

TABLE OF CONTENTS

SECTION 12 – SYSTEM-WIDE ELECTRICAL DESIGN

12.1	GENERAL	2
12.2	CONDUIT, DUCTBANKS, AND RACEWAYS.....	2
12.2.1	Codes and Standards.....	2
12.2.2	Conduit, Ductbank, and Raceway Products.....	2
12.2.3	Functional Requirements	3
12.2.4	High Voltage Ductbanks.....	3
12.2.5	Utility and Street Lighting Raceways.....	4
12.2.6	Systemwide Ductbanks	4
12.3	SYSTEMWIDE RACEWAYS.....	5
12.3.1	Conduit.....	5
12.3.2	Station Platforms	5
12.3.3	Pedestrian Bridges	5
12.3.4	Maintenance Facilities	6
12.3.5	Parking Structures	6
12.3.6	Park-n-Ride Lots	6
12.3.7	Cable Tray.....	6
12.3.8	Cable Trough.....	7
12.4	MANHOLES, HANDHOLES AND PULLBOXES.....	7
12.5	SYSTEMS GROUNDING.....	8
12.5.1	Platforms	8
12.5.2	Fences.....	8
12.5.3	Metallic Objects within ROW	8

List of Tables

Table 12-1 - Minimum Illumination Levels	7
Table 12-2 - Grounding Requirements for Typical ROW Structures*	8

SECTION 12 - SYSTEM-WIDE ELECTRICAL DESIGN

12.1 GENERAL

This section establishes the design criteria for various electrical facilities including passenger stations, park-n-ride stations, systems buildings, and ductbanks. The entire infrastructure needed to support the signal systems, communications systems, traction electrification, corrosion control, lighting, grounding, etc. shall be designed and installed with the civil portion of the project. Coordination and interfacing with the other systems designers, civil design, architectural, mechanical, utility, structural, and trackwork shall be maintained to ensure uniform approach to all installations.

12.2 CONDUIT, DUCTBANKS, AND RACEWAYS

This section describes the design criteria necessary to provide raceway and ductbank systems for all power wiring and system cables on RTD's Commuter Rail and facilities. The system wide electrical raceway and ductbank system includes conduits, ductbanks, cable trays and cable trough installations and related manhole, handhole and pullboxes. The following sections apply to all conduit, ductbanks, and raceways for traction power, signals, communications, and corrosion control.

12.2.1 CODES AND STANDARDS

All conduits, ductbanks, and raceways designs shall conform to the latest edition of the following codes where applicable:

- National Electrical Code (NFPA-70)
- National Electrical Safety Code (ANSI/IEEE C.2)
- Electrical Codes or Amendments of the local Authority having jurisdiction
- American National Standards Institute (ANSI)
- National Electrical Manufacturers Association (NEMA)
- Institute of Electrical and Electronics Engineers (IEEE)
- National Fire Protection Association (NFPA 10 and 130)
- The Occupational Safety and Health Act (OSHA)

12.2.2 CONDUIT, DUCTBANK, AND RACEWAY PRODUCTS

All conduit, ductbank, and raceway products used shall in all cases be listed and labeled by a nationally recognized electrical safety testing organization.

Raceways shall be galvanized rigid steel conduit (GRSC), PVC Schedule 40 conduit, PVC Schedule 80 conduit, PVC Schedule 40 Multi-celled conduit, Multi-Celled Micro-duct conduit, PVC coated galvanized rigid steel conduit (PVC/GRSC), rigid non-metallic fiberglass reinforced epoxy conduit, electrical metallic tubing (EMT), liquid-tight flexible metal conduit or flexible metal conduit.

Cable trays shall be aluminum, fiberglass-reinforced plastic, welded or swaged steel hot-dipped galvanized after fabrication, ladder type with formed rungs and channel type side rails with inward or outward turned flanges. Special design circumstances may require physical protection of the cables, and solid or ventilated cable trays and covers may be used.

Cable trough and cover shall be a dielectric material, High Density Polymer Concrete, pre-fabricated, nonmetallic, rated for exterior below grade use, resistant to sunlight exposure and suitable for use in wet locations. Individual cable trough sections shall interlock together to make a continuous cable trough without gaps. Covers shall sit inside the trough, be flush with the finished grade, be designed to withstand excessive loading and not shatter and be secured with stainless steel vandal proof hardware. The weight of each cover shall not exceed the allowable handling weight as per OSHA requirements.

12.2.3 FUNCTIONAL REQUIREMENTS

All power wire and systems cables shall be protected by conduit, cable tray, or cable trough per this section, except for low voltage signal or communication wiring protected from physical damage within traction electrification facilities, signal or communication buildings and rooms, bungalows, or cases. Installations shall comply with the NEC and all county and city codes.

Spare raceway capacity shall be provided in the mainline signal and communication (SC) ductbank, TE, HV, and lateral ductbanks or conduit runs including station platforms. Spare capacity shall be defined as the remaining useable capacity within a raceway in conjunction with NEC requirements. Spare cable tray or cable trough capacity shall be provided in all installations for future equipment. RTD may determine that the spare capacity is not necessary at various locations; due to the expense that would be incurred and this requirement may be reduced in capacity or eliminated.

Manholes and Handholes shall be provided in mainline SC ductbanks, where required. Handholes shall be provided in lateral ductbanks and conduit runs at junction points as required for wire and cable pulling. On commuter rail bridges, in tunnels and shafts, pull boxes shall be provided with the raceways.

Ductbanks shall be located precisely on all plan view design drawings. Ductbanks shall be sloped where possible to drain to manholes or handholes, be located to avoid interference with new or existing utilities, and be located at a minimum depth of 36 inches below finished grade. Conduits shall be limited to a maximum of 270° of bend between manholes, handholds, junction boxes, or termination points.

12.2.4 HIGH VOLTAGE DUCTBANKS

High voltage (greater than 600V) and traction electrification ductbanks shall be GRSC, PVC/GRSC, or PVC schedule 40 conduits encased with 2500 psi red concrete, and the conduits separated from other systems per the NEC requirement.

If required because of electromagnetic interference (EMI), high voltage AC conductors shall be installed in galvanized rigid steel conduit or other means shall be taken to mitigate the effects of the EMI.

12.2.5 UTILITY AND STREET LIGHTING RACEWAYS

Utility raceway and ductbank installations shall meet the construction and material of the local utility if installed under an RTD contract.

For all street lighting systems not maintained by RTD, but installed under an RTD contract, the raceways shall meet the construction and material requirements of the local authority having jurisdiction.

12.2.6 SYSTEMWIDE DUCTBANKS

Mainline Ductbanks shall be PVC Schedule 40 conduit, Multi-celled PVC Schedule 40 conduit, or Multi-celled Micro-duct conduit, embedded in Controlled Density Fill (CDF) concrete. Use GRSC, PVC Multi-celled Schedule 40, or PVC Schedule 40 elbows with a radius greater than 6 foot as required per the Contract Specifications. Signal/Communication Lateral Ductbanks shall be PVC Schedule 40 conduit encased in 1500 psi concrete using GRSC or PVC Schedule 40 elbows with a radius greater than 6 foot as required per the Contract Specifications. Traction electrification (TE) ductbanks initiating from facilities to the first manhole outside of the alignment shall be PVC Schedule 40 conduit encased in 2500 psi steel re-enforced red concrete using GRSC or PVC Schedule 40 elbows with a radius greater than 6 foot. TE Ductbanks initiating from the first manhole outside of the alignment to all subsequent manhole and feeder poles within the alignment shall be PVC Schedule 40 conduit encased in 2500 psi non-steel re-enforced red concrete using GRSC or PVC Schedule 40 elbows with a radius greater than 6 foot. Ductbanks with reinforced steel rebar shall be used for special utility and roadway crossings. The exact ductbank dimensions vary with the number and size of conduits. Plastic spacers shall be provided between conduits to allow for concrete-encasement around the conduits. The minimum spacing between conduits is 1.5 inches for signal/communication conduits and 3 inches for traction electrification and power conduits unless otherwise required by the NEC. The overall concrete-encasement around the outside conduits shall be a minimum of 3 inches on all sides.

Ductbanks shall be located longitudinally along the length of the trackway and between the mainline tracks. Generally, the ductbank is located below the end of the track ties at a depth of 36 inches so that conflict with OCS and signal foundations is avoided and the ductbank runs in a straight line between conduit transitions into manholes. If required, due to special circumstances, ductbanks located other than between the mainline tracks will be determined solely at the discretion of RTD. Ductbanks are to be set on a prepared and compacted bed.

When it is necessary, lateral ductbank crossings below the track are permitted as long as the ductbank meets the minimum depth requirements.

Where obstacles such as underground utilities or foundations are encountered the ductbank shall be gradually offset around or under them and must meet the concrete-encasement and conduit bending requirements.

12.3 SYSTEMWIDE RACEWAYS

12.3.1 CONDUIT

The final signal/communication raceway connections (normally the last 10 feet of the conduit installed) to signal equipment or into houses and cases may be direct buried and shall be schedule 80 PVC conduit.

On bridges, exposed raceways for signal, communication, traction electrification, and lighting shall be galvanized rigid steel conduit or rigid non-metallic fiberglass reinforced epoxy conduit. If raceways are concealed as an integral part of an emergency pedestrian walkway schedule 40 PVC conduit may be used, except for transitions at the end of the bridge, which shall be PVC/GRSC conduit direct buried or ductbank with GRSC conduit. Transitions at the end of bridges and bridge expansion joints require expansion couplings.

12.3.2 STATION PLATFORMS

For station platforms, raceways shall be schedule 40 PVC conduit embedded in fill and located at a minimum depth of 18 inches below the finished grade of the platform slab. All conduit stub-ups through the platform slab or foundations shall be PVC/GRSC conduit. Platform handholes shall be located along the platform, generally towards each end and in the middle of the platform to provide junction points for the communication cables and power wiring. Handholes and covers shall be pre-cast high density polymer concrete type with split covers if used for communication cables and power wiring and the box sections shall be divided. For all mainline platform conduit penetrations into the handholes that run the length of the platform, they shall enter the side of the handhole and be provided with bell ends. All lateral conduit penetrations into handholes shall enter the bottom of the handhole and be provided with bell ends.

Communication conduits shall be provided to all planned and future communication equipment on the station platforms. Spare conduits shall be provided to all mainline conduit runs along the length of the platform, and to all shelters including future shelters. All exposed conduits shall be painted to match the structure which to it is attached.

12.3.3 PEDESTRIAN BRIDGES

For pedestrian bridges, raceways for signal, communication, traction electrification, and lighting conduits shall be GRSC conduits, PVC/GRSC conduits, or rigid non-metallic fiberglass reinforced epoxy conduit if exposed or concealed.

12.3.4 MAINTENANCE FACILITIES

For maintenance facilities, interior installations of raceways shall be EMT, GRSC, or flexible metal conduits at dry locations not subject to damage; GRSC at dry locations subject to damage; and PVC/GRSC or liquid tight flexible metal conduits at wet or damp locations. All exterior installations of raceways shall be GRSC, PVC/GRSC, or liquid tight flexible metal conduits. All raceway installations under-slabs or in-slabs of structures shall be GRSC, PVC/GRSC or PVC conduit, and all conduit stub-ups through the building slab or foundations shall be PVC/GRSC.

For the yard and site areas of maintenance facilities, ductbanks with manholes and handholes shall be provided. All street or yard lighting system raceways within the track areas of the maintenance facility shall be schedule 80 PVC conduit, and direct buried 36 inches minimum below grade. For parking lot lighting and street lighting systems, outside the track areas, the raceways shall be schedule 40 PVC conduit, and direct buried 30 inches minimum below grade.

System raceways shall be provided to all planned and future system equipment at the maintenance facility. Provide spare capacity in all system raceways for future equipment. Spare capacity shall be defined as the remaining useable capacity within a raceway in conjunction with NEC requirements

For communication, signal, or traction electrification facilities rooms within the maintenance building, cable trays may be used. Spare cable tray capacity shall be provided for future equipment.

12.3.5 PARKING STRUCTURES

The raceways requirements for parking structures shall be the same as for maintenance facilities.

12.3.6 PARK-N-RIDE LOTS

For park-n-ride lot lighting and street lighting systems that are maintained by RTD, raceways shall be schedule 40 PVC conduit, and direct buried 30 inches minimum below grade. Raceways buried less than 30 inches below grade shall be concrete encased.

Communication conduits and pullboxes shall be provided to all planned and future communication equipment at the park-n-ride lots. Pull box requirements shall be the same as listed for station platforms.

12.3.7 CABLE TRAY

The use of cable trays is restricted to use within systems buildings. 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. The use of fiberglass cable tray shall generally be limited to DC cables.

12.3.8 CABLE TROUGH

The use of cable trough is restricted to trackways and its use shall be determined solely at the discretion and approval of RTD. If required, due to special circumstances, cast-in-place type cable troughs may be located on commuter rail bridges. Covers for cast-in-place cable troughs shall be pre-fabricated high density polymer concrete and be secured with stainless steel vandal proof hardware. The capacity of the approved cable trough shall be 200% of the feeding conduit system.

Cable trough may be used for signal, signal power and communication cables only. The cable trough shall have integral dividers to maintain separation between signal, signal power and communication cables. Cables shall only enter or exit the cable trough through cable trough handholes or pullboxes that are an integral part of the cable trough system.

The cable trough shall be located longitudinally along the length of the trackway and shall not be located between mainline tracks. Cable troughs shall not be located directly above longitudinal runs of track drains or other utilities. Where obstacles, such as OCS and signal foundations, or utility manholes are encountered, the cable trough shall be gradually offset around the structure. Cable trough shall be placed in a level trench, with the lids flush with finished grade.

Cable troughs shall not be used in station platform areas, road and pedestrian crossings, high rail accesses and any areas accessible to pedestrians.

12.4 MANHOLES, HANDHOLES AND PULLBOXES

Manholes and handholes shall be of the pre-cast concrete type or pre-cast polymer type, complete with cable supports, pulling irons, and a ground rod, and all metallic parts shall be internally grounded. Manholes or handholes installed in streets shall be equipped with a cast iron cover and grade ring suitable for H-20 street loading and which can be adjusted for final grade. In other locations, manhole covers shall be torsion assisted hot-dipped galvanized steel diamond plate suitable for H-20 street loading and handhole covers shall be hot-dipped galvanized steel diamond plate or polymer suitable for H-20 street loading.

Pullboxes shall be welded hot-dipped galvanized steel boxes or cast-in-place boxes with hot-dipped galvanized steel diamond plate covers, for use on commuter rail bridges, in tunnels and in shafts. All manholes, handholes and pull boxes shall be identified with welded raised lettering, except platform handholes, which shall be cast integral with the cover. The lettering shall indicate the contents of the item.

Manholes, handholes, and pull boxes shall be located such that the raceways do not exceed 270 degrees between wire and cable pull points.

12.5 SYSTEMS GROUNDING

12.5.1 PLATFORMS

Grounding for passenger stations shall consist of a ground system under each facility composed of a buried exothermically welded grid or counterpoise wire-and-rod system. All metal components of transit facilities and within 15 feet of centerline of track including shelters, fences, poles, guardrails, handrails, swing gates, pedestrian barriers, and bollards that are susceptible to contact by patrons and/or operating and maintenance personnel shall be electrically grounded to the ground grid. Lighting and low-voltage power distribution systems shall be grounded per National Electrical Code. At strategic points along the platform, determined by the Architects, provide copper ground plates bonded to the platform ground grid. Install the ground plates flush with the platform surface. The ground system of each platform shall be connected to the running rails via impedance or drain bonds to maintain the rails and platform at equal potential. Static wire, OCS poles and supports shall be grounded as required for grounding at passenger stations in SECTION 09 TRACTION ELECTRIFICATION SYSTEM DESIGN,

12.5.2 FENCES

Conductive fencing within 15 feet of the centerline of the near rail shall be grounded. Distance between ground connections for long fences shall be determined by a Grounding Study during detail design phase. Where gates interrupt the fence, the fence shall be grounded at each side of the gate and a flexible ground strap used to bond the gate to the fence. Fences shall also be grounded at or near the location where a supply line crosses them, and additionally, at distances not exceeding 150 ft on either side.

12.5.3 METALLIC OBJECTS WITHIN ROW

Metallic objects within 15 feet of the centerline of energized track, including OCS poles, signal cabinets, bungalows or buildings, and guardrails on bridges, shall be grounded. Ground electrode or electrodes shall be installed to obtain ground resistance of 25 ohms or less. Protective barriers and guard rails on bridges shall be grounded via connection to the static wire. Refer to SECTION 9.4 of TRACTION ELECTRIFICATION SYSTEM DESIGN for additional grounding requirements.

TABLE 12-2 - GROUNDING REQUIREMENTS FOR TYPICAL ROW STRUCTURES*

Structure	Requirement
Fences	$\leq 25\Omega$
Signal Houses	$\leq 15\Omega$
Comm Houses	$\leq 25\Omega$
Metallic Buildings	$\leq 25\Omega$
Bridge Guardrails	$\leq 25\Omega$
OCS Poles	$\leq 25\Omega$
Lightning Arrestors	$\leq 5\Omega$

*This table does not include all structures that will require grounding

END OF SECTION

THIS PAGE LEFT INTENTIONALLY BLANK