SYSTEMWIDE BASELINE
CHANGE NOTICE (SBCN)

DOCUMENT/TITLE/NUMBER/REVISION:
Revised Design Criteria Section 7 – Electrical Revision 2

CHANGE IMPACT ASSESSMENT SUMMARY: (Attach written explanation of impacts identified)

SCHEDULE ISSUES?: N OTHER DOCUMENT REVISIONS REQUIRED?:
ROM (RANGE): NO COST DESIGN ISSUES?: N COST RECOVERY POTENTIAL: N
TIME IMPACT: N/A SAFETY ISSUES?: N OTHER CONTRACTS/PROJECTS?: N/A
CAL DAYS N/A THIRD PARTY?: N

Related Request(s)-For Change: NONE

JUSTIFICATION (including benefit or impact if not pursued):
Design Criteria Section 7 – Electrical Revision 2 is being issued for inclusion in Contract C0980 Regional Connector RFP. Formal review and approval process will follow. Any additional changes identified will be processed in a subsequent revision, and issued through the SBCN and Addenda process.

Revisions are based on the lessons learned from Foothill and Expo projects. This is to rectify provisions in the Design Criteria to avoid future change orders.

Revisions are as follows:

1. Rail Operation Control (ROC) Facility shall have two separate sources, a stand by generator, UPS equipment and plug-in for a mobile generator.

2. Underground ductbanks shall be encased in concrete and shall have steel reinforcements.

3. Lighting shall be easy to maintain and shall not require scaffolding.

4. Minimum lighting level requirement for street train crossing shall be 5fc. Minimum pedestrian train crossing at the station shall remain at 15fc.

PROJECTS/CONTRACTS AFFECTED: For new projects only

PROJ CONTRACT CN # ACTION STATUS

TOTAL ESTIMATED CHANGE COST: (DIRECT)
TOTAL ESTIMATED CHANGE COST: (INDIRECT: POTENTIAL COST RECOVERY)
TOTAL ESTIMATED CHANGE COST: (INDIRECT+ DIRECT)

RECOMMENDATION AND APPROVAL SIGNATURES: (R = RECOMMEND, A = APPROVE)

RTG APPROVAL NAME/TITLE SIGNATURE DATE
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R DIRECTOR PROJ. ENGINEERING, FACILITIES A. DAVIDIAN
R DIRECTOR PROJ. ENGINEERING, SYSTEMS M. RATNASINGHAM
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A EXECUTIVE DIRECTOR TRANSIT PROJECT DELIVERY K.N. MURTHY
A IMPACTED PROJECT MANAGER – N/A
METRO RAIL DESIGN CRITERIA

SECTION 7

ELECTRICAL
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7.1 GENERAL

This section lists the requirements for the design, installation, and operation of all lighting and electrical equipment of the fixed facilities and central control facilities for the Metro Heavy and Light Rail Transit system, including the underground structure, tunnels, at-grade and elevated structures and trackways, but excluding electrical power for the operation of the train.

All designs described in this section shall comply with the requirements of the Fire/Life Safety Criteria.

All electrical equipment and support shall be designed for seismic zone 4.

7.2 SCOPE

These criteria shall cover the following in this Section and other relevant Sections of this document including but not limited to:

1. Lighting, including interior, parking lots and other exterior Metro Rail related lighting and lighting along underground tunnels.
2. General power distribution for:
   a. heating, ventilating, and air-conditioning equipment and other mechanical equipment.
   b. Escalators, elevators, and other architectural equipment.
   c. Emergency ventilation system.
   d. Sump pumps.
   e. Tunnel fans and dampers.
   f. Fire pumps
   g. TVM, SAV, and faregates
   h. Emergency hatches
   i. Roll up doors/grilles
   j. Lighting
3. Classification of electrical loads.
4. Yard and shop services and facilities power requirements.
5. Grounding requirements
6. Corrosion control

7.3 REFERENCE CODES STANDARDS

Electrical systems shall conform to applicable sections of the latest edition of federal, state, and local electrical and fire codes and regulations including ordinances, general regulations and safety orders.

- National Electrical Code (NFPA-70)
- National Electrical Safety Codes (ANSI/IEEE C.2)
7.4 CLASSIFICATION OF ELECTRICAL LOADS

**Critical:** Loads that cannot tolerate any interruption longer than 1/4 cycle, and shall be served by a battery or Uninterruptible Power Supply (UPS).

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

**Nonessential:** Includes all loads not classified essential or critical. Such loads may not be backed up by an automatic primary transfer to an alternate power source and may be disconnected if necessary during emergency conditions.

### 7.4.1 Critical Loads

A. Alarm, supervision systems, and control power for operation of electrical equipment including medium-voltage and low-voltage switchgear.

B. Emergency lighting in passenger stations, tunnels, emergency egress and signage.

C. Exit Signs, area of rescue signs.

D. Fire protection system and public address systems.

E. Gas mitigation ventilation.

F. Control power for emergency ventilation system.

G. Control power for traction power system.

H. Control power for emergency communication system (including emergency management panels, SCADA, and all Carrier Transmission Systems and equipment), gas monitoring system, and security systems.
Control power for load shed panel.
I. UFS station network equipment.
J. Seismic equipment units.
K. Train Control equipment
L. Control power for emergency communication system (including emergency management panels (EMP), SCADA, and all Cable Transmission Systems and equipment), gas monitoring system, security systems including CCTV system. Refer to MRDC Section 9.5.4.

7.4.2 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 system
G. Normal power supply of the UPS system
H. Normal electrical power for train control systems
I. Emergency electrical power for central control and dispatch functions
J. Fire pumps
K. Normal lighting
L. Station roll-up grille
M. TVMs, SAVs and Faregates
N. Equipment or other subsystems not required for evacuation or security surveillance

7.4.3 Non-essential Loads

A. Normal lighting
B. Escalators.
B. Mapcases, grand pylons and canopies
C. All other loads not classified as critical or essential loads.
C. Station roll-up grille.
D. Equipment or other subsystems not required for evacuation or security surveillance.
E. All receptacles at the station and along tunnels.
F. Fare gates

7.5 POWER SUPPLY RELIABILITY

Electrical system reliability varies, depending on the transit system configuration. An underground system, requiring a stringent emergency ventilation system has the greatest need for system reliability. An elevated or at-grade rail system requires a lesser degree of reliability.

7.5.1 Underground Stations

Power supplied to each underground passenger station shall be from two separate sources. Power supplied to the emergency ventilation system shall
have two independent power sources from the Utility Company. The lighting and ventilation system inside underground tunnels shall also be supplied from these power sources.

7.5.2 At-Grade and Elevated Passenger Stations

Electrical service to at-grade or elevated stations shall be either from traction power substation or directly from the utility company. There shall be a provision to transfer, either manually or automatically, to an alternate power source in the form of a portable generator.

7.5.3 Other At-grade Facilities

Depending on the serviceability requirement at each facility, the power distribution system may be designed as described under Sections 7.5.1 and 7.5.2 above.

7.5.3.1 Yard and Shop, and Maintenance of Way (MOW)

Yard and Shop facilities shall have two separate feeder sources and a back-up generator.

7.5.3.2 Rail Operations Control (ROC) Facility

The Rail Operations Control (ROC) Facility may select a dedicated power backup or a standby generator with battery backup for a short duration. They shall have two separate sources, full capacity permanent stand by generator, Transfer Switches, UPS equipment units and plug-in for full capacity mobile/portable generator.

7.6 POWER SOURCES

7.6.1 Underground Passenger Stations and Tunnels

A. Electrical service for stations shall be provided by two independent primary power sources and shall terminate in a traction power or auxiliary power substation room. The main service shall be used jointly with the traction power system. Testing and metering equipment will be provided by the utility company and located as required by the utility company.

B. Electrical service to an underground station having a traction power substation shall be supplied by the same primary feeder supplying the traction power substation.

C. Electrical service to a station without traction power substation shall be supplied by two independent primary feeders from the utility company or as described in Paragraph A.

D. The transfer between the two power sources shall be on the low voltage side via bus coupler breakers. The bus coupler and main breakers shall not be able to parallel the two power sources.
E. The design of electrical power to emergency ventilation system and fire pumps shall comply with NFPA-20, Standard for Installation of Stationary Fire Pumps and Fire Protection, and NFPA-130, Standard for Fixed Guideway Transit and Passenger Rail Systems. Overcurrent protection devices for this equipment shall not trip due to overload or short circuit of other normal loads.

7.6.2 At-grade or Elevated Passenger Station

A. Electrical service for at-grade or elevated stations shall be provided by one primary feeder. When a traction power substation is near the station, the auxiliary power supply shall be served from a primary feeder supplying the traction power substation.

B. Electrical service to stations without a TPSS shall be supplied by a single primary feeder at medium or low voltage.

C. The critical loads at an elevated or at-grade station are the emergency lighting, public address, and equipment used in an emergency situation, which shall be designed per National Electrical Code NFPA-70.

7.6.3 Yard and Shop, Maintenance of Way, Central-Rail Operations Control (ROC) Facility and other At-grade Non-Passenger Structures

A. Yard and Shop, Maintenance of Way, Central Control and other at-grade facilities shall be designed under Section 7.5.3 above.

B. Yard and shop and maintenance of way Facilities shall be fed from the medium voltage switchgear jointly used for traction power system, otherwise power shall be delivered directly from the utility company.

C. The Central-Rail Operations Control Facility shall be supplied from a single primary feeder, the same as at-grade stations, but shall be equipped with the full capacity UPS system and backup generator designed under Section 7.5.3.2.

D. Other at-grade non-passenger facilities shall be designed under Section 7.6.2 above.

7.7 POWER DISTRIBUTION SYSTEM

7.7.1 Underground Passenger Stations

A. Each station shall have two auxiliary power rooms, one at each end of the station, and located near the large motor loads.

B. Each auxiliary power room shall receive both power sources from medium voltage switchgear located in the traction power room.
C. Conversion of medium voltage dual power sources to low voltage power shall be by two sets of auxiliary power transformers, with a bus coupler at the line side of the low voltage switchboards.

D. Each auxiliary power transformer shall be designed to accommodate all electrical loads of the station and adjoining tunnels including portals and cross passages. If one power supply is interrupted or disconnected by the Utility Company, the other auxiliary power transformer shall carry the load. Forced air cooling of the transformer can be used to increase rating during this abnormal condition.

E. There shall be two essential buses fed from two switchboards at each end of the station and one non-essential bus.

F. Both essential buses shall supply normal and standby power to the uninterruptible power supply system, which will be the source of critical power for the station and tunnels.

G. All ventilation system fans used during both normal operation and also during an emergency fire duration, shall be fed from essential buses.

H. Non-essential buses shall sub-feed from one of the essential buses and shall be able to trip all non-essential loads during an abnormal situation or when the auxiliary power transformer is overloaded. Non-gas purging fans may be load shed.

I. Communications rooms and traction power substation room shall be provided with a critical power from UPS.

7.7.2 At-grade and Elevated Passenger Stations

A. Each at-grade station shall be equipped with one electrical room with panelboards to supply power to fare collection equipment, lighting and all other station equipment. a minimum of one electrical equipment room or closet.

B. Each elevated station shall be equipped with a minimum of one electrical room.

C. Main electrical service to the stations shall be at low voltage level and terminated at power panel.

D. There shall be a power receptacle at street level for connection to an alternate source. For stations served by SCE the power receptacle shall be 480V/277V, 4P, 5W NEMA 3R. For stations served by LADWP, the power receptacle shall be 240/120V, 4P, 5W, NEMA 3R.

E. Transfer of power source from normal to an alternate source shall be by a manual transfer switch.
Only portions of the essential loads that require backup power shall be connected to the mobile generator. Other non-essential loads will be tripped during the interruption of normal power sources.

Electrical power to emergency lights, exit lights, and other life safety system shall be transferred to an uninterruptible power system upon loss of power.

### 7.7.3 Electrical Power Distribution Spare Capacity for Stations

**A.** Power distribution system shall be provisioned with sufficient power capacity, electrical power equipment and conduits to serve all future major equipment.

**B.** Power distribution system shall be provisioned for additional minimum 30% spare power capacity and spare electrical power equipment in addition to Section 7.7.3A.

### 7.8 GROUNDING AND GROUND FAULT PROTECTION

#### 7.8.1 Underground Passenger Stations

**A.** A ground grid underneath the base slab at the platform area shall be established to serve as the main ground path of any fault current. This ground grid shall cover the whole length of the platform.

**B.** Traction power substation room and incoming electrical service room shall utilize the station main ground grid.

**C.** There shall be redundant and separate 500 kKcmilCM conductors from each traction power room and incoming electrical service room to the main ground grid.

**D.** The total ground resistance of the ground grid measured shall not exceed five (5) ohms.

**E.** The non-current carrying parts of all electrical equipment, devices, panelboards, and metallic raceways shall be grounded and bonded to the copper ground bus to assure electrical continuity and the capacity to safely conduct any fault current likely to be imposed.

**F.** There shall be no metallic structures less than 5 feet from the edge of platforms.

**G.** Grounding inside the train control and communication room shall be by a copper ground bus of appropriate size and length on the inside wall which is connected directly to the main ground grid.
H. Feeders to all electrical loads, such as motors, panelboards, feeders, etc. shall have a bare copper ground wire which is connected to the ground bus of each equipment. Metallic conduit shall not be used to ground equipment.

I. All major electrical equipment such as generators, power transformers, switchboards, motor control centers, etc., shall be provided with at least two (2) ground pads or ground terminals and shall be connected at different locations to the main ground grid.

J. A copper ground bus of appropriate size and length shall be installed in the traction power substation and auxiliary power rooms on the inside wall and connected to the main grounding grid in the floor slab with bare copper wire.

K. Ground above ground metal structures at station entrance and plaza including but not limited to bike lockers/racks, handrails, canopies, mapcases, and grand pylons.

7.8.2 Grounding at Grade-level or Elevated Structures

A. Passenger Stations

1. Ground all metal structure projecting above platforms including but not limited to bike lockers/racks, handrails, canopies, mapcases, grand pylons, and fences.
2. Bond ground cable to lateral rebar at 4’ intervals in station platforms.
3. Provide copper ground plates of appropriate size in Communication vaults and electrical equipment rooms.
4. Provide grounding in shop buildings in accordance with requirements of National Electrical Code.
5. The total ground resistance of the ground grid measured shall not exceed five (5) ohms.
6. All grounding electrodes that are present at each structure/building on the station shall be bonded together to form the grounding electrode system.

7.8.3 Ground Fault Protection

A. Ground fault protection shall be provided for the following equipment:

1. Auxiliary Power Transformers.
2. 480V switchboards.
3. Motor control centers.
### 7.9 SUPPLY VOLTAGE & VOLTAGE DROP

#### 7.9.1 Supply Voltages

A. AC power for general facilities shall be supplied at nominal 480 volts, 3-phase, 3-wire or 4-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:

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<th>Voltage</th>
<th>Phase</th>
<th>Notes</th>
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<tr>
<td>Fluorescent lighting</td>
<td>277 V</td>
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<tr>
<td>Fluorescent lighting</td>
<td>120V</td>
<td>single phase</td>
<td>(grade station)</td>
</tr>
<tr>
<td>Incandescent lighting</td>
<td>120 V</td>
<td>single phase</td>
<td>(ETS application only)</td>
</tr>
<tr>
<td>HID lighting</td>
<td>277 V</td>
<td>single phase</td>
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<tr>
<td>Convenience outlets</td>
<td>120 V</td>
<td>single phase</td>
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<td>Motors 1/2 to 250 HP</td>
<td>480 V</td>
<td>three phase</td>
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<td>Under 1/2 HP</td>
<td>120 V</td>
<td>single phase</td>
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</tr>
<tr>
<td>Motor control</td>
<td>120 V</td>
<td>single phase</td>
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<td>Heaters for motors or electric equipment</td>
<td>120 V</td>
<td>2- or 3-wire</td>
<td>single phase</td>
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<td>Dry-type Transformers</td>
<td>480 V to 3-wire delta primary.</td>
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<tr>
<td></td>
<td>480/277 V</td>
<td>4-wire wye secondary</td>
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<td></td>
<td>480 V to 3-wire, delta</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>120/208 V</td>
<td>primary, 4-wire, wye secondary</td>
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<td>Auxiliary service to tie breaker stations</td>
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<td>Fare collection</td>
<td>120/208 V</td>
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<td>four wire</td>
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<td>Train control</td>
<td>120/208 V</td>
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<td></td>
</tr>
<tr>
<td>134. Exit signs</td>
<td>277 V single phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>145. Tunnel lighting</td>
<td>277 V single phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>156. Area and parking</td>
<td>277 V single phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>167. Power outlet</td>
<td>480 V three phase, 120 V single phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>178. Emergency Lighting</td>
<td>277 V single phase (Quartz) (@ grade station)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>189. LED Lighting</td>
<td>277 V single phase</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 7.9.2 Voltage Drops

A. Voltage drops from the secondary side of auxiliary power transformer to the farthest device or equipment shall be no greater than 5 percent, and may be limited at the following levels:

1. All feeder circuits down to distribution points 3-2 percent.
2. All motor branch circuits 5 percent.
3. All lighting and receptacle branch circuits 3 percent.

B. For a direct service feeder from the utility company, the total voltage drop, including feeder circuit, to the farthest motor loads shall be limited to 10 percent.

C. In the tunnel section, the average voltage drop along each section of tunnel shall be no greater than 5 percent from the distribution point per Section 7.9.2A above.

D. The voltage drop calculation for motor circuits shall be based on an 80 percent power factor, lagging. For heating and other induction loads, the voltage drop calculation shall be based on 100 percent power factor.

### 7.10 BASIC ELECTRICAL MATERIAL AND EQUIPMENT

#### 7.10.1 Conduit

A. Rigid, hot-dip galvanized steel conduit (GRS) 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. Both IMC and EMT shall not be used.
B. Conduits, boxes and fittings installed in damp or wet locations shall be listed for use in wet locations. Conduit installation shall be sealed to ensure that cables remain in dry condition.

C. Nonmetallic electrical conduit shall be used only for embedment or in ductbanks. Stub up shall be rigid metallic conduit.

D. Rigid nonmetallic conduit (minimum schedule 40) shall be used for underground use, encased in concrete, or for applications where rigid metallic conduit is not applicable and the resistance to impact and crushing of nonmetallic conduit is acceptable. Underground ductbanks shall be encased in concrete. Ductbanks under roadways, crossing railroad tracks and heavy-load bearing areas shall be designed and be provided with steel reinforcements. Ductbanks shall be in compliance to CPUC requirements. Minimum cover shall be per CPUC GO 128 requirement. Where multiple conduits or ducts are run as a ductbank, plastic spacers shall be used to support the rows of conduit and to maintain a clear separation of 2” between conduits. Power and Communication wiring systems shall have separate ductbanks and be provided with required spacing and clearance.

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

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

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

H. Underground ductbanks and electrical substructures including manholes and in-ground pullboxes shall be designed to prevent water infiltration and flooding the interior space. Ductbanks and substructures shall be watertight sealed.

I. Minimum thirty percent (30%) spare conduits shall be provided for power and communication/low voltage systems sized to match largest size conduit. Provide minimum one (1) spare conduit sized to match largest size if quantity of system conduits is less than four (4).

J. For underground station and tunnel, feeder and branch circuit conduits shall be in compliance to NFPA 130 and Metro Fire Life Safety Criteria.

7.10.2 Cable Trays

Cable trays shall be galvanized steel, ladder type, for installation inside rooms, and with solid bottoms for outside the rooms. The use of cable trays is restricted for use within systems buildings or rooms. Cable trays and supports
shall be designed to provide adequate strength to support the weight of the tray, cables, and future cables and meet the local seismic requirements.

7.10.3 Receptacles

A. Convenience Outlets

Convenience outlets shall not be on lighting circuits. There shall be no more than 8 receptacles per 120-volt circuit in track and public areas, and no more than 6 receptacles on each 120-volt circuit in service areas.

Convenience outlets shall be specification-grade 20 amperes, 120-volt, grounding type. Weatherproof covers shall be provided at all receptacles inside tunnels. Receptacles in tunnels shall be provided with ground fault protection.

Convenience outlets in the station mezzanine and platform areas and outside of the station shall be GFCl in a weatherproof, tamperproof and lockable enclosure or receptacle box.

Convenience outlets shall be located on walls, columns and equipment 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. These shall be vandal-resistant/tamper proof with lockable door.

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.


   These shall be equipped with convenience outlets so that any point in the shaft below grade level can be reached with a 25-foot cord.

7.10.4 Wall Switches

Wall switches shall be specification-grade and installed inside each room for controlling general lighting and for conserving energy in accordance with California Title 24. Wall switches shall be installed outside battery rooms. They shall not be used for controlling general lighting at public and entrance areas. Switches shall be "T" rated, 20 amperes at 277 volts, silent type.

7.10.5 Control Stations
In general, control stations shall have watertight enclosures. The number and arrangement of control switches shall be as required for the service.

A UL listed, factory-assembled lighting control panel [with 365-day astronomic time clock, photoelectric cell, daylighting controls, and ten (10) year minimum battery backup for time-of-day, manual overrides of individual relays, zones or the entire panel and can control both 120V and 277V system adjustment] shall be supplied in conjunction with the circuit breaker for controlling normal lighting at public areas and at-grade facilities. Photoelectric cell may also be used instead of electric timers for at-grade station.

Timers—Lighting control panel and/or circuit breakers shall be installed in the electrical room accessible to the transit police and maintenance personnel.

7.10.6 Wiring Methods and Materials

A. Wiring Materials

All power feeders and branch circuits shall be copper, single or multiple conductor cables, and suitable for installation in cable tray (with thermosetting outer jacket). Power wiring shall be temperature rated at 90°C and not smaller than No. 12 AWG. Control wiring shall be multiple conductor cable with color coding per ICEA standard. Control cable shall not be smaller than No. 14 AWG and shall be rated for 90°C. Fixture wiring shall be type SF-2 or BF with temperature rating of 150°C and No. 16 AWG minimum. Aluminum conductors are not permitted.

B. Wiring Methods

1. Wiring within facility areas shall, in general, be in conduit or ducts. Cable trays may be used in non-public areas.

2. In tunnels, power and lighting feeders (except traction power feeders) shall be installed in galvanized rigid steel conduits.

3. Feeders for dual vent shaft fans and/or sump pumps in tunnels shall be installed with one circuit in each single-bore tunnel or on opposite sides of a single-bore double-track tunnel. Otherwise, the power shall be supplied by two independent feeders from two separate power sources.

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

5. When raceway is installed through a 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.

6. Indoor transformers shall be dry type with standard taps on the high voltage (primary) winding. Three phase transformers shall be connected Delta primary and Wye secondary.

7. Transformer sound ratings shall not exceed ANSI C57.12.57 requirements. Quiet-type transformer designs shall be used in office and other areas sensitive to noise.

8. For underground station and tunnel, feeder and branch circuit wiring shall be in compliance to NFPA 130 and Metro Fire Life Safety Criteria.

9. All power distribution and communication system equipment and associated component including but not limited to conductors, conduits, pullboxes and materials shall be properly identified, tagged and labeled. Labeling shall be in accordance to Metro requirement, applicable standards, and in conformance to approved final design plans.

7.10.7 Power Transformers

Auxiliary power transformers shall be dry-type when used indoors and dry or liquid-filled type when used outdoors. Construction shall be in accordance with applicable sections of ANSI and NEMA standards. Primary and secondary coils of transformers having a primary voltage above 16kV shall be of cast-coil type. Low voltage connection from transformer to switchboard may be either solid bus bar or cable bus system. In general, transformers shall be three-phase, delta-wye connected. Low voltage transformers shall be K-rated type for non-linear loads with copper windings.

7.10.8 480-Volt Switchgear, Switchboards

A. All switchgear and switchboards shall conform to NEMA Standard PB-2 and UL 891. Provision for anticipated future loads and additional minimum of 320% spare capacity and circuit breaker locations.

B. Main 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 loss of voltage on normal supply. The transfer of power shall be accomplished by a bus coupler.

C. Feeders shall consist of power circuit breaker's manually or remotely operated.

D. Interrupting capacity shall equal or exceed prevailing short circuit current but shall not be less than 50,000 amperes rms symmetrical at 480 volts.
E. Where applicable, provision shall be made for mounting instrument transformers and metering equipment.

F. Transient voltage surge suppression (VSS) at main 480 V if fed from utility.

7.10.9 Motor Control Centers and Local Starters

A. All motor control centers shall conform to NEMA Class II Type B construction.

1. In general, circuit breaker combination starters shall be used in motor control centers for 460-volt motors. However, individually mounted circuit breaker combination starters may be used where practical.

2. All starters shall be magnetic, full-voltage start, single-speed, non-reversing type, except for emergency fans and other driven equipment where requirements call for other types such as reversing or 2-speed. Each starter shall be equipped with a 120-volt control transformer and three phase thermal overload relay. Emergency fans shall utilize only magnetic trip type circuit breakers.

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

4. In general, enclosures shall be NEMA Type 12 except where outdoor or tunnel installation is necessary. Outdoor and tunnel enclosures shall be NEMA Type 4X.

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

B. Local starters shall be combination type with accessories as shown on the elementary diagrams.

7.10.10 Panelboards

A. General

1. Separate panelboards shall be provided as necessary for nonessential, essential, critical circuits, and dc distribution. Panelboards shall be surfaced-mounted in all non-public areas. In public areas and offices, panelboards shall be flush-mounted.

2. Panelboards shall include spare breakers for future loads, and shall be equipped with buswork and terminations to accept additional breakers.
3. The following guide selection of panelboard sizes shall be used:

<table>
<thead>
<tr>
<th>Active Single Pole Breakers</th>
<th>Spare Single Pole 20 A Breakers</th>
<th>Panel Size Single poles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 6</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>6 to 12</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>12 to 18</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>18 to 24</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>24 and up</td>
<td>6</td>
<td>42</td>
</tr>
</tbody>
</table>

B. Circuit Breakers

1. The 120-volt panelboards shall be equipped with 20 ampere single pole breakers rated at a minimum of 10,000 amperes symmetrical interrupting capacity.

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

3. All circuit breakers shall be the bolt-on thermal-magnetic type.

7.10.11 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.

A. Switches shall be heavy duty type with visible quick-make, quick-break blades.

B. Fusible switches shall have rejection type fuse holders.

C. Terminal lugs shall be rated for 75 degrees centigrade.

D. Enclosures, unless otherwise noted, shall be NEMA 12 for indoor locations, and NEMA 4 for outdoor locations as a minimum.

E. The enclosure shall be interlocked with the switch handle such that the enclosure door or cover cannot be opened with the switch in the “ON” position. The switch handle shall be capable of being padlocked in the “OFF” position but not in the “ON” position.

F. Disconnect switches installed between any variable speed drive type of unit (VFD, AFD, USD, etc.) and its respective motor(s), shall have auxiliary break before break (open) interlock control contact.
These switches 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.

A. The size, number of poles, and fusing for each switch shall be as denoted on the drawings. As a minimum, no less than one pole for each ungrounded conductor shall be provided. Switches shall be rated 250 VAC or 600 VAC as required by the circuit to which it is connected.

B. Switches serving motors with more than one set of windings shall have the number of poles necessary to disconnect all conductors to all windings in a single switch. Switches serving motor loads shall be horsepower rated of sufficient size to handle the load.

7.10.12 Lighting Transformers

A. Lighting transformers shall be dry type with copper windings and standard taps on the high voltage winding. Transformer shall be 3-phase or single-phase as required. They shall be wall-mounted or floor-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:

<table>
<thead>
<tr>
<th>Power Range</th>
<th>Noise Level (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 9 kVA</td>
<td>40</td>
</tr>
<tr>
<td>10 - 50 kVA</td>
<td>45</td>
</tr>
<tr>
<td>51 - 150 kVA</td>
<td>50</td>
</tr>
</tbody>
</table>

7.10.13 Uninterruptible Power Supply

A. Requirements

The UPS shall include a solid state rectifier, seal type battery, inverter, and high-speed solid state transfer switch and external manual by-pass switch. UPS equipment with batteries shall be inside air conditioned electrical room with required vent and H2 sensors.

B. Rectifier

The Rectifier shall be solid state type with adequate capacity to supply power to the inverter at full rated output and charging the battery from a completely discharged condition in less than 10 times the discharge period. The battery charger shall have an adjustable charge rate for equalization, and shall provide a "no charge" indication to the supervisory control system.

C. Battery
Seal type batteries shall be rated and have sufficient capacity to carry the following UPS load continuously for the times indicated, with a final terminal voltage of not less than 1.75 volts per cell.

1. Underground Stations
   a. 4 Hours (All Communication System back up power refer to MRDC Section 9.5.4)
      - PA System
      - Fire Protection Detection
      - Security System/CCTV
      - Radio
      - Gas Monitoring
      - Emergency Telephone
      - Load Shed panel and Traction Power Substation (TPSS) Control power
   b. 90 minutes
      - Emergency Lights
      - Exit Signs and ETS Lights
      - Tunnel Lighting
      - Emergency Exit Door Operation

2. At-Grade and Elevated Stations
   a. 4 Hours (All Communication System back up power refer to MRDC Section 9.5.4)
      - PA System
      - Fire Protection Detection
      - Security System/CCTV
      - Radio
      - Gas Monitoring
      - Emergency Telephone
   b. 1 ½ hours
      - Emergency Lights
      - Exit Signs and ETS Lights

D. Inverter

The inverter shall be solid state type, DC input, 277/480 volts, 3-phase, 4-wire, 60 Hz ac output and powered from the station battery.

E. Static Transfer Switch

1. 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 1/4 cycle.
2. Operation of the transfer switch shall be indicated on the supervisory control system and alarm panels.

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

F. Manual By-Pass Switch

An external manual by-pass switch shall be provided for maintenance and to allow removal of the UPS. It shall transfer the load to the alternate ac power source without any interruption to the loads.

7.10.14 Automatic Transfer Switch

An automatic transfer switch shall be used where there is more than one power source feeding the same load. It shall be designed such that only one power source can supply power to a switchboard without the possibility of paralleling the two sources. They shall be electrically operated and be equipped with a by-pass isolation switch for maintenance. Automatic transfer switch and by-pass isolating switch shall be an integral unit and shall be installed in the same line-up switchboard enclosure arrangement for convenience of operation.

7.10.15 Stand-by Generators

Portable and stand-by generators shall be used as a backup power source to the normal utility power source. Output voltage shall be 480V, 3-phase and connected to the station distribution system by a power receptacle.

The main yard and shop shall have a standby stationary generator. All necessary accessories for the generator such as shall include but not limited to, double wall containment fuel day tank, and underground storage tank, generator main circuit breaker, battery, battery charger, remote annunciator panel for monitoring and control, and automatic transfer switch shall be compatible with the generator sized for 24 hours of continuous service. A sound attenuating enclosure shall be provided for standby generators. Permanently installed Load banks shall be provided with breakers and controls designed for stand-by generator testing.

Portable and Standby generators shall meet Southern California Air Quality Management District (SCAQMD) requirements, shall be certified and permitted upon commissioning.

7.11 POWER SUPPLY TO MECHANICAL AND ARCHITECTURAL EQUIPMENT

7.11.1 Emergency Ventilation System for Underground Station and Tunnels

Emergency ventilation fans are part of the life safety system and shall be designed per Section 7.6.1E. Overcurrent devices designed to protect
conductors shall operate on magnetic principles and not depend upon thermal properties. Fans designed for emergency ventilation shall have the thermal overload relays by-passed and shall not trip due to overload unless excess current is sensed simultaneously with a no-air-flow signal. They shall be fed from essential buses supplied from dual power sources.

Cables used for emergency ventilation fans and associated dampers shall pass the flame propagation criteria of IEEE Standard 383. Cables shall be protected from physical damage by transit vehicles or other normal transit system operations, and from fire in the transit system by suitable embedment or encasement.

7.11.2 Normal Ventilation System

Power supply for normal ventilation fans and mechanical equipment shall be from essential buses located in the nearest auxiliary power or electrical room. All underground installation is classified as gassy and requires sufficient ventilation to prevent accumulation of gases to an explosion level. Normal ventilation fans shall, even be designed for continuous operation.

7.11.3 Sump Pumps

Each pump station shall be equipped with dual pumps. They shall be fed from different essential buses nearest to the pump station. Only one pump at a time may be out of service except during an area-wide power outage.

7.11.4 Ventilation System for At-grade and Elevated Stations

Where locations of at-grade and elevated stations are not classified as "gassy", all ventilation systems shall be fed from non-essential buses.

7.11.5 Elevators

This equipment is considered essential during an emergency condition, and shall be fed from the nearest essential bus. The electrical power supply to the equipment shall consist of a nominal 480-volt, 3-phase, 60 Hz supply terminated in a fused disconnect switch in the machine room.

7.11.6 Escalators and Station Roll-Up Grille

These items are considered non-essential loads. Power shall be supplied from the nearest non-essential bus.

7.12 POWER REQUIREMENTS FOR SYSTEMWIDE SUBSYSTEMS AND MISCELLANEOUS YARD FACILITIES

7.12.1 Train Control and Communication Equipment Room
A. 120/208V, three-phase, 4W power from the uninterruptible power supply shall be provided in the TC&C room for the operation of the PA system, Fire Protection Detection, Security System/CCTV, Radio, Gas Monitoring and Emergency Telephone.

B. Two 120/208V, three-phase, 4W power from the essential busses shall be provided in the TC&C room for the ATC panel, voltage conversion as well as DC distribution system shall be covered in the subsystem volume.

7.12.2 Fare Collection and Station Fare Collection Control Unit (SFCCU)

Each underground passenger station is 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 interface cabinet. Two under-floor ducts for power and signal circuits, each with a minimum cross section of 8.5 square inches, shall be installed underneath the fare gate and ticket vending machines. Adequate junction boxes shall be provided wherever the raceways change direction. All other raceways for signal and power circuits shall be metallic conduits. The power supply to fare collection equipment shall be fed from the panelboard located in the nearest electrical room.

7.12.3 Ticket Vending Machines (TVMs) / Stand Alone Validators (SAVs), and Fare Gates

A. Power shall be supplied from the 120/208 V, 3-phase, 4-wire distribution panel nearest to the machines. Each unit shall be powered via dedicated circuits.

A-B. For at-grade station, panelboard shall be in a ventilated lockable electrical room.

7.13 LIGHTING

7.13.1 General

Included in this subsection are requirements for normal and emergency lighting systems. For lighting terms, definitions, goals and application overview, see Appendix A. Appendix A is for reference only.

A. The lighting system shall:

1. Be functional, yet complementary to those other aesthetic features in the space which provide an atmosphere of relative comfort, pleasantness and cleanliness of surroundings, and a sense of personal safety and security. Lighting for passenger stations should be bright and cheerful.
2. Provide adequate lighting levels rated for continuous operation, contrast ratios and other visibility attributes necessary to stimulate productivity, facilitate the use of facilities by patrons or the successful completion of tasks in a timely yet safe manner, and maintain appropriate surveillance levels under all ambient light conditions.

3. Be relatively simple and economical to construct and maintain.

4. Be energy-efficient.

5. Be vandal-resistant/tamper-proof (in spaces accessible to patrons or to the general public).

6. Effectively control glare or other extraneous reflections in the visual field.

7. Lighting shall be easy and safe to maintain. Lighting shall not require scaffolding for access and maintenance.

8. Lighting design and photometric calculations in accordance to tables 7.1, 7.2 and 7.3 shall take into consideration actual equipment layout, placement and location of appurtenances, machineries, catwalks, hoists, parked rail vehicles etc. which will impact illuminance or foot-candle at ground level. Illuminance level shall be maintained in the entire lighting area regardless of equipment size, location, etc. Illuminance level in between parked rail vehicles and buses shall also be maintained.

B. Lighting system efficiency shall be achieved by:

1. Selecting high efficiency light sources, ballasts, and appropriate fixtures.


3. Employing supplementary luminaires to achieve high task-illumination levels.

C. Consideration should be given to the location and arrangement of lighting circuits and panel configuration to accommodate retrofitted automated energy control devices.

D. Yard lighting shall provide sufficient illumination to permit operations and maintenance activities to be performed safely on a 24-hour basis. A minimum illumination of average-maintained 1 footcandle, as measured at ground level, shall be provided. Light poles shall be grounded and bonded.

Yard lights, towers, poles or stanchions should be designed and located to maximize maintenance accessibility, minimize shadows, light pollution, and avoid interference with operations.
High mast poles used for area illumination shall be climbable and limited to 70 feet in height. Poles with fixture-lowering mechanisms shall not be used. Where practical, poles shall be located in the aisles used for OCS supports.

E. Fixtures shall be provided with integral ballasts and fuses.

### 7.13.2 Normal Illuminance Values

A. The design illuminances shall be target, average maintained values as listed in Table 7.1 and 7.2. However, illumination levels for tasks requiring sustained visibility shall be a minimum of 20 footcandles.

B. Illuminance values not listed in Table 7.1 and 7.2 shall be those recommended by the IES for the particular (or sufficiently similar) activity, using a zero weighing factor.

C. The illumination on all entrance and exit roadways shall be graduated up or down to the illumination level of the public street or highway, as much as practical.

D. Illumination for access roadways shall be in accordance with IES RP-8 recommended levels for the local intermediate vehicular traffic classification, with an "R2" roadway surface.

E. Art work illumination shall be approved by the architect.
### TABLE 7.1

**PARTIAL NORMAL LIGHTING LEVELS TARGET ILLUMINANCE VALUES**  
*(AVERAGE, MAINTAINED IN A HORIZONTAL PLANE UNLESS OTHERWISE NOTED)*

<table>
<thead>
<tr>
<th>Footcandles</th>
<th>At</th>
</tr>
</thead>
</table>

**A. Transit Right-of-Way and Storage**
- Entrance and exits within 300 feet of portal in the underground structures  
  1.5 Pavement
- Yard and other special trackwork areas  
  2 Rail
- Transit vehicle storage area  
  2 Rail

**B. Operations and Central Control Facility (Central Control Room)**
1. General Illumination  
   10 2'x6" AFF
2. Face of Control Panels  
   30 Vertical
3. Shining on CRT displays  
   3 Vertical
4. Rear of Control Panels  
   10 Vertical
5. Dispatch Desks  
   50 Vertical
6. Shining on rear projection displays  
   3 At Desk Level

**C. Maintenance in Central Control Facility**
1. Inspection Area  
   150 Task
2. Repair Work Area  
   200 Task

Illumination levels should be within 10% of the target values indicated

**D. Yards and Shops**
1. Paint Shop Area  
   30 to 50
2. Paint Both "Inside"  
   100
3. Wheel Truing Area  
   100
4. Car Wash Area  
   100
5. Offices  
   50 to 70
6. Maintenance Area  
   50 to 70
7. Outside Areas 1 footcandle minimum for emergency egress. 5 footcandles minimum outside building entrance and parking stalls for individuals with disabilities.
8. Storage Tracks 1 footcandle minimum, in the aisles with cars parked on the tracks and casting shadows.
**TABLE 7.2**  
Illuminance/Exitance Requirements

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>MINIMUM MAINTAINED ILLUMINANCE</th>
<th>MINIMUM MAINTAINED EXITANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg Max/Min Avg/Min</td>
<td>Cell</td>
</tr>
<tr>
<td>EXTERIOR PUBLIC AREAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train Platform (general)</td>
<td>15 10:1 6:1</td>
<td>23</td>
</tr>
<tr>
<td>Train Platform (edge)</td>
<td>15 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Fare Vending Equipment (vertical)</td>
<td>20 5:1 3:1</td>
<td>N/A 156</td>
</tr>
<tr>
<td>Train Grade Crossing (street)</td>
<td>5 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Train Pedestrian Crossing (at station)</td>
<td>15 5:1 3:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Stairs and Escalators (steps)</td>
<td>15 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Stairs/Escalators (pt. of transition)</td>
<td>30 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Pedestrian Pathways</td>
<td>5 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Bus Loading/Unloading</td>
<td>5 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Kiss-and-Ride</td>
<td>5 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Parking-Open</td>
<td>1 (note 8 and 9) 10:1 4:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Parking-Covered</td>
<td>5 (note 9) 10:1 4:1</td>
<td>1</td>
</tr>
<tr>
<td>Plaza</td>
<td>5 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Plaza @ Station Entrances</td>
<td>10 10:1 6:1</td>
<td>5</td>
</tr>
<tr>
<td>Bike Paths</td>
<td>5 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>INTERIOR PUBLIC AREAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrance Escalators and Stairs</td>
<td>30 D /15N7 10:1 6:1</td>
<td>10D/5N67</td>
</tr>
<tr>
<td>Escalators and Stairs (steps)</td>
<td>15 10:1 6:1</td>
<td>56</td>
</tr>
<tr>
<td>Escalators/Stairs (pt. of transition)</td>
<td>30 10:1 6:1</td>
<td>56</td>
</tr>
<tr>
<td>Passageways</td>
<td>30 D /15N7 10:1 6:1</td>
<td>10D/5N7</td>
</tr>
<tr>
<td>Fare Vending Equipment (vertical)</td>
<td>30 5:1 3:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Fare Gates (@30&quot;)</td>
<td>30 5:1 3:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Mezzanine</td>
<td>15 10:1 3:1</td>
<td>26</td>
</tr>
<tr>
<td>Platform (general)</td>
<td>15 5:1 3:1</td>
<td>26</td>
</tr>
<tr>
<td>Platform (edge)</td>
<td>30 5:1 3:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Bike Room</td>
<td>5 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Toilets</td>
<td>20 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>INTERIOR ANCILLARY AREAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical and Equipment Rooms</td>
<td>30 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Train Control/Communication (@30&quot;)</td>
<td>50 5:1 3:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Storage Rooms and Trash Areas</td>
<td>10 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Staff/Security/Mechanical Rooms</td>
<td>30 10:1 6:1</td>
<td>N/A</td>
</tr>
<tr>
<td>Toilets</td>
<td>20 10:1 6:1</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1) All illuminance numbers are for average horizontal illuminance (in footcandles) at ground level, unless otherwise noted.
2) All exitance numbers are for average exitance (in footlamberts) at surface noted. Exitance = Illuminance x % Reflectance of surface.
3) Ceiling exitance at exterior platform on visible surface of underside of canopy.
4) Exitance at wall area (where it exists) within 4 feet of fare vending equipment.
5) Exitance at floor area within 4 feet of fare vending equipment.
6) Requirements for ceiling and wall exitance may be swapped if design intent and/or art installation are shown to benefit from such.
7) D (day) vs. N (night) requirements; consideration of visual adaptation is critical in these areas.
8) Illuminance level shall be no less than 0.5fc (minimum maintained) on pavement in the entire lot.
9) Parking lot entrance Illuminance level shall be at higher level in accordance to Metro Security requirement for CCTV field of view and operating requirements.

The higher illumination/exittance values are for the transition from outside to inside only.

### 7.13.3 Light Contrast

A. Outdoor luminaires should be so positioned that they do not result in glare or otherwise hinder nighttime train movements. Care must be taken to minimize glare on adjacent properties or to motorists. This is particularly important in residential areas.

B. Small areas for accent, design interest, or message purposes, such as for station identification, destination sign, map case, safety or guidance, will be allowed to have brightness ratios in excess of the preceding criteria.

C. Luminaires in staffed control rooms should be so positioned that no reflected glare from meter faces or cathode ray tube monitoring screens meets the operator's eyes while at his workstation.

### 7.13.4 Emergency Illuminance Values

A. Emergency levels shall be target, average maintained values as listed in Table 7.3.

B. Emergency lighting fixtures exit lights in underground areas shall be located so as to minimize the possibility of being obscured by stratified smoke from a fire.

#### TABLE 7.3

<table>
<thead>
<tr>
<th>Area</th>
<th>Minimum Illumination Levels (fc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egress paths in passenger station areas including platform, mezzanines, ticketing areas, passageways and entrances</td>
<td>1</td>
</tr>
<tr>
<td>Electrical service rooms</td>
<td>1</td>
</tr>
<tr>
<td>Stairs, escalators</td>
<td>2</td>
</tr>
<tr>
<td>Underground areas (future underground structures)</td>
<td>1</td>
</tr>
<tr>
<td>Tunnel Walkways</td>
<td>0.25</td>
</tr>
</tbody>
</table>

### 7.13.5 Emergency Lighting

All public areas within passenger stations shall be equipped with emergency lights. For tunnel lighting, see 7.13.7.
All emergency lighting branch circuits shall be carried in separate conduits running from the emergency lighting power supply unit to the emergency lighting fixture. Pull boxes shall be separate boxes or common boxes with barriers. All other requirements shall conform to National Electric Code Article 700.

If the battery pack lighting fixture is used, it shall be rated correspondingly to its area of application and the installation shall comply with applicable code.

7.13.6 Lighting Control

A. Emergency Lighting

Emergency lighting in underground structure shall only be switched at the breaker panel.

For exterior emergency lighting and in transition area between exterior and interior, a photocell unit and/or timer can be used to turn off the lighting during daytime.

The photocell unit, if used, shall be located where no artificial light interferes with its function.

B. Normal Lighting

Normal lighting at ancillary areas shall be controlled with wall switches. Since all stations are designed as unattended areas, only one switch at each room or area is required. Other structures that are occupied daily shall be designed with two switches at each room, unless there is only one light.

C. Lighting Control

Both normal and emergency lighting at street level shall be controlled by electric timers. Normal lights at public areas shall be switched off during non-revenue hours. These lights shall also be manually controlled at the rooms accessible to the transit police or the maintenance crew.

7.13.7 Tunnel Lighting

Each tunnel shall be illuminated by Light Emitting Diode (LED) fixtures spaced evenly throughout the tunnel. Fixtures shall be a type to eliminate glare to train operator. Each tunnel lighting fixture shall be equipped with two LED boards and each board fed from two different emergency sources. Power to tunnel lights shall be provided from two stations adjacent to each tunnel. Spacing of fixtures shall be 25 feet on center, with two high lumen output lamps.

7.13.8 Egress
Egress shall have an illuminance level as per Table 7.2, with an emergency lighting minimum as per Table 7.3.

7.13.9 Calculations

A. Calculations shall conform to the procedures and recommendations in the applicable IES publications (and their appendixes).

Calculated values shall be presented on calculated illuminance/exitance summary form 7-A shown herein.

B. A computer software photometric calculations must be performed for all areas including but not limited to station public areas and egress routes train crossing, etc. to assure competent and thorough lighting design. Photometric drawings with lighting summary and calculations shall be provided.

C. Illumination levels for work areas shall be calculated at the working plane, generally a horizontal plane set at 2'-6" above the finished floor level, except that for task lighting the actual working height shall be used whenever this information is available.

D. Illumination levels for walking surfaces, egress paths and security lighting shall be calculated at the surface being illuminated, except as otherwise required by codes or regulations or as specified herein.

E. An average Light Loss Factor for use in all areas of the transit system lighting other than offices should not exceed 70%.

F. Reflectance values shall be based, whenever possible, on the actual reflectances of the proposed materials. Generally, material used shall meet the reflectance values tabulated in Tables 7.2, and 7.4. Where specific reflectances are not available, use appropriate value from IES Standard.
### TABLE 7.4
**RECOMMENDED PERCENT REFLECTANCE VALUES**

A. Control Room

<table>
<thead>
<tr>
<th>Surface</th>
<th>% Reflectance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ceilings</td>
<td>60 to 90</td>
</tr>
<tr>
<td>2. Walls</td>
<td>50 to 85</td>
</tr>
<tr>
<td>3. Floors</td>
<td>15 to 35</td>
</tr>
<tr>
<td>4. Furniture &amp; Consoles</td>
<td>20 to 40</td>
</tr>
</tbody>
</table>

B. Other indoor areas

<table>
<thead>
<tr>
<th>Surface</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ceiling</td>
<td>50</td>
</tr>
<tr>
<td>2. Wall</td>
<td>50</td>
</tr>
<tr>
<td>3. Floor</td>
<td>10</td>
</tr>
</tbody>
</table>

C. Outdoor areas

<table>
<thead>
<tr>
<th>Surface</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ceiling</td>
<td>10</td>
</tr>
<tr>
<td>2. Wall</td>
<td>50</td>
</tr>
<tr>
<td>3. Floor</td>
<td>10</td>
</tr>
</tbody>
</table>
## FORM 7-A, CALCULATED ILLUMINANCE/EXITANCE SUMMARY

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>CONTRACT #</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>MINIMUM ILLUMINANCE</th>
<th>MAINTAINED ILLUMINANCE</th>
<th>MINIMUM MAINTAINED EXITANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg</td>
<td>Max/Min</td>
<td>Avg/Min</td>
</tr>
<tr>
<td><strong>EXTERIOR PUBLIC AREAS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train Platform (general)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train Platform (edge)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Fare Vending Equipment (vertical)</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train Crossing</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Stairs and Escalators (steps)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Stairs/Escalators (pt. of transition)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Pedestrian Pathways</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Bus Loading/Unloading</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Kiss-and-Ride</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Parking-Open</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Parking-Covered</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Plaza</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Plaza @ Station Entrances</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td><strong>INTERIOR PUBLIC AREAS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrance Escalators and Stairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Escalators and Stairs (steps)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Escalators/Stairs (pt. of transition)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passageways</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fare Vending Equipment (vertical)</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fare Gates (@30&quot;)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Mezzanine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platform (general)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platform (edge)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

I certify that all numbers recorded above are true and accurate:

NAME ____________________________ DATE _____

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De304.07
Metro Baseline
Revision 12: 10/06/2011 15/13
Re-Baseline: 03/05/10
7.14 CONTROLS AND INSTRUMENTATION

7.14.1 General

Under normal conditions, supervision of the local auxiliary electrical equipment, including control and monitoring of the essential functions shall be performed remotely at central control. This supervision shall be accomplished by integration of SCADA system, the cable transmission system (CTS), and the fire and Emergency Management (F&EM) system.

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

7.14.2 Functions

Tables 7.5 and 7.6 list the various local and remote supervisory control function for the auxiliary electrical systems equipment.

7.14.3 Communications Interface Cabinet (CIC)

A Facilities Communications Interface Cabinet (CIC) shall be installed in the electrical room to provide an interface between the Supervisory Systems and auxiliary electrical system. Control, status indication, and annunciation elements of the auxiliary electrical systems and other station facilities shall be connected to terminals of the interface cabinet.

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

These cabinets may be used to terminate the communications and supervisory system circuits such as public address, fire protection, telephone, etc.

7.14.4 Local Annunciation

Local trouble indication shall be annunciated in the local annunciator panel adjacent to the equipment or in the TC&C Room, as required.
Table 7.5

LOCAL AND REMOTE SUPERVISION AND CONTROL FUNCTIONS:
AUXILIARY POWER PRIMARY DISTRIBUTION SUBSYSTEM

<table>
<thead>
<tr>
<th>Function</th>
<th>Control</th>
<th></th>
<th></th>
<th></th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Local</td>
<td>Remote</td>
<td>Local</td>
<td>Remote</td>
<td></td>
</tr>
<tr>
<td>SWITCHING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-Voltage AC Switchgear (if any)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Incoming Line Circuit Breakers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Incoming Circuit Breakers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ALARMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary Power System Trouble</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substation Ambient Temperature High</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Voltage AC Switchgear Bus Voltage</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High/Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling Fan Failure</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-Temperature (Alarm)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>High-Temperature (Trip)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-Voltage Circuit Overcurrent</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lockout</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 7.6

LOCAL AND REMOTE SUPERVISION AND CONTROL FUNCTIONS
AUXILIARY POWER SECONDARY DISTRIBUTION SUBSYSTEM

<table>
<thead>
<tr>
<th>Function</th>
<th>Control</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Local</td>
<td>Remote</td>
</tr>
<tr>
<td>ALARMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution Switchboards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Circuit Breakers</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Essential Load Bus on Standby Power Source</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Essential Load Bus Voltage Low</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nonessential Load Bus Loss of Power</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Main Circuit Breakers Lockout</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Motor Control Centers (MCC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Circuits Tripped</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Motor Trouble</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Essential Loads Panelboards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder Circuit Tripped</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Essential Loads Panelboard Trouble</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Uninterruptible Power Sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Power Source Failure</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Battery Voltage Low</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Battery Charger Failure</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Inverter Failure</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Distribution Panelboard Voltage Low</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Feeder Circuit Tripped</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>UPS Trouble</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>480V Essential Loads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency Fans</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Station Ventilation Fans</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sump Pump Trouble</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Station Temperature High</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Traction Power Ventilation Trouble</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Tunnel Lighting Failure</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
APPENDIX A LIGHTING SYSTEM

INTRODUCTION AND GOALS

"The associations we have with light are inevitably made early on, more so than with many other aspects of architecture...Light can symbolize comfort and security to those whose recollections are of lamps left on at night to guide them home or just to make a house feel warm. And comfort mixed with a hint of the exotic, for those whose early memories are of candlelight and the glow of a fire. What is most important about all of these things is that they deal with emotional associations. They are not pure fact, the recollection of the knowledge that one plus one equals two, but something that strikes much deeper than empirical knowledge...light inevitably has these kinds of associations for people."

Paul Goldberger
Address to Lighting World III
April 1985

A. Introduction

For most of us, vision is the primary method by which we gather information about our surroundings. What we see influences a multitude of levels of the perception of our environment and how we respond to it, from immediate issues of "there is a step here" to more remote issues such as "it feels safer over there". Light is the vehicle by which these messages are transported to our visual system, and has the ability to either enhance or detract from the clarity of the message. Lighting is also one of the many pieces in the multi-disciplinary puzzle we call design.

In striving to provide a facility that is inspiring yet practical and economical, the entire design team is faced with a delicate balancing act. The guidelines set forth are a compilation of the experiences of many designers in addressing the lighting portion of this act, and are intended to assist the team in establishing design goals, and ultimately solutions.

B. Goals

A transportation facility must function both for the first time user and for the daily commuter. For this broad spectrum of users, lighting plays a key role in one's perception of the safety and quality of the space, and ultimately ones desire to return. This, in essence, is the primary goal of the lighting system.to render the spaces in such a way as to make them a desirable destination. This involves the cooperation and collaboration of a number of factors - beginning with the design team, the client and the artist, followed by the budget, the contractor, the maintenance team, and finally the commuter.
In the end, the overall impression of quality is greatly influenced by the degree to which the lighting is integrated into the architecture and the design process. As the design team is setting initial goals, lighting related issues such as the following should be on the agenda:

- Safety
- Security
- Economy
- Maintenance
- Architecture
- Artwork

Integrate the lighting with the architecture to produce a visual environment that people will want to return to.

QUANTITY/QUALITY OF LIGHT

A. Quantity of Light-Illuminance

Most tasks and activities require specific amounts of light for successful visual performance. The Illuminating Engineering Society (I.E.S.) publishes light level guidelines for most tasks as a result of many years of input from its professional members. These guidelines are recognized as an industry standard. All station area footcandle levels presented in these standards are in accordance with these recommendations. Experience has shown, however, that knowledge of horizontal illuminance alone does not define or guarantee a successful lighted environment.

B. Quality of Light-Exitance

In an attempt to more accurately predict the quality of the luminous environment, guidelines have also been established for the perceived brightness of the surfaces within the field of view. This value, Exitance, takes into account the reflectance values of the surfaces and thus, what the eye ultimately "sees" within the space.

It has been proven that the careful balancing of room surface brightness (exitance/luminance) can greatly affect occupant's behavior and perceptions of a space (i.e.: a brightly lighted wall can draw attention and effect flow of traffic, or a glowing vault can visually lift a ceiling).

Lighting composition, the placement of light and lighting equipment with respect to architecture then becomes a design consideration. The objective of station lighting design should be to achieve a balance between the quantity of incident light (illuminance) and the quality of reflected light (exitance) to achieve an appropriate, meaningful perception of the overall luminous environment.

C. Intended Lighting Composition

Station lighting systems can reinforce positive impressions (safety, spaciousness) resulting in a more "user friendly" environment. With this in mind, Designers
should identify the "mood" or "atmosphere" (with respect to light) intended for each area of the station. Examples of commonly utilized lighting compositions for reinforcing positive impression are as follows:

Security

"Dark corners" are as often a result of highly contrasting values of exitance as they are of low levels of illuminance. The perception of security is thus reinforced by the use of broad washes of light onto fairly light surfaces (typically walls or ceilings), and the avoidance of extremely dark surfaces juxtaposed to extremely light ones (such as a luminous globe of a light fixture against a black wall).

Spaciousness/Relaxation

The sense of volume within a space is also enhanced by broad washes of light, "lifting" ceilings or "expanding" walls.

Orientation/Circulation

Contrast is not always a villain; it is, in fact helpful in providing important visual cues (when used in moderation). Noticeably brighter surfaces (higher exitances) will attract attention and interest and can assist in way-finding within a space. A combination of lighter surfaces with increased (accent) lighting at specific points of decision or destination will help establish a hierarchy of visual information.

It is necessary to keep in mind that the design intent in part is to counteract the effects of subterranean gloom and claustrophobia associated with underground stations. The spaces should appear bright, airy and cheerful which is effectively achieved by directly illuminating walls and ceilings.

Exterior stations can potentially leave passengers feeling vulnerable due to the station's remote locations. Lighting as many available surfaces as possible, including canopies helps to define station boundaries, reinforce the sense of shelter and protection, and promote a sense of security.

Prior to addressing the Illuminance Requirements part of the standards, the Designer should observe not only the necessary amount of light, but exactly where that light is needed. When a space has sufficient general lighting for most tasks, but certain areas require higher light levels, that particular area only should receive additional light. Examples of areas requiring supplemental task lighting are ticket vending equipment, signage, platform edge, and station entrances.

D. Guidelines for Architectural Surface Reflectance

Room surface exitance is directly related to surface finish reflectance. The lighter the surface, the more light is reflected and perceived as "bright". Therefore, surface reflectance should be a conscious design goal. The use of these reflectance guidelines, along with a selection of appropriate color finishes, should
help to control exitances and keep within the ratio limits without creating a bland and uninteresting environment. It is highly recommended to take advantage of lighter finishes as they contribute reflected light to a space and visually promote a sense of security and spaciousness.

It should be noted that potential problems can arise when surfaces are specular, or shiny. Such surfaces can act as "mirrors" and cause uncomfortable glare. The individual Designer is responsible for assessing glare potential when highly reflective surfaces are utilized.
LIGHTING TERMS AND DEFINITIONS

Adaptation:

The process by which the retina becomes accustomed to more or less light than it was exposed to during an immediately preceding period. It results in a change in the sensitivity to light.

Ambient Lighting:

Lighting throughout an area that produces general illumination.

Baffle:

A single opaque or translucent element to shield a source from direct view at certain angles, to absorb or block unwanted light, or to reflect and redirect light.

Ballast:

A device used with an electric-discharge lamp to obtain the necessary circuit conditions (voltage, current and waveform) for starting and operating.

Beam Spread:

(in any plane) The angle between the two directions in the plane in which the intensity is equal to a stated percentage (typically 10%) of the maximum beam intensity.

Candela, cd:

The SI unit of luminous intensity, equal to one lumen per steradian.

Cavity Ratio (CR):

A number indicating cavity proportions calculated from length, width and height.

Ceiling Cavity:

The cavity formed by the ceiling, the plane of the luminaires and the wall surfaces between these two planes.

Ceiling Cavity Ratio (CCR):

A number indicating ceiling cavity proportions calculated from length, width and height.

Coefficient of Utilization (CU):

The ratio of the luminous flux (lumens) from a luminaire calculated as received on the workplane to the luminous flux emitted by the luminaire’s lamps alone.
Color Rendering:

A general expression for the effect of a light source on the color appearance of objects in conscious or subconscious comparison with their color appearance under a reference light source.

Color Rendering Index (of a light source) (CRI):

A measure of the degree of color shift objects undergo when illuminated by the light source as compared with those same objects when illuminated by a reference source of comparable color temperature.

Emergency Lighting:

Lighting designed to supply illumination essential to safety of life and property in the event of failure of the normal supply.

Floor Cavity:

The cavity formed by the workplane, the floor, and the wall surfaces between those two planes.

Floor Cavity Ratio (FCR):

A number indicating floor cavity proportions calculated from length, width and height.

Footcandle, fc:

A unit of illuminance.

General Lighting:

Lighting designed to provide a substantially uniform level of illumination throughout an area.

Glare:

The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort of loss in visual performance and visibility.

Illuminance:

The area density of the luminous flux incident at a point on a surface.

Lamp Lumen Depreciation Factor (LLD):

The fractional loss of lamp lumens at rated operating conditions that progressively occurs during lamp operation.
Light Loss Factor (LLF):

The ratio of illuminance for a given area to the value that would occur if lamps operated at their (initial) rated lumen output and if no system variation or depreciation had occurred. Components of this factor may be either initial or maintained.

Lumen:

The luminous flux emitted within a unit solid angle by a point source having a uniform luminous intensity of 1 cd.

Lumen (or flux) Method:

A lighting design procedure used for predetermining the relation between the number and types of lamps or luminaries, the room characteristics and the average illuminance on the workplane. It takes into account both direct and reflected flux.

Luminaire Dirt Depreciation Factor (LDD):

The fractional loss of task illuminance due to luminaire dirt accumulation.

Luminance:

The physical measure of "brightness"; luminous intensity per unit projected area of a surface

Luminance Ratio:

The ratio between the luminances of any two areas in the visual field.

Luminous Exitance:

The area density of luminous flux leaving a surface at a point.

Nonrecoverable Light Loss Factors:

(initial or maintained) Factors that give the fractional light loss that cannot be recovered by cleaning or lamp replacement, consisting of those components that are due to the lamps operating at other than their rated luminous value. These factors are applied to lighting calculations irrespective of the age of the lighting system.

Point Method:

A lighting design procedure for predetermining the illuminance at various locations in lighting installations, by use of luminaire photometric data.

Quality of Lighting:

Favorable distribution of luminance in a visual environment, with regard to visual performance, visual comfort, ease of seeing, safety and esthetics of the specific visual tasks involved.
Recovered Light Loss Factors:

Factors which give the fractional light loss that can be recovered by cleaning or lamp replacement.

Reflectance of a Surface or Medium:

The ratio of the reflected flux to the incident flux.

Room Cavity:

The cavity formed by the plane of the luminaries, the workplane, and the wall surfaces between these two planes.

Room Cavity Ratio (RCR):

A number indicating room cavity proportions, calculated from the length, width and height.

Subjective Brightness:

The subjective attribute of any light sensation giving rise to the perception of luminous magnitude.

Task Lighting:

Lighting directed to a specific surface or area that provides illumination for visual tasks.

Visual Perception:

The interpretation of impressions transmitted from the retina to the brain in terms of information about a physical world displayed before the eye.

Workplane:

The plane at which work usually is done, and on which the illuminance is specified and measured.
APPLICATIONS OVERVIEW

A. Introduction

The applications overview section is intended as an 'ideas' resource throughout the process of design. Lighting is most successful when it is an integral part of the architecture and of the architectural design process - not an applied dressing at the end.

Each area has a unique set of lighting requirements which the Designer should address, while maintaining vision for the overall station design and concepts. Below you will find a brief discussion of the typical areas in both interior and exterior stations, followed by a number of sketches for illustration.

B. Typical Areas

INTERIOR STATION public areas discussed in this section are Entrance Stairs/Escalators, Passageways, Ticket Vending, Fare Gates, Mezzanine, Stairways/Escalators, and Platform.

1. Entrance Stairs/Escalators

Issues:

The change in grade coupled with transition from exterior to interior space as experienced in station entrance stairs and escalators is a critical perceptual task. In the daytime, the commuter must deal with the "dazzle" of daylight (as much as 10,000 fc on a sunny day), and at night, the darkness of the sky beyond.

Solutions:

Proper entrance stair and escalator lighting is one of the most challenging issues facing the Lighting Designer. Improperly placed luminaires can be an uncomfortable source of glare as one ascends the steps and looks up and out to see what's next.

Semi-perforated canopies over the entrances are quite helpful in providing a transition in light level and automatically modulate the light with the amount of daylight. They also provide a convenient 'home' for lighting equipment.

As well as providing uniform light on the ground plane, light on surrounding vertical surfaces is helpful in defining boundaries, assisting adaptation, and reinforcing a sense of safety.
2. Passageways

**Issues:**
Issues of orientation and information gathering become more critical in the passageway. Adaptation continues to occur, and the scale of the space is also greatly reduced (either from the entrance stair or from the mezzanine).

**Solutions:**

Light can play a role in direction giving as well as influence perceived scale. As mentioned earlier, it can "lift" the ceiling or "expand" the walls. A focal point of light at the next visual task (perhaps artwork or ticket vending) will help draw the commuter through the space.

3. Ticket Vending Equipment

**Issues:**

It is quite possible for a first time commuter to proceed all the way to the train platform without having seen the ticket vending machines. The seasoned commuter may have no trouble finding them, but poor vision may make the transaction difficult.

**Solutions:**

A visibly increased quantity of illumination is necessary at and around the vending machines. Due to the relatively dark finish on the machines themselves, the Designer is encouraged to use architectural materials with reflectance values of 70% or more on the surrounding walls, ceiling, and floor.

4. Fare Gates

**Issues:**

For similar reasons to those listed above, fare gates require visibly increased levels of illumination.

**Solutions:**

It is again helpful to provided strong visual cues with a combination of architectural finishes and increased lighting.

5. Mezzanine

**Issues:**

As a circulation space with the visual tasks of adaptation and orientation accomplished, the mezzanine is an opportunity for visual texture. This is
the area where artwork most often occurs, and providing accent to the architecture and artwork is a pleasant method of lighting the space.

**Solutions:**

Grazing light along walls and/or pools of light at points of interest can relieve potential monotony and allow the space to feel more expansive. Wallwashing techniques can bring out different elements of the design. Fixtures placed close to the wall will graze it with light and enhance the texture, fixtures placed further away will provide a more even, flat wash of light.

6. Interior Escalator and Stairs

**Issues:**

Faced once again with a change in grade, the interior escalators and stairs require increased visual levels of illumination.

**Solutions:**

Lightened architectural finishes coupled with increased levels of light at the beginning and end of the transition are helpful in providing critical visual cues.

7. Platform

**Issues:**

A majority of the lighting at the platforms is provided by the standard edge lighting equipment. This equipment directs critical light to the platform edge for safety reasons and washes the remainder of the platform with a uniform wash of light. As this is where the passenger is likely to spend the most time, however, Designers are encouraged to augment the edge lighting to enhance the visual interest of the space.

**Solutions:**

The columns and ceiling provide an opportunity for accent lighting with the possibility of moving light in both an upward and downward direction. Any artwork or special architectural details should be featured.

**EXTERIOR STATION** public areas discussed in this section are Train Platform, Ticket Vending, Train Crossing, Pedestrian Pathways, Bus Loading/Kiss and Ride, Plaza and Landscaped Areas.

1. Train Platform

**Issues:**
The exterior train platform is an interesting challenge for the lighting engineer as the commuter is placed in an exposed environment with potentially dark surroundings.

A careful balance must be struck between the need to feel secure with high levels of light and the likelihood of glare from the lighting equipment used to achieve these levels.

**Solutions:**

Glare is most often experienced when a bright luminaire is viewed against a dark surround. Simple devices such as luminous canopies or fixture set against lightly finished columns can help alleviate glare. Again, light architectural finishes create an atmosphere that light bounces easily around and ‘feels’ brighter. Based on past experience, lighted vertical surfaces should be used whenever possible and appropriate.

2. Ticket Vending

**Issues:**

As a critical visual task, illumination on the vertical surface of the ticket vending machines is a necessity.

**Solutions:**

Care must be taken in the placement of the machines relative to the lighting equipment and vice versa. While the placement of the machines next to a standard luminaire will achieve the desired effect, placement of them underneath will do little more than light the dust on the top.

3. Train Crossing

**Issues:**

Safety is a critical issue at the crossing of pedestrian and train pathways. Strong visual cues are required to alert the passenger of potential danger.

**Solutions:**

A combination of lightened architectural finishes with increased illumination levels is recommended.

4. Pedestrian Pathways

**Issues:**

An integral part of the Metro Rail experience, the pathway between other modes of transportation and the train platform can be quite long, and as the commuter moves further from the luminous platform, potentially disconcerting.
Solutions:

Care must be taken in transitioning between the station and its' surroundings. A gradual decrease in light level (1 footcandle over 100 feet of travel or so) is recommended. Coordination with local authorities and survey work of existing surrounding lighting is helpful in planning these transitions.

5. Bus Loading/Kiss and Ride

Issues:

Because of their remoteness to the station, these areas require lighting which identify them as destination points and provides a sense of safety for waiting passengers.

Solutions:

Typically, the bus stops adjoin to parking lots and are illuminated with parking lot fixtures. Although horizontal illuminance may be sufficient, bus station lighting should include one or two additional pedestrian scale (+/- 15’ tall) pole fixtures for visual emphasis and security.

6. Plaza

Issues:

Safety is the key issue in the plaza area where passengers make the transition from an enclosed and protected environment into an open surrounding which, at nighttime, is dark and potentially unsafe. It is of the most importance to provide not only the light levels at the required locations (the ground), but to provide the sensation of light in the peripheral zone (vertical surfaces). Likewise, those passengers entering stations at night will experience adaptation from very low light levels outside to higher levels inside. This further reinforces the need for the sensation of brightness (high surface luminance) in the plaza itself.

Solutions:

The station entrance should be the brightest region of the plaza, with a prominent portal, to establish a quickly identifiable destination focus. This may be accomplished by lighting any available architectural features such as walls or ceiling or by applying points of light to those surfaces.

7. Landscaped Areas

Issues:

Landscaped areas are an opportunity to provide visual texture and an added sense of light to exterior scenes.
Solutions:

When trees and shrubs are together in a composition, trees are the best (and easiest) "target" for accent uplighting. It is important to include the tree trunk so that the canopy does not appear "detached" from the ground. Both side-lighting and front-lighting are acceptable, but caution is advised in placing fixtures so that pedestrians or vehicles are not subject to glare. Uplighting shrubs is not generally recommended; however, if low-level vegetation is situated in front of a wall, uplighting that wall can create a dramatic "back-lit" effect.
ARTWORK LIGHTING

The Metro Art Program encourages the active participation of artists in ways that oftentimes produce unique results. While some art of this program takes a traditional form -- such as an object within a plaza or a mural on a wall -- much of the art is of a less traditional kind. While we cannot pre-design specific lighting for such an unpredictable exercise, we can offer design approaches utilizing the standard palette of equipment that will address a number of common conditions.

Artwork is an important component at all Metro stations and critical to the identity of each station. Under current Metro Art Guidelines, lighting, lasers, or any other electronically-based artwork are not permitted. Artwork lighting referred to in this section describes the illumination of artworks in the Metro transit system.

Lighting design shall include and specify light fixture types and lighting elements used to illuminate artworks at station sites. Artworks shall be illuminated appropriately to best reflect their viewership characteristics. All artwork lighting shall be coordinated through Metro Creative Services.

Lighting equipment shall be standard equipment that is accessible and maintainable by Metro and must not require special operational expertise. New lighting technologies may be considered as they emerge, but shall be reviewed in keeping with expectations of durability, longevity, and cost effectiveness compared to established equivalents.

A. Wall Mounted Art

This is perhaps the most common location of artwork within the interior stations. Lighted walls have been established as a desirable goal for typical spaces, providing a valuable sense of space and boundary. The recommended source of light is a recessed linear fluorescent wallwash, with high quality color rendition and a relatively uniform wash of light.

B. Column Mounted Art

Columns in both interior and exterior stations have been transformed from the predictable soldiers of structure to various flights of fancy and design. It is possible to bring further texture and focus to these points of interest with the integration of lighting. The light may be placed within with the use of neon or fluorescent sources, or placed above or below, with the use of recessed high color rendition metal halide accent lights.

C. Ceiling Mounted Art

The integration of artwork into ceiling surfaces may be dealt with in a manner similar to the lighting of walls. A cove mounted high color rendition linear fluorescent luminaire will wash the ceiling with light, or wall or column mounted high color rendition metal halide uplights may be used.

D. Floor Mounted Art
When artwork is an integral part of the floor plane, it may be accented with increased usage of ceiling or pole mounted downlights. The Designer is encouraged to increase illumination levels by a factor of 3 or 4 where appropriate to provide focus and visual texture.

E. Other

When the artwork defies categorization (as it often will), the Designer is encouraged to utilize lighting equipment within the standard palette in creative ways, such as the surface mounted adjustable accent light, placed into a notch in the surrounding architecture. If the standard palette does not provide suitable equipment, special equipment should use standard palette lamps in the interest of maintenance and stocking.
REFERENCES


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4. New York City Transportation Authority - Lighting Guidelines