Recommended Instructions for Cross-bonding In Electrified Territory Where Impedance Bonds are Used To Bridge Insulated Joints

New 2025 (10 Pages)

A. Purpose

This Manual Part recommends instructions for the design, installation, and maintenance of impedance bonds and cross-bonding in electric traction territory to ensure track circuit shunting and broken rail detection are not negatively impacted by their application. Cross-bonding in this manual part applies in electrified territory where it is necessary to pass traction return current around insulated joints used to define the limits of low frequency (i.e., less than 500Hz) or DC pulsed track circuits and to equally distribute traction return current in rails.

B. Definition of Cross-bonding

The collection of cables in the return path of the propulsion power distribution system between the traction return conductor and the rails of an electric railway or between rails of one or more tracks for equalizing the return current flowing in the rails and for bridging around possible open rail head joint bonds.

C. General

Since electric traction and signal systems utilize the rails as part of their electrical circuits, ac and dc traction systems operating over a rail system interact directly with the track circuits used to detect trains. Care shall be taken in the design of any electric traction system to ensure that the signal system can continue to function as intended to safely control the operation of trains and not inhibit the track circuits ability to detect a train, an open rail head joint or broken rail.

D. Impedance Bonds

As the majority of traction return current is passed through the rails on its return path to a substation, the installation of impedance bonds provides a means to pass return current from one track circuited section isolated by insulated joints to an adjacent track section. The impedance bond offers a high impedance to the signal track circuit while permitting traction return current to pass through a low impedance on its path back to the substation.

1. Impedance bonds shall conform to Manual Part 8.4.5 Recommended Design Criteria for Low Frequency Untuned Impedance Bonds or Manual Part 8.4.9 Recommended Design Criteria for Low Frequency Tuned Impedance Bonds.

2. Impedance bonds shall be installed in accordance with Manual Part 8.6.30 Recommended Installation and Maintenance Instructions for Lower Frequency Range Impedance Bonds.

E. **Bonding**

1. The running rails are used as the primary return path for the electric traction current. Bonding shall be sized to keep the voltage drop of the return circuit at or below the prescribed limit, using bonds that are heavy enough and strong enough to carry double the full load current under the environmental conditions per Manual Part 11.5.1 Recommended Environmental Requirements for Electrical and Electronic Equipment Class A (Roadbed) while withstanding normal vibration, fatigue, and mechanical damage.

2. Bonding shall conform to AREMA recommended practices in accordance with Manual Part 8.1.20 Recommended Application Criteria for Track-Circuit Bonding and AREMA Manual for Railway Engineering, Part 7 Traction Electrification System Grounding & Bonding.

3. Exothermic rail head joint bonding shall be in accordance with Manual Part 8.1.31 Recommended Design Criteria for Copper Based Welded-Type Propulsion Rail-Head Bonds.

4. Exothermic rail web joint bonding shall be in accordance with Manual Part 8.1.33 Recommended Design Criteria for Copper Based Exothermically Welded-Type Propulsion Rail-Web Bonds and Track Connections.

5. Mechanical-type rail web joint bonding shall be in accordance with Manual Part 8.1.35 Recommended Design Criteria for Copper Insert Mechanical-Type Propulsion Rail-Web Track Contacts.

6. Mechanical type rail web joint bonding shall conform to Manual Part 8.1.36 Recommended Instructions for Mechanical-Type Tin Plated Copper Insert Rail Web Contacts.

7. Grounding and bonding of all metallic structures shall be compatible with the signal system.

F. **Design**

1. To maximize broken rail detection probability, the location of track circuit boundaries and cross-bond connections shall be carefully coordinated. The interconnecting of impedance bonds indiscriminately can produce undesirable paths through which the signal current could flow. Impedance bonds shall not be connected in such a manner as to allow an undesired path for track circuit signals to flow through impedance bond center taps around a broken rail.

2. Gas pipelines and other utilities may request return current connections to dc electrified railroads. These types of connections shall be viewed as equivalent to a parallel track (A or B points) which can potentially compromise track circuits in the same manner as an improperly cross-

bonded parallel track. These connections should only be permitted at the substation return (D point) and only under the direction of the railroad.

3. Most impedance bond connections are designated as “A”, “B”, or “C” point connections.

   a. **“A” Point** – Impedance bonds on all tracks connected to the center taps (or neutral leads) of the bonds and to the traction return network.

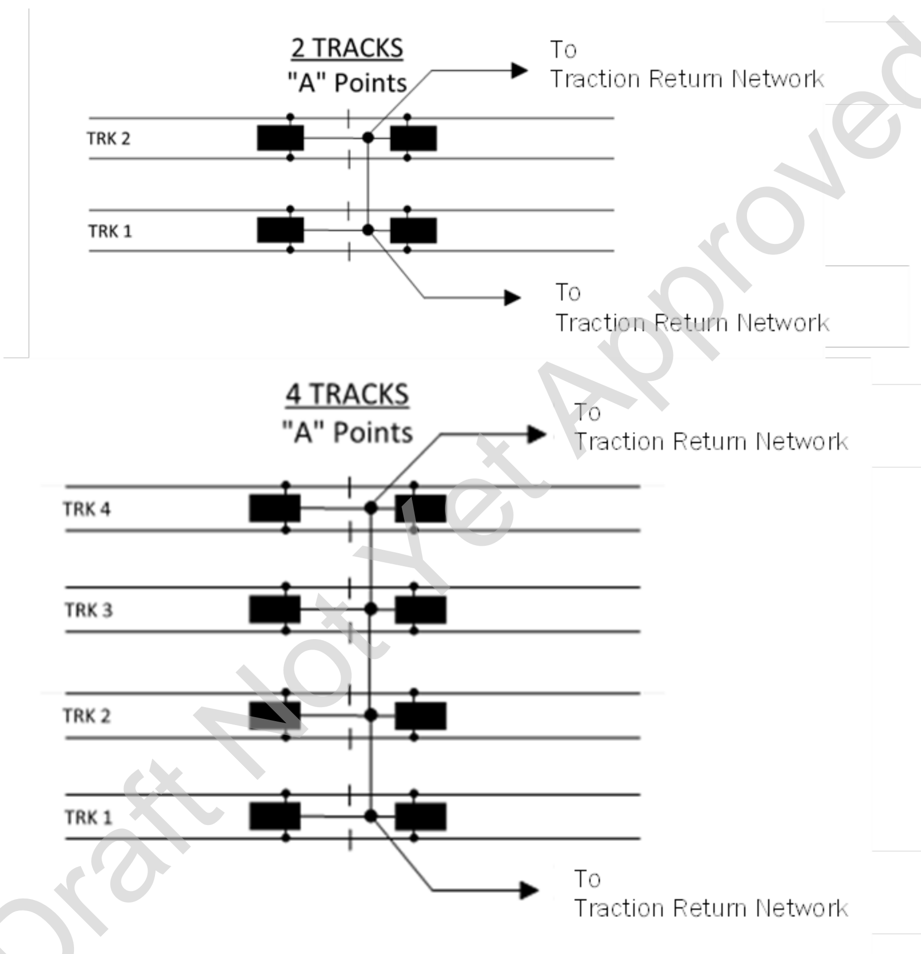

Figure 8614-1: “A” Point Connections

b. **"B" point** – The center taps of the impedance bonds on two tracks are connected but not connected to the return network.

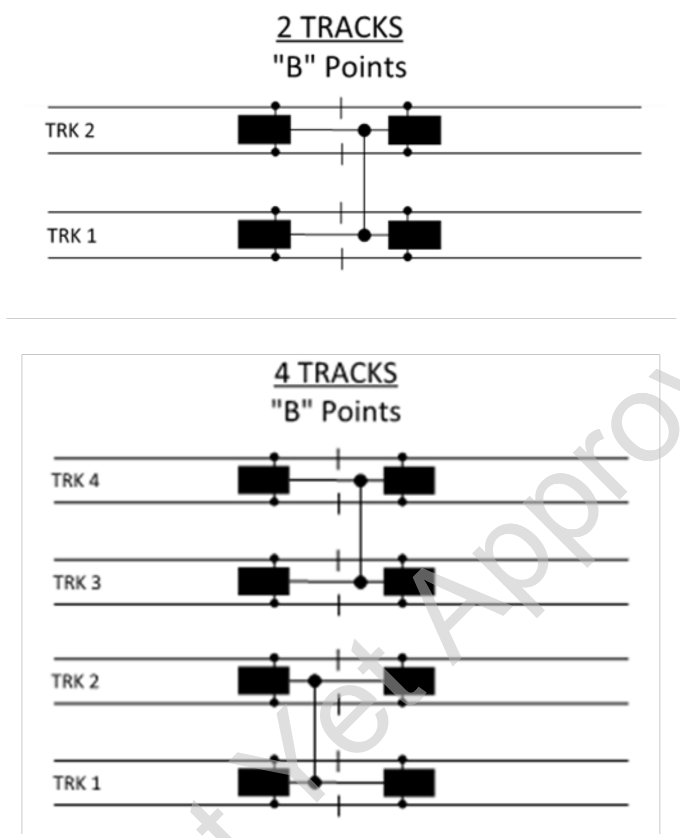

Figure 8614-2: "B" Point Connections

c. **"C" point** – The center taps of two adjacent impedance bonds on the same track connected.

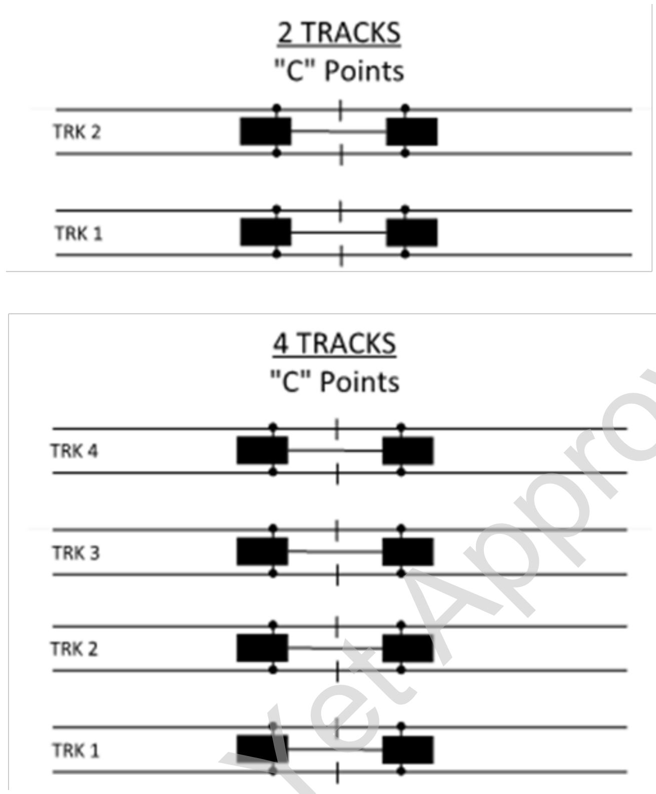

Figure 8614-3: "C" Point Connections

d. **"D" Point** – A "D" point, commonly referred to as a drain bond, is used to provide a substation return or grounding connection to the track. A "D" point is to be considered the same as an "A" or "B" point for broken rail detection.

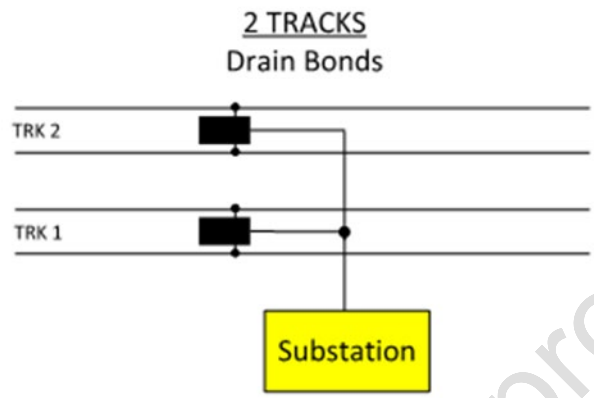

Figure 8614-4: Drain Bond Connection

e. **End of Track Circuit** - Track circuit to the left of insulated joint, no track circuit on right.

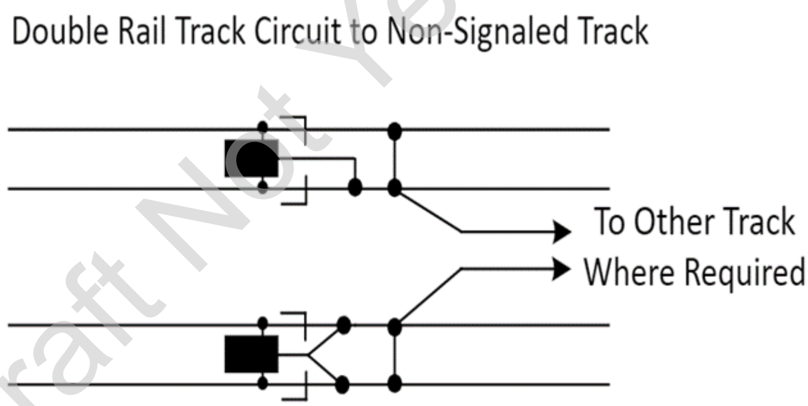

Figure 8614-5: End of Track Circuit

4. The minimum allowable separation between "A" or "B" points should be 6000 ft., however the optimum spacing of cross bonds for broken rail detection should be determined by considering the network impedance of the track circuit compared with the network impedance of any alternate path under conditions of a broken or high impedance rail. To ensure high impedance to an alternate path such that a broken rail can be detected, in addition to a 6000 ft minimum distance, a minimum of two track circuits shall be placed between cross bonds with no track circuit within the cross bonded points being longer than 60% of the total length of the distance between the

cross bonds. "A" or "B" point connections shall never be applied at both ends of a track circuit (successive impedance bond locations).

5. Figure 8614-6, Illustrates where the "A" points at 053+00 and 172+00, and the cross-bond boundary is D(xb). The longest track circuit, D(lt)is 6200'. In this example D(xb) is 11,900' [5700'+6200'] such that (D(xb)/D(lt) = %). 6200/11900 = 52%, which falls with the acceptable range of <60%. The ideal arrangement would be two equal length track circuits between crossbond points with each being 50% of the total distance between them.

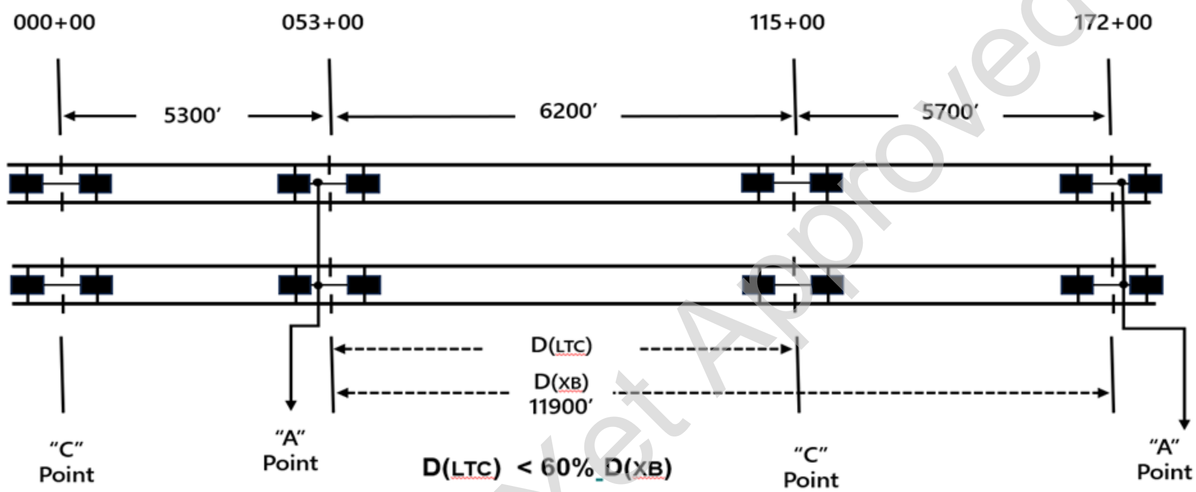

Figure 8614-6: "A" or "B" Point Separation

6. When nonstandard return configurations are used (e.g., supplemental returns), considerations should be given when calculating impedance values.

7. Drain bonds, ("D" points), constitute an "A" point when located at other than insulated joint locations (see Figure 8614-7). Where D(LTC) is the total length of the longest track circuit in the section between cross bonded "A" and "D" points, D(LTC) at 5700' is the longest track circuit in the affected section. D(XB) is the total length of the cross bonded section [5100+5700 = 10800], The calculated percentage of 5700' to 10800' is approximately 53% which is within the criteria established in F.4.

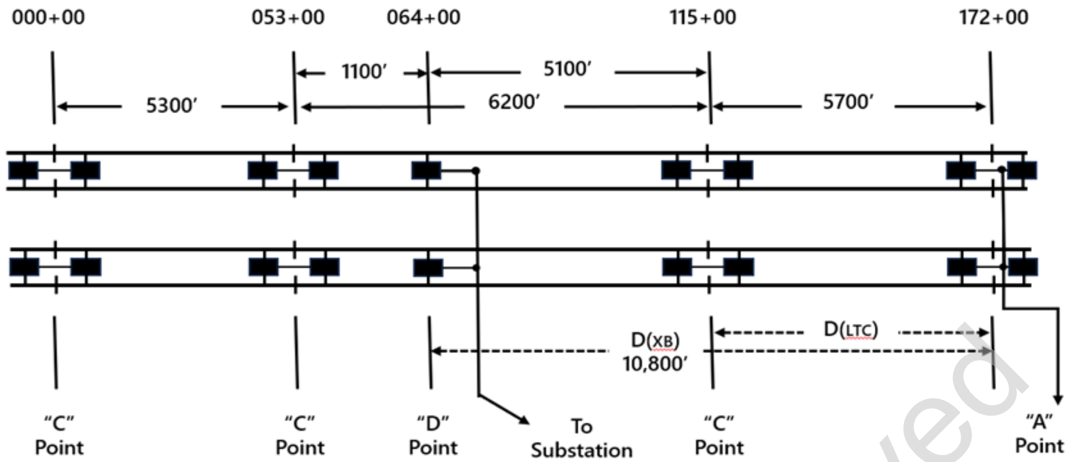

Figure 8614-7: Drain Bond Track Circuit Separation

8. For cross-bond locations less than 6,000 feet apart:

   a. There shall be a minimum of three (3) track circuits between the cross-bond locations ("A" or "B" points).

   b. The total length of any track circuit, any portion of which is between the cross-bond points, should not exceed 40% of the distance between the cross-bond points.

   c. In no case shall a distance of less than 3,000 feet between cross-bond locations ("A" or "B" points) be permitted.

9. Cross-bonding should be placed as close to interlocking crossovers as possible to reduce the possibility of flash-over of insulated joints in crossovers. If possible, an "A" or "B" point should be placed at one of the interlocking home signal locations at each interlocking. This shall be done consistent with paragraphs 3 through 7.

10. At a turnout, only one impedance bond should be provided at the insulated joints on the turnout track. The neutral leads on this impedance bond shall be tied to the neutral leads between the impedance bonds located at the adjacent insulated joints on the main or straight track (Figure 8614-8).

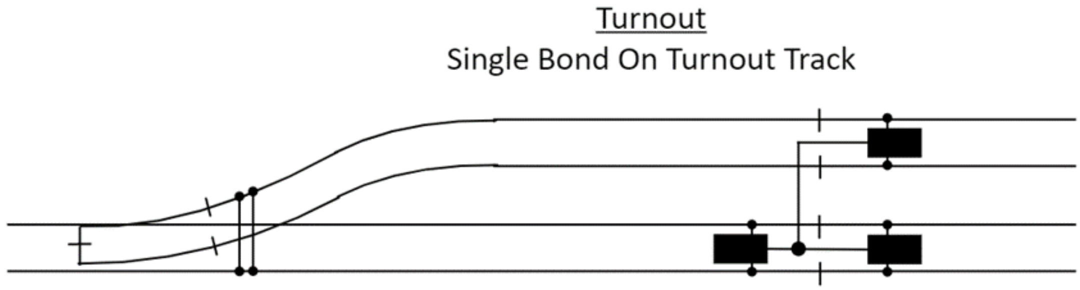

Figure 8614-8: Turnout – Single Impedance Bond

11. When a "split" track circuit (two relays from a common feed) is used on a turnout, an attempt should be made to use the single bond layout (Figure 8614-8), as the elimination of one impedance bond reduces the combined load on the track circuit.

12. If there are no insulated joints on the main track within approximately 20 feet (6.1 m) of the insulated joints on the turnout track, then a second impedance bond located on the switch point side of the joints should be used on the turnout track at the insulated joints (Figure 8614-9). In this case, the neutral leads of the impedance bonds on the turnout track shall not be connected to the neutral leads on the main track. The impedance bonds on the turnout track should be arranged in a "C" point configuration. The impedance bonds on the main track should conform to paragraphs F – 3 through 8.

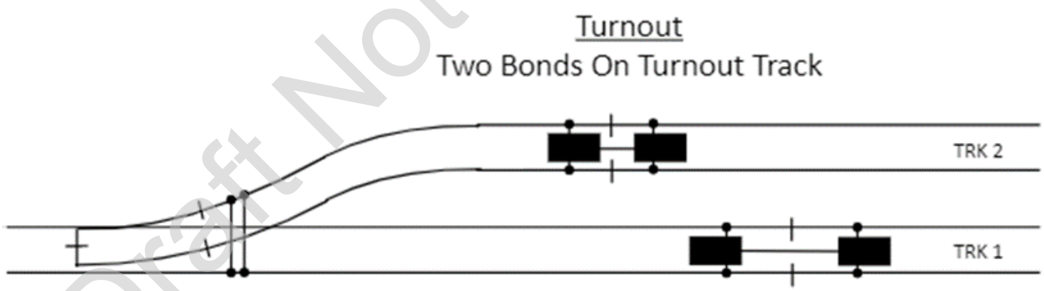

Figure 8614-9: Turnout – Two Impedance Bonds

13. Where two impedance bonds are used on a turnout track, the signal fouling wires may carry substantial traction currents and shall be sized and maintained accordingly.

14. In dc propulsion traffic, where rail return currents are considerably higher than in typical ac systems, negative return buses to the substations are spaced much closer together than they would be in ac propulsion systems. Cross-bond connectivity to all tracks is required at each of these locations. To facilitate the blocking of ac signal power to the return bus, non-saturable air-core reactors may be installed to block signal run-around paths while still

providing a path for dc traction currents to return to the negative bus. The reactors are installed in series with a cross-bond or a negative feeder and are effective in mitigating the issues of compromising broken rail protection. Reactors should only be prescribed when mutually agreed upon by the signal and propulsion engineers.

15. When non-standard cross-bonding conditions are necessary, deviation from recommended practices in bonding arrangements and track circuit adjustments shall be made only after careful review by signal and traction power engineering personnel.