronically controlled temperature compensated fuel control systems, which shall include the following:

21 .2.3.3.16.1 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.

21 .2.3.3.16.2 Computer based adjustable control of sequential set points for low, mid and high banks of storage with full low flow cut off.

21 .2.3.3.17 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%.

21 .2.3.3.18 High Flow Cut Off - provides shutoff of fuel flow if gas is dispensed at a rate determined by fleet requirements.

21 .2.3.3.19 Pressure Drop Cut Off - provides shutoff of fuel flow if there is a sudden pressure drop during fueling process.

21 .2.3.3.20 Pressure Rise Cut Off - provides shutoff of fuel flow if the fueling pressure does not rise in accordance with the mass of gas dispensed.

21 .2.3.3.21 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.

21 .2.3.3.22 A pit frame shall be provided for dispenser mounting that can be installed at installation site.

21 .2.3.3.23 Fueling dispenser shall be designed, constructed, and tested in conformance with the following:

21 .2.3.3.23.1 American Gas Association (AGA).

21 .2.3.3.23.2 American National Standards Institute (ANSI).

21 .2.3.3.23.3 American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code, Section VIII, Division 1.

21 .2.3.3.23.4 Compressed Gas Association (CGA).

21 .2.3.3.23.5 Underwriters Laboratories (UL).

21 .2.3.3.23.6 Nationally Recognized Testing Laboratory (NRTL).

21 .2.3.3.23.7 Factory Mutual Research Association (FM).

21 .2.3.3.23.8 National Electrical Manufacturers Association (NEMA).

21 .2.3.3.23.9 National Fire Protection Association (NFPA) NFPA70 National Electric Code NEC.

21 .2.3.3.23.10 National Fire Protection Association (NFPA), NFPA52.

21 .2.3.3.23.11 National Pipe Threads (NPT)

21 .2.3.3.23.12 Uniform Fire Code (UFC)

21 .2.3.3.23.13 Occupational Safety and Health Administration (OSHA)

21.2.3.4 Fuel Management System

21 .2.3.4.1 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.

21 .2.3.4.2 Fuel Management System Performance Requirements:

21 .2.3.4.2.1 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.

21 .2.3.4.2.2 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.

21 .2.3.4.2.3 System to be capable of controlling and relaying information to a remote computer system.

21 .2.3.4.2.4 System components to be FCC and UL listed.

21 .2.3.4.2.5 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.

21 .2.3.4.2.6 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.

21.2.3.5 Code Compliance and Industry Standards

21 .2.3.5.1 NFPA 30A -

21 .2.3.5.2 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.

21 .2.3.5.3 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.

21 .2.3.5.3.1 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.

21 .2.3.5.3.1.1 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.

21 .2.3.5.3.1.2 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.

21 .2.3.5.3.1.3 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.

21 .2.3.5.3.1.4 NFPA 497 -

21 .2.3.5.3.1.5 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.

21 .2.3.5.3.1.6 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.

21 .3 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.

21 .3.1 Mechanical Systems and Equipment

21.3.1.1 Ventilation System - Service and Maintenance Areas

21 .3.1.1.1 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.

21 .3.1.1.2 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.

21 .3.1.1.3 Where possible, ventilation fans shall be located directly above CNG service bays.

21.3.1.2 Ventilation System - Storage Areas

21 .3.1.2.1 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.

21 .3.1.2.2 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.

21.3.1.3 Space Heating System

21 .3.1.3.1 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.

21 .3.1.3.2 Electrical Systems and Equipment

21 .3.1.3.2.1 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.

21 .3.1.3.2.2 Equipment - (Motors, Light Fixtures, etc.)

21 .3.1.3.2.2.1 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.

21 .3.1.3.3 Specialty Service Equipment

21 .3.1.3.3.1 Welding and Grinding

21 .3.1.3.3.1.1 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.

21 .3.1.3.3.1.2 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.

21 .3.1.3.3.2 Hand Tools

21 .3.1.3.3.2.1 Hand held lighting and electrical tools shall be appropriate and listed for Class 1, Division 2 rated areas.

21 .3.1.3.3.2.2 Hand held methane detectors should be provided to inspect CNG Vehicle fueling lines and storage tanks, prior to commencing service work.

21 .3.1.3.4 Facility Design - Coordination Issues

21 .3.1.3.4.1 Roof trusses shall be of open design, and not allow gas to be "trapped" in ceiling spaces, design shall allow for through ventilation.

21 .3.1.3.4.2 Facility indoor partitions should be continuous from floor to ceiling, securely anchored, and have a minimum of 2 hour fire resistance.

21 .3.1.3.4.3 CNG service bays shall be located directly under any necessary "high points" in ceiling design.

21 .3.1.3.4.4 Deflagration panels may be designed into exterior facility walls where highly hazardous areas are considered.

21 .3.1.3.5 Gas Detection System

21 .3.1.3.5.1 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.

21 .3.1.3.5.2 The gas detection system shall open outside doors, start emergency ventilation fans, sound alarms, and disable certain equipment.

21 .3.1.3.6 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.

21 .3.1.3.6.1 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.

21 .3.1.3.6.2 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.

21 .3.1.3.6.3 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.

21 .4 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

21 .5 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 22 LIGHT RAIL (FUTURE)

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SECTION 23 POWER

23 .1 GENERAL

These design criteria include functional and design requirements for the supply and supervision of all electrical power to the Washington Metropolitan Area Rapid Rail Transit System.

The Electrical System shall supply power to all transit facilities to provide safe, efficient and continuous operation of the entire system. Design of the Electrical System shall be coordinated with the requirements of the individual power companies in D.C., Maryland and Virginia providing primary power to the system.

23 .1.1 Clearance to Installations

A minimum of 2" is required between any fixed installation (e.g., pipes, pipe hangers, pipe supports, signals, lighting fixtures, etc.) and the design vehicle dynamic outline. This is 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.

23 .1.2 SCOPE

The following shall be included in the Electrical System Scope of work:

23 .1.2.1 Traction Power System providing for propulsion requirements including contact rail, running rails and tie breaker station.

23 .1.2.2 Traction Power Substations required for conversion and supply of power to the contact rail system including transformers, rectifiers, AC/DC switchgear, their locations and installed capacity requirements.

23 .1.2.3 Auxiliary AC Electrical Systems (Refer to Facilities criteria)

23 .1.2.4 Lighting systems for illumination (Refer to Facilities criteria)

23 .1.2.5 Electrical Supervisory Control functions required for supervising and controlling the performance of power, ~~and~~ electromechanical and solid- state equipment vital to the continuous operation of the transit system. The Electrical Supervisory Control functions will interface with the Data Transmission System described in Facilities Design criteria.

23 .1.2.6 Energy Management System required for monitoring and controlling field equipment via the remote terminal units as described elsewhere in this criteria and Facilities criteria.

23 .2 TRACTION POWER

23 .2.1 General

WMATA is a heavy rail transit system. Tthe transit cars shall be propelled by electric traction motors driving steel wheels through appropriate gearing. Electric traction power

shall be supplied to the cars by means of a contact rail installed parallel to the running track, upon which one or more collector shoes attached to each car will maintain sliding contact.

Both running rails of both inbound and outbound acks shall be used as negative return conductors for the traction power system, except at crossover locations and in service and inspection yards where only one running rail provides the negative return.

The entire conductor system including the contact rail, the running rails, and associated cable connections shall be capable of supporting voltages to the transit cars within the limits set forth below.

Direct current traction power shall be provided by rectifiers with rated voltage output of 700 volts at one hundred percent (100%) load. Maximum voltage output at one percent load at the substation bus shall not exceed 742 volts. Substation regulation shall not exceed six percent (6%) from one percent to one hundred percent of rated transformer/rectifier capacity and shall be approximately linear to four hundred fifty percent.

23 .2.2 Maximum Voltage Drops and Negative Rail Potentials

23 .2.2.1 In order to sustain high traction motor performance, the design voltage drop from rated voltage output of 700 volts~~, including substation regulation~~, shall not exceed 195 ~~100~~ volts ~~(14%)~~ at any train, under normal operating condition. Negative rail potential shall not exceed 10 volts for normal operation, 120 volts for abnormal operation and 150 volts for emergenct conditions.

23 .2.2.2 Normal operating condition is defined as a rail system operating with eight car-trains with a head way of 120 seconds, and with all transformer-rectifier units within a traction power substation in service.

23 .2.2.3 As part of the abnormal operating conditions, under heavy service demands, such as train bunching, special event services, etc., and a substation with only one transformer-rectifier unit ~~in~~ out of service, a voltage drop of 225 ~~175~~ volts (~~25%~~) at the train shall be permitted. Reduced train performances under these voltage condition shall not be allowed.

23 .2.2.4 For emergency condition ~~Anticipating the~~ total loss of AC power at any one substation~~, and the loss of one transformer-rectifier unit at an adjacent substation~~, the traction power system shall be designed to restrict the voltage drop to a maximum of 250 volts ~~(36%)~~. Reduced train performance characteristics, as defined by operations, under these lowered voltage conditions would be allowed.

23 .2.3 Cable

23 .2.3.1 All direct current traction power cables shall be stranded, shielded (for positive), non-shielded (for negative), tinned copper conductors, and shall have low smoke, zero halogen generation characteristics .

23 .2.3.2 All cables shall be flame retardant and shall be rated 90 degree centigrade in dry and wet locations.

23 .2.3.3 The number and size of traction power cables connecting the DC feeder breakers to the contact rail, and from the running rails to the negative bus shall

be capable of accepting maximum overload currents with a temperature rise not to exceed safe insulation design limits of the cables, based on a minimum insulation life of 30 years.

23 .2.3.4 The positive power cable shall be monitored on a continuous basis to avoid fire hazard, ground fault, and risk of arcing and fire due to cable insulation deterioration. A positive cable insulation monitor device shall be installed in substation facilities fulfilling or exceeding the following requirements:

23 .2.3.4.1 Monitoring and displaying of the total positive power cable insulation resistance on a continuous basis.

23 .2.3.4.2 Free programmable alarm set-points, for remote and local indication, ; one for pre-alarm and one for the main alarm or feeder breaker trip.

23 .2.3.4.3 Control wiring for the monitor device shall be rated, as a minimum for ~~5~~ 2,000 volts for a 12 AWG conductor.

23 .2.3.5 The designer shall provide a root-mean-square ampere loading analysis to support design. The traction power cables shall be 1000 KCMIL and be rated 2 kV. Standard duty ASTM class D stranded shielded cables shall be used for positive traction power feeders to points adjacent to the contact rails. Extra flexible, ASTM class G stranded non shielded cable shall be connected to each Class D cable with bolted type connectors at points adjacent to the contact rail and extended to the contact rail. The cable shall be connected ~~welded~~ to ~~composite~~ the contact rail to ensure required current flow. The negative traction power cables shall be class D stranded non shielded cables. The negative cables from the substation shall be terminated at 8000 A impedance bonds connectors between the running rails.

23 .2.3.6 The traction power DC cables in substations and tie-breaker stations shall be run in fiberglass cable trays. Where traction power cables are to be installed in shaftways they shall be installed exposed with insulated clamps, unless the shaftway is an emergency exit, in which case the cable shall be run in concrete encased duct bank ~~FRE conduit~~. Where the cables are run in conduit in vertical shafts, pull boxes ~~at intermediate levels with cable supporting means shall be included to adequately distribute support of vertical cables~~ shall be inserted at the required intervals with approved insulating support, to prevent the weight of the conductor from damaging insulation or placing strain on termination point. At the end of the conduit approved type of sealant shall be used to prevent moisture and spread of fire.

23 .2.3.7 The positive traction power cables feeding to contact rails on aerial trackway structures shall be routed external to (not through) the aerial sturcture ~~steel girders~~. The cables shall be separated from and electrically insulated from all structural steel and concrete.

23 .2.3.8 At all locations where cables are exposed, the positive and negative return cables shall be ~~separated~~ installed in separate electrical chases.

23 .2.3.9 FRE conduit size for 1000 KCMIL cables shall be 4" IPS Standard (one cable per FRE conduit). Minimum conduit quantities (including spares) for various rail connections for feeders of less than 250 feet in length shall be as follows:

23 .2.3.9.1 Substation positive feeder for a full section of contact rail: eight conduits.

23 .2.3.9.2 Substation positive feeder for a short rail section at an acceleration sectionalizing gap: five conduits.

23 .2.3.9.3 Tie breaker station feeder for a full section of contact rail: seven conduits.

23 .2.3.9.4 Tie breaker station feeder for a short rail section at an acceleration sectionalizing gap: five conduits.

23 .2.3.9.5 Substation negative return: twelve conduits to each track.

23 .2.3.9.6 Surface trenching: is not recommended. In special conditions high density polymer concrete (HDPC), Plastibeton or equal for above ground installations shall be used. Cables to be installed with HDPC separators between individual cables.

23 .2.3.10 Feeders in excess of 250 feet in length may require additional conduits to satisfy voltage drop requirements. Cable derating shall be provided for the duct bank configuration. To the extent possible, two high ducts (2 rows high) shall be provided to reduce the derating.

23 .2.3.11 Typical details of conduits and cable installations are shown on the Electrical Design Drawings.

23 .2.3.12 Conduit ends shall be sealed after installation of cable, and spare conduits shall be plugged or capped with best qualified conduit sealing bushings as shown on Electrical Design Drawing (DD-E-081) .

23 .2.4 Cable Supports

23 .2.4.1 Traction power positive cables from the DC feeder breaker connections and negative cables from the negative switchboard connections shall be laid or run in fiberglass cable trays, in the substation and tie breaker rooms. Such raceways shall provide adequate cross-sectional area to permit a neat alignment of the cables and avoid crossing or twisting which may damage the cable insulation.

23 .2.4.2 Supporting arms or racks shall be spaced to avoid excessive weight or pressures against the cable insulation. The cables shall be arranged in one layer. Raceways for positive and negative cables shall be physically separated, and fiberglass raceways for positive cables shall be insulated from ground. The minimum vertical clearance for bus duct and cable trays shall not be less than 11 inches apart.

23 .2.5 Positive Contact Rail

23 .2.5.1 Positive contact rail will be a composite steel/aluminum rail on main line tracks and in yard areas. Composite rail connections will be bolted.

23 .2.5.2 Composite contact rail shall have a resistance at 20°C of not more than 0.0020 ohms per 1000 ft. Voltage drop calculations shall be based on contact and return rail resistance adjusted for 40°C ambient and 50°C rise in temperature due to the traction current.

23 .2.5.3 The relative position of the contact rail to the running rails, the type of support, insulator, cover board bracket, and the supporting hardware are shown on the Electrical Design Drawings.

23 .2.5.4 Electrical continuity shall be provided in the contact rail from substation to substation except for locations at which sectionalizing or tie circuit breakers are installed. At these locations and at the substations the rail continuity shall be broken to provide definite power zones. The system shall be designed to permit isolation of each power zone.

23 .2.5.5 Where separations of contact rail are necessary, such as at crossovers, emergency exits and other obstructions, electrical continuity shall be maintained by the use of jumper cables. End approaches shall be provided at each separation to facilitate contact shoe return to the contact rail.

23 .2.5.6 Where contact rail sectionalizing occurs adjacent to the end of a passenger station, a "gap-segment-gap" arrangement of contact rail shall be utilized on both the tracks. This arrangement shall also be used in selected areas (such as a steep up-hill grade over which high speeds are maintained) where vehicles are expected to routinely consume high levels of traction power. The short gaps and short contact rail segment of a gap-segment-gap arrangement shall be dimensioned to prevent simultaneous bridging of both gaps by one car. Dedicated feeder breaker shall power a gap.

23 .2.5.7 Contact rail through passenger stations shall be located at trackside opposite the platform. Contact rail at-grade shall be located in the area between running tracks, except at special trackwork and center platform stations. Contact rail on aerial structures shall be located in accordance with the General Plans and Design Drawings. The contact rail sections shall be bolted into continuous lengths except for sectionalizing as described above or at expansion joints and at locations where the contact rail is required to be terminated or transposed to suit physical conditions.

23 .2.5.8 In sections of contact rail of 1800 feet or less, a contact rail anchor shall be provided at midpoint. In sections of contact rail exceeding 1800 feet, rail anchors shall be provided at maximum 1000 foot intervals, together with expansion joints at midpoint between rail anchors. Spacing of anchors shall be adjusted to provide an anchor near the middle of curved sections, with expansion joints in tangent sections. Typical rail anchor locations and details are shown in the Electrical Design Drawings and General Plans.

23 .2.5.9 At all locations where jumper cables or bonding are used to provide electrical continuity, such as around expansion joints, such bonding or cabling shall provide conductivity which will not reduce the circuit capability. Jumper cables shall be installed in conduits.

23 .2.6 Running Rails

23 .2.6.1 The running rails for mainline operation shall be 115 pounds per yard RE section, AREA Specifications. Each new single rail shall not have a resistance of more than 0.003486 ~~.00905~~ ohms per 1000 ft. at 20°C. Voltage drop calculations shall be based on a single rail resistance of .01 ohms per 1000 ft. at 20°C and adjusted for 50°C rise at 40°C ambient for higher rail operating temperature. Both running rails shall serve as negative conductors except in crossovers, yards or other noted special rail sections. Generally, rails shall be

welded in continuous lengths. Where rails are furnished with uninsulated "glued" joints electrical continuity shall be enhanced by using jumper cables. At locations requiring insulated joints, the traction power direct current continuity of running rails shall be maintained by use of impedance bonds.

23 .2.6.2 Between substations negative rails shall be cross-bonded for traction power equalization cables, through impedance bonds at maximum intervals of 2000 feet. ~~Crossbonding shall also be provided at tie breaker stations, to facilitate connection of cable for negative polarity reference.~~ A negative rail polarity reference, number 6 AWG wire in conduit, shall be provided from each track at the tie-breaker station. Where train control impedance bonds occur within the spacing interval, these bonds may be utilized for traction power cross-bonding.

23 .2.7 Mainline Sectioning

23 .2.7.1 At locations shown on the General Plans covering Traction Power, circuit breakers shall be installed to provide isolation of contact rail sections or zones. Each circuit breaker shall be equipped for automatic trip operation on a current rate of rise basis, with load sensing automatic re-closure. All circuit-breakers controlling power zones shall normally be operated remotely from the centrally located control room by means of the supervisory control system. Local controls shall be provided to permit local manual operation of all circuit breakers within each substation and each breaker room. The circuit breaker feeding the short contact rail segment at an acceleration gap shall trip open when either of the adjacent contact rail section feeders or tie breakers are tripped or opened.

23 .2.7.2 Emergency trip stations, combined with emergency telephone stations, shall be located at intervals not exceeding 800 feet throughout the rapid transit system and at each end of each passenger station. Additional trip stations shall be provided at special trackwork such as crossovers. ~~If required ETS shall be provided with fiber optic communication link and PLC devices for fail-safe operation.~~

23 .2.8 Contact Rail De-icing System

23 .2.8.1 The contact rail de-icing system shall be designed to remove ice from the head of the contact rail and consists of a flexible, electrically insulated, conductive heating element enclosed in a corrosion resistant aluminum outer sheath mounted under the head or on the web of the contact rail. The heating element shall be covered with a protective fiberglass channel held against the contact rail with steel attachment clips located on 18 inch centers.

23 .2.8.2 The heating element shall be of a constant wattage type design. The constant wattage circuit shall be designed with a control circuitry to turn automatically ON/OFF the heating element power based on ambient temperature and humidity conditions.

23 .2.8.3 The rated nominal output power of the heating element, eight feet or longer, shall be 30 watts per foot at 750 volts DC mounted on a 32°F substrate.

23 .2.8.4 750 volts shall be supplied to the heating element by tapping off the contact rail though a fuse box disconnect switch mounted adjacent to the contact rail. The negative side of the heating element shall be connected to the running rail

negative return system through a trackside heater control panel. Each trackside heater control panel shall provide control and indication to two 400 foot sections of heater element on the outbound or inbound track. 750 volts shall be supplied to the heating element from the contact rail it attaches too.

23 .2.8.5 The trackside heater control panels control the 750 volts DC power supply (negative side) to the segments of heat tape installed on the contact rail.

23 .2.8.6 The supervisory control and indication functions shall be carried back to a zone control panel located in the traction power facility serving the traction power zone that the heater elements are installed on. Control cables shall be installed in the mainline ductbank.

23 .2.8.7 The zone control panel supplies 480V ac control power and 120V DC power for indication functions to the trackside heater control panels located in its traction power zone. The zone control panel shall be operated locally or remotely through the Data Transmission System back to the OCC.

23 .2.8.8 Each zone control panel shall control a specified number of trackside heater control panels. Individual manual control of heater elements is available for each track. Outbound or inbound heater elements shall be turned on or off individually. The heater zone shall be turned on/off automatically in relation with the weather conditions.

23 .2.8.9 Storage track isolation switch shall provide isolation for the heater tape.

23 .2.8.10 Details of the contact rail heater system are shown on the Electrical Design Drawings.

23 .3 TRACTION POWER SUBSTATIONS

23 .3.1 Substation Spacing and Capacity

23 .3.1.1 The spacing and capacity of traction power substations shall be based on supplying power to the trains as demanded by the operating schedule, during maximum traffic periods, within the limits of the permissible voltage drops, and equipment ratings. It will also include the loads imposed by Contact Rail De-icing System and the Switch Heaters.

23 .3.1.2 Substation buildings will be designed to accommodate three rectifier/transformer units, each rated at 3000 kW. Substation capacities will be based on operation of 8-car trains at 120-second headways for two ~~a hour~~ three (3) rush hour periods.

23 .3.1.3 Each traction power substation rectifier unit and rectifier transformer shall be capable of withstanding the loading cycle defined in NEMA RI-9 for "Extra Heavy Traction".

23 .3.1.4 The following shall constitute the basis of traction power calculations:

AW2 = 110,250 ~~110, 500~~ pounds per car

Worn wheels-25 inches

AW0 = 84,000 ~~77,500~~ pounds per car.

Max. car speed - 75 mph. Max. Car speed -75 mph with worn wheels

Max. rate of acceleration - 2.8 mphps. ~~Max rate of acceleration (P5)-2.8 mphps~~

Traction motors per car - 4 ~~Traction motors per car- 4~~

New wheel diameter- 28 inches ~~diameter - 28 inches~~

~~Gear ratio (assumed) - 5.414 to 1~~ ~~Gear ratio (assumed)-5.414 to 1~~

Speed- tractive effort from traction motor efficiency curves assumed in initial calculations are shown in Fig. 23.1

Auxiliary power - 90.0 ~~75.0~~ kW per vehicle.

Nominal voltage 700 VDC

Maximum voltage 860 VDC

Minimum voltage 450 VDC

23 .3.1.5 Preliminary calculations to determine optimal substation locations and spacings will be based on the traction power system simulation study. Locations shall be indicated on the General Plans.

23 .3.1.6 For maximum substation reliability, at least two rectifier units of 3000 kW capacity shall be installed. Alternate unit ratings at selected substations may be permitted as directed by the Authority.

23 .3.2 System Simulation

23 .3.2.1 The design of the traction power systems shall be based on load flow simulations. Operation of 8 car-trains along the appropriate alignment shall be simulated to calculate all necessary parameters for the traction power system design. 8 car-trains shall be simulated to operate on the system at the minimum projected headways as specified by the authority, under normal and individual substation outage conditions, with the cars loaded to AW2. Under these operating conditions the traction power system design shall be shown to operate successfully within the required design parameters and the voltage at the trains shall not exceed the requirements in Section 23.2.2.

23 .3.3 Substation Power Supply

23 .3.3.1 In 13.8 kV incoming service areas, the Power Company will deliver to each substation within its territorial boundaries two dedicated underground, 13.8 kV, 3-phase, 60 hertz power circuits as primary service. The same feeders may also supply power to the AC switchboard rooms in the adjoining passenger station. Each of these 13.8 kV power services will be furnished from separate Utility Company substations, or from separate buses of "high reliability" substations as an alternate. At each substation and passenger station, the 13.8 kV incoming service feeders will be metered. The Designer shall coordinate with the Utility Company for minimum clearance at the front and rear of the 13.8 kV incoming service switchgear and for clearance in front of the Utility Company's metering cabinet.

23 .3.3.2 In 34.5 kV incoming service area, the Power Company will deliver to each substation within its territorial boundaries two dedicated underground, 34.5 kV, 3 phase, 60 hertz power circuits as primary services. Each of these 34.5 kV primary services will be furnished from separate Utility Company substations or from separate buses of "high reliability" substations.

23 .3.3.3 In 34.5 kV incoming power service area, combined metering for certain numbers of traction power substations and passenger stations shall be provided. At designated traction power substations, each 34.5 kV incoming power feeder will be metered. The metering transformers and meter cabinet will be furnished by the power company. These transformers shall be installed by the Utility Company in an enclosure furnished under a stage or section contract. The Designer shall coordinate with the Utility Company for minimum clearance at the front and rear of the 34.5 kV incoming serving switchgear, and at the designated traction power substations for clearance in front of and around the Utility Company's metering enclosure.

23 .3.3.4 In 34.5 kV incoming power service area, each incoming power feeder for each traction power substation and passenger station shall be provided with an isolation switch furnished, installed, and maintained by the utility company. The isolation switches shall be installed outside of WMATA facilities.

23 .3.3.5 The capacity of each power company's circuit shall be sufficient to support the load of the traction substation and passenger station including the overload capacity of traction power transformers, maintaining voltage to the transformer within plus or minus 5% of normal rating. Either of the two utility services shall be made available to each of the rectifier transformers by use of line and tie breakers on an automatic basis. Adjacent traction power substations will not be supplied from the same power company substation, whenever practicable.

23 .3.4 Traction Power Equipment

23 .3.4.1 Substations shall be equipped with a minimum of two completetransformer rectifier units. Each transformer rectifier unit shall be rated 3MW or higher. Provision shall be made in each substation for one additional transformer rectifier unit to allow a total of 3 units.

23 .3.4.2 Traction power equipment shall be designed to operate unattended. Controls shall be provided to operate all switchgear from the Operation Control Center (OCC) or from local control switches in the equipment, as well as from a control panel remotely located in the Traction Power Substation.

23 .3.4.3 A one line diagram for a typical traction power substation is shown for reference in the Electrical Design Drawings.

23 .3.4.4 Equipment for each substation shall include incoming line, bus tie, and AC feeder breakers of metal-clad, drawout type rated at 750 MVA symmetrical interrupting capacity for 13.8 kV service and 1500 MVA symmetrical interrupting capacity for 34.5 kV service.

23 .3.4.5 Rectifier transformers shall be cast coil or VPE dry type for indoor application and oil filled type for outdoor application. Transformers shall be, self-cooled designed for extra heavy duty traction service, capable of carrying two three

hour peak period loading cycles per day within a four hour interval of each other. New rectifier transformers shall be 12 pulse, rectifier connected per ANSI circuit No. 31, and shall be design so that the maximum overall regulation rate is not greater than 6% +/_ 0.5% between 1% rated load and 450% rated load with temperatures rise limits in accordance with the latest ANSI/IEEE standards. All outdoor transformers shall comply with the latest EPA requirements. The transformer -rectifier design and component selection shall minimize harmonic distortion and shall comply with IEEE 519. The traction power substation rectifier shall be silicon diode type , self-cooled by natural ventilation.

23 .3.4.6 Thyristor controlled rectifiers will be considered where necessary to provide improved voltage regulation or reduce overall costs. It shall consist of full wave bridges providing 12-pulse rectification capable of withstanding the loading cycle defined in NEMA RI-9 for “EXTRA HEAVY TRACTION” without exceeding the manufacturer’s allowable diode junction temperature and without damage to any component. The rectifier shall also be capable of withstanding the maximum theoretical short circuit current on the rectifier until cleared by the protective devices.

23 .3.4.7 In the service and inspection shop substation, rectifier transformer unit shall be capable of withstanding the loading cycle defined in NEMA RI-9 for “ HEAVY TRACTION” without exceeding the manufacturer’s allowable diode junction temperature and without damage to any component.

23 .3.4.8 DC cathode and feeder breakers shall be high speed metal-enclosed drawout type with direct ~~reverse~~ current series device, capable of carrying the rated over load RI-9.

23 .3.4.9 Auxiliary equipment shall include interconnecting buswork, control battery and UPS; provision for stray current corrosion control drain cables and stray current remote monitoring systems, provision for supervisory control equipment and interface with the data transmission system, and provision for control indication, and monitoring functions of complete substation and tie breaker station via an "Automated Energy Management System".

23 .3.4.10 All substation interconnecting buses shall be copper. Buses shall be sized on the basis of maximum current density of 800 amperes per square inch of cross sectional area. Temperature rise shall be within the permitted ANSI/NEMA standards. All buses shall be adequately supported to withstand available short circuit currents, and insulated for the appropriate voltage level.

23 .3.4.11 The designer shall provide a root means square ampere loading analysis to support design.

23 .3.4.12 The sizes of major equipment shall be provided by the manufacturers. These details shall be reconfirmed by the Section Designers during final design of substation equipment. Particular attention should be paid to design of structural floor in view of small base design of transformers.

23 .3.4.13 The primary service cables from the Utility Company will be extended into the substation and terminated in the appropriate cubicles by the power company. Four 5 inch FRE conduits shall be provided for 13.5 kV incoming primary service cables. Six 8 inch PVC conduits shall be provided for 34.5 kV Utility Company primary service cables at non-metered substations. Ten 8 inch PVC

conduits shall be provided for 34.5 kV Utility Power Company primary service cables at metered substations. Power company metering equipment shall be installed as required by their standards. Conduit and cable seals fittings, as required, shall be provided.

23 .3.4.14 Protective relaying of the incoming line breakers, as well as relay control of the primary bus tie breaker, shall be in accordance with the standards of the power company. The design drawings illustrate typical single line diagrams and supervisory control for traction power substations. Designer shall perform a complete short circuit study for frame and trip sizes of breakers, cable withstand duty, protective relay coordination, etc.

23 .3.4.15 Digital Power Meters (DPM) shall be installed in each incoming line, leader breaker and auxiliary transformer feeder breaker cubicles. Each DPM shall be connected to the automatic energy management system (AEMS) for remote monitoring.

23 .3.5 Equipment Arrangement

23 .3.5.1 Substation structures shall have adequate floor area and loading capabilities to permit placement of electrical equipment and ancillary components of any manufacturer in the general arrangements shown on the Electrical General Plans and Design Drawings. Relative spacing and positioning of each transformer and rectifier unit shall permit the removal, replacement, or maintenance of such unit without the necessity of moving other units. The arrangement of the equipment shall permit doors to be opened, panels to be removed, and circuit breakers to be withdrawn.

23 .3.5.2 Rectifier unit and the DC switchgear line up along with all connecting bus work and positive cable trays shall be insulated from ground. An additional three feet of floor insulation all around the equipment shall be provided to prevent accidental contact with grounded structures. DC switchgeer shall have 4'-6" of floor insulation in front and 3'-0" on all other sides. Design shall provide for all uninsulated walls, columns, ducts, ground bus, fixtures, other grounded equipment or structures to be located at least three feet away from the insulated equipment.

23 .3.5.3 Ceiling heights, vertical clearance below ceiling hung equipment, and structural openings shall permit entry and removal of the largest components which will be installed in the structure.

23 .3.5.4 Substations located below grade shall be constructed with equipment hatches, not located directly over any electrical equipment to permit the removal of equipment from the substation to the street level above. Below grade substations shall be designed to allow personnel carrying large test equipment safe access into facilities. All electrical rooms which are below grade shall be waterproofed. All entering conduit through which surface or subsurface water may seep, shall be provided with water seal fittings for conduits and cables on both ends. Water seal fitting shall also be provided for all manholes. Conduit through substation ceiling shall be prohibited. Drip loop shall be provided for all cable entering through walls. Where waterproofing is not feasible, electrical equipment shall be compatible with the environment, and facilities for drainage or pumping shall be provided. No mechanical or drainage piping shall be permitted in electrical rooms.

23 .3.6 Grounding

23 .3.6.1 Stray Current and Cathodic Protection

23 .3.6.1.1 Stray current control shall reduce or limit the level of stray currents at the source, under normal operating conditions. Traction power substations shall be spaced at interval such that maximum track-to-earth potentials do not exceed 50 volts DC during normal operations.

23 .3.6.1.2 Metallic tunnel liners and structural reinforcing steel for underground concrete structures, including wire mesh reinforcing for shotcrete tunnel lining, shall be bonded or welded to provide electrical continuity as shown on Structural ~~Design and~~ Standard Drawings ST-S-007, ST-S-021 thru ST-S-023. The metallic reinforcing of floating slabs shall be bonded to adjacent invert reinforcing at each corner of the floating slab to maintain slab-to-track potential at the same level as in normal invert construction.

23 .3.6.1.3 Reinforcing steel in concrete retaining walls, abutments, aerial structures, and other similar structures shall be made electrically continuous. To allow for stray current tests, one No. 2 AWG insulated wire shall be exothermic welded to the reinforcing and terminated in a flush mounted junction box for periodic testing. The junction box spacing shall not exceed 500 feet in continuous structures.

23 .3.6.1.4 At each traction power substation associated with underground Metro structures, provisions shall be made to connect the electrically continuous tunnel lining or reinforcing via cable to the traction power substation negative bus through relays (normally open), the mitigation stray current diodes and the current monitoring/test shunts.

23 .3.6.1.5 These diodes and associated drainage equipment will be furnished as part of traction power equipment. Each design section incorporating a traction power substation shall include termination connections to the reinforcing steel or liner, as well as all embedded conduits and cables into the substation, as required on the standard drawings.

23 .3.6.1.6 The stray current remote monitoring/test facility located in the substation negative switchboard should be implemented to allow for periodic remote monitoring of stray current to identify changing conditions associated with track-to-earth resistance. Substation shall be provided with remote monitoring systems to record the negative bus to earth potential, the stray current returning through the shunt. The remote monitoring system shall consist of a stand-alone data acquisition module and communication package via the substation's "Automated Energy Management System".

23 .3.6.1.7 Provisions shall be included to monitor track-to-earth potentials on a continuous basis. Monitoring facilities shall be located at traction power substations. Provision shall be made for future installation of Negative Grounding Devices (NGD).

23 .3.6.1.8 At each fan and vent shaft, provision shall be made for stray current test boxes. Conduits, junction boxes, cables, and waterproof sleeves shall be installed as shown on the Standard ~~design~~ drawing.

23 .3.6.1.9 Ferrous piping for Metro facilities, buried in contact with earth, shall be coated and provided with cathodic protection where required by soil conditions, as defined by corrosion surveys. Recommended types of coating and details of the design of the cathodic protection system will be furnished by the Authority to the Section Designer. The Section Designer is expected to review corrosion survey reports and to submit request for development of required details to the Authority, covering those elements of his design requiring corrosion protection.

23 .3.6.1.10 Permanent ferrous metal foundation piling directly above or immediately adjacent to underground subway structures shall be bonded and provided with stray current drain cables to a traction power substation, when adjacent to the substation. Metal piling remote from a substation shall be provided with stray current drain cables into the subway structure for test purposes. To assist in shielding stray currents, soldier piles to be left in place shall be bonded for continuity and provided with drainage connections. Bonding of soldier piles shall be accomplished by using No. 4/0 AWG insulated cable, thermite welded between piles. Soldier piles so bonded and drained to traction substations shall not be used for current ground purposes.

23 .3.6.1.11 Underground metallic structures of other jurisdictions such as gas lines, metal water mains, etc., in the vicinity of traction power substations may require connection to substation negative buses. These connections will be based on stray current tests performed jointly by the Utility Company and WMATA. To permit such future connections, at least four 3-inch conduits shall be stubbed-out and capped, approximately 30 inches below grade, and at a distance of 3 feet outside of each traction substation. These conduits shall be brought into the substation and turned up at a wall adjacent to the negative switchboard.

23 .3.7 Substation and Tie Breaker Station Grounding

23 .3.7.1 Each substation and tie breaker station room shall be equipped with a 1/4" x 2" copper ground bus on the inside periphery, at the wall facing the equipment cubicles, and necessary extension cabling connected to a ground grid. Each substation ground bus shall have a maximum resistance to ground of 2 ohms.

23 .3.7.2 Each tie breaker station ground bus shall have a maximum resistance to ground of 5 ohms.

23 .3.7.3 Equipment enclosures and raceways for alternating current equipment, including AC switchgear and rectifier transformers, shall be firmly grounded to the ground bus. Structural metalwork where exposed within the substation, supervisory control cabinets, and ventilation equipment or ductwork shall be grounded to the ground bus.

23 .3.7.4 Enclosures for traction power rectifier, DC switchgear, and DC positive buswork, and metallic raceways supporting DC positive traction power cables shall be ungrounded and installed in such a manner as to maintain maximum possible resistance to ground.

23 .3.7.5 Where metallic enclosures interconnect grounded and ungrounded equipment (e.g., the anode bus enclosure between rectifier transformer and rectifier), adequate insulation methods shall be employed to provide high resistance to ground.

23 .3.8 Automated Energy Management System (AEMS)

23 .3.8.1 Each traction power substation and tie breaker station shall be provided with an Automated Energy Management System with remote terminal unit (RTU) for total monitoring of equipment . Indications and control functions , listed in Table 23.2 under AEMS column, shall be available remotely at the OCC AEMS as specified by the authority. using an energy management system. The system shall consist of providing transducers for analog output signals, contacts for indication, contacts for control functions, and interconnection wiring between I/O functions and remote terminal unit (RTU) located in the substation. The AEMS-RTU shall be compatible with the Authority's QEI, Inc. master station located at the BOCC room.

I/O point count for RTU shall be as follows:

		Points
Analog Input	0-1 Ma	16
	4-20 mA	16
Status Input:		40
Control Output:	Latching	16
	Momentary	16
Pulse Accumulator:		8

23 .4 AUXILIARY ELECTRICAL SYSTEMS

23 .4.1 General

23 .4.1.1 This section identifies the requirements for installation and operation of auxiliary electrical equipment in the Rapid Rail Transit system.

23 .4.2 AC Switchboard Room Power Supply

23 .4.2.1 Power Source

23 .4.2.1.1 As stated in Section 23.3.3, the utility company shall provide the source of power within the territory served by each company.

23 .4.2.1.2 Service voltage to WMATA facilities shall generally be either 13.8 kV or 34.5 kV. In some areas and facilities (e.g., chiller plants which are located at considerable distances from the nearest passenger stations), service at 277/480 volts may be economically preferred. Final determination of the

type of service at such sites shall be made by the Authority. Design of facilities for 277/480 volt services shall comply with local codes and Utility Company requirements.

23 .4.2.1.3 In general, each passenger station shall have either two AC switchboard rooms (one at each end of the station), or one combined AC switchboard room with both AC unit substations located in this room. Each unit substation shall receive a separate three phase service from the power company serving the area and will transform and distribute the power to loads within the station and adjacent line and facilities as shown on General Plans.

23 .4.2.1.4 13.8 kV power areas shall have one primary dedicated underground power service to each AC unit substation. The two dedicated feeders to traction power substation may also supply power to the AC switchboard rooms in the adjoining passenger station. 34.5 kV incoming power service area, shall have AC substation with two dedicated feeders where combined metering for certain numbers of traction power substations and passenger stations shall be provided or each passenger station incoming feeder shall be provided with an isolation switch located outside WMATA facility, furnished, installed, and maintained by the utility company. One normally open tie breaker shall connect the two unit substation secondary buses in the combined AC switchboard room, and two normally open tie breakers shall connect the two unit substation buses in the physically separated AC switchboard rooms to form a secondary selective network as indicated on the Electrical Design Drawings.

23 .4.2.1.5 Minimum clearance in front of and at the rear of incoming service switchgear shall be coordinated with the utility company as applicable.

23 .4.2.2 Metering

23 .4.2.2.1 In a 13.8 kV service area, a unit substation or secondary distribution center shall include provisions for power company metering in accordance with their requirements. Provisions shall be made in the combined AC switchboard room or in one of the two AC Switchboard Rooms at a passenger station for mounting a meter cabinet on the wall. The metering transformers and meter cabinet will be furnished by the power company. Minimum clearance in front of the metering cabinet shall be coordinated with the utility company.

23 .4.2.2.2 The transformers shall be installed in the auxiliary switchgear cubicle by the WMATA Contractor. The power consumption of each passenger station shall be totalized. Details of the meter tie conduit requirements for this purpose are shown on the Electrical Design Drawings. A 120 volt, 15 ampere dedicated essential circuit shall be provided to the metering locations. Provision shall be made for remote meter reading through WMATA AEMS system.

23 .4.2.3 Service Ducts

23 .4.2.3.1 Cable ducts for primary power service shall be provided in the WMATA facility structures as required and approved by the Utility Company. Primary cable ducts shall generally extend from the switchboard room through the outside wall to a point three feet below ground level and a

minimum of five feet beyond the outside of the structure or to the WMATA right-of-way limit and then capped. Provision shall be made te seal all penetrations at both end to prevent water intrusion.

23 .4.2.3.2 The Utility Company will furnish and install the ductwork from their manhole or substation to connect to the ductwork from the structure and will furnish and install the service cables.

23 .4.2.3.3 For 13.8 kV services FRE conduits shall be installed as follows:

To single AC switchboard rooms: 3-5"⌀

To combined AC switchboard rooms: 4-5"⌀

23 .4.2.3.4 For 34.5 kV services PVC conduits shall be installed as follows:

To single AC switchboard rooms: 4-8"⌀

To combined AC Switchboard rooms: 6-8"⌀

Non-metered Traction Power Substation: 6-8"⌀

Metered Traction Power Substation: 10-8"⌀

23 .4.2.3.5 Provide best quality bushings to plug empty Utility Company service ducts.

23 .4.2.3.6 The design of incoming primary service cable ducts shall be included in the design of facilities by the Section Designer and shall be coordinated with the Utility Company to obtain their approval.

23 .4.2.3.7 When the Utility Company is required to supply 480Y/277V power to a traction substation or chiller plant, the service ducts shall be included in the design of the substation/chiller plant. Quantities, sizes, and routing of service ducts shall be approved by the power company and shall comply with all local codes.

23 .4.2.4 Service Cables

23 .4.2.4.1 Provision shall be made for drip loop on each incoming service cable.

23 .4.3 AC Unit Substations

23 .4.3.1 AC unit substations shall be housed in free-standing, ventilated, indoor, metal enclosures located in each switchboard room to provide clear space of not less than 6'-0" at the front and 3'-6" at the back and end.

23 .4.3.2 AC unit substations shall contain incoming primary switchgear (including auxiliary cubicle for 13.8 kV service), distribution transformer, 480 volt switchgear, and switchboard; and shall form a dead front assembly.

23 .4.3.2.1 Equipment for 15KV Primary Service Area

23 .4.3.2.1.1 AC Incoming 15kV Primary Switchgear - either 1 or 2 below:

23 .4.3.2.1.1.1 One primary circuit breaker rated at 1200 amperes, 15 KV indoor, drawout, vacuum break, 3 phase, 60 hertz, having 750 MVA interrupting capacity of the stored energy type, with relays, necessary potential transformers, and current transformers. The primary service breaker shall be provided with local control and both local and supervisory status indication. Tripping and closing mechanisms shall draw power from a local 125 volts DC source. The primary switchgear shall be provided with digital protective relay capable of storing events and provide remote monitoring through WMATA AEMS.

23 .4.3.2.1.1.2 All high-voltage primary (draw out) circuit breakers in the AC switchgears of 13.8KV or higher shall be located on the floor of the cubicle. Separate handling devices for removal or insertion of the circuit breaker, other than transfer truck or fifth-wheel steering bar, are prohibited.

23 .4.3.2.1.1.3 Provisions shall be made for field mounting incoming service cable terminators, which shall be furnished by the Utility Company and installed by the contractor.

23 .4.3.2.1.2 Auxiliary Cubicle

23 .4.3.2.1.2.1 One auxiliary cubicle with provisions for mounting and connecting metering potential transformers and current transformers for each primary service furnished by the Utility Company and all necessary transition buswork.

23 .4.3.2.1.3 Transformer for 13.8 KV or for 34.5 KV

23 .4.3.2.1.4 The transformer shall be indoor, ventilated, cast coil, dry type, 13.8 KV, 3 phase, 60 hertz, delta primary, 480Y/277V, 4-wire secondary, industrial.

23 .4.3.2.1.4.1 It shall have sufficient self-cooled capacity to serve the total demand load (largest of winter or summer) of both unit substations, plus 20% for future growth. In addition, provision shall be made for auxiliary fans connections.

23 .4.3.2.1.4.2 To the extent practicable, the demand loads supplied by both unit Substations supplying a passenger station and transit facility shall be equalized. Where unusual demand loads occur, (such as a chiller plant load near one end of a passenger station, or a fan shaft on one side of a passenger station but not on the other) which results in a large difference in the demand loads of the two unit substations, the designer shall advise the Authority who shall coordinate and assist in determining the solution.

23 .4.3.2.1.4.3 In passenger stations, the designer shall design a unit substation design wherein all loads are connected to the main secondary bus. For unit substation designs, the transformers shall have sufficient self-cooled capacity to serve the total

demand load of both unit substations plus 20% for future growth.

23 .4.3.2.2 Equipment for 34.5 KV Primary Service Area

23 .4.3.2.2.1 AC incoming 34.5 kV Primary Switchgear

23 .4.3.2.2.1.1 One primary circuit breaker rated at 1200 amperes, 34.5 kV, indoor, vacuum break, drawout type, 3 phase, 60 hertz, having 1500 MVA interrupting capacity of the stored energy type, with relays, current transformers, and potential transformers. The primary breaker shall be provided with local control and both local and supervisory status indication. Tripping and closing mechanisms shall draw power from a local 125 volt DC source. The primary switchgear shall be provided with digital protective relay capable of storing events and provide remote monitoring through WMATA AEMS.

23 .4.3.2.2.1.2 Provisions will be made for field mounting incoming service cable terminators, which will be furnished by the Utility Company and installed by the contractor.

23 .4.3.2.2.2 Transformer

23 .4.3.2.2.2.1 The transformer shall be indoor, ventilated, cast coil, dry type, 34.5 KV, 3 phase, 60 hertz, delta primary, 480Y/277 volts, 4 wire secondary, industrial.

23 .4.3.2.2.2.2 It shall have sufficient self-cooled capacity.to serve the total demand load (largest of winter or summer) of both unit substations, plus 20% for future growth. In addition, provision shall be made for auxiliary fans. In addition, provision shall be made for auxiliary fans connections.

23 .4.3.2.2.2.3 To the extent practicable the demand loads for both unit substations shall be equalized.

23 .4.3.2.2.3 480 Volt Switchgear and Switchboard

23 .4.3.2.2.3.1 Switchgear and Switchboard shall include Programmable Logic Controllers, connected to AEMS-RTU for remote monitoring through.

23 .4.3.2.2.3.2 Secondary main and tie breakers, shall be rated at 480 volts, 3 phase, 60 hertz; and they shall be drawout type low voltage power circuit breakers with stored energy closing mechanisms. These circuit breakers shall be manually actuated close with manual and electrically operated trip; except that the tie breakers shall include electrically actuated close.

23 .4.3.2.2.3.3 Each secondary main and tie breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor-based controlled phase over current trip device and flux-transfer shunt trip, ground-fault protection, position indicating lights, spare auxiliary contacts for DTS,

accessories and interlocks. The trip device shall have long-time and short-time elements, communication interface, power metering and non-volatile memory for protective settings. The trip unit shall be equipped with an energy monitoring function processor to provide at a minimum; Phase Current (amps), Peak Demand (Kilowatts), Present Demand (Kilowatts) and Energy Consumption (Kilowatts-hours).

23 .4.3.2.2.3.4 For each secondary main and tiebreaker, provide a Digital Power Metering with power quality features system as follows:

23 .4.3.2.2.3.4.1 Provide Digital Power Metering to provide continuous monitoring of a three phase system as required and to measure the real-time RMS values of phase currents, ampere demand and phase and line voltages plus power measurements including kW, kW demand, kW-hours, kVA, kVAR-hours, voltage/current unbalance. Power factor and frequency shall also be measured. Resettable minimum and maximum values for each measured value shall be recorded and date/time stamped in a nonvolatile memory.

23 .4.3.2.2.3.4.2 Power quality analysis features shall include an event recorder, waveform capture, trace memory, harmonic spectrum display (through the 62nd harmonic with total harmonic distortion) and a data logger function. Meter shall be able to sample harmonic spectrum at 256 samples per cycle. All analysis data shall be non-volatile.

23 .4.3.2.2.3.4.3 The digital power meter shall derive power from a separate 125V ac or DC source, and includes the following:

Internal illuminated display for reading all real-time and min\/max measured values as well as programming initial configuration and any relay setpoints.

Three programmable relay outputs shall be provided to activate and release based on threshold and time-delay values associated with any of the measured parameters.

Communications module to remotely read real-time and min/max measured values, interrogate the event log, reset min/max and kW/kVAR-hours, program configuration and any relay set points. Meter shall be capable for web access.

Extended memory

Portable Interface Device

Software

The digital power meter shall be connected to the AEMS-RTU for remote monitoring.

23 .4.3.2.2.3.4.4 In a 34.5 kV area, power company metering requirements are described in Section 3.3.2.

23 .4.3.2.2.3.4.5 All breakers shall have short circuit interruption capacity as determined by short circuit calculations and approved by the Authority. Feeder breakers in switchboard shall be ambient compensated and shall be molded case bolt-on type. Integrally fused circuit breakers may be used where necessary to obtain suitable protection of down-stream equipment and wiring.

23 .4.3.2.2.3.4.6 Time coordinated ground fault protection on secondary main, tie breakers and feeder breakers shall be provided. Single point grounding shall be provided as indicated on the electrical design drawings.

23 .4.3.2.2.3.4.7 480 volt switchgear buses and secondary main circuit breaker frame sizes shall be based on transformer forced air-cooled capacity. Breaker trip ratings shall be based on calculated initial loads plus allowance for future 20% growth.

23 .4.3.2.2.4 Breaker Operation

23 .4.3.2.2.4.1 Control power shall be provided at 125 volts DC, and shall be fed using a minimum of two No. 6 AWG wires. Unit substations for 34.5 kV or 13.8 kV service through metal-clad switchgear shall have the following control operation:

23 .4.3.2.2.4.1.1 Primary breaker is tripped by primary undervoltage condition (detected by 27/59 relay for 13.8 kV service and 27 relay for 34.5 kV service), residual ground, or phase overcurrent relays. Primary breaker is closed via manually operated switch.

23 .4.3.2.2.4.1.2 Secondary main breaker is tripped automatically by tripping of primary breaker. Secondary main breaker is closed via manually operated switch.

23 .4.3.2.2.4.1.3 When the secondary main breaker is tripped by the primary breaker due to an undervoltage at the primary service, and if the other secondary main breaker is closed, the tie breaker(s) shall automatically close. Closing of the tie breaker(s) is blocked if the primary breaker or secondary main breaker has tripped because of overcurrent, or ground fault condition; closing of the breaker(s) is also blocked if both secondary main breakers in a passenger station are closed.

23 .4.3.2.2.4.1.4 Second stage transformer overtemperature device shall trip the primary breaker.

23 .4.3.2.2.4.1.5 Where two tie breakers are required due to unit substation being located in separate switchboard rooms, both tie breakers shall close simultaneously, and the tripping of either tie breaker shall instantaneously trip the other tie breaker.

23 .4.3.2.2.5 At each passenger station provide an emergency standby generator system or a quick connect system rated for 500KW , 480Y/277 Volts. with the following requirements:

23 .4.3.2.2.5.1 For Quick Connect:

23 .4.3.2.2.5.1.1 Quick connect breaker shall be capable to handle up to 500kW power from an emergency diesel generator.

23 .4.3.2.2.5.1.2 Provide a normally open quick connect circuit breaker in the three phase, 480V ac switchboard bus that feeds the normal side of the UPS system.

23 .4.3.2.2.5.1.3 The generator plugs shall be rated 600 amp, 4-pole Leviton or equal. . The receptacle shall be installed outside the building but close to the station entrance as possible in an area suitable to park a 500 kW mobile generator. The cable from the generator to the receptacle shall not exceed 100 feet in length.

23 .4.3.2.2.5.1.4 Provide "warning nameplate" on quick connect circuit breaker that reads "Generator Quick Connect Circuit Breaker - Do not Close without Permission from Maintenance Operating Center, Phone Number 21058".

23 .4.3.2.2.5.2 For Standby Generator:

23 .4.3.2.2.5.2.1 Provide a 100KW emergency standby diesel generator system with connection for remote monitoring.

23 .4.3.2.2.6 Provision for System Growth

23 .4.3.2.2.6.1 AC power service facilities shall be designed to permit an increase of 20% in load. This includes all switchboards, distribution transformers, feeders, panelboards, and motor control centers. Space shall be provided at each unit substation for the installation of one additional switchboard cubicle.

23 .4.3.2.2.7 Provisions for substation maintenance equipment.

23 .4.3.2.2.7.1 In each AC unit substation provide the following:

23 .4.3.2.2.7.1.1 72" x 36" x 36" heavy-duty metal storage cabinet with 4 shelf arrangement.

23 .4.3.2.2.7.1.2 Eight (8) foot fiberglass step ladder.

23 .4.3.2.2.7.1.3 Full set of as-built, half-size, Electrical Contract and Equipment Shop Drawings bound in stiff cover resistant to oil, water and wear. Drawings shall be capable of being stored in the metal cabinet.

23 .4.3.2.2.7.1.4 11" x 17" Wall mounted Maintenance Map/Single Line Diagram. Mounting frame shall be metal with lexan or plexiglass. Mount frame as directed by the Engineer.

23 .4.3.2.2.7.1.5 30" x 48" heavy-duty metal work bench with reinforced steel top and task stock. Work bench shall be 34" high with one No. 12 gauge steel shelf, full width and depth of bench with back turned up 2 inches. Provide 1/4" rubber matting to cover entire top of work bench.

23 .4.4 General Electrical Characteristics (Refer to Facilities criteria)

23 .4.5 Panelboards

23 .4.5.1 Designations

23 .4.5.1.1 The designation of each panelboard shall indicate the following information about the panelboard:

23 .4.5.1.1.1 General location of the panelboard in a passenger station -- (N) north, (S) south, (E) East, and (W) west.

23 .4.5.1.1.2 Specific location of the panelboard in a passenger station -- whether in AC switchboard room or electrical room, on mezzanine, or in a mechanical room.

23 .4.5.1.1.3 Identity of panel source Normal or emergency.

23 .4.5.1.1.4 Service voltage -- 480Y/277 volt AC or 208Y/120 volt AC, or 125volt DC.

23 .4.5.1.2 The panelboards shall be designated and located as shown in Table 23.1. All circuits shall be identified with the panel identity and the branch circuit number. Thus a circuit fed by breaker #3 in panelboard NE is identified NE-3. The top of all panelboards shall be located 6'-6" maximum from the floor level.

23 .4.5.1.3 TABLE 23.1 - LOCATIONS & IDENTITIES OF PANELBOARDS

AC Switchboard or Electrical Room		NORTH	EAST	SOUTH	WEST
480/277V	Normal	NN	EN	SN	WN
208/120V	Normal	NNS	ENS	SNS	WNS
480/120V	Emergency	NE	EE	SE	WE
208/120V	Emergency	NEE	EEE	SEE	WEE
125V DC		ND	ED	SD	WD
Mezzanine (Where only one mezzanine exists in a station the first letter of the designation (N, E, S or W) may be omitted.)		NORTH	EAST	SOUTH	WEST
480/277V	Normal	NIMN	EMN	SMN	WMN
208/120V	Normal	NMNS	EMNS	SMNS	WMNS
480/120V	Emergency	NME	EME	SME	WME
208/120V	Emergency	NMEE	EMEE	SMEE	WMEE
480/277V	Normal	NAN	EAN	SAN	WAN
208/120V	Normal	NANS	EANS	SANS	WANS
Traction Substation, Tie-Breaker Station (Note that the general location letter designation (N, E, S or W) is not required.)		TRACTION POWER SUBSTATION		TIE BREAKER STATION	-
480/277V	Normal	S		TB	-
208/120V	Normal	SS		TBB	-
125V DC		SD		TBD	

23 .4.5.2 DC Panelboard

23 .4.5.2.1 The DC Panelboard shall be fed directly from the rectifier/ charger side of the battery disconnect switch or breaker. This panel shall be equipped with 250 volt DC rated, 2 pole main breaker and 2 pole branch breakers suitably sized for their respective loads. This panel shall be mounted on the wall adjacent to the battery charger.

23 .4.5.2.2 This panel shall supply power for:

23 .4.5.2.2.1 High voltage and 480 volt switchgear and switchboard control.

23 .4.5.2.2.2 DC switchgear control at adjacent DC tie breaker room, or traction power substation. For long feeders increase wire size to compensate for voltage drop.

23 .4.6 Emergency Power System

23 .4.6.1 Provide an Uninterruptible Power Supply (UPS) system rated 50 kVA, 480/277 volt, three phase in at-grade or aerial passenger stations. Provide a UPS rated 62.5 kVA 480/277 volt, three phase in underground passenger stations.

23 .4.6.2 Emergency power for loads listed below shall be provided from a UPS system. The UPS output is backed up by an alternate essential feeder and automatic transfer switch. The rectifier/charger, inverter, and transfer switch shall be located in the AC Switchboard room adjacent to the battery room. The battery disconnect device (enclosed circuit breaker) shall be wall mounted inside and next to battery room entry door, if possible. The UPS shall be capable of operation from the power source of a mobile generator.

23 .4.6.2.1 Rectifier/Charger

23 .4.6.2.1.1 A silicon rectifier/charger shall be of adequate capacity to provide DC input to inverter to give rated output while simultaneously providing charge to battery at rate to give full charge in 12 hours after battery has been fully discharged, and to provide control power for high voltage and 480 volt switchgear.

23 .4.6.2.2 Battery

23 .4.6.2.2.1 Storage batteries shall be UPS cycle duty, sealed, industrial flooded lead acid round cell.

23 .4.6.2.2.1.1 The discharge capacity capable of providing DC inverter input to give rated inverter output at unity power factor for three hours at 77°F while simultaneously providing DC continuous and final minute load for switchgear. Minimum battery terminal voltage of 105 volts under full load at end of three hour discharge period.

23 .4.6.2.2.1.2 The two tier battery rack is 1'-3" wide by 2'-6" long by 6'-4" high. Each rack has two cells per tier.

23 .4.6.2.2.1.3 The battery room in Aerial or At-grade Passenger Stations with 50 kVA UPS shall have 60 cells batteries. Where the load exceeds the capacity of 60 cells, a second set of 60 cells shall be connected in parallel.

23 .4.6.2.2.1.4 The battery rooms in Underground Passenger Station with 62.5 kVA UPS systems shall have one set of 60 cells batteries. Where the load exceeds the capacity of 60 cells, a second set of 60 cells shall be connected in parallel.

23 .4.6.2.2.1.5 Minimum battery room size in Aerial or At-grade Stations:

23 .4.6.2.2.1.5.1 13.8 kV Area: 18'-0" long by 24'-0" wide by 12'-0" clear height

23 .4.6.2.2.1.5.2 34.5 kV Area: 18'-0" long by 24'-0" wide by 16'-0" clear height

23 .4.6.2.2.1.6 Minimum battery room size in Underground Stations:

23 .4.6.2.2.1.6.1 13.8 kV Area: 18'-0" long by 24'-0" wide by 12'-0" clear height

23 .4.6.2.2.1.6.2 34.5 kV Area: 25'-0" long by 18'-0" wide by 16'-0" clear height

23 .4.6.2.2.2 Each battery room shall be ventilated as stated in Design Criteria, Section 14.4.2.3 and the ventilation fan shall run continuously from an essential power source. Interlock to charger shall be provided to prevent operation if fan is not operating.

23 .4.6.2.2.3 Inverter

23 .4.6.2.2.3.1 Inverter shall be of solid state design with 480/277V, 3 Phase, 4 wire, 60 Hertz output and capable of delivering rated KVA into load which has power factor of .8 lagging, minimum.

23 .4.6.2.2.4 Automatic Transfer Switch

23 .4.6.2.2.4.1 The switch shall be static type and capable of transferring automatically emergency power load to AC by-pass line under the following conditions:

23 .4.6.2.2.4.2 Capable of transferring automatically emergency power load to AC by-pass line under the following conditions:

23 .4.6.2.2.4.2.1 inverter failure

23 .4.6.2.2.4.2.2 inverter output voltage dropping to 80% of rated voltage.

23 .4.6.2.2.4.3 The switch shall automatically retransfer emergency load from by-pass line to inverter when inverter output voltage returns to 90% of rated voltage.

23 .4.6.2.2.5 Load Requirements

23 .4.6.2.2.5.1 The following loads shall be connected to the UPS:

23 .4.6.2.2.5.1.1 Communications.

23 .4.6.2.2.5.1.2 Exit lighting and 20% of indoor lighting.

23 .4.6.2.2.5.1.3 Emergency trip station lights.

23 .4.6.2.2.5.1.4 Kiosk emergency panel.

23 .4.6.2.2.5.1.5 Elevator car light, fan, and controls.

23 .4.6.2.2.5.1.6 Escalator newel and comb lights, 10% of balustrade lights, and entrance escalator controls.

23 .4.6.2.2.5.1.7 Fire suppression systems.

23 .4.6.2.2.5.1.8 Train control equipment (normal feeder).

23 .4.6.2.2.5.1.9 Public Service Radio System.

23 .4.6.2.2.5.1.10 Chemical detector.

23 .4.6.2.2.5.1.11 Passenger Information Display System(PIDS)

23 .4.6.2.2.5.1.12 Automatic Fare Collection (Normal Feeder)

23 .4.6.2.2.5.2 Data for these loads are provided elsewhere in this Section.

23 .4.6.2.2.6 Wiring

23 .4.6.2.2.6.1 Emergency system wiring shall not occupy raceways common to other system wiring.

23 .4.7 Conduit

23 .4.7.1 Applications for the use of conduit shall include the following:

23 .4.7.1.1 Where access to wire or cable will not be available or required.

23 .4.7.1.2 Where concealed wiring is required, such as in public areas.

23 .4.7.1.3 Where mechanical protection is required beyond that provided by armored cable.

23 .4.7.1.4 Where clearances are limited, buried conduits shall be used.

23 .4.7.2 Types and Materials

23 .4.7.2.1 Rigid Aluminum Conduit

23 .4.7.2.1.1 Aluminum conduit may be used only for traction power cables when surface mounted.

23 .4.7.2.2 Liquid-tight Flexible Metal Conduit

23 .4.7.2.2.1 Flexible conduit shall be used where vibration isolation is required (e.g., motors, transformers) and for short connections between items of equipment whose alignment precludes the use of rigid conduit.

23 .4.7.2.3 Rigid Galvanized Steel Conduit

23 .4.7.2.3.1 Generally, galvanized rigid steel conduit may not be embedded. It shall be used only for surface runs in normally dry underground areas including fan and vent shafts, on interior ceilings and walls, or concealed where conditions are normally dry, such as above drop ceilings, and in CMU walls.

23 .4.7.2.4 Fiberglass Reinforced Epoxy (FRE) Conduit

23 .4.7.2.4.1 All embedded conduit for incoming service (with the exception of Virginia Power) for traction power, train control, communications, and auxiliary AC power requirements shall be FRE. Conduit embedded in concrete structure is encased, while conduit embedded in earth shall have concrete encasement added.

23 .4.7.2.4.2 Surface mounted conduit for traction power cable shall be FRE conduit with or without concrete encasement, or rigid aluminum as approved by the Authority.

23 .4.7.2.4.3 Conduit directly buried in ballast for train control cable shall be Heavy Wall FRE conduit, with minimum wall thickness of 0.095 inch.

23 .4.7.2.4.4 All embedded incoming service conduits for 13.8 kV to WMATA facilities shall be fiberglass. Location and method of installation shall be coordinated with and approved by the Utility Company.

23 .4.7.2.5 PVC Conduit

23 .4.7.2.5.1 All embedded incoming service conduits for 34.5kV to WMATA facilities shall be PVC. Location and method of installation shall be coordinated with and approved by the Utility company.

23 .4.7.3 General Requirements

23 .4.7.3.1 Conduit size for train control and communications shall be as shown on electrical and train control Design or Standard Drawings.

23 .4.7.3.2 FRE conduit size for individual traction power cable shall be 4". The number of bends shall not exceed 225° total between two pulling points.

23 .4.7.3.3 Minimum size conduit shall be 3/4", and all conduits shall be sized in accordance with NEC Appendix 'C'.

23 .4.7.3.4 Where non-metallic conduits are used for AC power cables, proper equipment grounding conductors shall be provided. Conduits shall not be installed in floating slabs unless absolutely necessary and shall do so only at right angles to the slab. Suitable isolation of conduit stub-ups shall be provided as indicated on Structural Design Drawings. Twenty percent spare conduits in embedded conduit runs and ductbanks and sleeves in floors and walls shall be provided in the design for future needs.

23 .4.7.4 Terminate empty conduits as follows:

23 .4.7.4.1 For all non-traction power service conduits provide O. Z. Gedney Push-Pull Tab Cups, Type PPC, or Rayflate Duct Sealing System or equal.

23 .4.7.4.2 For traction power positive conduits, install O. Z. Gedney Type CSBE bushings with blank seals, or Rayflate Duct Sealing System or equal.

23 .4.7.4.3 For conduits under 1.5 inch diameter, install heavy wall shrink tube as a seal.

23 .4.7.4.4 For traction power negative conduit, install O. Z. Gedney Type CSBI-300P-1 with blank seals, or Rayflate Duct Sealing System or equal.

23 .4.7.4.5 Stub-up with minimum 3 inch of concrete cover shall be provided for all traction power track side positive cables.

23 .4.8 Electrical Boxes

23 .4.8.1 Boxes shall be provided where surface mounted multi-conductor cables interface with single conductor cable in embedded conduits for proper termination of cable and cable fittings. Boxes located in underground locations (except electrical equipment rooms) shall be fiberglass or stainless steel, watertight construction with threaded conduit hubs.

23 .4.8.2 Boxes located in outdoor above ground locations shall be of fiberglass, watertight construction with threaded conduit hubs. All other boxes should be provided with knockouts.

23 .4.9 Conductors

23 .4.9.1 Material and Insulation

23 .4.9.1.1 AC power, lighting and grounding conductors shall be copper with flame retardant insulation and jacket. Minimum conductor size shall be No. 12 AWG, except for control and signal wiring.

23 .4.9.1.2 Power and lighting cables for all work shall be:

23 .4.9.1.2.1 Cable having specific low-smoke and zero halogen generation characteristics for use in underground structures.

23 .4.9.1.2.1.1 Fixture wire shall be stranded copper conductor of No. 16 AWG minimum size with Type SF-2 silicone rubber insulated or as necessary to suit temperature ratings of lighting fixture, minimum of 90° C.

23 .4.9.1.2.2 Cable having specific low-smoke and zero halogen generation characteristics for use in all locations not in (1) above.

23 .4.9.1.2.2.1 Fixture wire shall be stranded copper conductor of No. 16 AWG minimum size with Type SF-2 silicone rubber insulated or as necessary to suit temperature ratings of lighting fixture, minimum of 90° C.

23 .4.9.2 Voltage Drop

23 .4.9.2.1 Voltage drop calculations shall be carried out on all long and heavily loaded circuits and feeders.

23 .4.9.2.2 Maximum total voltage drop for feeders plus branch circuits shall not exceed five percent.

23 .4.9.3 Feeders

23 .4.9.3.1 When the nearest WMATA-owned power source is at an excessive distance from the facility to be served, consideration may be given to use a separate utility service. The designer shall perform an economic evaluation to develop a recommended service scheme for these facilities. Final determination as to preferred service scheme will be made by the Authority, based on reliability and economics.

23 .4.9.3.2 The neutral conductor shall be installed with three phase feeders only when required. An equipment ground conductor, sized in accordance with NEC, shall be provided with each feeder and cable assembly.

23 .4.9.3.3 It is preferred that fan shaft motor feeders shall be protected using motor circuit protectors located in the motor control center.

23 .4.9.4 Cable

23 .4.9.4.1 In order to provide the most economical installation of power and lighting feeder circuits, multi-conductor type MC cable shall be installed on channel inserts in air plenum under station platforms, in cable trough at aerial and at-grade sections, in ductbanks, and underfloor duct.

23 .4.9.4.2 All cables shall be readily accessible for future maintenance and protected from mechanical damage. In general, surface mounted channel inserts shall be used throughout underplatform air plenums at passenger stations for the support of cable and conduits. Cables which must be continued past adits and areas at fan shafts and drainage pumping stations open to both tunnels shall be routed past the opening in embedded conduits. Direct burial cables for stray current and cathodic protection shall be protected as specified in Standard Specification.

23 .4.9.4.3 Feeder cables shall be sized to accommodate 20% future growth in loads. Cables and conduit shall not be exposed in public areas.

23 .4.9.4.4 Only one length of cable shall be used in any feeder as far as it practicable. Cable splices where required shall be made in junction boxes. Splice box shall be used at any transition between MC cables and single conductor cable in conduit.

23 .4.9.5 Wiring methods

23 .4.9.5.1 Wiring of emergency and essential AC systems, and DC systems shall each be independent of each other and shall not occupy common raceways or enclosures.

23 .4.10 AC System and Equipment Grounding

23 .4.10.1 For grounding requirements in traction power substations and tie breaker stations see "Substation Grounding",.

23 .4.10.2 A complete AC power grounding system shall be provided for the protection of property and human life. The grounding system shall comply with the National Electrical Code and with requirements in this criteria, guide specifications and design drawings. In addition to the grounding of all enclosures and raceways of the AC power and distribution system the grounding system shall provide a low impedance path to ground for all exposed metallic structures, railings, stairways, etc., in the vicinity of the AC power systems.

23 .4.10.3 The grounding system shall be physically isolated from structural rebars, stray current systems, and cathodic protection systems. Intentional metallic contact or electrical bonding between the two systems is not permitted. Where soldier piles are used for AC power system grounding purposes, any number of soldier piles may be bonded together provided they are in the same row and are adjacent to each other. Soldier piles for grounding shall be independent from other soldier piles which are bonded and connected to drainage circuits and from reinforcing bars in the structure.

23 .4.10.4 A ground grid shall be provided for each AC service at shop buildings, passenger stations, traction power substations, tie breaker stations, chiller plants and fan shaft and pumping stations. Ground grid/bus resistance shall not exceed two ohms for AC switchboard rooms, traction power substations and chiller plants, and five ohms for tie breaker stations, electrical rooms, fan shafts, and pumping stations. Where a traction power substation or a tie breaker station is in close proximity to a passenger station AC unit substation, independent ground grids are is required. Grid shall consist of bare or insulated copper conductors and ground rods conductors and ground rods buried in earth and in a pattern to suit the structure; a rectangular pattern is preferred. In at-grade locations grid shall be 24 inches minimum below grade. Where grid is below the bottom of the slab or near metallic objects, minimum 24" separation shall be maintained. In underground locations, grids may be installed under the structure. A minimum of 24 inches separation must be provided between grid and soldier piles used for stray current control between grid and cathodic protection systems. In soils of high resistivity and in rock construction where normal grounding grid design does not provide required low resistance, alternate methods of ground grid design, or location, or soil treatment, etc., are to be submitted to the Authority for approval. Grounding of outdoor service transformers shall be provided by means of a grounding electrode conductor from the transformer pad to the nearest ground grid, as well as to the substation ground bus.

23 .4.10.5 After locations for ground grid(s) are determined and staked by survey personnel, a professional engineer registered in the site jurisdiction shall conduct a soil resistivity survey and report the data for use in design.

23 .4.10.6 Main ground bus on walls of substation rooms shall be used to ground the neutral of the secondary AC power distribution systems and to connect grounding sub-buses in kiosk, train control and communication rooms, dispatcher and Bell system rooms, escalator pits, elevator machine rooms and other grounding as required. Ground bus shall be copper, approximately 24

inches above floor and mounted on insulators 1-1/2 inches from wall. Where there is insufficient clearance behind the electrical AC or DC switchgear, install ground bus bar above the switchgear.

23 .4.10.7 Requirements for installing grounding connections in train control and communication rooms shall be as follows:

23 .4.10.7.1 The only connection on the bus bar provided for train control/ communication equipment grounding is the cable leading to the AC switchboard room. This grounding cable shall not be connected to the traction power grounding system.

23 .4.10.7.2 No equipment or metallic structure shall be bonded to the ground bus provided for train control and communications equipment.

23 .4.10.7.3 For items requiring bonding, the grounding conductors must go to the nearest ground bus beyond the ground bus provided for the train control and communications equipment.

23 .4.10.7.4 Grounding transformers to the dedicated train control and communication room ground bus bars is not permitted.

23 .4.10.8 Ground bus shall be installed as follows:

23 .4.10.8.1 AC switchboard room: 1/4" x 2" main bus installed around the inside periphery of the room.

23 .4.10.8.2 Chiller plants: 1/4" x 2" x 24" main bus installed on the wall adjacent to service equipment.

23 .4.10.8.3 Train control room: 1/4" x 2" x 24" sub-bus near power supply switch and connected to AC switchboard room bus with No. 2/0 AWG insulated grounding conductor. The sub-bus insulated grounding conductor shall be connected to the AC switchboard room ground bus within 2" of the grounding conductor connection for the transformers supplying power to the train control room per electrical design drawing.

23 .4.10.8.4 Communications room: 1/4" x 2" x 24" sub-bus near power supply switch and connected to AC switchboard room bus with No. 2/0 AWG insulated grounding conductor. The sub-bus insulated grounding conductor shall be connected to the AC switchboard room ground bus within 2" of the grounding conductor connection for the transformer supplying power to the train control room per electrical design drawing.

23 .4.10.8.5 Kiosk: 1/4" x 2" x 12" sub-bus connected to ground bus in nearest AC switchboard room via No.2/0 AWG insulated ground conductor in 1" conduit. The sub-bus insulated ground conductor shall be connected to the AC switchboard room ground bus within 2" of the grounding conductor connection for the transformer supplying power to the kiosk emergency panel. Sub-buses in Kiosk, Train Control, and Communications rooms are respectively dedicated to kiosks, train control, and communications equipment, and no other grounding to these buses is permitted.

23 .4.10.8.6 Others: Sub-bus in electrical and mechanical rooms, dispatcher and bell system rooms, as required for convenient grounding of separately derived AC power systems.

23 .4.10.8.7 One No. 4/0 AWG insulated copper ground conductor (sub-bus) shall be provided in each tunnel section, in each cable trough of aerial section, in ductbank of at-grade section of main line and in each cable tunnel or cable space located below station platform.

23 .4.10.8.8 Fan Shafts: 1/4" x 2" x 24" main bus installed on the wall adjacent to the AC power equipment.

23 .4.10.8.9 Drainage pumping stations: 1/4" x 2" x 24" main bus installed on the wall adjacent to the AC power equipment.

23 .4.10.8.10 Escalator Pits and Elevator Machine Rooms: 1/4" x 2" x 24" long grounding sub-bus bar installed on wall adjacent to AC power equipment.

23 .4.10.8.11 Battery Rooms: 1/4" x 2" x 24" long grounding sub-bus bar located below battery disconnected device.

23 .4.10.9 The complete AC power grounding system shall include ground bus in each distribution equipment enclosure such as switchgear, panelboards, motor control centers, and load centers, which shall be interconnected by insulated equipment grounding conductors that run with the feeders from the source panelboard or switchboard. Such conductors shall be identified by a continuous green color and be sized in accordance with NEC and shall run in a common conduit with the associated phase and neutral conductors. Multiple-conductor cables with metallic sheaths shall be provided with insulated or bare equipment grounding conductors; use of the metallic covering for grounding is not considered adequate.

23 .4.10.10 Equipment grounding conductors shall be provided by means of insulated copper grounding conductors for the following services:

23 .4.10.10.1 All feeders.

23 .4.10.10.2 All branch circuits.

23 .4.10.11 Grounding for personnel safety shall be provided to minimize shock hazards as follows:

23 .4.10.11.1 In substations, electrical and mechanical rooms, fan shafts and pumping stations, all exposed metallic structures, motor frames, AC equipment enclosures, ductwork and metallic piping shall be bonded to the local main ground bus with an exterior No. 6 AWG minimum insulated grounding conductor.

23 .4.10.11.2 Escalators, elevators and kiosks metallic structure shall be bonded to equipment grounding conductor in the AC feeder and to local ground bus bar. All electrical equipment (motor frames, AC equipment and lighting fixture enclosures) shall be provided with a minimum of two ground paths as follows:

23 .4.10.11.2.1 Bonding to green insulated equipment grounding conductor in the AC feeder/branch circuit.

23 .4.10.11.2.2 Connection to grounded metallic structure using metallic fasteners, metallic conduit and/or bonding jumper.

23 .4.10.11.2.3 For escalators and elevators provide a second ground path connecting trusses and guide rails using a No.1/0 AWG insulated ground conductor connected to ground bus bar in AC switchboard room. Leave a 20-foot length of conductor coiled up in pits or wellways.

23 .4.10.11.2.3.1 Metallic structure grounding may be supplemented by a connection to the ground grid where conveniently available.

23 .4.10.11.2.4 For kiosks, provide a second ground path connecting the metallic structure to nearest ground bar bus using a No. 2/0 AWG insulated ground conductor in 1 inch conduit. Leave 10 feet length of conductor coiled up at kiosk.

23 .4.10.11.3 Where a dielectric water fitting is installed for cathodic protection of underground piping, only the exposed piping may be grounded. Do not install jumper around the fitting. (The use of municipal water system as a grounding electrode is not permitted.) All exposed structural metalwork such as stairways, handrails and safety walk gratings within reach of AC power equipment (5'-0"+) shall be bonded to the nearest AC equipment ground bus or sub-bus.

23 .4.10.11.4 Exposed metallic structures in open areas such as light standards, handrails, cable trough and metallic deck structures on aerial track, and fence on at-grade construction, shall be bonded and grounded to separate ground rods.

23 .4.10.11.4.1 Handrails and cable troughs on aerial tracks shall be grounded at each pier and abutment to a ground rod or piles with an embedded insulated grounding conductor. All fencing shall be grounded at approximate 50-foot intervals to ground rods, and jumpers provided where required for grounding continuity. Fencing around transformer pads shall be suitably grounded. Flexible jumpers shall be provided at gates to ensure continuity.

23 .4.10.11.5 Exposed metallic structure of passenger and supervisor shelters equipped with lighting fixtures or receptacles, illuminated diorama, pylon equipped with lighting fixture, map case and telephone enclosures shall be provided with a minimum of two ground paths as follows:

23 .4.10.11.5.1 Bonding to green insulated equipment grounding conductor in AC branch circuit.

23 .4.10.11.5.2 Connection to nearest ground bus in electrical room or sub-bus or to 5/8-inch diameter by 10-feet long ground rod buried

adjacent to the structure, using a minimum No.6 AWG insulated grounding conductor.

23 .4.10.11.5.3 For metallic structures on station platforms bond to No.4/0 AWG ground conductor in cable space under the platform.

23 .4.10.11.6 Manholes, handholes, junction and pull boxes metallic body, cover frame and cover shall be grounded as follows:

23 .4.10.11.6.1 Metallic cover shall be bonded to metallic frame using a minimum No. 6 AWG insulated grounding conductor and a bronze or brass chain inside rubber hose.

23 .4.10.11.6.2 Metallic body and frame shall be grounded to 5/8-inch diameter by 10-feet long ground rod using a minimum No. 6 AWG insulated grounding conductor.

23 .4.10.11.6.3 When a cable is spliced or tapped in handhole, manhole and junction or pull box, metallic body and frame shall be also bonded to equipment grounding conductor.

23 .4.10.11.7 Connections to metallic structure, safety walk grating, cable trough, stairway, hand railing, telephone and map case enclosures, fence, frame columns of shelters, pylon frame, diorama metallic cover and metallic body and metallic cover frame of handhole, manhole and junction box shall be made by exothermic welding or gas torch brazing.

23 .4.10.11.8 In outdoor public areas (passageway, parking lot, kiss and ride area), use of manholes, handholes, junction and pull boxes shall be avoided. When necessary, only handholes with non-metallic cover and non-metallic junction and pull boxes shall be installed in landscape and grassy areas.

23 .4.10.11.9 Cable splices and taps in outdoor handhole, manhole, junction and pull boxes shall be covered by watertight heat-shrinkable tubing or wraparound sleeve in accordance with Electrical Design Drawings.

23 .4.11 Automated Energy Management System (AEMS)

23 .4.11.1 At each traction power substation and tie breaker station, Service and Inspection Shops, Maintenance Shops and AC Switchgear Rooms, provisions shall be made for indication and control functions to be available remotely at the OCC using an energy management system. The system shall consist of all sensors, transducers for analog output signal, power supplies, transmitters, wiring and accessories required for a complete and operational automated energy management system (AEMS). Local area network/Wide area network (LAN/WAN) shall be provided for each room.

23 .4.11.1.1 The AEMS shall have provisions for interconnection wiring from each status, control and analog telemetry points to the AEMS interface cabinet located in equipment rooms where equipment requires monitoring.

23 .4.11.1.2 The AEMS-RTU shall be compatible with the Authority's QEI, Inc. master station located at the OCCB. AEMS RTU’s shall be provided

in traction power substations, and AC Switchboard Rooms. RTU point counts and wiring requirements shall be as follows:

23 .4.11.2 AEMS RTU REQUIREMENTS

RTU Location	Control Points		Status Points	Analog Points		Accum Points	Analog Control
	Momentary	Latching		0-1mA	4-20mA		4-20mA
Traction Power Substation	8	8	24	16		16	8
Passenger Station (AC SWBD RM)	16	16	40	16		16	8
S&I Shop (AC SWBD RM)	40	40	88	16		16	8
Tie Breaker Station	8	8	24	16		16	8

23 .4.11.3 Wiring Requirements

Function	Wire Type	Number of Conductors	Minimum Size
Power	Stranded copper	3	No. 12 AWG
Meter, Pulse Accum.	Stranded copper	6	No. 14 AWG
Communications	Solid copper, shielded	4	No. 24 AWG
Analog	Stranded copper, shielded	2	No. 16 AWG
Ground	Bare stranded copper	1	No. 6 AWG

23 .4.11.4 PASSENGER STATION ENERGY MANAGEMENT INTERFACE REQUIREMENTS

23 .4.11.4.1 PULSE ACCUMULATOR POINTS (Contact Closure)

23 .4.11.4.1.1 Utility Meter or Switchgear Power Meter kWH

23 .5 LIGHTING SYSTEMS (Refer To Facilities criteria)

23 .6 SUPERVISORY CONTROL AND INDICATION OF ELECTRICAL SYSTEMS

23 .6.1 General

23 .6.1.1 These design criteria include functional and design requirements for supervision and control of Traction Power and Auxiliary Electrical Systems of the Washington Metropolitan Area Transit Authority's rail rapid transit system.

23 .6.1.2 The Electrical Supervisory Control System utilizes the Data Transmission System (DTS) installed under the Train Control Contract for transmission of all supervisory data between field controlled facilities and the Central Control Room. The Central Supervisory Display and Control Console is also designed and installed under the Train Control Contract. The design of these two systems must be closely coordinated, particularly with respect to interface details and locations.

23 .6.2 Scope

23 .6.2.1 The Electrical Supervisory Control System shall monitor, and in some instances have control of the traction power and other electrical equipment necessary for the continuous operation of the system. The following is included in the design of this system:

23 .6.2.1.1 Facilities required for control and supervision of Traction Power Substation and Tie Breaker Stations, except in yards and service and inspection shops.

23 .6.2.1.2 Facilities for monitoring of passenger station auxiliary equipment and AC power unit substations.

23 .6.3 Glossary

23 .6.3.1 Definitions pertaining to Supervisory Control are included in the general Glossary of CENF this Criteria.

23 .6.4 Standards

23 .6.4.1 The Supervisory Control equipment for electrical functions shall embody modern designs which provide the highest degree of safety and reliability. Whenever applicable, design of equipment for these functions shall be in accordance with ANSI, NEMA and IEEE Standards and Specifications. The functional principles of these specifications shall also be maintained where new devices or techniques are developed, even though the technicalities of the specifications may require modification.

23 .6.5 Equipment and System Interfaces

23 .6.5.1 Control Center Console

23 .6.5.1.1 The Control Center located in the OCC shall contain an Electrical Display and Control Console which shall give immediate alarm and visual indication of status changes, faults, or other abnormal conditions associated with traction power substations, tie breaker stations, and AC switchboard rooms. This Control Console shall be further equipped to

provide the operating attendant with the capability to control or adjust electric power systems (as indicated in Tables 23.2 and 23.3) serving the transit facilities, to maintain continuous rapid transit operation.

23 .6.5.1.2 Additional functions of the Control Console are described in subsequent sections of these criteria. This equipment is designed and installed under the Train Control and Communications contracts.

23 .6.5.2 Remote Terminals and Interface to DTS

23 .6.5.2.1 Traction Power Substations and Tie Breaker Stations Cabling and connections from the equipment to a terminal cabinet, and the terminal cabinet itself (located in the respective substation or tie breaker station) will be furnished and installed by the contractor. Extension of wiring from the terminal cabinet to OCCB will be by the train control stage contractor. Extension of wiring to yard control tower shall be by the section contractor.

23 .6.5.2.2 Passenger station AC switchboard rooms - Cabling and connections from the equipment to a terminal cabinet, and the terminal cabinet itself (located in the respective switchboard room) will be furnished and installed by the section contractor. Extension of wiring from the terminal cabinet to OCCB will be by the train control stage contractor.

23 .6.5.2.3 For fan shafts, vent shafts, drainage/pumping stations, and chiller plant located at passenger stations, the terminal cabinet shall be located in the nearest AC switchboard room and shall also serve the AC switchboard room equipment. Extension of wiring from the terminal cabinet to OCCB will be by the train control stage contractor.

23 .6.6 System Functions

23 .6.6.1 The field response equipment in the remote zone control units shall permit the traction power substation functions to be supervised or controlled remotely from the Operation Control Center.

23 .6.6.2 Tables 23.2 and 23.3 list the various location and supervisory control functions for traction power substations and auxiliary electrical equipment respectively. Local and supervisory control functions for these systems and for other equipment shall be as shown on electrical, mechanical and train control design and standard drawings.

23 .6.7 Control of Traction Power Substations

23 .6.7.1 The control and operation of a typical traction power substation is described below. For schematic control diagrams refer to Electrical Design Drawings.

23 .6.7.2 TABLE 23.2 - LOCAL AND REMOTE INDICATION AND CONTROL FUNCTIONS FOR TIE BREAKER STATIONS AND TRACTION POWER SUBSTATIONS

	DTS				AEMS
FUNCTION	CONTROL		INDICATION		DATA
	Local	Remote	Local	Remote	Remote Indication
AC Incoming Line Breakers	X	X	X	X	
AC Tie Breakers (Status)	X	(Note 1)	X	X	
AC Rectifier Transformer Feeder Breakers	X	X	X	X	
AC Auxiliary Transformer	X	X	X	X	
Digital Power Meter					X
Digital Protective Relays					X
AC Incoming Line Breakers (86L) (Lockout)			X	X	
AC Tie Breakers (Lockout) (86BT)			X	X	
AC Rectifier Transformer Feeder Breakers (Lockout) (86R)			X	X	
AC Auxiliary Transformer Feeder Breakers (Lockout)			X	X	
DC Cathode Breakers	X		X	X	X (Current)
DC Feeder Breakers	X	X	X	X	X (current)
Transformer Low Oil (63QL)			X		
Transformer Winding Over-Temp 1st Stage (49T1)			X	X	
Transformer Oil Over-Temp lst Stage (26TI)			X	X	

Note (1): Control circuitry for remote control is installed from the AC Tie Breaker to the D.T.S. cabinet only.

TABLE 23.2 (continued)

	DTS				AEMS
FUNCTION	CONTROL		INDICATION		Data
	Local	Remote	Local	Remote	Remote
Rectifier Over-Temp lst Stage (26RTI)			X	X	
Rectifier Diode Failure (95)			X	X	
Rectifier Grounded Structure (64X)			X		
Transformer Sudden Pressure (63SP)			X		
Transformer Explosion Diaphragm (63MR)			X		
Transformer Winding Over-Temp.2nd Stage (49T2)			X		
Transformer Oil Over-Temp 2nd Stage (26T2)			X		
Transformer Low Oil Level (63QL)			X		
Auxiliary Transformer Over-Temp.			X	X	
Rectifier Hot Structure (64C)			X		
Rectifier Over-Temp 2nd Stage (26RT2)			X		
AC Overcurrent (50/51,5ON/51N, 51A)			X		

TABLE 23.2 (continued)

	DTS				AEMS
FUNCTION	CONTROL		INDICATION		Data
	Local	Remote	Local	Remote	Remote
DC Switchgear Bus Voltage					X (Voltage)
DC Switchgear, Grounded Structure (64Y)			X		
DC Switchgear, Hot Structure (64D)			X		
UPS Transfer Switch Position (83b)			X	X	
ETS Alarm			X	X	
Battery Charger Failure			X	X	
Inverter Output Failure			X	X	
AC Line Voltage (High-Low) (27/59)			X	X	
DC Control Power Failure			X	X	
DC Shield Cable Monitor			X	X	
Substation DC Load (MW), DC Amps, DC Voltage					X
Substation AC Load and Parameters, e.g. voltage, frequency, power factor, etc. measured by the digital power meters on the incoming lines			X		X
DC Stray Current		~~X~~			X (Current)
Rail -to-Earth Voltage					X (Voltage)
3rd Rail Heater	X	X	X	X	

23 .6.7.3 TABLE 23.3 - LOCAL AND REMOTE INDICATION AND CONTROL FUNCTIONS FOR AUXILIARY ELECTRICAL EQUIPMENT

	DTS				AEMS
FUNCTION	CONTROL		INDICATION		Data Acquisition
	Local	Remote	Local	Remote	
AC Incoming Line Primary Breakers	X	X	X	X	
AC Incoming Line Primary Breakers Lockout (86)			X	X	
Secondary Tie Breaker	X		X	X	
Secondary Main Breaker	X		X	X	
Transformer Over-Temp 1st Stage	X	X	X	X	
Battery Charger Failure			X	X	
Inverter Output Failure			X	X	
Battery Room Exhaust Fan Operation			X	X	
UPS Transfer Switch Position			X	X	
Substation AC loads (Mechanical equipment and exterior lighting loads) measured by digital power meter	X	X	X	X (Note 2)	X

23 .6.7.3.1 Substation Starting Sequence

23 .6.7.3.1.1 The following depicts the starting sequence for a typical rectifier substation from the Electrical Supervisory Control Console.

23 .6.7.3.1.1.1 Select substation zone. Master control relay for selected zone (Device No. 4) automatically closes and is indicated by zone identification light illuminating on operator's console.

23 .6.7.3.1.1.2 Select incoming line breaker (Device No. 52L1 or 52L2).

23 .6.7.3.1.1.3 Verify non-lockout status of incoming line breaker.

23 .6.7.3.1.1.4 Close incoming line breaker.

23 .6.7.3.1.1.5 Select Rectifier Transformer AC feeder breaker (Device No. 52R).

23 .6.7.3.1.1.6 Verify non-lockout status of rectifier transformer unit.

23 .6.7.3.1.1.7 Close Rectifier-Transformer AC feeder breaker.

23 .6.7.3.1.1.8 DC associated cathode breaker (Device No. 72) automatically closes.

23 .6.7.3.1.1.9 Select DC feeder breaker (Device No. 172).

23 .6.7.3.1.1.10 Close DC feeder breaker.

23 .6.7.3.1.2 Conditions Preventing Start

23 .6.7.3.1.2.1 The conditions which will prevent starting of a rectifier substation remotely through Supervisory Control shall include, but are not limited to:

23 .6.7.3.1.2.1.1 Failure of master control relay in zone unit.

23 .6.7.3.1.2.1.2 Failure of AC rectifier transformer feeder breaker to close.

23 .6.7.3.1.2.1.3 Failure of air flow device where applicable to actuate.

23 .6.7.3.1.2.1.4 Equipment LOCAL-REMOTE switch in LOCAL position.

23 .6.7.3.1.2.1.5 Loss of control voltage.

23 .6.7.3.1.2.1.6 Hand reset lockout relay not reset.

23 .6.7.3.1.3 Substation Shutdown Sequence

23 .6.7.3.1.3.1 The following steps sequence the procedure for shutdown of a rectifier substation from the Electrical Supervisory Control Console at the Operations Control Center.

23 .6.7.3.1.3.1.1 Select substation zone. Master control relay for selected zone (Device No. 4) automatically closes and is indicated by zone identification light illuminating on operator's console.

23 .6.7.3.1.3.1.2 Select rectifier transformer AC feeder breaker (Device No. 52R).

23 .6.7.3.1.3.1.3 Trip rectifier transformer AC feeder breaker (Device No. 52R).

23 .6.7.3.1.3.1.4 The associated DC cathode breaker will automatically open.

23 .6.7.3.1.3.1.5 AC Incoming Line Breaker will remain closed unless tripped from operator's console.

23 .6.7.3.1.3.1.6 DC feeder breakers will remain closed unless tripped from operator's console. DC feeder breakers may be required to function as "tie" feeders thereby remaining closed.

23 .6.7.3.1.3.1.7 All shutdown breaker operations shall prevail, regardless of position of the "LOCAL-REMOTE" switch on any breaker.

23 .6.7.3.1.4 Transformer-Rectifier Lockout

23 .6.7.3.1.4.1 The following devices shall operate the Transformer-Rectifier AC Feeder Lockout relay (Device No. 86) and cause shutdown unit it is hand reset. One alarm shall be transmitted to Central Control to indicate the transformer lockout. The specific device that caused the lockout shall be annunciated on the local annunciator panel in the substation.

23 .6.7.3.1.4.1.1 Transformer winding over-temperature device, second step (49 T2)

23 .6.7.3.1.4.1.2 Transformer oil over-temperature device, second step (26 T2)

23 .6.7.3.1.4.1.3 Transformer sudden pressure device (63 SP)

23 .6.7.3.1.4.1.4 Transformer explosion diaphragm device (63 MR)

23 .6.7.3.1.4.1.5 Rectifier over-temperature, device, second step(26 RT2)

23 .6.7.3.1.4.1.6 Rectifier ground relay, hot structure (64C)

23 .6.7.3.1.4.1.7 AC overcurrent phase relay, time (51A)

23 .6.7.3.1.4.1.8 AC overcurrent phase relay, instantaneous and time (50/51)

23 .6.7.3.1.4.1.9 AC overcurrent residual ground relay, instantaneous and time (50N/51N)

23 .6.7.3.1.4.1.10 Rectifier diode failure second stage

23 .6.7.3.1.5 DC Switchgear Lockout

23 .6.7.3.1.5.1 The DC switchgear hot structure ground relay (Device 64D) shall trip the DC switchgear lockout relay (Device 86) and annunciate its operation on the local annunciator panel in the substation. Device 86 shall trip and lock out all cathode breakers and DC feeder breakers in the substation until it is hand reset.

23 .6.7.3.1.6 Safety Devices

23 .6.7.3.1.6.1 The following safety devices shall be annunciated continuously on the Electrical Console at the Control Center until the trouble is acknowledged or corrected. These devices shall all illuminate an annunciator panel provided in the substation:

23 .6.7.3.1.6.1.1 Transformer winding over-temperature, first stage (49T1)

23 .6.7.3.1.6.1.2 Transformer oil over-temperature, first stage (26T1)

23 .6.7.3.1.6.1.3 Rectifier over-temperature, first stage (26 RT1)

23 .6.7.3.1.6.1.4 UPS transfer switch position (83b)

23 .6.7.3.1.6.1.5 Battery "charge" relay indicating "no charge"

23 .6.7.3.1.6.1.6 UPS Inverter output failure

23 .6.7.3.1.6.1.7 DC control power failure

23 .6.7.3.1.6.1.8 Rectifier diode failure (95)

23 .6.7.3.1.6.1.9 Cable failure

23 .6.7.3.1.6.2 The following safety devices shall illuminate an annunciator panel provided in the substation.

23 .6.7.3.1.6.2.1 Rectifier ground relay, grounded structure (64X)

23 .6.7.3.1.6.2.2 [5]DC Switchgear, grounded structure (64Y)

23 .6.7.3.1.6.2.3 [1]DC Switchgear, hot structure (64D)

23 .6.7.3.1.6.2.4 Transformer low oil level (63 QL)

23 .6.7.3.1.6.2.5 Rectifier diode failure (95)

23 .6.7.3.1.6.2.6 Transformer sudden pressure relay (63SP)

23 .6.7.3.1.6.2.7 Cable failure

23 .7 MAINTAINABILITY AND CONSTRUCTIBILITY

23 .7.1 The design of the electrical system comprising equipment, raceways, fixtures, devices, wires and cables shall be coordinated with structural, mechanical architectural and other disciplines for the purposes of providing adequate space, clearances and structural support, and to ensure non-interference with other trades during construction. It shall take into account the ease of maintainability of the electrical equipment installed. Maintenance operations include inspection, adjustments, cleaning, trouble shooting, servicing, repairs and replacement of electrical equipment. The equipment selected should be subject to minimal system component failure.

23 .7.1.1 Space

23 .7.1.1.1 Sufficient working space and adequate access shall be provided for the maintenance and replacement of electrical equipment. Adequate space around electrical equipment shall be provided and maintained to allow for heat dissipation and cooling. This requirement shall include adequate space for movement of equipment during initial installation, and during

[5]In tie breaker stations, these safety devices shall illuminate an annunciator panel provided in tie breaker station.

subsequent unscheduled maintenance involving removal and replacement of failed equipment.

23 .7.1.2 Accessibility

23 .7.1.2.1 All electrical system switching and overcurrent protection devices shall be accessible to authorized persons only. Access to cables or conduits installed in return air plenums under station platforms shall be provided through manhole covers at appropriate locations.

23 .7.1.2.2 Adequate means, such as lifting eyes and/or I beams with a running hoist, shall be provided for raising, lowering, shifting, removal or replacement of heavy electrical equipment. Pulling eyes shall be provided for the pulling of cables at the following locations:

23 .7.1.2.2.1 AC Switchboard Rooms

23 .7.1.2.2.2 Traction Power Substations

23 .7.1.2.2.3 Tie Breaker Stations

23 .7.1.2.2.4 Train Control Rooms

23 .7.1.2.2.5 Communications Rooms

23 .7.1.2.2.6 Electrical Rooms

23 .7.1.2.2.7 Cable shafts

23 .7.1.2.2.8 Manholes

23 .7.1.2.2.9 Other locations where considered necessary

23 .7.1.3 Equipment Protection Against Water and Moisture:

23 .7.1.3.1 Each substation building and electrical room shall be designed to preclude any entry of water. Seals shall be provided on raceway and cable penetrating a building wall, floor or ceiling at a point. No water or sewage piping shall be installed inside substation and electrical equipment rooms. No pipe or mechanical duct that could cause moisture or condensation to fall on the electrical equipment shall be located above any major electrical equipment. Manholes shall be sealed to prevent water pressure to break cable conduit seals in the facilities.

23 .7.1.4 Embedded Conduits, Conduit Sleeves and Channel Inserts:

23 .7.1.4.1 Embedded conduits can be installed in the space available between rebars. Where a slab has to carry a large number of conduits, steps shall be taken to ensure that it will be feasible to install all the conduits without compromising the structural integrity of the concrete structure. Adequate cross sections shall be shown on the drawings to indicate how the raceways and other embedded items will be installed and cross each other where applicable. Where embedded FRE conduit emerges from a concrete slab or a wall, a FRE to galvanized rigid steel conduit adapter shall be provided, except traction power conduit.

23 .7.1.4.2 Where conduits are not provided as raceways, channel inserts shall be installed for supporting multiple conductor cables located under platforms, and in manholes. Spare conduit and sleeves shall be provided in concrete walls, floors or ceiling slabs of the AC Switchboard Rooms, Electrical

Rooms, Traction Power Substation, Tie Breaker Stations, Mechanical Rooms, ductbanks and other areas as required for possible future requirements.

23 .7.1.5 Electrical Plans, Details and Schedules:

23 .7.1.5.1 Plans and details showing physical arrangement and elevation with dimensions shall be provided on the drawings for all major electrical and mechanical equipment, raceways, junction boxes, fixtures and other items so that the design and construction can be coordinated with mechanical, structural and other disciplines.

23 .7.1.5.2 Schedules of all major electrical equipment including switchgear, switchboards, panelboards, transformers, disconnect switches, conduits, and cables shall be provided on the drawings. These schedules shall be complete and consistent with plans on associated electrical and mechanical drawings.

23 .7.1.6 Lighting System (Refer to Facilities criteria)

23 .7.1.7 Operation and Maintenance Manual:

23 .7.1.7.1 Operation and Maintenance Manual shall be provided for major electrical equipment. It shall include manufacturer's operation and maintenance instructions, Preventive maintenance inspection, wiring diagram, control and power elementary diagrams, list of spare parts and recommended stock quantities for one year routine maintenance and repair. A copy of approved shop drawing of equipment and other items where considered necessary shall be included.

23 .8 STANDARDS AND CODES

23 .8.1 Where applicable, Traction Power, AC Power and lighting system design shall conform to the following standards and codes:

23 .8.1.1 National Electrical Code (NEC)

23 .8.1.2 National Electrical Safety Code (NESC)

23 .8.1.3 Electrical Codes of the District of Columbia and Counties of Maryland and Virginia through which the Transit System will operate

23 .8.1.4 American National Standards Institute (ANSI)

23 .8.1.5 National Electrical Manufacturers Associations (NEMA)

23 .8.1.6 Institute of Electrical and Electronic Engineers (IEEE)

23 .8.1.7 Insulated Cable Engineers Association (ICEA)

23 .8.1.8 Underwriters Laboratories, Inc. (UL)

23 .8.1.9 Intertek Testing Services (ITS)

23 .8.1.10 Occupational Safety & Health Administration (OSHA)

23 .9 GLOSSARY

23 .9.1 Standard Terminology

23 .9.1.1 In general, definitions applied to Traction Power, AC Power, and Supervisory Control Functions shall conform to definitions listed in ANSI/IEEE C37.100 of the American National Standards Institute and the Institute of Electrical and Electronics Engineers.

23 .9.1.2 Basic electrical terminologies used in these criteria, which are not defined in the ANSI/IEEE reference or in the following Special Terminology, are to be interpreted in their normal usage.

23 .9.2 Special Terminology

23 .9.2.1 The following definitions of special terms shall apply. Terminology more pertinent to Train Control may also be used in the Electrical Criteria.

23 .9.2.1.1 Anode Bus:

23 .9.2.1.1.1 An assembly of rigid conductors with associated connections, joints and insulating supports connecting the AC output of a rectifier transformer to a rectifier.

23 .9.2.1.2 Cathode Breaker (Rectifier Main Breaker):

23 .9.2.1.2.1 A direct current circuit breaker protecting the positive output side of a rectifier.

23 .9.2.1.3 Cathode Bus:

23 .9.2.1.3.1 An assembly of rigid conductors with associated connections, joints and insulating supports carrying positive direct current from the output side of a rectifier to a cathode breaker.

23 .9.2.1.4 Contact Rail Anchor:

23 .9.2.1.4.1 An insulated assembly attached to contact rail and invert or ties, which restrains the rail against thermal movement parallel to the tracks.

23 .9.2.1.5 Contact Rail Assembly:

23 .9.2.1.5.1 The bus bar at trackside which carries electric energy for the propulsion of trains; the assembly includes supports, insulation and protective covering.

23 .9.2.1.6 DC Feeder Breaker:

23 .9.2.1.6.1 A direct current circuit breaker with associated load sensing devices, the purpose of which is to provide energization to, or remove energization from, a section of contact rail. The feeder breaker may operate as a tie feeder or as a radial feeder, or both.

23 .9.2.1.7 End Approach:

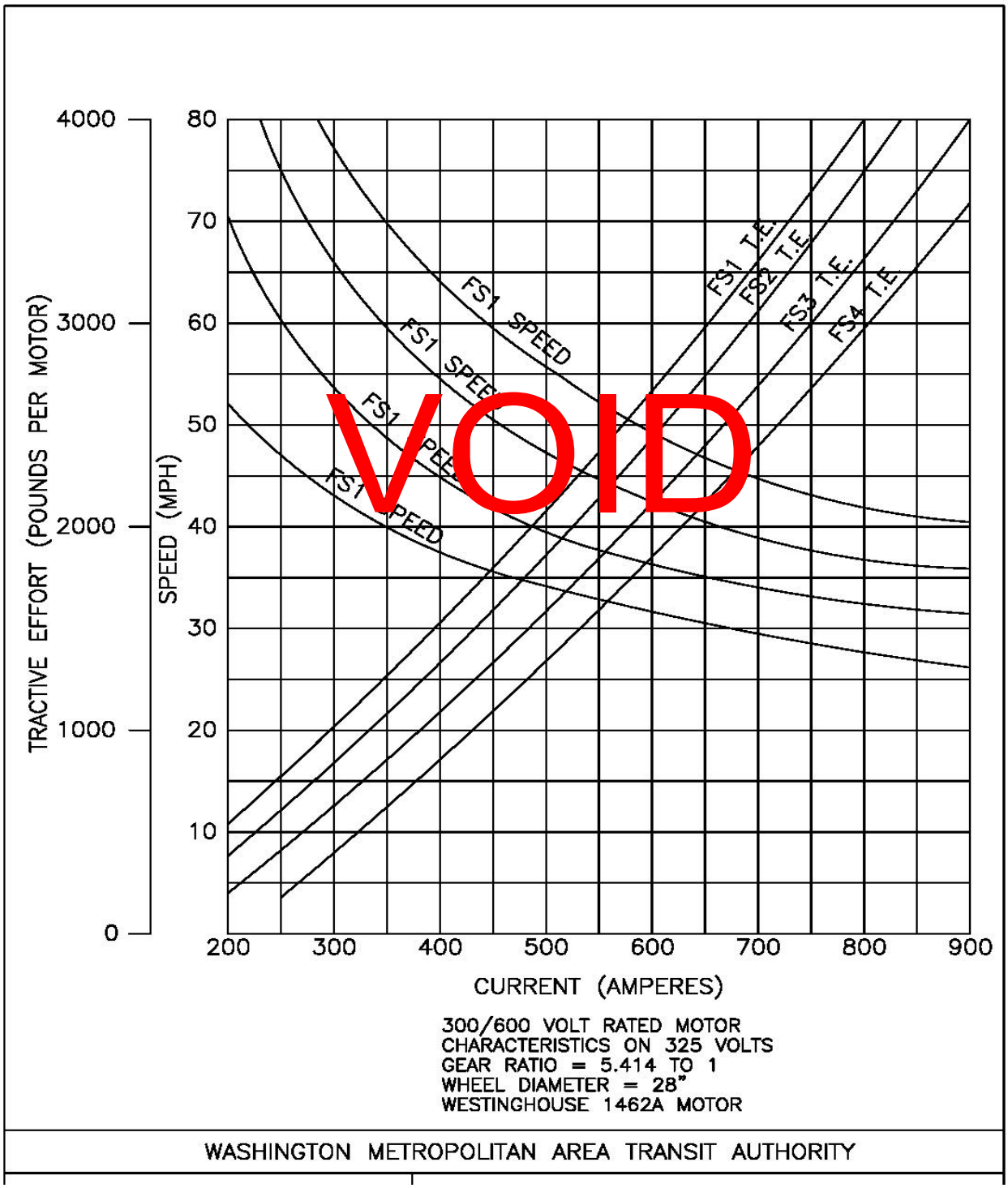
23 .9.2.1.7.1 Segment of contact rail graduated from minimum height to full height, to permit car shoes to ride up onto the contact rail or leave it at a contact rail gap.

23 .9.2.1.8 Interface:

23 .9.2.1.8.1 The junction between two systems or subsystems. A point where the two systems or subsystems are common.

23 .9.2.1.9 Rectifier - Transformer AC Feeder Breaker:

23 .9.2.1.9.1 A primary voltage alternating current circuit breaker in the line side of a rectifier transformer.


TRACTIVE EFFORT (POUNDS PER MOTOR)
4000
3000
2000
1000
0
SPEED (MPH)
80
70
60
50
40
30
20
10
200
300
400
500
600
700
800
900
CURRENT (AMPERES)
FS1 SPEED
FS1 SPEED
FS1 SPEED
FS1 T.E.
FS2 T.E.
FS3 T.E.
FS4 T.E.
VOID
300/600 VOLT RATED MOTOR
CHARACTERISTICS ON 325 VOLTS
GEAR RATIO = 5.414 TO 1
WHEEL DIAMETER = 28"
WESTINGHOUSE 1462A MOTOR
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

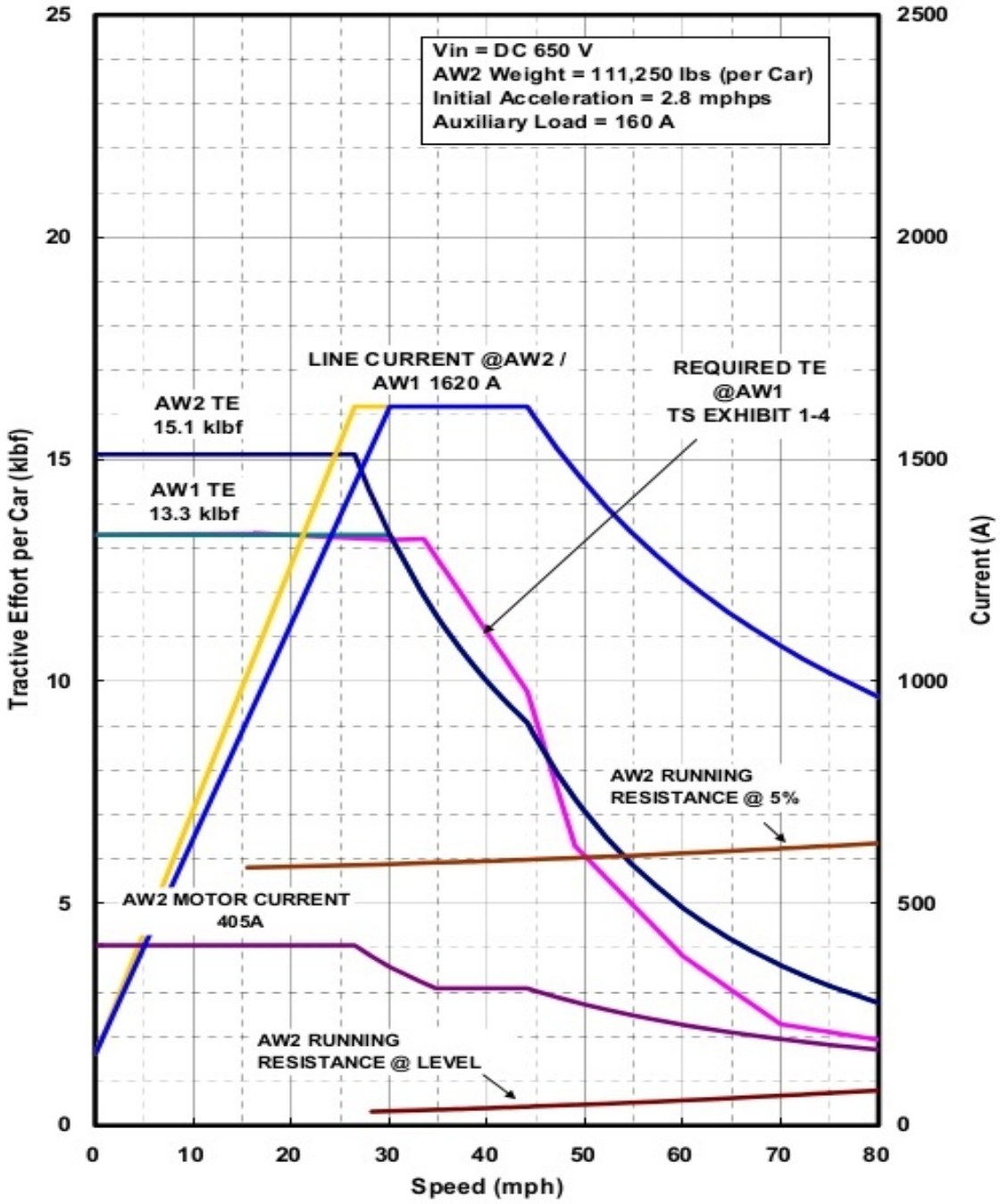


FIGURE 23.1

Railcar Electrical **Performance Characteristics**

FIGURE 23.1

24.1.1.1.1.1.1. AUTOMATIC FARE COLLECTION (AFC)

24.2 General (Future)

24.3 Central Computer Systems (Future)

24.4 Bus Garage/Shop Facilities (Future)

24.5 Bus Farebox

24.6 Light Rail (Future)

24.7 Heavy Rail Station

24.7.1 Mezzanine Layouts and Locations (Future)

24.7.1.1 Walker Ducts (Future)

24.7.1.2 Conduits (Future)

24.7.1.3 Wire and Cable (Future)

24.7.1.4 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 will 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.

24.7.1.5 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.

24.7.1.6 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 exitfare 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.

24.7.1.7 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.

24.7.2 Power Requirements (Future)

24.7.3 Data Communication Network (Future)

24.7.4 SMADS (Future)

24.7.5 Vending Equipment (Future)

24.7.6 Faregates (Future)

24.7.7 Performance and Reliability (Future)

24.7.8 Fire and Intrusion (Future)

24.7.9 Signage and Equipment Appearance (Future)

24.7.10 Mezzanine Railing (Future)

24.8 Parking Facilities (Future)

24.9 Administration and Regional Facilities (Future)

SECTION 25 AUTOMATIC TRAIN CONTROL (ATC)

SECTION 25 GENERAL

25 .1.1 Criteria Coverage

25 .1.1.1 Scope

These Criteria include all functional and design criteria for Train Control Systems for the Washington Metropolitan Area Transit Authority (WMATA) METRORAIL Transit System. This includes criteria for the Automatic Train Control (ATC) System for the mainline Revenue Service portion of the METRORAIL System, and for the Signal Control and Interlocking Systems applicable to the yards and other non-revenue service portions of the METRORAIL System. These Train Control Criteria (Section 3) do not include criteria for the WMATA Operations Control Center (OCC). See Section 26.2.1 for an overview of the Computer Systems portion of the criteria.

25 .1.1.2 Intent

The intent of these Criteria is to prescribe conditions which must be specified, designed, properly implemented, tested, and documented, to result in WMATA Train Control Systems and equipment which shall control the movement and certain operations of trains in a safe and expeditious manner, and in complete compatibility with the current Train Control Systems in use on the WMATA METRORAIL System.

25 .1.1.3 Standards

The design of WMATA Train Control Systems must be coordinated with the design standards of current and new transit car equipment, propulsion power equipment, and communications equipment, and with the current WMATA Train Control Systems.

25 .1.1.3.1 Organizational Standards

25 .1.1.3.1.1 The design and implementation of WMATA Train Control Systems shall be guided by the requirements of:

25 .1.1.3.1.2 Part 236-Rules, Standards, and instructions governing The Installation, Inspection, Maintenance, and Repair of Signal and Control Systems, Devices and Appliances, of the: Rules and Regulations Governing Railroad Signal and Control Systems, as prescribed by the Department of Transportation -Federal Railroad Administration - Office of Safety;

25 .1.1.3.1.3 National Electrical Code and all applicable local codes.

WMATA Train Control Systems shall conform to the recommendations of applicable Parts of the Signal Section Manual of the Association of American Railroads/American Railway Engineering and Maintenance-of-Way Association (AAR/AREMA Signal Manual of Recommended Practice) unless otherwise specified.

25 .1.1.3.2 WMATA Standards and Practices

25 .1.1.3.2.1 The design and implementation of WMATA Train Control Systems shall comply with the requirements of:

- Current WMATA METRORAIL clearance standards;
- Current WMATA METRORAIL Standard Operating Procedures;
- Current WMATA METRORAIL wayside signal aspects, names, and indications;
- Current WMATA METRORAIL nomenclature, terminology and definitions of terms.

25 .1.2 Current Wayside METRORAIL System Configurations

25 .1.2.1 Current METRORAIL "Routes," "Lines" and Yards

25 .1.2.1.1 Routes

The various geographical METRORAIL "Routes" are designated by a letter of the alphabet and a geographical destination name, usually the outer terminus of the Route as follows:

"A" Route/Shady Grove Route:
Metro Center (Upper) to Shady Grove;

"B" Route/Glenmont Route:
Metro Center (Upper) to Glenmont;

"C" Route/Huntington Route:
Metro Center (Lower) to Huntington;

"D" Route/New Carrollton Route:
Metro Center (Lower) to New Carrollton;

"E" Route/Greenbelt Route:
Gallery Place (Lower) to Greenbelt;

"F" Route/Branch Ave. Route:
Gallery Place (Lower) to Branch Ave.

"G" Route/Addison Road Route:
D-G Junction to Largo Town Center;

"J" Rte/Franconia/Springfield Rte.:
C-J Jct. to Franconia/Springfield;

"K" Route/Vienna Route:
Rosslyn to Vienna;

"L" Route/Potomac River Crossing:

L'Enfant Plaza (Upper) to Pentagon.

25 .1.2.1.2 Lines

There are five color-coded Revenue Service "Lines" normally operated by the Authority, as follows:

Line	From	To	Routes Used
Red	Shady Grove	Glenmont	A & B
Orange	Vienna	New Carrollton	K, C & D
Blue	Franconia/ Springfield	Largo Town Center	J, C, D & G
Yellow	Huntington	Fort Totton	C, L, F & E
Green	Greenbelt	Branch Ave.	E & F

25 .1.2.1.3 Yards

There are eight Yards on the METRORAIL System, as follows:

Yard Name	Type
Brentwood	Heavy Repair/S&I
Greenbelt	Heavy Repair/S&I
Alexandria	S&I
New Carrollton	S&I
Shady Grove	S&I
West Falls Church	S&I
Glenmont	Storage
Branch Avenue	S&I

25 .1.2.2 Current Wayside Train Control System Configurations

25 .1.2.2.1 Mainline Automatic Train Control

Systems shall conform to current WMATA practices as follows:

25 .1.2.2.1.1 The mainline, revenue service Automatic Train Control (ATC) System shall be controlled primarily from wayside Train Control Rooms located at Passenger Stations and certain intermediate locations. The vital, fail-safe relay and microprocessor-based control equipment comprising the wayside portion of the Automatic Train Protection (ATP) subsystem shall be located in these TCRs, along with non-vital control and indication equipment used in the wayside portion of the Automatic Train Operation (ATO) and Automatic Train Supervision (ATS) subsystems.

25 .1.2.2.1.2 The equipment in the TCRs shall be hard-wired to the various Train ATC Control track circuits, switch machines, signals, loops, marker coils, pushbuttons, snowmelters and other trackside train control equipment, and to DTS junction boxes for various ancillary devices and equipment furnished and installed by others.

25 .1.2.2.1.3 For supervisory purposes, the ATC and ancillary device equipment shall be hard wired to a Remote Terminal Unit (RTU) in each

mainline TCR in a prescribed sequence as shown on pre-approved RTU Scan Sheets. The RTU shall in turn be wired to a TC/COMM interface junction box in an adjoining Communications Equipment Room. The Communications System (by others) provides the link between the field RTUs and the ATS Operations Control Center (OCC) at WMATA Headquarters in downtown Wash-ington, DC. See Section 26.2.1 for an overview of the Computer Systems portion of the criteria.

25 .1.2.2.2 Yard Signal Control and Interlocking Systems shall conform to current WMATA Yard Train Control System practices as follows:

25 .1.2.2.2.1 Yard Signal Control and Interlocking Systems shall be controlled by vital and non-vital Train Control (TC) equipment installed in Train Control Rooms located at strategic points in the Yard.

25 .1.2.2.2.2 The TC equipment in the TCRs shall be hard-wired to the various switch machines, signals, snowmelters, dragging equipment detectors and other trackside train control equipment in accordance with WMATA standard practices and in a manner approved by the Authority.

25 .1.2.2.2.3 A Yard (Interlocking) Control Machine shall be provided in the Yard Control Room to enable WMATA Interlocking Operators to supervise the movement and routing of transit cars and railborne maintenance/ service equipment within the limits of the yards.

25 .1.2.2.2.4 Control of a portion of the yard lead tracks adjacent to a mainline passenger station may have to be made transferable between the Yard Interlocking Operator and Central Control.

25 .1.2.3 Train Control Room Configuration

25 .1.2.3.1 Racks and Cable Trays

Cable trays and 19-inch equipment racks for Train Control equipment, power supplies, and cable entrance terminations, shall be installed in rows in the TCRs in compliance with WMATA standard spacing requirements and in coordination with lighting, power source, grounding and HVAC equipment installed by others.

25 .1.2.3.2 Train Control Power

Automatic power transfer and bypass-isolation equipment, room prime ground bus bars, and, where applicable, large interlocking control panels, shall be wall-mounted in the TCRs at locations pre-approved by the Authority.

25 .1.2.3.3 Maintenance Furniture and Equipment

Maintenance furniture and equipment, as specified, shall be provided at appropriate locations in each TCR.

25 .1.3 Basic Train Control Functions, Principles and Requirements

25 .1.3.1 Train Location Detection

Determination of train location on the WMATA METRORAIL System shall be accomplished by means of the shunting of track circuits by the wheel-and-axle sets of the transit cars.

25 .1.3.1.1 Vital Track Circuits

25 .1.3.1.1.1 Vital Audio Frequency (AF) track circuits (of the type described in Section 25.2.2.1.1.1, shall be used for "train detection" purposes on mainline tracks in the revenue service areas and on certain yard lead tracks.

25 .1.3.1.1.2 Vital, single-rail, AC power frequency track circuits (of the type described in Section 25.1.6.1), shall be used for train detection purposes on mainline crossover tracks and on yard interlocking, yard lead, and yard running tracks, and as otherwise specified.

25 .1.3.1.2 Non-vital Track Circuits

Non-vital, series-type, alternating current (60 Hz) track circuits (of the type described in Section 25.3), shall be used for train detection purposes on yard storage, wash track, and shop lead tracks.

25 .1.3.2 Train Separation

25 .1.3.2.1 Block Design

The Block Design shall perform three basic functions:

25 .1.3.2.1.1 Provide track blocks and speed determination for safe train operation, i.e. provide safe-braking distance (SBD) train separation for both "ideal" and "worst case" trains at all times.

25 .1.3.2.1.2 Provide the required operational headways (in both directions);

25 .1.3.2.1.3 Allow trains to travel as fast as safely possible.

25 .1.3.2.1.4 In addition, the Block Design shall provide such track circuit boundaries as are necessary for:

- crossbonding and negative propulsion return requirements;
- safe definition of interlocking boundaries;
- proper operation of program station stopping;
- automatic train routing and automatic terminal operation.
- The methods, procedures and formulae used to determine Safe Braking Distance and intermediate block boundaries shall be as specified in the latest WMATA Automatic Train Control Contract Specifications.

25 .1.3.2.2 Speed Control

Appropriate mainline speed limit "commands" shall be generated by the wayside Automatic Train Protection (ATP) System as determined by the Block Design, based upon trackwork character-istics, transit vehicle characteristics, train routing, passenger comfort considerations, and train occupancy of the various track blocks. These speed commands shall be transmitted by the wayside ATP system to the Audio Frequency track and loop circuits where they will be detected and acted upon by the carborne Automatic Train Control systems to safely control the acceleration, speed, and braking of the transit car trains.

25 .1.3.2.3 Traffic Control

25 .1.3.2.3.1 Vital traffic circuits shall be provided to prevent opposing moves of trains between interlockings on mainline tracks and on certain yard lead tracks. These vital traffic circuits shall be integrated with non-vital, automatic traffic initiation circuits, and configured and implemented in the same manner as the vital traffic circuits currently in use on the WMATA METRORAIL System.

25 .1.3.2.3.2 Yard running tracks shall be equipped with non-vital traffic and traffic initiation circuits configured and implemented in the same manner as those currently in use on WMATA Yard running tracks.

25 .1.3.3 Train Routing

Route initiation shall be accomplished by identifying the desired route in terms of the entering signal and exiting signal.

25 .1.3.3.1 Manual Route Initiation from Central or Local Interlocking Control Panel

Manual route requests at an interlocking shall be initiated and selected as follows:

25 .1.3.3.1.1 The desired entrance point (home signal) control device shall first be activated. Once this has been done, the Entrance-Exit system circuits (logic) shall determine the "status" of all possible routes emanating from the chosen entrance point, based upon conditions in the field, and shall indicate which of these possible route exit points are "available," i.e., can safely accept a train exit movement from the interlocking without conflicting with any other route previously granted or requested. (A route request originating at an intermediate or hold-out signal has only one possible route "exit." The "availability" of this route will depend upon the current availability of the desired "traffic" direction on the applicable exit track.)

25 .1.3.3.1.2 The desired route through the interlocking shall be "selected" by activating the control device at the "available exit" point desired.

25 .1.3.3.2 Automatic Route Initiation

Facilities shall be provided at designated locations for train routing to be automatically initiated in one of three ways, as applicable:

25 .1.3.3.2.1 By track occupancy in approach to a converging switch (first-come, first-served);

25 .1.3.3.2.2 By recognition of train destination code by the TWC System (in approach to one or more diverging switches);

25 .1.3.3.2.3 By terminal mode selection in approach to a terminal interlocking.

25 .1.3.3.3 Wayside PB Route Initiation

Facilities shall be provided to enable train operators to initiate their own desired routes at certain designated locations, by means of wayside pushbuttons.

25 .1.3.3.4 Initiation Coordination

The methods of route initiation described above shall be coordinated to protect against misrouting and lockups. Coordination shall include: local-remote control to prevent both local control and central control from being active at the same time; lockout control to prevent any active initiation method from functioning while another method is being used to initiate a route, and; time-out control to cancel an unidentified entering signal if an exit is not identified in a predetermined time.

25 .1.3.3.5 Route Completion

After the route initiation is completed by identifying both the entering signal (PBS relay energized) and the exiting signal (XS relay energized), the route completion circuits (logic) shall complete the route by requesting the proper switch positions, de-energizing the unselected “available exit” (EX) relays, making a preliminary check of the route integrity, initiating the vital locking, and initiating the request for signal clearing. Route completion shall be accomplished as described in the latest WMATA Train Control Specifications.

25 .1.3.3.6 Time Released Approach Locking

Approach locking with timed release shall be provided for all controlled signals. One such locking circuit shall be provided for each signal or group of converging-route signals. This form of locking shall be initiated when the Route Check (RC) relay becomes energized and shall remain in effect until released by one of the following:

25 .1.3.3.6.1 The signal is accepted by the train (two track release).

25 .1.3.3.6.2 The signal is set to stop and no train is within the approach limits.

25 .1.3.3.6.3 The signal is set to stop and a predetermined “approach” time has expired.

The approach locking (AS) relay circuits shall be arranged such that a momentary interruption of track circuit energy will not

release the locking. This shall be accomplished by using "two track release," (the last track circuit within the interlocking, and the first, "exit" track circuit beyond the interlocking). The two track circuits shall be driven from different branch fuses, and the AS relays shall be cross checked so that, if opposing AS relays are both de-energized, as would be the case with a dc bus failure, time must be run to release the locking.

25 .1.3.3.7 Route Locking

25 .1.3.3.7.1 Route locking shall be provided to maintain security of the route ahead of the train as it progresses through the interlocking. Route locking shall be initiated by the initiation of approach locking and shall be released when approach locking is released and there are no occupancies in the route. In some cases the route shall be divided into contiguous sections for route locking purposes and locking of the section(s) of the route behind the train shall be released (sectional route release) as the train progresses through the route.

25 .1.3.3.7.2 Route Locking shall be performed by Route Stick (RS) relays.

25 .1.3.3.8 Detector Locking

Detector locking shall be estab-lished by the track relay(s) for the track circuit(s) in which each switch (or crossover) in the route is located and shall prevent switches from being thrown under a train. At interlockings with automatic route initiation, loss of shunt protection shall be provided by requiring track relays to be energized for a predetermined time before locking is released.

25 .1.3.3.9 Switch Control and Indication

25 .1.3.3.9.1 The switch control relays (NWZ and RWZ) shall be driven from the switch call relays (lever repeaters NLP and RLP) in the route completion network. The switch control relays shall be circuited to provide storage of the switch call, provide premature indication prevention, and prevent preconditioning.

25 .1.3.3.9.2 The mainline switch control repeater relays shall be vital relays, primarily for maintenance convenience.

25 .1.3.3.9.3 The mainline switch control repeater relays shall control pole changed energy to the switch operating relays (NWR and RWR) through lock stick relay (LSR) contacts. The lock stick relay contacts shall be wired to provide a short circuit across the switch operating relays when the LSR is deenergized.

25 .1.3.3.9.4 A lock stick relay (LSR) shall be used to provide mainline switch stroke completion in the event that the lock relay becomes deenergized prior to completion of the switch stroke.

25 .1.3.3.9.5 Overload protection of mainline switch machine motor circuits shall be provided by an overload stick relay (OR), which has one coil in series with the motor circuit. The second coil shall be used as

a stick coil and shall be energized (through contacts of the same relay) from the drive circuit for the switch operating relays.

25 .1.3.3.9.6 Mainline switch machine motor circuits shall be two-wire, pole-changed circuits controlled by magnetic blow-out contacts on the switch operating relays.

25 .1.3.3.9.7 Mainline switch position indication shall be controlled by a set of switch circuit controller contacts within the switch machine which are part of a two wire, pole changed circuit, driving a pair of biased switch repeater relays (NWPR and RWPR). Where two switch machines are operated as one, such as at a crossover, the indication circuit shall be controlled by the switch circuit controllers in both switch machines connected to one another by way of the Train Control Room to drive a single set of switch repeater relays.

25 .1.3.3.9.8 Switch correspondence relays shall be provided to verify that the switch repeater relays are indicating that the switch is in the position required by the switch control and switch operating relays.

25 .1.3.3.9.9 NOT USED

25 .1.3.3.9.10 Signal Control

Signals shall be controlled by home signal (HG) relays which are energized by route check (RC) network relays. The following checks shall be included in these networks:

- Approach locking is in effect.
- Route locking is in effect.
- Traffic locking beyond the exit signal is in effect.
- Lock (and mainline Lock Stick) relays are deenergized.
- Switches are in proper correspondence.
- Route is not occupied.
- Timers associated with release of locking are at zero time.
- There has not been an overrun of a red signal at the interlocking.

Where a number of control lines extend past a mainline facing point signal location, route sensitive signal repeater relays shall be provided for use in the speed circuits.

25 .1.3.3.9.11 Signal Clearing

Once the desired route has been aligned and checked, locking activated, and, where applicable, suitable traffic direction established, the ATP system shall:

25 .1.3.3.9.11.1 Cause the applicable wayside signal to display the appropriate "clear" aspect. Signal lighting energy shall be controlled through front and back contacts of the home signal (HG) relays. (The two red lenses of the STOP aspect shall be independently lighted from separate energy buses.)

25 .1.3.3.9.11.2 Where applicable, cause the appropriate speed commands to be transmitted (in the proper sequence).

25 .1.3.3.9.11.3 The ATS System shall then indicate the route aligned and locked, and the cleared signal, to Central and to the local control panel(s).

25 .1.3.3.9.12 Speed Command Loop Control

Mainline speed command loop control and selection circuits shall be provided to sequence the transmission of speed commands through interlockings. The circuits and sequencing shall be such that a speed command never appears behind a train and only one loop is energized downstream of the track circuit occupied by the train.

25 .1.3.3.9.12.1 Loop control circuits shall be organized to require that the appropriate home signal be clear and a train be on the first track circuit in the approach before the sequence can begin.

25 .1.3.3.9.12.2 Overrun protection shall be provided to interrupt the sequence and stop the transmission of all speed commands within the interlocking in the event of an overrun of a red signal.

25 .1.3.4 Rail/Impedance Bond Circuit Connections

25 .1.3.4.1 Negative Propulsion Return Current Connections

The yard and mainline Train Control Systems shall include all running rail and impedance bond connections of the types and sizes required by the applicable Specifications for negative-return rail transposition purposes, for current equalizing purposes, and for the return of propulsion current from the trains, through the running rail(s), to the substation-return conductors (furnished by others). This shall include compression-cone type, compression -eyelet type, compression-bolted type, and base-of-rail-clamped type bonds, as specified.

25 .1.3.4.2 Track Circuit/Rail Connections

25 .1.3.4.2.1 All power-frequency track circuit leads and bonding shall be provided.

25 .1.3.4.2.2 Power frequency track circuit leads shall be connected to the running rails by means of rail-web, pin-type connectors of the specified type and size.

25 .1.3.4.2.3 Signal rails shall be bonded by means of exothermically connected rail-head bonds of the specified type wherever possible, and by rail-web, pin-type bonds where necessary.

25 .1.3.4.3 Snowmelter Related Rail Connections

25 .1.3.4.3.1 All rail connections necessary for the safe operation of switch point snowmelters and switch rod heater units shall be provided in the specified manner. This shall include:

25 .1.3.4.3.1.1 Exothermic connection of snowmelter and rod heater unit negative return leads to the center of the web of the proper negative return rail(s).

25 .1.3.4.3.1.2 Exothermic connection of snowmelter case-heater negative return leads to the proper negative-return rail, or bolted connection to appropriate impedance bond center tap.

25 .1.3.4.3.1.3 Base-of-rail exothermic connection of the snowmelter fuse box positive energy lead to the appropriate third rail.

25 .1.3.5 Basic Criteria for TC Circuits and Equipment

25 .1.3.5.1 Clearances

All wayside Train Control equipment shall be designed and installed to provide 4-inch clearance for the dynamic outline of the METRO transit cars wherever possible. This shall include allowances for the end and center overhang of transit cars on curved track (and when passing through crossovers and diverging turnouts), and for the tilting of the transit cars on superelevated track. In all cases where a 4-inch transit car clearance envelope cannot be maintained, an absolute minimum 2-inch clearance envelope shall be maintained. See , Figure 25 - TC-2.

25 .1.3.5.2 Maintainability

All Train Control equipment shall be designed and installed in such a manner that it will be easy to maintain and replace.

25 .1.3.5.3 Track Circuit Length

The running rail portion of every track circuit (or contiguous portion thereof) shall be at least 50 feet in length (to avoid the possibility of being straddled by the transit car wheelbase).

25 .1.3.5.4 Cross Bonding

Negative propulsion return cross-bonding of mainline tracks shall be provided at intervals of approximately 2000 feet wherever practicable, i.e., where cross bonding conduit has been furnished in place by others. Under no circumstances shall both ends of an AF track circuit be crossbonded nor shall any AF track circuit exceed in length 55% of the distance between a crossbond to which it is connected and the

next crossbond. Note that a substation return location shall be considered to be a crossbonding location.

25 .1.3.5.5 Environmental Requirements

25 .1.3.5.5.1 Physical

25 .1.3.5.5.1.1 All Train Control equipment provided shall function normally throughout the applicable tempera-ture and humidity ranges prescribed in the applicable WMATA METRORAIL Train Control Specifications.

25 .1.3.5.5.1.2 All Train Control equipment provided shall function normally while being vibrated under the conditions prescribed in the applicable WMATA METRORAIL Train Control Specifications.

25 .1.3.5.5.2 Electrical

All Train Control equipment and systems provided shall function properly in the unfavorable electrical environment of the WMATA METRORAIL Rapid Transit System, which will tend to cause electro-static, electromagnetic, inductive, conductive and radiated interference.

25 .1.3.5.6 Cable and Wiring

25 .1.3.5.6.1 All Train Control cable and wiring provided shall meet all the requirements specified for such cable and wiring in the latest applicable WMATA METRORAIL yard or mainline Train Control Specifications.

25 .1.3.5.6.2 All TC cable and wiring conductors shall be sized to provide equipment-rated current and voltage, within specified tolerances, at each piece of TC equipment supplied under full load conditions.

25 .1.3.5.6.3 The types of cable, insulation, and number of conductors provided for each type of application shall be in accordance with the requirements of the latest applicable WMATA METRORAIL Train Control Specifications.

25 .1.4 Support Systems

25 .1.4.1 Data Transmission System (DTS)

All Data Transmission System extensions shall consist of microprocessor based Remote Terminal Units (or their equivalent) located in mainline Train Control Rooms, and associated hard wiring and other data transmission media to accurately transmit non-vital Train Control information and ancillary facility control and indication information between the Communications Carrier Transmission System (CTS) and the various wayside Train Control and ancillary system equipment.

25 .1.4.1.1 Remote Terminal Units

A Remote Terminal Unit (RTU) (or acceptable alternative) shall be provided for each major mainline wayside control site, which shall include a main TCR at each passenger station. These RTUs shall be appropriately sized individually to serve the applicable number of non-vital Train Control and ancillary system "control" and "status" data points necessary at each "control location," plus a 20 percent spare capacity. Data points shall be assigned and wired in a WMATA-prescribed sequence as indicated on Authority approved "RTU Scan Sheets." The RTUs provided shall operate in complete harmony with the current METRORAIL Data Transmission System (DTS) parameters, and shall interface properly with the current METRORAIL Communications "Carrier Trans-mission System" (CTS).

25 .1.4.1.2 Train Control System Functions

The DTS shall provide the wayside portion of the non-vital link between Central and the types of wayside Train Control (control and indication) functions listed in TABLES OF DTS FUNCTIONS I and III, as applicable.

25 .1.4.1.3 Ancillary System Functions

The DTS shall provide the wayside portion of the link between Central and the types of ancillary control and indication functions listed in DTS FUNCTION TABLES II, IV and V, as applicable.

25 .1.4.1.4 DTS Interfacing

25 .1.4.1.4.1 Remote Terminal Units

The various TC and ancillary control and indication data points shall be hard wired to the Remote Terminal Units in the mainline TCRs using appropriate twisted-pair or twisted-triple wire of appropriate gauge. This interface wiring shall be kept separate from internal RTU wiring. Most of the Train Operation function wiring will be within the Train Control Rooms.

25 .1.4.1.4.2 Communications Systems

25 .1.4.1.4.2.1 The DTS Remote Terminal Units shall be hard wired to the appropriate Carrier Transmission System (CTS) on the Main Distribution Frame in the applicable wayside Communications Equipment Room using appropriate multipair special control and indication cable.

25 .1.4.1.4.2.2 The ATC/COMM Interface Cabinet will be provided in applicable Communications Equipment Rooms for the interface of special station, and/or parking lot ancillary DTS functions - primarily fire and intrusion alarm indications and passenger station Kiosk functions. Appropriate multi-twisted pair DTS cable shall be used to connect these controls and indications to the RTU in the applicable TCR.

25 .1.4.1.4.3 Ancillary Facilities

DTS Interface Junction Boxes (Cabinets) are installed and partially wired by power, ventilation, and other ancillary system contractors at their respective wayside facilities. Appropriate multi-twisted pair DTS cable shall be use to connect these ancillary equipment junction boxes to the RTU in the applicable TCR.

25 .1.4.1.4.4 Yards

Appropriate non-vital hard wiring and/or fiber optic interface systems shall be provided to connect certain non-vital yard Train Control and ancillary functions to the RTU in the terminal station Train Control Room.

25 .1.4.1.4.5 DTS Junction Box Wiring Diagrams

Legible, moisture-proof wiring diagrams showing the as-built wiring nomenclature for all wires terminated in TC/COMM Interface Boxes and DTS Interface Junction Boxes shall be provided in all such DTS boxes.

25 .1.4.2 TC Power Distribution Systems

25 .1.4.2.1 Description

A complete Train Control Power Distribution System shall be provided inside each Train Control Room and Train Control Equipment Room. Each of these Power Distribution Systems shall include all transfer and bypass equipment, power supplies, transformers, buses, feeders and mains necessary to accept electrical energy from the power sources furnished by others, modify it as necessary, and distribute it at proper voltages to the various pieces of Train Control equipment mounted in the TCR in compliance with Authority standards.

25 .1.4.2.2 Load Balance and Power Factor

Each TC Power Distribution System shall be designed to achieve the best load balance and power factor practicable.

25 .1.4.2.3 Power Failure Alarm

Each TC Power Distribution System shall include a power failure and over current alarm system circuited in compliance with Authority standards. Where a Remote Terminal Unit (RTU) is located in the TCR, this alarm system shall include a check of the five volt internal power supply of the RTU.

25 .1.4.2.4 Protective Devices

Each TC Power Distribution System shall include an array of monitoring, isolation and protective facilities in compliance with Authority standards.

25 .1.4.2.5 Voltage and Capacity

All TC Power Distribution Systems, regardless of rated system voltage, current or frequency, shall deliver the system voltage to the TC modules, de-vices, or appliances connected to that system at not less than 95 percent, or more than 105 percent of the nominal voltage rating of the modules, devices, or appliances, and with sufficient capacity for continuous operation of the applicable equipment.

25 .1.4.2.6 Configuration

Each TC Power Distribution System shall be configured in compliance with all applicable Authority standards and practices, and shall be compatible with the commercial power sources furnished by others.

25 .1.4.2.7 Supplementary Power Sources

For those TCRs or TCERs not furnished with commercial power sources by others, the TC Power Distribution System shall also include provision of necessary power sources from the nearest TCR having one or more commercial power sources.

25 .1.4.3 Lightning/Surge Protection and Grounding Systems

25 .1.4.3.1 Lightning/Surge Protection

25 .1.4.3.1.1 A complete, coordinated system to protect the Train Control circuits and equipment from lightning and other electrical surges shall be included in the Train Control system. This lightning/surge protection system shall include:

25 .1.4.3.1.2 Segregation of high voltage wiring from low voltage wiring;

25 .1.4.3.1.3 Segregation of Train control wiring from power/operating wiring and communications wiring;

25 .1.4.3.1.4 Provision of short, direct, low resistance conductor paths for the grounding of equipment and protective devices;

25 .1.4.3.1.5 Provision of initial lightning protection and surge protection by means of low resistance (15 ohms) earth grounds for outside Train Control equipment, and at the point where TC cables and wiring first enter the buildings housing the Train Control Rooms;

25 .1.4.3.1.6 Provision of primary, high-current-capacity, properly grounded arresters of characteristics and type(s) appropriate to the application(s);

25 .1.4.3.1.7 Provision of three-stage secondary surge protection, which shall consist of:

25 .1.4.3.1.7.1 Stage 1 - Dual overvoltage devices, each containing a gas-filled surge arrester, a varistor-type overvoltage protection module, and zener-type suppression diodes;

25 .1.4.3.1.7.2 Stage 2 - Fast-blow fuses rated at the maximum current capable of being delivered by the device(s) being protected, and;

25 .1.4.3.1.7.3 Stage 3 - a duplication of Stage 1, circuited as shown on Drawing TC-23 of the Technical Appendix.

25 .1.4.3.2 Grounding

25 .1.4.3.2.1 Low resistance grounding shall be provided for all TC circuits and metallic equipment and racks in Train Control Rooms, and for all metallic outdoor TC equipment.

25 .1.4.3.2.2 Ground connection to the track rails or use of the neutral conductors of the power company or any signal power supply system will not be permitted.

25 .1.4.3.2.3 All ground connections in each TCR shall be made to a room prime ground bus bar (provided by others) in the manner prescribed by the latest applicable WMATA METRORAIL Train Control Specifications.

25 .1.4.3.2.4 The grounding of each piece of metallic outdoor TC equipment shall be provided by means of an individual connection to a driven copper ground rod, or rods driven in series, one on top of the other. The resistance of the connection from each piece of equipment to earth ground shall not exceed 15 ohms.

25 .1.4.4 Microprocessor Support Systems(MPS) and Drawing Editor Systems

25 .1.4.4.1 Microprocessor Support Systems

25 .1.4.4.1.1 A WMATA prescribed number of microprocessor-based service systems capable of supporting the programming, maintenance and modification of all other microprocessor systems in the Train Control System shall be provided as part of each Train Control System. Each of these MPS Systems shall include:

25 .1.4.4.1.2 All of the applicable contract-prescribed equipment, fixtures, software and instructional information necessary to program, reprogram, and maintain all of the other microprocessor systems, as prescribed in the applicable Train Control Specifications;

25 .1.4.4.1.3 A simulator/diagnostic program for each type of microprocessor-based system included in the Train Control System, and;

25 .1.4.4.1.4 All cables, connections and interface facilities necessary to allow the MPS System to be used in conjunction with Train Control Test Fixtures for all the related operating microprocessor systems in the Train Control System.

25 .1.4.4.2 Drawing Editor Systems

25 .1.4.4.2.1 A WMATA prescribed number of Drawing Editor Systems (CAD/CAM Computer Systems) shall be provided as part of each

Train Control System. Each Drawing Editor System shall include the same items as an MPS System, except that the RAM and the monitor for the Drawing Editor System shall be larger as prescribed. Each Drawing Editor System shall also include the following:

25 .1.4.4.2.2 A complete set of high quality computer furniture as prescribed;

25 .1.4.4.2.3 A latest generation Plotter, as prescribed, complete with automatic switch and cabling to provide remote access from up to six MPS Systems in addition to access from the Drawing Editor System.

25 .1.4.5 TC Maintenance Telephone System

25 .1.4.5.1 Hardware

All telephone jacks and plugs, terminals, jack boxes, rotary selector switches, interconnecting twisted pair wiring and speaker phones of the types prescribed in the latest applicable WMATA METRORAIL Train Control Specifications shall be provided to extend the existing METRORAIL Train Control (TC) Maintenance Telephone System throughout each new METRORAIL TC Contract area in the WMATA prescribed manner.

25 .1.4.5.2 Location of Jacks

TC Maintenance Telephone jacks shall be provided in each of the following pieces of equipment, as applicable to the given Train Control Contract:

- Power, Entrance, and Equipment Racks (2 per rack)
- Large Junction Boxes (to include TC/COMM Interface Cabinets and DTS interface boxes or cabinets furnished by others, and Wayside Interface Junction Boxes furnished by the Contractor)
- Signal Junction Boxes
- Wall-Mounted and desk-mounted Interlocking Control Panels (Main-line)
- Switch-and-Lock Movements (Main-line)
- Trailable Switch Mechanisms (Yard)
- Yard Control Machine (Yard)

25 .1.5 Miscellaneous TC Functions

25 .1.5.1 Platform Edgelight Control

TC non-vital control circuitry shall be provided from the passenger station TCR to the appropriate station AC Service Room(s) to control, individually, the illumination of eight segments of platform edge lights on each passenger

platform, based upon the length of train and type of station stop to be made by each approaching train.

25 .1.5.2 NEXT TRAIN Sign Control

A three position (Track 1/Automatic/ Track 2) control switch shall be provided on the Dispatcher's Control Panel at tail-track terminal stations. This switch and its associated control circuitry shall enable the Dispatcher to control the illumination of the passenger NEXT TRAIN signs (by others) at such terminal stations. The "Automatic" setting shall result in NEXT TRAIN sign illumination based upon "First-in/First-out logic.

25 .1.5.3 Inclement Weather Operation

Appropriate TWC fly-by transmitters (and control wiring) shall be provided at suitable locations on outdoor approaches to station platform tracks to transmit "Performance Level 4" (PL-4) ATO speed commands to trains approaching such stations during wet rail conditions.

25 .1.5.4 Train Arrival Bus Indication Lights (TABIL)

Circuitry shall be provided to control the illumination of Train Arrival Bus Indication Lights (TABIL) (by others) at Rail/Bus transfer stations. This circuitry shall detect the close approach of outbound trains to the applicable passenger stations during evening rush hours and close a contact in the station AC Service Room which shall in turn cause the illumination of a "train arrival warning light" (by others) in the bus pickup area for an adjustable length of time.

25 .1.5.5 Snow and Ice Buildup Prevention

All power operated track switches on the WMATA METRORAIL System which are exposed to the weather shall be provided with special snowmelter layouts to prevent buildup of snow and/or ice in the area of the switch points and rods. These snowmelter layouts shall consist of two types of heaters (one type for the switch points and a second type for the switch rods); a wayside control case to control the application of propulsion power to these heaters, and; all necessary associated control and indication circuitry and installation hardware, all in conformance with current WMATA practices.

25 .1.5.6 Right-of-Way Intrusion Detection Warning (IDW) System

Wherever the WMATA METRORAIL tracks closely parallel a railroad or major highway, a system shall be provided to detect tilting of the fence posts of intervening segments of the WMATA property boundary fence, and to automatically turn off all ATP speed commands in the METRORAIL track areas opposite or in approach to the detected intrusion location, all in conformance with current WMATA practices.

25 .1.5.7 Dragging Equipment Detection

A system shall be provided to detect equipment or cabling protruding from the underside of the transit cars to a distance below the tops of the running rails (at locations designated by the Authority), and to indicate such a condition to

the train operators and as an alarm condition to Central and local control points.

25 .1.5.8 Automatic Train Approach Warning System (ATAWS)

(Criteria To Be Developed)

25 .1.6 Basic Wayside Equipment Criteria

25 .1.6.1 Power Frequency Track Circuits

Power Frequency (60 Hz) AC Track Circuits shall be of the single rail, balancing impedance type using AC vane-type vital relays. This type of track circuit shall be used for train detection purposes on mainline crossover tracks, and on yard interlocking, yard lead, and yard running tracks, and as otherwise specified.

25 .1.6.2 Wayside Signal Layouts

Controlled and marker signal layouts provided shall be complete with:

- signal heads having three lamp compartments;
- appropriate signal-head lamp adjusting transformers
- appropriate lamps, adjustable lamp holders, lenses, blanking plates, terminal blocks; and, for outdoor signals, lens hoods.
- appropriate masts and bases;
- appropriate signal number plates;
- appropriate foundations for all ballast-mounted signals;
- appropriate ladders or climbing steps; all fabricated, assembled and mounted in the WMATA prescribed manner.

25 .1.6.3 Cases and Junction Boxes

Appropriately equipped cases and junction boxes, complete with applicable foundations or pedestals, shall be provided for all yard wayside train control equipment. These housings shall be so located and constructed that they meet all transit vehicle clearance criteria. All metallic cases shall be made of stainless steel, and shall be equipped for proper grounding. All cases and junction boxes shall be suitably equipped for waterproof closure and, where applicable, lockable.

25 .1.6.4 Maintenance Furniture and Equipment

25 .1.6.4.1 Appropriate tables, storage cabinets, lockers, ladders, and other maintenance furniture and equipment shall be provided in each TCR, as specified.

25 .1.6.4.2 Appropriately sized and constructed Gang Boxes (for storage of tools and equipment) shall be provided in the field at interlocking locations as specified.

25 .1.7 ATC Systems Integration

(Criteria To Be Developed)

25 .2 MAINLINE OPERATION - AUTOMATIC TRAIN CONTROL

25 .2.1 General

25 .2.1.1 Mainline Operating Principles

25 .2.1.1.1 Operating Modes

The WMATA METRORAIL trains operate in one of three modes:

25 .2.1.1.1.1 AUTOMATIC: Movement controlled automatically by ATP and ATO commands;

25 .2.1.1.1.2 MANUAL OPERATION WITH OVER-SPEED PROTECTION: Movement controlled manually by train operator, subject to speed limits imposed by ATP speed commands. If no ATP speed command is received, the train will be forced to stop, and then will be permitted to proceed at no more than 15 MPH (Stop and Proceed Mode) until such time that an ATP speed command above 15 MPH is received, whereupon the train may be operated up to the received speed command;

25 .2.1.1.1.3 ATP CUTOUT: All ATP control is bypassed when in this mode. The train operator must obtain permission from Central Control to enter this mode of manual operation.

25 .2.1.1.2 Direction of Traffic

Normal running on the Revenue Service portion of the WMATA METRORAIL System is “forward on the right hand track,” i.e., right-hand-running. However the ATC System shall permit safe operation in either the “Normal” or the “Reverse” direction on all mainline tracks. These tracks shall be protected by vital “Traffic Circuits” between interlockings.

25 .2.1.1.3 Station Stopping

Automatic station stopping to within plus or minus five feet of the desired location at the station platform shall be provided by programmed braking following a predetermined deceleration profile. This programmed braking shall be initiated and updated by electronic signals caused by the interaction of coils on the transit cars with wayside marker coils located between the running rails at fixed distances from the center of the station platform track. The wayside inductive coils shall indicate to the trains:

- the direction of travel for which the information applies (where necessary), and;
- the type of programmed stop to be made (or skipped):
- Type “A” (Long) Stop: Head of train to far end of station platform;
- Type “B” (Short) Stop: Head of train to middle of station platform;
- Type “C” (Center) Stop: Center of train to center of station platform.
- No stop to be made.

25 .2.1.1.4 Terminal and Turnback Moves

25 .2.1.1.4.1 Trains approaching a terminal double-crossover interlocking from the mainline shall be automatically routed to the appropriate tail track in accordance with the “Mode” of automatic terminal operation selected by Central or by operation of the local Dispatcher or Inter-locking Control Panel, as follows:

- Mode 1: Route to track 1
- Mode 2: Route to track 2
- Mode 3: Route to first available (unoccupied) tail track, with preference to the “inbound” track if both tail tracks are unoccupied.

25 .2.1.1.4.2 Tail track selection may also be controlled manually by either Central Control or from the local Dispatcher or Interlocking Control Panel, or by means of wayside pushbuttons operated by the Train Operator.

25 .2.1.1.4.3 Trains turning back at a pocket-track interlocking shall be automatically routed into the turnback pocket track based upon the destination code carried by the train, or they may be manually routed into the pocket track by Central or by operation of the local Interlocking Control Panel.

25 .2.1.1.4.4 Provision shall be made for turning trains back at: emergency double-crossover interlockings; the converging end of junction interlockings; and the mainline converging ends of pocket track interlockings, by providing one or more “turnback blocks” on the mainline tracks at the end(s) of such interlockings.

25 .2.1.1.5 Dispatching

25 .2.1.1.5.1 Transit trains will normally be dispatched from terminal passenger station platform tracks, but may also be dispatched in a similar manner from pocket tracks, non-revenue service connecting tracks, or other locations specially equipped with TWC impedance bonds.

25 .2.1.1.5.2 The departure routing of a train from a terminal interlocking (or other train dispatching inter-locking or turnback point location) shall not be initiated until the train has been assigned "Identity" and the train operator has sent a "Train Ready" indication through the Train-to-Wayside (TWC) System. The departure routing shall be initiated manually by Central, or by operation of a local Dispatcher or Interlocking Control Panel. In an emergency situation, at certain locations, the train operator may be able to initiate a route from wayside pushbuttons.

25 .2.1.1.6 Headway

25 .2.1.1.6.1 The ATC System provided shall enable the METRORAIL System trains to operate at 90 second headways in either direction on either mainline track, unless otherwise specified.

25 .2.1.1.6.2 The ATC System shall, wherever economically practical, enable the METRORAIL System trains to operate with a sustained 10-minute headway in each direction during single track, run-around service between successive interlockings made necessary by maintenance or emergency conditions.

25 .2.1.2 Special Mainline Wayside Equipment Criteria

25 .2.1.2.1 Audio-Frequency Track Circuits

Audio Frequency track circuits shall consist of:

- Vital AF transmitter units capable of generating the proper coded ATP train detection and/or speed and door command signals, and, where applicable, TWC signals;
- Vital AF receiver units capable of detecting the various coded train detection signals and driving vital track relays;
- Track impedance bonds of proper negative-propulsion-return ampacity capable of properly interfacing the various train detection, speed/door command and, where applicable, TWC signals to the running rails, and of defining the boundaries of the track circuits within acceptable tolerances in accordance with WMATA standard practice;
- All interconnecting wiring, relays, adjusting devices and miscellaneous mounting hardware.

25 .2.1.2.2 Audio Frequency Speed Command Loops

Audio Frequency Speed Command loop circuits shall be used in conjunction with vital power frequency track circuits to transmit speed commands to trains in track crossover areas. They shall consist of:

- AF transmitter units capable of generating the proper coded ATP speed command signals;

- Wire loops installed in an appropriate, workable configuration in the cross-over tracks;
- All interconnecting wiring and mounting devices.

25 .2.1.2.3 Switch-and-Lock-Movement Type Track Switch Layouts

25 .2.1.2.3.1 All mainline track switches and (certain yard lead switches designated by the Authority) shall be equipped with Track Switch Operating Layouts which shall consist of:

- A Switch-and-Lock Movement
- An arrangement of rods and hardware to connect the Switch-and-Lock Movement to the switch points for throwing, locking and point detection purposes.

25 .2.1.2.3.2 The switch machines (S&L movements) shall be equipped with/for the following:

- Integral point detection.
- Manual operation by hand crank.
- No less than 1000 lbs. closing force on the switch points.
- Operation (throw time) within the limits shown in Section 3.5.3 Figure TC-8.

25 .2.1.2.4 Marker Coil Layouts

25 .2.1.2.4.1 Inductive Marker coil layouts of the functional types currently used on the WMATA METRORAIL System shall be provided at certain fixed distances from the center of each passenger station platform track to convey to the approaching trains their distance from the platform centers and, where applicable, the type of ATO stop (if any) to be made.

25 .2.1.2.4.2 Inert, distance-only marker coil layouts shall consist of a single, fixed-frequency effect coil unit, or a pair of fixed-frequency effect coil units.

25 .2.1.2.4.3 “Variable frequency” marker coil units, used to indicate both station center distance and type of stop to be made, shall consist of two individual marker coil units, one of fixed frequency effect and the other having a variable frequency effect controlled remotely from a Train Control Room.

25 .2.1.2.4.4 The various types of Marker Coil Layouts shall be fabricated, located and installed in compliance with current WMATA practice. See . Figure 25 - TC-6.

25 .2.1.3 Interface with Yards

25 .2.1.3.1 Vital traffic circuits shall be provided on Yard Lead tracks between the mainline station tracks and the area of the yard normally controlled exclusively by the Yard Interlocking Operator.

25 .2.1.3.2 Train movements between yards and terminal station platforms will be made in the manual Stop and Proceed Mode of operation. No speed commands shall be provided for such moves.

25 .2.2 ATC Subsystems

25 .2.2.1 Automatic Train Protection (ATP) System

The Automatic Train Protection (ATP) System is that part of the ATC System which provides protection against collisions and overspeed conditions. The ATP System also provides control of interlockings, route security through interlockings, and control of train door operation. Principal functions of the ATP System are Train Detection, Speed Command Selection, Speed Command Transmission, Interlocking Control and Security, Train Door Control, and all related carborne equipment to receive, decode, and safely act upon the ATP commands.

25 .2.2.1.1 Train Detection

25 .2.2.1.1.1 AF Track Circuits

Mainline train detection shall be provided by jointless audio frequency track circuits except in certain areas of special trackwork. These track circuits shall have the tuning unit and impedance bond mounted between the rails at the block boundary. Audio frequency track circuits in special trackwork areas shall use a shunt bar and loop to inject the signal into the rails and an untuned impedance bond to couple the signal from the rails to the receiver in a center-receive configuration. Balancing-impedance-type, 60 Hz track circuits shall be used in the diamond of double crossovers and in the crossover track of single crossovers.

25 .2.2.1.1.2 Train Detection Frequencies

25 .2.2.1.1.2.1 The audio frequency track circuits shall use eight frequencies (two sets of four) for train detection purposes. The frequencies to be used are:

Set 1	Set 2
(for Tks 1 & 3)	(for Tk 2)
F1 - 2100 Hz	F2 - 2320 Hz
F3 - 2580 Hz	F4 - 2820 Hz
F5 - 3100 Hz	F6 - 3370 Hz
F7 - 3660 Hz	F8 - 3900 Hz

25 .2.2.1.1.2.2 Only one set of the above frequencies shall be used on a given track and the same set shall not normally be used on adjacent tracks.

25 .2.2.1.1.3 Adjustment

Audio frequency track circuits which have both the transmitter and receiver in the same room shall be adjusted for a shunting sensitivity of 0.1 ohm. Track circuits which have the transmitter and receiver in separate rooms shall be adjusted for a shunting sensitivity of 0.2 ohms.

25 .2.2.1.2 Speed Command Selection

Speed command selection shall be via vital relay contacts. The selection contacts shall represent the following:

- Traffic locking
- Occupancy of track circuit for which the speed command transmitter is effective
- Occupancy of track circuits downstream of the speed command transmitter
- Occupancy of track circuits upstream of the speed command transmitter if these circuits are within a more restrictive civil speed zone and the more restrictive civil speed limit is less than 2200 feet upstream of the speed command transmitter
- Position of switches down-stream of the speed command transmitter
- Status of signal clearing networks downstream of the speed command transmitter
- Position of switches upstream of the speed command transmitter, when the position of such switches can create a more restrictive civil speed limit as in (iv) above
- Condition of temporary speed restriction control
- Additional conditions as required to provide safe train separation, speed, and door control, and to provide schedule control at station platforms and dispatching locations.
- Where track circuit occupancy and signal clearing network status must be transferred from one train control room to another for speed command selection purposes, such information transfer shall be accomplished via polar direct current line circuits.

25 .2.2.1.3 Speed Command Transmission

Speed command transmission shall be via one of two audio frequency carriers, 4550 Hz and 5525 Hz, ON/OFF AM modulated at one of five discrete frequency code rates. One additional code rate shall be used for the transmission of door opening commands. The command code chart is as follows:

Modulation Code Rate		Audio Frequency Carrier		
		F9	F10	F9 + F10
No.	Frequency	(4550 Hz)	(5525 Hz)	
1	3.0 Hz	Open Doors Left (when Stopped)	Open Doors Right (when stopped)	Stop
2	4.5 Hz	15 MPH	45 MPH	Stop
3	6.83 Hz	22 MPH	50 MPH	Stop
4	10.1 Hz	28 MPH	55 MPH	Stop
5	15.3 Hz	35 MPH	65 MPH	Stop
6	21.5 Hz	40 MPH	75 MPH	Stop
None of the above	Stop	Stop	Stop	Stop

25 .2.2.1.3.1 The speed selection network shall select a code rate generator output to drive the modulator, and energize a carrier generator, in accordance with the above code chart, to cause the appropriate command to be transmitted.

25 .2.2.1.3.2 In all areas, except special trackwork areas, speed command transmission shall be via the same transmitter as the train detection frequency. The transmitting equipment shall be shared between the train detection frequency and the selected speed command frequency on a time division multiplexing basis. The multiplexing shall be controlled by the selected code rate which shall alternately key the train detection and speed command frequencies.

25 .2.2.1.3.3 In special trackwork areas two speed command transmission methods shall be used, as follows:

- shunt bar locations transmission shall be via the same equipment as the train detection frequency with the code rate slaved from the transmitter on the opposite side of the shunt bar.

- At receive/receive locations and for the loops through 60 Hz track circuits, transmission shall be via an independent speed command transmitter, the output of which shall be directed through loop selection networks to energize the proper inductive loop for the routing and position of the train.

25 .2.2.1.4 Interlocking Control and Security

For purposes of this description, interlocking control and security is divided into the following categories and shall be accomplished as described in Section 25.1.3.3 Train Routing:

- Route Initiation
- Route Completion
- Time Released Approach Locking
- Route Locking

- Detector Locking

- Switch Control and Indication
- Signal Control
- Loop Control

25 .2.2.1.5 Train Door Control

25 .2.2.1.5.1 Train doors shall be controlled by commands transmitted via the vital, wayside-to-train command transmission system used for speed commands. Two commands shall be used; OPEN RIGHT DOORS and OPEN LEFT DOORS. The absence of either of these commands shall be interpreted as CLOSE DOORS.

25 .2.2.1.5.2 Door control commands shall be transmitted only at block boundaries associated with platform ends. Block boundaries associated with side platform stations shall be equipped to transmit the OPEN RIGHT DOORS command at the normal traffic-leaving end and the OPEN LEFT DOORS command at the normal traffic-entering end. Block boundaries associated with center platform stations shall be equipped to transmit the OPEN LEFT DOORS command at the normal traffic-leaving end and the OPEN RIGHT DOORS command at the normal traffic-entering end.

25 .2.2.1.5.3 Carborne ATP equipment shall compensate for direction of travel of the controlling "A" car and ensure that it is safe to open the train doors prior to acting upon the commands. One of the safety checks which shall be made is the verification that the train is at a passenger station. This check shall be accomplished by cycling a bit back and forth between the train and the station via the TWC system. The cycling of the TWC bit shall be used to keep a vital relay (PSCR) on the train energized as long as the train is in TWC communications with a passenger station.

25 .2.2.1.5.4 The application of the door control commands shall be under control of the station dwell control circuits.

25 .2.2.2 Automatic Train Operation (ATO) System

The Automatic Train Operation (ATO) System is that part of the ATC System which provides automatic train stopping and starting at passenger station platforms and provides speed control compensation for varying conditions of grade and curvature. Description of the Carborne portion is in the Vehicles Criteria Manual

25 .2.2.2.1 Wayside Portion

The wayside portion of the ATO system shall consist of station stopping markers which shall provide the distance-to-centerline information as well as the type of stop (long, short, center, or skip) information.

The marker units shall be tuned circuits, the inductance of which is an air core coil with an inside diameter of approximately 11 inches. The coil shall be the coupling element to the carborne equipment and shall be located between the running rails with its axis vertical. The top edge of the coil shall be between 1/4 and 3/4 inches below the top of rail. The relationship between the coil center and the track centerline shall be as follows:

RADIUS OF CURVE	OFFSET FROM CENTERLINE
Greater than 8500'	0"
8500' - 2900'	1"
2900' - 1750'	2"
1750' - 1250'	3"
1250' - 975'	4"
975' - 800'	5"
800' - 700'	6"
Less than 700'	7"

Offset from centerline of track shall be toward the outside of the curve. See the Figure 25-TC-6 , "Marker Coil Offset vs. Curve Radius."

Each marker layout (except the single-unit 160 ft. marker) shall consist of two independent tuned circuit units. This configuration is used to provide for double direction running and to provide the required amount of data with fewer frequencies.

25 .2.2.3 Automatic Train Supervision (ATS) System

The Automatic Train Supervision (ATS) System is that part of the ATC System which provides centralized monitoring and supervision capabilities and certain automatic ATC supervision facilities at wayside. The ATS system consists of a computer system and central control consoles located at the Operations Control Center (OCC) in the Jackson Graham Building, Remote Terminal Units (RTUs) located at wayside Train Control Rooms (TCRs), and a Data Transmission System (DTS) linking the equipment at the OCC with that in the TCRs. A Train-To-Wayside Communications system (TWC) is also included to provide a two-way link between the TCR equipment and trains at stations. The RTUs are hard-wired remote control devices dedicated to the monitoring and supervision of certain wayside ATC functions and devices as well as the electrical and support facilities at the location.

25 .2.2.3.1 Central Control Facility

See Section 26 for an overview of the Computer Systems portion of the ATS system.

25 .2.2.3.2 Wayside Portions

The following portions of the ATS System shall be located on the wayside, primarily in the Train Control Rooms at passenger stations:

- Door and dwell controls
- Train-to-wayside communications (TWC)
- Performance level translators
- Data Transmission System (DTS)

25 .2.2.3.2.1 Door and Dwell Controls

Door and dwell control modules shall provide the local hardware to implement the controls generated by central control or automatically by normal train operations. This hardware shall be configured to provide a backup means of door and dwell control in the event that control from central is interrupted. The configuration shall be such that the local backup provisions are exercised on each train movement to make failures self-evident. The sequence of operation shall be as follows:

- When an arriving train completes its station stop a TRAIN BERTHED signal shall be transmitted to the station via the TWC system. Receipt of this signal shall cause the speed commands to be removed from the platform block and the block downstream of the platform, the door open commands to be applied at both ends of the platform after a 2 second delay, and energy to be applied to the local dwell timer. The TRAIN BERTHED signal shall then be transmitted to central control via the DTS.
- Upon expiration of the preset time of the dwell timer, the door open commands shall be removed and speed commands

restored unless override controls are received from central control.

- The dwell shall be permitted to terminate prior to the expiration of the preset time upon receipt of the TERMINATE DWELL control from central control, or by the manual closing the train doors.
- The dwell shall be permitted to extend beyond the preset time with the doors held open upon receipt of the HOLD WITH DOORS OPEN control from central control.
- The dwell shall be permitted to extend beyond the preset time with the doors closed upon receipt of the HOLD WITH DOORS CLOSED control from central control. In this case the door open commands shall be removed but the speed commands shall not be restored until the HOLD WITH DOORS CLOSED control is no longer received.

25 .2.2.3.2.2 Train-to-Wayside Communications (TWC) System

The TWC system shall provide the communications link for the following ATS functions between revenue trains and the wayside:

Train-To-Wayside	Wayside-To-Train
Train Destination	Train Destination
Train Number	Train Number
Manual Push button Right (Tk 1 & 2)	Passenger Station Check
Manual Push button Left (Tk 1 & 2)	ATS Acceleration
Doors Closed Right (Tk 1 & 2)	ATS Speed Limit
Doors Closed Left (Tk 1 & 2)	Hold With Doors Closed
PSS Active (Tk 1 & 2)	Hold with Doors Open
Train-To-Wayside	Wayside-To-Train
ATP in Effect (Tk 1 & 2)	Terminate Dwell
Train in ATO (TK 1 & 2)	Door Close Warning, Platform 1
Passenger Station Check	Door Close Warning, Platform 2
Train Ready	

Train-To-Wayside	Wayside-To-Train
All Doors Closed	
Train Berthed	
Motion Detection	
Train Length	

25 .2.2.3.2.2.1 The TWC System shall function in the same manner as the current continuous-scanning, time-division multiplex transmission system in which communications transmitted to wayside and received from wayside are time-shared.

25 .2.2.3.2.2.2 The carborne TWC System shall be inductively coupled to the wayside TWC System via coils on the cars. At wayside receiver locations other than flyby locations, the area of effective two-way communications shall be at least 600 feet long.

25 .2.2.3.2.2.3 The following message formats shall be transmitted by the train and received by the wayside:

SHORT MESSAGE FORMAT

Bit No.	
1-3	Message Prefix
4-7	Word 1 (ATS Speed Limit)
8	Parity, Word 1
9-11	Message Suffix

LONG MESSAGE FORMAT

Bit No.	
1-3	Message Prefix
4-11	Word 1 (Train Destination)
12	Parity, Word 1
13-24	Word 2 (Train Number)

LONG MESSAGE FORMAT

Bit No.	
25	Parity, Word 2
26-37	Word 3 (Spare)
38	Parity, Word 3
39	Passenger Station Check
40	ATS Acceleration
41-42	Spare
43	Parity, Word 4
44-47	Word 5 (ATS Speed Limit)
48	Parity, Word 5
49-51	Message Suffix

25 .2.2.3.2.2.4 The prefix bit configuration for the short message mode is MARK-SPACE-MARK. The prefix bit configuration for the long message mode is MARK-MARK-MARK. The suffix bit configuration for both long and short message modes is MARK-MARK-MARK.

25 .2.2.3.2.2.5 The message structure is a non-synchronous, return-to-zero, serial code at a bit rate of 100 bps. There shall be a 100 millisecond pause between successive message transmissions from the trains. The message shall start 60 ms after the transmitter is keyed. The TWC carrier frequency is 9800 Hz.

25 .2.2.3.2.2.6 A frequency of 9950 Hz is interpreted as a "MARK." A frequency of 9650 Hz is interpreted as a "SPACE." Parity is "ODD."

25 .2.2.3.2.2.7 The existing impedance bonds which are tuned to transmit and receive the TWC signals exhibit an impedance of approximately 1.0 ohms at 9800 Hz. With this impedance, the TWC system will work reliably with a receiving bond current of .016A rms to 0.3A rms. The transmit rail current produced by the bond is approximately 1.5A rms with a train adjacent to the bond. Input to the TWC receiver shall be 400 mV p'p'.

25 .2.2.3.2.2.8 The following message formats shall be transmitted to the trains depending upon the location of the transmitter:

SHORT MESSAGE FORMAT

Bit No.	
1-3	Message Prefix
4-7	Word 1 (ATS Speed Limit)
8	Parity, Word 1
9-11	Message Suffix

LONG MESSAGE FORMAT

Bit No.	
1-3	Message Prefix
4-11	Word 1 (Train Destination)
12	Parity, Word 1
13-24	Word 2 (Train Number)
25	Parity, Word 2
26-37	Word 3 (Spare)
38	Parity, Word 3
39	Passenger Station Check
40	ATS Acceleration
41-42	Spare
43	Parity, Word 4
44-47	Word 5 (ATS Speed Limit)
48	Parity, Word 5
49-51	Message Suffix

25 .2.2.3.2.2.9 Long messages are transmitted to trains in response to a received message from the train at all locations other than flyby

locations. Short messages are transmitted to trains in response to a received message at flyby transmitter locations.

25 .2.2.3.2.2.10 Performance Level Translators

25 .2.3.2.2.10.1. Performance Level Translators shall convert the two bit performance level control received from Central Control into a four bit binary code, which shall identify the ATS speed limit required to achieve the desired performance level.

25 .2.3.2.2.10.2. The ATS speed limit code produced by the performance level translator for a given performance level code input shall be determined by the wiring of a programming plug. The correlation between performance level and ATS speed limit (programming plug wiring) for a given station-to-station run shall be based on computer simulations of station-to-station runs with each of the ATS speed limits.

25 .2.3.2.2.10.3. The performance level translator shall be a part of the TWC transmitter module. The ATS speed limit code produced by the translator shall be transmitted to the train via the TWC system. The trains shall interpret the ATS speed limit code as follows:

ATS CODE	SPEED LIMIT (mph)	ATS CODE	SPEED LIMIT (mph)
0000	79	1000	44
0001	79	1001	49
0010	14	1010	54
0011	19	1011	59
0100	24	1100	64
0101	29	1101	69
0110	34	1110	74
0111	39	1111	79

25 .2.2.3.2.3 Data Transmission System (DTS)

The Data Transmission System shall be as described in Section 3.1.4.1.

25 .3 YARD TRAIN CONTROL OPERATION

25 .3.1 General

25 .3.1.1 Yard Definition and Purpose

A Yard is primarily a system of tracks, buildings, and special facilities provided for the inspection, washing, cleaning, maintenance, storage and/or repair of transit cars, and for the make-up of transit car trains.

25 .3.1.2 Yard Configurations

There are three basic types of yards in the WMATA METRORAIL System:

25 .3.1.2.1 "Storage Yards" provide washing, cleaning, inspection and storage facilities for transit cars, and storage facilities for maintenance equipment.

25 .3.1.2.2 "Service & Inspection" (S&I) Yards are essentially Storage Yards having a shop Building added for the maintenance and minor repair of transit cars.

25 .3.1.2.3 "Major Repair Yards" contain facilities for the major repair and overhaul of transit cars.

25 .3.2 Yard Control Facilities

25 .3.2.1 Yard Train Control Rooms

25 .3.2.1.1 Train Control Rooms (TCRs) (by others) are furnished at certain strategic locations within the yard for the installation of Yard Signal Control and Interlocking System equipment. Additional prefabricated TCRs shall be provided where necessary.

25 .3.2.1.2 Yard TCRs shall be equipped with applicable vital and non-vital Train Control equipment necessary to implement the Yard Signal Control and Interlocking System.

25 .3.2.2 Yard Control Room

Each Yard contains a Yard Control Room which contains facilities for the Yard Interlocking Operators to control propulsion power and train movements within the Yard, and to communicate within the yard and with the WMATA Operations Control Center.

25 .3.2.3 Yard Control Machine

A Yard Control Machine shall be provided in the Yard Control Room for the monitoring and control of train movements within the yard, and between the yard and the main line. This Yard Control Machine shall be located, wherever possible, in an area which provides the operator with visual oversight of the yard area.

25 .3.2.3.1 Control Machine Configuration

25 .3.2.3.1.1 The Yard Control Machine shall consist of one or more consoles which support control and indication panels (face plates) which display an engraved diagram of all tracks and interlockings within

the yard limits and the associated mainline station platform. These panel face plates shall be either large sectional phenolic plates, or made up of a mosaic of small, uniformly sized individual plates supported on a rigid grid structure.

25 .3.2.3.1.2 Right-hand track switches (in the field) shall be engraved as right-hand switches on the control panel, and left hand switches (in the field) shall be engraved as left-hand switches on the control panel. A small "dot" shall be engraved on the panel next to the applicable diverging track indicator LED for each power switch layout to indicate the arbitrarily designated "NORMAL" alignment for that switch.

25 .3.2.3.1.3 The base(s) of these control machine consoles shall be used to house Train Control system equipment such as the Computerized Yard Control System modules, on roll-out or swing-out racks.

25 .3.2.3.1.4 Pushbuttons, toggle switches and LED indicators shall be mounted on the control panel faceplates to initiate safe routes for trains, manually control track switches for test and maintenance purposes, interface with Central Control, and monitor train movements, dragging equipment detectors, snowmelters, and various alarm conditions. Audible alarm devices shall be mounted within the control machine console.

25 .3.2.3.2 Control Machine Controls

25 .3.2.3.2.1 A Key Switch shall be provided to control energization of the Yard Control Machine.

25 .3.2.3.2.2 Train routing shall be initiated by a non-vital Entrance/ Exit system.

25 .3.2.3.2.3 Appropriate pushbuttons shall be provided to request routes for train movement and signal fleeting.

25 .3.2.3.2.4 Individual Test Keys (toggle switches) shall be provided for the independent operation of track switches and crossovers.

25 .3.2.3.2.5 Appropriate pushbuttons shall be provided to check (momentarily energize) all indicator lights on the Yard Control Machine.

25 .3.2.3.2.6 Pushbuttons shall be provided to cause the display of the current alignment of all electrically powered switches in the yard.

25 .3.2.3.2.7 Appropriate pushbuttons shall be provided for Transfer of Control of the mainline interface portion of the yard to and from Central Control.

25 .3.2.3.2.8 A pushbutton shall be provided to acknowledge alarm conditions and silence audible alarms.

25 .3.2.3.2.9 A toggle switch shall be provided for the control of yard snowmelter layouts.

25 .3.2.3.2.10 A device shall be provided on the outside of the Control Machine Console which shall uniformly control the light intensity of the variously colored indication LEDs.

25 .3.2.3.3 Control Machine Indications

25 .3.2.3.3.1 Light Emitting Diodes (LEDs) and appropriate circuitry shall be provided for all visual indications, to include:

- Track Occupancy
- Track Vital Traffic Direction
- Track Route Locked
- Track Switch Locked
- Track Switch Position
- Track Available Exit Points
- Track Wayside Signal Status and Fleeting
- Track Snowmelter Status
- Track Blown Fuse
- Track Power Status
- Track Grounding Status
- Track Microprocessor Status
- Track Dragging Equipment Status
- Track Individual Snowmelter Failure
- Track Next Train Needed
- Track Central/Local Control
- Track Dispatch Warning

25 .3.2.3.3.2 Audible indications shall be provided as follows:

25 .3.2.3.3.2.1 A single-stroke bell tone to indicate a change in status of certain normal operational features.

25 .3.2.3.3.2.2 An acknowledgeable (cancelable) bell or buzzer to indicate alarm conditions.

25 .3.2.3.4 Control Machine Furniture

An appropriate armchair and a file cabinet, both on casters, shall be provided for the Yard Interlocking Operator in the Yard Control Room.

25 .3.2.4 Computerized Yard Control System

25 .3.2.4.1 Non-vital functions

Non-vital functions of the Yard Signal Control and Inter-locking System shall be performed by solid-state, electronic processors unless otherwise specified. These processors shall be configured in a manner approved by the Authority and shall meet the Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR) requirements shown in the Train Control Appendix of Basic Design Information. (Section VIII.A.4.)

25 .3.2.4.2 Quality

The logic and operation of the computerized system shall be at least equivalent in safety and speed of operation as the best operation achievable by a system implemented with non-vital relays and discrete component circuitry.

25 .3.2.4.3 Documentation

Complete documentation shall be furnished for all software and hardware to be included in the Yard Control System. This shall include both conventional relay logic drawings and computer-equivalent circuit drawings (or equivalent software logic statements) for all of the non-vital functions which are to be performed by the processors in the Yard Control System, and a complete test and inspection program for all hardware and software included in the system.

25 .3.2.4.4 Compliance

The Yard Control System shall comply with all basic environmental, mechanical, electrical, programming diagnostic, and spare requirements and current practices for WMATA Yard Train Control Systems.

25 .3.2.5 Special Yard Wayside Equipment Criteria

25 .3.2.5.1 Vital Track Circuits

Single-rail, power frequency track circuits of the balancing impedance type, using vane-type vital track relays, shall be provided for all interlocking tracks, running tracks, and other yard tracks specified. These track circuits shall provide train detection for up to 0.6 ohms shunting resistance.

25 .3.2.5.2 Non-Vital Track Circuits

Series-type AC track circuits shall be provided for the wash track and all shop lead tracks and storage tracks in the yard. These track circuits shall provide train detection for up to 0.6 ohms shunting resistance.

25 .3.2.5.3 Yard Track Switch Layouts

Trailable switch machine layouts, complete with switch point detection, and all necessary rods and connecting hardware, shall be provided for all power track switch layouts in the yard. The switch machines shall exert at least 1000 lbs. closing force on the switch points. The switch layouts shall be trailable at low speeds without damage to the switch machines, rods, or special trackwork.

25 .3.2.6 Special Functions

25 .3.2.6.1 Sectional Route Release

Sectional Route Release shall be provided in the control of long or complex interlockings in order to reduce delays to trains and improve yard throughput.

25 .3.2.6.2 Dragging Equipment Detection

Facilities shall be provided for detecting dragging equipment or cabling for trains leaving the yard, and for indicating such situation on the Yard Control Machine.

25 .3.3 Yard Monitoring Facilities

25 .3.3.1 Event Recording System

25 .3.3.1.1 Description

Each Yard Train Control System shall be equipped with a complete, properly operating, microprocessor controlled Event Recording System which shall monitor, record, store, and print or display, in various prescribed formats, the status of various prescribed Yard Train Control functions over a period of time. The Event Recording System shall be accurate, user friendly, versatile in output formats, easily expandable, easy to troubleshoot and maintain, and shall meet all of the following basic minimum requirements:

25 .3.3.1.1.1 The system shall be equipped to monitor 250 points. Modular construction shall be utilized such that the initial system can be easily expandable in the field to monitor up to 500 points.

25 .3.3.1.1.2 All data points shall be monitored continually including during viewing and/or printing.

25 .3.3.1.1.3 All detected changes of state shall be recorded with the device identification, new status, and the time and date of occurrence.

25 .3.3.1.1.4 Event printouts and/or displays shall be accurate to one second.

25 .3.3.1.1.5 Displays and printouts shall be menu driven and manually initiated from a local or remote keyboard or other interrogating device.

25 .3.3.1.1.6 Displayed and/or printed data shall include the following information in a format easily readable and understandable by Train Control maintenance personnel:

- Type of Event,
- Julian date,
- Time of occurrence,
- Point identification, and
- New state.

25 .3.3.1.1.7 Standby battery shall be provided as an integral part of the Event Recording System to prevent loss of the time base during external power failures or shut-down periods up to seven days in duration.

25 .3.3.1.1.8 Controls shall be provided for setting the date and the time; for initiating the viewing and/or printing of stored data in the desired format, and for adding new devices to be monitored.

25 .3.3.1.1.9 The printer shall be capable of printing one event per line, two lines per second.

25 .3.3.1.1.10 The system shall include a standard RS232C interface wired to one or more plug couplers.

25 .3.3.1.1.11 Input wiring to the system shall be easily removable to facilitate testing.

25 .3.3.1.1.12 Detection of an error in the Event Recording System (by the internal diagnostic subsystem) shall cause a change in status of the externally wired error detection contact closure.

25 .3.3.1.1.13 The system shall include automatic and manually-initiated screen saving.

25 .3.3.1.2 Input Storage

25 .3.3.1.2.1 The minimum storage capability of the hard disk drive provided shall be 100 megabytes or greater. Sufficient storage media for 32 days of events shall be furnished initially.

25 .3.3.1.2.2 The program which controls the hard disk drive storage shall store the yard events in a file format labeled on a daily basis (0000-2400 hours) by date and year, with one separate file for each day. These files shall be further subdivided by the type of event, i.e., switch machines, controlled signals, track occupancy, auxiliary devices, alarms, etc.

25 .3.3.1.2.3 The event storage program shall automatically rotate through the storage area, erasing the oldest of the 32 daily files at the start of each new day's recording.

25 .3.3.1.3 Outputs

The processor shall have the capability of outputting information to a local or remote monitor, printing device or floppy disc in various menu-driven, operator-selectable formats as approved by the Engineer. These formats shall be as described in the applicable Yard Train Control Contract documents.

25 .3.3.1.4 Equipment and Installation

25 .3.3.1.4.1 The major computer components of the Event Recording System shall be installed on a rack in the Yard (main) Train Control Room in a manner previously approved by the Engineer.

25 .3.3.1.4.2 Indication contacts shall be provided on appropriate equipment for use by the Event Recording System.

25 .3.3.1.4.3 Plug connector receptacles shall be provided for the Event Recording System wiring on the racks containing equipment to be monitored in the various Yard TCRs.

25 .3.3.1.4.4 Interconnecting cables shall be provided between the event recording equipment and test contact receptacles on the various racks, and between the rack test contact receptacles and the appropriate test contacts on the equipment mounted on the racks.

25 .3.4 Mainline Interface

25 .3.4.1 Information Interface

25 .3.4.1.1 Vital

Vital information, such as vital traffic circuits and vital track repeaters, shall be transferred between the nearest mainline station TCR and the appropriate yard TCR(s) by hard wired circuits carried in vital, multiconductor signal cable.

25 .3.4.1.2 Non-Vital

Non-Vital information shall be transferred between the mainline station TCR and the appropriate yard TCR(s) by means of a Fiber Optics Interface System (FOIS) as prescribed in the applicable Yard Train Control Contract documents.

25 .3.4.1.3 TC Maintenance Telephone

Two twisted-pair special control and indication cables shall be installed to connect the Yard Train Control Maintenance (TCM) Telephone System to the mainline TCM Telephone System in the manner prescribed in the applicable Yard Train control Contract documents.

25 .3.4.2 Transfer of Control

Wherever applicable, a portion of the Yard Lead Tracks containing one or more interlockings adjacent to the mainline station shall be so equipped that normal Yard control of that area may be transferred to Central Control upon request from Central, or may be transferred to control from the local mainline

Interlocking Control Panel(s) in an emergency situation. The circuits and operational protocols necessary to accomplish the transfer of control shall be as prescribed in the applicable Yard Train Control Contract documents.

25 .4 Light Rail (To be developed in future)

25 .5 Train Control Appendix of Basic Design Information

25 .5.1 Definition of Train Control Terms

25 .5.1.1 Standard Definitions by Others

25 .5.1.1.1 Definitions pertaining to the Train Control Design and Equipment Criteria shall conform to the standard definitions promulgated by the following organizations unless otherwise defined in the Glossary of WMATA Train Control Terminology:

25 .5.1.1.1.1 Applicable Parts of the Association of American Railroads (AAR)/American Rail-way Engineering and Maintenance-of-Way Association (AREMA) Signal Manual of Recommended Practice;

25 .5.1.1.1.2 Electronic Industries Association (EIA);

25 .5.1.1.1.3 The Institute of Electrical and Electronics Engineers, Inc. (IEEE).

25 .5.1.1.2 Where definitions conflict, the order of priority shall be:

25 .5.1.1.2.1 Glossary of WMATA Train Control Terminology contained herein;

25 .5.1.1.2.2 AAR/AREMA Signal Manual;

25 .5.1.1.2.3 EIA;

25 .5.1.1.2.4 IEEE.

25 .5.1.2 Glossary of WMATA Train Control Terminology

The following words, terms and phrases, as used in these Criteria, are defined as follows:

25 .5.1.2.1 Abnormal Condition (as referred to in ATS description)

An event of unusual nature (i.e., associated with a low probability) exceeding the capabilities of Strategy Selection and Rescheduling.

25 .5.1.2.2 Active Component

An electronic component, such as a transistor, which requires power supply energy in addition to the input signal to function, and produces current or voltage gain.

25 .5.1.2.3 Active Element

An electronic component which converts or controls energy (e.g., a single integrated circuit, transistor, diode, relay, or operational amplifier).

25 .5.1.2.4 Active Element Group

A network of piece-part components functioning with an active element.

25 .5.1.2.5 Address

The bits of a message used to identify the destination or origin of the message.

25 .5.1.2.6 Aerial Structure

Track support structure which carries the track above the local surrounding ground level.

25 .5.1.2.7 Alarm Condition

Any off-normal condition which requires the attention of an operator, supervisor or maintainer.

25 .5.1.2.8 Aspect, Signal

See "Signal Aspect."

25 .5.1.2.9 At-Grade

That portion of the system which is constructed at the approximate elevation of the adjacent ground surface.

25 .5.1.2.10 Audible Alarm

The sounding of a bell, buzzer, or other acoustic device to draw the attention of a Train Operator, ATC Maintainer, or Central Control Supervisor to an alarm condition.

25 .5.1.2.11 Audio Frequency Track Circuit

See "Track Circuit, Audio Frequency."

25 .5.1.2.12 (The) Authority,

Washington Metropolitan Area Transit Authority (WMATA).

25 .5.1.2.13 Automatic Local Control

A mode of system operation in which functions such as route initiation and dispatching are performed automatically by local wayside equipment.

25 .5.1.2.14 Automatic Speed Regulator

That portion of the carborne ATO System which measures actual train speed and controls positive and negative tractive effort to maintain the desired speed.

25 .5.1.2.15 Automatic Train Control (ATC)

The system for automatically controlling train movement, enforcing train safety, and directing train operations. ATC includes subsystems for Automatic Train Operation, Automatic Train Protection, and Automatic Train Supervision.

25 .5.1.2.16 Automatic Train Operation (ATO)

The subsystem within Automatic Train Control which performs the on-train functions of speed regulation, program stopping, and performance adjustment. This subsystem, in conjunction with the Automatic Train Protection (ATP) System and the Train-to-Wayside Communications (TWC) System, also shares control of train door operation and train starting.

25 .5.1.2.17 Automatic Train Protection (ATP)

The subsystem within Automatic Train Control which maintains safe train operation. ATP subsystems include train detection, speed-limit enforcement, train separation, interlocking, and train door control.

25 .5.1.2.18 Automatic Train Supervision (ATS)

The subsystem within Automatic Train Control which monitors and provides controls necessary to direct the operation of a system of trains in order to maintain intended traffic patterns and minimize the effects of train delays on the operating schedule.

25 .5.1.2.19 Auxiliary Switch Operation

The operation of a switch-and-lock movement or trailable yard switch by means of an independent manual control without clearing a signal or calling for a signal to clear. See also; “Switch Test Key.”

25 .5.1.2.20 Availability

The portion of total elapsed time that a system is operating or ready for operation.

25 .5.1.2.21 Back-to-Back Signals

See "Signals, Back-to-Back.”

25 .5.1.2.22 Ballast Resistance

The total interrail resistance caused by electrical leakage paths of a given section of electrically isolated unoccupied track.

25 .5.1.2.23 Ballasted Track

Track structure in which the running rails and the propulsion rail insulators are affixed to individual crossties which are in turn supported by loose ballast.

25 .5.1.2.24 Berth

The portion of track occupied by a train when stopped for loading and discharging passengers at a station platform.

25 .5.1.2.25 Berthing

The precise positioning and stopping of a train at a passenger station platform.

25 .5.1.2.26 Bit

A binary digit, 0 or 1 in number representation, with the radix 2.

25 .5.1.2.27 Blending

The simultaneous action and proportional effort of both dynamic and mechanical braking to achieve the required total braking effort during the transition from all dynamic to all mechanical.

25 .5.1.2.28 Block

A contiguous section of track of defined limits on which the movement of trains is governed by Automatic Train Control or wayside signals or both.

25 .5.1.2.29 Block, Absolute

A block into which no other train is permitted to enter while it is occupied by another train.

25 .5.1.2.30 Block, Interlocking

A contiguous section of track within an interlocking plant, the entrance to which is governed by interlocked signals and the use of which is governed by interlocking rules for automatic or manual train operation. An interlocking block may contain one or more track switches or track circuits or both.

25 .5.1.2.31 Block, Traffic

A contiguous section of track between interlocking plants on which the prescribed direction of running can be reversed only when the block is unoccupied and no routes are established for entry into that block.

25 .5.1.2.32 Block, Turnback

See "Turnback Block."

25 .5.1.2.33 Block Design

The process of dividing the METRO trackage into sections having defined limits for the purpose of train detection and ATP speed command transmission, and the determination of the speed commands to be transmitted in each of the blocks so determined. The locations of the block boundaries and the speeds to be transmitted are determined by:

1. The location of fixed facilities such as substation negative-propulsion return points, crossbonding locations, insulated rail joints and station platforms.

2. Civil restrictions due to grades, curves and special trackwork.

3. Safety considerations based upon the acceleration and braking characteristics of the transit vehicles.

4. Passenger comfort considerations for both the people on the transit vehicles and on station platforms.

25 .5.1.2.34 Bond, Clamped

A type of electrical bond attached to the base of one or more running rails by means of a mechanical clamp.

25 .5.1.2.35 Bond, Compression-Bolted

A type of electrical bond attached to the web of one or more running rails by means of a metal collar swaged onto a ribbed metal “pin” passing through the rail web and the bond connecting lug(s).

25 .5.1.2.36 Bond, Cross

An electrical connection between the negative-propulsion-return rails of adjacent tracks, used to equalize negative propulsion return currents in the running rails. In audio-frequency track circuit territory, these bonds must be connected between the center taps of impedance bonds on the adjacent tracks.

25 .5.1.2.37 Bond, Exothermic

A type of electrical bond attached to the running rails by exothermic means.

25 .5.1.2.38 Bond, Impedance

A copper, single-turn, center-tapped coil unit of low resistance, wound with coils for inductively coupling train detection, speed command and TWC frequencies, as required. These units are installed between the running rails of WMATA mainline tracks for one or more of the following purposes:

1. To provide a path for negative propulsion return currents around insulated joints and/or from running rails to crossbonding or substation return cables.

2. To delineate the boundaries of audio frequency track circuits.

3. To inductively connect AF train detection signals between the running rails and ATP transmitter and/or receiver modules.

4. To inductively connect AF speed commands and/or door control signals between the running rails and ATP transmitter and/or receiver modules.

5. To inductively connect TWC signals between the running rails and wayside TWC modules via the ATP modules.

25 .5.1.2.39 Bond, Negative Return (or Propulsion Return)

A type of electrical rail bond designed to carry heavy negative propulsion return current at impedance bonds, rail joints, frogs, and switch point rails.

25 .5.1.2.40 Bond, Pin Type

A type of electrical rail bond designed to be attached to the running rails by means of metal pins driven into holes in the web or head of the rails.

25 .5.1.2.41 Bond, Railhead

A type of rail bond consisting of a length of electrical conductor having a device on one or both ends to facilitate connection to the head portion of the rail(s) to be bonded.

25 .5.1.2.42 Bond, Rail Web

25 .5.1.2.42.1 A type of rail bond consisting of a length of electrical conductor having a device on each end to facilitate connection to the web portion of the rails to be bonded together.

25 .5.1.2.42.2 A type of rail bond consisting of length of electrical conductor welded, bolted or otherwise connected to the web portion of a rail.

25 .5.1.2.43 Bond, Signal

A type of electrical rail bond designed to carry the relatively light current of a power frequency (60 Hz) track circuit.

25 .5.1.2.44 Bond, Substation Return

25 .5.1.2.44.1 An electrical connection from the center tap of an AF track circuit impedance bond or from the negative return rail of an ac track circuit or to a negative propulsion return bus lead from a substation.

25 .5.1.2.44.2 An impedance bond having its center tap used for the negative propulsion return connection to a substation.

25 .5.1.2.45 Bond, TWC

An impedance bond equipped with extra coils for the transmission and/or reception of TWC messages.

25 .5.1.2.46 Bonding

The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

25 .5.1.2.47 Bridging Receiver (BR)

A device for receiving and decoding train detection frequency signals directly from the running rails and driving an appropriate track relay. See “Terminating Receiver.”

25 .5.1.2.48 Brake Rate

The rate of deceleration caused by the braking system.

25 .5.1.2.49 Bus

A conductor, or group of conductors, that serve as a common connection for two or more circuits.

25 .5.1.2.50 Cab Signal

See "Signal, Cab."

25 .5.1.2.51 Cable Jacket

A protective outer covering over the insulation, core, or sheath of a cable.

25 .5.1.2.52 Cable Sheath

A conductive protective covering applied to cables. Note: A cable sheath may consist of multiple layers, of which one or more is conductive.

25 .5.1.2.53 Central Computer Control

A mode of system operation in which functions such as route initiation and dispatching are performed by the Central Control Computer through the local equipment.

25 .5.1.2.54 Central Control

25 .5.1.2.54.1 The Operations Control Center (OCC) area in the Jackson Graham Building (WMATA Headquarters) where the main train control console, display units, and central automatic train supervision equipment and personnel are located.

25 .5.1.2.54.2 Supervisory Control from the OCC as opposed to Local Supervisory Control from wayside locations.

25 .5.1.2.55 Central Control Supervisor

The ATC system control console operator on duty at Central Control.

25 .5.1.2.56 Central Manual Control

A mode of system operation in which ATC functions such as route initiation and dispatching are performed manually from Central Control through the local equipment.

25 .5.1.2.57 Circuit, Track (See also "Track Circuit, Audio Frequency", "Track Circuit, Power Frequency", "Track Circuit, Series Type," and "Track Circuit, Vital.")

An electrical or electronic circuit in which defined portions of one or both running rails of a track constitute a portion of the conductors, and in which the shunting of the running rails is used to detect the presence of trains or equipment on the track. Three basic types are used on the WMATA METRORAIL System:

1. Double-Rail Track Circuit; A track circuit in which both running rails are isolated signal rails.

2. Single-Rail Track Circuit; A track circuit in which one running rail is an isolated signal rail and the other running rail is a common, non-isolated rail.

3. Series-Type Track Circuit; A non-vital, single-rail track circuit which is energized only when its signal rail is shunted to the opposite running rail.

25 .5.1.2.58 Circuit, Traffic

A vital circuit used to determine the permissible direction of train operation over a segment of track between two interlockings and/or set(s) of back-to-back signals. (See "Block, Traffic.")

25 .5.1.2.59 Circuit, Vital

Any circuit whose function directly affects the safety of train operation.

25 .5.1.2.60 Civil Speed Limit

See "Speed Limit, Civil."

25 .5.1.2.61 Clearance Point

The location between the diverging tracks emanating from a turnout at which the Authority's required clearance is achieved between the diverging tracks. This point is usually defined by the distances (along each of the diverging tracks) from the point-of-switch.

25 .5.1.2.62 Closing-In

Operating a following train toward a preceding train which is either stopped or running slower than the following train.

25 .5.1.2.63 Code Rate

The rate of on/off modulation. See "Rate Coding."

25 .5.1.2.64 Command (noun)

1. (As used with respect to ATP or TWC messages from TCRs to trains) An electronic signal to start, stop, cancel, change or continue an operation governed by ATP or ATO, respectively.

2. (As used with respect to DTS messages from Central Control to TCRs) See "Request" and "Control."

25 .5.1.2.65 Computer

Any device capable of accepting information, applying prescribed processes to it and supplying the results of these processes in a usable form.

25 .5.1.2.66 Conduit

A tube-like structure for electrical wires or cables. Conduit may be either rigid or flexible, metallic or non-metallic, as specified.

25 .5.1.2.67 Consist (noun)

The number and specific identity of cars which make up a train.

25 .5.1.2.68 Contact Rail Assembly

An assembly of a special, insulated, non-running rail and its supports and coverboards, which is installed alongside a track and which carries high voltage electrical energy for the propulsion of trains on that track. See also "Rail, Third."

25 .5.1.2.69 (The) Contractor

The successful Bidder who is awarded a Contract for providing all facilities and equipment described in Authority Specifications for the applicable Train Control System Contract.

25 .5.1.2.70 Control (noun) (As used with respect to DTS messages from

Central Control to wayside Train Control Rooms) A "Control" is actually only a non-vital supervisory "request" for certain action. If the applicable function is non-vital, the "Control" will be acted upon, but if the applicable function is a vital Train Control function, the "Control" will be treated as a "request" to the vital ATC wayside logic circuits and equipment, and will be granted only if it is safe to do so. See "Command" and "Request." See also, "Indication."

25 .5.1.2.71 Control, Continuous

A type of control in which the train borne equipment is constantly in operative relation with the track elements and is immediately responsive to a change of conditions in the controlling section of track which affects train movement.

25 .5.1.2.72 Control Limit

The extent of route over which a train protection (speed limit) command is controlled.

25 .5.1.2.73 Control Limits

The boundaries limiting the area of trackage controlled from a Train Control Room (and its satellite TCER, if applicable). (See TCR and TCER).

25 .5.1.2.74 Controlled Signal

See "Signal, Controlled."

25 .5.1.2.75 Converging Route

See "Route, Converging."

25 .5.1.2.76 Coupling (verb)

The act of connecting one married-pair of transit vehicles to another by pushing their aligned automatic couplers together.

25 .5.1.2.77 Cross Bond

See "Bond, Cross."

25 .5.1.2.78 Crossover

Two turnouts, with track between the frogs, arranged to form a continuous passage between two tracks.

25 .5.1.2.79 Crossover, Diamond

A double crossover which has the trailing point and facing point crossovers installed at the same location and in which the two crossover tracks between the running track frogs cross each other in a "diamond" configuration.

25 .5.1.2.80 Crossover, Double

A pair of crossovers, one of the facing point type and another of the trailing point type, located in close proximity between the same two tracks. These two crossovers may be located either successively (Universal Crossover), or concurrently (Diamond Crossover).

25 .5.1.2.81 Crossover, Facing Point

A crossover installed in such a manner that trains traveling in the normal direction of traffic on the main tracks will move from the points to the frog of the first turnout encountered, i.e., in which the crossover represents a potential diverging route to such trains.

25 .5.1.2.82 Crossover, Trailing Point

A crossover installed in such a manner that trains travelling in the normal direction of traffic on the main tracks will move from the turnout frog to the switch points, i.e., in which the crossover represents a converging route to such trains.

25 .5.1.2.83 Crossover, Universal

A double crossover which has the trailing point and facing point crossovers installed successively between the same two running tracks.

25 .5.1.2.84 Crosstalk

Undesirable interference created by inductive coupling between one system and another system or from one portion of a system to another portion of the same system.

25 .5.1.2.85 Current Schedule

The schedule residing in the Control Computer which is the set point for system control by the Traffic Regulation Program.

25 .5.1.2.86 Current Revised Schedule

A revised schedule replacing the existing current schedule in the Control Computer.

25 .5.1.2.87 Daily Safety Test (DST)

The speed command cycle test performed on a complete train before permitting the train to operate in the automatic mode.

25 .5.1.2.88 Data Bit

One of the bits used to convey information in a message. (As opposed to a “housekeeping” bit.)

25 .5.1.2.89 Data Transmission System (DTS)

The bi-directional, non-vital, digital communications system between Central Control and the Train Control Rooms.

25 .5.1.2.90 Days

Unless otherwise stated, days that are listed as multiples of the number "15" shall be considered calendar days. Days that are listed as less than the number "15" shall be considered as working days.

25 .5.1.2.91 Deceleration Rate

The rate of deceleration due to braking effort, train resistance, grade and curve resistance, or some combination of the above factors, as specified.

25 .5.1.2.92 Decoder

A device which responds to valid incoming data and converts the incoming data format to the data format required by the device for which the data is intended.

25 .5.1.2.93 Derail

A trackwork device for derailing rolling stock in case of an emergency.

25 .5.1.2.94 Destination Code

A code consisting of two decimal digits assigned to a train to indicate the desired destination and type of service for the train. The code is used to control the destination signs on the train, and to select automatic routing for the train.

25 .5.1.2.95 Diamond Crossover

See "Crossover, Diamond."

25 .5.1.2.96 Direct Fixation

A type of track structure in which the running rails and the propulsion rail insulators are affixed to a concrete support slab or to special grout pads on the slab rather than to individual crossties set in ballast.

25 .5.1.2.97 Dispatcher's Control Panel

A special type of Interlocking Control Panel for use by Dispatchers at terminal stations to locally control the terminal interlocking. Controls for the NEXT TRAIN signs are also included, where applicable.

25 .5.1.2.98 Dispatching

The process of starting a train into revenue service from a terminal station, or from a specially equipped intermediate location.

25 .5.1.2.99 Dispatch Receiver

A Train-to-Wayside Communications System receiver which is used to accept Train Ready and Train Length data from trains leaving a dispatch point other than a station platform.

25 .5.1.2.100 Diverging Route

See "Route, Diverging."

25 .5.1.2.101 Double Crossover

See "Crossover, Double."

25 .5.1.2.102 Downstream

Relative to a specified reference point and for a given direction of travel, the area which will be reached after passing the specified reference point. Used in the same sense as the AAR term "in advance of." (See "Upstream.")

25 .5.1.2.103 Drop (or Drop-Out)

A relay is said to "drop" or "drop-out" when the energization of its coil(s) is reduced to the point where its front contacts open.

25 .5.1.2.104 Duct

A single enclosed runway for wires or cable.

25 .5.1.2.105 Duct Bank

An arrangement of conduit or ducts providing two or more continuous ducts between two points.

25 .5.1.2.106 Dwell (or Dwell Time)

The period of time measured from the instant a train stops in its berth at a station until the instant it resumes motion.

25 .5.1.2.107 Dynamic Train Tests

The field tests conducted by the Contractor utilizing trains under electrical power.

25 .5.1.2.108 Elevated

That portion of the system which is constructed above the adjacent ground surface. See "Aerial Structure."

25 .5.1.2.109 Encoder

A device which adds security to and converts the data format produced by input devices to the data format required by associated data transmission links.

25 .5.1.2.110 (The) Engineer

Wherever in the Criteria the term "Engineer" is used, it shall mean the Resident Engineer or other duly authorized representative of the Contracting Officer.

25 .5.1.2.111 Entrance-Exit Type Route Control

Automatic route control implemented by defining first an entrance point and then an exit point.

25 .5.1.2.112 Fail-Safe

An inherent characteristic of a system or circuit which ensures that any malfunction affecting safety will cause the system or controlled function of the circuit to revert to a state that is known to be safe.

25 .5.1.2.113 Failure

An inability to perform an intended function.

25 .5.1.2.114 Fiber Optics Interface System

A type of Wayside Code System (WCS).

25 .5.1.2.115 Fleeting

A method of route control in which a route request is not canceled by the passage of a train, thus permitting safe automatic following moves over the same route.

25 .5.1.2.116 Flyby Receiver

A Train-to-Wayside Communications System receiver which is used to accept and store destination codes from moving trains in approach to junctions and terminals.

25 .5.1.2.117 Flyby Transmitter

A Train-to-Wayside Communications System transmitter which is used to transmit performance level information to moving trains at locations between passenger stations.

25 .5.1.2.118 Frog

A trackwork component used at the intersection of two running rails to provide support for wheels and passageways for their flanges, thus permitting wheels on either rail to cross the other.

25 .5.1.2.119 Grade Crossing

A location where a roadway and the METRORAIL tracks cross each other at the same elevation.

25 .5.1.2.120 Guard Rail

A rail or other structure fastened parallel with the running rails of a track and used to prevent wheels from being derailed, or to hold wheels in correct alignment to prevent their flanges from striking either crossing frogs or the points or switches, or to prevent a derailed train from leaving the track right-of-way. See also, "Restraining Rail."

25 .5.1.2.121 Hand Throw Switch

See “Switch, Hand Throw.”

25 .5.1.2.122 Headway

The time separation between two trains both traveling in the same direction on the same track. It is measured from the time the head-end of the leading train passes a given reference point to the time the head-end of the following train passes the same reference point.

25 .5.1.2.123 Home Signal

See "Signal, Home."

25 .5.1.2.124 Impedance Bond

See "Bond, Impedance."

25 .5.1.2.125 Indication (as used with respect to messages from local equipment and trains)

A DTS message from the Train Control Room to Central or a Train-to-Wayside Communications System message from the train to the Train Control Room which carries information concerning the status of some device or system. See "Control."

25 .5.1.2.126 Indication, Signal

See "Signal Indication."

25 .5.1.2.127 Inspection

Visual observation to ascertain proper physical condition, attachments, connections, clearances, size, joints, motion, rotation, operation and/or similar characteristics.

25 .5.1.2.128 Insulated Joint (IJ)

See "Joint, Insulated."

25 .5.1.2.129 Interface

The interconnection and/or inter-relationship between two or more systems, subsystems, circuits, persons or contracts, required to ensure continuity and proper operation.

25 .5.1.2.130 Interlocking

An arrangement of signals and signal appliances so interconnected that their operations must succeed each other in proper sequence, thereby permitting train movements over controlled routes only if safe conditions exist.

25 .5.1.2.131 Interlocking Control Machine

See “Yard Control Machine.”

25 .5.1.2.132 Interlocking Control Panel (ICP)

A panel displaying a line diagram of the trackage in and near a particular interlocking or group of interlockings, and equipped with various pushbuttons, electrical switches, indicator lights and audible alarms to allow the control and monitoring of that section of trackage. See also, Dispatcher's Control Panel.

25 .5.1.2.133 Interlocking Limits

The boundaries of an area of trackage controlled by an interlocking, as defined by the insulated joints at the extreme opposing home signals of that interlocking. The term "within interlocking limits" denotes the area of trackage over which routes are established and protected by the signals and signal appliances comprising that interlocking.

25 .5.1.2.134 Interlocking Operator

A qualified person designated by the Authority to control the movement of transit cars and railborne maintenance/service equipment within the limits of a METRORAIL yard.

25 .5.1.2.135 Intrusion Detection Warning (IDW) System

A system used to detect tilting or penetration of WMATA METRORAIL boundary fence in areas adjacent to railroad or highway right-of-way, and to remove speed commands from WMATA tracks where such intrusion is detected.

25 .5.1.2.136 Jerk (or Jerk Rate)

Rate of change of acceleration or deceleration equal to the second derivative of velocity. The normal unit is miles per hour per second per second (mphpsps).

25 .5.1.2.137 Joint, Insulated (IJ)

A rail joint designed to prevent the flow of electric current from rail to rail by means of insulations placed so as to separate the rail ends and other metal parts connecting them.

25 .5.1.2.138 Joint, Rail

A fastening design to align and connect the abutting ends of contiguous rails.

25 .5.1.2.139 Joint Electronic Device Engineering Council (JEDEC)

Cooperative effort of Electronic Industries Association (EIA) and National Electrical Manufacturers Association (NEMA).

25 .5.1.2.140 Junction

A location where train routes converge or diverge.

25 .5.1.2.141 Line

As used with a color prefix, e.g., "Blue Line," "Red Line," one of the operational routings over which revenue service is regularly scheduled by the Authority. A "Line" may include all or parts of one or more geographical "Routes." See also "Route."

25 .5.1.2.142 Load Weighing

A function incorporated in the rail transit vehicles which measures gross car weight and uses this information to achieve a constant effort-to-weight ratio in the vehicles' traction system.

25 .5.1.2.143 Local Control

Supervisory "control" from a local, wayside location as opposed to supervisory control from the OCC.

25 .5.1.2.144 Locking

The electrical or mechanical establishment of a condition for a switch, interlocked route, speed limit, or automatic function which cannot be altered except by a prescribed and inviolate sequence of unlocking.

25 .5.1.2.145 Locking, Approach

Electric locking effective while a train is approaching, within a specified distance, a signal displaying an "INTERLOCKING CLEAR" aspect, and which prevents, until after the expiration of a predetermined time interval after such signal has been caused to display a "STOP" aspect, the movement of any interlocked switch or derail in the route governed by the signal, and which prevents an "INTERLOCKING CLEAR" aspect from being displayed for any conflicting route.

25 .5.1.2.146 Locking, Detector

Electric locking, effective while a train occupies a given section of a route, which prevents operation of switch-and-lock movements within that section.

25 .5.1.2.147 Locking, Route

Electric locking, effective when a train passes a signal displaying an "INTERLOCKING CLEAR" aspect, which prevents the clearing of an interlocked signal for any conflicting route. It also prevents the movement of any switch or derail downstream of the train within the route entered. When required, it may be arranged so that as a train clears a track section of the route, the locking affecting that section is released. See "Sectional Release."

25 .5.1.2.148 Locking, Time

Electrical locking which, after an interlocked signal is cleared, prevents the operation of any switch or derail in the route governed by that signal until the expiration of a predetermined time interval after that

signal has displayed a STOP aspect. It also prevents other interlocked signals from being cleared for any conflicting route during the same time interval.

25 .5.1.2.149 Locking, Traffic

Electrical locking which prevents changing the direction of traffic on a section of track between consecutive interlockings and/or between opposing intermediate signals while that section of track is occupied or while a request which would permit entry into that section has been granted or is being processed.

25 .5.1.2.150 Logic Code

A tabular or graphic representation of control lines representing the speed commands that shall be transmitted in each block (for a given direction of traffic and route alignment) and the conditions under which each of the speed commands shall be transmitted.

25 .5.1.2.151 Maintenance, Preventative

Maintenance procedure carried out on a routine basis in order to reduce in-service equipment failure.

25 .5.1.2.152 Manual Local Control

A mode of system operation in which functions such as route initiation and dispatching are performed manually by personnel using local wayside equipment such as a local Interlocking Control Panel.

25 .5.1.2.153 Marker (as used in the Program Stop System)

A wayside device used to transfer data to trains at a precise location.

25 .5.1.2.154 Married Pair

Two transit cars, semipermanently coupled together, which share certain common equipment.

25 .5.1.2.155 Maximum Authorized Speed (MAS) (or Maximum Allowable Speed)

The highest ATP speed command that can safely be transmitted to a train in a block for the purpose of enforcing civil speed limits. MAS is independent of block occupancy downstream from the given block. In blocks which lie in the approach to crossovers or diverging junctions, MAS can depend on which route is aligned.

25 .5.1.2.156 Mean Time Between Failures (MTBF)

The arithmetic mean of the time between successive failures.

25 .5.1.2.157 Mean Time to Restore (MTTR)

The arithmetic mean of time required to restore service after a failure has occurred. This time is measured from the time troubleshooting or

repair work begins until restoration is complete. Time the equipment is out of service prior to the beginning of the repair work is not included in the "MTTR."

25 .5.1.2.158 Modem

A modulator and demodulator housed in a common assembly.

25 .5.1.2.159 Mole

A device containing four or more sockets for multiple connection of 1000 kcmil negative return cables.

25 .5.1.2.160 Multiplexing

The simultaneous transmission of two or more message in either or both directions over the same transmission path.

25 .5.1.2.161 Negative Return

Related to the return of 750 Vdc train propulsion current to the substations.

25 .5.1.2.162 Negative Return Bond

See "Bond, Negative Return."

25 .5.1.2.163 Negative Return Rail

See "Rail, Negative Return."

25 .5.1.2.164 Negative Testing

Testing conducted to ensure that applicable systems and/or equipment are not performing in any manner which could have an unsafe or undesirable effect upon METRORAIL operations, METRO riders, or the public in general. See "Positive Testing."

25 .5.1.2.165 Noise

Interference brought about by undesirable voltages or currents.

25 .5.1.2.166 Nonsynchronized (as used in a data transmission system)

A type of code format which does not use timing as the basis for bit separation.

25 .5.1.2.167 Non-Vital

Not affecting the safety of train operations.

25 .5.1.2.168 Non-Reporting Block

A condition detected by the ROCS Computer when track circuits report their occupancy out of sequence.

25 .5.1.2.169 Normal Direction (of Traffic)

For a given track, the direction in which all regularly scheduled revenue service operations are conducted. For a terminal station and its associated terminal crossover, when the crossover is on the "revenue service" end of the terminal station, the normal direction of traffic on a given platform track shall be the same as the normal direction of traffic on the same track on the opposite end of the terminal crossover. For pocket tracks, the normal direction of traffic shall be in the outbound direction.

25 .5.1.2.170 Normal Position (of a track switch or derail)

The position arbitrarily defined by the track plans and control circuits as being the "normal" alignment. The "Normal Position" for a derail is the derailing position. See "Reverse Position."

25 .5.1.2.171 Normal Route: See "Route, Normal."

25 .5.1.2.172 Normal Running: See "Running, Normal."

25 .5.1.2.173 Off-Normal Operation

Operation at other than the normal schedule.

25 .5.1.2.174 Operator

See "Train Operator" and "Interlocking Operator."

25 .5.1.2.175 Overcurrent Protection

A form of protection that operates when electrical current exceeds a predetermined value.

25 .5.1.2.176 Overspeed Control

The portion of the carborne ATP equipment which enforces speed limits.

25 .5.1.2.177 Parallel Format

A data format in which a group of data bits are input or output simultaneously. (See also, "Serial Format")

25 .5.1.2.178 Performance Level (PL)

A designation for a ratio of desired average actual speed between successive stations, to the maximum average speed which can be achieved between those successive stations, or; a ratio of the desired average actual speed between successive stations to the average speed used to determine normally scheduled run times between those successive stations. The desired Performance Level for a given direction between given stations (or flyby transmitter locations) is implemented by the transmission of a particular Performance Level

related maximum ATS speed limit to the train at the initial station or fly-by transmitter.

The Performance Levels are defined as follows:

- PL1: Maximum Performance; minimum run time.
- PL2: Normal Performance; run time 10% higher than that achieved with PL1 adjustment.
- PL3: Reduced Performance; run time 20% higher than that achieved with PL2 adjustment.
- PL4: Retarded Performance; run time 50% higher than that achieved with PL2 adjustment.

25 .5.1.2.179 Pick (or Pick-Up)

A relay is said to "pick" or "pick-up" when energization of its coil(s) causes its front contacts to close.

25 .5.1.2.180 Point Detector (or “Switch Circuit Controller”)

A device used to monitor the “position” of the points of a track switch and to open/close electrical circuits in accordance with the position detected; operated by a “point detector rod” connected to one of the switch points.

25 .5.1.2.181 Point-of-Switch (PS)

The location on a track switch layout where the tips of the tapered switch-point rails touch the stock rails. See "Switch Point."

25 .5.1.2.182 Positive Testing

Testing to ensure that applicable equipment circuits, systems and subsystems are performing the tasks which they are required to perform, in the manner specified. See "Negative Testing.”

25 .5.1.2.183 Processor

1. (Computing Systems) A system or mechanism that accepts a program as input, prepares it for execution, and executes the process so defined with data to produce results.
2. (Software) A computer program that includes the compiling, assembling, translating, and related functions for a specific programming language.

25 .5.1.2.184 Program Stop: See "Stop, Program.”

25 .5.1.2.185 Propulsion Rail: See "Rail, Third.”

25 .5.1.2.186 Propulsion Return Rail: See "Rail, Negative Return.”

25 .5.1.2.187 Provide

As used in these Criteria, the word "provide" means "complete the final design, furnish, install, test, place in service, document, and train, in the manner described, and to the greatest extent possible compatible with the intent and limits of the Criteria," unless otherwise indicated.

25 .5.1.2.188 Rack

A free standing, shock mounted, metal support frame or enclosure for the mounting of terminal boards, power supplies, equipment modules, relays or other train control devices.

25 .5.1.2.189 Rack, Entrance

A rack equipped primarily with terminal boards for the termination of cables coming from outside the room or housing in which the rack is located.

25 .5.1.2.190 Rack, Equipment

A rack equipped primarily with relays, equipment modules and/or other TC devices, other than power supplies.

25 .5.1.2.191 Rack, Power

A rack equipped primarily with TC Power Supply units.

25 .5.1.2.192 Rail (Track)

A rolled steel shape, commonly a T-section, designed to be laid and fastened end-to-end in two parallel lines on cross ties or other suitable supports to form a track for railway rolling stock. See "Rail, Running."

25 .5.1.2.193 Rail, Closure

Either of the two rails of a turnout which connect the frog to the heels of the two switch point rails.

25 .5.1.2.194 Rail, Contact

See "Rail, Third."

25 .5.1.2.195 Rail, Guard

See “Guard Rail.”

25 .5.1.2.196 Rail, Negative Return

A running rail used also for the return of electrical propulsion energy to a substation. Also known as a Propulsion Return Rail.

25 .5.1.2.197 Rail, Propulsion

See "Rail, Third."

25 .5.1.2.198 Rail, Propulsion Return

See "Rail, Negative Return."

25 .5.1.2.199 Rail, Restraining

See "Restraining Rail."

25 .5.1.2.200 Rail, Running

One of the two rails of a track which carry and guide the wheels of the rolling stock.

25 .5.1.2.201 Rail, Signal

A running rail which carries low voltage electrical signals used for the detection, and possibly the control, of rolling stock carried thereon.

25 .5.1.2.202 Rail, Stock

Either of the two continuous outside running rails of a turnout, against which the switch point rails bear.

25 .5.1.2.203 Rail, Third

A non-running rail, fastened parallel to, and outside of the running rails of a track, but isolated electrically from the running rails, and used to carry high-voltage electrical energy to be used for the propulsion of certain rolling stock on the track. Also known as the Propulsion Rail or Contact Rail.

25 .5.1.2.204 Rate Coding

A method of applying intelligence to a carrier by means of On/Off modulation at fixed sub-audio frequencies.

25 .5.1.2.205 Reaction Time

25 .5.1.2.205.1 For automatic control:

Time from the occurrence of a step change of control command or request to the first attainment of the new steady-state value of the controlled variable, within a designated accuracy.

25 .5.1.2.205.2 For human control:

The interval between the beginning of a stimulus and the beginning of the response of an observer.

25 .5.1.2.206 Redundancy

The existence in a system of more than one means of accomplishing a given function, for purpose of increasing security or reliability.

25 .5.1.2.207 Reliability

The probability of performing a specified function, without failure and within design parameters, for the period of time intended under actual operating conditions.

25 .5.1.2.208 Remote Terminal Unit (RTU)

A modem or microprocessor unit installed at each ATC field control location (usually at passenger station TCRs) to act as the interface unit between the Data Transmission System (DTS) and the local ATC and support system functions.

25 .5.1.2.209 Request (noun) (As used with respect to DTS messages from Central Control to wayside Train Control Rooms)

An electronic signal indicating a desire to start, stop, cancel, change or continue some ATC or support system function. (See "Command" and "Control.")

25 .5.1.2.210 Rescheduling

The development of a new schedule based on a corrective strategy.

25 .5.1.2.211 Restraining Rail

A special type of guard rail fastened in close proximity to the gauge side of the inside running rail on sharp curves. The purpose of the restraining rail is to bear upon the back of the transit vehicle wheels on the inner running rail in order to prevent undue pressure and head wear on the inside of the outer running rail of the curve. See "Guard Rail."

25 .5.1.2.212 Revenue Service

The transportation of passengers who have paid a fare.

25 .5.1.2.213 Revenue System

The portion of the METRO System on which revenue service is conducted.

25 .5.1.2.214 Reverse Direction (of Traffic)

The direction opposite to the normal direction of traffic on a given track.

25 .5.1.2.215 Reverse Position (of a track switch or derail)

The position opposite to the position arbitrarily defined by the track plans and control circuits as being the "normal" alignment. The "Reverse Position" for a derail is the non-derailing position. See also, "Normal Position."

25 .5.1.2.216 Reverse Running

See "Running, Reverse."

25 .5.1.2.217 Revised Schedule

A new schedule generated and/or selected as described under Strategy Selection and Rescheduling.

25 .5.1.2.218 Right Hand Running

Moving forward on the right-hand track, i.e., Normal Running.

25 .5.1.2.219 Right-of-Way

The land or structure surface occupied by the Metrorail transit system, especially for its main line. Also, the land or structure surface used by another transportation facility such as a railroad or highway.

25 .5.1.2.219.1 The right of traffic on a given route to take precedence.

25 .5.1.2.220 Right-of-Way, Track

An area encompassing the track ties and rails and extending two feet beyond each end of each crosstie.

25 .5.1.2.221 Right-of-Way Hazard

The existence of an abnormal condition on or near the tracks which could impair safe train movement.

25 .5.1.2.222 Route

25 .5.1.2.222.1 A block or specified succession of contiguous blocks in a given direction over which trains operate between two controlled signals.

25 .5.1.2.222.2 A continuous track path in a given direction from one controlled signal to another.

25 .5.1.2.222.3 A designation, e.g., "E" Route or "Greenbelt" Route, for a specific, contiguous geographical segment of the METRORAIL System. See also, "Line."

25 .5.1.2.223 Route, Conflicting

One of two routes crossing, converging, overlapping, or opposing, which cannot be executed concurrently by trains without the possibility or certainty of collision. See also, "Route, Parallel."

25 .5.1.2.224 Route, Converging

25 .5.1.2.224.1 One route of two or more routes (through an interlocking) having different originating (entrance) points, but coming together in the same direction to share the same destination (exit) point.

25 .5.1.2.224.2 A route over one or more trailing-point switches, having an exit point in common with one or more other routes originating at other entrance points. See also, "Route, Diverging."

25 .5.1.2.225 Route, Diverging

25 .5.1.2.225.1 One of two or more routes (through an interlocking) from a common entrance point, passing over one or more facing-point switches, and having an exit point different than another route from that same entrance point. See also, "Route, Converging."

25 .5.1.2.225.2 A route differing from the arbitrarily defined NORMAL or "through" route, i.e., a route in which at least one facing-point switch is lined in its "REVERSE" position. This is usually a route departing from the tangent alignment of the switch (or switches). See also, "Route, Through" and "Route, Converging."

25 .5.1.2.226 Route, Following

A route for movement of a successive train in the same direction into a given track block as allowed by the immediately preceding route into that track block.

25 .5.1.2.227 Route, Interlocked

A route within interlocking limits, i.e., a route (over special trackwork) which is protected by an interlocking, fail-safe system of controls and controlled signals in such a manner that all conflicting or potentially conflicting routes must first be prevented. (See also, "Routes, Conflicting").

25 .5.1.2.228 Route, Normal

25 .5.1.2.228.1 With regard to traffic direction, a route established in the normal direction of train travel, i.e., a route which results in normal running.

25 .5.1.2.228.2 A route (through an interlocking) in which all switches are lined in their defined "NORMAL" position.

25 .5.1.2.229 Route, Opposing

A route which has as its destination or exit point a signal which serves as the entrance point for another route (over the same track) in the opposite direction.

25 .5.1.2.230 Route, Parallel

One of two (or more) routes (through an interlocking) which can be executed concurrently (by trains) without danger of collision. See also, "Route, Conflicting."

25 .5.1.2.231 Route, Reverse

With regard to traffic direction, a route in which trains run opposite to the normal direction of train travel, i.e., a route which results in reverse running.

25 .5.1.2.232 Route, Through

The most commonly used or "main" route through a track switch, usually the tangent (straight) alignment. Also usually the route through the NORMAL setting of the switch. See also, "Route, Diverging."

25 .5.1.2.233 Route Designation

The input to a train supervision device reflecting a desired routing by means of a two-digit destination codeRoute Locking

See "Locking, Route."

25 .5.1.2.234 Route Request

A non-vital electrical or electronic message ("command") from Central or a local Interlocking Control Panel to a wayside interlocking operational control point, requesting the establishment of a desired interlocking route.

25 .5.1.2.235 Route Segment

A defined portion of route consisting of contiguous ATC blocks.

25 .5.1.2.236 Routes, Conflicting

Two or more routes, opposing, converging, overlapping, or intersecting, over which train movements cannot be made simultaneously without possibility or certainty of collision. See also, "Routes, Parallel."

25 .5.1.2.237 Routes, Parallel

Two or more routes (through an interlocking) over which train movements can be made simultaneously without danger of collision. See also, "Routes, Conflicting."

25 .5.1.2.238 Running, Normal

Train movement forward on the right hand track, which is in the normal direction of traffic. Right-hand running.

25 .5.1.2.239 Running, Reverse

Train movement forward on the left hand track, which is opposed to the normal direction of traffic. Left-hand running.

25 .5.1.2.240 Running, Right-Hand

See "Right Hand Running."

25 .5.1.2.241 Running Rail:

See "Rail, Running."

25 .5.1.2.242 Safety Critical

A designation placed on a system, subsystem, component, device, or function denoting that correct operation is critical to the safety of personnel or equipment. Such a designation dictates incorporation of special safety design features. Vital functions are a subset of Safety Critical functions which must be implemented in a fail safe manner.

25 .5.1.2.243 Safety Speed Limit

See "Speed Limit, Safety."

25 .5.1.2.244 Scan Sheets

Sheets listing the successive "control" and "status" (indication) data points required for a given Remote Terminal Unit.

25 .5.1.2.245 Schedule

A set of data providing the time/location information for all trains to be operated in a feasible manner on a system or in a specified area of a system, over a fixed period of time such as a 24-hour day or portion thereof.

25 .5.1.2.246 Schedule Control

Traffic regulation, corrective strategy selection and rescheduling performed by the ATS system.

25 .5.1.2.247 Schedule Error

The difference between actual time and current schedule time for a given event (e.g., the arrival of a train at a station).

25 .5.1.2.248 Schedule Tolerance

Maximum permissible schedule error; for each schedule, direction, location and time, a different schedule tolerance may exist.

25 .5.1.2.249 Sectional Release (of Route Locking)

The release of route locking in sections behind a train as the train proceeds past the clearance point(s) of one or more diverging switches through an interlocking. This is for the purpose of expediting the establishment of subsequent routes through the interlocking.

25 .5.1.2.250 Sectional Release (of Switch Control)

The release of switch locking in sections behind a train as it first occupies, then vacates, detector tracks for one or more diverging switches as it proceeds through an interlocked route.

25 .5.1.2.251 Security Bit

A bit inserted in a message to permit a validity check of that message after it is decoded.

25 .5.1.2.252 Serial Format

A data format in which the data bits are input or output consecutively. (See also, "Parallel Format.")

25 .5.1.2.253 Service Brake

The primary train brake system which is used to control train deceleration under normal operating conditions.

25 .5.1.2.254 Sign (noun)

A wayside appliance which conveys information concerning train operation or location.

25 .5.1.2.255 Sign, Approach Warning (AWS)

A sign which warns a train operator that the train is approaching a wayside signal which is not currently visible.

25 .5.1.2.256 Sign, Next Train

An illuminated sign used at tail-track terminal stations to indicate to passengers which track the next revenue-service train will depart from.

25 .5.1.2.257 Sign, Station Stop

A sign bearing the letter "S" which indicates the starting point for a programmed station stop.

25 .5.1.2.258 Sign, Turnback

A sign bearing the letters "TB" which indicates the end of a turnback block and the location of a virtual Turnback Signal.

25 .5.1.2.259 Signal (noun)

A wayside appliance which uses colored light aspects to convey information governing train movement. See "Signal Aspect."

25 .5.1.2.260 Signal, Cab

An indicator or group of indicators located in the operating cab of a transit car or locomotive, which display(s) speed command information.

25 .5.1.2.261 Signal, Clear

A signal displaying an aspect for an indication which permits movement of the train past the signal.

25 .5.1.2.262 Signal, Controlled

A wayside signal capable of displaying either a stop aspect or an aspect indicating that train movement is permissible, the aspect displayed being determined by fail-safe control circuitry.

25 .5.1.2.263 Signal, Holding (or Signal, Holdout)

A controlled signal located at a track circuit boundary on a tail track or yard lead, and used to prevent trains from moving into an area of trackage required to be left unoccupied in order to provide safe braking distance for trains stopping at a terminal station.

25 .5.1.2.264 Signal, Home

A controlled signal located at an entrance to an interlocking and used to govern the movement of trains into that interlocking.

25 .5.1.2.265 Signal, Intermediate

A controlled, non-Home, wayside signal located at the entrance to a yard lead or yard running track protected by Traffic Locking, and used to govern the movement of trains onto that track.

25 .5.1.2.266 Signal, Marker

A wayside signal capable of displaying only a stop aspect and used to mark end-of-track locations.

25 .5.1.2.267 Signal, Repeater

A wayside signal installed at a specified distance upstream from a wayside “controlled” or marker signal having limited sighting distance, and used to indicate the current aspect of that signal.

25 .5.1.2.268 Signal, Turnback

A simulated, controlled wayside signal located at a turnback point and used, when approached in its "non-cleared" state, to initiate automatic turnback operation through an interlocking. The location of the turnback point, i.e., the location of the simulated wayside signal, is indicated in the field by a Turnback Sign.

25 .5.1.2.269 Signal, Wayside

A signal located beside the track.

25 .5.1.2.270 Signal Aspect

25 .5.1.2.270.1 The appearance of the illuminated lens(es) of a wayside signal conveying an indication, as viewed from the direction of an approaching train.

25 .5.1.2.270.2 The appearance of a cab signal conveying an indication as viewed by an observer.

25 .5.1.2.271 Signal Aspect Name

The specific, unique term used to identify a particular signal aspect; often used as an abbreviation for the indication conveyed by that signal aspect, e.g., "Diverging Clear."

25 .5.1.2.272 Signal Indication

The specific "operating instruction" information conveyed by the aspect of a signal.

25 .5.1.2.273 Signal Rail

See "Rail, Signal."

25 .5.1.2.274 Signals, Back-to-Back

25 .5.1.2.274.1 A pair of controlled signals mounted to face in opposite directions along a given track, at a track circuit boundary and used to control train movements in both directions across that track circuit boundary.

25 .5.1.2.274.2 Two controlled signals physically mounted back-to-back, i.e., facing in opposite directions between two adjacent tracks, with one signal governing train movements in one direction on one track and the other governing train movements in the opposite direction on the adjacent track. See also, "Signal, Intermediate."

25 .5.1.2.275 Skip-Stop

The operating procedure or command which causes a train to pass a scheduled station-stop platform intentionally, without stopping.

25 .5.1.2.276 Slide, Wheel

An extreme slip condition wherein the wheel has zero rotational speed and slip speed equals train speed.

25 .5.1.2.277 Slip, Wheel

The difference between the surface speed of wheel tread and rail, usually transient and sporadic.

25 .5.1.2.278 Speed, Balancing

The steady-state speed attained by the carborne traction system when resisting forces are exactly equal to applied forces.

25 .5.1.2.279 Speed Limit, ATC

The upper limit of safe train speed as enforced by the ATP subsystem.

25 .5.1.2.280 Speed Limit, ATO

The upper limit of train speed as enforced by the ATO Subsystem.

25 .5.1.2.281 Speed Limit, Civil

For a given section of track, the maximum speed allowed as determined by the physical characteristics of the track structure and limited to ensure the comfort of passengers on trains and on station platforms.

25 .5.1.2.282 Speed Limit, Safety

The maximum speed at which a train can safely negotiate a given section of track. The safety speed limit is set to minimize potential passenger injury.

25 .5.1.2.283 Speed Sensor

A device which produces an output signal whose frequency is proportional to axle angular velocity.

25 .5.1.2.284 Speed Zone

A section of track which has the same civil speed limit throughout its length. For a given direction of traffic, a more restrictive speed zone is one which has a lower civil speed limit than the preceding adjacent speed zone; a more permissive speed zone is one which has a higher civil speed limit than the preceding adjacent speed zone.

25 .5.1.2.285 Static Testing

All levels of testing which can be completed without using an electrically energized train.

25 .5.1.2.286 Stock Rail

See "Rail, Stock."

25 .5.1.2.287 Stop, Absolute

A train stop which permits no exceptions such as reduced speed running, movement within restricting limits, or similar alternatives.

25 .5.1.2.288 Stop, Emergency

A train stop initiated by an emergency brake application. Once initiated, the brake application cannot be released until the train has stopped.

25 .5.1.2.289 Stop, Program

The stopping of a train at a station platform under closed-loop braking in accordance with a speed-distance profile which will cause the train to stop at a predetermined point.

25 .5.1.2.290 Storage Track

A track used for the storage of rapid transit cars or railborne maintenance vehicles.

25 .5.1.2.291 Strategy Selection and Rescheduling

A set of actions initiated by Central Control designed to compensate for major disturbances to METRO operation. These actions include altering the current schedule, skipping stations, changing routes, and changing the number of trains in revenue service.

25 .5.1.2.292 Subsystem

A subsystem comprises elements within a system which are interconnected to perform a specific function.

25 .5.1.2.293 Subway

That portion of the WMATA-METRORAIL system which is constructed beneath the ground surface.

25 .5.1.2.294 Superelevation

The increased elevation of the outer rail of a track on a curve to counteract overturning force.

25 .5.1.2.295 Superelevation, Unbalanced (Eu)

For a given gauge, radius of curvature, and speed and configuration of rolling stock; the difference between the superelevation required to exactly balance the overturning force and the actual superelevation (Ea) installed.

25 .5.1.2.296 Supervisor

A qualified WMATA METRORAIL employee whose function is to supervise METRORAIL mainline operations. See also, “Interlocking Operator.”

25 .5.1.2.297 Switch (Electric)

A device by mean of which an electric circuit may be opened or closed.

25 .5.1.2.298 Switch (Track)

A pair of switch points with their fastenings and operating rods providing the means for establishing a route from one track to another. See also "Turnout.”

25 .5.1.2.299 Switch, Hand Throw

A non-power-operated track switch, i.e., a switch which has its points operated only by a rod-connected hand-throw mechanism.

25 .5.1.2.300 Switch, Trailable

A track switch which may be trailed at limited speed without damage to the switch layout. See “Trail” and “Trailable Switch Operating Layout.”

25 .5.1.2.301 Switch-and-Lock Movement

A device which performs the three functions of unlocking, operating and locking a switch or derail.

25 .5.1.2.302 Switch Correspondence

Agreement between the called-for alignment of a switch and the actual alignment of that switch.

25 .5.1.2.303 Switch Machine

A general term for a mechanism used to control the movement of the points of a track switch.

25 .5.1.2.304 Switch Point

A moveable tapered running rail, the point of which is designed to fit against one of the stock rails of a switch.

25 .5.1.2.305 Switch Position, Normal

See "Normal Position."

25 .5.1.2.306 Switch Position, Reverse

See "Reverse Position."

25 .5.1.2.307 Switch Test Key

A control panel device (twist button or toggle switch) which controls the operation of a turnout (or crossover) without calling for a route over that turnout. If a route over that turnout has already been called and locked, the Switch Test Key shall not be able to control the turnout until the route is unlocked and the Test Key has been restored to correspondence with the track switch position. See also; “Auxiliary Switch Operation.”

25 .5.1.2.308 System

When used alone as a proper noun, shall refer to the WMATA Rail Rapid Transit System. When "system" is used alone as a common noun, it shall refer to the specific assemblage of equipment and circuitry under discussion.

25 .5.1.2.309 Tail Track

25 .5.1.2.309.1 Mainline Terminal Tail Track

A portion of track located beyond the outbound end of the terminal turnback interlocking. If the interlocking is located at the inbound end of the terminal station, the station platform tracks will be located on the two tail tracks, thus requiring the installation of NEXT TRAIN signs, since both platform tracks may normally be used to dispatch revenue service trains.

25 .5.1.2.309.2 Yard Tail Track

The portion of a non-storage track from a bumping post or other end-of-track location to the first interlocking special trackwork location encountered by that track. Usually used by trains making a turnback move at a converging route switch.

25 .5.1.2.310 Technician, Train Control

An employee whose function is to maintain and repair Automatic Train Control equipment and to perform certain emergency manual operations as required.

25 .5.1.2.311 Terminal

25 .5.1.2.311.1 A METRORAIL station and its associated turnback interlocking which is designated as the terminus of a route in the Regional METRO System. Usually located at the outbound end of a "Line."

25 .5.1.2.311.2 A device to which electrical conductors may be connected conveniently.

25 .5.1.2.312 Terminal, Tail Track

A METRORAIL terminal station having its turnback interlocking located at the inbound end of the station. See "Tail Track."

25 .5.1.2.313 Terminal, Temporary

A station and its associated turnback interlocking which is not located at the planned permanent terminus of a route in the Regional METRORAIL System, but which is used as a terminal temporarily until the route can be extended.

25 .5.1.2.314 Terminate

To fasten or attach to one or more electrical terminals in a prescribed manner. As used in these Criteria, the term does not necessarily imply stub ending, i.e., a circuit which is "terminated" in a certain location does not necessarily end at that location; more than one wire may terminate on a given terminal.

25 .5.1.2.315 Terminating Receiver (BR)

A special type of Bridging Receiver which is configured/tuned in such a manner that the applicable train detection frequency signal(s) will not

be permitted to propagate beyond the point in the track at which the receiver is connected to the track.

25 .5.1.2.316 Time, Door Open

The elapsed time from the instant the train doors are fully open until they are requested to close.

25 .5.1.2.317 Time, Down

The elapsed time during which equipment is not capable of doing useful work because of misadjustment, malfunction, or maintenance in progress.

25 .5.1.2.318 Time, Reaction

See "Reaction Time."

25 .5.1.2.319 Time, Warmup

The elapsed time from application of power to an operable device until it is capable of performing its intended function.

25 .5.1.2.320 Time Constant

Time interval from the beginning of change of a controlled variable, in response to a step forcing function, to the attainment of a stated value.

25 .5.1.2.321 Time Division Multiplexing (TDM)

The process of transmitting two or more signals over a common path by using different time intervals for different signals.

25 .5.1.2.322 Timetable

A tabulation of the times that trains are expected to arrive at, or depart from certain locations based upon a feasible operating schedule, with time measured by the master clock. The time location information for passenger stations is the same as is found in the schedule to which the timetable is related.

25 .5.1.2.323 Track

An assembly of two running rails and the associated material used to fasten them in parallel a fixed distance apart, for the purpose of supporting the movement of trains of transit cars, locomotives and various work equipment.

25 .5.1.2.324 Track, Main

A track which is normally under the control of the Automatic Train Control System, i.e., a Revenue Service track.

25 .5.1.2.325 Track, Yard Running

A yard track connecting two non-adjacent, but successive interlockings or intermediate signal locations.

25 .5.1.2.326 Track, Platform

A 600-ft. mainline track aligned with the ends of a passenger station platform and defined by a TWC impedance bond at each end.

25 .5.1.2.327 Track Circuit

See “Circuit, Track.”

25 .5.1.2.328 Track Circuit, Audio Frequency (AF Track Circuit)

A double rail track circuit designed to be energized by alternating current in the Audio Frequency range. AF Track Circuit isolation is achieved by the installation of specially tuned impedance bonds, with or without insulated rail joints.

25 .5.1.2.329 Track Circuit, Power Frequency

A track circuit designed to be energized by 60 Hz alternating current.

25 .5.1.2.330 Track Circuit, Series-Type

Non-vital, normally deenergized track circuit in which the track relay becomes energized only when rolling stock completes a series circuit by shunting the running rails comprising part of that circuit.

25 .5.1.2.331 Track Circuit, Vital

A normally energized arrangement of electrical and/or electronic equipment and conductors which include defined lengths of the track running rails, and which permits detection of trains within the defined limits of the running rails due to deenergizaton of the track relay caused by the shunting of the running rails. See also, "Circuit, Track."

25 .5.1.2.332 Track Transformer

A transformer designed to couple signal energy to or from the rails of a track circuit.

25 .5.1.2.333 Traction Supply System or Traction Power System

The electrical system which supplies and distributes propulsion power.

25 .5.1.2.334 Traction System

The system of wheels, motors, driving mechanism, brakes, direct controls and appurtenances which propel or brake a married pair of transit cars in response to input commands or requests from the train control system.

25 .5.1.2.335 Tractive Effort, Negative

Retarding force developed by the train braking system.

25 .5.1.2.336 Tractive Effort, Positive

Propelling force developed by the train propulsion system.

25 .5.1.2.337 Traffic

Having to do with the direction of train operations over a segment of track between consecutive interlockings and/or sets of signals. See "Traffic, Normal" and "Traffic, Reverse."

25 .5.1.2.338 Traffic Circuit

See "Circuit, Traffic."

25 .5.1.2.339 Traffic, Normal

See "Normal Direction (of Traffic)."

25 .5.1.2.340 Traffic, Reverse

See "Reverse Direction (of Traffic)."

25 .5.1.2.341 Traffic Regulation

The use of changes in dwell time, performance level, and acceleration rate to return a train to its schedule.

25 .5.1.2.342 Traffic Regulation Program

An ATS program to correct or stabilize schedule error within the schedule tolerance.

25 .5.1.2.343 Trail (verb), or Trail Through

To operate a piece of railborne equipment in the converging direction through a mis-aligned track switch.

25 .5.1.2.344 Trailable Switch Operating Layout

An assembly consisting of a special, trailable switch machine and its associated rods and miscellaneous hardware, which, in addition to operating the switch in the normal manner, also permits the switch to be trailed through by a train at limited speed without damage to the switch points or the layout.

25 .5.1.2.345 Train

A single married pair or multiple married pairs (of transit cars), coupled together to form a single unit which shall be suitably identified when used in Revenue Service. See "Train Identity."

25 .5.1.2.346 Train, Non-Revenue

Any train in test, maintenance, emergency or inspection service, which may not be used by the public.

25 .5.1.2.347 Train, Revenue

Any train in transit service on main tracks, which may be used by the public. See "Revenue Service."

25 .5.1.2.348 Train Control (TC)

A general term indicating equipment, circuitry, material or documentation related to the controlled operation and routing of the transit vehicles.

25 .5.1.2.349 Train Control Equipment Room (TCER)

A room housing wayside Train control equipment, but no Remote Terminal Unit. A "satellite" train control room located and used primarily to house train control energy equipment and track circuit modules due to operational distance restrictions imposed by track circuit signal attenuation and/or voltage drop considerations. See Train Control Room (TCR).

25 .5.1.2.350 Train Control Room (TCR)

25 .5.1.2.350.1 Mainline

A room located in a passenger station or at some other strategic point to house wayside ATC equipment including a Remote Terminal Unit. A major wayside control point for the ATC System.

25 .5.1.2.350.2 Yard

A room located at some strategic point in the yard to house Train Control equipment.

25 .5.1.2.351 Train Detection Equipment

The track circuits and associated equipment used to detect the presence of trains.

25 .5.1.2.352 Train Identity (ID)

The code assigned to each train which contains the train destination, train number, and train length.

25 .5.1.2.353 Train Operator

An Authority employee aboard the controlling cab of a train in service whose principal duties are to oversee safety and to execute non-automatic operations.

25 .5.1.2.354 Train Shunt Impedance

The interrail impedance affected by a train.

25 .5.1.2.355 Train-to-Wayside Communications (TWC) System

A non-vital, bi-directional, digital data communications system for the transfer of information between the trains and wayside equipment at passenger station platforms and certain other intermediate locations. See “Dispatch Receiver,” “Flyby Receiver” and “Flyby Transmitter.”

25 .5.1.2.356 Turnback Block

A contiguous section of mainline track, defined at one end by an interlocking home signal and at the other end by a Turnback Sign (and by a virtual “Turnback Signal.”) Within this block, the direction of running of a train leaving the interlocking may be reversed while the track is occupied by that train and the associated “Turnback Signal” has not been cleared. See “Signal, Turnback.”

25 .5.1.2.357 Turnback Point

That point along a mainline track, at least maximum train length downstream from the exit point from interlocking limits, which will not be passed by a train which is to use that interlocking to reverse direction. Required turnback points will be indicated by appropriate symbols on the Contract Drawings. Turnback points are always located at a track circuit boundary and shall be identified by a Turnback (TB) sign.

25 .5.1.2.358 Turnback Sign

See “Sign, Turnback.”

25 .5.1.2.359 Turnback Signal

See "Signal, Turnback.”

25 .5.1.2.360 Turnout

An arrangement of a switch and a frog with closure rails by means of which rolling stock may be diverted from one track to another.

25 .5.1.2.361 Unsafe Condition

Any condition which endangers human life or property.

25 .5.1.2.362 Universal Crossover

See "Crossover, Universal.”

25 .5.1.2.363 Upstream

Relative to a specified reference point and for a given direction of travel, the area which will have been passed prior to reaching the specified reference point. Used in the same sense as the AAR term "in approach of." See also, "Downstream.”

25 .5.1.2.364 Vital

Affecting the safety of train operations.

25 .5.1.2.365 Wash Track

A shop track or Yard Lead equipped with machines for washing the transit cars.

25 .5.1.2.366 Wayside (adjective)

Having to do with, or located along, the METRORAIL trackwork right-of-way.

25 .5.1.2.367 Yard Control Machine, or; Yard Control Console

An assembly of equipment in and on a cabinet, including a panel containing a diagram of the yard trackage and major service buildings, which is used for the control and monitoring of track switches, wayside signals, snowmelters and other Train Control functions in the Yard. See also, Interlocking Control Panel.

25 .5.1.2.368 Yard Control Room

The room containing the Yard Control Machine, Communications Console, and other panels and equipment for monitoring and controlling propulsion power and other yard functions.

25 .5.1.2.369 Yard Lead

25 .5.1.2.369.1 A length of yard running track connecting the yard storage and service area with the mainline.

25 .5.1.2.369.2 A length of non-Revenue-Service mainline track connecting the Revenue Service area of mainline track to a yard.

25 .5.1.2.370 Yard Limits

The outer boundaries of the area of trackage normally controllable by the Yard Control Machine.

25 .5.1.2.371 Yard Running Track;

See “Track, Yard Running.”

25 .5.1.2.372 Yard Storage Track

See “Storage Track.”

25 .5.1.2.373 Yard Train Control Room

See “Train Control Room” (TCR).

25 .5.1.3 Abbreviations

WMATA MANUAL OF DESIGN CRITERIA
SECTION 25

This section lists various abbreviations for terms and organizations and prescribes the meanings for the abbreviations as used in these Criteria.

ABBREVIATION LIST

Abbreviation	Meaning
A	Amber or Approach or Arrival
AAR	Association of American Railroads 50 F Street, N.W. Washington, DC 20001
ABN	Abnormal
AC	Alternating Current
ACI	Automatic Car Identification
AEG	Active Element Group
AF	Audio Frequency
AFF	Above Finished Floor
AHD	Ahead
AIIM	Association for Information and Image Management (Formerly "NMA" - National Micrographics Association) 1100 Wayne Ave. Silver Spring, MD 20910
Amp	Ampere
ANSI	American National Standards Institute, Inc. 1430 Broadway New York, NY 10018
APTA	American Public Transit Association 1201 New York Ave., N.W. Washington, DC 20005
ARB	Always Reporting Block
A.R.E.A.	American Railway Engineering Association (Obsolete; See “AREMA”)

ABBREVIATION LIST

Abbreviation	Meaning
AREMA	American Railway Engineering and Maintenance-of-Way Association 8201 Corporate Dr., Ste. 1125 Landover, MD 20785-2230
ASQC	American Society for Quality Control 230 W. Wells Street Milwaukee, WI 53203
ASTM	American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
ATU	Auxiliary Terminal Unit
AWG	American Wire Gauge
AWS	Approach Warning Sign
B	Back or Barrier
BCD	Binary Coded Decimal
BK	Back
BP	Bumping Post or Bypass or Back Repeater
BR	Terminating Receiver
C	Centigrade (Celcius) or Check or Central or Case or Correspondence or Curve
CAU	Computerized Analyzer Unit
CB-CL	Crossbond Conduit Line
C.C.	Curve to Curve

ABBREVIATION LIST

Abbreviation	Meaning
CD-ROM	Compact Disk - Read-Only Memory
CHK	Check
CHP	Chilled Water Plant
CIA	Communications Interface Assembly
CIOC	Communications Input/Output Channel
Ckt	Circuit
cm	Centimeter
CMOS	Complementary Metal Oxide Semiconductor
COMM	Communications or Communications Equipment Room
CRT	Cathode Ray Tube
C.S.	Curve to Spiral
C.S.A.	Canadian Standards Association
CSXT	CSX Transportation (Railroad)
CTS	Carrier Transmission System
CWR	Continuous Welded Rail
D	Deploy or Deployed
DC	Direct Current
DEJ	WMATA IDW/Railroad Derailment/Dragging Equipment Interface Junction Box
DJ	Distribution Junction Box
DIO	Direct Input/Output
DOS	Disk Operating System

ABBREVIATION LIST

Abbreviation	Meaning
DPS	Drainage Pumping Station or Design Profile Speed
DR	Dispatch Receiver
DTS	Data Transmission System
E	Light or East or End or Superelevation or Equivalent
E_a	Actual Superelevation (in inches)
E_u	Unbalanced Superelevation (in inches)
ECTFE or E-CTFE	Ethylene-Chlorotrifluoroethylene
EE	Emergency Exit
EIA	Electronic Industries Association 1722 Eye Street, N.W. Washington, DC 20006
EMI	Electromagnetic Interference
EMS	Engineer's Monitoring System
ENSS	WMATA Office of Engineering Support Services
E.O.C.	End of Contract
E.O.L.	End of Loop
EOP	End of Platform
E.O.T.	End of Track
EPROM	Erasable Programmble Read-Only Memory
ES	East Stick
ETFE	Ethylene-Tetrafluoroethylene
ETLT	Equal To or Less Than
ETS	Emergency Trip Station

ABBREVIATION LIST

Abbreviation	Meaning
F	Fahrenheit or Traffic or Flashing or Field or Failure
F&I	Fire and Intrusion
FA	Fire Alarm
Fig	Figure
FL	Flasher or Flashing or Fleeting
FOIS	Fiber Optic Interface System (A type of WCS)
FR	Fly-by Receiver
FRA	Federal Railroad Administration (Part of U.S. Government -Dept. of Transportation) 400 7th Street, S.W. Room 8206 Washington, DC 20590
F.R.E.	Fiberglass Reinforced Epoxy
FS	Fan Shaft
FSK	Frequency Shift Keyed
ft	Foot, Feet
FT	Fly-by Transmitter
FTA	Federal Transit Administration(Part of U.S. Government - Dept. of Transportation; formerly, Urban Mass Transportation Administration) 400 7th Street, S.W. Room 9400
FUT	Future
FUTU	Future (on RTU Scan Sheets)
FVD	Flammable Vapor Detector
G	Signal or Guard

ABBREVIATION LIST

Abbreviation	Meaning
G.R.S.	Galvanized Rigid Steel
GRS	General Railway Signal Corporation P.O. Box 20600 Rochester, NY 14602-0600
GTET	Greater Than or Equal To
I	Interface or Interlocking or Insulated
I.B.	Inbound
ICEA	Insulated Cable Engineers Association 155 East 44th Street New York, NY 10017
I.C.P.	Interlocking Control Panel
ID	Train Identity
IDW	Intrusion Detection Warning
IEEE	Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street New York, NY 10017
IF	Interface
IFC	Interface Case
IFJ	Interface Junction Box
IJ	Insulated Joint or Interlocking Junction Box
in	Inch, Inches
IVP	Interlocking Vital Processor
J	Junction Box
JB	Junction Box
K	Indication or Thousand
kcmil	Thousand Circular Mils

ABBREVIATION LIST

Abbreviation	Meaning
L	Loop or length or light
LCC	Local Console Controller
LED	Light Emitting Diode
L.H.	Left Hand
LJ	Loop Junction Box
LMC	Local Manual Control
LSTS	LS Transit Systems, Inc 2 Whipple Place, Suite 302 Lebanon, NH 03766-1356
LTET	Less Than or Equal To
LW	Lunar White
M	Marker Coil or Maintainer or Manual
mA	Milliampere
MAL	Malfunction
MAS	Maximum Authorized Speed
max	Maximum
MDS	Maintainer's Diagnostic System
METRO	Washington Metropolitan Area Transit Authority See "WMATA"
mg	Milligram
min	Minimum or minute
MIS	Management Information System
MJ	Marker Junction Box
mm	Millimeter
MTBF	Mean Time Between Failure
M/W	Maintenance of Way

ABBREVIATION LIST

Abbreviation	Meaning
N	Normal or North or Negative or Next
NBD	Normal Braking Distance
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association 2101 L St., N.W., Suite 300 Washington, DC 20037
N.I.C	Not Included in (this) Contract
N.I.S.T.	National Institute of Standards and Technology (Part of U.S. Government Department of Commerce; formerly, National Bureau of Standards) Gaithersburg, MD 20899
NMA	National Micrographics Association (VOID) See "AIIM"
N/mm²	Megapascal (Newtons per millimeter squared)
NOR	Normal
NRB	Non-Reporting Block
NS	North Stick
NTP	Notice toProceed
N.T.S.	Not to Scale
NV	Non-Vital
NVIP	Non-Vital Interlocking Processor
NX	Entrance/Exit
O	Overload or Operating or Overlap
O.B.	Outbound
OCC	Operations Control Center (Central) (Located in the Jackson Graham Building)

ABBREVIATION LIST

Abbreviation	Meaning
OFS	Order For Services
ORD	Operational Readiness Date
P	Repeater or Processor or Panel or Platform
PAU	Portable Analyzer Unit
PB	Pushbutton
PC	Printed Circuit
P.I.T.O.	Point of Intersection (of centerlines) of Turnout
PL	Panel Lighting or Performance Level
P.O.C.	Point on Curve
P.O.T.	Point on Tangent
PROM	Programmable Read-Only Memory
PS	Point of Switch
PSS	Program Station Stop
PVC	Polyvinyl chloride
P.V.C.	Point of Vertical Curve (Begin Vertical Curve)
P.V.I.	Point of Vertical Intersection (of profile tangents)
P.V.T.	Point of Vertical Tangent (End Vertical Curve)
Q	Request or Quality Factor
R	Radius or Red or Reverse or Receive or Route or Retract or Retracted or Restriction or Rail or Restraining, or, as a suffix, Vital Relay
RAFTS	Rail Audio Frequency Test Set

ABBREVIATION LIST

Abbreviation	Meaning
RAP	Rail Administrative Procedure (WMATA)
RCVR	Receiver
R.E.	Resident Engineer
R.H.	Right Hand or Relative Humidity
rms	Root Mean Square
ROD	Revenue Operations Date
RTU	Remote Terminal Unit
R.W.	Retaining Wall
S	Stick or South or Station Stop or Start or Storage or System or Spiral or Sign
SAS	Supervisory Alarm System
S&I	Service and Inspection (Yard)
SBD	Safe Braking Distance
S.C.	Spiral to Curve
SCI	Substantial Completion Inspection
S.C.& I.	Special Control & Indication (cable)
SEJ	Sewage Ejector
Sig	Signal
SM	Snowmelter
SMF	Snowmelter Failure
SOP	Standard Operating Procedure (WMATA)
SP	Sump Pump
SS	Substation or Station Stop or South Stick

ABBREVIATION LIST

Abbreviation	Meaning
SSR	Substation Return
SSR-CL	Substation Return Conduit Line
S.T.	Spiral to Tangent
STA	Station or Stationing
STAP	Station Processor
SYPM	WMATA Systems Program Management (Part of Department of Design and Construction)
SZJ	(IDW) Sub-Zone Junction Box
T	Track or Time or Transmit or Tunnel or Tangent
TABIL	Train Arrival Bus Indication Light
TAILS	Train Arrival Indication Light System
TB	Turnback or Tie Breaker
TBS	Tie Breaker Station
TC	Train Control
TCER	Train Control Equipment Room
TCR	Train Control Room
TD	True Distance
TE	Time Element
TJ	Track Junction Box
TK	Track
TM	Track Module
TPS	Traction Power Substation
TRK	Track
TRN	Train

ABBREVIATION LIST

Abbreviation	Meaning
T.S.	Tangent to Spiral
TWC	Train-to-Wayside Communications
TYP	Typical
UE	Unauthorized Entrance
UG	Underground
UL	Underwriters Laboratories
US&S	Ansaldo Signal N.V. (formerly Union Switch & Signal, Inc.) 1000 Technology Drive P.O. Box 420 Pittsburgh, PA 15219-3120
V	Volt(s) or Vital or Velocity
V_c	Civil Speed Limit
V_s	Safety Speed Limit
VAC, Vac	Volts Alternating Current
VC	Vertical Curve (Length)
VDC, Vdc	Volts Direct Current
VP	Vital Processor
VS	Vent Shaft
VXI	VMEbus Extensions for Instrumentation
W	Switch or West or Warning or White or Wall
WCS	Wayside Coding System (See FOIS)
WMATA	Washington Metropolitan Area Transit Authority 600 Fifth Street, NW Washington, DC 20001
WS	West Stick

ABBREVIATION LIST

Abbreviation	Meaning
WTP	Wayside Test Procedure
W.W.	Wing Wall
X	Transmit or Cross
XFMR	Transformer
XLPE	Cross-Linked Polyethylene
XMTR	Transmitter
Y	Combination or Collector
Z	Control or call
ZB	Impedance Bond

25 .5.2 Tables of DTS Function:

TABLE I, TRAIN OPERATION "CONTROLS"

Group	No.	Function Name
Train/ Station	1A	Set Train Identification; RUN NUMBER, PLATFORM (No.) and DESTINATION, PLATFORM (No.)
Train/Sta.	1B	HOLD WITH DOORS CLOSED, PLATFORM (No.)
Train/Sta.	1C	HOLD WITH DOORS OPEN, PLATFORM (No.)
Train/Sta.	1D	TERMINATE DWELL, PLATFORM (No.)
Train/Sta.	1E	ATS-PERFORMANCE, PLATFORM (No.)
Train/Sta.	1F	ATS-PERFORMANCE, FLY-BY (No.) TK (No.)
Train/Sta.	1G	ATS-ACCELERATION, PLATFORM (No.)
Train/Sta.	1H	SKIP STOP MARKER (Tk./Dir./Dist.)
Train/Sta.	1I	DOOR CLOSE WARNING, PLATFORM (No.)
Track	1J	RESET IDW SYSTEM
Interlkg.	2A	SET LOCAL CONTROL
Interlkg.	2B	SET CENTRAL CONTROL
Interlkg.	2C	SET NORMAL SWITCH (No.)
Interlkg.	2D	SET REVERSE SWITCH (No.)
Interlkg.	2E	CANCEL SWITCH (Number)
Interlkg.	2F	ROUTE REQUEST SIG (No.)

TABLE I, TRAIN OPERATION "CONTROLS"

Group	No.	Function Name
Interlkg.	2G	CANCEL ROUTE
Interlkg.	2I	CANCEL FLEET SIG (No.)
Interlkg.	2J	SET AUTO ROUTE SIG (No.)
Interlkg.	2K	CANCEL AUTO ROUTE SIG (No.)
Interlkg.	2L	INHIBIT AUTO OPER SIG (No.)
Interlkg.	2M	CLEAR DEST REG SIG (No.)
Interlkg.	2N	TERMINAL MODE (Number)
Interlkg.	2O	SET SNOWMELTER ON
Interlkg.	2P	SET SNOWMELTER OFF
Misc.	3A	DESTINATION, PLATFORM (No.)
Misc.	3B	TRAIN LENGTH, PLATFORM (No.)
Misc.	3C	TIME PULSE - MIN
Misc.	3D	TIME PULSE - HRS/24 HRS.
Train Dispatch	4A	TRAIN NEEDED, PLATFORM (No.)
Train Dispatch	4B	DISPATCH WARNING

TABLE II, ELECTRICAL AND SUPPORT EQUIPMENT CONTROLS

GROUP	NO.	FUNCTION NAME
Traction Pwr.	1A	AC INC LINE BRK (No.) CLOSED
Traction Pwr.	1B	AC INC LINE BRK (No.) TRIP
Traction Pwr.	1C	AC RECT TRANS FDR BRK (No.) CLOSED
Traction Pwr.	1D	AC RECT TRANS FDR BRK (No.) TRIP
Traction Pwr.	1E	DC FDR TIE BRK (No.) CLOSED
Traction Pwr.	1F	DC FDR TIE BRK (No.) TRIP
Ventilation	2A	FANS (No.) EMERGENCY OFF
Ventilation	2B	FANS (No.) EMERGENCY ON
Ventilation	2C	FANS (No.) AUTOMATIC ON
Ventilation	2D	FANS (No.) SUPPLY
Ventilation	2E	FANS (No.) EXHAUST

TABLE III, TRAIN OPERATION INDICATIONS

GROUP	NO.	FUNCTION NAME
TWC	1A	RUN NUMBER, PLATFORM (No.)
TWC	1B	DESTINATION, PLATFORM (No.)
TWC	1C	TRAIN LENGTH, PLATFORM (No.)
TWC	1D	DOOR OPEN MANUAL TK (No.)
TWC	1E	TRAIN READY TRACK (Number)
TWC	1F	TRAIN BERTHED TRACK (Number)
TWC	1G	TRAIN MOTION TRACK (Number)
TWC	1H	DOOR CLOSE (RIGHT or LEFT) TK (No.)
TWC	1I	PSS ACTIVE TK (Number)
TWC	1J	ATP CUTOUT TK (Number)
TWC	1K	TRAIN IN ATO TK (Number)
Track	2A	BLK OCCP TK (No.)
Track	2B	TEMP SPEED RESTRICTION TK (No./Dir.)
Track	2C	RIGHT OF WAY HAZARD (No.) TK (No.)
Track	2D	DRAGGING EQUIPMENT DETECTED FOR (RR) TK (Number)
Interlkg.	3A	LOCAL IN CONTROL
Interlkg.	3B	CENTRAL IN CONTROL
Interlkg.	3C	LOCAL CONTROL REQUEST
Interlkg.	3D	SWITCH (No.) CALLED NORMAL

TABLE III, TRAIN OPERATION INDICATIONS

GROUP	NO.	FUNCTION NAME
Interlkg.	3E	SWITCH (No.) CALLED REVERSE
Interlkg.	3F	SWITCH (No.) NORMAL
Interlkg.	3G	SWITCH (No.) REVERSE
Interlkg.	3H	SIG CLEAR TK (No.) SIG (No.)
Interlkg.	3I	ENT RECV TK (No.) SIG (No.)
Interlkg.	3J	FLEETED TK (No.) SIG (No.)
Interlkg.	3K	AUTO ROUTE IN EFFECT SIG (Number)
Interlkg.	3L	APPR LKD TK (No.) SIG (No.)
Interlkg.	3M	RTE LKD TK (Number)
Interlkg.	3N	AUTO OPER MODE (No.)
Interlkg.	3O	CENTRAL LOCKED OUT (Sig. No., No., No.)
Interlkg.	3P	DEST SIG (No.)
Interlkg.	3Q	TRAFFIC DIRECTION NORMAL (or REVERSE) TK (No.) and Direction of Traffic Zone ® or N)
Interlkg.	3R	SNOWMELTER ON
Interlkg.	3S	PROCESSOR FOR INTLKG FAILURE
Interlkg.	3T	PROCESSOR FOR INTLKG PROBLEM or; PROCESSOR FOR STATION PROBLEM
Interlkg.	3U	PROCESSOR (A, B, C, or D) FOR INTLKG ONLINE
Misc. TC Room	4A	CIRCUIT POWER FAILURE
Misc. TC Room	4B	POWER TRANSFER

TABLE IV, ELECTRICAL AND SUPPORT EQUIPMENT INDICATIONS (2 BITS)

Group	No.	Function Name
Traction Power	1Ai	AC INC LINE BRK (No.) CLOSED
Traction Power	1Aii	AC INC LINE BRK (No.) TRIP
Traction Power	1Bi	AC SEC TIE BRK (No.) CLOSED
Traction Power	1Bii	AC SEC TIE BRK (No.) TRIP
Traction Power	1Ci	AC RECT TRANS FDR BRK (No.) CLOSED
Traction Power	1Cii	AC RECT TRANS FDR BRK (No.) TRIP
Traction Power	1Di	AC FDR BRK, AUX PWR TRANS (No.) CLOSED
Traction Power	1Dii	AC FDR BRK, AUX PWR TRANS (No.) TRIP
Traction Power	1Ei	DC RECT BRK (No.) CLOSED
Traction Power	1Eii	DC RECT BRK (No.) TRIP
Traction Power	1Fi	DC FDR TIE BRK (No.) CLOSED
Traction Power	1Fii	DC FDR TIE BRK (No.) TRIP
Traction Power	1Gi	TRANS OVER TEMP (No.) NOR/OFF
Traction Power	1Gii	TRANS OVER TEMP (No.) ABN/ON
Traction Power	1Hi	RECT OVER TEMP (No.) NOR/OFF
Traction Power	1Hii	RECT OVER TEMP (No.) ABN/ON
Traction Power	1Ii	RECT TRAINS LOCKOUT (No.) NOR/OFF
Traction Power	1Iii	RECT TRAINS LOCKOUT (No.) ABN/ON
Traction Power	1Ji	AC INC LINE VOLTS (No.) NOR/OFF
Traction Power	1Jii	AC INC LINE VOLTS (No.) ABN/ON
Traction Power	1Ki	AC SUPPLY (No.) TO SWGR FAIL NOR/OFF

TABLE IV, ELECTRICAL AND SUPPORT EQUIPMENT INDICATIONS (2 BITS)

Group	No.	Function Name
Traction Power	1Kii	AC SUPPLY (No.) TO SWGR FAIL ABN/ON
Traction Power	1Li	AUX PWR TRANSFER SW (No.) NOR/OFF
Traction Power	1Lii	AUX PWR TRANSFER SW (No.) ABN/ON
Traction Power	1Mi	BAT CHARGE RLY (No.) NOR/OFF
Traction Power	1Mii	BAT CHARGE RLY (No.) ABN/ON
Traction Power	1Ni	AC FDR BRK, AUX PWR TRANS TEMP NOR/OFF
Traction Power	1Nii	AC FDR BRK, AUX PWR TRANS TEMP ABN/ON
Traction Power	1Oi	AC GROUP NOR/OFF
Traction Power	1Oii	AC GROUP ABN/ON
Traction Power	1Pi	RECT GROUP NOR/OFF
Traction Power	1Pii	RECT GROUP ABN/ON
Traction Power	1Qi	BATTERY CHARGE GROUP (No.) NOR/OFF
Traction Power	1Qii	BATTERY CHARGE GROUP (No.) ABN/OFF
AC Svc. Room	2Ai	AC INC LINE BRK (No.) CLOSED
AC Svc. Room	2Aii	AC INC LINE BRK (No.) TRIP
AC Svc. Room	2Bi	AC SEC MAIN BRK (No.) CLOSED
AC Svc. Room	2Bii	AC SEC MAIN BRK (No.) TRIP
AC Svc. Room	2Ci	AC SEC TIE BRK (No.) CLOSED
AC Svc. Room	2Cii	AC SEC TIE BRK (No.) TRIP
AC Svc. Room	2Di	AC TRANS OVER TEMP (No.) NOR/OFF
AC Svc. Room	2Dii	AC TRANS OVER TEMP (No.) ABN/ON
AC Svc. Room	2Ei	BATTERY ROOM EXHAUST FAN (No.) NOR/OFF

TABLE IV, ELECTRICAL AND SUPPORT EQUIPMENT INDICATIONS (2 BITS)

Group	No.	Function Name
AC Svc. Room	2Eii	BATTERY ROOM EXHAUST FAN (No.) ABN/ON
AC Svc. Room	2Fi	AC EMERG TRANSFER SW (No.) NOR/OFF
AC Svc. Room	2Fii	AC EMERG TRANSFER SW (No.) ABN/ON
AC Svc. Room	2Gi	AC BAT CHARGE RELAY (No.) NOR/OFF
AC Svc. Room	2Gii	AC BAT CHARGE RELAY (No.) ABN/ON
Misc.	3Ai	INVERTER OUTPUT (No.) NOR/OFF
Misc.	3Aii	INVERTER OUTPUT (No.) ABN/ON
Misc.	3Bi	FANS (No.) EMERGENCY OFF
Misc.	3Bii	FANS (No.) EMERGENCY ON
Misc.	3Di	THIRD RAIL HEATER (No.) ON
Misc.	3Dii	THIRD RAIL HEATER (No.) OFF

TABLE V ELECTRICAL AND SUPPORT EQUIPMENT - INDICATIONS (1 BIT)

Group	No.	Function Name
Tunnel	1A	FANS (No.) SUPPLY
Tunnel	1B	FAN SHAFT DAMPER (No.) ABN/ON
Tunnel	1C	VENT SHAFT DAMPER (No.) ABN/ON
Tunnel	1D	FANS (No.) OPERATION ABN/ON
Tunnel	1E	FANS (No.) REMOTE CONTROL ABN/ON
Tunnel	1F	TUNNEL TEMP. (No.) HIGH ABN/ON
Tunnel	1G	TUNNEL TEMP. (No.) LOW ABN/ON
Station	2A	STATION AMBIENT TEMPERATURE ABN/ON
Station	2B	ACU FAN (No.) ABN/ON
Station	2C	FRESH AIR AHU FAN (No.) ABN/ON
Misc.	4A	SUBWAY DPS (No.) ABN/ON
Misc.	4B	SEWAGE PUMP (No.) AIR ABN/ON
Misc.	4C	FVD WARNING ACTIVE/ON
Misc.	4D	FVD ALARM ACTIVE/ON
Misc.	4E	FIRE ALARM (No.) ACTIVE/ON
Misc.	4F	UNAUTHORIZED ENTRANCE (No.) ACTIVE/ON
Misc.	4G	BLDG AMBIENT TEMP. ABN/ON
Misc.	4H	SUMP PUMP (No.) ABN/ON
Misc.	4I	GARAGE EXHAUST FAN (No.) ABN/ON

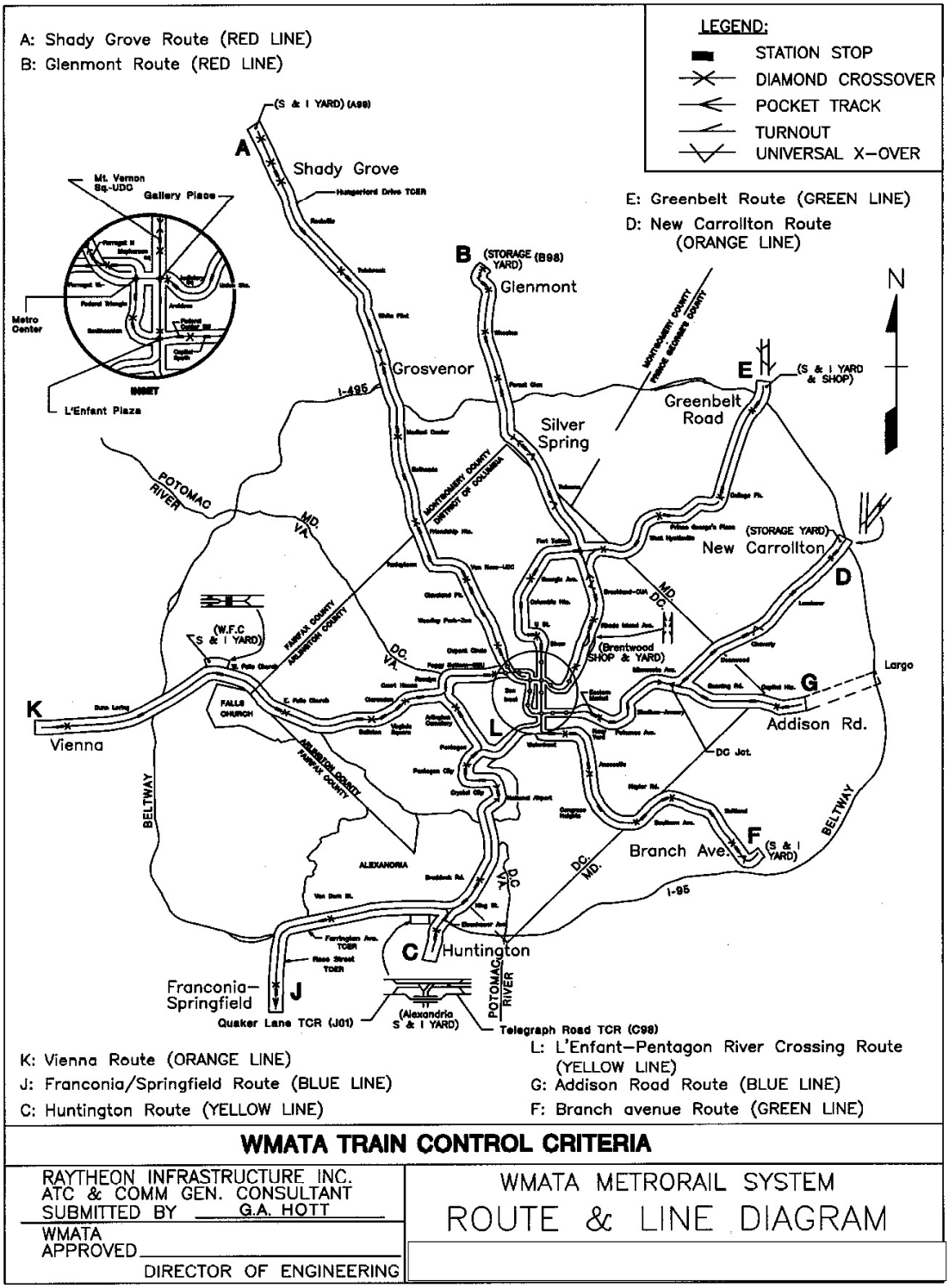
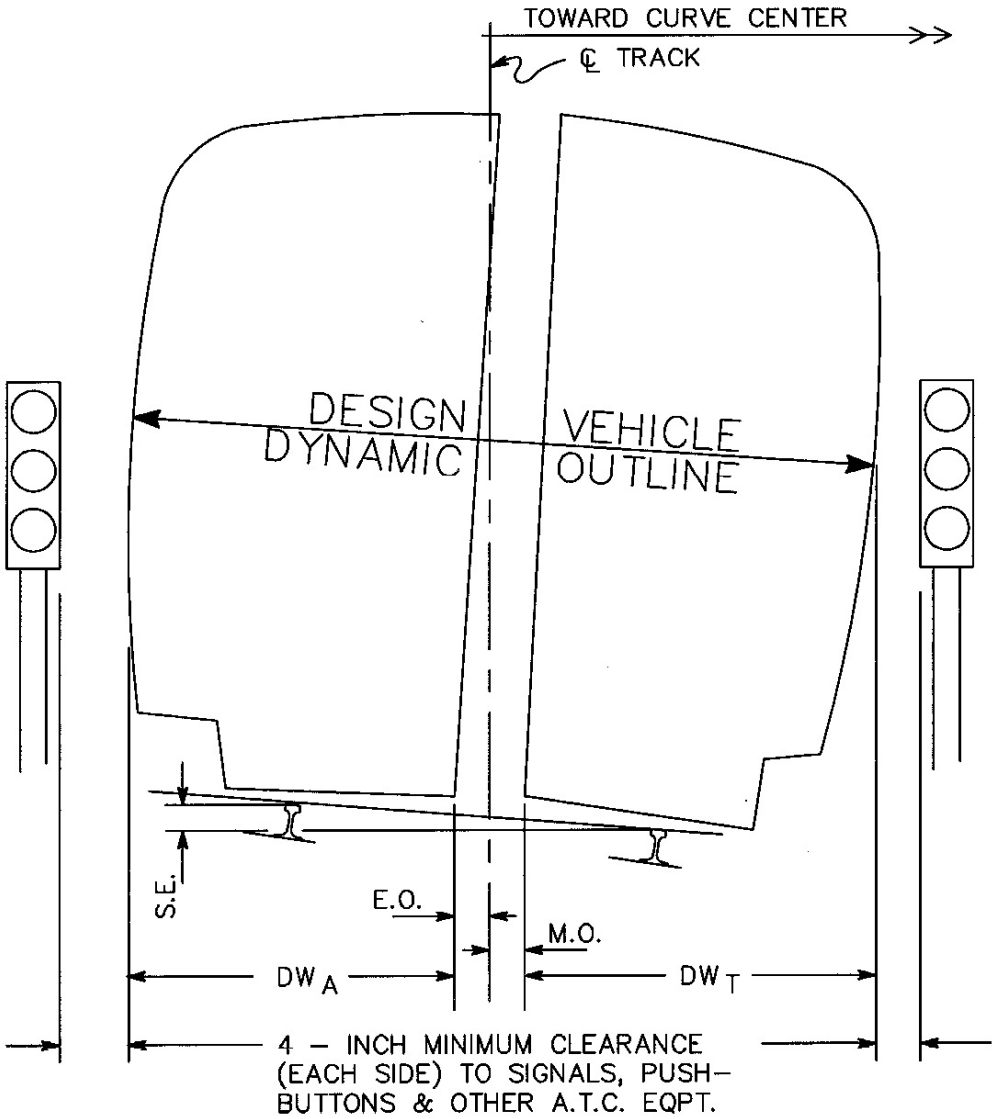


FIGURE 25 - TC-1

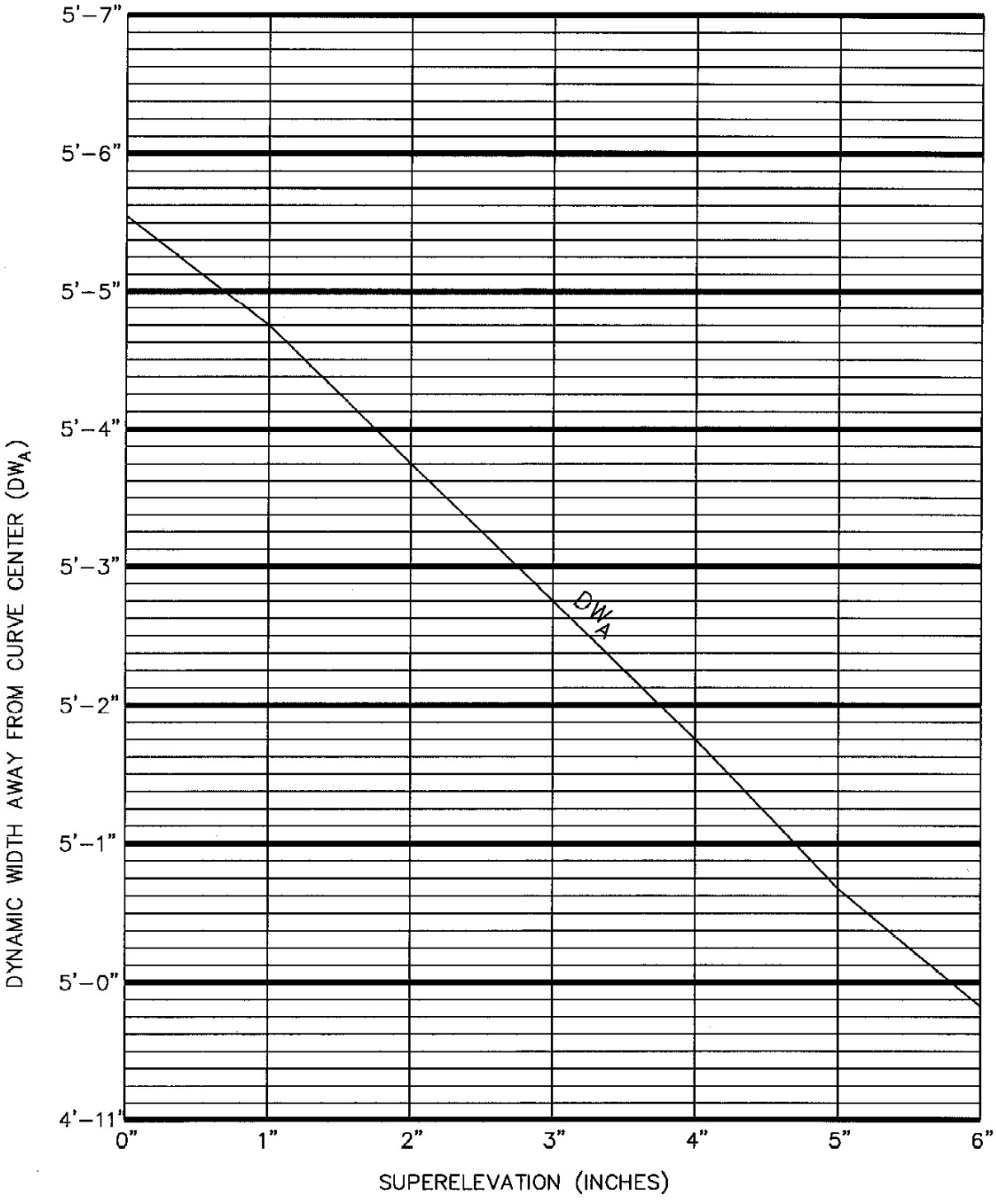


NOTES:

1. FOR DESIGN VEHICLE CLEARANCES, CONSIDER THE END OVERHANG, E.O., EQUAL TO THE MIDDLE ORDINATE, M.O.
2. M.O. (IN FT.) = $R - \sqrt{R^2 - 676}$
   WHERE R = CURVE RADIUS (IN FT.).
3. FOR VALUES OF DW_A AND DW_T, SEE PAGES TA–3 & TA–4
4. SEE ALSO DWG. ATCINF–CE–030, A.T.C. CLEARANCE ENVELOPE.

TC–2 – A.T.C. CLEARANCE DIAGRAM

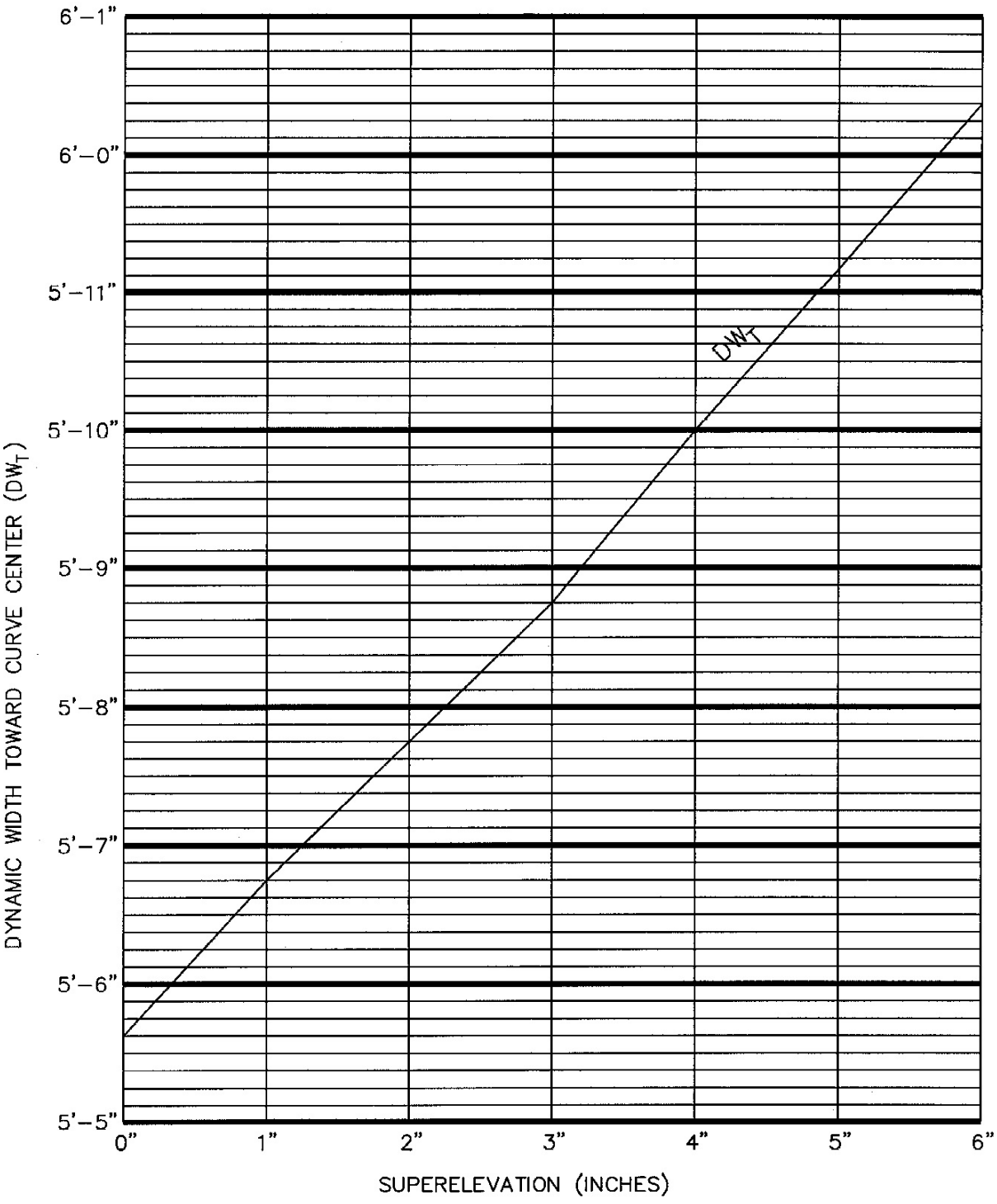
FIGURE 25 - TC-2



DYNAMIC WIDTH
AWAY FROM CURVE CENTER

FIGURE 25 - TC-3

TC–4



DYNAMIC WIDTH
TOWARD CURVE CENTER

FIGURE 25 - TC-4

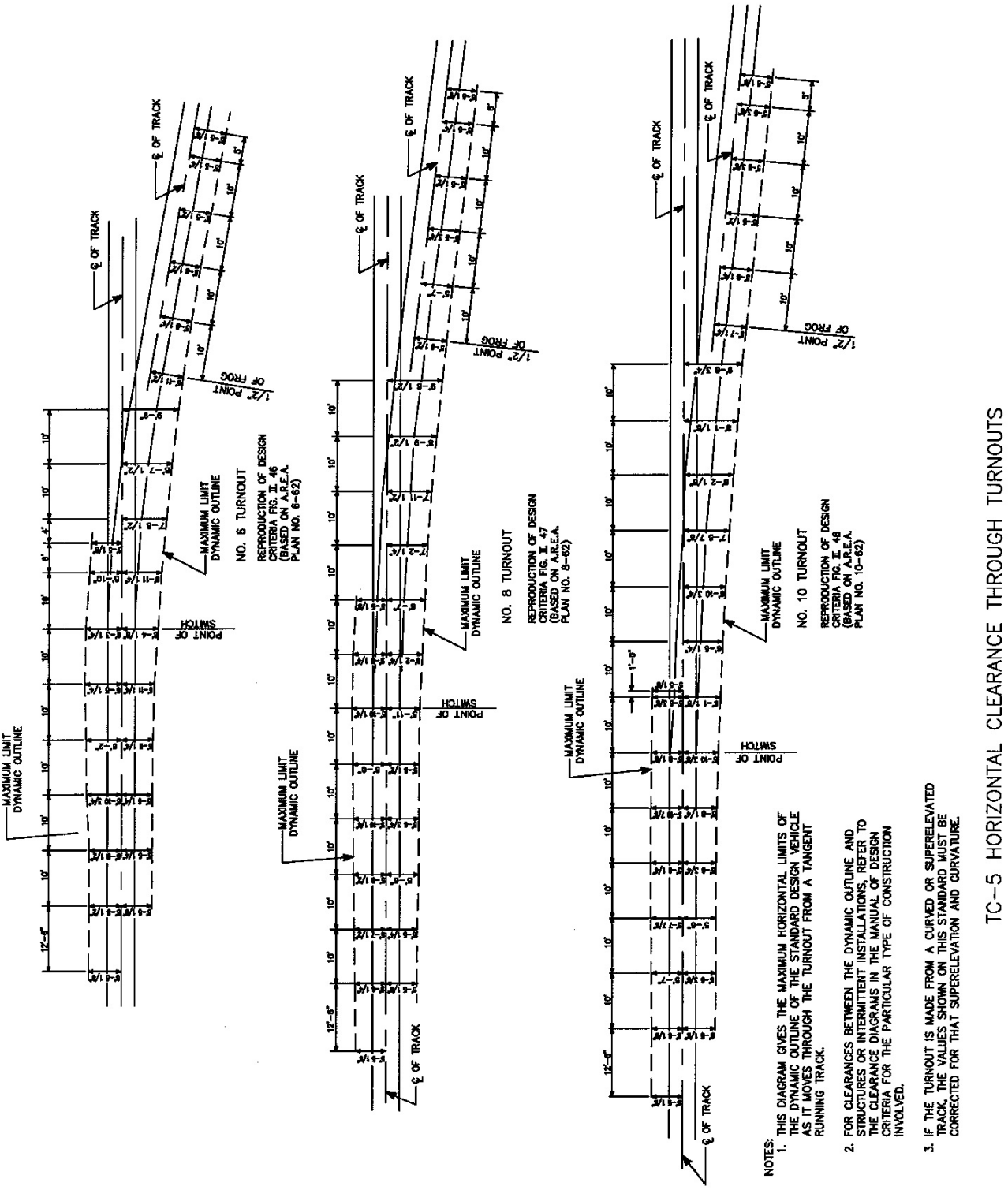


FIGURE 25 - TC-5

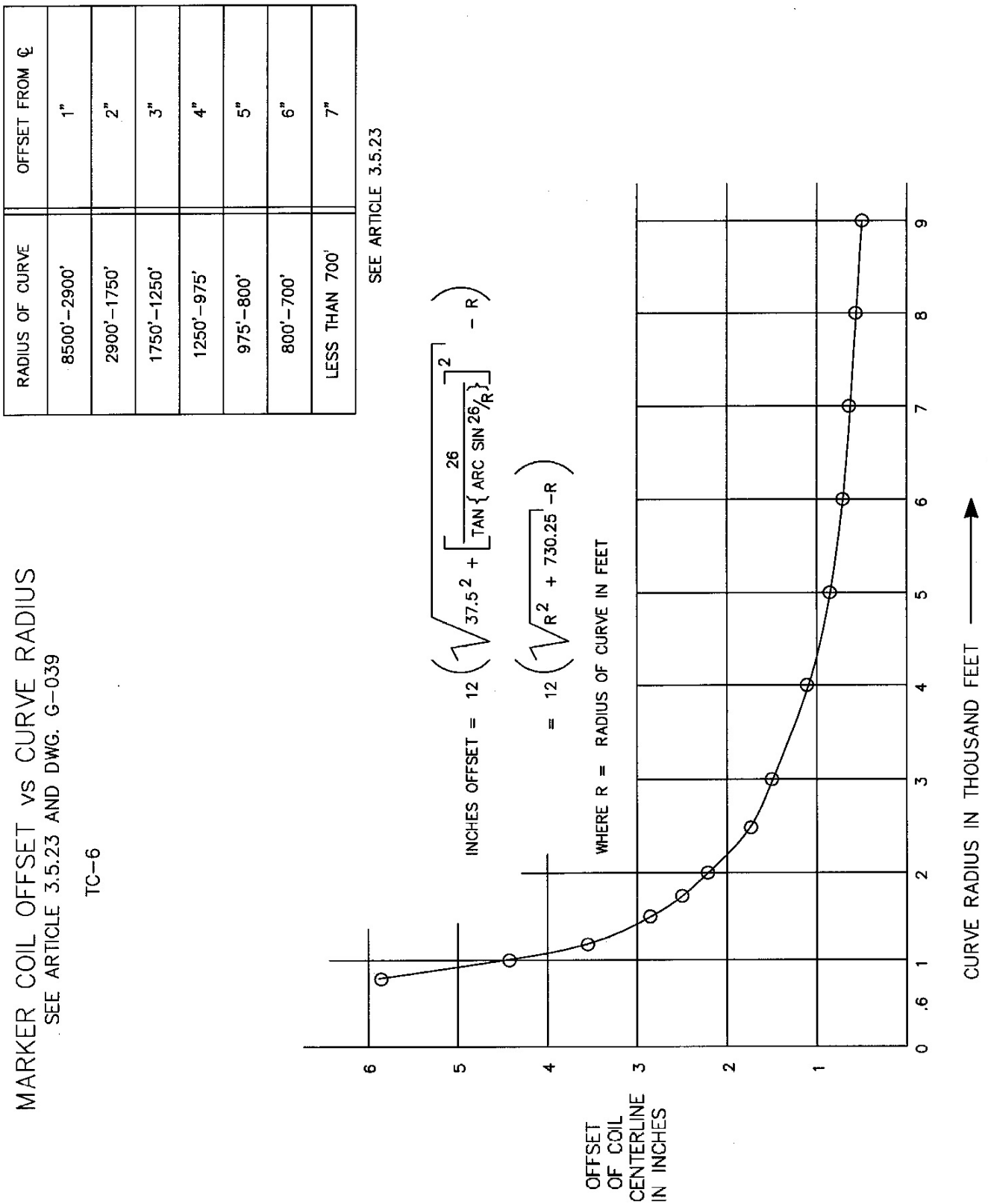
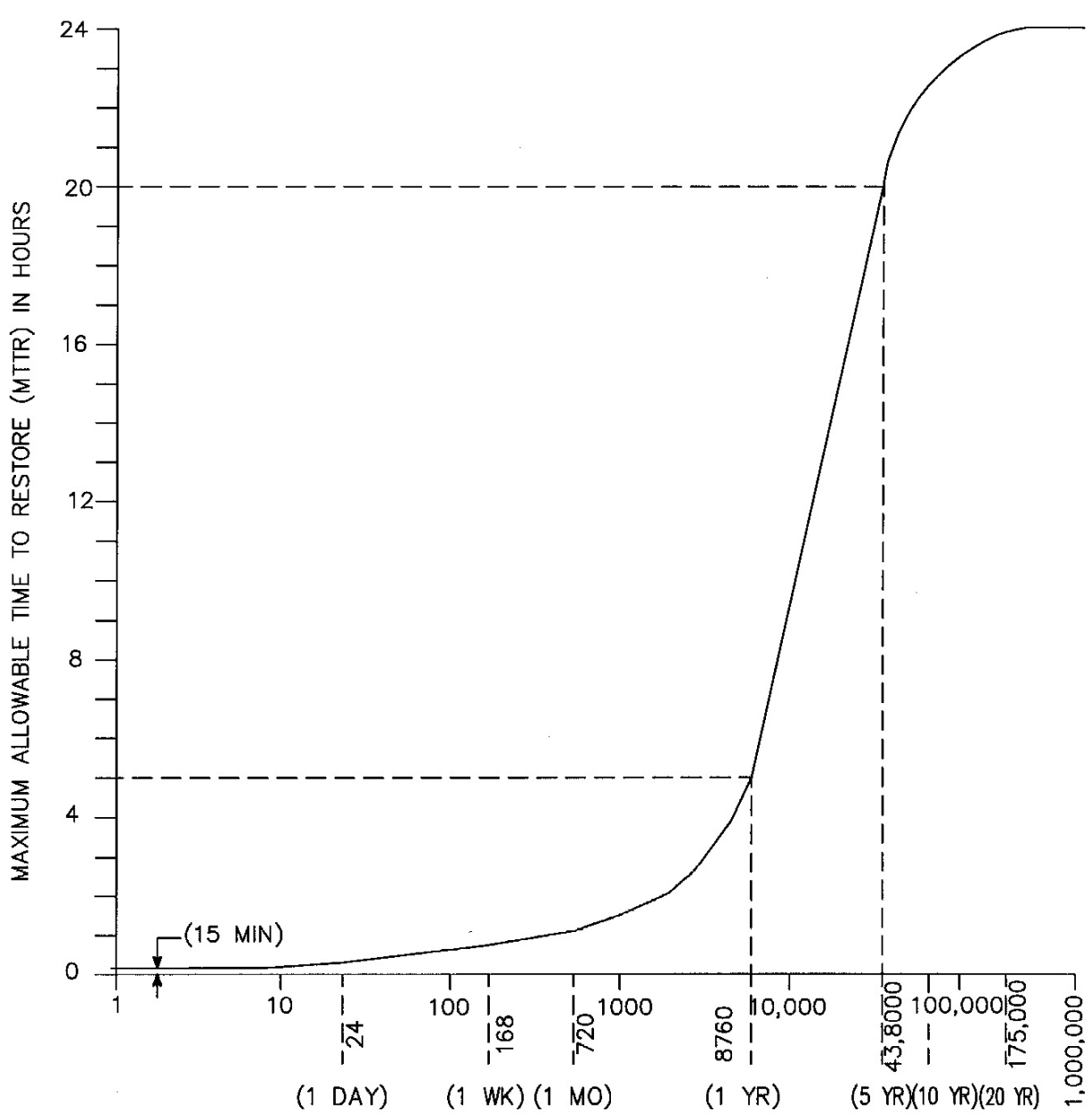


FIGURE 25 - TC-6

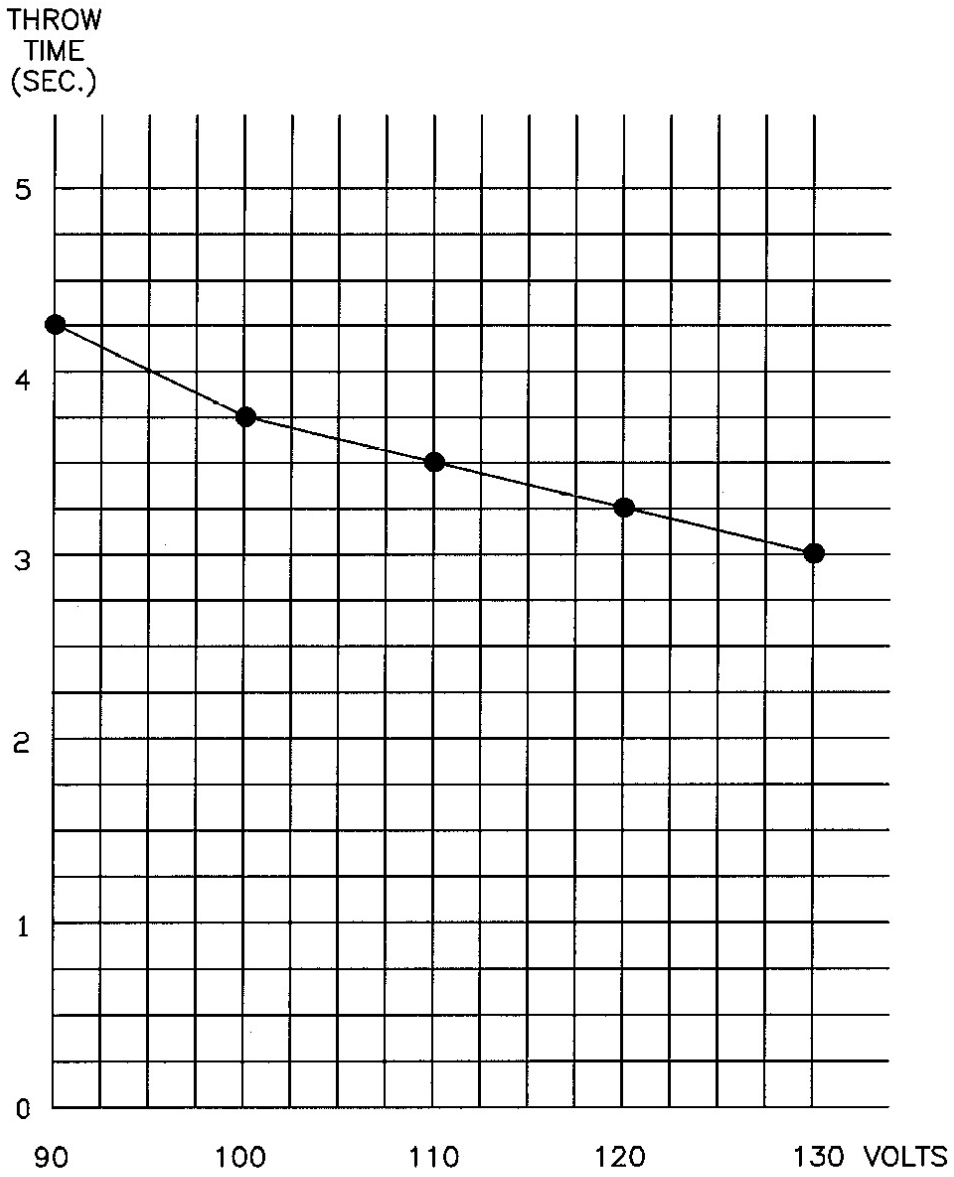


TC–7 – MICROPROCESSOR SYSTEM MTTR

GRAPH SHOWING THE MAXIMUM ALLOWABLE TIME TO RESTORE A MICROPROCESSOR SYSTEM FOR ANY MEAN TIME BETWEEN ITS FAILURES

FIGURE 25 - TC-7

SWITCH OPERATING TIME VS VOLTAGE



WHEN SWITCH–AND–LOCK MOVEMENT OPERATING VOLTAGE IS BETWEEN 90 VOLTS AND 130 VOLTS, SWITCH OPERATING TIME SHALL BE LESS THAN THE MAXIMUM THROW TIME INDICATED ABOVE.

FOR V=90–100, T= 8.75– .05 X V

FOR V=100–130, T= 6.25– .025 X V

FIGURE 25 - TC-8

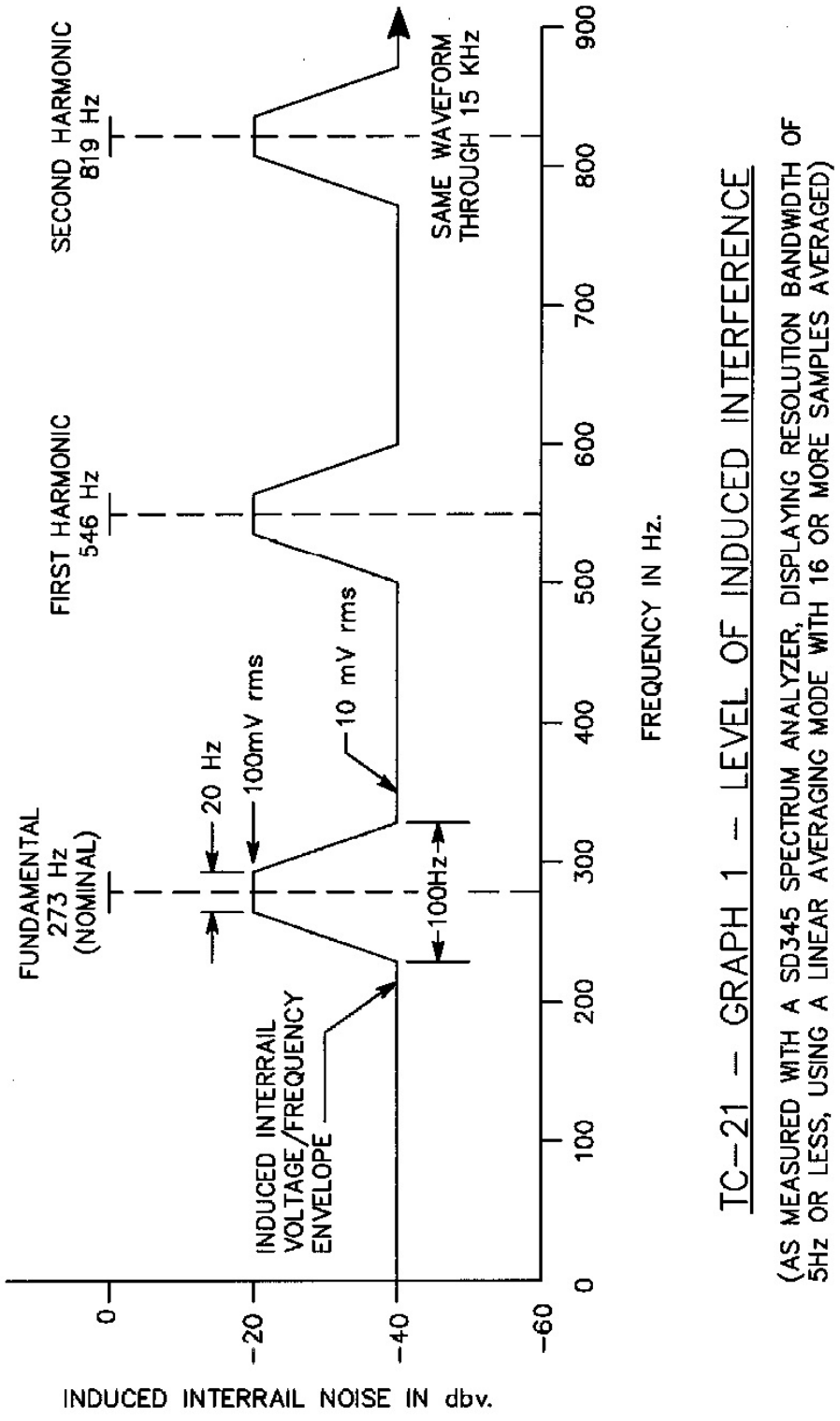
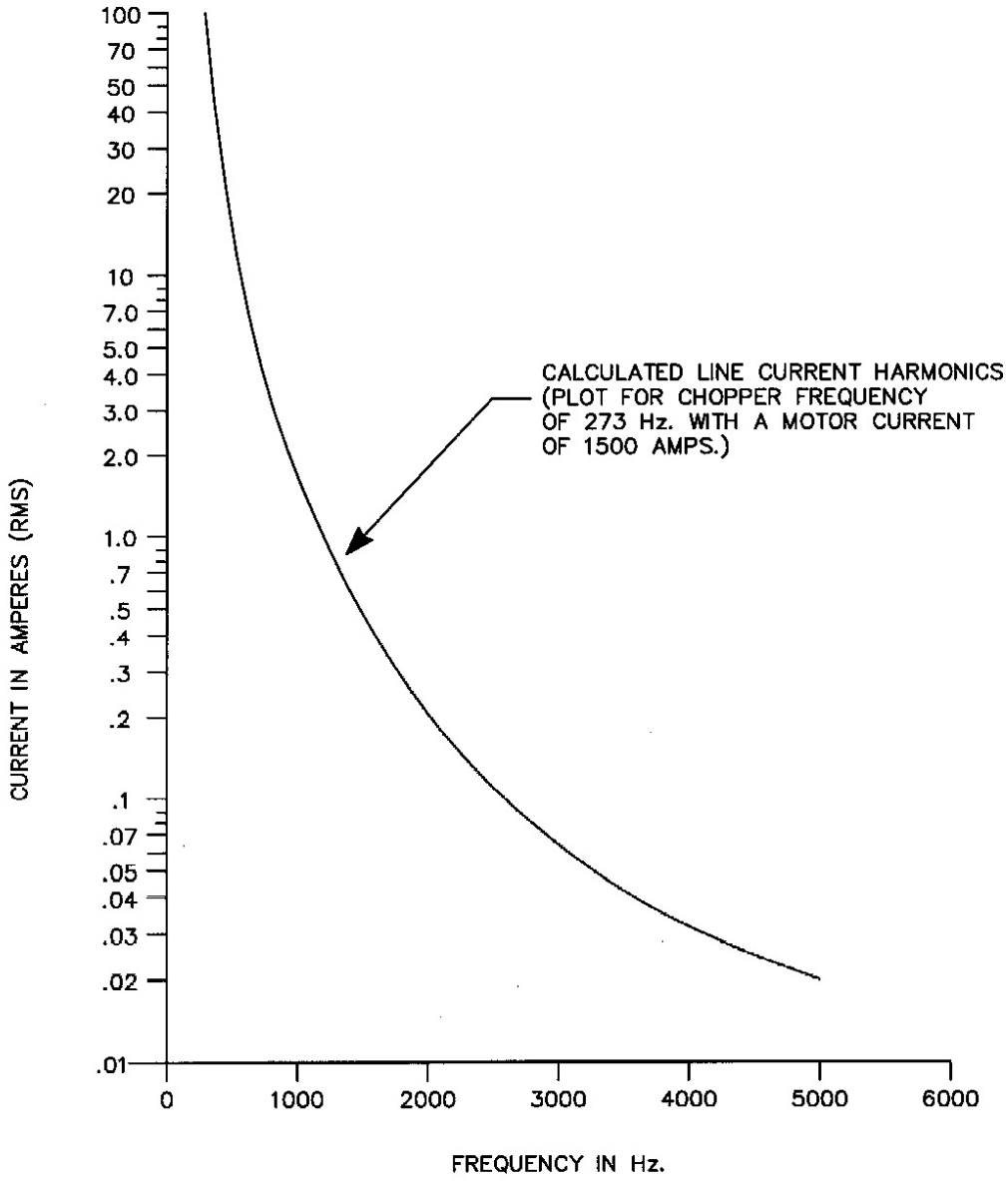


FIGURE 25 - TC-21

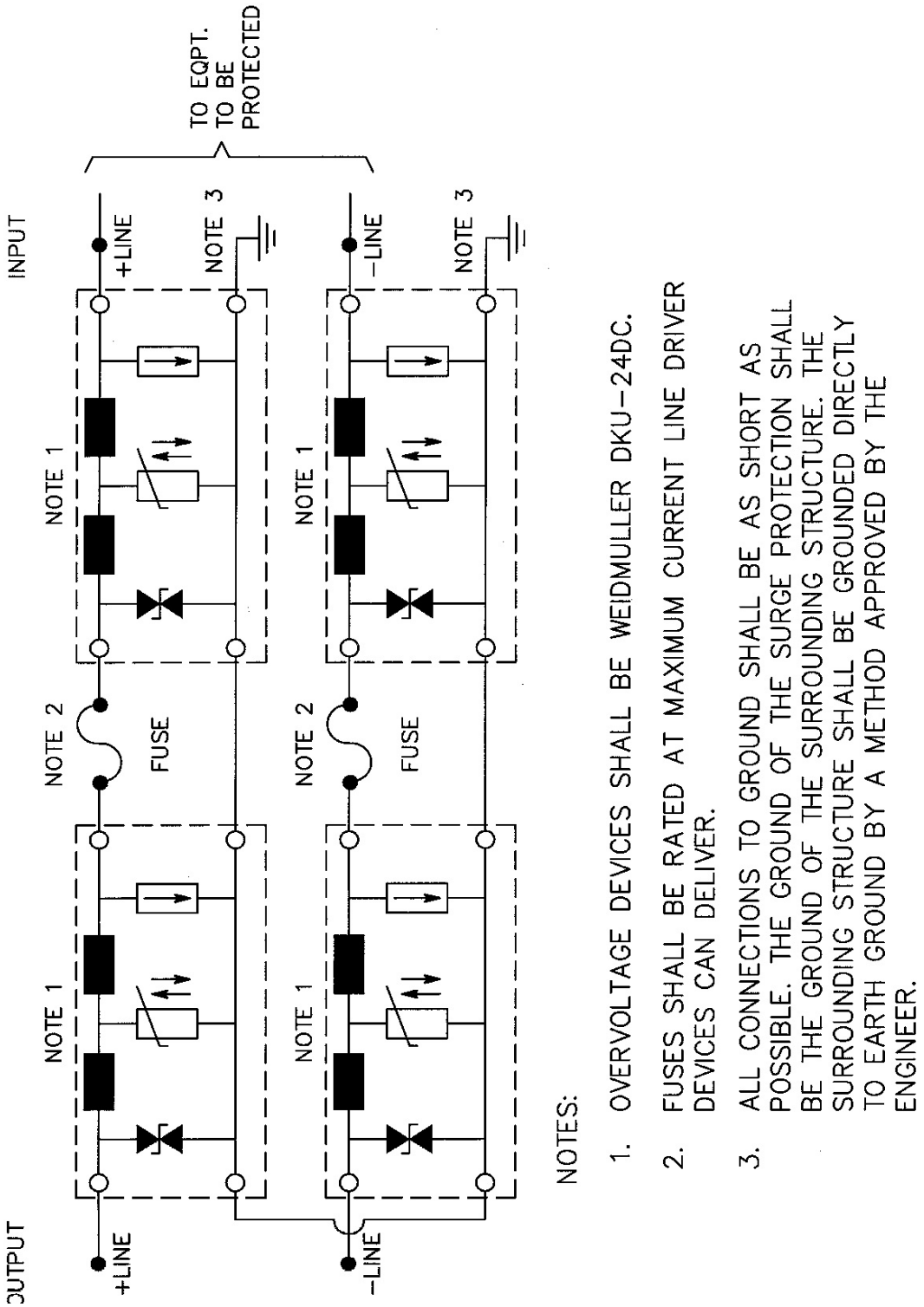


TC-22 – GRAPH 2 – LEVEL OF CONDUCTIVE INTERFERENCE

FIGURE 25 - TC-22

THREE–STAGE SECONDARY SURGE PROTECTION

TC–23



NOTES:

1. OVERVOLTAGE DEVICES SHALL BE WEIDMULLER DKU–24DC.
2. FUSES SHALL BE RATED AT MAXIMUM CURRENT LINE DRIVER DEVICES CAN DELIVER.
3. ALL CONNECTIONS TO GROUND SHALL BE AS SHORT AS POSSIBLE. THE GROUND OF THE SURGE PROTECTION SHALL BE THE GROUND OF THE SURROUNDING STRUCTURE. THE SURROUNDING STRUCTURE SHALL BE GROUNDED DIRECTLY TO EARTH GROUND BY A METHOD APPROVED BY THE ENGINEER.

FIGURE 25 - TC-23

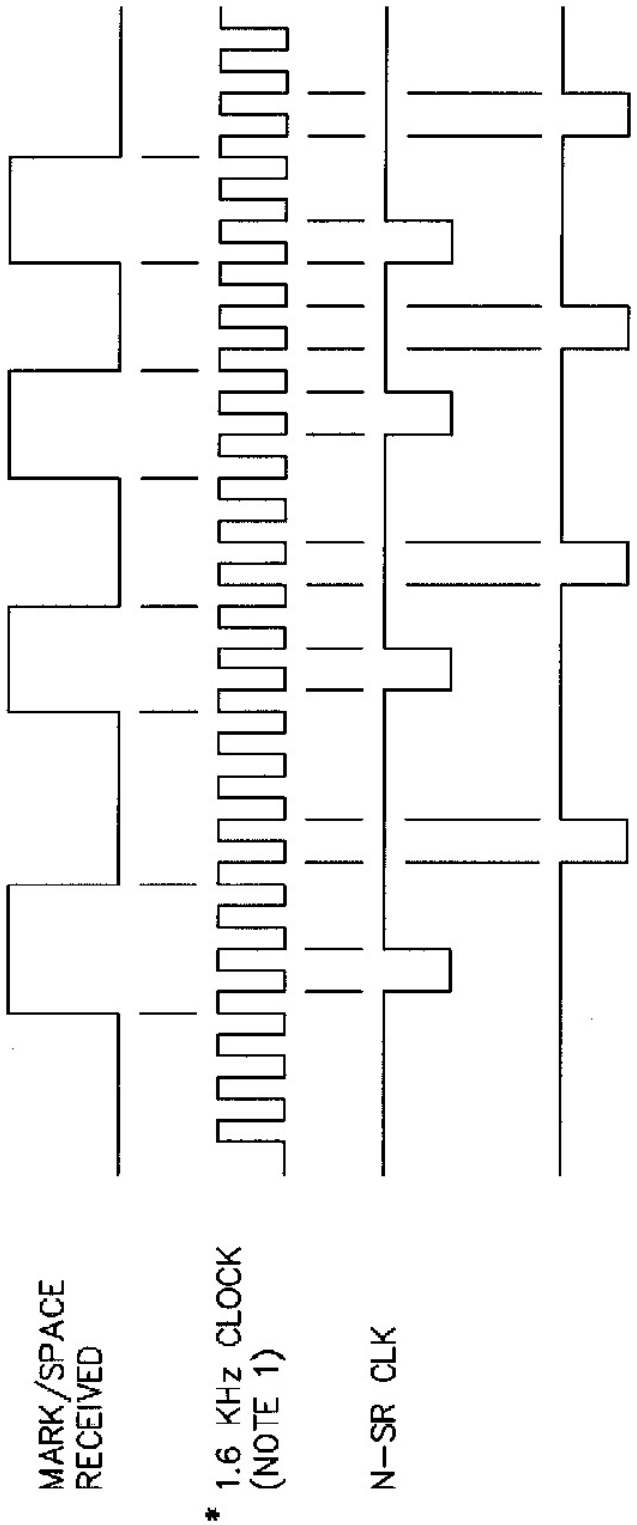


FIGURE 25 - TC-24