SECTION 34 24 13

CONTACT RAIL SYSTEM

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Contact rail assembly

B. Insulator assembly

C. Anchor assembly

D. Expansion joint assembly

E. Coverboard assembly

F. Miscellaneous materials

1.02 MEASUREMENT AND PAYMENT

Not used.

1.03 REFERENCES

A. General

1. Submit certification that products furnished conform to the applicable reference standards and specified requirements. All design, materials, and testing shall be in compliance with the latest edition of referenced standards, codes and regulatory requirements.

2. Where any requirements of these Specifications are more stringent than the requirements of applicable laws, regulatory requirements, standards, or codes, the requirements indicated in these Specifications shall govern.

3. A certification or published specification data statement by a manufacturer listed as a member of the National Electrical Manufacturers Association (NEMA), to the effect that products conform to the specified NEMA standards, will be acceptable evidence that the products meet the requirements of these Standards.

B. American National Standards Institute

1. ANSI B18.2.1 Square and Hex Bolts and Screws (Inch Series)

2. ANSI B18.2.2 Square and Hex Nuts (Inch Series)

3. ANSI B18.22.1 Plain Washers

4. ANSI C29.1 Test Methods for Electrical Power Insulators

5. ANSI C29.5 — Wet-Process Porcelain Insulators - Low- and Medium-Voltage Types

6. ANSI C29.7 — Wet-Process Porcelain Insulators - High-Voltage Line-Post Type

7. ANSI/ASC H35.1 — Alloy and Temper Designation Systems for Aluminum

C. American Plywood Association (APA):

1. Product Guide, Grades and Specifications

D. American Society for Testing and Materials

1. ASTM A108 — Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality

2. ASTM A153 — Specifications for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

3. ASTM A307 — Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile

4. ASTM A313 — Chromium-Nickel Stainless and Heat-Resisting Steel Spring Wire

5. ASTM A325 — High-Strength Bolts for Structural Steel Joints

6. ASTM A36 — Specifications for Structural Steel

7. ASTM A47 — Ferritic Malleable Iron Castings

8. ASTM A536 — Ductile Iron Castings

9. ASTM A563 — Carbon and Alloy Steel Nuts

10. ASTM B117 — Salt Spray (Fog) Testing

11. ASTM B134 — Brass Wire

12. ASTM B633 — Specification for Electroplated Coating of Zinc on Iron and Steel

13. ASTM B695 — Coatings of Zinc Mechanically Deposited on Iron and Steel

14. ASTM D116 — Vitrified Ceramic Materials for Electrical Applications

15. ASTM D149 — Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

16.	ASTM D1499	Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastics
17.	ASTM D2000	Rubber Products in Automotive Applications
18.	ASTM D2240	Rubber Property - Durometer Hardness
19.	ASTM D2303	Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials
20.	ASTM D256	Impact Resistance of Plastics and Electrical Insulating Materials
21.	ASTM D2583	Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
22.	ASTM D3359	Standard Test Methods for Measuring Adhesion by Tape Test
23.	ASTM D390	Specification for Coal-Tar Creosote for the Preservation Treatment of Piles, Poles, and Timbers of Marine, Land, and Fresh Water Use
24.	ASTM D495	High-Voltage, Low-Current, Dry Arc Resistance of Solid Electric Insulation
25.	ASTM D570	Water Absorption of Plastics
26.	ASTM D638	Tensile Properties of Plastics
27.	ASTM E84	Surface Burning Characteristics of Building Materials
28.	ASTM E662	Specific Optical Density of Smoke Generated by Solid Materials
29.	ASTM F436	Hardened Steel Washers
30.	ASTM G152	Operation Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials.

E. Industrial Fastener Institute

1.	IFI 100/107	Prevailing - Torque Type Steel Hex and Hex Flange Nuts Section F

F. Military Specifications

1.	MIL-P-23469/4	Pin-Rivet, Grooved, Round Head; Straight Shank, Multiple Locking Grooves, Aluminum Alloy, Corrosion-Resistant and Carbon Steel

G. National Fire Protection Association

1. NFPA 130 Fixed Guideway Transit Systems

H. Society of Automotive Engineers

1. SAE HS-1582 Manual on Design and Manufacture of Coned Disk Springs (Belleville Springs) and Spring Washers First Edition

I. Steel Structures Painting Council

1. SSPC-SP6 Commercial Blast Cleaning

2. SSPC-SP10 Near-White Blast Cleaning

J. Regulatory Requirements

1. California Code of Regulations, Title 24, Part 2.

2. California Electrical Code, Title 24, Part 3.

3. Cal/OSHA Standards and California Electrical Safety Orders, Title 8.

4. Regulations of the California Public Utilities Commission, Rapid Transit District Safety Branch.

5. National Electrical Safety Code (NESC).

1.04 DEFINITIONS

A. Anchor Assembly. A longitudinal assembly of products including insulated anchor rods, clevises, spacers, anchor straps, mounting plates, and fasteners which retains the contact rail in the longitudinal direction and prevents transmission of longitudinal force to the insulators.

B. Contact Rail. A trackside conductor consisting of steel rail with aluminum bars attached on the webs, used to transmit electrical energy from power source to transit vehicle via current-collector shoes.

C. Contact Rail Assembly. The arrangement of products consisting of contact rail, splice bars and pin bolts, expansion joints, end approaches, dip rail sections, and fastening hardware.

D. Contact Rail System. The contact rail assembly, insulator assemblies, anchor assemblies, coverboard assemblies, and fastening hardware comprising the system used for the positive power source to the transit vehicle.

E. Coverboard Assembly. An arrangement of products including coverboard, support brackets and fasteners, which when installed, prevents accidental personnel contact with contact rail. The coverboard is used for supporting the train control wayside station stop and identification antennae.

F. Current Collector Shoe. The part of the current collector attached to the vehicle which rides along the top of the contact rail.

G. Dip Rail Section. A portion of contact rail at an elevation which allows the current-collector shoe in its lowest position to pass over it without contact.

H. End Approaches. Special sections of contact rail used at the ends of contact rail sections that ramp the collector shoe from one elevation in full contact to another elevation out of contact with the contact rail, or vice versa.

I. Expansion Joint. An assembly used in the contact rail to accommodate thermal expansion and contraction of the rail.

J. Expansion Joint Shunt Cables. Cables attached to the contact rail at each side of the expansion joint to provide electrical continuity across the expansion joint.

K. Feeder Cable. Electrical conductors which connect the traction power substations and gap breaker stations to the contact rail system.

L. Insulator Assembly. The porcelain insulator, base plate and "O" ring, rail clips, bolt, locknut and rail cushions comprising the assembly which supports the contact rail and insulates it from ground and structures.

M. Insulator Mounting Bracket. A device by which insulators are mounted on concrete ties.

N. Jumper Cable. Electrical conductor that electrically connects two sections of contact rail.

O. Splice Bars. Connect end approaches to the contact rail or connect two sections of contact rail.

1.05 SUBMITTALS

A. General: Refer to Section 01 33 00 - Submittal Procedures and Section 01 33 23 - Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Shop Drawings and Product Data: Submit shop drawings and product data for all hardware and materials comprising the assemblies and components of the contact rail system no later than 90 days before scheduled start of manufacturing. Submittals shall show the contact rail assembled as a system, and shall include calculations demonstrating conformance of the submitted design to the specifications. Shop drawings for all assemblies and components of the contact rail system shall include complete bill of materials. The bill of material tables shall have a column for the BART inventory number. Contractor shall obtain the BART inventory number from the Engineer.

C. Samples and Mock-Up Demonstration: Perform a mock-up demonstration of the contact rail system products listed below to demonstrate conformance with specified requirements. The demonstration shall be at a location within 60 miles of BART Headquarters at 300 Lakeside Drive, Oakland, California.

1. Mock-up of contact rail products shall be prepared in accordance with the following assemblies:

a. Contact rail with end approach attached

b. Contact rail with dip rail ramp and dip section attached, mounted on both sizes of insulator assemblies with base plates attached to wood dunnage to simulate actual installation

c. Contact rail with splice bars and pin bolts attached

d. Contact rail with expansion joint attached

e. Contact rail with coverboard attached

f. Contact rail with anchor assembly attached, including spacer.

2. Unless specifically precluded, the Contractor shall demonstrate that the contact rail components are compatible and interchangeable with like components on the existing BART System by assembling the samples and BART's products into the six types of assemblies described in the mock-up installation described above.

3. During the mock-up demonstration, the Contractor shall demonstrate assembly and installation of the contact rail system including pin bolt installation as described in the Contact Rail System Installation and Assembly Manual.

4. Installation tools, equipment, and products used in the demonstration shall become the property of the District after the demonstration.

5. If demonstrations fail to indicate conformance with the specified requirements, the Engineer may require the Contractor to perform further testing or demonstrations at Contractor's expense.

D. Contact Rail System Installation and Assembly Manual.

1. The Contractor shall provide a detailed written narrative describing the installation and assembly procedure and maintenance instructions for the contact rail system products furnished, including all appurtenances supplied. Drawings, descriptions, part numbers, and sources of all special tools, gauges, and handling equipment required for assembly shall be provided. The Manual shall include procedures and recommendations for drilling holes for shunt and feeder connection plates and rail anchors and for cutting, bending, and drilling holes in the contact rail.

2. Draft versions of manuals shall be submitted for approval. Final versions of manuals shall be submitted 30 days after receipt of District's comments and not less than 60 days prior to start of contact rail installation.

3. Installation and assembly manual format and contents shall conform to the requirements for Operations and Maintenance Manuals as defined in Section 01 78 23 - Operation and Maintenance Data.

E. Submit test program plan, procedures, and results prepared in accordance with Section 01 45 24 - Testing Program Requirements. Submit expansion joint assembly installation data, prepared in accordance with Table 34 24 13 -1 herein, within 5 days after the data has been recorded.

F. Process Control Plan. Submit a process control plan for the coverboard and support bracket materials. The process control plan shall include a complete description of the process employed together with all parameters of the process and their allowable variations in producing the samples for qualification testing.

G. Steel Composition. Submit certification that the contact rail steel composition is in accordance with the specified requirements.

H. Shipping and Handling. Submit proposed procedures and methods for shipping, handling, loading, unloading, and storing of materials 60 days prior to first material shipment.

1.06 CONTRACT DRAWINGS

A. Contract Drawings represent basic arrangement, critical dimensions, and functional requirements, and are not intended to show all the elements required for the operation of the specified products. The Contractor shall develop the detailed design in conformance with the requirements shown on the Contract Drawings. The Contractor shall provide all elements necessary for the complete and functional installation of the products.

1.07 STANDARD PRODUCTS

A. Contact rail system components shall be proven standard products or equivalent to the products of manufacturers engaged in the production of such products for at least the past five years. Like components shall be supplied by a single manufacturer.

1.08 PRODUCT IDENTIFICATION

A. Contact Rail Identification: The name of the Manufacturer, the month and year of manufacture, and a BART part number identification shall be stamped on the aluminum clad surface. The hardware identification shall at all times coincide with its officially released engineering data. An eleven digit hardware identification numbering system will be provided by the District.

B. Identification of products other than contact rail shall be as follows:

1. Part Numbers

a. Except fastening hardware and industry or government standard products, manufactured products shall be permanently marked with name, symbol, or other identification.

b. Similar-appearing parts, not physically or functionally the same shall each be permanently marked, with the part number visible after product has been installed.

c. Superseding parts shall be marked in the same manner as the parts they supersede.

d. Parts marked with the same part number shall have the same functional and physical characteristics, shall be equivalent in performance and durability, and shall be interchangeable with no alteration to either themselves or to associated products.

e. Parts shall not be marked for identification by color, color dots, or serial or modification numbers.

f. Parts shall be marked to differentiate between old and new configurations by a part number change and shall be controlled by a new drawing number or a dash number added to the original drawing number.

2. Lot Number

a. Contractor shall ensure that part manufacturers develop a lot numbering and marking system that provides permanent lot identification and marking of parts for complete traceability to manufacturer's lot records.

b. A copy of lot records shall be attached to each shipment of products.

1.09 DELIVERY, HANDLING, STORAGE AND PROTECTION

A Delivery, loading/unloading, handling, storage, and protection of contact rail products shall be in accordance with Section 01 60 00 - Product Requirements.

B. Products shall be packaged for arrival at the site undamaged by handling and weather.

1. Temporary wood or steel braces, guides, skids, crates and other shipping devices necessary for transporting and temporary storage of the products shall be furnished.

2. Products shall be protected against corrosion, dampness, damage due to vibration, and any other damage during transportation and handling. All openings to the external environment shall be sealed before shipping. Products shall be packed in weather-resistant containers for storage outdoors.

C. The Contractor shall be responsible for and shall repair or replace products damaged due to shipping, handling, loading and unloading.

1.10 SPECIAL DEVICES

A. Furnish all special devices necessary for the handling and installation of the contact rail system components, such as lifting slings and bending devices.

PART 2 - PRODUCTS

2.01 GENERAL

A. Design: Contact rail system component parts shall be designed for a useful life expectancy of 25 years without refinishing or adding to the protective coating or finish. This design requirement establishes the standard of design, workmanship, and materials; it is not intended that Contractor extend the warranty beyond the period stated in the Contract, nor is it intended to be construed as imposing a warranty beyond that stated in the Contract.

B. Interchangeability:

1. It is not intended that products necessarily be identical to the ones on the existing BART system. Dimensional and performance criteria indicated shall govern. Unless precluded by requirements of the Contract Documents, the contact rail system components shall be interchangeable with like components on the existing system. The District will provide to the Contractor upon request any component of the existing contact rail system for compatibility and interchangeability design.

2. Like parts of duplicate units shall be interchangeable.

3. Units of the same rating and providing the same function shall be identical and interchangeable.

4. Component parts for each size of insulator shall be interchangeable with like components of like-size insulator assemblies existing on the BART System, as shown on the Contract Drawings. Rail clips, clip cushions, related bolts, and locknuts shall be interchangeable for use with any size insulator. Bases and base "O" ring cushions for insulators of all sizes shall be interchangeable.

C. Operating Environment: The contact rail system shall be suitable for operation in the specified environmental conditions. The contact rail system shall be completely operable with vehicle-mounted current collector speeds of 0 to 80 miles per hour, and in an environment containing contaminants normally found in electrified railway operations, including oils, metallic dust from wheels, rails and brake shoes, and dirt and mud from wheel splash.

D. Product Construction.

1. All products shall be made to American standard gauges.

2. The surfaces of the component parts shall be smooth, free of gaps, burrs, sharp edges, wrinkles, waves, and blemishes, and shall have uniformly rounded corners with constant radii.

2.02 CONTACT RAIL ASSEMBLY

A. Contact Rail

1. The contact rail shall consist of a steel rail not exceeding 75 pounds per yard, with a wearing surface of 1/2 inch minimum thickness with aluminum shapes attached to the webs. The aluminum shapes shall be attached to the webs either by pin bolts, or cast and rolled. The Contract Drawings show a contact rail, which is currently used in the existing BART system, with the aluminum bolted on the webs. The steel cross-section of the contact rail shall meet the dimensions for contact rail wear surface, height, width and base as shown on the Contract Drawings. The length of each contact rail section shall be 30 feet. The contact rail shall be manufactured in accordance with the latest editions of the specified standards except where otherwise specified.

2. Steel Composition. Composition of the steel portion of the contact rail shall conform to the following requirements:

a. The chemical composition of the steel section of the contact rail shall conform to the requirements of ASTM A36, or the chemical composition, in addition to iron, shall be as follows:

Constituent	Percent
Carbon	0.55-0.70
Copper	0.50 max.
Manganese	0.60-0.90
Phosphorus	0.04 max.
Silicon	0.10-0.35
Sulfur	0.05 max.

b. Surface classification shall conform to the following: Rails which contain surface imperfections in such number or of such character which, in the judgment of Contractor and the Engineer will not render them unfit for recognized uses, will be accepted subject to the following requirements:

1) Hot Marks: Hot marks such as shearing, scales, pits, guide marks, and hot scratches will be classified as follows:

a) Hot mark (except guide marks) which is not deeper than 0.010 inch will be accepted.

b) Guide mark in the head which is neither deeper than 0.010 inch nor wider than 0.062 inch will be accepted.

c) Not more than five percent of carbon steel rail may have defects deeper than the hot and guide marks described above, but not deeper than 0.020 inch.

d) Rail or portions of rails containing hot marks deeper than 0.020 inch will not be accepted.

e) If the depth of the hot mark cannot be determined by inspection, the area shall be probed with a grinder or magnaflux and, where necessary, a sample shall be sent to a metallurgical laboratory, for determination. If the area is determined to be acceptable, the ground area shall be cut out prior to shipment.

2) Longitudinal Cold Scratches: Longitudinal cold scratches (marks formed below 700 degrees F) will be classified as follows:

a) Rails containing a scratch not longer than 36 inches and not deeper than 0.010 inch will be accepted.

b) Rails containing a scratch deeper than 0.010 inch will not be accepted.

3) Transverse Cold Scratches: Transverse cold scratches (marks formed below 700 degrees F) will be classified as follows:

a) Rails containing a scratch which is not deeper than 0.008 inch will be accepted.

b) Rails containing a scratch which is deeper than 0.008 inch shall be either cut or scrapped.

4) Protrusions: Rail with protrusions not higher than 1/16 inch and not larger than 1/2 inch square shall not exceed three percent of the total tonnage.

c. Tolerances: The steel portion of the contact rail shall be straight within a tolerance of 3/8 inch maximum for 30-foot contact rail lengths. Twist tolerance of each length of contact rail section shall not exceed three degrees. The maximum vertical offset at any location on the contact surface shall not exceed 1/64 inch in one foot. Maximum sag with a 25-pound load at the midpoint between insulators spaced at ten feet shall be 1/64 inch. The rail ends shall be cut square and at right angles to the centerline of the rail with a variation in end squareness of not more than 1/32 inch. Standard rail lengths and tolerances shall be as indicated on the Contract Drawings.

3. Aluminum Shapes: The aluminum shall conform to the Aluminum Association Standard ANSI/ASC H35.1 for a 6101-T6 alloy and temper designation for the pin bolted shapes and Aluminum Grade EC, 1350 Alloy with International Annealed Copper Standard (IACS) rating of 59.5% for the cast and rolled shapes.

4. Rail Fabrication:

a. Cleaning and Grinding Steel: Steel portion shall be cleaned of rust and mill scale prior to assembly in accordance with and to the degree specified in SSPC-SP6 for Commercial Blast Cleaning, except that the head surface and surface of the steel to be mated with the aluminum shall be cleaned in accordance with and to the degree specified in SSPC-SP10 for Near-White Blast Cleaning. Head surface shall be further cleaned, if required, by grinding with a radial grinding wheel or stone to ensure no rust, mill scale, or surface irregularities remain.

b. Application of Oxide Inhibitor and Lightweight Oil: Coat surface of steel to be mated with aluminum with oxide inhibiting product immediately after cleaning. The oxide inhibiting paste shall be conductive and shall be compatible with aluminum to prevent iron oxide or rust re-forming on the steel rail, and prevent reformation of the aluminum oxide on the aluminum after cleaning. A coat of lightweight machine oil shall be applied to the steel as a preservative after aluminum extrusions have been attached. Product information/data sheets on the oxide inhibiting paste, including data on the shelf life, shall be submitted for District approval.

c. Cleaning Aluminum and Application of Oxide Inhibitor: Just prior to mating aluminum to steel rail, the mating surfaces of the aluminum extrusions shall be cleaned of all aluminum oxide using steel wool. The mating surfaces shall be liberally coated with the same oxide inhibiting paste used for the steel rail. The oxide paste shall be wire-brushed after coating. Coat mating surfaces immediately after cleaning, before rust or corrosion has started to form.

d. Drilling of Steel and Aluminum: Holes shall be drilled in the web of the rail, perpendicular to the vertical and longitudinal axes of the rail. Locations of the holes shall be as shown on the Contract Drawings. Dimension and number of holes on the web to bolt the aluminum to the web shall be established by the Manufacturer, with a maximum spacing of 18 inches. At each end of each contact rail section, the holes shall not interfere with the splice joint holes and shall be located so as to prevent the aluminum from separating from the steel rail. Aluminum sections shall be deburred before assembly. Punching of steel rail and aluminum extrusions (in the case of bolted aluminum) shall not be permitted.

e. Clamping: For contact rail with bolted aluminum extrusions, permanent aluminum pin bolts shall clamp together the metal components of the rail.

f. Drilling of Splice Joint Holes: Contact rail sections, dip rail sections and end approaches shall be fabricated with holes for bolted joints. Splice holes shall be as shown on the Contract Drawings. Holes shall be deburred and edges shall be rounded and made smooth. For contact rail and dip rail sections, drilling of splice joint holes shall be performed after the aluminum is attached to the steel rail. Assembly shall then be completed by adding a coat of oxide inhibiting paste to the aluminum holes and end of rails before any moisture or foreign matter can contaminate the mating surfaces.

5. Electrical Properties:

a. Contact rail shall have electrical resistance not greater than 0.0020 ohms per 1,000 feet, at 20 degrees Centigrade. Resistance shall be measured across not less than 20 ft. of test section with one splice joint in the middle, using not less than 5400 amperes.

b. Contact rail shall be capable of carrying 5,400 amperes continuous direct current without exceeding a temperature rise of 40 degrees Centigrade above 30 degrees Centigrade ambient in still air.

6. Mechanical and Physical Properties: Data specifying the mechanical and physical properties for the combined steel and aluminum contact rail shall be submitted.

B. Splice Bars: Splice bars shall be aluminum, sized mechanically and electrically to withstand overheating during short circuit conditions, and shall be flat to match flat aluminum web surface. The splice bar shall have adequate depth to meet the resistance and heat rise requirements. The splice bar holes shall be as indicated on the Contract Drawings and shall properly match with the holes in the rail ends. Aluminum for splice bars shall conform to the Aluminum Association Standard ANSI/ASC H35.1 for a 6101-T6 alloy and temper designation.

C. End Approaches: End approaches shall be precut at the angle indicated and holes predrilled at the factory in the pattern as indicated on the Contract Drawings. The cuts shall be square across the rail with a variation in end squareness of not more than 1/32 inch.

D. Dip Rail and Ramps: The top of the dip rail section shall be a minimum of three inches plus 1/8 inch or minus 0 inch below the upper surface of the contact rail. Dip rail ramps shall be provided with aluminum shapes on the web. The ends of each dip rail ramp section shall be pre-cut and six holes pre-drilled at the factory as shown on the Contract Drawings.

E. Pin Bolts. Pin bolts for splice bars and for fastening aluminum shapes to the rail web shall be as specified below.

1. Pin bolts shall have standard round head. Collars shall be the flanged type. The collar shall be designed for installation by cold-swaging to the bolt with a tool which breaks away the bolt at the designed clamping force. The breakaway shall be a feature of the bolt and tool design and shall not require special skill or judgment on the part of the operator. Grip range shall include the full thickness of material to be clamped, with allowances for the type of collar specified. Bolt ratings shall be certified by the Manufacturer. The assembled bolt and collar shall not be subject to plastic deformation when used within certified ratings.

2. Pin bolts for splice bars and for fastening aluminum shapes to the rail web shall be 3/4-inch diameter, aluminum grade 2024 in accordance with the Aluminum Association Standard ANSI/ASC H35.1, swage-locking, round head, straight shank, multiple locking grooves, in accordance with MIL-P-23469/4. Pin bolt collars shall be aluminum, grade 6061 in accordance with the Aluminum Association Standard ANSI/ASC H35.1. Assembled bolts and collars shall have the following ratings: shear, 16,400 pounds; tensile, 17,700 pounds; and pre-load clamping force, 13,300 pounds.

3. Alternate pin bolts and collars for fastening aluminum shapes to the rail web shall be 5/8-inch diameter, ASTM designation A325, Type 1 steel, zinc-plated in accordance with ASTM B633, swage-locking, round head, straight shank, multiple locking grooves, in accordance with MIL-P-23469/4. Assembled bolts and collars shall have the following ratings: shear, 22,500 pounds; tensile, 27,100 pounds; and pre-load clamping force, 19,200 pounds. Washers shall be stainless steel, SAE THRU HARD type, sized to fit the pin bolt and shall have an outside diameter of 1-5/16 inches. Following the installation of the pin bolts, the break-off surface shall be touch-up galvanized using a zinc-rich primer that forms a dry film of at least 90 percent pure zinc.

2.03 INSULATOR ASSEMBLY

A. General: Insulator size designations refer to the height of insulator assemblies. The dimensions of insulators for designated sizes are shown on the Contract Drawings. The maximum tolerances on the dimensions of the insulator assembly components shall not exceed the design tolerances shown on the Contract Drawings. The insulator assembly with all components in place shall be designed to withstand without any damage or deformation a force of 4,000 pounds applied to a 1-foot piece of contact rail mounted on top in the manner described herein for Qualification Testing, Insulator Assembly Strength Test.

B. Insulators: Contact rail support insulators shall be constructed of wet-process porcelain and shall conform to ANSI C29.5 and C29.7. Porcelain shall be sound, free from defects and thoroughly vitrified so that the glaze is not depended upon for insulation. The glaze shall be smooth, hard, and of a uniform shade of light gray conforming to ANSI Number 70; Munsell notation 5.0 BG 7.0/0.4. The glaze shall completely cover all parts of the insulator which are exposed to contamination, except that the portion of the insulator making contact with the shim need not be glazed. The minimum creepage distance over the insulator external surface from the contact rail clamps to the insulator base fastener shall be eight inches. The insulator shall be suitable for contact rail system with operating voltage of up to 1,200 Volts dc and surge voltages of up to 3,000 Volts dc.

C. Base Plate and Rail Clips

1. Base plates for securing the insulators to the foundation, and rail clips with cushions, bolts, and locknuts for attaching and securing the contact rail to the insulators shall be furnished as part of the insulator assembly as shown on the Contract Drawings. The rail clips shall allow free longitudinal movement of the contact rail assembly at any point in the contact rail system including at horizontal curves and at end ramps and dip rail sections located up to 400 feet away from an anchor assembly. Design the rail clips to allow such free longitudinal movement of the contact rail within a temperature range of -10 to +90 degrees C. The shape of the lower portion of the rail clip shall be such as to provide snug and secure fit around the head of the insulator when assembled with the neoprene cushion. The top of the rail clip shall not interfere with the extruded aluminum conductor or the splice bar.

2. Rail clips shall be either malleable iron conforming to ASTM A47, Grade 32510, or ductile iron conforming to ASTM A536, Grade 65-45-12. Bases shall be ductile iron conforming to ASTM A536, Grade 65-45-12. Rail clips and bases shall be hot-dip galvanized after fabrication, in accordance with ASTM A153.

D. Cushions and Base "O" Rings: Rail clip cushion shall cover the top, sides and dip into the bolt slot so that the cushion is between the rail clip and insulator. Cushions and base "O" rings shall be of the configuration indicated, neoprene in accordance with ASTM D2000, Specification 2BC415, and have a Durometer hardness between 65A and 75A for rail clip cushion and between 75A and 85A for base "O" ring in accordance with ASTM D2240.

E. Insulator Cantilever Bracket: Fabricate from extruded aluminum 6061-T6 alloy with dimensions as indicated on the Contract Drawings.

F. Spacer: In areas of direct fixation track construction the insulator assembly shall include a spacer with dimensions and installation requirements as indicated on the Contract Drawings. Material selected should have been used in similar or harsher environment and mechanical loading, and shall be submitted for District approval. The material shall be nonchip, noncreep, resistant to ultra-violet radiation, and shall provide a life cycle of no less than 30 years in actual operating environment. Submittals for the proposed material shall include physical properties with supporting test data that verifies the load bearing capabilities and resistance to creep, and verifiable installations of similar or more severe environmental and mechanical environment. The spacer material shall be either of the following two types:

1. Fiber-reinforced polymer composite, with reinforced fibers made of either glass, carbon, or aramid; and thermoset polymer resin, such as polyester, vinyl ester, or phenolic.

2. Epoxy grout, no less than 5000 psi; or grout with similar strength bonding agent. Material shall be premolded or fabricated into the spacer shape.

2.04 ANCHOR ASSEMBLY

A. Anchor Rods: The insulating material for the anchors shall be glass-reinforced polyester resin. The outer surface of the anchor rods shall be coated with a 1.5-mil film of light gray alkyd-type paint conforming to ANSI Number 70; Munsell notation 5.0 BG 7.0/0.4, resistant to weathering

and tracking, and containing an ultraviolet inhibitor. The complete rod, including clevises, shall be rated at a minimum of 15,000 pounds in tension.

B. Clevises: Malleable iron conforming to ASTM A47; galvanized per ASTM A153.

C. Anchor Mounting Brackets, Anchor Strap, and Anchor Mounting Plates: Fabricate of steel conforming to ASTM A36 and shall be hot dipped galvanized after fabrication in accordance with ASTM A153.

2.05 EXPANSION JOINT ASSEMBLY

A. Expansion joints shall be designed to allow thermal longitudinal expansion and contraction of the contact rail. Expansion joints must accommodate rail movement due to contact rail temperature variations from -10 degrees C to +90 degrees C on a contact rail length of up to 400 feet, measured from an expansion joint to contact rail anchor. Prepare a tabulation for the required initial setting of the expansion joint gap as a function of the ambient temperature during installation. The maximum acceptable misalignment on curves, if any, shall be calculated along with the corresponding maximum distance to anchors and end ramps, considering the specified temperature range. This information shall be included in the field installation manual, and shall be used as basis for the contact rail installation design. The expansion joints shall provide a flat surface, uniform with the rails, to allow smooth passage of the collector shoe. Expansion joint assemblies shall be connected to adjacent contact rail sections using aluminum bolts as specified herein for contact rail splice bars. Submit certification demonstrating compliance of the expansion joint assembly design with the specified requirements.

B. Material: Cast ductile iron conforming to ASTM A536, Grade 65-45-12 or the same material as the contact rail steel.

C. The expansion joint shall require no lubricant under any operating conditions.

D. The expansion joint assembly shall include 6-foot contact rail sections, connection plates, and other components as indicated on the Contract Drawings, and shall be delivered fully assembled with factory-drilled holes ready for field installation. The 6-foot contact rail sections shall be attached to the expansion joint sliding parts by bolted connection as indicated, or cast and weld.

E. Quantity and size of shunt cables connecting the outer ends of the expansion joint assembly shall be 7-500 kcmil.

2.06 COVERBOARD ASSEMBLY

A. Coverboard. The coverboard shall be designed, fabricated, and tested to provide protection against electrical hazard from the contact rail assembly. When stepped on, midway between support brackets spaced at ten feet, by a person weighing 250 pounds, the coverboard may deflect, but it shall not split, crack, or break, and shall return to its original shape and position when the weight is removed. Maximum deflection of coverboard under its own weight shall be 1/8 inch between support brackets.

1. Material. Coverboard material shall be reinforced polyester-resin fiberglass. Coverboard materials shall not propagate smoke or produce excessive smoke. Coverboard material strength and flammability characteristics shall be in accordance with NFPA 130, Section

6.4.2.5, and capable of passing the ASTM E662 test with a smoke emission optical density index (Ds) of 100 or less in 4 minutes.

2. Dimensions and Tolerances. The coverboard and bracket design shall provide the required clearances between the contact rail and the coverboard and brackets. These clearances, dimensions and tolerances as indicated on the Contract Drawings shall be maintained under normal use throughout the useful life of the coverboard assembly. Holes in the coverboard shall be drilled or punched in the factory prior to delivery. Coverboard thickness shall be uniform throughout its entire length.

3. Color. Color shall be light gray conforming to ANSI Number 70; Munsell notation 5.0 BG 7.0/0.4.

4. Treatment For Sunlight Protection. Coverboard surfaces exposed to sunlight, shall be treated with 2.0 mils dry film thickness coating of Sancryl 300 and Aqua-poxy-914 prime coat as manufactured by Sandstrom Product Company, or 2.0 mils dry film thickness coating of Sherwin Williams Polane S Plus, or approved equal. The material shall also contain an ultraviolet ray inhibitor to protect the coverboard substrate from ultraviolet ray degradation. The material shall be integrally manufactured into the surface. An alternative bonding technique conforming to the adhesion requirements of ASTM D3359 is acceptable subject to District approval. Contractor shall submit proposed material, method of bonding, and test procedures to demonstrate long-term performance and adhesion for District review and approval.

B. Support Brackets.

1. Material. The support brackets shall be manufactured of a non conductive, fire resisting material similar to the coverboard material. All support brackets shall be of the same material.

2. Support brackets shall be clamped directly on the contact rail with the clearance and tolerances indicated on the Contract Drawings. Brackets shall not encroach into the clearance envelope. Two types of brackets shall be furnished as shown on the Contract Drawings: standard fixed-height brackets and vertically adjustable brackets. The vertically adjustable brackets shall have the range of height adjustment as shown on the Contract Drawings for use with end approaches and dip rail sections. The coverboard at end approaches and dip rail sections shall be maintained at the specified height above the top of the running rail by using the vertically adjustable support brackets.

3. Color. Support bracket shall be the same color as the coverboard.

2.07 MISCELLANEOUS MATERIALS

A. Hardware: The following requirements shall apply to bolts, nuts, and washers, as well as to metal fastening devices which are components of various assembly items indicated herein. Where high strength or HS is indicated, bolts shall meet ASTM A325, Type 1; nuts shall meet ASTM A563. Hardened washers shall be quenched and tempered in accordance with ASTM F436. Bolts and nuts not indicated as high strength or HS, and washers not indicated as hardened, may be carbon steel. High-strength bolts shall be marked "A325" or with 3 radial marks on heads. High-strength nuts shall be marked with 3 circumferential lines. Hardened washers shall be marked with 3 radial marks or shall have a blue or red coating.

1. Bolts shall conform to the dimensional requirements of ANSI B18.2.1 for Square and Hex Bolts and Screws. Bolts shall have hex heads unless otherwise indicated. High strength bolts shall have heavy hex heads. Threads shall be National Coarse (NC) unless otherwise indicated. Submit factory test reports in compliance with ASTM A325 Section 3.1.9 and Section 13.1 for certification.

2. Nuts shall conform to the dimensional requirements of ANSI B18.2.2 for Square and Hex Nuts. Nuts shall be hex unless otherwise specified. High-strength nuts shall be heavy hex. Threads shall be National Coarse (NC) unless otherwise indicated.

3. Self-Locking Nuts shall conform to the requirements of IFI 100/107 Section F. In addition to the requirements specified above for square and hex nuts, self-locking nuts shall have steel locking pin which travels between the threads during application to prevent backing off under vibration. These nuts shall be removable without damage and without damaging threads of the bolts, so they can be re-used.

4. Flat washers shall be steel, round and conform to the dimensional requirements of ANSI B18.22.1.

5. Coned Disk Spring washers shall conform to the requirements of SAE HS 1582, Commercial Grade. Rating or capacity shall mean the nominal load in pounds to flatten. Dish shall mean the distance to flatten. Coned Disk Spring washers shall be zinc-plated as specified for other metal fastenings. Proof of compliance with the rating or capacity shall be submitted.

6. Cotter Pins shall conform to the requirements of ASTM B134.

7. Fasteners for coverboard connections excluding locking devices shall be of nonconductive materials, weather resistant glass reinforced polycarbonate No. 3412 with ultra-violet stabilizer, or approved equal. Fasteners shall conform to the requirements of ASTM D638 and shall have a minimum ultimate tensile strength of 8,000 pounds per square inch. Locking devices, such as easily removed hairpin cotters shall conform to ASTM A313 stainless steel, grade 304.

B. Insulator Shims: Shims shall be made of APA Grade C-C, plugged exterior-type plywood of the sizes indicated. All holes shall be drilled. Shims shall be pressure treated after fabrication with creosote preservative in accordance with ASTM D390 and D1760. Retention shall not be less than 0.6 pounds per cubic foot of wood. Pressure treatment shall be performed only by a firm regularly engaged in and licensed for such work. Insulator shims shall be provided in standard sizes of 1/2, 3/8, 1/4, and 1/8 inch thickness.

C. Fasteners for Securing Insulators, Insulator Cantilever Brackets, and Anchor Mounting Plates:

1. Hex Head Bolts: 5/8 inch diameter, 11 UNC, ASTM A307, Grade A, zinc-plated in accordance with ASTM B633, Class 5, Type III. Bolt lengths shall be sized in accordance with the following requirements:

   a. Bolts with length of shank and thread shall ensure thread engagement of 7/8 inch minimum for concrete tie installation, and 1-7/8 inch minimum for all other types

of installation, such as second pour in a subway box, concrete decks of aerial structures, and at-grade slabs.

b. Bolt thread shall extend 1/2 inch maximum beyond the nut in installations such as securing the insulator assembly to the cantilever bracket, or to insulator anchor mounting plate.

2. Hex Head Nuts and Lock and Flat Washers: ASTM A307, Grade A, zinc-plated in accordance with ASTM B633, Class 5, Type III.

D. Contact Rail Splice Shims: Shims shall be used for connection of contact rail with aluminum web to contact rail without aluminum web including that in the existing system. Shims shall be made of aluminum, grade 6101-T6, and shall conform to ANSI H35.1 alloy. Shape and dimension shall conform to contact rail designs, and where applicable, to the contact rail in the existing system. Contractor shall submit Shop Drawings for approval by the District.

E. Concrete Pedestals: Pedestals shall be cast-in-place concrete, Class 4000, with maximum 3/4 inch aggregate size. The same cast-in-place inserts specified herein for anchoring contact rail insulator assemblies shall be used.

F. Inserts for Anchoring Contact Rail Insulator Assemblies:

1. Except for concrete ties, inserts for all other applications shall be 2-1/2 inch long minimum, sized for 5/8 inch zinc-plated bolt, shall be made of ASTM A108 steel, zinc-plated on the inside in accordance with ASTM B633, and shall have allowable working tensile and shear loads of 2,000 and 2,500 pounds, respectively. The average ultimate tensile and shear loads shall be 8,000 and 10,000 pounds, respectively, on 4,000 psi concrete.

a. For inserts installed by the cast-in-place method or prefabricated in the resilient ties, the four inserts constituting an assembly shall be connected through hardened AWG No. 4 wires forming a welded cage, as shown on the Contract Drawings. The insert assembly shall be hot-dipped galvanized, with the inserts plugged, in accordance with ASTM A153, after being assembled and welded.

b. For inserts installed by the drill-and-grout method, the inserts shall be of the drop-in anchor type, and shall be hot-dipped galvanized on the outside.

2. Inserts for concrete cross ties shall be as shown on the Contract Drawings.

G. Connection Plates: Materials and dimensions for connection plates for contact rail termination cables and shunt cables shall be as shown on Contract Drawings.

H. Hardware for Anchor Assembly:

1. Hex Head Bolts: 5/8 inch diameter, 11 UNC; and 3/4 inch diameter, 10 UNC; both ASTM A325, Type 1, zinc-plated in accordance with ASTM B633. Bolt lengths shall be as required.

2. Hex Head Nuts: 5/8 inch and 3/4 inch diameter, self locking, HS, ASTM A325, zinc-plated in accordance with ASTM B633.

3. Lock Washers: ASTM A325, Type 1, hot dip galvanized in accordance with ASTM A153.

I. Coverboard Sealant: Matte Fever R910-G68, manufactured by Sandstrom Products, Port Byron, IL 61275, (309) 523-2121; Nuglas Plastic Refinisher, manufactured by Filon Division of Standard Oil Engineered Materials, Co., Hawthorne, CA 90250, (213) 757-5141, or equal. Sealant shall be compatible with the contact rail coverboard.

2.08 FINISH AND PLATING

A. Nuts, bolts and washers shall be zinc plated in accordance with ASTM B633, Class 5, Type III. All other ferrous metal hardware, other than stainless steel shall be hot-dipped galvanized in accordance with ASTM A153. Zinc plating shall be at least 0.0005 inch thick. Finish shall be natural on all items except high-strength flat washers, which shall be identified by a yellow chromate finish, unless otherwise indicated on the Contract Drawings. Proof of compliance with the requirements specified for plating for all fastenings shall be submitted.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General

1. Contractor shall furnish all materials, including consumable items, tools, and equipment necessary to perform the contact rail installation work.

2. The contact rail system shall be connected to and interfaced with the existing BART contact rail system. The work at the interface shall include removing the end ramp sections of the existing contact rail system, drilling, grinding, cleaning and splicing the new and existing systems, and constructing new pedestals as necessary to provide for one completely integrated contact rail system.

3. Cutting: When making a field cut in existing or new contact rail, the rail shall be sawed square and at a right angle to the centerline of the rail with a variation in end squareness of not more than 1/32 inch.

4. Hole Drilling:

   a. Drilling of the contact rail shall be in accordance with the manufacturer's written instructions.

   b. Drill each hole in one continuous operation with a power drill. Drill holes perpendicular to vertical and horizontal axis of rail. Deburr holes. Do not ream holes.

5. Bending: Bending of the rail for curves shall be made in gradual steps using a suitable mechanical or hydraulic operated rail bender. Bending shall be performed in the presence of the Engineer.

6. Cleaning and Grinding Contact Rail:

a. The contact rail to be installed and spliced shall be checked, inspected, and cleaned of rust or corrosion prior to installation. Prior to drilling and mating contact rail to aluminum splice bars, the mating surfaces portion of the contact rail (approximately within 1-1/2 feet from each end) shall be wire brushed in a manner which will remove adhering foreign materials, rust, or corrosion. The mating surfaces of the aluminum splice bars and contact rail shall be liberally coated with oxide inhibiting paste and then wire brushed through the oxide paste. Mating surfaces shall be coated immediately after cleaning. Wire brush contact rail using either an electric or pneumatic grinder having a wire brush attachment. Head surfaces for new and existing contact rail joints shall be further cleaned and aligned as required, by grinding with a radial grinding wheel or stone to ensure no rust, corrosion, or surface irregularities remain.

b. Grinding the contact rail head of a straight section with a hand held electrical or pneumatic radial grinder and grinding stone to remove mill scale and surface irregularities will not be permitted.

7. Touch-up Galvanizing. Touch-up scratched or damaged galvanized surfaces after the installation of the contact rail system with zinc rich primer to form a dry film of at least 90 percent pure zinc.

B. Inserts for Anchoring Contact Rail Insulator Assemblies.

1. Concrete cross ties and resilient tie blocks shall be arranged to provide proper orientation and location of the inserts as required by the contact rail system layout drawings.

2. Field installed inserts for cantilever brackets for insulators spaced at the nominal 10 feet interval shall be cast-in-place; otherwise, inserts shall be installed by the drill and grout method.

3. Inserts for insulators mounted directly on the second pour concrete shall be installed by drill and grout method or cast-in-place.

4. The Contractor shall set-up a prototype installation for both the cast-in-place and drill and grout method of installation and shall test the insert assemblies to verify conformance with the specified ultimate tensile and shear loads. The test shall be performed prior to contact rail system installation in a Contractor designated laboratory or in the field.

C. Insulator Assembly:

1. Remove cap-plug from inserts cast into the concrete ties or the second pour concrete structures. Remove (blow out) contaminants from inserts by using compressed air. Cap-plugs in inserts where contact rail insulators have not been installed shall be left in place to protect the unused inserts.

2. In areas of direct fixation track, and in locations where more than two inches of height adjustment is required, a spacer shall be provided at the bottom of the insulator as shown on the Contract Drawings. Achieve final top of contact rail profile by shimming. Install plywood shim directly beneath insulators on all surfaces. Where spacers are used, the

shim shall be installed between the spacer and the insulator base. Ensure insulator base plates, plywood shim and spacer surfaces are clean.

3. Install 6 inch insulators for dip rail section and approach ramps. Install 9 inch insulators for all other contact rail sections.

4. Torque bolts in accordance with manufacturer's recommendations. The torque shall be of sufficient force to clamp and avoid slippage of insulator base, shim and spacer, and avoid shearing of the bolts due to the mechanical forces resulting from the flow of short circuit current. Bolts shall be provided with lock washers.

5. Install insulators on 10 foot centers. Do not exceed maximum allowable spacing of 10 feet 8 inches. At end approaches, install the last insulator at 18 inches from the end of rail.

6. No attachments of any kind shall be made to contact rail within 7 inches of an insulator.

D. Contact Rail Assembly:

1. Allowable deviation of contact rail installation from indicated dimensions and positioning shall be:

   a. Total deviation of horizontal and vertical position of contact rail with respect to track alignment: plus or minus 1/8 inch.

   b. Rate of change of deviation of horizontal and vertical position of contact rail with respect to track alignment: 1/8 inch in 30 feet.

   c. Gap width between rail ends at splice bar locations: not more than 1/16 inch.

   d. Difference in elevation of joined rails at expansion joints on contact surface shall be ground smooth at both rail to rail and rail to expansion joints.

   e. Gap between rail ends due to temperature variation: plus or minus 8 inches.

   f. Vertical allowable clearance between the bottom of contact rail and top of cantilever bracket at dip section: not less than 3-1/4 inches.

   g. Clearance between lowest end of end approach and any object: not less than 6 inches in every direction.

   h. Contact rails shorter than 25 feet shall not be installed except as indicated or approved by the Engineer.

   i. Tolerances shall not be cumulative except as accepted in writing from the Engineer.

2. Splice Bars: Just prior to mating aluminum splice bars to contact rail, the mating surfaces of the splice bars and the rails shall be cleaned of all foreign debris and aluminum oxide using wire brush. The mating surfaces shall be liberally coated with an oxide inhibiting

paste and then wire brushed through the oxide paste. Mating surfaces shall be coated immediately after cleaning.

3. End Approaches:

   a. Assemble aluminum splice bar on rail.

   b. Set end approach in splice bar.

   c. Align top surface of rail and tighten collar to torque specified by pin bolt and collar manufacturer.

   d. Grind high rail head at joint to ensure smooth transition.

4. Dip Rail Sections:

   a. Assemble splice bars on each rail.

   b. Set the two ramp rail sections in their corresponding splice bars.

   c. Assemble splice bars on each end of ramp rail sections.

   d. Set the dipped sections between the two ramp rail sections in its splice bars.

   e. Align top surface of rail and tighten collars to torque specified by pin bolt and collar manufacturer.

   f. Grind high rail head at joint to ensure smooth transition.

5. Anchor Assemblies:

   a. Assembly procedure shall be in accordance with anchor assembly manufacturer's printed instructions.

   b. Install anchor brackets and expansion joint assembly before connecting anchor rods to contact rail.

   c. Connect anchor rods to anchor bracket.

   d. Drill two holes in contact rail for connection of anchor rods as indicated.

   e. Connect anchor rods to contact rail. Use spacers as indicated.

6. Expansion Joint Assemblies:

   a. Record length of expansion joint gap, ambient temperature, date, and time of installation as indicated in Table 342413-1 herein. Expansion joint gap shall be set in accordance with gap settings calculated as a function of ambient temperature during installation.

b. Install the expansion joint assembly in accordance with manufacturer's printed instructions.

c. Just prior to mating splices between the expansion joint and contact rail assembly, the mating surfaces shall be cleaned of all foreign debris and aluminum oxide using wire brush. The mating surfaces shall be liberally coated with an oxide inhibiting paste and then wire brushed through the oxide paste. Mating surfaces shall be coated immediately after cleaning.

7. Splice of Existing Contact Rail to New Contact Rail:

a. Prior to splicing, clean existing contact rail in accordance with the cleaning and grinding procedures specified herein.

b. Splice existing contact rail to new contact rail.

c. Assemble splice bars on each rail. Place shim as required to suit the shape of existing and new contact rail. Place compression fasteners.

d. Align top surface of rail and tighten collars to torque specified by pin bolt and collar manufacturer.

e. Grind high rail head of joint in a manner to ensure smooth transition.

f. Perform Alignment and Insulation Resistance Tests.

E. Coverboard Assembly: Install coverboard assembly only after insulator assembly and contact rail assembly have been installed and field testing has been completed.

1. Support Bracket:

a. Attach brackets to contact rail and fasten and torque bolts in accordance with manufacturer's printed installation instructions or 17 lbs-ft.

b. Install support brackets at not greater than 6 foot intervals and not less than 10.88 inches from an insulator, centerline to centerline. Ten foot long coverboard sections shall be supported by a minimum of three support brackets, one at each end and one in the middle. Two support brackets are acceptable for coverboard sections six feet or shorter.

c. At dip rail and end approach sections, attach adjustable support brackets to contact rail and fasten and torque bolts to 17 lbs-ft. in accordance with manufacturer’s printed installation instructions. Determine the required height of adjustable bracket and torque adjusting bolts to 21 lbs-ft., ensuring that the assembly remains square. The Adjustable Bracket is at the proper height when the coverboard is level with the previous section.

2. Coverboard:

a. Minimum length of coverboard for installation shall be 4 feet long.

b. Coverboard shall extend not less than 12 inches but not more than 15 inches beyond the end of contact rail.

c. Attach coverboards to support brackets in accordance with the manufacturer's printed installation instructions and as shown on Contract Drawings. Depending on coverboard configuration, secure coverboard to bracket by inserting hairpin cotter pin in the appropriate hole of the coverboard pin for best fit. Use one washer minimum and up to one additional washer as a shim if necessary to achieve best fit. Coverboards shall not be allowed to rattle on the support bracket.

d. The coverboard sections shall be installed with overlap at the ends. The overlapping shall be arranged such that based on the normal direction of train travel the first coverboard shall be on top of the next coverboard.

e. Where cutting is required, cut coverboard ends square and straight.

f. Apply coverboard sealant to raw edges of field-sawn cuts as listed in Part 2.07.I.

3. Coverboards at Expansion Joints: Coverboard installation at expansion joints shall be in accordance with the installation manual.

F. Concrete Pedestals. Pedestals shall be set on stirrups embedded on the second pour concrete by drill and grout method.

G. Signage. Decals and warning signs shall be provided on the coverboard of the contact rail system as indicated. In locations where the train wayside antenna is mounted on the contact rail coverboard, the warning signs shall be located to avoid overlapping with the antenna.

3.02 TESTING

A. General

1. Testing shall be performed in accordance with Section 01 45 24, Testing Program Requirements.

2. All tests shall be made on the same production runs from which deliveries under this Contract will be made.

3. Products which have been used for qualification testing shall not be included in quantities to be delivered unless permitted in writing by the District. Submit test certification with the test data showing that materials have passed all specified tests.

4. The Engineer reserves the right to witness any or all tests. Contractor shall inform the Engineer two weeks in advance of any test dates.

B Factory Tests

1. Contact Rail and Contact Rail Assembly Testing.

a. Qualification Testing.

1) Contact Rail Steel Mill Tests. Mill tests shall be performed and certified on steel portions of contact rail. Verify conformance with the steel composition specified herein.

2) Contact Rail Resistance Tests. A resistance test using 5400 amperes of test current shall be performed on the steel contact rail with aluminum shapes attached to the web to demonstrate that the contact rail resistance meets the specified rating.

   a) Test Section of Contact Rail: Middle 20 foot section of two 30-foot contact rail sections spliced together. Three test sections shall be tested.

   b) Mounting of Test Section: Support the contact rail on electrical insulators spaced at 10 foot intervals.

   c) Instrumentation: Digital voltmeter, accurate to +/- 10 microvolt shall be used, with its calibration certified by an accredited testing laboratory within the last year.

   d) Procedure: Mount probes in a holding vise or jig, and apply them to the top steel surface of the contact rail in a manner which will ensure that ohmmeter probe spacing is accurate to within one percent of required spacing. Hand wire brush rail to ensure integrity of electrical connections.

   e) Temperature: Sample the rail temperature at 5 equal spacings within the 10 foot test section using a Fluke temperature probe. The temperature shall be averaged and results noted on test data sheets. Measured rail resistance shall be corrected to 20 degree Centigrade.

   f) Test Acceptance Criteria: If calculated resistance exceeds the specified rating, the contact rail design will be rejected.

3) Splice Bar Joint Resistance Test: A resistance test shall be performed on the contact rail in the splice bar joint area to demonstrate that the contact rail resistance across the jointed rail is equal to or less than the resistance of an equal length of unjointed rail at the same temperature. Tests shall be performed on three splice bar joints.

   a) Test Section of Contact Rail With Splice Bars: Two 30-foot sections of contact rail shall be joined together with splice bars. Test the 20 foot section with splice bars centered. Three test sections shall be assembled and tested.

   b) Mounting of Test Sections: Support the length of two contact rail sections on electrical insulators spaced at 10 foot intervals.

   c) Test instrumentation, procedure, temperature measurement, and resistance calculation shall be as specified for Resistance Test for Contact Rail.

d) Test Acceptance Criteria: If calculated resistance of splice bar joint area exceeds the resistance of an equal length of unjointed rail, the splice bar design will be rejected.

4) Contact Rail Heat Rise Current Rating Test. A continuous direct current of 5,400 amperes shall be passed through two 30-foot sections of contact rail joined together with splice bars to demonstrate that the contact rail is capable of carrying 5,400 amperes continuous direct current with a temperature rise not exceeding 40 degrees Centigrade over a 30 degree Centigrade ambient in controlled atmosphere.

a) Test Section of Contact Rail: The same three test sections, mounted in the same arrangement as specified for Resistance Test on Splice Bar Joints shall be used.

b) Instrumentation: Six thousand ampere power unit.

c) Test Connection: Thoroughly clean electrical contact area at each end of the test section using motorized wire brush, acetone and clean rags. Attach a connection plate to each end of the test section using three bolts tightened to maintain surface contact. Bolt power cables from the power unit to the connector plates on the test section.

d) Temperature: Attach thermocouples to test section using an epoxy bond. The thermocouples shall be connected to a Fluke Temperature monitoring system.

e) Procedure: At a stable ambient temperature, apply the test current to the test section and monitor the temperature. The temperature rise shall be recorded at 30-minute intervals until the contact rail temperature becomes stable.

f) Test Acceptance Criteria: If at any time during test the temperature rise exceeds the specified value, the test shall be concluded and the contact rail shall be rejected.

5) Contact Rail Corrosion Resistance Test. An accelerated salt spray corrosion test of 300 hours shall be performed, in conformance with ASTM B117. The test specimen shall be a five foot section cut from a contact rail section. The resistance between the aluminum and steel shall be measured before and after the corrosion tests with a Digital Low Resistance Ohmmeter as used in the Contact Rail Resistance Test. After the test, less than 2 percent of the contact surface between the aluminum, steel, and steel pin bolts shall show products of corrosion, and the resistance between the metals and collars shall not have increased.

6) Contact Rail Sag Test. Perform a sag (deflection) test by placing a 25 pound weight on top of a 30-foot section of rail supported by insulators spaced at nominal ten foot centers in accordance with the intended installation. The weight shall be placed midpoint between two insulators. The actual amount of sag (deflection from horizontal) with and without the weight shall be noted on

test report. If the sag is greater than 1/64 inches, the contact rail shall be rejected.

7) Contact Rail Mechanical Strength Test. The following mechanical strength test shall be performed on one 30-foot section of contact rail to demonstrate the integrity of the aluminum extrusion of the contact rail. Provide means to measure the distortion and deformation.

a) A 30-foot section of contact rail shall be mounted on holding vise or jig and bent to a horizontal radius of 300 feet. The contact rail shall remain bent for 24 hours, at which time, the rail shall be removed from the holding apparatus and inspected. In the case of pin bolted aluminum, the aluminum shall not become loose from the contact rail. For cast and rolled aluminum, the inspection shall be performed using a magnifying glass. The aluminum shall not exhibit any abnormal splits, cracks, warps and delamination.

b) For cast and rolled aluminum, five samples, each six inches in length, shall be cut from the contact rail tested. Each sample shall show the slot or hole at one end in order to examine the bonding of the aluminum to steel at the web interface and the flow of aluminum from one side of the web to the other via the slot or hole. The cast and rolled contact rail shall be deemed unacceptable if the aluminum exhibits splits, cracks, warps, delamination, and separation of the aluminum from the steel by more than 1/64 of an inch.

8) Expansion Joint Test. Tests shall be performed to demonstrate the expansion joint sliding and alignment capabilities. The expansion joint shall be installed between two contact rail sections.

a) One or both sections of contact rail shall be arranged for sliding in and out of the expansion joint to simulate movement due to contact rail expansion and contraction.

b) The top surface of the expansion joint shall remain flat and uniform with the adjacent rail, and shall allow smooth passage of a current collector shoe.

c) Test Acceptance Criteria: If the prototype expansion joint fails to demonstrate its sliding and alignment capability, and its top surface compatibility with a current collector shoe, the prototype will be rejected.

b. Production Testing: The Contractor shall include the following test in its Quality Assurance Program.

1) Resistance Test.

a) Contact rail resistance test as specified above for qualification testing shall be performed on one rail section out of each 50 rail sections manufactured. Rail sections to be tested will be selected by the Engineer. Resistance test values shall be noted on test data sheets and

will be evaluated to assure repetitive product conformity to design requirements.

b) Test Acceptance Criteria. If test results show a failure to achieve specified value, three rail sections of the 50 rail sections represented by the failure shall be tested. If a failure occurs on any of the three test sections, the entire production run represented by the 50 rail sections shall be rejected.

2) Tolerance Test. One contact rail section out of every 100 rail sections shall be tested to verify that the tolerances are within the requirements specified in Article 2.02-A.2.C herein, and as shown on the Standard Drawings. . Rail sections to be tested will be selected by the Engineer.

2. Insulator and Insulator Assembly Testing.

a. Qualification Testing. Three glazed or three unglazed insulators as specified shall be tested of each size of insulator supplied.

1) Water Absorption Test on Unglazed Insulators. Sample insulators shall be tested per ASTM D116. Samples shall be dried at a temperature of 120°C for at least 36 hours or until the weight of each piece is constant, and then weighed. The pieces shall then be immersed in water for 48 hours at a maintained temperature of 20°C to 40°C. Upon removal from the water, the surfaces shall be dried with a cotton towel and the pieces weighed. The increase in weight of any piece tested shall not exceed 0.2 percent.

2) Resistance Test on Glazed Insulators. Electrical contact on sample insulators shall be provided by a wet clay pad on the top and bottom of the insulator. The resistance shall be measured with a 2,500 volt motor operated megohmmeter, or other method approved by the Engineer. After 72 hours of immersion in water, all surfaces shall be dried, and the insulator shall demonstrate a resistance of not less than 8 megohms.

3) Dielectric Strength on Glazed Insulators. Sample Insulators shall be tested per ASTM D149. The same insulators used in the resistance test shall be used, again immersed in water for 72 hours, and all surfaces dried. Contact shall be made in the same manner as in the resistance test. The insulation shall not breakdown when 15,000 volts rms is applied for three minutes.

4) Dry Voltage Withstand Test on Glazed insulators. Sample insulators shall be tested per ANSI C29.1. A dry voltage test of 30 kV, 60 Hz, for one minute shall be performed.

5) Wet Voltage Withstand Test on Glazed Insulators. Sample insulators shall be tested per ANSI C29.1. A wet voltage test of 20 kV, 60 Hz, for 10 seconds shall be performed.

6) Mechanical Strength Test on Glazed Insulators. Sample insulators shall have a Drop Test performed as follows: An oak block with a cup to center the insulator shall be placed on a concrete foundation. The insulator shall be set

directly on the centering cup. A malleable iron cap shall be placed on the top of the insulator. A disc of hardened steel 3/4 inch thick and of the same diameter as the cap shall be riveted to the cap. Between the insulator and the cap, a lead disc 1/4 inch thick or a canvas pad 1/16 inch thick shall be placed. The insulator shall be subjected to 10 blows of a 15 pound spherical iron weight dropped from a height of 36 inches. The insulator shall not crack, break or fracture.

7) Insulator Assembly Strength Test. Sample insulators assembled with spacer, shim, base plate and "O" Ring, rail clips, bolt, locknut and rail clip cushions and one foot of contact rail shall be mounted in manner specified for installation of contact rail and insulator assembly on direct fixation track. A lateral load test shall be performed to simulate the overturning force on the insulator assembly due to a contact rail short-circuit condition. The lateral force on the contact rail during short circuit condition is expected to be 4000 pounds. Reject insulator assembly exhibiting values less than 4,000 pounds at failure, or exhibiting any signs of permanent deformation with a force of 4000 pounds.

a) Test procedure: Apply lateral force to the contact rail side at its centerline, and symmetrical with respect to the insulator, at a 15 degree angle relative to the horizontal plane so that there is an upward component to the force. The force shall be increased in increments of 100 pounds until failure occurs.

b) Test Data: Make and maintain records of force at which failure occurs and descriptions of nature of failure.

b. Production Testing. The Contractor shall include the following tests in its Quality Assurance Program. One sample insulator from each kiln shall be tested.

1) Dry Voltage Withstand Test, as specified above for qualification testing.

2) Wet Voltage Withstand Test, as specified above for qualification testing.

3) Test Acceptance Criteria. If a sample insulator is cracked or fractured in the tests, the entire kiln represented by the sample shall be rejected.

3. Anchor Rod and Anchor Assembly Testing

a. Qualification Testing. Sampling and conditioning procedures shall be as specified in the listed standard test methods, and recorded on certified test reports, as required. Where listed standard methods do not specify requirements, conditioning shall be at room temperature, and sampling shall consist of two specimens.

1) Water Absorption Test on Insulator Rod Material. Water absorption shall not be greater than 0.2 percent in 24 hours, when tested in accordance with ASTM D570.

2) Track Resistance Test on Insulator Rod Material. The time to track shall be 600 minutes minimum at 2,500 volts, when tested in accordance with ASTM D2303.

3) ARC Resistance Test on Insulator Rod Material. The time to failure shall not be less than 180 seconds, when tested in accordance with ASTM D495.

4) Dielectric Strength Test on Insulator Rod Material. Dielectric strength shall be 200 volts per mil of thickness minimum, when tested in accordance with ASTM D149.

5) IZOD Impact Strength Test on Insulator Rod Material. The average IZOD impact strength shall not be less than eight foot-pounds per inch of notch, when tested in accordance with ASTM D256, Method A. Each sample shall measure 1/4 inch wide and conform to Figure 4.

6) Anchor Assembly Tensile Strength Tests. The tensile strength of anchor rods and clevises within a temperature range of zero degrees to 100 degrees F shall not be less than 15,000 pounds when tested in accordance with ASTM D638. The Contractor shall report tensile strength at failure and describe the nature of the failure.

7) Test Acceptance Criteria. If tested anchor rods and clevises fail to satisfy test requirements, anchor rods and clevises shall be redesigned to correct cause of failure.

b. Production Testing. The Contractor shall include the following test in its Quality Assurance Program.

1) Tensile strength test, as specified above for qualification testing shall be performed on one anchor rod and clevises from each 100 supplied at a maximum of 15,000 pounds. The Contractor shall report tensile strength at failure, if failure is below 15,000 pounds, and describe the nature of the failure. Test data shall be evaluated to assure repetitive product conformity to design requirements.

2) Test Acceptance Criteria. If anchor rods and clevises fail to meet the 15,000 pound tensile test requirement, test three additional anchor rods and clevises from the lot of 100 represented by the failure. If another failure occurs, the entire production run will be rejected.

4. Coverboard and Coverboard Assembly Testing

a. General: Tests shall be performed on the coverboard and support bracket material, and on the assembled coverboard and support brackets. A sample coverboard and support bracket material shall be specially manufactured to fit the respective tests. Test sample shall be of the same material and composition produced by the same manufacturing techniques and under the same process conditions but not necessarily of the same shape as the coverboard or support bracket. A lot, as used herein, is a group of coverboard or support brackets which have been manufactured in a continuous production run from one mix of homogenous raw

materials and under identical process conditions. Coverboard, as used herein, shall mean the finished coverboard material with the surface treated with polyvinyl fluoride as specified.

b. Qualification Testing. The Contractor shall use its approved Process Control Plan in providing the samples for the qualification testing. Sampling and conditioning procedures shall be as specified in the listed standard test methods. Where listed standard methods do not so specify, conditioning shall be at room temperature (68 to 72 degrees F), and sampling shall consist of two specimens.

1) Weathering Test on Coverboard and Support Bracket Material. The total time for exposure shall be 2,000 hours but shall not exceed six months on samples tested in accordance with ASTM G152 and ASTM D1499. ASTM G152 shall be followed with cycles of 102 minutes of light followed by 18 minutes of light and water spray. At the end of the exposure time, there shall be no visible evidence of deterioration such as warping, cracking, peeling, delamination, or any other defects.

2) Surface Burning Characteristic Test on Coverboard and Support Bracket Material. The Surface Burning Characteristic rating shall not be greater than 25 when tested in accordance with NFPA 255 (ASTM E84) and NFPA 130, Section 6.4.2.5.1.

3) Smoke Generation Test on Coverboard and Support Bracket Material. The smoke generation specific optical density, Ds, shall be determined by tests in accordance with the flaming and nonflaming modes of ASTM E662. The Ds values shall not exceed 50 within 90 seconds after the start of the test, and shall not exceed 50 within four minutes after the start of the test.

4) Water Absorption Test on Coverboard and Support Bracket Material. Water absorption shall not be greater than 0.3 percent in 24 hours, when tested in accordance with ASTM D570.

5) Track Resistance Test on Coverboard and Support Bracket Material. The time to track shall be 600 minutes minimum at 2,500 volts, when tested in accordance with ASTM D2303.

6) ARC Resistance Test on Coverboard and Support Bracket Material. The time to failure shall not be less than 180 seconds, when tested in accordance with ASTM D495.

7) Dielectric Strength Test on Coverboard and Support Bracket Material. Dielectric strength shall be 200 volts per mil minimum, when tested in accordance with ASTM D149.

8) IZOD Impact Strength Test on Coverboard and Support Bracket Material. The Average IZOD impact strength shall not be less than eight foot-pounds per inch of notch, when tested in accordance with ASTM D256, Method A, Figure 4. Each sample shall measure 1/4 inch wide.

9) Toxicity Test on Coverboard and Support Brackets. The University of Pittsburgh Rodent Toxicity Test shall be used to assess the acute inhalation toxicity of combustion products of materials. It determines an LC50 – the concentration of combustion products, which cause 50% lethality in the test animals exposed for 30 minutes and observed for 14 day following exposure.

   a) The test results shall be current, not more than one year from date of test.

   b) The test must be certified and a certified copy of the report submitted to the District with any First Article Requirements.

10) Mechanical Strength Tests on Coverboard and Support Brackets. The following mechanical strength tests shall be performed on an assembly of 30 feet of coverboard, 4 brackets, the necessary coverboard pins, and a section of contact rail, set up as intended to be installed on the BART system. The Contractor shall provide means to measure the distortion and deflection.

   a) Vertical Load Cyclic Test: A 250 pound weight consisting of a sand bag or a similar object with a bottom surface 6 by 12 inches shall be placed at any point between two support brackets as selected by the Engineer. The weight shall remain in place for 30 seconds and then be removed for 60 seconds. This cycle shall be repeated 50 times. After this 50 cycle test, the coverboard and support bracket separately, shall be inspected with a 7-power magnifying glass and shall show no splits, cracks, peels, or breaks. The coverboard and support bracket separately, shall then be measured and shall not show any permanent distortion or deflection from original coverboard and support bracket configuration.

   b) Vertical Load Impact Test: The assembled bracket and coverboard shall be tested for vertical impact with a 165 pound weight dropped twice from a minimum height of 30 inches above the high point on the arch of the coverboard between brackets onto a 12 X 42-inch area of coverboard. Deflection may be one inch maximum with impact but the coverboard and bracket shall immediately return to its original configuration with no permanent distortion or deflection.

   c) Horizontal Impact Test: A 165 pound weight shall be suspended from a point eight feet directly above the leading edge of the coverboard at a bracket. The weight shall be held aside so that it will swing a distance of at least 2 feet and strike against the coverboard at the bracket. The length of the coverboard contacted by the weight shall not be greater than 1 foot. After impact, there shall be no permanent distortion or deflection.

11) Test Acceptance Criteria.

   a) Material: If coverboard and support bracket material fails to satisfy test requirements, coverboard and support bracket material shall be redesigned to correct cause of failure.

b) Coverboard: If any of the tested coverboard fails to meet any of the requirements of the mechanical strength tests, one additional coverboard from the same lot shall be tested. If it fails, the entire lot of coverboard will be rejected by the Engineer.

c) Support Bracket: Tested brackets from the mechanical strength tests shall not show splits, cracks, breaks, or any other detrimental effects. If one bracket of a lot fails to meet specified requirements, three additional brackets from the same lot shall be tested. If any bracket fails to meet any of the requirements, the bracket shall be redesigned to correct the cause of failure.

c. Production Testing. The Contractor shall include the following tests in its Quality Assurance Program.

1) Vertical Load Cyclic Test as specified under Qualification Testing above shall be performed on one coverboard and two support brackets per each one thousand coverboards produced.

2) BARCOL Hardness Test shall be performed on one coverboard and one support bracket from each lot produced.

a) The BARCOL Hardness Test shall be performed using a Barber Colman Company BARCOL Impressor. The BARCOL Hardness shall be obtained by direct reading of the dial indicator. The test shall be performed in an area as directed by the Engineer.

b) BARCOL Hardness Test Minimum Reading. The results of the BARCOL Hardness Test reading of cured finished sections shall be a minimum of 40 averaged, when tested in accordance with the requirements of ASTM D2583. Any coverboard or bracket failing to meet the minimum average requirement, the entire lot shall be rejected. However, if the product meets the requirements of the Vertical Load Cyclic Test, it shall take precedence and the lot shall be acceptable.

3) Coverboard Pin IZOD Impact Strength Test. The test shall be performed on a random sample of one percent, but no less than three pins in each process batch. The stem of the pin shall be held firmly in a vise or similar device. A force of 150 pounds shall be applied for 5 seconds to the head of the pin in a direction perpendicular to the stem. Thereafter, a prying force of 150 pounds shall be applied for 5 seconds to the head of the pin, in line with the axis of the stem. Cracking or fracture of one pin shall constitute failure and cause rejection of the batch in which the failed pin had been manufactured.

C. Field Tests

1. General:

a. Test installed contact rails in the presence of the Engineer.

b. Perform visual inspection of all joints prior to performing field tests.

2. Contact Rail Electrical Resistance Test:

   a. Method: Ohmmeter measurement.

   b. Contact Rail Section for Testing:

      1) Composition: 3 feet of contact rail with splice joint centered and between test probes in section.

      2) Quantity: 20 joints per mile.

      3) Selection of locations used for testing will be made by the Engineer.

   c. Reference of Comparison: 3 feet length of solid contact rail.

   d. Instrumentation:

      1) Digital low resistance ohmmeter (DLRO).

      2) Calibration: Certified by testing laboratory at intervals of not more than six months.

      3) 500 ampere power supply.

   e. Test Procedures:

      1) Mount probes in a holding vise or jig accurately within 3/8 inch of required spacing.

      2) Position vise or jig correctly to ensure that splice will be centered within 1/8 inch.

      3) Check electrical wiring to ensure proper connections and obtain correct resistance reading.

      4) Read microhm across the test section of contact rail and across the three-foot length of solid contact rail section, using a minimum of 500 amperes of test current.

      5) Resistance through splice of test section shall not be more than the resistance of the solid contact rail section.

      6) Replace splice joints exhibiting resistance more than that of the solid contact rail section. Retest until resistance reading through the splice does not exceed allowable resistance.

      7) If one of the splice joints tested is defective, test resistivity of every completed contact rail splice joint.

3. Alignment Test:

a. Check for conformance to allowable tolerances. Contractor shall design and fabricate a jig approved by the Engineer for contact rail alignment test.

b. Contact rail alignment shall be within the tolerances specified herein.

4. Insulation Resistance Test:

a. Test installed new contact rail system in sections without insulated jumper and shunt cables connected by means of a 5000 volt megohmmeter.

b. Test reinstalled existing contact rail sections without jumper and shunt cables connected by means of a 1000 volt megohmmeter.

c. Insulation resistance shall not be less than 80 megohms to ground per 1,000 feet of contact rail.

d. Record and submit test data for District approval.

3.03 CLEAN-UP

A. Remove wrapping paper and clean installed coverboards after installation.

B. Clean installed insulators of foreign material with manufacturer's recommended cleaning solvent.

TABLE 34 24 13 -1

EXPANSION JOINT ASSEMBLY INSTALLATION AREA

STATION	DATE	TIME	TEMP ^{O}F	RAIL GAP	REMARKS

Performed By: _____
Contractor Representative & Title

Witnessed By: _____
Engineer or Authorized Representative

END OF SECTION 34 24 13