Southern California Rapid Transit District

METRO RAIL PROJECT

System Design

Criteria & Standards

VOL. 4

MECHANICAL/ELECTRICAL

RTD

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SCRTD METRO RAIL SYSTEM DESIGN CRITERIA & STANDARDS

SYSTEM DESIGN CRITERIA AND STANDARDS

VOLUME: IV SECTION: FOREWORD

REVISION RECORD

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1	None/1	------	Foreword Summary Contents Vol. IV	Replaces 6/30/83 issue. Format corrections and

FOREWORD

The Metro Rail Project, undertaken by the Southern California Rapid Transit District (SCRTD), will have a significant role in the future development of the Los Angeles region. As part of the 1976 Regional Transportation Development Program, Metro Rail is designed to help solve the increasing transportation problems of Los Angeles' high-density urban center - the regional core.

SYSTEM DESCRIPTION

The Metro Rail line will be a conventional two-track, steel wheel, steel rail system. The initial segment will be approximately 18 miles long and will serve the central business district, Wilshire Boulevard, Fairfax, Hollywood, and North Hollywood areas. On December 20, 1982, SCRTD adopted the route and station locations shown on the following figure.

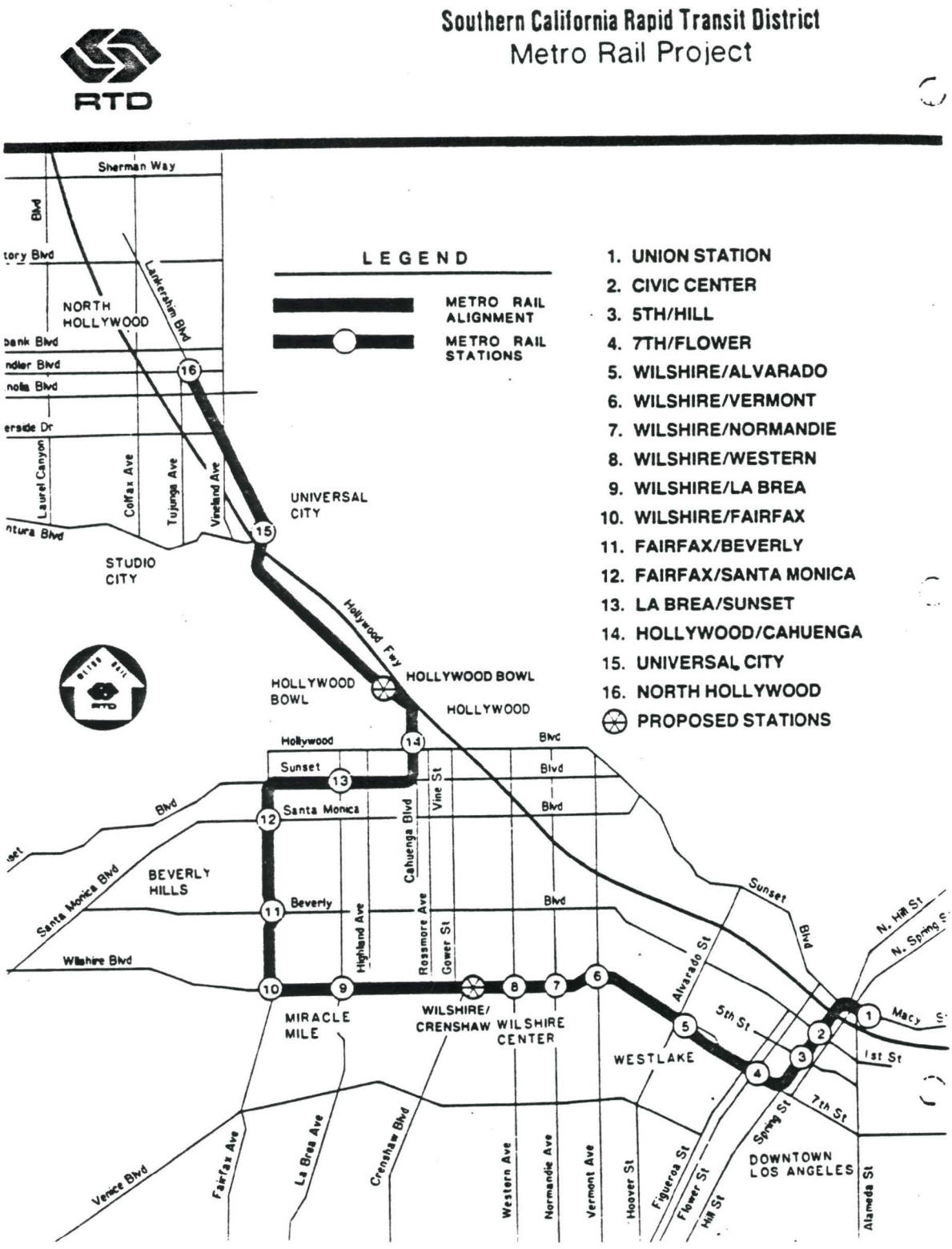
The initial line is being designed with future line extensions in mind. Seven Metro Rail corridor extensions have been analyzed to estimate the effect of additional travel demand on the initial line. The ultimate regional system under consideration is a 150-mile rapid transit system, to be developed on an incremental basis. Different types of transit - light rail, bus-on-freeway, rail rapid transit - will be evaluated as each extension is planned. The most appropriate type will be selected, but in some cases, the system design will allow upgrading to other types of high-capacity transit as demand increases.

A basic policy of the SCRTD Board of Directors is that the Metro Rail System be designed with the flexibility to connect with any of the seven corridors and be able to accommodate increased patronage from additional future corridors. This policy ensures that the initial 18-mile system will accommodate line extensions without major cost or disruption to existing services.

The Metro Rail system can be described in terms of its four system elements: ways and structures, yard and shops, station, and sub-systems.

- Ways and structures: Ways and structures consist of the major fixed facilities of the system, including the tunnels and trackwork. The initial segment will be entirely underground, primarily in mined tunnel.

- Yard and shops: The main yard and shops constitute the facilities required to store and maintain Metro Rail transit vehicles and to provide maintenance to the system's physical plant and equipment. These facilities will be located southeast of Union Station.


RTD
Southern California Rapid Transit District
Metro Rail Project
LEGEND
METRO RAIL ALIGNMENT
METRO RAIL STATIONS
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Vineland Ave
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STUDIO CITY
Hollywood Fwy
HOLLYWOOD BOWL
HOLLYWOOD
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Venice Blvd
Fairfax Ave
La Brea Ave
Crenshaw Blvd
Western Ave
Normandie Ave
Vermont Ave
Hoover St
Figueroa St
Flower St
Hill St
Alameda St

- Stations: Stations provide riders access to the trains from the street level. Stations include stairs, escalators, elevators, a platform area for boarding and leaving trains, and a mezzanine area for fare collection. The stations also provide space for such elements as train control equipment and ventilating equipment. The stations will be constructed by the cut-and-cover method.

- Subsystems: The subsystems are the operating equipment portions of the system, such as the passenger vehicles, train control and communications equipment, traction power, and fare collection equipment. The passenger vehicles will be similar to those currently in use in modern U.S. rail rapid transit systems. It will comfortably carry approximately 76 seated or 94 standing passengers. Trains will consist of up to six passenger vehicles, and will be run by one operator. Automatic devices will be provided for routine operating functions and to ensure safe operations.

PROGRAM DEVELOPMENT

When Metro Rail goes into operation, it will have passed through the five conventional stage of rapid transit development: (1) planning and alternatives analysis; (2) preliminary engineering/environmental impact analysis; (3) final design; (4) construction, manufacturing, and installation; and (5) operational testing.

The first phase ran from 1977 to 1980. Since June 1980, SCRTD has been engaged in the preliminary engineering (PE) phase. This phase has three major objectives: (1) to define and resolve major design and engineering issues; (2) to provide precise location and design data for detailed environmental analysis; and (3) to produce reliable cost estimates. Upon completion of the preliminary engineering phase and the commitment of necessary capital funding, the final design phase will commence. This will be followed by a four-to-six year construction period culminating with system inspection and testing.

One of the major project documents developed during the PE phase is the design criteria. The criteria define detailed functional requirements for all aspects of the Metro Rail System, and will determine the direction taken by the final designers of the various facilities and subsystems elements. The Metro Rail Project System design criteria and standards are presented in five volumes, as follows:

- Volume 1, Systemwide--Contains criteria that affect the whole system, including contract drawing standards, fire/life safety, system safety, security, and system assurance.

- Volume 2, Civil/Structural--Contains civil and structural criteria for all facilities (tunnel, stations, yard and shops), and functional criteria for certain specific elements (trackwork, yard and shops).

- Volume 3, Station--Contains criteria, primarily architectural, for stations.

- Volume 4, Mechanical/Electrical--Contains criteria for mechanical and electrical elements of the facilities' heating, ventilating, and air conditioning; plumbing; facilities electrical; elevators and escalators; and miscellaneous criteria for several other subjects, such as corrosion control, and noise and vibration control.

- Volume 5, Subsystems--Contains functional criteria for the passenger and auxiliary vehicles, train control and communications, traction power and distribution, and fare collection.

It should be recognized that none of these volumes stands alone, and that criteria in more than one volume will apply to the design of any particular system facility or equipment element. A summary table of contents for each individual volume is included in the foreword to that volume as an aid to the designer.

VOLUME IV, MECHANICAL/ELECTRICAL

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(Major Headings Only - See Appropriate Section for Detailed Contents)

Volume IV, Mechanical/Electrical (cont'd)

Volume IV, Mechanical/Electrical (cont'd)

SYSTEM DESIGN CRITERIA AND STANDARDS

VOLUME: IV SECTION: 1

REVISION RECORD

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2	CR 4-026/	2/13/85	1.4.2.D	
3	CR 5-032/	5/01/85	Table of Contents List of Tables 1.10.1 I(NEW)	Page # changes on contents pages. Adds new subsection.
4	CR 5-065A/	5/20/86	1.7.1.D.2	p. 30
5	CR 5-088/	5/20/86	1.4.2.D. Note 7 & 1.9.1.H Added	p. 10 p. 40
6	CR 6-017/	6/10/86	1.4.2.A.4 & 1.4.2.B.4	p. 7 p. 8
7	CR 6-015/ CR 5-084 A	6/20/86 6/20/86	1.9.1.B.3.a TABLE OF CONTENT	p.38 p.ii

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SCRTD METRO RAIL SYSTEM DESIGN CRITERIA

Volume IV, Section 1

ENVIRONMENTAL CONTROL

VOLUME IV, SECTION 1, ENVIRONMENTAL CONTROL

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VOLUME IV, SECTION 1

ENVIRONMENTAL CONTROL

1.1 SUBSYSTEM DESCRIPTION

1.1.1 Introduction

This document describes criteria for the design of Subway Environmental Control Systems (ECS) for the Southern California Rapid Transit District (SCRTD) Metro Rail Project. The systems covered in these criteria are for the fixed facilities.

1.1.2 Background

The Metro Rail System (Eventual System) will be a rail rapid transit network consisting of approximately 100 miles of grade-separated, double-track main line with associated stations, electrically powered rail passenger vehicles, yard and shop facilities, auxiliary vehicles, and related ancillary facilities. The initial stage of the Metro Rail System (Starter Line) will comprise 18.6 miles running west and north from the Central Business District (CBD) to North Hollywood. The southeastern end of the route terminates at Union Station.

The main storage yard and the shop facility for the Starter Line will be located in the vicinity of the southeastern terminus. A small storage yard with limited service and inspection capabilities will be located near the North Hollywood terminal. Crossover tracks, storage tracks, and pocket tracks will be situated at suitable locations to enable trains to turn back at both ends of the corridor and at selected midline locations. These tracks will also provide temporary storage for malfunctioning trains, storage of trains at the northern end of the route, and reverse running during emergency situations.

A Rail Control Center will be located in the downtown area near Union Station. The facility will contain the necessary displays, control consoles, communications apparatus, and the operating personnel responsible for the overall safety and security of passengers and for the daily operations of the trains, stations, ECS, and all

supporting wayside apparatus. The Rail Control Center will serve as the focal point from which the Metro Rail Project operations will be supervised, monitored, and controlled.

1.1.3 Environmental Control System (ECS) Components

The Environmental Control System will consist of the following components:

A. Underplatform Exhaust System

1. Captures heat released by trains in the station.

2. May serve as a supplemental to the emergency system and off-hour gas purging means.

B. Station Supply Air System

1. Supplies and distributes at ceiling level at the ends of platform. The system will have provisions to add mechanical cooling of supply air when required in the future. The air distribution system will be modified to supply air over the total length of the platform when mechanical cooling is added.

C. Ventilation Shafts

1. Located at both ends of each subway station.

2. Adjacent fan rooms house fans to provide ventilation during emergencies.

3. Provide air passage to surface to permit ventilation by means of piston action of moving trains.

D. Mid-Tunnel Shafts

1. House fans to provide ventilation to the tunnels when needed during normal and emergency operations.

2. Provides air passage to surface to permit ventilation by means of piston action of moving trains.

E. Future Chiller Plant

1. Produces chilled water for station air conditioning.

2. Consists of chillers, cooling towers, pumps, and related equipment.

3. Typically incorporated into each individual station; one chiller room to house two chillers, each sized for 50 percent of total capacity.

F. Ancillary Space HVAC Systems

Provide heating, ventilation, and air conditioning for ancillary rooms and equipment rooms.

G. Yards and Shops HVAC Systems

Provide heating, ventilation, and air conditioning for offices, equipment rooms, and maintenance shops.

H. Local Control Panels

1. Located in stations and motor control centers.

2. Used by maintenance personnel and in event of failure of central control system.

I. Central Control and Monitoring

1. Located in the Rail Control Center and operated by skilled personnel.

2. Controls and monitors mechanical and electrical equipment throughout system.

3. Normal HVAC Systems operate automatically with override controls as required.

4. Emergency ventilation activated manually for preprogrammed sequence after selection of evacuation route by Supervisor of Operations.

VOLUME IV, SECTION 1 ENVIRONMENTAL CONTROL (Cont'd.)

1.2 APPLICABLE DOCUMENTS

Unless otherwise required herein, the air-conditioning, heating, and ventilation system design shall conform to the latest editions and applicable standards, codes, and recommended guidelines of the following organizations:

Building Officials and Code Administration (BOCA) International, Inc.

National Building Code (NBC)

Occupational Safety and Health Act (OSHA)

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)

Sheet Metal and Air-Conditioning Contractor's National Association (SMACNA)

Subway Environmental Design Handbook Vol. 1, 2nd Edition, 1976

American National Standards Institute (ANSI)

American Society for Testing and Materials (ASTM)

National Fire Protection Association (NFPA) "National Fire Codes"

Safety Code for Mechanical Refrigeration

American Public Transportation Association - Rapid Transit Design Guidelines

National Electric Code (NEC)

Los Angeles City and County Building Codes

Los Angeles City and County Mechanical Code

Los Angeles City and County Plumbing Code

Los Angeles City and County Fire Protection Code

Air Moving and Conditioning Association, Inc.

California State Administrative Code, Title 24

Standard 210 "Laboratory Methods of Testing Fans for Rating"

Standard 301 "Methods for Calculating Fan Sound Ratings from Laboratory Test Data"

Standard 300 "Test Code for Sound Rating Air Moving Devices"

Standard 500 "Test Method for Louvers, Dampers and Shutters"

1.3 FUNCTIONAL REQUIREMENTS

1.3.1 Station and Tunnel ECS

This section applies to the Environmental Control System (ECS) for the public areas of the Metro Rail System. Control of environmental conditions (temperature, air velocity, air pressure, smoke removal, noise, etc.) in the stations and tunnels is necessary to meet the diverse needs of normal operations congestion, and emergencies, including a fire, within the Metro Rail System.

Station ventilation is achieved through an air supply/exhaust system. An underplatform exhaust captures much of the heat released from trains while they are in the station before it can enter the passenger (platform) space. During the initial years of systems operation (3½-minute headway) filtered outside air will be supplied to the station to maintain platform conditions at 89°F (see Subsection 1.4.1.1.A for outside air temperature). When traffic reaches the ultimate capacity (2-minute headway), mechanical refrigeration will be required and platform conditions will be reduced to 85°F (see Subsection 1.4.1.1.A for outside air temperature). Provisions will be made for future installation of mechanical refrigeration system when the stations are constructed. However, purchase and installation of the chillers, coils, and cooling towers will be deferred until increased train traffic warrants it. Make provision in the design of the stations to facilitate the installation of deferred equipment.

Tunnel ventilation is achieved through the piston action of moving trains as they pass ventilation shafts. Tunnel air is expelled from the system as a train approaches a

ventilation shaft, and outside air is drawn into the system in the wake of a train.

During emergencies, especially if a fire occurs within the system, the ventilation system will provide outside air to assist passenger evacuation and purge smoke from the system. Station ventilation is achieved by drawing outside air in through the entrances, sweeping it through the mezzanine and platform area, and exhausting it through ventilation shafts at both ends of the station. A smoke exhaust system is provided at the mezzanine ceiling of each station to purge pockets of smoke. Tunnel ventilation is achieved using a "push-pull" system of operating fans on one side of the emergency in supply, while fans on the other side are operated in exhaust. This produces a longitudinal air movement in the affected tunnel, allowing passengers to be evacuated toward the supply of outside air.

1.3.2 Ancillary Space HVAC

HVAC systems will be provided in ancillary spaces to maintain an optimum environment for the operating and maintenance personnel and to prolong the life of equipment by proper control of temperature, pressure, humidity, and odor as required therein.

1.3.3 Yard and Shops HVAC

HVAC systems will be provided in these facilities to maintain an optimum environment for the operating and maintenance personnel and to prolong the life of equipment by proper control of temperature, pressure, humidity, and odor as required therein.

1.4 DESIGN PARAMETERS

1.4.1 Ambient Conditions

A. Subway ECS Design

1. Summer Outside Peak Design Conditions

a. Dry Bulb Temperature (Based on ASHRAE 5% frequency of	84°F

occurence adjusted to 5:00 PM)

b. Wet Bulb Temperature 68.5°F

2. Winter Minimum Dry Bulb Temperature 36°F

B. Ancillary Spaces and Yards and Shops Design

1. Summer Outside Peak Design Conditions

a. Dry Bulb Temperature (Based on ASHRAE 2½% frequency of occurence) 92°F

b. Wet Bulb Temperature 70°F

2. Winter Outside Minimum Dry Bulb Temperature 36°F

C. Cooling Tower Design

Design Wet Bulb Temperature (Based on ASHRAE 1% frequency of occurence) 72°F

1.4.2 Design Conditions for Normal Operations

A. Station Design Conditions - Ventilated Station

1. Dry Bulb Temperature 89°F

2. Humidity No Control

3. Air Velocity - Horizontal (Platform, Mezzanine, Horizontal Entranceways)
Average (maximum) 600 fpm
Peak 1000 fpm

4. Air Velocity - Sloping (Escalators and Stairways)
Outflow Average (maximum) 600 fpm
Inflow Average (maximum) 600 fpm
Outflow Peak 1000 fpm
Inflow Peak 1000 fpm

5. Air Pressure Transients

The criterion for rapid pressure changes, applicable when the total change in pressure is greater than 0.10 psi (2.8 in. wg), is that no person, patron or employee, shall be subjected to a rate of pressure change greater than 0.06 psi per sec (1.7 in. wg per sec).

B. Station Design Conditions - Air-Conditioned Station

1. Dry Bulb Temperature	85°F
2. Humidity (maximum)	65% RH
3. Air Velocity - Horizontal (Platform, Mezzanine, Horizontal Entranceways)	
Average (maximum)	600 fpm
Peak	1000 fpm
4. Air Velocity - Sloping (Escalators and Stairways)	
Outflow Average (Maximum)	600 fpm
Inflow Average (Maximum)	600 fpm
Outflow Peak	1000 fpm
Inflow Peak	1000 fpm

5. Air Pressure Transients

The criterion for rapid pressure changes, applicable when the total change in pressure is greater than 0.10 psi (2.8 in. wg) is that no person, patron or employee shall be subjected to a rate of pressure change greater than 0.06 psi per sec (1.7 in. wg per sec).

C. Tunnel Design Conditions

1. Dry Bulb Temperature Expected Average Maximum	104°F
2. Humidity	No Control
3. Air Velocity	
Unoccupied Tunnels	No Control
Occupied (maintenance workers, etc.)	2000 fpm

4. Air Pressure Transients

The criterion for rapid pressure changes, applicable when the total change in pressure is greater than 0.10 psi (2.8 in. wg), is that no person, patron or employee, shall be subjected to a rate of pressure change greater than 0.06 psi per sec (1.7 in. wg per sec).

D. Ancillary Space Design Conditions

Space	Indoor Peak Design Conditions With Systems Energized: Winter °F	Summer °F D.B.	Summer %RH	Space Pressure	Minimum Air Changes: Circulate	Outside Air	Vent Type	Heat Type
Train Control/Communication Room	65	80	50	P	See 1.9.1.A	10%	S&R	
Traction Power Substations		Note 6	-	P	See 1.9.1.B	100%	S	
Incoming Service				P	10/Hour	100%	S	
Electrical Equipment Room		Note 6		P	10/Hour	100%	S&E	
Auxiliary Power Room		Note 6	-	P	See 1.9.1.D	100%	S&E	
Battery Room			-	N	15/hour	100%	E	
Staff Rooms	68	78			10/hour		S&E	
Custodial Room			-	N	10/Hour		E	Note 3
Trash Room	-	-	-	N	15/hour		E	Note 3
Elevator Machine Room		Note 6	-	N	10/Hour		E	Note 3
Mechanical Equipment Room		Note 6	-	N	10/Hour		E	Note 3
Storage Room			-		10/Hour		E	Note 3
Chilled Water Plants			-	N	See 1.9.1G	100%	E	
Valve Room			-		10/Hour		E	Note 3
Sewage Ejector Room & Sump Pump Room			-	N	10/hour		E	Note 3
Toilet	68		-	N	10/Hour		E	Note 3

NOTES:

1. Space Pressure: N - Slightly Negative; P = Slightly Positive.
2. Vent Type: S = Supply; E = Exhaust; R = Return.
3. If located at platform level, shall have an S & E
4. Heat Type: Electric heat coil in A.C. unit
5. Air changes are minimum and may be increased as required by local codes.
6. 10°F above outdoor temperature.
7. Corridors, enclosed elevator shafts, cross passages, and other unventilated areas should be kept under negative pressure with a minimum continuous circulation rate of 10 air changes per hour. Emergency exits from platform or mezzanine direct to surface shall be naturally ventilated.

E. Yards and Shops Design Conditions

Space	Indoor Peak Design Conditions With Systems Energized: Winter °F	Summer °F D.B.	Summer %RH	Space Pressure	Minimum Air Changes: Circulate	Outside Air	Vent Type	Heat Type
Enclosed Specialty Repair and Shop Areas	65	78	--	P	--	per code	S	A
General Offices	72	78	55	P	--	per code	S	A
Telephone Room	65	Note 4	--	--	--	--	--	--
Open Shop Areas	65	Note 4	--	N	--	--	E	B
Storage Areas	45	--	--	--	6/Hour	100%	E	--
Electrical Equipment Room	--	Note 4	--	--	10/Hour	--	S	--
Mechanical Equipment Room	--	--	--	--	6/Hour	--	E	--
Degrease Room	--	--	--	N	10/Hour	--	--	--
Car Wash Area	--	--	--	--	--	--	--	--
Lunch Room	72	78	--	N	--	--	--	--
Locker Room	68	Note 4	--	N	10/hour	--	E	Note 3
Toilet	68	--	--	N	10/Hour	--	E	Note 3

NOTES:

1. Open shop area and boiler room outside air is required only for summer.
2. Heat Type: A. Gas furnace in A.H. Unit.
   B. Gas radiant heaters.
3. Air changes are minimum any may be increased as required by local codes.
4. 10° above outdoor temperature.

1.4.3 Design Conditions for Transit Vehicle Air Conditioners

The air temperature at the intake to the vehicle air conditioner condensers should not exceed 113°F.

A. Station Design Conditions

If the condensers are located below the floor of the train, then this applies to the temperature of the air beneath the floor. If the condensers are located on the train rooftops, then this applies to the temperature of the air above the train.

B. Tunnel Design Conditions

If the condensers are located below the train, this temperature will be the bulk (fully mixed in a vertical plane) tunnel air temperature. If the condensers are located on the train rooftops, this temperature will be the temperature of the stratified layer of air above the train.

1.4.4 Design Conditions for Emergency Operations

The temperature and air change rate design criteria in this paragraph are based on the emergency scenario of a serious fire involving a single six-car train.

Fuel (Combustible) Load Per Car	60,000,000 BTU
Maximum Heat Release Rate	92,000,000 BTU/hr.

A. Station Design Conditions

The following design conditions are applicable to platform areas and entrances, including the evacuation route of passengers in an emergency.

Maximum Temperature in Evacuation Route: 120°F

B. Tunnel Design Conditions

Tunnel design conditions are applicable in the evacuation route only. For tunnel fires, mechanical ventilation can move smoke in one direction or the other. Sufficient ventilation is to be provided to maintain tolerable conditions in the evacuation route, at the expense of the downwind side.

Maximum Temperature in Evacuation Route: 120°F

The air velocity in the path of evacuation should range between 500 fpm in an open tunnel section and 2,200 fpm in the annulus between train and tunnel walls. An air velocity of 500 fpm is the minimum that can be sensed by a person and thus serve as an "indicator" of the direction for the evacuating subway patrons. Above 2,200 fpm people may experience difficulty in walking.

Sufficient emergency ventilation should be provided with one of the most critical ventilation fans malfunctioning. Under these conditions the criteria for indicating evacuation route (500 fpm) is waived, provided sufficient air velocity is present to control smoke movement and prevent backlayering.

1.4.5 Design Velocities for Air Distribution Systems

Design velocities shall be selected for the required system performance and to minimize airborne noise generation, draft, and intake of dust particles. Following are the maximum velocities in air distribution systems:

A. Sheet Metal Ducts

Main Supply Duct	1800 fpm
Branch Supply Duct	1500 fpm
Outside Air Intake Duct	1500 fpm
Main Exhaust and Return Ducts	1800 fpm
Branch Exhaust and Return Ducts	1200 fpm
Transfer Duct	350 fpm

B. Concrete Ducts/Plenums

Underplatform Exhaust (UPE)	1500 fpm
All Others	1800 fpm

C. Air Outlets and Intakes

Supply Registers	To be selected for throw and noise criteria

Diffusers	To be selected for throw and noise criteria
Exhaust and Return Grilles	500 fpm over gross area
Transfer Grilles	250 fpm over gross area
Transfer Louvers	250 fpm over gross area

1.4.6 Noise Criteria

See Vol. IV, Section 7

1.5 STATION ENVIRONMENTAL CONTROL SYSTEMS

1.5.1 Underplatform Exhaust Ventilation System

A. System Description

For a typical station, two 64,000 cfm fans shall be provided - one at each end of the mezzanine with a ducted connection to the plenum below the platform.

Air distribution shall be nearly uniform over the length of the station; however, provisions shall be made for "tuning" the system to match the heat release profile of the vehicle. These provisions will consist mainly of volume of adjustment, at each register.

The underplatform exhaust system may also be used during emergencies to exhaust smoke and hot gases from a burning train located within a station or to supplement the air flow of the emergency fans. The plenum below the platform shall be constructed of fireproof materials and shall not be used to house electrical cables, pneumatic lines, or other critical items.

B. Calculation of Pressure Losses

1. Pressure loss calculations shall be performed in accordance with the American Society of Heating Refrigeration and Air Conditioning Engineers Handbook of Fundamentals, latest edition and the Singstad Equation, where applicable.

2. The static pressure differential across any register shall be less than 0.25 in. wg. when the system is operating at full exhaust capacity.

C. Equipment and Accessories

1. Each fan-motor unit will be of the axial-flow type, with internally mounted, direct-drive motor construction. Fan-motor units will have blades with adjustable, remotely controllable pitch to permit a change of flow or pressure.

2. Fan equipment shall include an inlet and an outlet transition piece, a flexible connector, and inlet and outlet sound attenuators.

3. Fan-motor units will be selected to have a total efficiency of not less than 70 percent. The operating speed of fan-motor units will not exceed 900 rpm. The location of underplatform fans, nominal capacity, total pressure and motor horsepowers are given in Table IV-1-4

4. All system components, including fan-motor units located in the air stream, shall be capable of operating in an ambient temperature of 300 degrees Fahrenheit for a minimum of one hour, as the ventilation system may be used in an emergency to purge hot smoke from the station.

1.5.2 Supply Air Ventilation for Underground Stations

A. System Description

For a typical station, four 37,500 cfm air handling units shall be provided - two (2) at each end of the mezzanine level with supply air discharged above the top of the train at platform level. The equipment rooms housing these air handling units may also

contain underplatform exhaust and smoke exhaust fan assemblies.

Systems shall be designed to supply 100 percent outside air. Outside air shall be obtained from separate shafts extending to grade. Ventilation shafts and gratings shall conform with paragraph 1.7 entitled "Ventilation Shafts and Terminals At Grade", and paragraph 1.4.5 entitled "Design Velocities for Air Distribution Systems".

B. Air Distribution System at Platform Level

Supply air shall be filtered, ducted and distributed as described in Subsection 1.1.3.B.1.

C. Equipment and Accessories

Air-handling units shall be factory prefabricated units and shall include the following components:

1. Intake section.

2. Motor-operated outside air dampers of the parallel blade type.

3. Automatic roll type filter section.

4. Blank section for future installation of chilled water cooling coils.

5. Fan sections shall be of the centrifugal type. Fans shall be double-width, double-inlet (DWDI) type with nonoverloading air-foil type blades. Each fan shall be complete with variable pitch V-belt drive, electric motor, belt guard, magnetic starter, local manual on-off-automatic fan switch, and terminal for remote control from the space thermostat and remote monitoring and control from the supervisory control system. Motors for each fan unit shall be selected so that the fan power requirement at any point of the fan power-capacity curve does not exceed the horsepower rating of the motors. Fan outlet velocity shall not exceed 2200 fpm.

6. Access to Air-Handling Unit. Access doors shall be provided for maintenance of fans, coils, dampers, and filters.

1.5.3 Air Conditioning for Underground Stations

A. Station Cooling Loads

Station cooling loads and system design are based on the following:

1. The peak cooling load for each underground station will be determined for conditions at time of peak rush hours. The station cooling loads do not include provision for air-conditioning mezzanine or concession areas.

2. Supply air flow capacities will be 150,000 cfm per station (37,5000 cfm per unit). Chilled water flow will be determined on the basis of 16°F temperature difference and on the basis of the cooling load in each station.

B. Chilled Water Distribution

1. Chilled Water Coil Section. Water coils shall have a maximum face velocity of 500 fpm. Fin spacing shall not be more than 8 fins/inch. Velocity of water in tubes shall be maximum of 6 fps. Where velocities less than 2 fps are encountered, a method of turbulation shall be provided.

2. Cooling coils shall be designed for a water inlet temperature of 46°F and a water outlet temperature of 62°F.

3. Chilled water lines shall be arranged to permit air venting and drainage of the water system and to facilitate removal of the cooling coils from the unit casing.

Table IV-1-1

Station Cooling Load

STATION	ESTIMATED COIL LOAD (TONS OF REFRIGERATION)
1. Union	180
2. Civic Center	180
3. 5th & Hill	200
4. 7th & Flower	325
5. Alvarado	275
6. Vermont	250
7. Normandie	225
8. Western	250
9. Crenshaw	450
10. La Brea	435
11. Fairfax	300
12. Beverly	225
13. Santa Monica	425
14. Sunset	350
15. Hollywood/Cahuenga	350
16. Universal City	350
17. North Hollywood	180

1.5.4 Air Distribution System Design

A. General

All air distribution duct systems shall be designed based on recommendations, and in accordance with information contained in the latest edition of the ASHRAE Handbooks. Supply duct sizes shall be selected for an equal pressure drop of not more than 0.10 in. of W.G. per 100 ft. of duct. Maximum velocities shall not exceed those described under paragraph 1.4.5, entitled "Design Velocities for Air Distribution Systems." All sheet metal ducts shall be constructed of galvanized steel with joints practically air tight. All ducts shall be sufficiently stiffened and supported to avoid sagging and vibration.

B. Supply Air Registers and Diffusers

All supply air registers and diffusers shall be selected to provide the required throw and spread with the least amount of draft and noise. All registers shall be provided with adjustable and double deflection louvers and opposed blade adjustable volume dampers. Volume dampers shall be key operable through the face of the register. All ceiling diffusers shall be square, rectangular, circular, or linear type with adjustable throw, opposed-blade adjustable volume dampers, and adjustable air extractors. The volume dampers shall be key-operable through the face of the diffuser.

C. Exhaust and Return Grilles and Registers

All exhaust and return air grilles shall be equipped with fixed, non-see-through blades or louvers, or the duct behind them shall be painted black. All grilles and registers shall be equipped with opposed blade adjustable volume dampers key operable through the face.

D. Volume Dampers in Branch Ducts

Adjustable opposed blade volume dampers shall be provided for all branch ducts serving more than one outlet. All dampers shall be equipped with locking

quadrants, blades sufficiently stiffened at the edges to effectively close off the duct, and be free from vibration under all conditions of operation.

E. Splitter Dampers in Duct Fittings

Splitter dampers may be used in multiple duct fittings for initial balancing in lieu of individual opposed blade volume dampers in each branch off the multiple duct fitting. These splitters shall be adjustable through quadrants, and shall be single blade type with edges sufficiently stiffened to avoid vibration under all conditions of operation.

F. Fire Dampers

Fire dampers shall be provided in ducts where required. All fire dampers shall be subject to approval by the Fire/Life Safety Committee and shall have Underwriters Laboratories Inc. label.

G. Backdraft and Relief Dampers

Backdraft dampers shall be used on exhaust fans where more than a single fan discharges into a common exhaust plenum. Barometric relief dampers shall be used in exhaust ducts and openings where positive pressure is required to be maintained by forced air supply and gravity exhaust. All backdraft and relief dampers shall be of multiblade gravity type with neoprene or felt cushioning on blade edges.

H. Extractors

Air extractors may be used in branch duct connections and for registers and diffusers where there is inadequate space for installing multiblade volume dampers. All air extractors shall be of movable blade, pivoted type.

I. Turning Vanes

All elbows shall have full centerline radius of at least 1 1/2 times the width of the duct. Where full radius curves are not feasible, elbows shall be provided with turning vanes.

J. Access Doors in Ducts and Plenums

Access doors shall be provided in ducts and plenums to service dampers, coils, filters, etc. Access doors in plenums and in station supply air units shall be hinged, furnished with latches operable from both inside and outside, and edges shall rest against neoprene or felt gaskets for airtight enclosure. Access door in ducts shall rest against felt or neoprene gaskets and shall be fastened by sheet metal screws.

K. Flexible Duct Connectors

Flexible duct connectors shall be used on all fan units to connect fans to ductwork. The length of each joint shall be adequately selected to accommodate both horizontal and vertical deflections of the fan units. All flexible duct connectors shall be mechanically secured to fan and duct to provide airtight joints. Temperature rating of the flexible duct connector shall not be less than the requirement of the fan it is serving.

1.5.5 Air Filtration

Roll-type air filters shall be provided for all ventilating and station supply air units with 10,000 cfm capacity or above.

Filters shall be of automatic roll type with renewable media for all air volumes 10,000 cfm and higher unless otherwise indicated. The filter media shall have a minimum of 80 percent efficiency when tested by the National Bureau of Standards Cotterell and Lint Type Test Method at rated capacity and an initial pressure drop not exceeding 0.20 inch of w.g., and have a maximum pressure drop not greater than 0.50 inch of w.g. Automatic filter controls shall be interlocked so that they are energized whenever the fan is operating. An automatic timer shall advance the media with an adjustable time interval, plus adjustable time delay relay to vary media advancement. A pressure drop override shall advance the filter media if the pressure drop exceeds the "cut-in" point before the timer-activated advancement. The filter assembly shall be complete with warning signal light for high pressure differential, contactor for remote monitoring of high

pressure differential and media runout manual switch, and access door solenoid to lock out pressure differential override. Air filter material shall be Underwriters' Laboratories Inc. listed as Class 1 or 2. Where the available material is listed both as Class 1 and 2, Class 1 type material shall be provided.

Systems with air volumes less than 10,000 cfm, shall have replaceable (throwaway) media filter sections arranged in banks as appropriate. At rated capacity, the replaceable filter media shall have an efficiency of not less than 80 percent when tested by the National Bureau of Standards Cotterell and Lint Type Test Method and an initial pressure drop not greater than 0.20 inch of w.g. Air filter material shall be rated Class I in Underwriters Laboratories Inc. listing.

1.5.6 Chilled Water Plants (Future)

In the future, chilled water plants serving SCRTD Metro Rail subway stations will generally be located on the mezzanine level of each station. The cooling load for each station and the capacity for each chiller are shown in Table 1.1 of these criteria.

Cooling towers shall be located at or above grade as close as possible to the chilled water plant served, unless other factors such as availability of real estate or requirements of local jurisdictions dictate otherwise.

A. Water Chillers

Chillers shall be of the hermetic centrifugal type. Units shall be factory packaged, charged, and tested. Chilled water shall be cooled from 62°F entering to 45°F leaving. Condenser water shall range from 85°F entering to 95°F leaving.

The water side of the condensers and evaporators shall be selected for a maximum water velocity through the tubes of 6 fps.

In the design and selection of the water chiller and accessories, consideration shall be given to the energy efficiency of their operation.

B. Chilled Water and Condenser Water Pumps

Typically, chilled water shall be distributed from the chillers to chilled water cooling coils in station supply air units through a closed loop distribution system. Chilled water pumps shall be selected to handle the resistance of the chiller served and the resistance of the distribution loop. Pumps shall be nonoverloading throughout their entire operating range.

Chilled water and condenser water pumps shall be of end-suction, centrifugal, flexible-coupling, mechanical-seal, base-mounted type. Pumps shall be constructed so that they may be serviced without any removal of the piping system or disconnection of piping from the pump. Pumps shall have the following characteristics:

Maximum pump speed	1750 rpm
Operating efficiency	within 5 percent of maximum efficiency
Motor type	nonoverloading

C. Cooling Towers

Cooling towers shall be of the induced draft type. Selection shall be based on the following:

Water Flow Rate	3 gpm/ton
Water Temperature	95°F entering, 85°F leaving
Entering Air	See paragraph 1.4 entitled "Design Parameters"

When required, sound attenuation shall be provided to prevent cooling tower noise levels from exceeding the levels indicated in Volume IV Section 7 entitled "Noise and Vibration."

Provisions shall be made for elimination of any plume formation at the discharge of cooling towers where

such plume would interfere with the visibility of vehicular traffic.

D. Drainage of Lines

Chilled water and condenser water lines shall be arranged to permit complete drainage of the water system.

1.6 TUNNEL ENVIRONMENTAL CONTROL SYSTEMS

1.6.1 Mid-Tunnel Ventilation Shafts and Equipment

A. Equipment

1. Mid-tunnel fans shall be of the axial-flow type, with internally mounted, direct-drive motor, and shall be set with its axis horizontal. Fan-motor unit will be reversible so as to either supply air to the trackway or exhaust air from the trackway. Fans shall have manually adjustable pitch blades to permit a change in pressure and/or air flow capacity for either system balancing or future system modification. The minimum acceptable reverse (supply) flow capacity shall be 60 percent of forward (exhaust) flow capacity.

2. Fan-motor units shall have a total efficiency of not less than 70 percent in the forward flow mode. The operating speed of fan-motor units will not exceed 1200 rpm.

3. Fan power curve will not exceed 100 percent of the motor rating at any point. The brake horsepower for reverse flow will not exceed the brake horsepower for forward flow.

4. Sound attenuating duct elements shall be selected such that the noise levels generated by the fans do not exceed the limits indicated in Volume IV, Section 7, entitled "Noise and Vibration."

5. Fan equipment shall include inlet and outlet screens; flexible connections; sound attenuators and appropriate transitions on inlet and outlet; and motor-operated dampers and controls. Provisions shall be made in the connections at the fan inlet and outlet for access to the fan components.

6. Fan dampers, bypass dampers and isolation dampers shall be of the parallel-blade type and shall be industrial, heavy duty type with a weatherproof design. Two end switches shall be provided in each damper actuator for remote monitoring of damper open and closed positions.

7. All ventilation system components, including fan-motor units, fan dampers and bypass dampers located in the air stream shall be capable of operating in an ambient temperature of 300 degrees Fahrenheit for a minimum of one hour, because the ventilation system may be used in an emergency to purge hot smoke from the subway.

B. Calculation of Shaft Losses and Fan Total Pressure

A computerized evaluation of the fan-motor unit performance for steady-state (no trains operating in subway) and unsteady-state (trains operating in subway) conditions for typical line ventilation shaft will be undertaken with the Subway Environment Simulation (SES) program.

The steady-state losses through ventilation shafts and sound attenuators shall be calculated for the actual configuration of each ventilation shaft design. These shaft losses shall be adjusted as follows to obtain the operating pressure range:

1. Adding the "System Pressures" for emergency operation to the forward (supply) and reverse (exhaust) operating pressure

2. Adding the "Damper Blockage Loss" for emergency operation to the forward (supply) and reverse (exhaust) operating pressure

3. Adding and subtracting the "Train Induced Transient Pressure" to the steady-state operating pressure to obtain the operating pressure range.

C. Fan Selection

The mid-tunnel fan-motor units will have a capacity of 150,000 cfm or 185,000 cfm and will be selected to operate in the stable range of the fan curve through the entire operating pressure range. The variation expected in the fan point of operation is due to the piston-action-generated airflow's either aiding or opposing the fan operation, depending on whether the trains operating in the line section are approaching or departing from the fan.

The location of mid-tunnel ventilation shafts, number of fans in each shaft, nominal capacity, total pressure and motor horsepower for each fan are given in Table IV-1-2.

1.6.2 Emergency Ventilation Shafts

A. Emergency Ventilation Shaft Equipment

1. Emergency fans will be the axial-flow type, with internally mounted, direct-drive motor construction, and will be set with its axis horizontal. Fan-motor units will be reversible so as to either supply air to the trackway or exhaust air from the trackway. Fans will have manually adjustable pitch blades to permit a change in pressure and/or air flow capacity for either system balancing or future system modification. The minimum acceptable reverse (supply) flow capacity will be 90 percent of the forward (exhaust) flow capacity.

2. Fan-motor units will be selected to have a total efficiency of not less than 70 percent in the forward (exhaust) flow mode. The operating speed of fan-motor units will not exceed 1200 rpm.

3. Fan power curve will not exceed 100 percent of the motor rating at any point. The brake horsepower for reverse flow will not exceed the brake horsepower for forward flow.

4. Sound attenuating duct elements shall be selected such that the noise levels generated by the fans do not exceed the limits indicated in Volume IV, paragraph 7.7.2, entitled "Fan and Vent Shafts".

5. Fan equipment shall include inlet and outlet screens; flexible connections; sound attenuators and appropriate transitions on inlet and outlet; and motor-operated dampers and controls. Provisions shall be made in the connections at the fan inlet and outlet for access to the fan components.

6. Fan dampers, bypass dampers and isolation dampers shall be of the parallel-blade type and shall be industrial, heavy duty type weatherproof design. Two end switches shall be provided in each damper attenuator for remote monitoring of damper open and closed positions.

7. All ventilation system components, including fan-motor units, fan dampers and bypass dampers located in the air stream shall be capable of operating in an ambient temperature of 300 degrees Fahrenheit for a minimum of one hour, as the ventilation system may be used in an emergency to purge hot smoke from the subway. (See Fire/Life Safety Criteria, Volume I, Subsection 2.3.5.5.7.)

B. Calculation of Shaft Losses and Fan Total Pressure

A computerized evaluation of the fan performance for steady-state (no trains operating in subway) and unsteady-state (trains operating in subway) conditions for typical emergency ventilation shaft will be undertaken with the Subway Environment Simulation (SES) program.

Steady-state losses through ventilation shafts and sound attenuators shall be calculated based on the configuration of the ventilation shaft design. These shaft losses shall be adjusted by:

1. Adding the "System Pressures" from emergency operation to the forward (supply) and reverse (exhaust) operating pressure

2. Adding the "Damper Blockage Loss" from emergency operation to the forward (supply) and reverse (exhaust) operating pressure

3. Adding and subtracting the "Train Induced Transient Pressure" to the steady-state operating pressure to obtain the operating pressure range.

C. Fan Selection

The emergency fan-motor units will have a capacity of 150,000 cfm or 185,000 cfm and will be selected to operate in the stable range of the fan curve through the entire operating pressure range.

The location of emergency shafts, number of fans in each shaft nominal capacity, total pressure and motor horsepower for each fan are given in Table IV-1-3

1.6.3 Smoke Exhaust System

Each station will have two smoke exhaust systems, one at each end. System capacity will be based on SCFM/Sq. Ft. of projected mezzanine public space ceiling area (roof area less nonpublic area). Operations and electric power requirement shall be as described in Section 4.

1.7 VENTILATION SHAFTS AND TERMINALS AT GRADE

1.7.1 General

The maximum air velocity through a grating or louver shall be computed using the gross face area of the grating or louver, exclusive of any supports.

All ventilation shafts and terminals at or above grade shall be sized, designed, and spaced in accordance with the following criteria:

A. Normal Operations

1. Outside air intakes at sidewalk level - the maximum air velocity shall not exceed 1,000 fpm.

2. Outside air intakes ten feet or more above grade or away from public areas - the maximum air velocity shall not exceed 1,200 fpm.

3. Exhaust air at sidewalk level - the peak outflow air velocity shall not exceed 500 fpm.

4. Exhaust air 10 feet or more above sidewalk level or away from public areas - the peak discharge velocity should be limited by noise criteria but shall not exceed 1,000 fpm.

B. Emergency Operations

1. Exhaust air at sidewalk level - the maximum air velocity shall not exceed 1,500 fpm.

2. Exhaust air 10 feet or more above sidewalk level or away from public areas - the noise criteria are waived; velocity shall not exceed 1,500 fpm.

C. Shaft Locations

1. Ventilation shaft terminals at street level shall be located to avoid pedestrian and vehicle crossings and to minimize the danger of flooding from the sidewalk or street. When located in sidewalks, they shall occupy not more than 40 percent of the sidewalk width. Where possible, they shall be located in median strips or off-street locations and shall be suitably screened with planted or other decorative treatment. Under no circumstance shall ventilation shaft openings be located in roadways, driveways or near vehicle stops where exhaust gases and contaminants can be drawn or where fuel may leak into the ventilation shafts.

2. At grade, surfaces shall be sloped away from gratings of shafts terminating at-grade to minimize the flow of water into the shafts.

3. Exhaust air shafts may be combined into a common shaft. Outside air intake shafts may be combined into a common shaft. Under no circumstances shall exhaust and intake shafts be combined into a common shaft.

D. Shaft Design

1. In the design of fan shafts, sudden expansions and contractions in the shaft cross section shall be avoided. The minimum number of turns and elbows shall be used. Turning vanes may be used to reduce pressure losses. Streamlining of obstructions in fan shaft passages shall be undertaken where economically warranted. Air passages shall be constructed of smooth concrete or heavy metal ductwork.

2. Ventilation shaft terminals at grade shall be located as follows:

   a. Openings for blast relief shafts, and underplatform and smoke exhaust shafts at grade shall be separated by a minimum horizontal distance of 40 feet from the closest station entrance, surface emergency stair doorways, unprotected outside air intake or other openings, or from each other.

      Where this distance is not practical, the horizontal distance may be reduced to 15 feet if the closest blast relief or underplatform and smoke exhaust shaft terminal is raised a minimum of 8 feet above the station entrance, emergency stair doorway and unprotected outside air intake or other opening, or the underplatform and smoke exhaust shaft terminal is raised a minimum of 8 feet above the blast relief shaft terminal.

   b. The minimum distance between the edges of adjacent openings for outside air intake shafts protected by smoke dampers and blast relief shafts or underplatform and smoke exhaust shafts shall be as follows:

      $d = 0.25 \times (L_1 + L_2)$

      Where: d = minimum distance in feet between the edges of the adjacent openings.

      L_1 and L_2 = lengths in feet of the adjacent parallel sides of the openings.

1.8 STATION AND TUNNEL ECS CONTROLS

1.8.1 Local Control

Local control panels shall provide control and indication for ECS equipment. They shall be located either near each motor control center or in close proximity to the controlled equipment. Local control panels shall be used primarily for equipment maintenance, and can also be used to operate the equipment in event of a failure of the Supervisory Control and Data Acquisition system (SCADA). In addition, manual remote control shall be provided in an Emergency Management Panel located in a strategic point of the station for control of station supply air units, underplatform exhaust fans, smoke exhaust fans, and nearest emergency fans.

1.8.2 Central Control

The SCADA system is provided in the Rail Control Center to operate and supervise the ECS and other equipment. Equipment can be remotely operated and supervised. Equipment operation will be supervised through feedback of equipment status and alarms. Central control will coordinate transit operations, operation of ECS equipment, electrical equipment, and other equipment. During emergencies, central control will coordinate rescue and evacuation activities.

1.8.3 Station Supply Air System Control

The station supply air system will be activated in sequence and supervised from the Rail Control Center. An automatic mode can be activated which will switch control to a local auto control system. An emergency mode is also provided to override certain local protective devices and local control loops to provide appropriate equipment operation.

1.8.4 Underplatform Exhaust System Control

Operations of the underplatform exhaust system shall be controlled from the Rail Control Center, with local control at the station as required for maintenance and backup in the event of failure of the Central Control System. Fan blade pitch shall be controlled through Train Control System to exhaust air at the train dwell

period in the station, when the air conditioning in the station has been installed.

1.8.5 Tunnel Ventilation System Control

The tunnel ventilation system shall be controlled and supervised from the Rail Control Center. During emergencies the tunnel and station ECS equipment is activated from the Rail Control Center in a predetermined pattern which depends upon the nature and location of the emergency, choice of evacuation route and other factors. In addition there shall be provisions for remote or local manual override as described above under "Local Control."

1.9 ANCILLARY SPACE HVAC SYSTEMS

1.9.1 General

The concepts described in these criteria are applicable to the heating, ventilation and air-conditioning systems, equipment, operation, and controls in the indicated areas.

Outside and indoors summer and winter peak design conditions shall conform to the requirements covered in paragraph 1.4, entitled "Design Parameters."

A. Train Control and Communications Equipment Rooms

1. System Concepts

Air-conditioning system shall be designed so that air-handling unit can modulate from minimum outside air required for ventilation to 100 percent outside air.

Approximately 90 percent of the supply air shall be recirculated, and 10 percent of the supply air shall be exhausted by exfiltration to maintain a positive pressure within the space. Supply air shall be filtered. Ten percent outside air shall be introduced into the system through manually operated dampers in the outside air intake duct. A separate ventilation system to purge halon, at the rate of 6 air changes per hour, shall be

provided. Discharge from this ventilation system shall be routed to the outside.

2. Cooling Load

Cooling load shall be based on a summation of the following heat gains:

a. Eleven(11) KW internal for each station without a Zone Center

b. Lighting load of 3 watts per square foot

c. Minimum ventilation 10 percent outside air

d. Solar and transmission gains, where applicable.

3. Equipment and Accessories

a. Air-Handling Unit

Equipment shall be of the direct-expansion, split-system type, with air-handling unit in fan room adjacent to Train Control Room. Air-handling unit shall consist of disposable filters, DX cooling coils section, electric duct heat coil, centrifugal fan, and condensate drain pan. Installation shall include automatic temperature controls and a remote air-cooled condenser/compressor unit. Although not essential, a system with dual compressors, each with 50 percent capacity is preferable.

b. Condensing Unit

Air-cooled condensing unit shall be located within mechanical equipment rooms for subway stations, with air ducted to subway line sections or grade level. Condensing unit may be part of the air-handling unit, or remote from it.

4. Operation and Control

   a. A room thermostat shall be provided to cycle the compressor(s) or electric heater to maintain the room temperature at the thermostat setting. The fan shall operate continuously. An automatic economizer control shall not be used for the Train Control Room system.

   b. Another room thermostat shall be provided to transmit an indication of high temperature to the Rail Control Center.

   c. The air conditioning system shall be automatically shut down in the event of fire detection.

5. Reliability

   All air-conditioning equipment serving the Train Control Room shall be wired to the essential bus of the Ancillary Electrical Room.

B. Traction Power Substations

1. System Concepts

   The ventilation system is required in all enclosed traction power substations to remove heat generated by the transformers and rectifiers and to ensure that the operating temperatures within substations do not exceed the design operating conditions. A central ventilation system shall be provided to supply filtered, 100 percent outdoor air to traction power substations.

2. Ventilation Capacity

   The ventilation capacity shall be based on a summation of the following internal heat gains:

   a. Lighting load of two watts per square foot

   b. Solar and transmission gains, where applicable

c. The heat gain caused by equipment loss in the Traction Power Substation shall be calculated based on the following:

At-grade Traction Power Substation Equipment - 35 kw; Underground Traction Power Substation Equipment - 120 kw.

It shall be noted that rectifiers and rectifier transformers are normally designed under special performance specifications and the above figures shall be used only as a guide in preliminary design. The equipment factory test data shall be used in actual design.

3. System Arrangement and Associated Equipment

a. The system designed to remove heat gain from equipment shall consist of not less than two supply fans with motorized dampers, filters, air distribution system, and automatic temperature controls.

b. One supply fan shall be capable of providing 100 percent of the ventilation requirement. The other supply fan shall serve as a standby unit or shall operate, should the inside air temperature exceed 94°F.

c. Air shall be exhausted from room to the outside through relief opening connected to the station exhaust air shaft. Backdraft damper shall be installed on the exhaust duct to prevent backflow. Ventilating air shall not be taken from the subway or exhausted into the subway.

d. A separate third fan, running continuously shall supply a minimum of 5000 cfm into the Traction Power Substation to maintain a slight positive space pressure and to prevent methane gas buildup.

In lieu of a third fan, the Incoming Service Room supply fan may be used with additional ductwork as required to pressurize the substation and to mitigate gas accumulation.

e. Fans should be selected with sound power levels such that, with one supply fan in operation, the noise level in the substation does not exceed 85 dBA.

f. Fans shall be powered from the essential bus.

4. Operation and Control

a. The operation of the large supply fans shall be controlled by a thermostat located within the substation. When the space temperature rises to 86°F, the first supply fan shall start. On a continued rise to 94°F, the second fan shall start. On a fall in temperature to 90°F, the second fan shall stop. On a continued fall in temperature to 80°F, the first fan shall stop. The third small supply fan shall run continuously. Local manual control shall be provided for fan operation of the ventilation system during human occupancy of the substation. Remote control shall be provided from the Rail Control Center, and the EMP.

b. The ventilation system shall be automatically shut down in the event of fire detection within the traction power substation.

c. A high-temperature thermostat and the dirty filter indicator shall each transmit a system fault indication to the Rail Control Center.

C. Auxiliary Power Rooms

1. System Concepts

A supply and exhaust ventilation system shall be provided to remove heat produced by transformers and lights within the space and discharge it at-grade.

Outside air shall be obtained from a supply air shaft. Air filtration shall be provided at the intake to room, and a positive pressure shall be maintained in the room by the supply fan.

2. Ventilation Requirement

The ventilation requirement shall be based on a summation of the following internal heat gains:

a. Two percent of the installed transformer capacity

b. Lighting load of 2 watts per square foot

c. The heat produced by the UPS

d. Solar and transmission gains, where applicable.

3. Equipment and Accessories

The system shall consist of one or more supply and exhaust fans, distribution ductwork and devices, filters, and automatic temperature controls.

4. Operation and Control

a. Supply and exhaust fans shall run continuously. Local manual control and remote control from the Rail Control Center shall be provided.

b. A high temperature thermostat shall transmit a system fault indication to the Rail Control Center.

c. The ventilation system shall be automatically shut down in the event of fire detection within the room.

d. A positive pressure within the room shall be maintained by the supply fan.

D. Battery Rooms

1. System Concepts

Exhaust ventilation shall be provided to limit the concentration of hydrogen gas within the space to one percent by volume. Exhaust air shall be drawn from a high level within the space and shall be discharged to grade level. Air filtration shall be provided at the air intake to the battery room.

2. Equipment and Accessories

The system shall consist of an exhaust fan with motor, air distribution ductwork and devices, air outlet damper, and manual controls. All fans, starters, etc. shall be explosion proof.

3. Operation and Control

a. Ventilation systems for battery rooms shall run continuously. Operation shall be monitored by an airflow switch located in the discharge duct of the fan. Indication of malfunction of the ventilation system shall be transmitted to the Rail Control Center.

b. The ventilation system shall be shut down automatically in the event of detection of fire or smoke within the room.

E. Other Ancillary Rooms

1. System Concepts

Exhaust ventilation shall be provided for each ancillary room. Air shall be discharged to grade. Ventilation air shall be provided, as required, and shall be taken from adjacent areas, or outside, as applicable. Each ventilation system shall be shut down automatically in the event of detection of fire or smoke.

2. Operation and Controls

Ventilation shall be as follows:

a. Toilets - continuous operation.

b. Custodial Room - Continuous operation.

c. Trash Rooms - Continuous operation.

d. Sewage Ejector Rooms and Sump Pump Rooms - Continuous operation.

e. Elevator Machine Rooms - Continuous operation, with provisions for thermostat control.

f. Mechanical or Electrical Equipment Rooms -

Continuous operation, with provisions for thermostat control.

g. Storage Rooms - Continuous operation.

F. Chilled Water Plants

1. System Concepts

For chilled water plants located within a underground subway structure, exhaust air shall be discharged to a ventilation exhaust shaft extending up to grade, and outside air shall be drawn from ventilation shaft from grade.

2. Ventilation Requirements

Exhaust ventilation shall be provided (1) so as to achieve a maximum temperature rise to 10°F above outside temperature, or (2) as required by the Safety Code for Mechanical Refrigeration, based on the quantity of refrigerant in the plant, whichever air quantity is the greater.

3. Equipment and Accessories

a. The ventilation system shall consist of an exhaust fan, air distribution devices and ductwork, and motorized outlet damper.

b. The make-up air system shall consist of filters and outside air intake with motorized damper.

4. Operation and Control

Local manual control and remote control from the Rail Control Center shall be provided.

a. Initial Period - Chilled Water Equipment is Not Installed

The fan shall operate continuously, and shall be electrically interlocked with its outlet damper and the outside air damper. For future use a manual switch with indication sent to the Rail Control Center shall be provided at the door outside the room to manually shut down the chiller plant during human occupancy. Shut down will be accomplished without preventing operation of the ventilation system.

b. Future - Chilled Water Equipment Is Installed

Same as above, except fan shall operate continuously only during chiller operation unless continuous run is required for gas mitigation.

G. Incoming Service Room

1. System Concepts

Incoming service room shall be ventilated by a supply and exhaust system. Exhaust air shall be discharged through a shaft extending up to grade.

Outside air shall be drawn from an outside air intake shaft. Air filtration shall be provided and positive pressure shall be maintained in the room by the supply fan.

2. Ventilation Requirements

- Ventilation shall be provided at the rate of 10 air changes per hour.

3. Equipment and Accessories

The ventilation system shall consist of a supply fan, filter, ductwork, motorized supply and relief dampers.

The supply fan may be used to pressurize the Traction Power Substation with additional capacity.

4. Operation and Control

The fan shall run continuously and shall be interlocked with its outlet damper. Local manual control shall be provided inside the Incoming Service Room. Remote control shall be provided from the Rail Control Center. The ventilation system shall be automatically shut down in the event of fire within the Incoming Service Room.

H. Emergency Exits

To alleviate possible methane gas accumulation, emergency exit stairs direct to surface shall be naturally ventilated through a screened opening at the topmost portion of the enclosure, equipped with fire damper, and leading into an areaway with grating at street level.

1.10 YARD AND SHOPS HVAC SYSTEMS

1.10.1 General

The concepts described in these criteria are applicable to the heating, ventilation and air-conditioning systems, equipment, operation, and controls in the indicated areas.

Outside and indoors summer and winter design conditions shall conform to the requirements covered in paragraph 1.4, entitled "Design Parameters."

A. General Office Areas

1. System Concepts

A HVAC system shall be provided consisting of a split package air conditioner or single packaged air conditioner, air distribution system, controls, drives and accessories. All air-conditioning systems, except where noted otherwise, shall be designed so that air-conditioning units can modulate from minimum outside air required for ventilation to 100 percent outside air as required by codes.

2. Cooling Load

Cooling load shall be based on a summation of the following heat gains:

a. Occupancy

b. Lighting and equipment loads

c. Ventilation make-up air

d. Solar and transmission gains, where applicable.

3. Heating Load

   Heating load shall be based on a summation of the following:

   a. Transmission Load

   b. Ventilation Air Load

4. Equipment and Accessories

   a. Air-conditioning units shall include the following components:

      (a) Mixing plenum

      (b) Economizer cycle arrangement with all required components included as a complete operational unit.

      (c) Filter section

      (d) Refrigeration System

      System shall consist of serviceable hermetic reciprocating type compressors, DX condensing coils with integral subcooling, supporting casing with stand, direct-drive, propeller-type fans, motors, and head pressure control. System shall be factory-packaged, cleaned, dehydrated, leak-tested and shipped with a holding charge. Saturated suction temperature shall be 40°F, condensing temperature 120°F with 89°F dry bulb entering condenser with 15°F subcooling.

      (e) Direct expansion, and natural gas heating section. DX coils shall have a maximum face velocity of 500 fpm. Fin spacing shall not be more than 8 fins/ inch.

      (f) Fan sections shall be of the centrifugal type. Centrifugal fans shall be Double-Width, Double-Inlet (DWDI) type or Single-Width, Single-Inlet (SWSI) type, with nonoverloading air-foil or forward curved type blades. Each fan shall be

complete with variable pitch V-belt drive, electric motor, vibration isolators for mounting of fan and motor base, belt guard, magnetic starter, local manual on-off automatic fan switch, and terminal for remote control from the space thermostat and remote monitoring and control from the supervisory control system. Electric motors for each fan unit shall be selected so that the fan power requirement at any point of the fan power-capacity curve does not exceed the horsepower rating of the motors. Fan outlet velocity shall not exceed 2200 fpm.

(g) Access to Air Conditioning Unit. Access shall be provided for maintenance of fans, coils and filters.

5. Operation and Control

Individual room temperature controls shall be provided by means of room thermostats controlling the supply air temperature or varying the air volume as the space load changes. Economizer control shall be provided by means of an exhaust fan and outside air and return air dampers in the unit. Control sequences shall be provided as standard with the unit manufacturer.

B. Open Shop Areas

These include areas for service and inspection, heavy repair, truck shop and wheel shop.

A summer ventilating system shall be provided consisting of roof-mounted exhaust fans with backdraft or motor-operated dampers, wall louvers with screen filters, motor-operated dampers, and automatic temperature controls. Equipment shall be located to provide uniform air flows through all areas to the extent practical. A room thermostat shall be provided for each set of wall louver and exhaust fan. Ventilation requirements shall be based on the first 15 feet of building height and as required by local codes. Gravity ventilation could be used in some areas of facilities, if adequate.

Heating shall be provided by high intensity gas fired radiant heaters and controlled by room thermostats. The heaters shall be sized and located to provide uniform temperatures. Units shall be mounted as high as practicable above the floor to preclude obstruction of work spaces. A thermostat shall be provided for the heater.

C. Enclosed Shop Areas

Main Shop Building:

- Air conditioned areas:
  Air Brake Shop, Air Conditioning Shop, Electrical Repair Shop, Electronics Shop, Control Tower and its Equipment Rooms.

- Not air conditioned:
  Welding Shop, Sheet Metal Shop, Machine Shop, Upholstry Shop, Paint Shop and Parts Cleaning.

D. Paint Spray Area

The ventilation system shall be sized for the supply air to be slightly less than the air exhausted by the paint spray booth exhaust, and and as per code requirements. Filtration of air should be provided as recommended by the spray paint equipment supplier and as required by applicable codes.

E. Car Wash Area

Ventilation shall be similar to Open Shop Areas described above.

Heating shall be provided by continuous hot water fin-tube radiation controlled with a room thermostat and motor-operated valve.

F. Degrease Room

The ventilation shall consist of a roof-mounted exhaust fan with air drawn from the shop areas through transfer grilles. The fan shall have continuous operation with manual override switch.

Heating shall be provided in the make-up air unit, controlled by room thermostats.

G. Electrical Equipment Rooms

Electrical equipment rooms shall be ventilated or air conditioned as required.

H. All Other Areas

HVAC criteria for all other areas shall conform to paragraph 1.9 entitled "Ancillary Space HVAC System," unless otherwise required herein.

I. Blow-Down Facility

For general description of blow-down facility see Volume II, Section 3.10.3.

1. System Concepts

A supply and exhaust ventilation system shall be provided to remove air borne dust.

2. Ventilation Requirements

Exhaust ventilation at the rate of 4 cfm per square foot of pit area shall be provided. Make-up air, or supply air shall be equal to the exhaust air. General exhaust ventilation at the rate of 10 air changes per hour should be provided.

3. Equipment and Accessories

One or more wet scrubbers shall be provided for exhaust air system to remove dust particles before exhausting the air to the outdoors. The scrubber shall be dynamic precipitator type with an exhauster and water spray. The water/dust slurry shall be discharged to the sanitary sewer after clarification. Clean air shall be discharged to atmosphere. One or more make-up air units with filters shall be provided. Roof-mounted exhaust fans shall be used for general ventilation. Exhaust air intake grills shall be located near the pit floor with minimum face velocity of 175 fpm. Make-up air supply shall be introduced at the roof and near the walk platform. Appropriate distribution ductwork and devices, filters, and automatic temperature controls and interlocks shall be provided.

4. Operation and Control

a. General exhaust fans shall be thermostatically controlled (electric type) to run when temperature exceeds 85 degrees Fahrenheit and off when temperature falls below 70 degrees Fahrenheit.

b. Scrubbers shall be interlocked with make-up air systems and water supply, system pressure switch. Scrubbers shall be manually started and stopped.

1.11 CHILLED AND CONDENSER WATER PIPING

1.11.1 General

All piping systems shall be designed to meet the requirements of the Code for Pressure Piping, ANSI B31, all applicable volumes, and be sized in compliance with methods presented in Crocker's Piping Handbook. All piping systems shall be designed and arranged for neat appearance, properly sloped for drainage and venting, and properly arranged, supported, guided, and anchored to provide complete flexibility and to maintain the integrity of all systems without any damage or leaks during operating conditions. All valves and accessories shall be installed in a systematic manner and in places accessible for operation without the use of chains or additional operating platforms. Sleeves shall be provided wherever pipes pass through structures. All piping shall be arranged to facilitate removal of tubes, coils, pumps, and other appurtenances served by it. The installation of water chilling equipment, cooling coils, piping, etc., will be deferred to a later date when the two minute headway is reached in the operation of trains. The present design shall be such that the installation of the deferred chilling equipment can be accomplished without any disruption to the system operation. This will require the installation of an inaccessible and embedded portion of chilled and condenser water piping in the station structure and routing of the condenser water piping to and from the future location of the cooling towers.

A. Pipe Unions and Flanges

Unions or flanges shall be provided on both inlets and outlets of all apparatus, control valvues, and accessories to facilitate easy removal of these items for

servicing. Where two different materials are connected, a dielectric coupling shall be provided.

B. Valves

Isolation valves shall be provided on both sides of apparatus such as pumps, heating coils, cooling coils, control valves, perimeter hot water radiation, and refrigeration apparatus in multiple installation; in piping branches at headers; and in station mains connecting to outside services. Valves shall be located to give neat appearance and easy grouping, with all parts accessible for operation and maintenance. The use of chain-operated valves shall be restricted to non-maintenance areas only, but if it is at all possible, the use of chain-operated valves shall be avoided. Wherever possible, valve stems shall be horizontal. All valves (gate, globe, pressure reducing, and relief valves; balancing cocks; etc.) shall be of one manufacturer throughout any one facility, wherever possible, to facilitate the standardization of parts inventory.

C. Piping Accessories

All required piping accessories shall be provided to assure trouble free operation of all piping systems. These accessories shall include, but not be limited to, strainers, vent cocks, dirt and drip legs with drain and flush connections, expansion tanks, refrigerant driers, liquid flow indicators, balancing cocks, relief valves, and pressure and temperature gauges. All piping accessories requiring maintenance or replacement shall be located in accessible places. All dials of gauges and indicators shall be of sufficient size and be arranged so as to be easily seen and read from operating floor levels.

D. Pipe Expansion Joints

The use of pipe expansion joints shall be avoided wherever possible. Pipe systems shall be arranged to have sufficient offsets and expansion loops to accommodate thermal expansion and vibration. In subway line sections, where pipe expansion loops are impractical, ball-joint type expansion joints shall be used; slip-type expansion joints shall not be used. Bellow-type expansion joints shall be of

shall be flanged to facilitate easy and quick replacement. Provision for expansion of piping in subway line sections shall be based upon a maximum subway temperature of 120°F. Every attempt shall be made to use only seamless pipe with welded joints when the pipe will be exposed in subway line sections.

E. Flexible Pipe Connectors

The use of flexible pipe connectors to connect piping to heating apparatus shall be restricted to cases where providing piping offsets for flexibility is impractical. Flexible pipe connectors shall be used in resiliently mounted air-handling units, pumps, hot water boilers, and chillers. These flexible pipe connectors shall be of stainless steel or Monel metal construction and shall have flanged ends for quick and easy dismantling from the pipe systems. They shall be of sufficient length to provide an overall stiffness less than that of the resilient mounts used for supporting the apparatus.

F. Pipe Supports, Hangers, Guides, and Anchors

Pipe supports, hangers, guides, anchors, and thrust blocks shall be designed to assure proper alignment of all pipes during operating conditions. All components shall be designed to support the weight of fluid, pipe, valves, and insulation. All hangers and supports shall be arranged so as to prevent the transmission of vibration from piping to the structure. Anchors and guides shall be designed to allow pipes to expand and contract without a build up of excessive stress. Pipe rollers shall be used with all hangers where pipe movement due to expansion or contraction exceeds 1/2 inch. Spring hangers of the constant or variable load type, as the case requires, shall be used when piping is connected to vibrating equipment and where supporting vertical pipes.

1.12 ELECTRIC HEATING EQUIPMENT

1. Electric heating equipment shall include convectors, unit heaters, baseboard heaters, and duct heaters.

2. All electric heating equipment shall be thermostatically controlled and shall be provided with protective devices as required by the "National Electrical Code."

3. Electric duct and unit heaters shall be controlled by means of 120-volt remote thermostat. Electric baseboard and convector heaters shall be controlled by means of an integral thermostat (120-volt or 277-volt).

4. All electrical heating equipment shall be Underwriters' Laboratories (UL) listed.

5. All electric resistance heating equipment shall have high-limit controls.

6. All duct heater coils shall be of the resistor type, designed to slide into ducts. Duct heaters shall be interlocked with supply fans so that they do not operate when the fan is off and shall be provided with pressure-type air flow switches wired into the control circuit. Duct heaters shall be sized so that the air velocity through the coil face does not exceed the velocities for the air distribution system covered in Paragraph 1.4.5; the minimum air velocity through the coil face shall not be less than that recommended by the heater manufacturer.

1.13 PREPURCHASE OF ECS EQUIPMENT

All emergency, mid-tunnel, and underplatform exhaust fan-motor units will be procured by SCRTD and provided to facilities construction contractors for installation. Such central procurement will ensure that similar fan units are products of one manufacturer and that they are fabricated and tested under rigidly controlled specifications and conditions. The central procurement will also include fan sound attenuators, dampers, and companion flanges.

1.14 VIBRATION ISOLATION

All equipment producing vibration shall be isolated from the structure by means of spring or rubber-in-shear vibration isolators. All piping and ducts attached to

rotating equipment shall be isolated from such equipment by flexible connections. Inertia blocks shall be provided as required.

See Volume IV Section 7.

1.15 EQUIPMENT FOUNDATIONS

All floor-mounted equipment shall be placed on reinforced concrete housekeeping pads. Minimum pad height shall be four inches.

1.16 EQUIPMENT ACCESS HATCHES

Provisions shall be made for the installation and removal of each complete factory-built item of equipment. All shafts extending up to grade, opening into shafts, hatches, hatchways, removable gratings, access plates, and door intended for use in the installation and removal of mechanical equipment shall be sized, with adequate clearances, so that such equipment can be moved between grade and its location without the need for special disassembly of the equipment.

Preferably, the installations and removal of equipment from underground mechanical equipment rooms shall be accommodated by providing hatches in slabs and/or removable gratings to grade level. Where this is not feasible or economical, and with the prior approval of the General Engineering Consultant, installation and removal of equipment may be accommodated by providing openings above or adjacent to the trackway.

1.17 EQUIPMENT HANDLING

Provision shall be made in the form of monorail lifting hooks and removable panels for the installation and removal of equipment. Structural openings shall be sized so that each complete factory-built item of equipment can be installed without disassembly or special construction.

1.18 ROUGHING-IN

In stations which will be constructed in stages under separate contracts, sleeves and block-outs shall be

provided in the early stage structures to accommodate piping and ductwork installation by later stage contractors. The locations and sizes of the sleeves and block-out shall be accurately dimensioned to facilitate the subsequent piping and ductwork installation.

TABLE IV-1-2

MID-TUNNEL FAN-MOTOR UNIT SCHEDULE

District Fan-Motor Unit Designation Number	Mid-Tunnel Shaft Location	Flow Rate Per Fan (CFM) Forward Exhaust Mode	Total Pressure (inches W.G.)	Maximum Motor Nameplate Horsepower
MF-11		150,000	4.3	150
MF-12	Sta. 434+85	150,000	4.3	150
MF-13		150,000	4.3	150
MF-21		150,000	4.3	150
MF-22	Sta. 817+50	150,000	4.3	150
MF-23		150,000	4.3	150
MF-31		150,000	4.3	150
MF-32	Sta. 871+00	150,000	4.3	150
MF-33		150,000	4.3	150
MF-41		185,000	4.7	200
MF-42	Sta. 1000+00	185,000	4.7	200
MF-43		185,000	4.7	200

NOTE: Total pressures and maximum motor nameplate horsepowers are preliminary, for information only, and are subject to change.

LEGEND

ABBREVIATION	DESCRIPTION
MF-11	Mid-Tunnel Fan-Motor Unit - Number
CFM	Cubic Feet Per Minute

TABLE IV-1-3

EMERGENCY FAN-MOTOR UNIT SCHEDULE

District Fan-Motor Unit Designation Number	Emergency Shaft Location	Flow Rate Per Fan (CFM) Forward Exhaust Mode	Total Pressure (inches W.G.)	Maximum Motor Nameplate Horsepower
EF-011	Union Station	185,000	4.8	250
EF-012		185,000	4.8	250
EF-013	(Inbound)	185,000	4.8	250
EF-021	Union Station	185,000	4.8	250
EF-022		185,000	4.8	250
EF-023	(Outbound)	185,000	4.8	250
EF-031	Civic Center	185,000	4.8	250
EF-032	(Inbound)	185,000	4.8	250
EF-041	Civic Center	185,000	4.8	250
EF-042	(Outbound)	185,000	4.8	250
EF-051	5th/Hill	150,000	4.7	200
EF-052	(Outbound)	150,000	4.7	200
EF-061	5th/Hill	150,000	4.7	200
EF-062	(Outbound)	150,000	4.7	200
EF-071	7th/Flower	150,000	4.7	200
EF-072	(Inbound)	150,000	4.7	200
EF-081	7th/Flower	150,000	4.7	200
EF-082	(Outbound)	150,000	4.7	200
EF-091	Wilshire/Alvarado	150,000	3.7	150
EF-092		150,000	3.7	150
EF-093	(Inbound)	150,000	3.7	150

TABLE IV-1-3 (Cont'd.)

EMERGENCY FAN-MOTOR UNIT SCHEDULE

District Fan-Motor Unit Designation Number	Emergency Shaft Location	Flow Rate Per Fan (CFM) Forward Exhaust Mode	Total Pressure (inches W.G.)	Maximum Motor Nameplate Horsepower
EF-101	Wilshire/Alvarado	150,000	4.7	200
EF-102	(Outbound)	150,000	4.7	200
EF-111	Wilshire/Vermont	150,000	4.7	200
EF-112	(Inbound)	150,000	4.7	200
EF-121	Wilshire/Vermont	150,000	4.7	200
EF-122	(Outbound)	150,000	4.7	200
EF-131	Wilshire/Vermont	150,000	4.7	200
EF-132	(Inbound)	150,000	4.7	200
EF-141	Wilshire/Normandie	150,000	4.7	200
EF-142	(Outbound)	150,000	4.7	200
EF-151	Wilshire/Western	150,000	4.7	200
EF-152	(Inbound)	150,000	4.7	200
EF-161	Wilshire/Western	150,000	4.7	200
EF-162	(Outbound)	150,000	4.7	200
EF-171	Wilshire/Crenshaw	150,000	3.7	150
EF-172		150,000	3.7	150
EF-173	(Inbound)	150,000	3.7	150
EF-181	Wilshire/Crenshaw	150,000	4.7	200
EF-182	(Outbound)	150,000	4.7	200
EF-191	Wilshire/La Brea	150,000	4.7	200
EF-192	(Inbound)	150,000	4.7	200

TABLE IV-1-3 (Cont'd.)

EMERGENCY FAN-MOTOR UNIT SCHEDULE

District Fan-Motor Unit Designation Number	Emergency Shaft Location	Flow Rate Per Fan (CFM) Forward Exhaust Mode	Total Pressure (inches W.G.)	Maximum Motor Nameplate Horsepower
EF-201	Wilshire/La Brea	150,000	4.7	200
EF-202	(Outbound)	150,000	4.7	200
EF-211	Wilshire/Fairfax	150,000	4.7	200
EF-212	(Inbound)	150,000	4.7	200
EF-221	Wilshire/Fairfax	150,000	3.7	150
EF-222		150,000	3.7	150
EF-223	(Outbound)	150,000	3.7	150
EF-231	Fairfax/Beverly	150,000	3.7	150
EF-232		150,000	3.7	150
EF-233	(Inbound)	150,000	3.7	150
EF-241	Fairfax/Beverly	150,000	4.7	200
EF-242	(Outbound)	150,000	4.7	200
EF-251	Fairfax/Santa Monica	150,000	4.7	200
EF-252	(Inbound)	150,000	4.7	200
EF-261	Fairfax/Santa Monica	150,000	4.7	200
EF-262	(Outbound)	150,000	4.7	200
EF-271	La Brea/Sunset	150,000	4.7	200
EF-272	(Inbound)	150,000	4.7	200
EF-281	La Brea/Sunset	150,000	4.7	200
EF-282	(Outbound)	150,000	4.7	200

TABLE IV-1-3 (Cont'd.)

EMERGENCY FAN-MOTOR UNIT SCHEDULE

District Fan-Motor Unit Designation Number	Emergency Shaft Location	Flow Rate Per Fan (CFM) Forward Exhaust Mode	Total Pressure (inches W.G.)	Maximum Motor Nameplate Horsepower
EF-291	Hollywood/Cahuenga	150,000	4.7	200
EF-292	(Inbound)	150,000	4.7	200
EF-301	Hollywood/Cahuenga	150,000	3.7	150
EF-302		150,000	3.7	150
EF-303	(Outbound)	150,000	3.7	150
EF-331	Universal City	150,000	4.7	200
EF-332	(Inbound)	150,000	4.7	200
EF-341	Universal City	150,000	4.7	200
EF-342	(Outbound)	150,000	4.7	200
EF-351	North Hollywood	185,000	4.8	250
EF-352		185,000	4.8	250
EF-353	(Inbound)	185,000	4.8	250
EF-361	North Hollywood	185,000	4.8	250
EF-362	(Outbound)	185,000	4,8	250

NOTE: Total pressures and maximum motor nameplate horsepowers are preliminary, for informatin only, and are subject to change.

LEGEND

ABBREVIATION	DESCRIPTION
EF-011	Emergency Fan-Motor Unit - Number
CFM	Cubic Feet Per Minute

TABLE IV-1-4

UNDERPLATFORM FAN-MOTOR UNIT SCHEDULE

District Fan-Motor Unit Designation Number	Station Served	Flow Rate Per Fan (CFM) Forward Exhaust Mode	Total Pressure (inches W.G.)	Maximum Motor Nameplate Horsepower
UF-011	Union Station	64,000	3	50
UF-012		64,000	3	50
UF-021	Civic Center	64,000	3	50
UF-022		64,000	3	50
UF-031	5th/Hill	64,000	3	50
UF-032		64,000	3	50
UF-041	7th/Flower	64,000	3	50
UF-042		64,000	3	50
UF-051	Wilshire/Alvarado	64,000	3	50
UF-052		64,000	3	50
UF-061	Wilshire/Vermont	64,000	3	50
UF-062		64,000	3	50
UF-071	Wilshire/Normandie	64,000	3	50
UF-072		64,000	3	50
UF-081	Wilshire/Western	64,000	3	50
UF-082		64,000	3	50
UF-091	Wilshire/Crenshaw	64,000	3	50
UF-092		64,000	3	50

NOTE: Total pressures and maximum motor nameplate horsepowers are preliminary, for information only, and are subject to change.

TABLE IV-1-4 (Cont'd.)

UNDERPLATFORM FAN-MOTOR UNIT SCHEDULE

District Fan-Motor Unit Designation Number	Station Served	Flow Rate Per Fan (CFM) Forward Exhaust Mode	Total Pressure (inches W.G.)	Maximum Motor Nameplate Horsepower
UF-101	Wilshire/La Brea	64,000	3	50
UF-102		64,000	3	50
UF-111	Wishire/Fairfax	64,000	3	50
UF-112		64,000	3	50
UF-121	Fairfax/Beverly	64,000	3	50
UF-122		64,000	3	50
UF-131	Fairfax/Santa Monica	64,000	3	50
Uf-132		64,000	3	50
Uf-141	La Brea/Sunset	64,000	3	50
Uf-142		64,000	3	50
UF-151	Hollywood/Cahuenga	64,000	3	50
UF-152		64,000	3	50
UF-171	Universal City	64,000	3	50
UF-172		64,000	3	50
UF-181	North Hollywood	64,000	3	50
UF-182		64,000	3	50

LEGEND

ABBREVIATION	DESCRIPTION
UF-011	Underplatform Fan-Motor Unit - Number
CFM	Cubic Feet Per Minute

SCRTD METRO RAIL SYSTEM DESIGN CRITERIA & STANDARDS

SYSTEM DESIGN CRITERIA AND STANDARDS

VOLUME: IV SECTION: 2

REVISION RECORD

NOTICE NUMBER	CR NO/REV	DATE APPROVED	AFFECTED	COMMENTS
1	3-025A/1	1/25/85	Table of Contents (added) List of Tables (added) 2.5.2 2.6.1 2.6.2 2.6.3 2.6.4 2.6.8 C Table IV-2-1	Replaces 9/1/83 issue Spelling, punctuation and format corrections

SCRTD METRO RAIL SYSTEM DESIGN CRITERIA

Volume IV, Section 2

PLUMBING

VOLUME IV, SECTION 2 PLUMBING

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VOLUME IV, SECTION 2

PLUMBING

2.1 SYSTEM DESCRIPTION

The criteria herein describe the piping and plumbing system for water and other fluids serving the SCRTD Metro Rail passenger stations, and the sewage system for return of human waste, drainage, and other waste fluids to the City sewers.

All piping and plumbing pertaining to the fire protection system is excluded from these criteria, and is described in Volume I, Safety, Fire/Life Safety, Security, and Systems Assurance.

2.2 APPLICABLE DOCUMENTS

The plumbing design shall comply with all applicable local codes of the City and County of Los Angeles, and with the following State of California codes:

A. California Administrative Code, Title 8, Health and Safety Act.

B. California Administrative Code, Title 19, State Fire Marshall.

C. California Administrative Code, Title 24, Uniform Bullding Code.

In addition, plumbing design and components shall comply with applicable standards, set forth by the following agencies:

A. American National Standards Institute (ANSI)

B. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

C. American Society of Civil Engineers (ASCE)

D. American Society of Mechanical Engineers (ASME)

E. American Society for Testing and Materials (ASTM)

F. American Welding Society (AWS)

G. National Fire Protection Association (NFPA)

2.3 FUNCTIONAL REQUIREMENTS

All plumbing shall respond to the following functional requirements:

A. Convey fluids from Public Utilities' distribution and/or storage points to SCRTD Metro Rail stations consumption and/or service points.

B. Collect and convey drainage and sewage from station service areas to the public sewer system.

2.4 SYSTEM INTERFACES

Plumbing design shall interface with design criteria from the following systems:

A. Volume I, Safety, Fire/Life Safety, Security and Systems Assurance.

B. Volume III, Architectural Design Criteria.

C. Volume IV, Section 1, Environmental Control.

D. Volume IV, Section 5, Corrosion Control.

E. Volume IV, Section 8, Miscellaneous Mechanical/-Electrical Systems.

F. Volume V, Section 3, Communications.

2.5 PIPING

2.5.1 General Considerations

All pressure piping systems shall be designed to meet the requirements of the Code for Pressure Piping, ANSI B.31, all applicable sections. All pipe fittings, flanges, valves, and accessories will comply with ANSI B.16, all applicable sections, for dimensional requirements. All piping systems shall be designed and arranged for neat appearance, properly sloped for drainage and venting,

properly arranged, supported, guided, and anchored to provide complete flexibility, and to maintain the integrity of all systems without any damage or leaks during either hot or cold operating conditions. Piping shall be accessible and shall not be embedded in concrete structures unless embedment is unavoidable because of architectural or structural requirements. All valves and accessories shall be arranged in a systematic manner in places accessible for operation without the use of chains or additional operating platforms. Sleeves shall be provided wherever pipes pass through structures.

2.5.2 Piping Accessories

All required piping accessories shall be of sufficient size and provided to assure trouble-free balancing and operation of all piping systems.

These accessories shall include, but not be limited to, strainers, vent cocks, dirt and drip legs with drain and flush connections, refrigerant dryers, liquid flow indicators, balancing cocks, relief valves, and pressure and temperature gauges. All piping accessories requiring maintenance or replacement shall be located in accessible places. All dials of gauges and indicators shall be of sufficient size and arranged to be easily seen and read from operating floor levels. Piping expansion joints shall be selected to provide for not less than 150 percent of the calculated traverse.

2.6 PLUMBING AND DRAINAGE

All plumbing and drainage systems will be in accordance with the codes and regulations required in paragraph 2.2 above.

2.6.1 Plumbing Fixtures

Plumbing fixtures in all transit station toilet rooms shall be installed to accommodate physically handicapped people in wheelchairs. All wall hung fixtures shall be supported by standard chair supports.

All hose bibbs inside buildings and stations shall be installed in walls in stainless steel boxes with flanges flush with wall. All exterior hose bibbs shall be

installed in exterior walls in brass boxes with flanges flush with wall. All station lavatory faucets shall be of the spring loaded type.

2.6.2 Plumbing Fixtures Connections

All services and piping connections for plumbing fixtures shall be sized and installed in accordance with Table IV-2-1.

TABLE IV-2-1

SERVICES AND PIPING CONNECTIONS FOR

PLUMBING FIXTURES

Fixture	Fixture Symbol	Soil or Waste	Trap	Vent	HW Pipe	CW Pipe	Remarks
Water Closet Hung	WC	4"	Integral	2 "	no	1"	Wall
Lavatory Hung	LAV	1½"	1¼ x 1½"	1½"	3/8"	3/8"	Wall
Mop Service Basin	MS	3"	3"	1½"	1/2"	1/2"	Floor Mounted
Drinking Fountain	DF	1½"	1¼ x 1½"	1½"	no	3/8"	Wall Mounted
Hose Bibb	HB	no	no	no	no	3/4"	Flush with Walls
Floor Drain	FD	3"Min.	3"	1½"	no	no	Near or in Battery Room
Eye Wash/ Body Shower	-	no	no	no	no	1¼"	

2.6.3 Drains

All floor, area, and roof drains shall be of bottom outlet type wherever possible. Where space is not adequate to use bottom outlet drains, drains with side outlets may be substituted. All drains used in membrane waterproof floors and roofs shall be provided with flashing collars securely clamped to the waterproof membranes. Drains shall be provided as follows:

A. Floor drains shall be provided in and at lower pit of surface-to-mezzanine escalators, and in all ancillary rooms except Incoming Service Rooms.

B. Area drains shall be provided at station and building entrance areas and in vent shafts.

C. Track drains inside transit system stations shall consist of concrete drainage slots, concrete catch basins, and concrete manholes with cast iron gratings at 120-foot centers. No traps or vents shall be required for the track drainage system.

2.6.4 Traps

All traps shall be of plain pattern having a seal of not less than 2-1/2 inches and not greater than 4 inches. All traps shall be of material specified for the piping system to which they are connected. All exposed traps in toilet rooms shall have chromium finish.

2.6.5 Cleanouts

Cleanouts shall be provided on all soil, waste, and drain lines for each pair of 45 degree bends and for each 90 degree bend, and for each 75 feet of straight run, except track drainage for which maintenance of the drain pipes shall be through the catch basins. All cleanouts brought to finished floors shall terminate with removable cleanout brass covers, flush with the floor. Cleanout sizes shall be the same as the pipes served up to and including 4 inches, 4 inches on pipes up to and including 6 inches, and 6 inches, on all pipes larger than 6 inches.

2.6.6 Valves

Isolation valves shall be provided on the inlet side of each water heater, on each pressure main at building entrances, on each pressure branch of distribution mains, at each plumbing fixture (except where several units installed in a battery, one isolation valve shall be adequate) on both sides of in-line accessories, and equipment that require removal or isolation from pressure for maintenance. All valves for water and compressed air shall be made of bronze, with screwed ends up to 2 inch sizes, and all iron, with flanged ends for 2-1/2 inches and larger sizes.

2.6.7 Piping Accessories

All piping accessories that are required to make all systems trouble free shall be provided. These accessories shall include, but not necessarily be limited to, vacuum breakers, backflow preventers, shock absorbers and water hammer arresters, strainers, pressure reducing valves, safety relief valves, balancing cocks, drain and drip legs for gas and compressed air systems, moisture traps for compressed air, pressure and temperature gauges, etc.

2.6.8 Plumbing Equipment

Due consideration shall be given to performance, noise, durability, standardization, and handling characteristics when selecting equipment for the plumbing systems. All equipment selected for the plumbing systems shall be manufacturer's standard and cataloged product suitable for competitive bidding.

A. Electric Water Heaters

All electric water heaters used shall be of storage type, 30 gallons minimum storage, with 100°F recovery capacity sized for plumbing fixture demand. Heaters shall be glass-lined and equipped with fast acting immersion heating element, temperature and safety controls, and thermal insulation. Unit shall be suitable for 3-phase power supply.

B. Sewage Ejector Stations

Sewage ejector stations shall be of pneumatic type utilizing duplex ejector units. Each ejector unit shall be equipped with a cast iron sewage receiver designed for 50 psi working pressure, an air-cooled air compressor, interconnecting air piping and controls, sewage inlet and discharge piping with corrosion resistant check valves and isolation valves, air exhaust piping and controls, mechanical level controls, electric controls, and interlocks for the air compressor. All interconnecting air piping, control valves, sewage inlet and discharge valves, piping, and accessories shall be supplied by the ejector equipment supplier in subassemblies for field installation. The sizes and capacity shall be based on total head calculated for one ejector operating. The minimum size of any unit shall be 30 gpm capacity with 4 inches minimum sewage discharge and 2 inches minimum air exhaust. Each ejector unit shall operate automatically from local mechanical level controls and supervised from Central Control.

Abnormally high sewage levels in the receiver shall be annunciated to Central Control. Where units are installed in a concrete pit, the depth of each shall be selected to allow the upper flanged opening on the sewage receiver (the opening provided for the mechanical level control) to project above the rim of the pit. All automatic control devices, valves, and accessories requiring maintenance or replacement shall be located above the rim of the ejector pit. The bottom of the ejector pit shall be sloped to one corner where a pump and a submersible centrifugal sump pump shall be provided to return any leakage back to the sewage inlet pipe. The sewage return sump pump shall be controlled automatically by a mechanical float and through a local "on-off-automatic" switch. An electric probe to detect liquid in the ejector pit shall be located in this sump and wired for annunciation to Central Control.

C. Station Drainage Pump Stations

Each drainage pump station shall consist of a concrete wet well with two nonclog sewage pumps, or a wet well with two submersible pumps. Water level

controls, electric pump "on-off-automatic" switch, level rise indicator to annunciate at Central Control, and connections to street mains shall be provided.

Pump Rating - Each pump shall be sized for 100 percent of drainage volume including infiltration. Minimum pump capacity shall be 500 gpm.

Pump Head - To suit static and friction heads of each installation. Friction head shall be calculated with both pumps operating.

Pump Type - Nonclog sewage type.

Pump Clearance - To pass 2 inch solids.

Pump Speed - 1750 rpm maximum.

Electric Motor - Nonoverloading at any point of pump curve.

2.6.9 Plumbing Systems

A. Potable Cold Water Systems

Each passenger station shall be served with building mains sized for the total plumbing fixture demand. The domestic water service shall be provided with a pressure reducing valve when city pressure at the lowest point of use inside the structure is higher than 70 psig. The reducing valve shall be located on the discharge side of main shutoff valve immediately inside the building wall. Sizing of the domestic water lines shall be based on maintaining uniform pressure at plumbing fixtures located at the same level, to minimize shock and water hammer, and to maintain a minimum of 25 psig pressure at each flush valve. All pipe lines shall be run in a systematic manner, parallel and at right angles with walls, and properly pitched for drainage. Shock absorbers and water hammer arrestors shall be provided for long pipe runs and branches with flush valves. In addition to the station main shutoff valve, isolation valves shall be provided in branch lines and for each station floor level to facilitate maintenance in individual areas without losing service for the

entire facility. Pressure reducing valves and backflow preventers shall be provided where the potable water system is connected to automatic makeups.

B. Potable Hot Water Systems

Potable hot water systems for each passenger station shall include water heaters, circulating hot water pumps, hot water distribution piping, and pipe accessories. All hot water pipes shall be sized for the simultaneous fixture demand with a minimum pipe size of 3/4 inches when serving more than a single fixture. All pipes shall be arranged in a systematic manner, and provisions made for thermal expansion and drainage. All hot water pipes shall be insulated. Isolation valves shall be provided for all branches to facilitate maintenance.

C. Soil and Waste System

The soil and waste system for each underground passenger station shall include soil and waste piping from all plumbing fixtures and floor drains (except area drains and floor drains in equipment rooms), sewage ejector stations, and ejector discharge piping. All soil and waste pipes shall be sized for fixture demand as required by applicable plumbing codes and ordinances.

D. Vent Systems

Complete vent systems shall be provided for all soil and waste systems and sized in compliance with applicable plumbing codes and ordinances. All horizontal vent pipes shall be kept as short as possible, pitched at 1/4 inch per foot toward soil and waste pipes, then rise to the outside in the most direct way. Each vent riser shall be properly flashed at roof penetration and terminated by a vandal-proof vent cap.

E. Drainage Systems

Drainage systems shall include track area drains in passenger stations, area drainage for entrance areas, and drainage for vent shafts. Track drainage pipes

inside passenger stations shall be pitched at 1/4 inch per foot whenever possible but not less than 1/8 inch per foot. No vents or traps shall be required for the track drainage system. Floor drains from mechanical equipment rooms shall be connected to the track drainage system without traps and vents. Floor drains from the cold air plenums of the station air-conditioning system shall be connected to the track drainage system through a deep seal trap, vented and automatically primed to maintain a positive seal for the air plenum. No mechanical equipment drain shall be connected directly into any drain system. Indirect drain connectors with air gap shall be used. Oil separators shall be installed where required by code.

3. RESERVED

VOLUME IV, SECTION 3

(Reserved)

SYSTEM DESIGN CRITERIA AND STANDARDS

VOLUME: IV SECTION: 4

REVISION RECORD

NOTICE NUMBER	CR NO/REV	DATE APPROVED	AFFECTED	COMMENTS
1	3-025A/1	1/25/85	Table of Contents (added) List of Tables 4.2 A,I 4.3 p 4.4 4.5.1. B,G,H,I 4.5.2. A,B 4.6.2 4.6.4. A,B 4.7.1 4.7.2 A,B,C 4.8.2 B 4.8.3. 4.8.4 A,C 4.9 A,B 4.11 D,F 4.12 A,B,C,E 4.13.1 A,B,C 4.13.2 B,C 4.13.4 B 4.13.8 A 4.13.9 A,B 4.13.10 B 4.13.12 4.14.1 A,B 4.14.2 4.14.3 A,B,C,D 4.14.4 B 4.15 4.16.1 4.18.E 4.19.3	Replaces 9/1/83 issue Spelling, punctuation and format corrections

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SYSTEM DESIGN CRITERIA AND STANDARDS

VOLUME: IV SECTION: 4

AUXILIARY ELECTRICAL SYSTEMS
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1	3-025A/1	1/25/85	4.20.1 4.20.3 4.20.4 TABLE IV-4-2	
2	5-076	9/27/85	4.5.2.A 4.8.3	
3	6-014/	6/10/86	4.8.2.A 4.8.3	P.6 P.6
4	6-037/	7/7/87	4.16.2	P.19
5	7-017/	10/26/87	4.15 4.16.2	P.18 P.19

SCRTD METRO RAIL SYSTEM DESIGN CRITERIA

Volume IV, Section 4

AUXILIARY ELECTRICAL SYSTEMS

VOLUME IV, SECTION 4, AUXILIARY ELECTRICAL SYSTEMS

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VOLUME IV, SECTION 4 AUXILIARY ELECTRICAL SYSTEMS

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VOLUME IV, SECTION 4

AUXILIARY ELECTRICAL SYSTEMS

4.1 GENERAL

This section lists the requirements for the design, installation, and operation of all lighting and auxiliary electrical equipment throughout the SCRTD Metro Rail system.

4.2 SCOPE

These criteria cover all auxiliary electrical power systems required to serve the following:

A. Lighting, including parking lots and other exterior Metro Rail-related lighting.

B. Heating, ventilating, and air conditioning equipment

C. Escalators, elevators, and other mechanical equipment

D. Fare collection equipment

E. Communications systems

F. Train control equipment

G. Emergency power system

H. Illuminated signs

I. Alarm systems

J. Television and public address systems

K. Sump pumps

L. Tunnel fans and dampers

M. Yard and shop services

N. Wayside structures

O. Traction power control battery charger

4.3 DOCUMENTS

Auxiliary power systems shall conform to applicable sections of the following standards and codes:

A. Electrical codes of the cities and the counties through which the transit system will operate

B. Regulations imposed by the California Public Utilities Commission, Transit Districts Safety Branch

C. State of California Electrical Safety Orders, Title 8

D. State of California Administrative Code, Title 24

E. Los Angeles City and County Fire Department Ordinances

F. American National Standards Institute (ANSI)

G. Insulated Cable Engineers Association (ICEA)

H. Institute of Electrical and Electronics Engineers (IEEE)

I. Illuminating Engineering Society Handbook (IES)

J. National Electrical Code (NEC)

K. National Electrical Manufacturers Association (NEMA)

L. National Electric Safety Code (NESC)

M. National Fire Protection Association Handbooks (NFPA)

N. Cal/OSHA Standards

O. Uniform Building Code (UBC)

P. Underwriters Laboratories Inc. (UL)

4.4 CLASSIFICATION OF LOADS

Nonessential: Includes all loads not classified essential or critical. Such loads shall be backed up by an automatic primary transfer to an alternate independent

source but may be disconnected if necessary during emergency conditions.

Essential: Loads which can tolerate an interruption for the time required for a transfer switch or circuit breakers to operate. Such loads shall be backed up by an automatic transfer to an alternate independent source and shall not be disconnected.

Critical: All essential loads that cannot tolerate any interruption longer than 1/4 Hz. Such loads shall be served by a battery or Uninterruptible Power Supply System (UPS).

4.5 ESSENTIAL AND CRITICAL LOADS

4.5.1 Essential Loads

A. Elevators

B. Tunnel lighting normal power source

C. Emergency ventilation fans and dampers

D. Station duplex sump pumps

E. Tunnel duplex sump pumps

F. Fare collection equipment

G. UPS system

H. Train control system

I. Communication system.

4.5.2 Critical Loads

A. Alarm, supervision systems, and control power for all critical loads including medium voltage and low voltage switchgears.

B. Emergency lighting in passenger stations, rectifier substations, and tunnels

C. Exit signs

D. Fire protection system

4.6 SERVICE TO FACILITIES

4.6.1 Passenger Stations

A. Service for stations shall be provided by two independent separate primary power sources and shall terminate in an incoming service room. Switching and metering equipment in this room shall be provided by the serving utility.

B. The power service to each station having a traction power substation located nearby shall be supplied by the same primary feeders supplying the traction power substation.

C. Stations not having a traction power substation nearby shall be supplied by two independent separate primary feeders from the serving utility.

4.6.2 Emergency Fan Shafts

Fan shafts within 1,200 feet of a passenger station shall be supplied from two full capacity feeders at 480 volts, emanating from essential bus of the passenger station.

These feeders shall be routed in separate ducts encased in concrete, with one circuit in each track tunnel when twin bores are used. Remote shafts shall be supplied by two independent feeders directly from the utility source.

4.6.3 Tunnel Duplex Sump Pumps

Sump pumps located at station and tunnel low points shall be fed by individual 480-volt, 3-phase "essential" branch circuits routed to the pumps from two separate sources.

4.6.4 Tunnel Lighting and Convenience Outlets

A. Tunnel Lighting

Each tunnel shall be lighted by fixtures spaced at approximately 20-foot intervals throughout the tunnels. Fixtures shall be shielded to eliminate glare to train operators. The wiring shall be arranged so that every other fixture shall be wired

to two lighting circuits at one end of the tunnel segment, and the remaining fixtures shall be wired to two circuits at the other end. The circuits at each end shall provide for fixtures to be connected to the critical circuit.

B. Tunnel Convenience Outlets

Duplex 120 volts, 20 amperes convenience outlets shall be provided at 200-foot intervals.

4.7 STATION AUXILIARY POWER SYSTEM

4.7.1 Power Source

The electrical equipment rooms shall include space for locating the power utility metering equipment (if required), motor control center for nonessential and essential loads, panelboards for lighting and general power distribution, all necessary dry type transformers, and UPS system.

4.7.2 Power Distribution

A. Power supplied to each passenger station shall be terminated in 480 volt, 3-phase, 3-wire switchboard located in an electrical equipment room. The switchboard shall provide circuit breakers for distribution to loads within and adjacent to the station.

B. Nonessential and essential buses shall be established at each switchboard. Essential buses at each switchboard shall be supplied by two redundant feeders connected to the 480 volt switchgear at a substation.

C. In general, stations shall have two electrical equipment rooms, one at each end of the station.

4.8 UNINTERRUPTIBLE POWER SUPPLY

4.8.1 Requirements

Equipment for which a power interruption of greater than

1/4 cycle duration may cause a malfunction shall be classified as critical loads, requiring a UPS. The UPS shall include a rectifier charger, battery, inverter, and high-speed static transfer switch.

4.8.2 Battery and Charger

A. The battery, rated as required, shall supply the critical loads and the normal dc loads. The battery shall have sufficient capacity to carry the full UPS load continuously for two hours after utility-supplied power failure, with a final terminal voltage of not less than 1.75 volt per cell. A separate battery room, adequately ventilated, shall be provided.

B. The battery charger shall be a silicon rectifier type with adequate capacity to supply power to the inverter at full rated output and to charge the battery from a completely discharged condition in no more than twelve hours. It shall have an adjustable charge rate for equalization, and shall provide a "no charge" indication to the supervisory control system.

4.8.3 Inverter

The inverter shall be solid state, dc input to 277/480 volts, 3-phase, 4-wire, 60 Hz ac output, powered from the stationary battery.

4.8.4 Static Transfer Switch

A. An automatic high speed static transfer switch shall transfer the vital panel load to the essential bus in the event a fault occurs in the inverter. This transfer shall occur in less than one quarter cycle.

B. Operation of the transfer switch shall be indicated on the supervisory control system and alarm panels.

C. Any attempted retransfer from the bypass essential bus to the inverter shall be limited to two unsuccessful attempts.

4.8.5 Backup Generator

A manual transfer switch as well as the feeder and

receptacle shall be provided at street level for connection to a mobile generator, when the accident duration is extended longer than 2 hours.

4.9 SUPPLY VOLTAGES

A. Ac power for general facilities shall be supplied at nominal 480 volts, 3-phase, 3-wire, 60 Hz. Other nominal voltages shall be obtained by use of dry type transformers.

B. The rated voltages of the equipment shall be as follows:

1.	Fluorescent lighting	277 volts	single phase
2.	Incandescent lighting	120 volts	single phase
3.	HID lighting	277 volts	single phase
4.	Convenience outlets	120 volts	single phase
5.	Motors 1/2 to 250 HP	460 volts	three phase
	under 1/2 HP	115 volts	single phase
6.	Motor control	120 volts	single phase
7.	Heaters 1800 watts and over	480 volts	three phase
	Up to 1800 watts	120/240/volts	single phase, 3 w single phase
	Up to 200 watts	120 volts	
8.	Dry type transformers	480 v delta to 480/277 v	three phase four wire
		480 v delta grounded to 480 v wye non-grounded	three phase three wire
		480 v to 120/208 v	three phase four wire
9.	Auxiliary service to tie breaker stations	480 volts	three phase

10.	Fare collection equipment	120 volts	single phase
11.	Train control equipment	120/208 volts	three phase 4-wire, grounded neutral
12.	Communications equipment and alarm systems	120/208 volts	three phase 4-wire, grounded neutral
13.	Electric clocks	120 volts	single phase
14.	Exit signs	120 or 277 volts	ac (normal)
15.	Tunnel lighting	480 volts	single phase

4.10 MOTORS

In general, the motors for driven equipment shall be drip-proof, squirrel cage induction motors, NEMA Design B, unless the application requires other classifications. The enclosures shall be selected to suit the environmental conditions.

4.11 MOTOR CONTROL

A. In general, circuit breaker combination starters in motor control center type construction shall be used for the 460 volts motors. However, individually mounted circuit breaker combination starters may be used where practicable.

B. All starters shall be magnetic, full voltage start, single speed, nonreversing type, except tunnel fans and other driven equipment where characteristics require other types. Each starter shall be equipped with a 120 volts control transformer and three thermal overcurrent relays. Tunnel fans shall utilize only magnetic trip type circuit breakers and shall not be interrupted by thermal overload relays.

C. Where lock-out type stop buttons and a start button or "on-off-auto" switch are required, such control stations shall be provided near each motor.

D. In general, enclosures for local motor starter shall be NEMA Type 4 except where environmental conditions make other types more suitable.

E. Wiring for motors shall be sized in accordance with the data shown in NFPA 70, unless voltage drops require larger sizes.

F. Motor Control Center shall be a freestanding NEMA Class 2 Type B construction, 3-phase, 3-wire, 480 VAC, with ground bus.

4.12 WIRING METHODS

A. Wiring within facility areas shall, in general, be in conduit or ducts. Cable trays may be used in areas where approved by the District.

B. In tunnels, all power and lighting feeders shall be routed in metallic conduits.

C. Dual vent shaft fan and/or sump pump in tunnels circuits shall be routed with one circuit in each single bore tunnel or on opposite sides of a single bore double track tunnel otherwise supplied by two independent feeders from the utility source.

D. Expansion fittings shall be used where raceways pass through expansion joints.

E. When the raceway is installed through the floor or wall penetration, a sealing compound, with fire retardant rating and specially manufactured for the electrical system, shall be used to finish the surface to architectural requirements.

4.13 MATERIALS

Materials used shall conform to the following:

4.13.1 Conduit

A. Rigid, double dipped, hot galvanized steel or aluminum conduit shall be used for all exposed work in dry areas not likely to present corrosion problems. These conduits shall also be embedded in slabs where protection against electromagnetic interference is required, and in slabs subjected to high impact.

B. Nonmetallic electrical conduit shall be used for all conditions and locations except those specified above in 4.13.1.A.

C. Rigid nonmetallic conduit shall be used for below-ground use, encased in concrete, or for applications where rigid metallic conduit is not applicable and the resistance to impact and crushing of the nonmetallic conduit is acceptable. Examples of the application are for enclosing dc positive feeder conductors which run from the traction power substation to the contact rail, the negative return conductor between the running rails and the traction power substation negative bus, and all cables embedded in tunnel inverts.

D. Rigid nonmetallic conduit shall not be used for the support of lighting fixtures.

E. Flexible liquid-tight conduit shall be used for final connections to all motors, using a minimum 18 inches length.

F. The minimum size conduit used throughout the system shall be 3/4 inch for exposed, and 1 inch for all embedded installations.

4.13.2 Wire and Cable

A. Ground Wire

Ground wire shall be stranded bare copper unless other types are required for specific purpose. Any deviations must be approved. Ground wire shall, in general, be sized as required for the application and as specified in the National Electrical Code.

B. Power and Control Circuits

Wire for power and control circuits shall use copper

conductors, stranded, AWG rated at 600 volts. Minimum size conductors shall be #14 for control, and #12 AWG for all power circuits. Insulation shall be, as a minimum, type XHHW, in single or multiple conductor construction. Wiring at high temperature areas should be suitable for 150°C use. Cables used for all emergency fans, dampers, etc. shall pass the flame propagation test under IEEE 383.

C. Fixture Wires

Fixture wires shall be type SF-2 #16 AWG minimum with braided insulation or type BF, fluorinated ethylene propylene insulation.

4.13.3 Cable Trays

Cable trays shall be galvanized steel, ladder type, for power cables, and with solid bottoms for control cables. Cable trays with solid bottom should have a layer of approved insulation for the cable to rest upon.

4.13.4 Receptacles

A. Convenience outlets shall not be on lighting circuits except in tunnels, and there shall be no more than 8 receptacles per 120 volts circuit in track and public areas, and no more than 6 receptacles on each 120 volts circuit in service areas.

B. Specification grade 20 amperes, 120 volts, ground type, duplex convenience outlets shall be provided for receiving plug-in type equipment. The receptacles in the station mezzanine and platform areas shall be lockable and tamper-proof type. Weatherproof covers shall be provided in all receptacles. Receptacles in tunnels shall be provided with ground fault protection.

C. Convenience outlets shall be located as follows:

1. Public Areas:

   These shall be spaced so that no more than 50 feet of cord will be required to reach any point from the convenience outlets.

2. Service Areas:

   There shall be a minimum of one outlet for each 30 feet of wall inside the service rooms, or closer where indicated by special operational requirements.

3. Line Structures:

   A convenience outlet shall be located at each signal bonding point, each location, and at 200-foot intervals in tunnels.

4. Vent, Fan, and Access Shafts:

   These shall be equipped with convenience outlets so that any point in the shaft at track or grade level can be reached with a 50-foot cord.

4.13.5 Switches

Specification grade wall switches shall be installed inside, near the door, to control lighting in all ancillary rooms: Switches shall be "T" rated, 20 amperes at 277 volts, silent type.

4.13.6 Pushbutton Stations

In general, motor control pushbutton stations shall have watertight enclosures, and the number and arrangement of control buttons required for the service.

4.13.7 Disconnect Switches

All motor circuits shall have a separately mounted nonfusible disconnect switch only where required by the National Electrical Code and shall be within sight of the motor. These shall be heavy duty safety type having an enclosure suitable for the area in which installed. Elevator or escalator disconnect switches shall be fused in accordance with local codes.

4.13.8 Lighting Transformers

A. Lighting transformers shall be dry type Class H with standard taps on the high voltage winding. Transformers shall be 3-phase or single phase as may be appropriate. They shall be wall mounted with sound isolation mounting pads.

B. Noise levels shall not exceed the following values when measured in accordance with ANSI standard C.89.2:

1	- 9	KVA	40 dBA
10	- 50	KVA	45 dBA
51	- 150	KVA	50 dBA
151	- 300	KVA	55 dBA
300	- 500	KVA	60 dBA

4.13.9 480 Volts Switchgear, Switchboards, and Motor Control Centers

A. Switchgear and Switchboards

1. All switchgear and switchboard shall conform to NEMA Standard PB-2 and shall have buses braced to withstand the available short circuit duty without damage.

2. Protective devices shall consist of power circuit breakers, electrically operated, with control arranged to prevent paralleling of two sources, but to automatically transfer to backup supply upon less of voltage on normal supply.

3. Interrupting capacity shall equal or exceed prevailing short circuit duty but shall not be less than 50,000 amperes rms symmetrical at 480 volts.

4. Where applicable, provisions shall be made for mounting instrument transformers and metering equipment.

5. Quantity of breakers shall be selected as necessary to supply the connected loads.

B. Motor Control Centers

1. All motor control centers shall conform to NEMA Class II construction and shall have buses braced to withstand adequate short circuit current.

2. Protective devices shall consist of conventional molded case circuit breakers of adequate interrupting capacity and short circuit capacity. Motor starters shall be a combination type with accessories as shown on the elementary diagrams. All units, except size 6 motor starters, shall be drawn-out modules and equipped with terminal blocks for control cables. Quantity of branch circuit breakers shall meet design requirements and shall include space for future breakers of at least 15 percent of the total number of breakers used initially.

4.13.10 Panelboards

A. General

1. Separate panelboards nonessential, essential shall be provided as necessary for nonessential, essential critical circuits, and dc distribution. They shall be surface mounted in general, except where flush mounting is better suited to the location as determined by the Engineer.

2. Each panelboard shall bear a clearly identifiable code designation such as a prefix letter, N, S, E, or W, indicating location served from the panelboard. For example, panelboard "NP" would serve the north end of a station platform area.

   All circuits shall be identified with the panelboard protecting the circuit. For example, circuit "NP3" shall be protected by #3 breaker on panelboard "NP".

3. Panelboards shall include spare breakers for future loads, and shall be equipped with buswork and terminations to accept additional breakers.

4. The following guide selection of panelboard sizes shall be used:

Active Single Pole Breakers	Spare Singe Pole 20 A Breakers	Panel Size Single poles
Up to 6	2	12
6 to 12	4	18
12 to 18	4	24
18 to 24	6	36
24 and up	6	42

B. Circuit Breakers

1. The 120 volts panelboards shall be equipped with 20 amperes single pole breakers rated, minimum, 10,000 amperes symmetrical interrupting capacity.

2. The 480/277 volts panelboards shall be equipped with 20 amperes or larger branch breakers rated 14,000 amperes minimum symmetrical interrupting capacity.

4.13.11 Power Transformers

Auxiliary power transformers shall be dry-type when used indoors and dry or oil filled type when used outdoors. Construction shall be in accordance with applicable sections of NEMA standards.

4.13.12 Voltage Drop

A. Maximum voltage drop for feeders and branch circuits shall not exceed the following:

1. Lighting branch circuits - 3 percent

2. Electric heating circuits - 3 percent

3. Motor branch circuits - 3 percent

4. All feeder circuits - 2 percent

B. Voltage drop calculations for motor circuits shall be based on an 80 percent power factor, lagging. For lighting and heating circuits voltage drop

calculations shall be based on 90 percent PF lagging.

4.14 SERVICE REQUIREMENTS FOR ANCILLARY SPACES

4.14.1 Train Control and Communications Equipment Room

A. The Train Control and Communications equipment located at each station and midline vent shaft shall be fed from the two 480V feeders supplied from separate power sources. Voltage conversion as well as ac distribution system shall be covered in Volume V, Sections 2 and 3.

B. Equipment requiring ac power, when not located at a station or midline vent shaft, shall be fed from the nearest UPS, supplied from two separate services.

4.14.2 Traction Power Substation

Traction power substations shall receive auxiliary power from the 480-volt ac switchboard in the auxiliary power room.

4.14.3 Mechanical Equipment Rooms for Underground Stations

A. Station Emergency Fans

Electrical feeders shall be the same as described in paragraph 4.6.2, Ventilation Fan Shafts. Cable routing to each fan motor shall be designed such that a fire damage at one feeder shall not cause any damage to the cable of the other fan motor (see 4.6.2).

B. Station Supply Fans, Under Platform Exhaust Fans, and Smoke Exhaust Fans

Station Supply Fans, underplatform exhaust fans and smoke exhaust fans shall be fed from essential buses supplied from dual power sources.

C. Ancillary Mechanical Equipment Rooms

1. The following loads shall be fed from the 480 volts, 3-phase, essential bus from the nearest

auxiliary power room:

a. Communication/train control room HVAC and fans

b. Station sump pump

c. Sewage ejector pump

d. Auxiliary Power Room fans.

2. The rest of electrical loads shall be fed from 480 volts, 3-phase, 3 wire, nonessential bus at the nearest auxiliary power room. These loads are:

a. Miscellaneous exhaust fans

b. Power receptacles.

D. Chiller Plant

Feeders from 480 volt, 3-phase, 3-wire nonessential buses at the auxiliary power room shall be provided. This feeder shall supply power to the complete chiller plant equipment and be comprised of:

a. Chillers (Chiller starters)

b. Cooling tower

c. Oil pump

d. Condenser water pumps

e. Chilled water pumps

f. All controls 120 V ac.

4.14.4 Mechanical Equipment Rooms for Aerial and Above Ground Stations

A. Ancillary Mechanical Equipment Room

Follow same practice as in the underground stations, as appropriate.

B. Mezzanine Area

A 480 volt, 3-phase, 3-wire feeder shall be run from the nonessential bus in the electrical equipment room and terminated in the grouped control center located in the mezzanine area. This feeder shall have sufficient capacity to supply the ancillary loads of the station mezzanine.

Note: Requirements will vary with each station. The designer shall determine specific requirements during final design.

4.15 FARE COLLECTION AND STATION FARE COLLECTION CONTROL UNIT (SFCCU)

Each station shall be equipped with a fare collection system and a fare collection control system. Local station control and monitoring shall be at the station fare collection control unit and remote monitoring/patron registering shall be by a data transmission system via the nearest communication interface cabinet. Two underfloor ducts for power and signal circuits, each with a minimum crosssection of 8.5 square inches, shall be installed underneath the fare gates and TVM and AFM arrays. Adequate junction boxes shall be provided wherever the raceways change directions. All other raceways shall be metallic conduits for signal circuits and for power circuits. Power supply to fare collection equipment shall be fed from the panelboard located in the nearest electrical room or spaces dedicated for electrical equipment.

4.16 ESTIMATED ELECTRICAL LOAD - STATION

Allowance shall be made for the following estimated loads until more specific data are available:

4.16.1 Station General

A. CCTV Monitors - general allowance 1200 watts

B. Air Conditioning and Ventilation 500 kW

4.16.2 Fare Collection Equipment @ 120 Volts, Single Phase

A.	Gates	each 600 watts
B.	Ticket vending machine	each 1200 watts
C.	Addfare machine	each 1200 watts
D.	Ticket reader	each 600 watts

Note: Fare collection equipment requirements will be determined in the design process.

4.16.3 Parking Lot Attendant's Booth (when required)

Heating and Controls	2,000 watts

4.16.4 Parking Lot Lighting

Lighting and Control	Varies

Note: The exact quantity of listed items shall be determined during final design.

4.17 SERVICE REQUIREMENTS FOR ESCALATORS AND ELEVATORS

The electrical power supply to each escalator or elevator machine room shall consist of a nominal 480 volt, 3-phase, 60 Hz supply terminated in a fused disconnect switch in the machine room. The electrical supply for machine area lighting shall be 120/208 volts and shall terminate in a suitable lighting panel. The 120/208 volt service shall be sufficient for 5 KVA per unit. An

emergency lighting circuit will be routed to the machine room. Emergency control power at 120 volts single phase shall be provided from the nearest critical loads panelboard.

The final designer shall provide conduits, wiring, disconnect switches, panels, and transformers to furnish the services to each machine room or pit. The escalator or elevator contractor shall furnish all extensions of such services within the escalator wellway, elevator shaft or machine room and furnish all lighting, controls, heating, and power utilizing devices necessary to complete the installation.

4.18 GROUNDING

A. The ground conductor of the serving utility service shall be connected to the grounding electrode or ground bus in accordance with local code requirements.

B. The facility ground bus shall be designed and established to maintain a resistance to ground measurement of not more than 2 ohms by the "fall of potential" method.

C. A copper ground bus of appropriate section and length shall be installed in the electrical rooms on the inside wall, connected to the above grounding network with bare copper cable.

D. The noncurrent carrying parts of all electrical equipment, devices, panelboards, and metallic raceways shall be bonded to the ground bus.

E. Instrument grounding system at automatic train control and communication room(s) shall be by an insulated ground wire and separate from the equipment grounding system. Provision shall be made for eliminating high voltage spikes between the two grounding systems and installed in auxiliary power room.

4.19 LIGHTING SYSTEMS

4.19.1 Station Lighting

Refer to Volume III, Section 12, Lighting, for criteria for lighting of stations and adjacent areas.

4.19.2 Tunnel Lighting

In general, tunnel area illumination levels shall be 1.5 footcandles, minimum average maintained, over the tunnel walkways. In tunnel trackway crossover locations the illumination level shall be 3 footcandles, minimum average maintained.

4.19.3 Lighting Control

Lighting in tunnel areas shall be controlled by means of breakers in essential and critical lighting panels.

4.19.4 Emergency Lighting

Emergency lighting requirements are given in the Fire/ Life Safety Criteria, Volume I, Section 2.

4.20 EQUIPMENT OPERATION SUPERVISION

4.20.1 General

Under normal conditions, Central Control shall remotely perform the essential operation supervision and control functions for the auxiliary electrical systems equipment at each Metro Rail facility. This shall be accomplished from the power control center at Central Control, through elements of the data transmission system (DTS) and cable transmission system (CTS) located at each facility (see Volume V, Section 3, Communications). The SCADA shall provide the interface between Central Control and the auxiliary electrical systems equipment.

Local controls and annunciation (alarm indication) shall also be provided at each facility to permit standby supervision and control of the equipment.

4.20.2 Functions

Tables IV-4-1 and IV-4-2 list the various local and remote supervision control functions for the auxiliary electrical systems equipment.

4.20.3 Communications Interface Cabinet (CIC)

A communications interface cabinet (CIC) shall be installed in the room at each facility to provide an interface between the DTS and auxiliary electrical system. Control, status indication, and annunciation elements of the auxiliary electrical systems and other station facilities will be connected to terminals of the interface cabinet.

The cabinet shall be of a steel construction, indoor type; it shall be provided with terminal blocks mounted on an interior panel within the cabinet. All the supervisory control interface connections shall be made at these terminal blocks.

These cabinets may be used to terminate the supervisory control circuits of systemwide procurement subsystems, such as public address system, fire protection systems, telephone systems, etc., and will be called Communication Interface Cabinet at future contracts.

4.20.4 Local Annunciation

Local annunciation (alarm) panels shall be provided at each facility in the main electrical rooms. The annunciator panel will provide local trouble indication and remote annunciation at Central Control through the communications interface cabinet.

The local annunciator panel shall be wall- or floor-mounted. The annunciator relays shall be of the electromechanical or solid-state type, with individual alarm signal indicators having back-lit nameplates. A control power isolation switch shall be provided. The panel shall be designed to operate from a 125 volts dc control power source. Local alarms at the panel shall be annunciated by means of a flashing indication, together with an audible warning. Local annunciation panel may be substituted by the annunciation supplied with the motor control center.

Table IV-4-1

LOCAL AND REMOTE SUPERVISION AND CONTROL FUNCTIONS

AUXILIARY POWER PRIMARY DISTRIBUTION SUBSYSTEM

Function	Control		Indication	
	Local	Remote	Local	Remote
SWITCHING				
High-Voltage Ac Switchgear				
Incoming Service Circuit Breakers			X	X
Feeder Circuit Breakers	X	X	X	X
Low-Voltage Ac Switchgear				
Incoming Line Circuit Breakers	X	X	X	X
Feeder Circuit Breakers	X	X	X	X
ALARMS				
Auxiliary Power System Trouble			X	X
Control Battery Voltage Low			X	X
Substation Ambient Temperature High			X	X
Utility Supply Voltage High/Low			X	X
High-Voltage Ac Switchgear Bus Voltage High/Low			X	X
Low-Voltage Ac Switchgear Bus Voltage High/Low			X	X
Low-Voltage Power Distribution Transformer				
Cooling Fan Failure			X	
High-Temperature (Alarm)			X	
High-Temperature (Trip)			X	
High-Voltage Circuit Overcurrent			X	
Low-Voltage Circuit Overcurrent			X	
Lockout				X

Table IV-4-2

LOCAL AND REMOTE SUPERVISION AND CONTROL FUNCTIONS

AUXILIARY POWER SECONDARY DISTRIBUTION SUBSYSTEM

Function	Control		Indication	
	Local	Remote	Local	Remote
ALARMS				
Distribution Switchboards				
Main Circuit Breakers	X	X	X	X
Essential Load Bus on Standby Power Source			X	X
Essential Load Bus Voltage Low			X	X
Nonessential Load Bus Loss of Power			X	X
Main Circuit Breakers Lock-out			X	X
Motor Control Centers (MCC)				
Bus Voltage Low			X	
Motor Circuit Tripped			X	
MCC Trouble				X
Essential Loads Panelboards				
Bus Voltage Low			X	
Feeder Circuit Tripped			X	
Essential Loads Panelboard Trouble				X
Uninterruptible Power Sources				
Normal Power Source Failure			X	
Battery Voltage Low			X	
Battery Charger Failure			X	
Inverter Failure			X	
Distribution Panelboard Voltage Low			X	
Feeder Circuit Tripped			X	
UPS Trouble			X	X

Table IV-4-2 (Cont'd.)

Function	Control		Indication	
	Local	Remote	Local	Remote
480V Essential Loads				
Emergency Fans	X	X	X	X
Station Ventilation Fans	X	X	X	X
Smoke Exhaust Fans	X	X	X	X
Under Platform Exhaust Fans	X	X	X	X
Sump Pump Trouble			X	X
Station Temperature High			X	X
Traction Power Ventilation Trouble			X	X
Tunnel Lighting Failure			X	X
Emergency Management Panel Activated			X	X
Intrusion Alarm Activated			X	X
Fire Panel Activated			X	X

SYSTEM DESIGN CRITERIA AND STANDARDS

VOLUME: IV SECTION: 5

REVISION RECORD

NOTICE NUMBER	CR NO/REV	DATE APPROVED	AFFECTED	COMMENTS
1	4-081	10/31/84	5.2.1 D 5.2.8 A 5.3.2.1 D 5.3.2.2 E 5.3.4.2 B	
2	5-010	02/13/85	5.2.1 D	

VOLUME IV, SECTION 5 CORROSION CONTROL

CONTENTS

VOLUME IV, SECTION 5

CORROSION CONTROL

5.1 GENERAL

This section describes design criteria for the control of corrosion for all aspects of the Metro Rail Project. Corrosion control criteria have been established to reduce, or eliminate, material degradation and deterioration to the degree that the following objectives will be met.

A. To realize the design life of Metro Rail facilities by avoiding premature failure caused by corrosion.

B. To minimize annual operating and maintenance costs associated with material deterioration.

C. To maximize continuity and safety of operations by reducing or eliminating corrosion related failures of Metro Rail facilities and subsystems.

D. To minimize detrimental effects to Metro Rail facilities, and to facilities belonging to others, caused by stray earth currents generated by operation of the system.

5.1.1 Scope

These criteria shall apply to all aspects of the Metro Rail Project. Corrosion control design may include specific requirements from each of the following categories:

A. Stray current corrosion control.

B. Underground (or soil) corrosion control.

C. Atmospheric corrosion control.

5.1.2 Applicable Documents

Corrosion control design shall conform to the following regulations, codes and laws as well as all applicable local or city laws, codes or statutes.

A. U.S. Department of Transportation, Regulations for the Transportation of Natural (or other) Gas by Pipeline, Parts 191 and 192, Title 49

B. U.S. Department of Transportation, Regulations for the Transportation of Liquids by Pipeline, Part 195, Title 49

C. Uniform Fire Code

D. National Fire Protection Association, Flammable and Combustible Liquids Code

E. California Pipeline Safety Act of 1981, Assembly Bill 911

Where no city or state codes are applicable, the standards, recommended practices and guidelines of the following regulatory and advisory agencies shall be followed:

A. National Association of Corrosion Engineers (NACE) - Recommended Practices

B. American Association of State Highway and Transportation Officials (AASHTO)

C. American Society for Testing and Materials (ASTM)

D. American Water Works Association (AWWA)

E. National Electrical Manufacturers Association (NEMA)

F. Steel Structure Painting Council (SSPC)

5.1.3 System Interfaces

Corrosion control design shall interface with the following design criteria.

VOLUME IV, SECTION 5 CORROSION CONTROL (Cont'd)

A. Volume I - Systemwide

I-2	Fire/Life Safety
I-5	System Assurance

B. Volume II - Civil/Standard

Civil

II-1.7.6	Trackway Drainage
II-1.7.7	Undertrack Structures
II-1.8	Trackwork
II-1.9	Utilities
II-1.10	Drainage

Structural

II-2.4	Underground Structures
II-2.8	Reinforced and Prestressed Concrete
II-2.12	Miscellaneous Structures
II-2.13	Plumbing
II-2.14	Drainage

Yard

II-3.7	Yard Facilities
11-3.10	Shops
II-3.12	Test Track

B. Volume III - Stations

III-10	Heating, Ventilation and Air Conditioning
III-13	Materials/Finishes
III-14	Power
III-20	Train Control

C. Volume IV - Mechanical/Electrical

HVAC

IV-1.11	Chilled, Condenser and Hot Water Distribution Piping

Plumbing

IV-2	Plumbing (entire section)

Auxiliary Electrical Systems

IV-4.13	Materials
IV-4.18	Grounding

Elevators/Escalators

IV-6.5	Elevator Criteria

Miscellaneous

IV-8	Miscellaneous Mechanical/Electrical Subsystems

D. Volume V - Subsystems

Passenger Vehicle

V-1.4	General Design Criteria
V-1.5	Carbody
V-1.6	Trucks and Suspension (under frame)

Automatic Train Control

V-2.3	Functional Requirements
V-2.4	General Design Criteria
V-2.6	Wayside Apparatus
V-2.9	Yard ATC Apparatus
V-2.10	Test Track ATC Apparatus
V-2.11	Maintenance and Test Provisions

Traction Power

V-4	Traction Power and Distribution (entire section)

5.2 STRAY CURRENT CORROSION CONTROL

5.2.1 General

All systems, subsystems and fixed facilities shall be designed to meet the following general criteria.

A. Stray earth current generated by normal system operations shall not exceed 0.20 ampere per 1,000 feet of system.

B. The positive and negative traction power distribution circuits shall have no direct or indirect electrical connections to earth.

C. Ancillary systems and equipment connected to either the positive or negative traction power distribution circuits shall contribute no more than 5% of the system earth conductance.

D. Water infiltration into the trackway area shall not come into direct contact with the rails, fasteners and/or conductive rail appurtenances during normal system operations. Tunnel, trackwashing operations and deluge fire protection system are not required to meet this criteria.

E. The traction power distribution system shall be separated into three electrically isolated sections; the mainline, the yard and the shops.

5.2.2 Traction Power Substations (Mainline)

A. Traction power substations shall be spaced at intervals such that track-to-earth potentials along the mainline will be within the range of -80 to +80 volts during normal operations.

B. Traction power substation equipment (transformer/rectifier units) shall not be used to provide power to both the Metro Rail line and surface streetcar (LRV) lines. Transformer/rectifier units and other equipment may be housed in the same room, with common AC power inputs, grounding facilities and other ancillary systems, provided the DC power circuits are electrically segregated.

C. An allocated wall space shall be provided within substations, for stray current monitoring in close proximity to the negative bus or an extension thereof, with an open conduit between the dedicated wall space and negative bus if required. This space shall be six feet wide, seven feet high from the floor and twelve inches deep with access.

D. Electrical access, through ground level facilities shall be provided to the negative bus at each substation for future stray current testing by the utility operators.

E. Provisions to continuously monitor track-to-earth potentials, using permanently installed recorders shall be included at the following locations:

- Union Station TPSS
- 5th and Hill Passenger Station
- Wilshire and Normandie Passenger Station
- Wilshire and La Brea TPSS
- Fairfax and Santa Monica TPSS
- Hollywood Bowl TPSS
- North Hollywood TPSS
- Yard TPSS

F. Equipment shall be installed on each track, at each traction power substation to periodically measure track-to-earth resistance using rail voltage drop and rail-to-earth potential techniques.

5.2.3 Positive Distribution System (Contact Rail Systemwide)

A. The positive distribution system shall have a minimum in-service resistance-to-earth of 10 million ohms per 1,000 feet of contact rail. Individual contact rail insulators shall have a minimum resistance of 1,000 megohms.

B. The positive distribution system shall be operated as an electrically continuous bus with no breaks, except during emergency or fault conditions, and the intentional electrical segregation of yard, shop and mainline traction power distribution systems.

C. There shall be a barrier coating or dielectric gasket installed between the contact rail metallic support plates and the surface of the concrete support pedestals to prevent the direct interchange of leakage current between the support plate and the concrete.

5.2.4 Negative Distribution System (Mainline)

A. The mainline running rails, including special trackwork and all ancillary system connections shall have a minimum in-service resistance of 500 ohms per 1000 feet of track (2 rails). Individual mainline rail fixation fasteners shall have a minimum resistance of 10 megohms dry.

B. Track crossbonds shall be provided between mainline inbound and outbound tracks as follows:

1. At each traction power substation.

2. Within 500 feet of station platforms if not covered by (1) above.

5.2.5 Yard

A. The yard/mainline traction power segregation point shall be located such that all track on the mainline side of the segregation point is electrically insulated from earth and meets the criteria of section 5.2.4.

B. The yard traction power substation shall include provisions for emergency interconnection to the mainline traction power system.

C. The following minimum provisions shall be included in the yard traction power substation:

1. Dedicated wall space in close proximity to the negative bus, with internal conduit routing to the bus. This space shall be six (6) feet wide, seven (7) feet high from the floor, twelve (12) inches deep with access.

2. Access to the dedicated wall space from one or more conduits terminated at a manhole(s) located outside the perimeter of the substation near existing underground pipelines that may require stray current drainage (see 5.2.9.3.A5).

D. Yard track shall include the following minimum provisions:

1. Electrical insulation at all interconnects to existing railroad track.

2. Use of high-resistivity, well drained ballast material.

3. A minimum of 1-inch clearance between the ballast material and all metallic surfaces of the rail and of metallic track components in electrical contact with the rail.

4. All dead-ended tracks shall have the negative power rail crossbonded to other negative power rails within ten feet of the end of the track.

5. All dead-ended tracks shall have insulated joints installed to isolate bumping posts or similar devices that are electrically grounded.

6. Crossbonding negative feeder cables shall utilize a main cable run (possibly several cables) with taps to negative power rail(s) as opposed to long runs of individual cables connected to single negative power rails.

5.2.6 Maintenance Shop

A. Shop traction power shall be provided by a separate dedicated DC power supply electrically segregated in both the positive and negative circuits from the yard traction power system.

B. Shop track shall be electrically grounded to the shop building and shop grounding system.

C. Shop track shall be electrically insulated from yard track by the use of rail insulating joints. Actual locations of insulators shall ensure that parked vehicles will not electrically short the shop to the yard for periods of time longer than that required to move a vehicle in or out of the shop.

5.2.7 Water Drainage and Infiltration

A. Tunnels shall be designed to prevent water from dropping or running onto the contact rail, negative rails and rail appurtenances.

B. Mainline water drainage systems shall be designed to prevent water accumulation from contacting the rails and rail appurtenances.

C. Yard water drainage systems shall be designed to prevent water accumulation around ties and rail appurtenances.

D. Shop water drainage systems shall be designed to prevent water accumulation around the rail insulating joints immediately off the shop apron.

5.2.8 Tunnel and Passenger Stations

A. Reinforcing steel in the tunnel and passenger station inverts shall have electrical continuity. Minimum requirements shall include the following:

1. Welding of all longitudinal lap splices.

2. Welding of all longitudinal members to transverse members at intervals not exceeding 500 feet.

B. Segmented steel tunnel liners shall have electrical continuity within and between segments installed below the concrete invert.

C. Test reference electrodes shall be installed at maximum intervals of 1,000 feet through the tunnel wall most removed from the adjacent tunnel. This criterion does not apply to passenger stations.

D. Precast segmented concrete tunnel liners shall have permanent access to a section of steel reinforcing within the segment. This access point shall be located adjacent to the test reference electrodes described in C. above.

E. Electrical test stations shall be installed, in pairs, on the fabricated steel tunnel liners. Minimum requiements shall include the following:

1. Three-hundred feet (300') between individual test points within a pair.

2. One-thousand feet (1,000') between test station pairs.

5.2.9 Utility Structures (Piping and Conduits)

5.2.9.1 General

A. All piping and conduit shall be non-metallic unless metallic facilities are required for specific engineering purposes.

B. There are no special provisions required if non-metallic materials are used.

5.2.9.2 Metallic Facilities - Mainline

A. Pressure or non-pressure piping exposed within the tunnel structure or embedded in the invert shall not require special provisions.

B. Pressure piping that penetrates the tunnel or station walls shall be electrically insulated from the outside piping to which it connects and from watertight wall sleeves. Electrical insulation of interior piping from outside piping shall be made on the interior of the tunnel or station.

C. All buried pressure piping outside of the tunnel and station structures shall include the following minimum provisions.

1. Electrical continuity through installation of a minimum of two (2) copper wires across mechanical joints.

2. Permanent, test/access facilities, to allow for verification of electrical continuity, minimum of two, installed at intervals no greater than 200 feet.

D. All buried pipes shall be installed at normal utility depths, not exceeding ten (10) feet. When necessary, to meet this requirement, pipes shall be installed in vent shafts, utility chases or other vertical passageways.

5.2.9.3 Metallic Facilities - Yard

A. All buried pressure piping shall include the following minimum provisions for stray current control.

1. Electrical continuity through installation of copper wires, minimum of two, across mechanical joints.

2. Electrical insulation from interconnecting piping and other structures, including metallic casings.

3. Electrical separation of the piping into discrete insulated sections through use of insulating joints depending upon the length of the piping.

4. A protective coating with a minimum resistivity of 10^{10} ohm-centimeters to all external pipe surfaces in contact with soils. Coating shall have an established performance record for the intended service.

5. Facilities to drain stray currents from the piping to the yard traction power substation. Minimum requirements shall include conduits and cables routed from the piping to the substation (see 5.2.5.C2).

6. Permanent test/access facilities to allow for verification of electrical continuity installed at all insulated connections and at intervals no greater than 200 feet.

B. All metallic fencing surrounding the yard perimeter shall be made electrically continuous.

C. All existing abandoned pipelines which pass through the yard shall be excavated and a minimum of two feet of pipe removed just inside the yard perimeter fence.

5.2.9.4 Metallic Facilities Shop

A. All reinforcing and structural steel and rails within the shop building shall be electrically connected to a common grounding grid.

B. All pressure piping within the shop building or perimeter of the shop steel reinforcing grid shall have the following minimum provisions:

1. Electrical insulation from interconnecting pressure piping located outside the shop building or perimeter of reinforcing grid.

2. Electrical insulation from watertight wall/floor sleeves.

3. Electrical connection to the common ground grid at sufficient locations such that there will be only negligible potential differences between the piping and grounding network during fault or normal operating conditions.

C. All exposed non-pressure piping and electrical conduits within the shop building shall include the following minimum provision:

1. Electrical connection to the building grounding network in accordance with NEC at sufficient locations such that there will be only negligible potential differences between the piping or conduit and the grounding network during fault conditions or normal operations.

5.2.9.5 Facilities of Other Than SCRTD Ownership

A. Except as may be established by individual owners, no stray current control provisions are required for non-SCRTD facilities along the mainline.

B. All existing, replaced or relocated non-SCRTD facilities adjacent to the yard shall be reviewed to determine the need for test facilities and possible stray current corrosion mitigation.

5.3 SOIL CORROSION CONTROL

5.3.1 General

A. The control of corrosion of buried facilities in contact with the soils and ground waters shall be based on the following considerations:

1. Material of construction: provisions shall be required for all ferrous and concrete materials. All piping and conduit shall be non-metallic unless metallic facilities are required for specific engineering purposes. Aluminum and its alloys shall not be used for direct burial purposes.

2. Location within transit route: provisions shall be required for all facilities and structures that are located at such depths or in areas where maintenance is not practical or prohibitive because of inaccessibility.

3. Safety and continuity of operations: provisions shall be required for all facilities, regardless of location or material of construction when

failure of such facilities caused by corrosion will affect safety or interrupt continuity of operations.

B. Individual facilities must be reviewed to determine the need for, and extent of possible additional requirements, not established by these criteria.

5.3.2 Concrete and Reinforced Concrete Structures

5.3.2.1 Precast Segmented Conrete Tunnel Liners in Soil Contact

Corrosion control shall include the following minimum provisions:

A. Use of sulfate resistant Type V Portland cement.

B. A maximum water/cement ratio of .37 by weight.

C. Use of an air entrainment admixture resulting in a maximum air content of 6% by volume.

D. Limit chloride concentration in mixing water to a maximum of 200 ppm.

E. Application of an epoxy coating to the outer layer of steel reinforcing within precast segments installed between the yard portal and Wilshire/Crenshaw passenger station. Coating shall have an established performance record for the intended use.

F. Application of a waterproof coal-tar epoxy or phenolic protective coating, with a minimum resistivity of 10^{10} ohm-centimeters, to the external surfaces. Coating to withstand exposure to a pH of 3 and anticipated construction handling such that no more than 5% of the coated surface area per panel is damaged. Coating shall have an established performance record for the intended use.

G. Minimum of 1-inch of concrete cover over steel reinforcing on the external surface of the segment.

5.3.2.2 Cast-in-Place Reinforced Concrete in Soil Contact

There are no special or minimum provisions for concrete in contact with soils within the yard area. Concrete used in other areas, along the mainline shall include the following minimum provisions:

A. Sulfate resistant Type V Portland cement shall be used on all structures south and east of Wilshire/ Fairfax passenger station.

B. Sulfate resistant Type II Portland cement shall be used on all structures north and west of Wilshire/ Fairfax passenger station.

C. Maximum water/cement ratio of .40 by weight.

D. Use of an air entrainment admixture resulting in a maximum air content of 5.5% (maximum aggregate size of 1.5-inches) by volume.

E. Limit chloride concentration in mixing water to a maximum of 200 ppm.

F. Minimum 2-inches concrete cover on the soil side of all steel reinforcement when the concrete is poured within a form or a minimum 3-inches cover when the concrete is poured directly against soils.

5.3.2.3 Concrete Not in Contract With Soils

A. Maximum 200 ppm chloride concentrations shall be used in mixing water for concrete not in contact with soils.

5.3.3 Segmented Steel Tunnel Liners

The following minimum provisions shall be included with steel tunnel liner design.

A. Application of a flake-glass polyester protective coating and waterproof barrier, with a minimum resistivity of 10^{10} ohm-centimeters, to the soil contacting sides of liner segments. Coating shall have an established performance record for the intended service.

B. Provisions to allow for installation of cathodic protection after construction. Minimum requirements shall include:

1. Electrical continuity, both radically and longitudinally, of all steel segments beneath the invert.

2. Anode installation ports through the segment walls.

3. Dedicated space for future rectifier installation in crosspassages and/or station areas.

5.3.4 Piping and Conduits

5.3.4.1 Pressure Piping

A. All SCRTD owned buried cast iron, ductile iron and steel pressure piping installed along the mainline shall be cathodically protected. Minimum provisions for protection shall include the following:

1. Application of a protective coating with a minimum resistivity of 10^{10} ohm-centimeters to the external surfaces of pipe. Coating shall have an established performance record for the intended service.

2. Electrical insulation from interconnecting piping, other structures, and segregation into discrete electrically-insulated sections depending upon the total length of the piping.

3. Electrical continuity through installation of copper wires, minimum of two (2), across all mechanical joints.

4. Permanent test/access facilities to allow for verification of continuity, effectiveness of insulators and coating, and evaluation of protection levels, installed at all insulated connections and at intervals no greater than 200 feet.

5. Impressed current anodes and rectifier units or sacrificial anodes. Number of anodes and size of rectifier shall be determined on an individual structure basis.

B. Minimum provisions for buried copper piping shall be determined for each installation on an individual basis taking into account local soil characteristics and the piping to which the copper connects. Design of corrosion control systems shall be accomplished on an individual installation basis.

C. Reinforced or prestressed concrete pressure pipe installed within the yard area shall include continuity bonds for each pipe joint, and longitudinal shorting straps for prestressed pipe. Minimum provisions required for this piping along the mainline portion of the system shall include the following:

1. Application of a protective coal-tar epoxy coating with a minimum resistivity of 10^{10} ohm-centimeters to the external surfaces to provide an electrical and waterproof barrier. Coating shall have an established performance record for the intended service.

2. Water/cement ratio within the range of .22 to .30 by weight for the cement mortar coating.

3. Maximum of 200 ppm chloride concentration in the mixing water.

4. Use of sulfate resistant Type V Portland cement or Type II cement with a sulfate resistant pozzolan additive.

5. Electrical continuity by installation of continuity bonds for each pipe joint, and inclusion of longitudinal shorting straps for prestressed concrete pipes.

5.3.4.2 Gravity Flow Piping (Non-Pressured)

A. Corrugated steel piping shall include the following minimum provisions:

1. Galvanizing of both interior and exterior surfaces. Galvanizing to weigh a minimum of 2.0 oz. per square foot of coated surface.

2. Application of hot-applied asphaltic protective coating, with a minimum resistivity of 10^{10} ohm-centimeters on both the internal and external surfaces. Coating to have an established performance record for the intended service.

B. Cast or ductile iron piping shall include the following minimum provisions:

1. Internal mortar lining with a bituminous seal coating on ductile iron only (not required for cast iron soil pipe).

2. A bonded protective coating or unbonded dielectric encasement on the external surfaces in contact with soils.

3. A bituminous mastic coating on the external surfaces of pipe six (6) inches each side of a concrete/soil interface.

C. Reinforced concrete non-pressure piping shall include the following minimum provisions:

1. Application of a bituminous seal coating to the internal and external surfaces.

2. Water/cement ratios meeting the minimum provisions of AWWA.

3. Maximum 200 ppm chloride concrentration in mixing water.

4. Use of sulfate resistant Type V Portland cement or Type II Portland cement with a sulfate resistant pozzolan additive.

5.3.4.3 Electrical Conduits

A. Buried metallic conduits shall include the following minimum provisions:

1. Galvanized steel with a PVC topcoat or other coating acceptable for direct burial, including couplings and fittings.

2. Galvanized steel with a minimum of 3-inches concrete cover on soil sides within duct banks.

3. Electrical continuity for all metallic conduits runs through use of standard threaded joints or bond wires installed across non-threaded joints.

5.3.5 Hydraulic Elevator Cylinders

A. Steel hydraulic elevator cylinders shall include the following minimum provisions:

1. Application of an external protective coal-tar epoxy coating with a minimum resistivity of 10^{10} ohm-centimeters and resistance to deterioration by petroleum products (hydraulic fluid). Coating shall have an established performance record for the intended service.

2. An outer concentric fiberglass-reinforced plastic (FRP) casing.

3. Silica sand fill between the cylinder and FRP casing with a minimum resistivity of 25,000 ohm-centimeters, a pH of between 7 and 7.5 and a maximum chloride concentration of 200 ppm.

4. Cathodic protection through the use of sacrificial anodes installed in the sand fill.

5. Permanent test facilities installed on the cylinder, anodes and earth reference to permit evaluation and activation of the protection system.

6. FRP casing shall be sealed against moisture intrusion prior to installation of hydraulic cylinder. Casing seal shall be removable to permit installation of hydraulic cylinder.

5.3.6 Testing

5.3.6.1 All underground corrosion control design shall include provisions and facilities for testing to insure compli ance with design specifications. Minimum testing shall include:

- Electrical continuity.
- Electrical insulation.
- Coating effectiveness.

5.3.6.2 All underground corrosion control systems shall include operational and activation tests to establish proper and effective functioning.

5.4 ATMOSPHERIC CORROSION CONTROL

5.4.1 General

Criteria for atmospheric corrosion control are based on preservation of appearance and reduction of maintenance costs. Systemwide criteria for all areas shall include the following:

A. Materials selection: Materials shall have established performance records for the service intended. Dissimilar metal couples shall be avoided. Nonmetallics shall be used unless metallics are required for specific engineering purposes.

B. Sealants: Sealants shall be used in crevices and material recesses to prevent the accumulation of moisture.

C. Protective Coatings: Barrier or sacrificial type coatings shall be used on exposed metals.

D. Design: Use of dissimilar metals and recesses or crevices that may trap moisture shall be avoided wherever possible.

5.4.2 Metals and Coatings Exposed to Weather

5.4.2.1 Steels and Ferrous Alloys

A. Carbon steels, alloy steels, weathering steels, cast or ductile irons exposed to the atmosphere outside the tunnel area shall have a barrier and/or sacrificial type coating applied to all external surfaces.

B. Stainless Steels

Stainless steels used for above grade service shall meet the following minimum requirements:

1. Series 200, 300, or chromium-molybdenum ferritic types shall be used for exposed surfaces in unsheltered environments and where appearance is critical or a necessary consideration.

2. Columbium/titanium stabilized grades, or extra low carbon grades shall be used when welding is required.

3. A barrier type protective coating shall be used only when appearance is critical.

4. Stainless steel surfaces shall be cleaned and passivated after fabrication.

5. Ordinary series 400 stainless steels shall be used in sheltered areas only, or where appearance is not critical. (This restriction does not apply to the chromium - molybdenum ferritic types.)

5.4.2.2 Aluminum and Aluminum Alloys

Aluminum and aluminum alloys exposed to the weather shall have a sealed hard anodized finish.

5.4.2.3 Copper and Copper Alloys

All copper and copper alloys shall have a barrier type coating applied only where the natural patina is not desired or where there will be intermittent contact with acid rain or fog.

5.4.2.4 Magnesium Alloys

All magnesium alloys shall have a barrier type coating applied when long term appearance is critical.

5.4.2.5 Coatings Exposed to the Weather

Coatings shall have an established performance record for the intended service and be compatible with the base metal to which they are applied.

A. Steel and Ferrous Alloys

Primer and topcoat systems shall be compatible and supplied by the same manufacturer. Wash primers shall be used on stainless steels. Suitable generic coatings are as follows:

1. Hot dip galvanizing.

2. Flame sprayed zinc/vinyl seal coat.

3. Aluminum coatings.

4. Flame sprayed aluminum/vinyl seal coat.

5. Inorganic zinc, as a primer only with a vinyl or epoxy topcoat.

6. Fusion-bonded epoxy, polyester, polyethylene or nylon.

B. Non-Ferrous Metals

Coatings for non-ferrous metals shall consist of compatible primer and topcoat, supplied by the same manufacturer. The following provisions shall be included with all coatings:

1. Wash primers shall be used on copper and copper alloys, and magnesium alloys.

2. Topcoats shall consist of epoxy, where appearance is not critical, or with an additional topcoat of polyurethane for appearance.

3. Fusion-bonded epoxy, polyester, polyethylene, or nylon shall be applied by fluidized bed or electrostatic spray methods.

5.4.3 Below Grade Metals and Coatings (Inside Tunnels and Stations)

5.4.3.1 Steels and Ferrous Alloys (Excluding running rails and fasteners)

A. Carbon steels, alloy steels, weathering steels, cast or ductile irons, including those items which will be exposed to intermittent immersion or contact (splash) with seepage water, shall be coated using a sacrificial primer and heavy build barrier type topcoat.

B. Internal surfaces of segmented steel tunnel liners shall be coated with an inorganic zinc primer and a protective topcoat system with an established performance record for the intended service and capable of meeting all restrictions imposed by Volume I, Section 2, Fire/Life Safety.

C. Stainless Steels

Stainless steels, including those exposed to intermittent contact with seepage waters, shall include the following minimum provisions:

1. Type 304, 316, 317, 444, Carpenter 20 or higher grade shall be used. Where stains or discoloration is not acceptable, series 300 shall be used.

2. Coatings shall not be used when continuous contact or complete immersion in seepage water is anticipated.

5.4.3.2 Aluminum and Aluminum Alloys

A. Aluminum alloys exposed to seepage water shall be resistant to acid chloride stress corrosion cracking. Suitable alloys include 2024-T8, 2219-T6, 2219-T8, 6061-T6, 7075-T73, 7075-T736.

B. Anodized aluminum (finish A4X) exposed to seepage water shall have a barrier coating.

5.4.3.3 Copper and Copper Alloys

A. Barrier type coatings shall be used when exposure to seepage waters is anticipated.

B. A heat cured or thermosetting lacquer shall be used when discoloration is not permitted.

C. Brass alloys with a zinc content greater than 15 percent shall not be used in areas where exposure to seepage waters is anticipated.

5.4.3.4 Hardware Specific Items Used Inside Tunnels

A. Steel fasteners and steel bolt recesses used with precast segmented concrete tunnel liners shall be galvanized and shall have a mastic topcoat applied after assembly. Galvanizing shall be a minimum of 2 oz. per square foot of coated surface.

B. Electrical Equipment and Enclosures

1. There are no special or minimum atmospheric corrosion control criteria for these facilities provided they are located in an air-conditioned environment.

2. Facilities located in a non-air conditioned environment and not exposed to seepage waters

shall include one or more of the following minimum provisions.

a. A sacrificial primer and a barrier topcoat shall be used on steel and ferrous surfaces.

b. Unsealed cabinets shall be internally heated to prevent condensation.

c. Non-oil immersed internal metallic components shall be coated with a barrier topcoat.

d. Vapor phase inhibitors shall be used on sealed cabinets and enclosures where the seal is maintainable.

3. Facilities located in a non-air conditioned environment and exposed to seepage waters shall include one or more of the minimum provisions of section 5.4.3.4.B above and the following:

a. Non-metallic or stainless steel enclosures and fasteners shall be used wherever possible.

b. Standard manufacturers finish or uncoated galvanized steel fittings shall not be used.

C. Exposed steel electrical conduits shall be galvanized. Conduits shall have a ¼-inch separation to concrete surfaces. Conduit fastener surfaces contacting concrete surfaces shall have a barrier coating.

D. Pumps used for drainage water ejection systems shall have a barrier coating applied to all exterior steel surfaces. Impellers and internal parts shall have non-metallic linings suitable for the intended service.

5.4.3.5 Coatings - Below Grade Service (In Tunnels and Stations)

A. General

Coatings for use on metals located in tunnel and station areas shall be barrier type or sacrificial

coatings with established performance records for the intended service. Prolonged exposure or complete immersion will require additional consideration and possibly different coating systems based on separate review of the specific item.

B. Barrier Type Coatings

Coatings shall consist of a primer and suitable topcoat, or a self priming topcoat. Suitable generic coatings are listed in section 5.4.2.5.

5.4.4 Design and Mechanical Requirements

5.4.4.1 The following minimum provisions shall be included with the design of all facilities:

A. Crevices at joints and fasteners shall be avoided, otherwise a sealant shall be used.

B. Bimetallic couples shall be avoided, through design modification or use of a dielectric material between dissimilar metals.

5.4.4.2 Acceptable bimetallic couples, subject to review, are as follows:

- Aluminum/stainless steel
- Stainless steel/carbon steel
- Aluminum/zinc (galvanizing)

5.4.4.3 The following bimetallic couples shall be avoided through design modification or use of dielectric separators.

A. Aluminum/copper (except tinned metals used for electrical connections)

B. Copper/steel

5.4.5 Transit Vehicles

These criteria are directed towards reducing vehicle maintenance and enhancing vehicle appearance by reducing the affect of seepage waters that may contact the vehicles.

5.4.5.1 Outer Shell (Cladding Panels)

Stainless steels shall be series 200 or 300.

5.4.5.2 Structure

A. Anodized aluminum and stainless steel structural components not exposed to the weather or seepage waters do not require coating or other minimal corrosion control criteria.

B. Stainless steel shall be Type 304, 316 or equivalent grade. Aluminum shall be 5000 or 6000 series and anodized. Reduced fatigue strength of aluminum caused by anodizing shall be given consideration during design.

5.4.5.3 Underframe Components

A. Steel shall be coated with an inorganic zinc primer and an epoxy topcoat or flame sprayed aluminum with an epoxy topcoat.

B. Aluminum shall be anodized and coated with an epoxy primer and a topcoat.

5.4.5.4 Fasteners

A. Riveted joints shall have drilled holes and elastic panel seals to prevent fretting.

B. Fasteners shall be aluminum or stainless steel as follows:

Materials to be Joined	Fastener Material Required
Aluminum to aluminum	Aluminum or series 300 stainless steel
300 series stainless to 300 series stainless	300 series stainless steel
Aluminum to 300 series stainless steel	300 series stainless steel

SCRTD METRO RAIL SYSTEM DESIGN CRITERIA & STANDARDS

SYSTEM DESIGN CRITERIA AND STANDARDS

VOLUME: IV SECTION: 6

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SCRTD METRO RAIL SYSTEM DESIGN CRITERIA

Volume IV, Section 6

ELEVATORS AND ESCALATORS

Volume IV, Section 6, ELEVATORS AND ESCALATORS

CONTENTS

VOLUME IV, SECTION 6

ELEVATORS AND ESCALATORS

6.1 DESCRIPTION

The purpose of these criteria is to provide guidance in the selection of vertical circulation equipment in order to meet the system operational requirements, to provide reliable service, and to establish uniformity of design throughout the Metro Rail System.

A Central Control facility will contain the necessary displays, control consoles, communications apparatus, and operating personnel responsible for the overall safety and security of passengers and for the daily operations of the trains, stations, and all support system, including elevators and escalators.

The primary mode of vertical circulation in stations shall be escalators, the secondary mode shall be stairways, and the tertiary mode shall be elevators. The subsystem described herein consists of escalators and elevators.

Mezzanine-to-platform escalators are typically located parallel to the longitudinal axis of the station platform. The angle of inclination shall be 30 degrees from the horizontal, and the vertical rise shall vary depending on the station slope location and configuration, as shown in the General Plans and Standard and Directive Drawings.

The amount of elevator rise shall vary from station to station. Some elevators shall be located at the station platform, while other shall be in other locations, such as mezzanines and passageways, to reach street level.

6.2. APPLICABLE CODES

The codes of the State of California and the City of Los Angeles shall be followed for the design, fabrication, installation, and operation of elevators and escalators. These codes are:

A. City of Los Angeles Elevator Code.

B. State of California Administrative Code, Title 8, Chapter IV, Subchapter 6, Elevator Safety Orders, including Article 13, Escalators.

C. State of California Administrative Code, Title 19, Chapter I, Subchapter 1, General Fire and Panic Safety Standards; Subchapter 4, Fire Alarm Systems and Devices; Subchapter 8, Flame Retardants, Chemicals, Fabrics and Application Concerns.

D. State of California Administrative Code Title 24, Parts 2, 3, and 5.

E. United States General Services Administration Accessibility Standard.

Where no City or State Codes are applicable, the standards of the following regulatory and advisory agencies shall be followed:

A. American National Standards Institute (ANSI)

B. American Society of Civil Engineers (ASCI)

C. American Society of Mechanical Engineers (ASME)

D. American Society for Testing and Materials (ASTM)

E. California Public Utilities Commission (PUC)

F. Electronic Industries Association (EIA)

G. Insulated Cable Engineers Association (ICEA)

H. Institute of Electrical and Electronics Engineers (IEEE)

I. 1978 National Electrical Code (NEC)

J. National Electrical Manufacturers Association (NEMA)

K. National Fire Protection Association (NFPA)

L. Occupational Safety and Health Administration (OSHA) (Federal and State)

M. Underwriters Laboratories, Inc. (UL)

N. U.S. Department of Transportation (DOT/UMTA)

O. Life Safety Code - NFPA 101

P. Other city and county codes as applicable.

6.3 FUNCTIONAL REQUIREMENTS

6.3.1 Escalators

Escalators shall be the primary mode of vertical transportation in Metro Rail Systems Station. Their operation shall be continuous during system operating hours.

They shall be capable of transporting passengers safely and comfortably between station levels under the duty demands characteristic of transit operations. Operation shall be free of vibration, noise, and jerk. Emergency stops shall be accomplished smoothly and gradually to prevent passengers' loss of balance.

6.3.2 Elevators

Elevators shall provide vertical transportation between station levels for passengers in wheelchairs, elderly patrons, other disabled people, and equipment removal.

They shall operate on demand by means of call push buttons at the respective landings. Inside-the-cab operation shall be performed by the passenger by means of a push button station.

Operation shall be free of vibration, noise, and jerk. Emergency stops shall be accomplished smoothly and gradually.

6.4 GENERAL REQUIREMENTS

6.4.1 Transit-Specific Requirements

Escalators in transit use operate under conditions substantially more severe than in commercial establishments, handling thousands of patrons on a daily basis, and generally in large groups. Therefore, great care must be exercised to ensure that all elements are rugged enough to meet the usage demands, with a minimum of maintenance.

Elevators in transit use may experience less than commercial demands and are likely to be used largely by elderly and handicapped persons, who comprise a smaller percentage of the total patron requirements.

Life cycle should be considered in the selection of the supplier, to ensure quality of the equipment fabricated and to encourage design and installation for reduced maintenance cost.

6.4.2 Architectural Requirements

General architectural requirements are given in Volume III of the Design Criteria, and as shown in the Standard and Directive Drawings.

6.4.3 Seismic Requirements

Seismic requirements are given in Volume II of the Design Criteria.

6.5 ELEVATOR CRITERIA

6.5.1 General Considerations

Elevators shall be provided in each passenger station for the needs of those patrons who have mobility problems that preclude the use of escalators or stairs.

Elevator cab and enclosures shall be of the following configuration to permit visual observation of the cab interior:

A. Mezzanine to street level

1. Solid, opaque cab construction with glazed doors

2. Solid, opaque enclosure with glazed hoistway doors

B. Platform to mezzanine

1. Fully glazed cab construction with glazed doors

2. Fully glazed enclosure with glazed hoistway doors.

The elevator cab shall be lighted according to the requirements outlined in the Design Criteria, in Section 4 of this volume. An exhaust fan shall be provided, capable of circulating the air in the elevator cab. The cab interior shall provide minimum headroom clearance of 7 feet.

The elevator approaches, interior cab layouts, controls, and graphics shall be identical for all elevators throughout the system. Elderly and handicapped patrons and other elevator users should not have difficulty in orienting themselves in the system. Patrons shall be able to operate the elevators by using the cab controls or the call buttons at each landing. Central Control shall also be capable of operating the elevators. All directions for operating the elevator and calling the station attendant shall be written in English and Braille. A patron assistance intercom station will establish communication from the cab and from the landing to Central Control.

6.5.2 Service Life and Environment

Elevators shall have a design life of 30 years. Operation and maintenance costs are a prime consideration in determining total cost.

Technical specifications shall require that the elevators meet transit-specific requirements. The locations of

controls and machine rooms shall give adequate consideration to access, ease of maintenance, and vandal resistance. Enforceable specifications for reliability and availability shall reflect transit-specific requirements. Corrosion and fire protection, including fire suppression system, shall be provided.

6.5.3 Operating Requirements

An analysis of operational failure data and maintenance requirements of elevators shall be performed to establish their adequacy for transit usage.

Elevator cabs shall be sized to accommodate a stretcher, or one occupied wheelchair, or the largest unit of maintenance equipment that must be moved between levels. Clear dimensions should be based on the sizes shown on the Architectural Standard Drawings.

Elevator speed shall be 125 fpm.

6.5.4 Machine Rooms and System Elements

Adequate space shall be provided in machine rooms for installation and maintenance procedures as recommended by the manufacturer, including convenience outlets, lighting, and ventilation.

System elements shall include guide rails, speed governors, safety brakes, hydraulic lifts, pipes and pumps, cabs, and landing doors, all as appropriate to the particular design selected.

6.5.5 Operation

Each elevator car shall have a control panel with passenger-operated buttons to signal a stop at each landing, an emergency stop button, a key switch for operator control, and a key switch for fire department use. A duplicate set of controls shall be provided in the Emergency Management panel and Central Control Facility.

Each hoistway landing door shall have an "up" and/or "down" call button as appropriate.

6.5.6 Safety and Security

Elevator doors shall be interlocked to prevent their opening unless the car floor is within the legal code tolerance of each landing. Likewise, corridor doors shall not open unless the same condition is met. Hoistway door unlocking devices and car top emergency exit shall be provided as required by Code.

Comprehensive surveillance of elevator landing and door areas can have an impact in reducing vandalism and accidents. The effective use of closed circuit television (CCTV) and public address loudspeakers shall be determined in conjunction with the General Plans and in accordance with the Security Criteria, Volume I, Section 4.

Patron assistance intercom and P.A. in cabs, alarm bells, instructions in braille, and other requirements for the handicapped, shall be provided.

6.5.7 Reliability and Maintainability

A. Reliability

Elevator reliability is a major priority during the design of Metro Rail facilities. Elevators shall be installed to make the system or facility fully accessible to the elderly and handicapped patrons requiring special access provisions, as well as other patrons or SCRTD Personnel during the course of their duties.

Elevator reliability requirements shall be established considering that only single elevator installations shall be provided in many of the Metro Rail facilities and stations.

B. Maintainability

Elevator effectiveness will be obtained more economically through the application of maintainability design features (reduction in equipment repair time) than through reliability improvements (increases in the equipment mean time between failures).

Elevator availability shall be enhanced by a well planned and implemented maintenance program, which also results in a reduction of Mean Restoration Time (MRT).

Considerations in maintenance predictions shall include four different maintenance functions. The first two consist of scheduled services and the last two of unscheduled services.

1. Examination hours

2. Repair hours

3. Call backs, regular time

4. Call backs, overtime.

Examination hours shall be used to lubricate, adjust, and clean the equipment and its components during nonrevenue service.

Repair hours shall consist of time spent in replacing worn or damaged parts.

Emergency and call-back service on a 24 hour-a-day basis shall be provided and shall consist of time spent returning the equipment to service following service interruptions caused by activation of safety circuits or overload protection.

Refer also to the System Assurance Criteria, Volume I, Section 5.

To further enhance availability, an outside maintenance contractor shall be considered in the procurement and installation contract document.

6.5.8 Outline Dimensions

General outline dimensions and location of elevators shall be determined by the General Plans; and the Architectural Standard and Directive Drawings.

6.6 ESCALATOR CRITERIA

6.6.1 General Considerations

All escalators shall consist of a truss assembly, step-drive units, steps and step chains, driving machine and controller, safety devices, comb and deck plates, handrails and deck trim, newels and balustrades, balustrade lights, and other accessories and appurtenances. The sides and underside of the truss, exterior of the escalator, and machinery spaces shall be enclosed in stainless steel, as shown on the Architectural Standard and Directive Drawings.

Escalator safety devices shall, as required by code, include a safety brake activated if the step chains break or the step-chain tension drops below a predetermined level; a power supply cutoff to stop the escalator if it overspeeds by some fixed percentage; provision for automatic stopping if the direction of travel is accidentally reversed; provision for automatic stopping if the treads are separated from the comb plate or the interior skirt panels by a predetermined amount; emergency stop buttons at upper and lower landings; and a status monitoring control panel also located in the Central Control facility.

6.6.2 Service Life and Environment

Escalators shall have a design life of 30 years. Operation and maintenance (life-cycle) costs are a prime consideration in determining total cost.

Technical specifications shall require that the escalators meet transit-specific requirements, especially in the case of outdoor escalators. The locations of controls and machine rooms shall give adequate consideration to access, ease of maintenance, and vandal resistance. Technical specifications for reliability, availability, and maintainability of escalators shall be the prime consideration in the design of escalators.

6.6.3 Operating Requirements and Classification

Operating policy includes trade-offs between escalator time clock, direction controls, hours of operation, operating speed, and in-house versus contract maintenance.

Comprehensive surveillance of escalator areas can have an impact in reducing vandalism and accidents. The effective use of closed circuit television (CCTV) and public address loudspeakers shall be determined in conjunction with the Architectural Criteria, Volume III, and the Security Criteria, Volume I, Section 4.

Analysis of operational failure data and maintenance of escalators shall be performed to establish their adequacy for transit usage. A typical example is the development of escalators for lifts exceeding 20 feet.

When the escalator is undergoing repair, the treads shall remain in place in order for the escalator to function as an exitway.

Escalators shall be capable of operating at either 90 or 120 feet per minute (ft/min) and shall be reversible. The rated or nominal hourly capacity of escalators based on the indicated nominal width is:

Escalator Width, in.	Nominal capacity, passengers per hour	
	90 ft/min	120 ft/min
48	8000	9300

Tread illumination for escalators and adjoining stairs shall be provided by recessed lights in the balustrade. Specific lights as shown on the drawings shall be connected to the emergency circuit. Escalators shall have three classifications:

- Class A - up to 20 feet vertical height
- Class B - 20 feet to 60 feet vertical height
- Class C - over 60 feet vertical height

Escalators shall be designed to operate at 90 and 120 feet/minute and shall have level treads at top and bottom of runs as shown in the Architectural Standard and Directive Drawings.

6.6.4 Machine Space

Machines shall be provided with adequate space for installation and maintenance as recommended by the manufacturer, accessible for service, with lighting, convenience outlets, and ventilation. Drainage shall be provided in escalator pits.

6.6.5 Rated Loads and Structural Safety Factors

These factors shall be coordinated with the Structural Design Criteria, Volume II and the Architectural Design Criteria, Volume III.

6.6.6 Operation

Escalators shall be controlled from a set of start, stop, speed, and direction buttons located in the control panel in the machine room and at the upper and lower ends under a locked deck panel. Inside the panel the direction switch shall be key-operated. An additional switch shall be added to select automatic control. A duplicate set of controls shall be provided in the Central Control Facility and at the Emergency Management Panel.

6.6.7 Safety

Automatic safety devices that stop the escalator and activate an alarm shall be provided, including sensors to detect a limb or shoe caught in the combplate or by the handrail, and brakes to prevent motion when power fails. Step demarcation lights shall be provided inside moving steps in both landings.

The emergency stop buttons located at the upper and lower landings shall not be locked, and capable of being operated by anyone.

Refer also to the Safety Criteria, Volume I, Section 3.

6.6.8 Reliability and Maintenance

A. Reliability

Reliability is a key element in escalator operation because of its impact on passenger flow.

Projected usage for Metro Rail System escalators is 140 hours per week, which is substantially higher than usage factors for commercial installations. This could result in decreased reliability unless specific reliability requirements are established. Therefore, state-of-the-art MTBF and MTTR shall be investigated to establish a realistic reliability goal to be included as part of the procurement documents.

Refer also to the System Assurance Criteria, Volume I, Section 5.

B. Maintenance

Considerations in maintenance predictions shall include four different maintenance functions. The first two consist of scheduled services and the last two of unscheduled services.

1. Examination hours

2. Repair hours

3. Call back, regular time

4. Call backs, overtime.

Examination hours shall be used to lubricate, adjust, and clean the equipment and its components during nonrevenue service.

Repair hours shall consist of time spent in replacing worn or damaged parts. Components such as handrails, drive chains, and step chains shall be replaced periodically or when they wear out.

Emergency and call-back service on a 24 hour-a-day basis shall be provided and shall consist of time spent returning the equipment to service following service interruptions caused by activation of safety circuits or overload protection.

Refer also to the System Assurance Criteria, Volume I, Section 5.

6.6.9 Outline Dimensions

General outline dimensions and location of escalators shall be determined by the Architectural Design Criteria, Volume III, Section 23; the General Plans; and the Standard and Directive Drawings.

6.7 SCAVENGER PUMPS

Hydraulic pumping units with reservoirs of more than 20 gallons capacity shall be installed in pits with floor drains. A scavenger pump shall be fitted to the floor drain to collect hydraulic fluid leakage and return it to the reservoir, serving the dual function of avoiding spillage and recycling hydraulic fluid. The scavenger pump sending line shall have a particle filter and a water separator. Scavenger pumps shall be powered by 460 volts, 60 hertz, 3-phase electric motors.

6.8 PROTECTION

Fire Protection shall be provided as required by the Fire/Life Safety Design Criteria, Volume 1, Section 2.

SCRTD METRO RAIL SYSTEM DESIGN CRITERIA & STANDARDS

SYSTEM DESIGN CRITERIA AND STANDARDS

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SCRTD METRO RAIL SYSTEM DESIGN CRITERIA

Volume IV, Section 7

NOISE AND VIBRATION

VOLUME IV, SECTION 7, NOISE AND VIBRATION

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VOLUME IV, SECTION 7

NOISE AND VIBRATION

7.1 GENERAL INTRODUCTION

This document is intended to provide design criteria for all noise and vibration control problems relating to the construction and operation of the Southern California Rapid Transit District (SCRTD) Metro Rail System, excluding the transit vehicle noise and vibration specification.

The basic goals of these design criteria are to:

A. Provide transit system patrons with an acoustically comfortable environment by maintaining noise and vibration levels in vehicles along the way and in stations within acceptable limits.

B. Minimize the adverse impact of system operation and construction on the community by controlling transmission of noise and vibration to adjacent properties.

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

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

Community acceptance of construction noise and vibration requires that the contractors use machinery and equipment with efficient noise and vibration suppression devices and that other noise and vibration abatement measures be employed for protection of both employees and the public.

Providing a satisfactory and comfortable acoustical environment for patrons in station areas requires use of sound absorption materials on underplatform areas, platform level walls and ceilings, and the ceilings and

walls of mezzanine areas for control of noise and reverberation in the stations. Similarly, enclosed areas of above-grade stations, should have ceiling and, possibly, wall-mounted absorption materials. Overall control of station noise also requires inclusion of maximum noise limits in equipment specifications.

The criteria presented in this document are based upon scales that most closely correlate with subjective evaluation of noise. For most typical noise sources, it has been found that the A-weighted sound level gives good correlation with subjective evaluation of response to noise. Thus, the A-weighted sound level, which can be read directly from a sound level meter, is best for evaluating the response of people to the noise created by transit system operation and construction.

7.2 MEASUREMENT PROCEDURES AND ASSUMPTIONS

7.2.1 General

Unless otherwise indicated, all noise levels or measurements refer to the use of A-weighting and "slow" response of an instrument complying with the Type 2 requirements of the latest revision of American National Standard (ANSI) S1.4-1971, "Specification for Sound Level Meters" (Ref. 1).

All noise levels are expressed in decibels referenced to 20×10^{-6} Pa (0.0002 microbar) as measured with the A-weighting network of a standard sound level meter, abbreviated dBA.

7.2.2 Transit System Wayside Noise and Vibration Measurements

Transit wayside noise guidelines 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, vibration guidelines are based on measurements of vibration in the vertical direction on the ground surface or on building floors.

7.2.3 Construction Noise and Vibration Measurements

A. Measure construction noise in accordance with Section 7.2.1. In addition, all impulsive or impact noise levels or measurements refer to use of an impulsive sound level meter complying with the criteria of IEC 179 (Ref. 2) 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.

B. Noise levels at buildings affected acoustically by the Contractor's operations refer to measurements at points between 3 feet and 6 feet from building facades or building setback lines or a distance of 200 feet from the Construction Limits, whichever is closer.

C. Vibration levels at buildings affected by construction operations refer to vertical direction vibration on the ground surface or building floor, or 200 ft from the Construction Limits, whichever is closer.

D. Vibration levels at buildings affected by blasting operations refer to the 3-axis vector sum of vibration velocity on the ground surface or building floor, or 200 ft from the Construction Limits, whichever is closer.

7.3 COMMUNITY CATEGORIES AND RELATION TO CRITERIA FOR WAYSIDE NOISE AND VIBRATION

A wayside community noise impact criterion provides a basis from which to determine the type and extent of noise 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 passby 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.

The typical existing ambient or background noise and vibration levels vary significantly from one type of community to the next. Therefore, it is necessary to make a judgment as to the nature of the community in which the transit system is to be located before determining the appropriate criterion for permissible noise or vibration levels from the transit system in that community.

Table IV-7-1 indicates the five generalized categories of wayside areas into which the communities along the transit 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 several studies of rail transit corridor environments along with 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" (Ref. 3), and other field data obtained in many community areas in the U.S.A. and Canada.

Table IV-7-1

GENERAL CATEGORIES OF COMMUNITIES

ALONG METRO RAIL SYSTEM CORRIDORS

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

The categories defined in Table IV-7-1 are used in determining appropriate design criteria for the Metro Rail System noise and vibration. The land use or area categories presented above are similar to those used for other transit properties and presented in the APTA Publication, "Guidelines for Design of Rapid Transit Facilities" (Ref. 4). In most cases, experience with the new systems now in operation has indicated that these categories and the associated criteria provide for adequate results and most of the neighbors of the transit facility find the noise and vibration acceptable.

7.4 WAYSIDE NOISE AND VIBRATION DUE TO TRANSIT OPERATIONS

7.4.1 Airborne Noise from Above-Ground Train Operations

Table IV-7-2 presents design criteria for single-event maximum noise levels for airborne noise from transit trains for various types of buildings in each of the land use or area categories listed in Table IV-7-3. These criteria are generally applied to nighttime operations because the sensitivity to noise is greater at night than during 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 Table IV-7-2 are generally applicable at the nearside of the nearest dwelling or occupied building under consideration or at 50 ft from the track centerline, whichever is closer.

Table IV-7-2

CRITERIA FOR MAXIMUM AIRBORNE NOISE

FROM METRO TRAIN OPERATIONS

	Community Area Category	Maximum Single Event Noise Level		
		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 auditoriums, TV studios, schools, theatres, amphitheatres, and churches. Table IV-7-2 lists design goals for maximum airborne noise from transit operations in these areas.

Table IV-7-3

CRITERIA FOR MAXIMUM AIRBORNE NOISE FROM METRO TRAIN OPERATIONS NEAR SPECIFIC TYPES OF BUILDINGS

Building or Occupancy Type	Maximum Single Event Noise Level
Amphitheatres	65 dBA
"Quiet" Outdoor Recreation Areas	70 dBA
Concert Halls, Radio and TV Studios	70 dBA
Churches, Theatres, Schools, Hospitals, Museums, Libraries	75 dBA

7.4.2 Ground-Borne Noise from Train Operations

Table IV-7-4 presents the pertinent criteria for maximum ground-borne noise due to transit train operations for various types of residential communities. It is noted that ground-borne noise and ground-borne vibration are exactly the same phenomenon up to the point of perception at the dwelling. Ground-borne vibration describes waves in the ground which can be measured using vibration pickups mounted on sidewalks, foundations, basement walls, 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 into the room and thus can only be perceived inside buildings.

Wayside impact due to transit train vibration 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, but not every case, a criterion limiting audible noise levels will provide adequate protection again tactile ground-borne vibration levels.

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

Table IV-7-4

CRITERIA FOR MAXIMUM GROUND-BORNE NOISE

FROM METRO TRAIN OPERATIONS

Community Area Category		Maximum Single Event Noise Level		
		Single Family Dwellings	Multi-Family Dwellings	Commercial Buildings
I	Low Density Residential	30 dBA	35 dBA	40 dBA
II	Average Residential	35	40	45
III	High Density Residential	35	40	45
IV	Commercial	40	45	50
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 IV-7-5 presents design criteria for generally acceptable levels of transient ground-borne noise levels in occupied spaces of various types of buildings and occupancies. This table is not intended to be all inclusive but may be a convenient general guide to the designer.

Table IV-7-5

CRITERIA FOR MAXIMUM GROUND-BORNE NOISE

FROM METRO RAIL OPERATIONS NEAR

SPECIFIC TYPES OF BUILDINGS

Type of Building or Room	Maximum Single Event Noise Level
Concert Halls and TV Studios	25 dBA
Auditoriums and Music Rooms	30 dBA
Churches and Theatres	35 dBA
Hospital Sleeping Rooms	35-40 dBA
Courtrooms	35 dBA
Schools and Libraries	40 dBA
University Buildings	35-40 dBA
Offices	35-45 dBA
Commercial Buildings	45-55 dBA

Ground-borne noise which meets the design criteria listed above will not be inaudible in all cases, however, the level will be sufficiently low that no significant intrusion or annoyance should occur. In most cases, there will be noise from street traffic, other occupants of a building, or other sources, which will create intrusion that is equivalent or greater in level than the noise from transit trains passing by.

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

7.4.3 Ground-Borne Vibration from Train Operations

Table IV-7-6 presents the appropriate 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 IV-7-6

CRITERIA FOR MAXIMUM GROUND-BORNE VIBRATION

FROM METRO RAIL OPERATIONS

	Community Area Category	Maximum Single Event Ground-Borne Vibration Velocity Level (dB re 10^{-6} in/sec)		
		Single Family Dwellings	Multi-Family Dwellings	Commercial Buildings
I	Low Density Residential	70	70	70
II	Average Residential	70	70	70
III	High Density Residential	70	70	75
IV	Commercial	70	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 IV-7-7 presents design goals or generally acceptable levels of 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 IV-7-7

CRITERIA FOR MAXIMUM GROUND-BORNE VIBRATION

FROM TRAIN OPERATIONS

Type of Building or Room	Maximum Single Event Vibration Velocity Level (dB re 10^{-6} in/sec)
Concert Halls and TV Studios	65
Auditoriums and Music Rooms	70
Churches and Theatres	70-75
Hospital Sleeping Rooms	70-75
Courtrooms	75
Schools and Libraries	75
University Buildings	75-80
Offices	75-80
Commercial & Industrial Buildings	75-85
Vibration Sensitive Industrial or Research Library	60-70

Ground-borne vibration which meets 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, which will create intrusion that is equivalent or greater in level than the vibration from the metro trains.

A range for the maximum ground-borne vibration limit is given in some cases to permit the designer to adjust the design criterion to be suitable for the environment and location of the building. For example, at offices in a quiet, landscaped industrial park area the limit should be at the low end of the range, 75 dB, whereas for the offices located at a busy intersection or in a noisy central business district the limit can be near the upper end of the range, 80 dB.

7.5 NOISE AND REVERBERATION CONTROL IN STATIONS

7.5.1 Purpose

The purpose is to define criteria and acoustical treatment which will result in a desirable acoustical environment at and around stations throughout the Metro Rail System. The use of sound absorption material installed on the ceilings and walls of enclosed areas is necessary for control of noise and reverberation in the stations. Where appropriate and applicable, noise control can also be achieved through limitations on permissible noise from equipment. These design features are required because it is essential that acoustical control be included in the design of modern transit system facilities in order to provide a satisfactory and attractive environment for transit system patrons and to minimize impact on the neighboring community.

The inclusion of acoustical treatment in the design of transit system stations accomplishes four major purposes:

A. Control and reduction of noise from transit vehicle operations.

B. Provision for good intelligibility of announcements from the public address system.

C. Control of noise in enclosed areas generated by patrons and or noise from exterior sources.

D. Assistance in the control of noise from station air handling equipment, vertical circulation equipment, and any other station mechanical equipment.

Acoustical treatment of the stations accomplishes these objectives by the absorption of sound energy as it impinges on the interior surfaces of the station thus preventing multiple reflections and the buildup of reflected or reverberant sound energy. The amount of control of reverberation and the consequent reduction of noise obtained is dependent upon the area of the acoustical treatment, the absorption coefficient, and the placement of the treatment. The four basic goals which are to be accomplished with the treatment have been used to derive a set of criteria for determining the appropriate

areas, absorption coefficients, and placements of the acoustical material to obtain the most economical and appropriate design for the station acoustical treatment.

The criteria were developed to be consistent with the design goal maximum noise levels presented in Table IV-7-8. The noise levels inside stations are dependent on the design of the transit cars and station mechanical equipment and on the acoustical treatment in stations. The criteria and designs for the acoustical treatment take into account the general architectural characteristics expected of the Metro Rail stations and the expected noise to be radiated by the transit cars and other noise sources.

Table IV-7-8

MAXIMUM NOISE LEVELS IN UNDERGROUND STATIONS

On platform, trains entering and leaving	80 dBA
On platform, trains passing through	85 dBA
On platform, trains stationary	68 dBA
On platform or in mezzanine areas with only station ventilation system and auxiliaries operating	55 dBA
On platforms or other public areas with tunnel ventilation system and/or underplatform exhaust operating at any normal level	55 dBA
On platforms or other public areas with tunnel ventilation system operating in emergency status	70 dBA
In station attendants' booths or offices	50 dBA

Table IV-7-9 summarizes the criteria for reverberation time and acoustic treatment of the various areas of underground stations. Compliance with the criteria for acoustic treatment assures that the reverberation time criteria and the associated noise control will be achieved.

Table IV-7-9

SUMMARY OF STATION ACOUSTIC DESIGN CRITERIA

	Areas Exposed to Street Traffic	Enclosed Mezzanine Areas	Train Rooms
Maximum Reverberation Time (500 Hz)	1.2 to 1.4 sec	1.2 sec	1.5 sec
Maximum Mechanical Equipment Noise	---	55 dBA	55 dBA[1]
Treatment:			
Minimum wall/ceiling area	20-25%	35%[2]	35%[3]
Minimum ceiling only	70-100%	---	---
Treatment Properties:			
Minimum 500 Hz Absorption Coefficient	0.6	0.6	0.6[3]
Minimum NRC	0.6	0.6	0.6[3]

[1] 50 dBA maximum in station attendants' booths.

[2] Including at least 50% of ceiling area.

[3] Underplatform treatment also required -- minimum absorption coefficient at 250 Hz - 0.4, at 500 Hz - 0.65 (3"- to 4"-thick material).

7.5.2 Station Acoustical Design

A. Scope

This section presents guidelines to be used in designing appropriate acoustic treatment for the various enclosed areas of the Metro Rail System stations. The design of absorption treatment for enclosed areas consists of four basic steps:

1. Determine required reverberation times and quantities of absorption.

2. Determine locations that will provide maximum control of noise.

3. Select appropriate absorption coefficients for the treatment materials.

4. Select acoustical materials and design material installations.

B. Reverberation Time and Absorption Quantity

1. General

As summarized in Table IV-7-9 the acoustical criteria for stations includes maximum reverberation time at 500 Hz, minimum areas for treatment, and minimum absorption properties. Following these criteria will result in sufficient absorption to control reverberant noise levels and to provide good speech intelligibility for the PA systems.

2. Trainrooms

Analysis of underground train rooms indicates that optimum treatment is obtained with a reverberation time of about 1.3 seconds. This reverberation time will provide for good speech intelligibility while acting to efficiently control noise.

The design goal for reverberation time in the trainrooms should be 1.2 to 1.5 seconds, a sufficient range to allow flexibility in the architectural design of the stations.

The acoustical treatment should be continuous and uniform for the entire length of the enclosed space. When the trainrooms have a relatively constant cross-section, it is most appropriate to define the quantity of treatment in terms of treatment per linear foot of station platform. From this, it is a simple matter to determine the width of treatment that is required as a function of the absorption coefficient of the material. Table IV-7-10 indicates the treatment widths that are required to attain the recommended reverberation time on a typical station platform of 28 ft width.

The values given in Table IV-7-10 are based on consideration of the volumes, the surface areas, and the natural absorption of the finish surfaces of the stations. Because transit stations have relatively uniform cross-sections, the figures for treatment per lineal foot in Table IV-7-10 are sufficient to describe the criterion to be used in designing the acoustical treatment for the full length of the platforms.

Table IV-7-10

ACOUSTICAL TREATMENT CRITERIA FOR SUBWAY STATIONS

Station Type	Location	Acoustical Treatment per Foot of Station Structure	
		Typical Available Area (sq ft)	Design Criterion Area (sq ft)
Cut and Cover	Total	149	33
	Underplatform	8	80
	Ceiling	72	43

3. Passageways

For noise control in enclosed areas, such as corridors and fare collection area, reverberation time should not exceed 1.2 seconds. The appropriate reverberation time for these areas is lower than for the trainrooms because the enclosed volume of these spaces is significantly less than for the trainrooms.

4. Stations Areas At- or Above-Grade

In station areas directly connected to the street level and exposed to street traffic, noise control is less critical because of the presence of street noise and the short periods of time patrons normally spend in these areas. As a result, less noise reduction is needed and the design goal for the reverberation time in areas exposed to street noise can be increased to the range of 1.2 to 1.4 seconds at 500 Hz.

5. Ancillary Areas

Ancillary areas include service rooms, toilets, mechanical and electrical equipment rooms, and train control and communications equipment rooms. Such spaces used for fans and other potentially noisy equipment shall be separated from public areas as much as possible. Access to such noisy spaces should be through double doors or sound-treated doors. All such spaces either used by the public or adjacent to public spaces should have acoustical treatment applied which is appropriate to the noise levels and occupancy of the space.

6. Location of Absorption Material

a. General

The location of the sound control material is an important consideration in the architectural design of the stations.

The preferred locations for acoustical treatment in the stations are listed in Table IV-7-11 in the order of priority. As indicated above, continuous treatment of the underplatform surfaces is essential for effective control of train noise. It is also very effective to treat the side walls opposite the platform, however, as long as the underplatform areas have continuous treatment, the side wall treatment is not required to obtain good results.

The basic design criteria call for coverage of 60% minimum of the total projected ceiling area with acoustical treatment in addition to the underplatform treatment. For the three station type proposed by the Metro Rail System it is possible to suitably control reverberation characteristics and noise without placing acoustical treatment on the side walls.

Table IV-7-11

PREFERRED LOCATIONS FOR SOUND CONTROL TREATMENT

Platform Areas - Enclosed Station Trainrooms

1. Underplatform overhang surfaces

2. Trainroom ceilings

Mezzanine/Passageway areas

a. Mezzanines and Passageways

All enclosed public areas of the station shall receive acoustical treatment equal to a minimum of 35% of the projected wall and ceiling area. Acoustical material in public areas shall be placed out of reach of patrons, a minimum of 9 feet from floor surfaces.

b. Entrances

Entrance enclosures shall have acoustical treatment on a minimum of 25% of the wall and ceiling area.

c. Openings

Large openings in enclosed spaces may be considered as acoustical treatment for the purpose of calculation.

7. Acoustical Materials and Installations

a. General

This section covers the criteria for selection and application of acoustical materials appropriate for station facilities. Acoustical treatment for transit system stations consists basically of three elements:

(1) The sound absorption media or material

(2) A protective covering

(3) An architectural or trim facing

b. Flammability

All acoustical materials shall be noncombustible.

c. Materials

(1) Cellular glass blocks behind perforated sheet metal facings or slit-and-slat system facing. The material should be of 2" to 4" thickness in platform areas, 2" thickness in mezzanine areas, and 1" to 1½" thickness at other locations. This material is to be used because of the nonflammability and lack of need for protective covering film or cloth or for mechanical protection in most applications.

(2) Glass fiber blankets that are wrapped in close weave glass cloth or other non-flammable sheeting not to exceed 4 mils thickness. This material should be of 2 to 6 lb/cu ft density and of 2" to 4" thickness in platform areas, 2" thickness in mezzanine areas, and 1" thickness at other locations. Mechanical protection facings of expanded metal or architectural facings of perforated metal or slit-and-slat panels shall be used with this material. For design purposes, the expected sound absorption coefficients for glass fiber treatments are given in Table IV-7-12.

Table IV-7-12

TYPICAL SOUND ABSORPTION COEFFICIENTS TO BE EXPECTED FROM GLASS FIBER SOUND CONTROL MATERIALS MOUNTED DIRECTLY AGAINST A CONCRETE SURFACE

	Sound Absorption Coefficients				
Frequencies in Hz	125	250	500	1000	2000
1" thick Glass Fiber	.08	.30	.65	.80	.85
2" thick Glass Fiber	.20	.55	.80	.95	.90
3" thick Glass Fiber	.45	.80	.90	.95	.90

d. Under Platform Treatment

The horizontal and vertical surfaces other than exhaust fan inlets under the platform edge shall be completely covered with 4" cellular glass blocks, or 3"- to 4"-thick glass fiber panels.

e. Trainroom Treatment

Ceilings shall be covered with 2" to 4" thick non gas-absorptive, noncombustible acoustic material to achieve a 60% to 70% coverage.

f. Mezzanine and Passageways

Seventy to one hundred percent of the ceiling area shall be covered with acoustical treatment. For exposed, concrete ceilings greater than 11 feet in height, 2" thick non gas-absorptive, non-combustible acoustic material shall be used.

g. Mezzanine Areas

Ceilings shall be covered with 2" to 4" thick non gas-absorptive, noncombustible acoustic material to achieve a 60% to 70% coverage.

h. Installation

For the underplatform treatment, if glass fiber wrapped in glass cloth is used, the panels shall be retained in place using either an expanded metal facing, hardware cloth facing, or perforated metal facing. For center platform stations the use of expanded metal or hardware cloth is the most economical and is satisfactory since the material is not visible to patrons. Mechanical fastening is required at all applications.

Wherever perforated metal or slit-and-slat facings are used, the open area shall be at least 30% of the total area. With the use of either expanded metal or perforated metal facing the attachment to the underplatform surfaces can be through the use of simple metal brackets. Air space should be provided around the edges to allow free circulation of the air to prevent loading of the acoustical material panels due to air pressure transients created by the train movements. Panels with perforated metal or slit-and-slat facings -- either for underplatform or ceiling and wall installations -- shall have a dimpled screen placed between the metal facing

and the face of the acoustic blanket to establish an air space of about 1/2" thickness between the perforated facing and the blanket or glass cloth bag.

If a continuous panel system or a suspended acoustical tile ceiling type of system is used, it is essential that gaps or openings be provided to permit free air flow between the acoustical treatment panels and the concrete surface behind in order to prevent loading of the acoustical panel by the air pressure transients created by train piston action or the air due to train movements. All acoustic systems shall have positive anchorage designed to resist the shock of transient air pressure produced by the movement of the train through the station at maximum design speed.

i. Ancillary Room Treatment

For any ancillary spaces either of two basic types of materials shall be used. For spaces with equipment which radiates relatively low noise levels or in which the noise is intermittent, such as in switchgear rooms or shops, the acoustical treatment shall be a 1"-thick glass fiber application.

An alternate could be the use of 3/4"- or 1"-thick acoustical tile, acoustical ceiling board, or painted duct liner board for the absorption material. In spaces with noisy equipment such as fans and pumps, the acoustical treatment materials shall be 2" minimum thickness. In such spaces the material need not have an architectural trim facing. Application of 2"-thick (two layers of 1" thickness) duct liner blanket to the walls and ceiling, perhaps with hardware cloth facing for mechanical protection, provides appropriate sound absorption characteristics. In the ancillary spaces with the higher noise level equipment the treatment area shall be 30% of the wall and 50% of the ceiling area and the sound absorption material must be distributed reasonably uniformly over the

ceiling in panels or patches and the wall material must be distributed over at least two adjacent walls. That is, the material should not be concentrated on one part of the ceiling or concentrated on two opposite walls but rather must be distributed between the ceiling and walls and with the wall treatment located to give approximately equal division of area on walls located at right angles to each other.

7.5.3 Transit Station Areas Related to Street Traffic Noise

A. Scope

1. Entrance areas
2. Stairs from street level
3. Elevators from street level
4. Escalators from street level
5. Vent shafts from street level.

B. General Considerations

1. Where feasible and practical, these areas should be shielded from street and railroad vehicle noise.
2. Open areas, particularly platforms, should have sound barrier walls blocking the line-of-sight between significant noise sources and the patron areas.
3. The reverberation time of enclosed areas should be in the range of 1.2 to 1.4 seconds at 500 Hz when area is unoccupied.

C. Acoustical Treatment

Width of treatment equivalent to 20% to 25% of the cross-section perimeter or 70% to 100% of the ceiling is required. The treatment can consist of an absorptive wall panel system, an acoustical panel, or other acoustical absorption assembly applied to the ceiling

or a combination of these. The acoustical treatment should have a Noise Reduction Coefficient, NRC, of at least 0.60 and a minimum sound absorption coefficient of 0.60 at 500 Hz.

7.5.4 Enclosed Mezzanine Areas

A. Scope

1. Fare collection areas

2. Stairs

3. Escalators

4. Corridors.

B. General Considerations

1. The maximum noise level from mechanical and electrical equipment shall not exceed 55 dBA in the absence of occupants.

2. The reverberation time of the areas shall not exceed 1.2 seconds at 500 Hz when area is unoccupied.

C. Acoustical Treatment

The acoustical treatment shall cover not less than 35% of the combined surface area of ceiling and walls, or the equivalent, including coverage of at least 50% of the ceiling area where possible. The acoustical treatment shall have an NRC of at least 0.60 and a minimum sound absorption coefficient of 0.60 at 500 Hz.

7.5.5 Trainrooms

A. General Considerations

1. Maximum noise level on platform due to station ventilation system and other operating auxiliaries shall not exceed 55 dBA.

2. Maximum noise level on platform due to normal operation of tunnel ventilation system or under-platform exhaust fans shall not exceed 55 dBA.

3. Maximum noise level on platform due to emergency operation of ventilation systems shall not exceed 70 dBA.

4. The reverberation time of the platform area shall not exceed 1.5 seconds at 500 Hz when the area is unoccupied.

B. Acoustical Treatment

Acoustical treatment with a minimum NRC of 0.60 and minimum 500 Hz sound absorption coefficient of 0.60 shall cover not less than 35% of the combined surface area of ceiling and walls, or the equivalent. The underside of the platform overhang and the wall of the underplatform overhang space shall be covered with acoustical material having a minimum absorption coefficient of 0.40 at 250 Hz and 0.65 at 500 Hz (3- to 4-inch thick material).

7.5.6 Ancillary Areas

A. Scope

1. Fan rooms, blast relief shafts and mechanical room.

B. General Considerations

Spaces for noisy ancillary equipment shall be located away from public spaces if possible. Noisy ancillary spaces opening directly to public spaces shall have sound rated or double entrance doors. Acoustical treatment for each space or type of space depends on location, type of noise, and occupancy.

C. Acoustical Treatment

The acoustical material shall be an equipment room type of ceiling/wall treatment, such as 1-inch thick glass fiber boards, and shall have an NRC of at least 0.65. Mechanical equipment rooms housing fans, pumps, and other equipment that generate high

sound levels shall have sound absorption treatment equivalent to 2-inch thick glass fiber board or blanket (minimum NRC of 0.75) applied to cover 30% of the total wall area and 50% of the ceiling area in the rooms. In other spaces with equipment that generates only low or moderate noise, the acoustical treatment shall be as indicated above for electrical equipment rooms.

7.5.7 Vertical Circulation Equipment

A. Scope

1. Escalators

2. Elevators.

B. General Considerations

For equipment located in public areas and for all normal operating conditions, the noise level at 3 ft from the equipment shall not exceed 55 dBA for steady-state noise, and transient noise shall not exceed 60 dBA measured using the fast meter response.

C. Escalator Noise

Noise produced by escalators operating individually in either direction under no load and under maximum load in the station environment shall not exceed 55 dBA 5 ft above the tread at the entrance combs at both ends of the escalator.

D. Elevator Noise

Steady-state noise produced by elevators or associated equipment shall not exceed 55 dBA (Slow) in public spaces 3 ft or more from the elevator or associated equipment or within the elevator cab at any location 5 ft above the floor and 1 foot or more from any wall. Transient noise produced by elevators or associated equipment, not including entrance door operations, shall not exceed 60 dBA (Fast) in public spaces 3 ft or more from the elevator or associated equipment or within the elevator cab at any location 5 ft above the floor and 1 foot or more from any

wall. Transient noise produced by operation of the elevator door shall not exceed 65 dBA (Fast) 3 ft or more from the elevator door inside or outside of the elevator cab.

7.5.8 Ventilating Equipment

A. Scope

1. Fan and Equipment Rooms

2. Fan Equipment

3. Vibration isolation

4. Seismic considerations.

B. Fan and Equipment Rooms

Spaces for fans and other potentially noisy equipment shall be separated from public areas insofar as possible. If direct access into such rooms from public areas cannot be avoided, provide doors having a suitable sound rating. Control sound transmission through other openings by appropriate means such as acoustically lined ducts or shafts.

C. Fan Equipment

The noise levels from fan shafts and other stationary equipment are dependent on the sound level radiated by the machinery. For station ventilation fans and subway emergency ventilation fans the sound power level should not exceed the values given in Table IV-7-13.

Table IV-7-13

VENTILATION FAN SOUND POWER LEVEL LIMITS

Fan Type and Design Air Flow Rate	T.P.W.G.	Maximum Sound Power Levels (dB re 10^{-12} watts) 1	2	3	4	5	6	7	8
Emergency (150,000 cfm)	4.7	113	114	124	128	125	122	118	118
Emergency (185,000 cfm)	4.8	115	116	126	130	127	124	120	120
Mid-Tunnel (150,000 cfm)	4.3	110	111	121	125	122	119	115	115
Mid-Tunnel (185,000 cfm)	4.7	112	113	123	127	124	121	117	117
Underplatform (64,000 cfm)	3.0	95	102	107	106	103	98	93	91

T.P.W.G. = Total Pressure Water Gauge

Fans shall have certified sound power levels not to exceed the above decibel ratings (re 10^{-12} watts) when operating under specified load conditions and measured at the fan in accordance with the AMCA test code (Ref. 5). Emergency ventilation fans shall be operated in both directions with inlet bell and outlet cone for sound power verification tests.

D. Vibration Isolation

Because of the nature of subway station and other transit facility structures, it is generally not necessary to provide spring type vibration isolators for fans and other equipment, in the same manner as is provided in office or other general purpose buildings. Subway station structures are of heavy concrete construction and the fans and equipment are generally separated from public areas. Therefore, spring type vibration isolators are not required and simple rubber support pads between the concrete mounting surface and the machine or device are sufficient.

In subway structures, substation structures, and in any separate mechanical equipment or plant structures, except as noted below, vibration isolation consisting only of standard ribbed rubber pads or

1/2"-thick neoprene pads should be provided between the mounting feet or bracket and the support surface for the following items:

1. Fans
2. Pumps
3. Emergency generators
4. Elevator motors, motor generators, d.c. power convertors, and hydraulic power units
5. Electrical equipment containing reactors or choppers.

Flexible connectors should be provided in pipes and ducts only as necessary to prevent stress or load concentration or to provide for alignment tolerance, except for hydraulic elevator power units. Each hydraulic elevator power unit output line should have a muffler in the line and two flexible connectors located at right angles to each other and separated by at least 4 feet of line. The connectors can be located on each side of the muffler or both on the same side of the muffler, but in any case should be in close proximity to the hydraulic power unit.

In any location where fans are placed in a room that is located directly above a public area, spring isolators shall be provided for support of the fan and flexible connectors shall be used for connection of the fan to duct work. The static deflection for such spring isolators should be a minimum of 1". Rubber pads of 1/2" thickness shall be provided between the spring foot and the support surface.

In all cases where anchor bolts pass through the rubber support pads, a neoprene sleeve and washer shall be used to separate the anchor bolt shank and head (or nut) from the machine support foot or bracket.

E. Seismic Considerations

Since most equipment installed in transit facilities is rigidly fixed and not vibration isolated, seismic

restraints are not necessary. For any equipment which is vibration isolated because of close proximity to public spaces, seismic restraints should be included and should be designed to limit motion to 3/4-inch in any direction and to accept a force in any direction corresponding to at lest 1.0 g acceleration.

7.6 NOISE IN ABOVE-GROUND STATIONS (For Future Alignment Extensions)

7.6.1 General Considerations

In above-ground stations noise levels will be governed by train operations. For ballast and tie tracks the maximum noise level should not exceed 80 dBA on the train platform as trains leave and enter the platform. For concrete trackbed the appropriate limit is 80 to 85 dBA.

Station location is a potential problem, particularly when train platforms are located in a highway median, ad jacent to a street with a high volume of traffic travel ing at high speeds, or adjacent to a railroad right-of-way. An appropriate acoustical design with shielding can relieve patrons on platforms from an otherwise serious noise problem created by traffic or other noise sources. Design goals for maximum noise levels should be similar to those for the transit trains.

The maximum noise level design goal on the station platforms is 55 dBA for any ancillary mechanical or vertical circulation equipment. Ventilation system noise in station attendants' booths should not exceed 50 dBA.

7.6.2 Acoustical Design Criteria

Train noise levels are somewhat dependent on vehicle design. However, in enclosed or partially enclosed platform areas, train noise can be reduced by application of underplatform overhand treatments as for subway stations; see Section 7.5.5.

In fully or partially enclosed station platforms the reverberation time of the platform area should be between

1.2 to 1.5 seconds at 500 Hz when the area is unoccupied; a sufficient range to allow flexibility in the architectural design of the stations. This reverberation time will minimize reflection effects and provide good speech intelligibility while acting to efficiently control noise from trains, street traffic, or people.

7.7 AIRBORNE NOISE FROM TRANSIT ANCILLARY FACILITIES

7.7.1 General Introduction

There are sources of community noise in a subway or above-grade transit system other than trains. The two basic types of airborne noise from ancillary facilities are transient and continuous. For example, transient noise is transmitted from vent shaft openings during train passbys. Power substations, chiller plants, 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 goal limit depends on the activities of occupants as well as background noise in the areas. 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 IV-7-14 presents the design goals for the transit system ancillary facility noises in each of the community area categories listed in Table IV-7-1. This should result in general community acceptance.

Table IV-7-14

DESIGN CRITERIA FOR NOISE FROM

TRANSIT SYSTEM ANCILLARY FACILITIES

	Community Area Category	Maximum Noise Level, dBA	
		Transient	Continuous
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 IV-7-14 shall be applied at a distance of 50 ft from the shaft outlet or other ancillary facility or shall be applied at the setback line of the nearest building or occupied area, whichever is closer.

As stated previously, transient noise design goals apply to short time duration events such as train passby noise transmitted from vent shaft openings. Continuous noise design goals apply to noises such as fans, cooling towers or other long duration noises except electrical transformer hum. The design goals for transformer noise, or other sources with tonal components, should be 5 dBA less than given in Table IV-7-14.

7.7.2 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, Table IV-7-14.

Vent shaft noise reduction shall be achieved by 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. Sound absorption treatment shall consist of 2- to 4-inch thick mechanically attached panels, e.g. expanded cellular glass foam blocks.

7.7.3 Substation and Emergency Power Generation

Substation and emergency power generation equipment noise shall be limited to 5 dBA less sound level than listed for continuous noise in Table IV-7-14. 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.

7.7.4 Chiller Plant Noise

Chiller plant noise levels shall comply with design criteria listed for continuous noise in Table IV-7-14. Reduction of noise from chiller plants shall be achieved by barriers, enclosures, and sound absorption materials, as applicable to the individual facility or unit design.

7.8 NOISE IN SUBWAY TUNNELS

High speed train operations in tunnels can generate excessive noise levels and noise abatement techniques shall be used to reduce the noise to an acceptable level. The maximum interior car noise at maximum tunnel operating speeds shall not exceed 80 dBA. An acoustical absorption system may be employed in the tunnel or additional sound insulation may be provided on the cars to meet this design goal. Tunnel sound absorption treatment can, for instance, provide 5 dBA or more reduction of noise levels inside the car. Reducing tunnel noise by a sound absorption system improves the acoustical environment for system employees and aids in complying with the statutory noise limits set by the Occupational Safety and Health Administration.

7.9 SHOP EQUIPMENT NOISE

To avoid excessive noise exposure for employees and to comply with existing and proposed standards and requirements of the Occupational Safety and Health Administration, shop equipment noise should not exceed 85 dBA at operator stations and should not exceed 90 dBA at any point 3 ft from the equipment.

7.10 VIBRATION ISOLATION OF SUBWAY STRUCTURES

7.10.1 Scope

Vibration isolation shall be provided at any point where the subway structure is in very close proximity or directly against a building structure or building foundation elements.

7.10.2 General Considerations

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

7.10.3 Isolation Elements

A. The resilient element between the two structures shall consist of intervening soil of at least 2 feet thickness or depth, or there shall be an elastomer pad between the subway structure and building.

B. The elastomer pad shall be a 1 or 2 inch thickness closed-cell expanded neoprene, selected to give proper support of hydraulic or structural loads with deflection of the elastomer pad not to exceed 10% to 20% of pad thickness.

7.11 CONSTRUCTION NOISE AND VIBRATION CONTROL

7.11.1 General

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 California Occupational Safety and Health Administration (Ref. 6). 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.

7.11.2 Special Requirements

Compliance with the requirements of this Section will require the use of machines with effective mufflers or enclosures and selection of quieter alternative procedures. Compliance may also require the use of completely 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.

7.11.3 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.

7.11.4 Definitions

A. Daytime refers to the period from 7:00 a.m. to 8:00 p.m. local time daily except Sundays and legal holidays. Nighttime refers to all other times including all day Sunday and legal holidays.

B. 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.

C. Special Zones or Special Construction Sites, outside of Construction limits, may be designated by the agency having jurisdiction to be considered as being within the Construction Limits.

7.11.5 Noise Level Restrictions

A. 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 exceeding 140 dB as measured on an impulse sound level meter or 125 dBC maximum transient level as measured on a general purpose sound level meter on "fast" meter response.

B. Noise Level Restrictions at Affected Structures

Conduct construction activities in such a manner that the noise levels 200 feet from the Construction Limits or at the nearest affected building, whichever is closer, do not exceed the levels listed in the following schedules:

1. Continuous Noise

Prevent noises from stationary sources producing repetitive or long-term noise lasting more than a few hours from exceeding the limits of Table IV-7-15.

Table IV-7-15

LIMITS FOR CONTINUOUS CONSTRUCTION NOISE

Affected Structure or Area	Maximum Allowable Continuous Noise Level, dBA	
Residential	Daytime	Nighttime
Single family residence	60	50
Along an arterial or in multifamily residential areas, including hospitals	65	55
In semiresidential/ commercial areas, including hotels	70	60
Commercial	At All Times	
In semiresidential/commercial areas, including schools	70	
In commercial areas with no nighttime residency	75	
Industrial		
All locations	80	

2. Intermittent Noise

Prevent noises from nonstationary mobile equipment operated by a driver or from any source of nonscheduled, intermittent, nonrepetitive, short-term noises not lasting more than a few hours from exceeding the limits of Table IV-7-16.

Table IV-7-16

LIMITS FOR INTERMITTENT CONSTRUCTION NOISE

Affected Structure or Area	Maximum Allowable Intermittent Noise Level, dBA	
Residential	Daytime	Nighttime
Single family residence areas	75	60
Along an arterial or in multifamily residential areas, including hospitals	80	65
In semiresidential/ commercial areas, including hotels	85	70
Commercial	At All Times	
In semiresidential/commercial areas, including schools	85	
In commercial areas with no nighttime residency	85	
Industrial		
All locations	90	

C. 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 the 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.

D. More Than One Limit Applicable

Where more than one noise limit is applicable, use the more restrictive requirement for determining compliance.

7.11.6 Noise Emission Restrictions

Use only equipment meeting the noise emission limits listed in Table IV-7-17, as measured at a distance of 50 feet from the equipment in substantial conformity with the provisions of the latest revisions of SAE J366b, SAE J88, and SAE J952b (Refs. 7, 8, 9) or in accordance with the measurement procedures specified herein.

Table IV-7-17

NOISE EMISSION LIMITS ON CONSTRUCTION NOISE

TYPE OF EQUIPMENT	MAXIMUM NOISE LIMIT*	
	Date Equipment Acquired	
	Before 1-1-1982	On or After 1-1-1982
All equipment other than highway trucks; including hand tools and heavy equipment	90 dBA	85 dBA
	Date Equipment Acquired	
	Before 1-1-1982	On or After 1-1-1982
Highway trucks in any operating mode or location	83 dBA	80 dBA

*Peak levels due to impact pile drivers may exceed the above noise emission limits by 10 dBA.

7.11.7 Vibration Level Restrictions

A. Vibration Limits in All Areas

Conduct construction activities in such a manner that vibration levels at a distance of 150 ft from the Construction Limits or at the nearest affected building, whichever is closer, do not exceed root-mean-square (rms) vibration velocity levels of 0.01 inches per second in any direction over the frequency range of 1 to 100 Hz.

B. 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.

7.11.8 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.

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

B. Utilize sound retardant housings or enclosures around noise producing equipment.

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

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

E. Do not use air or gasoline driven saws.

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

G. 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.

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

I. Use vibratory pile drivers or augering for setting piles in lieu of impact pile drivers. If impact pile drivers must be used, their use is restricted to the hours from 8:00 a.m. to 5:00 p.m. weekdays in residential and in semiresidential/commercial areas.

7.12 BLASTING NOISE AND VIBRATION CONTROL

7.12.1 General

Perform blasting operations in a manner to minimize noise and vibration. Use blasting procedures and covers providing effective suppression of noise and vibration and employ other 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. 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.

7.12.2 Monitoring

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

7.12.3 Time of Blasting

A. General

Restrict blasting to daytime hours, 7:00 a.m. to 8:00 p.m. daily except Sundays and legal holidays.

B. Emergency

In the event that safety or emergency consideration require blasting during nighttime hours, 8:00 p.m. to 7:00 a.m. and Sundays and legal holidays, blasts may be fired at such times subject to prior notice to and approval by the Engineer and subject to the restrictions of Section 7.12.4.B.

C. Special Considerations

In addition to the restrictions of Section 7.12.3.A, if situations and circumstances require, restrict blasting to within reasonably safe distances of noise and vibration sensitive premises or facilities to specific daytime periods determined by the Engineer and schedule and coordinate each shot with the Engineer.

7.12.4 Ground Vibration Due to Blasting

A. General

Conduct blasting operations to avoid damage to structures or buildings and to prevent peak particle velocity of blast induced motion from exceeding 2.0 inches per second on or in the nearest structure or on the ground at the nearest structure or 200 feet from the Construction Limits, whichever is closer.

Peak particle velocity is defined as the instantaneous maximum vector sum of the velocity vectors in three mutually perpendicular directions at the point of interest.

B. Emergency Blasting

Emergency blasting required to protect the safety of the project during the nighttime period will be controlled to prevent peak particle velocity of ground vibration at the nearest building having nighttime occupancy or 200 feet from the Construction Limits, whichever is closer, from exceeding 0.2 inches per second. Notwithstanding the above, if the emergency arises from inability of contractor to fire loaded holes within the daytime period solely due to unavoidable conditions, peak particle velocity of ground vibration may exceed 0.2 inches per second but will not exceed 2.0 inches per second.

C. New Concrete

Conduct blasting operations to prevent peak particle velocity of ground vibration from exceeding 1.0 inch per second at concrete less than 3 days old or 2.0 inches per second at concrete less than 7 days old.

Do not blast within 25 feet of concrete less than 7 days old unless a satisfactory plan has been submitted in writing and accepted by the Engineer.

7.12.5 Noise (Overpressure) Due to Blasting

A. General

Conduct daytime blasting in such a manner as to limit instantaneous peak overpressure to 0.01 psi at the nearest building or 200 feet from the Construction Limits, whichever is closer. All instrumentation must be linear in response with a range of at least 5 Hz to 200 Hz.

B. Emergency

Conduct nighttime blasting in such a manner as to limit instantaneous peak overpressure to 0.0004 psi at the nearest building or 200 feet from the Construction Limits, whichever is closer.

C. Overpressure Control Measures

Notwithstanding the specific limitations specified herein, utilize control measures such as listed below to minimize to the greatest extent feasible the blasting overpressure in all areas outside the Construction Limits.

1. Utilize weighted covers on vertical and inclined shafts to contain blasting overpressure.

2. Utilize blasting mats at the excavation where feasible.

3. Minimize charge per delay.

4. Arrange covers and excavation to maximize underground volume exposed to blast pressure.

7.12.6 Test Blasts

Perform at least one small charge test blast at each new drill and blast excavation site prior to commencement of production blasting. The purpose is to establish local

ground-borne vibration and airborne overpressure propagation characteristics and anomalies to aid in determination of efficient charges that will not cause the ground-borne vibration and airborne over pressure limits to be exceeded. Coordinate schedul ing of each test blast with the Engineer.

7.12.7 General Precautions in Blasting Operations

A. Notify all parties owning or operating subsurface utilities 72 hours before commencing blasting operations.

B. Coordinate and obtain the Engineer's approval for the daily blasting schedule.

C. Use controlled blasting techniques to minimize fracturing the rock outside the neat lines of the excavation.

D. Use such sizes and arrangement of explosive charges and such methods of detonation that will reduce the magnitude of vibration resulting from the explosion to the limits specified in previous Sections to prevent damage to the constructed works as well as to services, buildings, or property in the neighborhood; and to minimize nuisance to nearby residents.

E. Employ all necessary and satisfactory means of protection such as temporary bridges, staging, chains, rope-nets, mats, timber and the like, to prevent any stones and fragments of rock or other materials from being shot or thrown out of any excavation.

F. As the excavation proceeds and immediately after each blast, test the roof and walls and scale loose any shattered rock which is liable to fall. Carry out similar checks on previously excavated sections at least every 48 hours.

G. Do not blast in ground which, in the opinion of the Engineer, is loose or liable to slips. Wedging and barring only shall be allowed in such ground.

H. Before blasting within 15 feet of an existing line of water, gas, or sewer pipes or within 50 feet of any completed part of the Works, submit and obtain

approval of a plan showing the relative positions of the existing service, or completed part of the Works and the area to be blasted, and the blasting technique to be employed.

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4. "Guidelines for the Design of Rapid Transit Facilities," Report by American Public Transit Association (APTA), January 1979.

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6. "California Occupational Noise Control Standards," California Administrative Code, Title 8, Industrial Relations, Chapter 4, Division of Industrial Safety, Subchapter 7, Group 15, Article 105; as revised June 28, 1982; effective July 28, 1982.

7. "Exterior Sound Level for Heavy Trucks and Buses." Society of Automotive Engineers SAE, J366b, 1973.

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SCRTD METRO RAIL SYSTEM DESIGN CRITERIA & STANDARDS

SYSTEM DESIGN CRITERIA AND STANDARDS

VOLUME: IV SECTION: 8

MISCELLANEOUS MECHANICAL/ELECTRICAL SUBSYSTEMS

REVISION RECORD

NOTICE NUMBER	CR NO/REV	DATE APPROVED	AFFECTED	COMMENTS
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SCRTD METRO RAIL SYSTEM DESIGN CRITERIA

Volume IV, Section 8

MISCELLANEOUS MECHANICAL/ELECTRICAL SUBSYSTEMS

VOLUME IV, SECTION 8,
MISCELLANEOUS MECHANICAL/ELECTRICAL SUBSYSTEMS

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VOLUME IV, SECTION 8

MISCELLANEOUS MECHANICAL/ELECTRICAL SUBSYSTEMS

8.1 GENERAL

The miscellaneous mechanical/electrical subsystems covered by these criteria will include the following:

A. Gas monitoring system

B. Automatic fire detection systems

C. Fire protection system monitoring apparatus

D. Earth movement (seismic) detection system

E. Pumping apparatus

The criteria will define the following parameters, where applicable:

A. Functions

B. Description of equipment

C. Sensing/detecting features

D. Location

E. Power requirements

F. Output signals

G. Controls

H. Warning/alarm features

8.2 APPLICABLE DOCUMENTS

The codes of Los Angeles City and County and the State of California will prevail, where applicable. Where no City, County, or State codes exist, the following regulatory and advisory agencies' standards will be followed:

A. California Public Utilities Commission (PUC)

B. Institute of Electrical and Electronics Engineers (IEEE)

C. American National Standards Institute (ANSI)

D. Electronic Industries Association (EIA)

E. National Electrical Manufacturers Association (NEMA)

F. Association of American Railroads (AAR)

G. Federal Communications Commission (FCC)

H. U.S. Department of Transportation (DOT/UMTA)

I. American Society of Mechanical Engineers (ASME)

J. Federal Railroad Administration (FRA)

K. 1978 National Electrical Code (NEC)

L. State of California Electrical Safety Orders

M. Occupational Safety and Health Administration (OSHA) (Federal and State)

N. Underwriters' Laboratories, Inc. (UL)

0. National Fire Protection Association (NFPA)

P. American Society for Testing and Materials (ASTM)

Q. American Society of Civil Engineers (ASCI)

R. Insulated Cable Engineers Association (ICEA)

8.3 FUNCTIONAL REQUIREMENTS

The following general requirements shall apply to all mechanical/electrical subsystems:

A. They shall be compatible with existing auxiliary power supply sources and communications systems.

B. They shall be easily serviceable and maintainable.

C. They shall have testing features such that they can be checked out without triggering the alarms at Rail Control Center (RCC).

D. They shall have built-in features in order to remain operational under all contemplated conditions.

Functional requirements particular to each mechanical/electrical subsystem are included in the description of each individual subsystem.

8.4 SUBSYSTEM INTERFACES

The miscellaneous mechanical/electrical subsystems shall interface with the following systems and facilities:

A. Communications

B. Auxiliary Power

C. Ways and Structures

D. Stations

8.4.1 Interface Parameters and Requirements

Interface requirements with the abovementioned subsystems are summarized in Table IV-8-1.

Table IV-8-1

SUBSYSTEM INTERFACES

	Interface			
System	Communi-cations	Auxiliary Power	Ways & Structures	Stations
Gas Monitoring	-Signal transmis-sion & conditioning -Wiring -Rail Control Center -Local fire and Security Control -Emergency Management Panels -Signal Cable -Power	-Power require-ments	-Location -Conduits	-Location -Conduits
Automatic Fire Detection	-Signal transmis-sion -Rail Control Center -Local Fire and Security Control -Emergency Management Panels -Signal Cable -Wiring	-Power require-ments	-Location -Conduits	-Location -Conduits

Table IV-8-1 (Cont'd)

SUBSYSTEM INTERFACES

	Interface			
System	Communi-cations	Auxiliary Power	Ways & Structures	Stations
Fire Protection System Monitoring Apparatus	-Signal transmis-sion -Rail Control Center -Local fire and security control -Emergency managment panels -Signal cable	--	-Location -Conduits	-Location -Conduits
Seismic Detection	-Signal transmis-sion -Rail Control Center -Signal cable	-Power require-ments	-Location -Conduits	-Location -Conduits
Pumping Apparatus	-Signal transmis-sion -Rail Control Center -Signal cable	-Power require-ments -Wiring	-Location -Discharge piping -Pump room and sump -Lifting beams -Conduits	--

8.5. GAS MONITORING SYSTEM

In areas classified as "gassy" by CAL/OSHA, a permanent gas monitoring system shall monitor hazardous gases in the atmosphere of subterranean structures and advise of any deterioration in conditions. Portable gas detectors shall be provided so that maintenance personnel can check for hazardous gases before entering manholes, sumps, and the like. The portable gas detectors shall also be available for locating points of gas infiltration within facilities.

8.5.1 Gases To Be Monitored

Hazardous gases to be monitored shall be determined initially by review of subsurface conditions reports and similar gas-related documentation. Gas-related data collected during construction shall be reviewed to confirm that the appropriate gases are being monitored.

8.5.2 Permanent System

The permanent gas monitoring system shall:

- Measure atmospheric levels of hazardous gases
- Provide warning annunciations when gas levels increase to a certain value (setpoint) that indicates a leak has occurred
- Provide alarm annunciations when gas levels reach a certain higher setpoint that indicates the possibility of a hazard may be developing
- Allow for expansion to permit monitoring of any additional gases encountered during construction or revenue service
- Allow for the use of less sensitive gas sensors to supplement the main monitoring system in selected areas
- Interface with the Supervisory Control and Data Acquision (SCADA) subsystem to provide gas measurement and alarm information to RCC and station EMP.

Warning setpoints shall be determined during prerevenue service on an individual location basis after evaluating

gas measurements made during and after construction. Warning setpoints shall be less than 1,000 parts-per-million (ppm) for combustible gases and 10 percent Threshold Limit Value - Time weighted Average (TLV) for toxic gases. If the main monitoring system is supplemented by less-sensitive sensors, the sensor control unit shall provide warning indications at 10 percent lower flammability limit (LFL) for combustible gases, and 50 percent TLV for toxic gases.

Alarm annunciations shall be provided when the combustible gas level reaches a setpoint not to exceed five percent LFL, and when the toxic gas level reaches a setpoint not to exceed 100 percent TLV. If the main monitoring system is supplemented by less-sensitive sensors, the sensor control unit shall provide alarm indication at 20 percent LFL for combustible gases, and at 100 percent TLV for toxic gases.

Analyzing, annunciating, control, and sampling equipment shall have standby-power supply in case of main-power failure. Peripheral equipment need not have standby power.

8.5.3 Rail Control Center

Personnel in RCC shall be able to silence audible annuniciations, but visual annunciations shall remain activated until the gas level drops below the setpoint, or, for equipment trouble conditions, the condition is corrected.

8.5.4 Portable Gas Detectors

Portable gas detectors shall be battery-powered, self-contained units that warn of the presence of combustible gases, hydrogen sulfide, and a deficiency of oxygen.

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8.6 AUTOMATIC FIRE DETECTION SYSTEM

8.6.1 General

Automatic fire detection systems shall comply with the Fire/Life Safety Criteria. All equipment shall be FM approved and UL listed.

8.6.2 Detectors

A. Detectors shall comply with NFPA 72E.

B. Automatic heat and smoke detectors shall be installed in station areas, where required by the Fire/Life Safety Criteria.

   Heat detectors shall be combination fixed-temperature and rate-of-rise type.

C. The car storage areas in the tunnel shall be protected by automatic fire detection systems using line-type detectors having combination fixed-temperature and rate-of-rise features. Smoke, fire-gas, spot, and/or other type detectors shall receive District's approval before use.

8.6.3 Annunciating Equipment

The local FSCP and EMP shall comply with NFPA 72, with signalling to RCC in compliance with NFPA 72D. Detection of fire and/or smoke shall trigger an audible alarm and activate an indicator that pinpoints the area of the emergency on the respective control panels. The visual indicators shall be capable of displaying emergency messages from a minimum of four locations simultaneously or sequencially. The audible alarms shall have a manual

override but the visual annunciators shall remain activated until the respective sensors are reset, or the emergency condition has subsided.

8.7 FIRE PROTECTION SYSTEM MONITORING APPARATUS

8.7.1 General

Waterflow sensing and valve position switches shall be FM approved and UL listed, and shall annunciate at the FSCP, EMP, and RCC in compliance with the Fire/Life Safety Criteria, NFPA 72A and NFPA 72D.

8.7.2 Water Flow Detection Apparatus

Water flow sensors shall be installed immediately downstream of the shutoff valve in each fire branch.

Activation of the flow sensors shall trigger audible and visual alarms at the FSCP, EMP, and RCC. The audible alarms shall have a manual override, but the visual alarms shall remain activated until water flow stops.

8.7.3 Valve Position Switches

A valve position switch shall be installed on each shutoff valve at each fire branch. The switch shall trigger audible and visual alarms at the FSCP, EMP, and RCC when the shutoff valve is opened (or closed). The audible alarms shall have a manual override, but the visual alarms shall remain activated until the valve is restored to its original position.

8.8 SEISMIC DETECTION SYSTEM

8.8.1 Seismic Switches

Seismic switches shall be installed at selected stations and shall indicate to RCC any significant earth tremors. The switches shall be installed at intervals and specific locations dictated by the Metro Rail System configuration, the type of sensing equipment used, geological conditions, and operational requirements.

8.8.2 Seismic Sensing Equipment

The sensing equipment shall be capable of filtering out routine vibrations caused by trains, and shall not be affected by electromagnetic interference from any source in the tunnels.

Significant seismic activity shall trigger audible and visual alarms at RCC. RCC shall initiate appropriate procedures when alarms are annunciated. Seismic activity of a predetermined level shall permit safe stopping of trains as required by the Fire/Life Safety Criteria, Volume I, Section 2.

8.8.3 Seismic Records

Seismic event recorders shall be installed at selected stations. Recordings of significant earth movements shall be hand carried to RCC for decoding and analysis.

8.9 PUMPING APPARATUS

8.9.1 Fixed-Installation Pumps

Sumps shall be located at low points in stations and tunnels and shall be sized to handle water resulting from seepage, weather, fire fighting operations, and other sources. Two submersible type pumps shall be utilized at each sump; each pump shall handle full anticipated load. Controls shall be such that, under normal conditions, one pump is operating and one is at standby. In order to equalize usage of each pump, control circuits shall be designed so that pumps operate alternately.

Sump pumps shall be designed to accommodate solids of up to two inches in diameter. Operating voltage for the electric motors shall be rated at 460 volts, 60 hertz, 3-phase.

Electric control apparatus shall be convenient to disconnect for maintenance purposes. Local controls shall provide manual override of the automatic controls to assist in performing maintenance.

Pumps shall be activated by displacement-type level controls, including high-level indicator to start up the standby pump when the water level continues to rise with one pump in operation. An alarm shall be activated at RCC if water level continues to rise after the second pump has been activated.

Pump controls shall include hour meters to assist in scheduling preventive maintenance and for indicating erratic operation of the control element.

Dimensions of the sump room shall be such that all parts of the pumps requiring periodic maintenance shall be easily accessible.

Wherever feasible, access to the pumps shall be possible without having to travel through the tunnels, by means of stairways or shafts opening to street level. Maintenance, installation, removal, and other repair operations shall be capable of being performed without interruption of revenue service. Mechanical lifting devices, such as hoist beams and fixed rings, shall be installed in sump rooms where appropriate, to aid in handling the sump pumps.

8.9.2 Auxiliary Portable Pumps

Facilities shall be included for connecting auxiliary pumps to the sump pump discharge line for locations that experience high-water level due to fire fighting, flooding, or other situations where the two sump pumps are insufficient to prevent water buildup.