Chapter 17: Train Detection - Track Circuits & Axle Counters

Section 1: Track Circuits

17.1.1 Track Circuits General

(a) A closed type track circuit shall be provided to prove the clearance of rail track.

(b) Double rail track circuits shall be provided on non-RE areas. In RE areas, Single Rail track circuit for D.C track circuit and Double Rail track circuit for AFTC shall be used.

(c) **Minimum Length:** The length of a track circuit shall not be less than the maximum wheel base of any vehicle. The Track circuits shall cover at least two rail lengths (26 meters).

(d) **Series Connection of Tracks:** The various portions of tracks in a line shall, as far as possible, be connected in series.

(e) Track relays shall be of an approved design.

17.1.2 Permanent Way Requirements of Track Circuits

(a) Glued Joints or Insulation Joints of approved type shall be provided for defining boundary of track circuit. In all future works of track circuiting, glued insulated joints should be provided. Glued joint should be tested before insertion.

Note: Where ever Insulation Joint is mentioned, it also applies to glued insulated joint.

(b) Where staggering cannot be avoided the distance between staggered joints shall not exceed the minimum wheel base of the vehicles.

(c) Rail ends of glued/insulated joints shall be square and true. All rough edges and burrs shall be removed from bolt holes. Battered ends shall be put right and the gap between the rails should be equal to the thickness of the end post.

(d) Fish bolts at the joints must be kept tight and the sleepers well packed in the vicinity of the joints.

(e) Proper drainage should be ensured so as to avoid flooding of tracks during rains, particularly in yards where watering of coaches is done and in water columns. It would be desirable to provide washable concrete aprons on platform lines at originating stations, in track circuited areas.

(f) Ballast shall be kept clean throughout the track-circuited section and care should be taken to see that the ballast is kept clear off the rails and rail fastenings. The clearance from the foot of the rail should not be less than 50 mm. Well screened ballast right up to the formation level shall be provided.

(g) Rail ends shall be kept free from brake-dust, dirt, sand, rust, other foreign materials etc. All rough edges and burrs at rail ends must be removed.

(h) To avoid crushing of end posts of insulated rail joints due to creep, at least one rail length on either side of insulated joint should be provided with anti creep devices.

(i) Rail screws should preferably be used in place of dog spikes at insulated joints.

Note: The requirements mentioned in the para no. 17.1.2(a) to (i) are covered in the chapter II, Part "H" of Permanent Way Manual.

(j) Wooden sleepers, concrete sleepers or any other approved type of insulated sleepers shall be provided for track circuiting. Concrete sleepers where used, shall have a minimum resistance of 500 ohms between insert to insert.

(k) Where short welded rail panels are used, SWR shall not butt against insulated joint. Two rail lengths of 13 meters/12 meters shall be interposed to isolate short welded rail from insulated joint. This standard length of rails shall be anchored effectively to arrest movement in either direction.

(l) In case of turnouts and crossings, insulated stretchers, insulated gauge tie plates and insulated crossing plates shall be provided as per approved drawings.

(m) GFN liners shall be provided in the track circuited area using concrete sleepers.

(n) Track circuited area shall be free of vegetation. Only insulated trolleys shall be used.

Section 2: Installation of DC Track Circuits

17.2.1 Location of Track Relays

(a) Track relays shall be located at the entry end of the track circuits wherever possible.

(b) Where track relays cannot be located in the cabin/Relay Room, they shall be housed in locations of an approved type.

(c) Where relays are likely to be subjected to vibration, suitable anti-vibration measures may be provided. They shall be mounted on shock absorbers such as rubber pad, foam etc.

(d) Connections between the track relays and track repeating relays shall be made in accordance with the approved wiring diagram and must invariably incorporate both cross protection and double cutting arrangements.

(e) The feed and relay ends shall be connected by separate and individual cables.

(f) Relay End and Feed End of the track circuit should be located at the boundaries of the track circuit.

(g) **Loading of Track Relay Contacts:** All the contacts of the track relay shall be loaded as far as possible. Where spare contacts are available, they shall be connected in parallel to the loaded contacts.

17.2.2 Jumper Connections

(a) Jumper connections shall normally be so made that the whole of track circuit is in series excluding traction return rail. When the rails of a track circuit are in parallel, care shall be taken that the jumper connections are effective.

(b) Jumper connections, preferably duplicated, shall be so arranged that they are as far as possible protected from damage.

(c) All connections to the track shall be of sufficient length and allow for rail creep. Connections shall be firmly fitted to the web of the rail.

(d) For short jumpers, galvanized iron wires and for long jumpers cables, may be used. Where galvanized iron jumper is used, duplicate jumpers shall be run. The cross section of galvanised iron wire shall not be less than 8 SWG. Where cables are used, the size shall not be smaller than 7/0.750 mm.

(e) The lead wires used for connecting the feed set to the feed end boot leg/track lead Junction Box (JB) and the track relay to the relay end boot leg/track lead JB shall preferably be of copper conductor having a minimum cross section of 2.5 sq.mm. Lead wires crossing the track should be protected through suitable means.

(f) Track lead JB shall be clear of ballast.

(g) The Feed as well as Relay Ends +ve & -ve leads shall be connected by using individual 2 x 2.5 sq.mm cable, duly paralleled at each end.

17.2.3 Bond Wires and Rope Wires

(a) Bond wires/Rope wires shall be of an approved type. Duplicate wires shall be installed close to the fish plate, it is desirable to use bond wire clips for securing the bond wire.

(b) Bond holes shall be drilled with a twist drill and the bonds driven-in immediately. The wires may be fixed by using channel pins in the holes or by brazing/welding.

(c) The resistance of rail and bonding per 1000 meters of track shall not exceed 0.5 ohm for track circuits longer than 700 meters. A rail and bond resistance up to 1.5 ohm per 1000 meters of track may be allowed for length of track circuit less than 700 meters.

(d) The rail bonding and connections to the relay and feed set shall be made according to approved drawings.

(e) The lugs of impedance bond connections shall be firmly fixed by pressing rivets into the web of the rail with a bond press.

17.2.4 Track Circuit Terminations

(a) For track circuited points or lines in a station, track circuit termination shall be provided sufficiently before the Fouling Mark* so as to avoid infringement to the standard dimension by any portion of the vehicle. The distance between track circuit termination and Fouling Mark shall not be less than 3 meters.

(b) **Cut Section (Fed Over) Arrangement of Track Circuits:** Where cut section track circuits are installed, the track relays concerned, when de-energized, shall open the track feed and shunt the track circuit.

**Note: Fouling marks should be fixed at the point at which the spacing between the tracks, begin to reduce to less than the minimum as laid down in the schedule of dimensions, i.e. not less than 4.265 m for existing yards and 5.3 m for new yard lines. (Para No. 650 of IRPWM)*

17.2.5 Insulated Rail Joints

(a) All components of insulated joint shall be of approved type and shall conform to RDSO drawings. The components shall be installed using correct sizes and combinations.

(b) Insulated Rail Joints shall, as far as possible, not be provided on the outer rail in curves. Insulated rail joints shall be so placed to minimise dead zone (where a standing vehicle is not detected).

(c) Before an insulated joint is installed, it shall be ensured that permanent way requirements stipulated in Para no. 17.1.2 are complied with. The installation of glued rail joints shall be done by Civil Engineering Department. The installation of Nylon insulated rail joints shall be done in accordance with RDSO's booklet No.STS/E/IRJ/IMI - Installation and Maintenance Instructions for Nylon insulated rail joint. Particular attention shall be paid to the following:

(i) Hammer driving of fish-bolt shall be avoided, as this will damage nylon bushes, If the rail hole and the fishplate holes are in their proper position and alignment, the fish bolt can be easily inserted by hand pressure.

(ii) If an end-post, projects above the rail at the ends, it shall be trimmed and brought to the level of the rail table, especially when inserted between the worn-out rails, before first wheel of a train passes over it.

(iii) The distance of 13 meters between the insulated Block Joint or Detection Point and the starter Signal can be reduced from 13 meters to 3 meters for Signaled movements. The insulated Rail Block Joint or Device of Axle Counter or Joint Less Track Circuit shall be so fixed that their boundary shall be within zero to 3 meters in advance of the starter signal.

(iv) In the case of point track circuits, the insulation joint shall not be in the stock rail joint but in the rail joint ahead of it wherever feasible.

(d) Only 'J' type clip shall be used in glued joint portion of track.

17.2.6 **Track Indicators:** At Track circuited stations where track indicators are provided, the following arrangements shall be made:

(a) **At Panel Interlocked/Route Relay Interlocked Stations**

(i) Normally, the track indicators would show no light when the line is unoccupied. When action is initiated to set the route for taking off a signal and the concerned route is set, the track indicator light for the route shows Yellow/White, if unoccupied. However, if any portion of the track circuited area is occupied, a "RED" indication is shown on the panel diagram, irrespective of the route being set or not.

(ii) The track indicators would show white/yellow light when the track is cleared after the intended movement is completed till the route signal button or switch is restored to normal unless the panel interlocking/route relay interlocking is provided with Automatic Route Release facility in which case the indication would be lit until the sub route/sectional route/ route is released.

(iii) In case of berthing track having multiple track circuit sections, it is desirable to show individual indications of each track circuit on the panel.

(b) **At Other Stations:** The indicator shall show yellow/white Light when the line is unoccupied and RED when line is occupied.

17.2.7 Limiting resistance of DC track circuits shall be adjustable and of an approved type.

17.2.8 **Track Relays**

(a) DC track relays of approved design shall be used. In future installations, only plug in type track relays (9 ohm) shall be used, both in Non-RE & RE areas.

(b) Q series track relay must be used in conjunction with Q series slow to pick up relay as a repeater relay.

(c) **Excitation of DC Track Relay:** The relay shall be excited at minimum 125% of its rated pick up voltage under minimum ballast resistance condition and normal working voltage of the supply. The maximum excitation shall not exceed 235% for QBAT Relays and 300% for other plug- in type relays.

17.2.9 **Maximum Length of Track Circuits:** Maximum length of track circuit under different track parameter conditions shall not exceed the limits as given in the following table. Maximum length of track circuit under different track parameter conditions shall not exceed the limits as given in the table below.

Sl. No.	*RE/ Non-RE*	*Sleeper*	*Section (Yard/ Block)*	*Min. Ballast Resistance in Ohm per Km*	*TSR in Ohms*	*Max. Length of Track Circuit in meters*	*Type of Track Relay to be used*
1	*Non-RE*	**Wooden/PSC*	*Block*	*4*	*0.5*	*1000*	*QT type 9 ohm*
2	*Non-RE*	**Wooden/PSC*	*Yard*	*2*	*0.5*	*670*	*-do-*
3	*RE*	**Wooden*	*Block*	*4*	*0.5*	*450*	*QT 9 ohms AC immune*
4	*RE*	**Wooden*	*Yard*	*2*	*0.5*	*450*	*-do-*
5	*RE*	*PSC*	*Block*	*4*	*0.5*	*450*	*-do-*
6	*RE*	*PSC*	*Yard*	*2*	*0.5*	*350*	*-do-*
7	*RE*	*PSC*	*Yard*	*2*	*0.5*	*750*	*QBAT in conjunction with QSPA1 with B type choke at relay end*

(where existing)*

17.2.10 **Track Feed**

(a) Approved type of secondary cells shall be used for feeding track circuits.

(b) Secondary cell(s) shall be used along with battery charger/solar panel of adequate capacity.

(c) Separate feed shall be provided for each track circuit.

Section 3: Maintenance of DC Track Circuits

17.3.1 **General:** Track circuits shall be so maintained that:

(a) There is always a good connection between power feed and track, Relay and track and also between adjoining rails, through jumpers and rail bonds.

(b) The ballast resistance always remains high and does not fall below prescribed minimum values.

(c) The limiting resistance shall be as high as possible.

(d) The insulating joints are of high resistance.

(e) The surface of rail is clean and is free of dust, sand and foreign materials.

(f) The circuit is properly energised during wet weather on minimum ballast resistance conditions and during dry weather on maximum ballast resistance conditions. The track circuit shall not be over-energised to such an extent that the shunting value drops below 0.5 ohms for all types of track circuits. These values shall be obtained irrespective of whether the track is provided with concrete sleepers or wooden sleepers.

(g) The connection of DC track relay shall be quarterly interchanged to prevent permanent magnetisation.

17.3.2 **DC Track Relays**

(a) Pick up and drop away values shall be maintained within the limits specified by the manufacturer.

(b) Track relays shall be inspected visually every quarterly by the JE/SSE and the following visual checks conducted:

(i) Movement of armature and contact carriage

(ii) Wiping of contacts

(iii) Arcing of contacts, if any

(iv) Pitting or charring of contacts

(v) Dust on contacts

(vi) Electroplating

(vii) Corrosion, rusting of components

(viii) Cracks or breakage in components

(ix) Presence of fungus, if any

(x) Charring of cover near contacts (for plug-in relays)

(xi) Correctness of label

(xii) Presence of seal

(c) The defective track relay should be immediately replaced and a brief report stating the nature of the defects shall be submitted to ASTE/DSTE/ Sr.DSTE. On no account should any attempt be made by the field staff to rectify the relay.

(d) Plug in type track relays have to be replaced on completion of 12 years or earlier if warranted by the actual condition of the relay and/or its usage.

17.3.3 **Insulated Rail Joints (IRJ):** Insulated Rail Joints shall be maintained in accordance with the instructions given in Booklet No. STS/E/IRJ/IMI "Installation and Maintenance Instructions for Nylon Insulated Rail Joint" issued by the RDSO/Lucknow, with particular attention being paid to the following:

(a) Before opening an insulated rail joint, the components required for replacement, conforming to the rail section, shall be kept ready by the side of the track.

(b) For replacement of an end-post when there is no gap at the Insulated Rail Joint, loosen the rail fastening and pull back the rail and insert end-post between the rail ends.

(c) It is imperative that when an insulated rail joint is provided at least three sleepers on either side of the insulated rail joint shall be packed properly.

(d) Fish bolts shall be kept tight. Nuts shall be tightened several times during the first two weeks after installation/replacement, until all components of an insulated rail joint are firmly set.

(e) A metal flow is seen often at the rail-table at the joints. Such metal flow of metal forms a lip and creates sharp burrs at the rail ends. Projections formed at the rail ends shall be chiseled without damaging the end post so that these do not bridge the rail expansion gap and cause a short circuit.

(f) Brake block dust, which may accumulate on the head and sides of the end post and top surfaces of the fish-plates, shall be brushed off frequently so that the possibility of electrical conductivity being established between the rail ends is eliminated.

(g) Opening & fixing of fish plates of Nylon insulation joint for installation/ replacement of joint shall not be done by S&T staff (as it is the responsibility of Engineering Department).

(h) Special type pandrol clips ('J' type) shall be provided at Nylon insulation joints/glued joint to avoid touching of pandrol clip with the fish plate.

(i) Periodic coating by insulating varnish/epoxy over the nylon-insulated joint/glued joint to avoid shorting due to brake dust shall be done.

A faulty insulated joint may be detected by taking the voltage readings across the track relay terminals and noting if this reading changes when the adjacent track circuit feed is shunted or disconnected. Any change in the voltage reading will indicate a faulty insulated joint.

17.3.4 **Stretcher Bars and Point Rodding Connections**

Insulation for stretcher bars and point rodding shall be periodically checked to see that they are in sound condition. All defective insulation shall be changed.

17.3.5 **Bond Wires/Rope Wires**

(a) Bonds shall be inspected frequently and maintained in good condition.

(b) Bonds shall be painted with aluminum paint, where bond corrosions are excessive.

(c) Voltage reading may be taken at every 15 rail lengths or less as required by special track circuits, to determine if the variation in voltage is gradual throughout the track circuit. If any unusual variations are found between any two readings, defective bonding may be detected by taking readings every rail length in that section or by inspection of each bond.

17.3.6 **Jumper Connections:** Jumper connections shall be inspected frequently and maintained in good condition. Long jumper connections shall be properly secured.

17.3.7 **Ballast:** Minimum ballast resistance of track should not be less than 2 ohms per km in station yard and 4 ohms per km in the block section.

Note: Wherever PSC Sleepers are used, availability of insulated liners upto a minimum level of 97% shall be ensured.

17.3.8 **Drainage**

(a) Special attention shall be paid during the rains to track drainage. Defects, if any, shall be reported to the SSE/JE(P-Way).

(b) All cases of defective valves of overhead water pipes in track circuited area shall be reported to the Inspector of works SSE/JE(Works).

17.3.9 **Joint Inspection of Track by S&T and Permanent Way Inspector**

(a) The track circuited portion of the track shall be jointly inspected by SSE (Signal)/incharge and SSE(P-way)/incharge and jointly by Sectional SSE/JE (Signal) & SSE/JE (P-way) at least once in six months.

(b) This is in addition to routine inspections to be carried out by each Branch. The condition of rail and insulation at the rail joints, ballast and sleepers, abnormal collection of brake dust, rusting of the rail and drainage system of the yard shall be particularly noted, it shall be ensured that percentage of missing liners for track circuit length not to exceed 3%. Maintenance work found necessary on insulation joints after such inspection should be carried out jointly.

17.3.10 **Train Shunt**

(a) A Train shunt test shall be taken every quarter and every time the track circuit is adjusted or any alteration is made.

(b) Shunt test shall be taken not only at relay end but also at other parallel portions of the track, such as, turnouts and crossovers.

17.3.11 **Track Circuit Test Record Card**

(a) Track circuit test record Card No.S&T/TC-1, Annexure: 17-MS1 for DC track circuits, shall be maintained for each track circuit. For other types of track circuits, suitable record card may be framed by the Principal Chief Signal and Telecommunication Engineer. Readings shall be recorded every six months. Suitable remedial action shall be taken when abnormal readings are noticed at any time.

(b) Test cards shall be easily accessible for inspection by officials.

(c) The test card shall be kept up-to-date in accordance with the instructions given on the cards.

17.3.12 **Track Batteries/Track Feed Apparatus:** Track batteries or the track feed apparatus, where provided, shall be so arranged that the track relay will operate under the most adverse conditions. Batteries shall be kept in good fettle and special care shall be taken in maintenance of the cells.

17.3.13 **Rusty Rails:** Where there are rusty rails in the track circuited areas zig-zag welding using steel wire shall be done by P-Way staff on top of rail to ensure shunting of track circuit by the vehicle. Such identified locations to be provided with Axle Counters. Till such time axle counters are being provided, working instructions should be issued that points are operated only after physical verification of complete arrival of train by ASM, and facility of sectional route release be restricted to be provided only where it is essential. (Axle Counters shall not be provided in parallel to "Rusty Rail Track circuit")

Note: Refer to Annexure: 17-MS2 for maintenance schedule of DC Track Circuits.

Section 4: Audio Frequency Track Circuits (AFTC)

17.4.1 Audio Frequency Track Circuits (AFTC) – General

(a) The use of audio frequency permits the physical limits of an individual track circuit to be defined by tuned short circuits between the rail rather than the insulation in the rails themselves. These types of track circuit have distinct advantage of not requiring IRJs (except Point Zones) and offers considerable saving in IRJs and impedance bond, especially on tracks subjected to high speed, high axle load traffic or where there is an intensive service.

(b) Main features of Audio Frequency Track Circuit are:

(i) Built in time delay, therefore a slow to pick up QSPA1 Relay as TPR is not required.

(ii) Can be used in most AC, DC electrified and non-electrified areas.

(iii) Can be used in end or centre-fed configuration.

(c) Only approved type Audio Frequency track circuit shall be used.

(d) Track circuit shall not be configured in single rail mode operation.

(e) Audio Frequency Track Circuit may be operated as local fed or in a remote fed mode.

(f) Audio Frequency Track Circuit's components are

(i) Tuning unit

(ii) Transmitter

(iii) Receiver

(iv) Power Supply

(v) Track Connections

(vi) Impedance Bond (as applicable)

17.4.2 Installation and Maintenance of AFTC

(a) Installation of track circuit shall strictly follow the instructions given for that type of track circuit.

(b) Tuning area shall be devoid of check rails, level crossing, insulated bond and each fish plated joint shall be bonded with jumpers of adequate thickness.

(c) Special precautions shall be taken to ensure the tightness of connection of rail and tuning unit.

(d) A frequency assignment scheme for the track circuit shall be decided in advance and it shall be strictly followed.

(e) Terminal junction on insulation joint to track circuits with the same frequency is prohibited; however, frequencies not belonging to same pair can be used.

(f) Cable cores of same cable shall not be used for connecting transmitter & receiver of a track circuit.

(g) When wiring and installing track circuit, circuit pairing should be observed in the line cables. Each transmission or reception shall use conductors from one same pair. Circuit pairing results in cable transmission parameters being changed and may induce significant cross talk levels in adjacent circuits.

(h) The design and installation of field equipments should take in account the requirements for mechanised track maintenance and should not be hazard for men walking along the track.

(i) Protection against atmospheric voltage surges shall be installed on each pair of conductors providing a link to the outside in order to limit the harmful effect of lightening on electronic equipment. This protective arrangement shall cover against both common mode and differential mode voltages on line.

(j) Transmitter, receiver and power supply shall be mounted in standard relay rack in a manner to allow maintenance and testing staff to view the track relay while making adjustments.

(k) TUs and ETUs shall be mounted at a minimum distance of two meters away from the near rail as it gives good safety margin to staff.

(l) In case of failure of track circuit, attempt shall not be made to pick up the track circuit by adjusting the gain of receiver of TC without investigating the cause of drift in the receiver voltage.

(m) Impedance bond within track circuit shall be tuned with the correct resonating capacitor across the auxiliary coil and this tuning shall match with the frequency of track circuit.

(n) Maximum length of track circuit depends upon various factors like ballast resistance, frequency adopted, track layout (whether any level crossing or bridge falls within track circuited area) and vendor of AFTC, and it can not be laid down in absolute terms. Broadly its length is limited to 700 meters in end fed mode.

Note: (i) AFTC shall not be used for new works. Existing one shall continue to be maintained.

(ii) Refer to Annexure: 17-MS3 for maintenance schedule of AFTC.

Section 5: Precautions for DC Track Circuits & AFTC in RE Area

17.5.1 Track Circuits in RE Area

Track circuit on AC electrified section may use IRJs (Insulated Rail Joints) or ESJs (electrical separation joint) and may be configured as single rail or double rail track circuit. Track circuit which use electric separation joint shall be configured only as double rail track circuit.

17.5.2 Single Rail DC Track Circuit

(a) With single rail track circuits, one of the rails is reserved for the traction return current. This rail is referred to as the uninsulated rail. Any connection from the O.H.E. mast or other structure shall be made only to the uninsulated rail. Similarly, connections for the return current at feeding points as well as from booster transformers and return conductors shall be made only to the uninsulated rail.

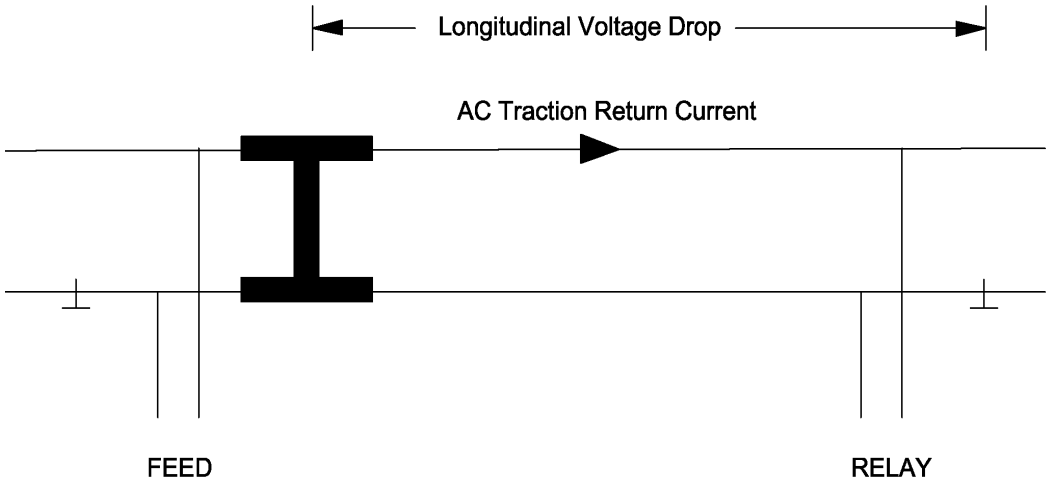
(b) As far as practicable, the rail adjacent to the O.H.E Mast shall be utilised as the uninsulated rail. However, this may not always be possible, particularly in yards where there are a large number of points and crossings or where the O.H.E masts are not always on the same side or where track circuits are staggered. In such case O.H.E. bonds crossing the track circuit rail shall be provided with suitable precaution by electrical department like insulating sleeve and clearance from bottom of the rail to avoid shorting of track circuit rail with uninsulated rail.

(c) In single rail track circuits, in the event of a break in the uninsulated rail, very heavy current will flow through the track relay as well as the equipment at the feed point. To avoid this, the uninsulated rails of the adjacent tracks shall be cross-bonded at intervals of not more than 100 meters. In case the track circuit is less than 100 meters, the cross bonding shall be provided on the uninsulated rail at either end of the track circuit. (Ref: Drg no. 17-D3)

(d) In the case of adjacent track circuits, the return rail shall be staggered.

DC Track Circuit in RE Area (Single Rail)

(a) This track circuit can only be configured to work as single rail track circuit.



(b) Interference Mechanism, With reference to fig. above traction return current flowing in the single traction return rails creates a longitudinal AC voltage along its length, which is a function of the current value and the impedance of the traction return rail. A wheel set at the feed end will impress this interfering voltage on the relay, whilst a wheel set at the relay end will similarly impress the interfering voltage on the feed set. The track circuit equipment must be immune both to false operation and to damage from such impressed voltages.

(c) Approved type of AC immunised track relays shall be used in AC traction area.

(d) Length of DC track circuit is restricted depending upon rail return current. With catenary current restricted to 300 Ampere on single track section and 600 Amperes on double track section, length of DC track circuits shall be restricted depending upon the use of type of relay and sleeper.

(e) The length of track circuit can be extended upto 450 meters when QTA 2 plug-in relay is used.

(f) Restriction on the track circuit length due to use of concrete sleeper can be relaxed upto 450 meters by PCSTE of Railway (if adequate ballast resistance can be consistently obtained).

(g) In view of the increased AC immunity due to the presence of biased magnetic arrangement, QBAT relays can be used upto a maximum length of track circuit of 750 meters using one additional 'B' type choke at the relay end, under minimum ballast resistance of 2 ohms/km. Operation of track circuit with this type of relay will require four cells delivering 8.8 V. QBAT relays shall be used in conjunction with QSPA1 relays conforming to BRS 933A.

(h) As an interim measure, length of DC track circuit may be retained at the existing level at higher catenary current of 800 Amperes on single-track section and 1000 Amperes. On double track section by providing one additional 'B' type choke in series with track relay. Audio Frequency Track Circuit or any other approved type of device shall be used on sections where catenary current exceeds 300 Amperes on single- track section and 600 Amperes on double track- section.

(i) Before installation of single rail DC track circuits in AC Electrified areas, measurements of stray DC currents shall be taken in accordance with the instructions in Annexure: 17-A1. The total stray current as measured, shall not exceed,

(i) 10 milli-amperes, if length of track circuit is less than 100 meters.

(ii) 100 milli-amperes, if length of track circuit is 100 meters and above.

(iii) If measured value of current exceeds the specified limit as above, other type of track circuit suitable to work in A.C. traction area shall be used.

(j) To protect the equipment from the effects of the rail voltage, a choke coil of approved type shall be provided in series with the feed resistance.

17.5.3 Audio Frequency Track Circuit for RE Area

(a) In double rail track circuits, since both rails are used for traction return current, impedance bonds shall be provided at the IRJs.

(b) No O.H.E mast or any other structure shall be connected to either of the rails. The Electrical Department shall run separate earth wire for earthing the O.H.E masts.

(c) Connections at the feeding points and from booster transformers and return conductors shall be made to the center points of impedance bonds.

(d) Only approved type Audio Frequency Track Circuit shall be used.

(e) Audio Frequency Track Circuit shall be configured only as double rail track circuit and like any double rail track circuit it requires both rails to be balanced with respect to earth and with respect to current flow in each rail.

(f) Impedance bond shall be used where there is no provision in design of Audio frequency track circuit to balance the traction rail return current.

(g) Electric Traction Units shall be critically examined for harmonics generated by them before they are brought into service.

17.5.4 **Impedance Bonds (as applicable) in RE Area for AFTC**

(a) Impedance bonds used on 50 Hz electrified lines shall be of approved type.

(b) The principles of operation of impedance bonds are equally applicable whether the traction return current is AC or DC The traction current rating of DC impedance bonds is usually much higher than those designed for AC traction systems. Thus, impedance bonds designed for DC traction current can usually be used on AC traction systems, although their bulk and cost is greater than a purposely designed AC impedance bond. Conversely, impedance bonds designed for AC traction systems are not suitable for use on DC traction systems.

(c) Generally, AC impedance bond shall be capable of supporting a current of 400 Amperes continuously (200 Amperes in each rail), with a peak loading of 1000 Amperes for a period of up to five minutes, without suffering damage or overheating.

(d) Leads between impedance bonds across IRJ on the same track shall be capable of carrying the traction current. It shall be PVC sheathed cables, terminated by compression lugs of an approved type and bolted to the impedance bond termination.

(e) The design and installation of impedance bonds should take into account the requirements for mechanised track maintenance and should not be a hazard for men walking along the track.

(f) The provision and maintenance of connections between rail and impedance bonds, and from one impedance bond to another on the same track is the responsibility of the S&T department.

(g) Cross bonds, earth wires, connections to sub-station current return busbars and connections to booster transformers must be terminated on the centre tap of impedance bonds. The installation and maintenance of these connections is the responsibility of the electrical department.

17.5.5 **Installation & Maintenance of Track Circuits in RE Area**

(a) RDSO’s guidelines shall be followed.

(b) It is, however, important to recognize that the operation of track circuit is dependent upon the integrity of traction return bonding. It is therefore important that attention is given to the testing during installation and also during maintenance of traction return bonding.

17.5.6 **Track Bonding in RE Area**

(a) The Objectives of Track Bonding are:

(i) To provide a path for traction return current, which ensures that no component of the track/traction return network rises above 25 V to remote earth, under normal traction load conditions and 430 V under traction short circuit conditions.

(ii) To ensure that protective equipment operates satisfactorily.

(iii) To minimize damage to installations due to traction short circuit.

(iv) To maintain correct operation of track circuits.

(b) Planning for Track Bonding

(i) When planning electrification schemes, base plans will be provided. The plans will be issued to the signal department showing the track layout and proposed position of all electrification and associated structures.

(ii) The signal department will then indicate on these plans the proposed position of insulated joints, impedance bonds, signal structures and track circuit bonding and in single rail track circuited areas, will identify the track circuit rail by marking with a thickened line. In double rail track circuited areas S&T department shall specifically indicate the provision of earth wire for structure earthing.

(iii) The plans must then be returned to electrical department who will indicate the position of continuity bonds, cross bonds, structure bonds and all earth connections to the traction system. The plans will then be returned to the signal department for final approval and issue to concerned parties.

(c) Bonding of Single Rail Track Circuits in RE Area

(i) The track circuit rail must be series bonded in order to ensure that defective bonding cannot cause a wrong side failure of the track circuit. Accordingly, the bonding arrangement of the track circuit rail must ensure that the conductive path between the track circuit feed connection and the relay or receiver end connection is interrupted in the event of a disconnection.

(ii) Because of traction return considerations, it is not possible for the traction return rail to be series bonded. It is therefore essential to avoid bonding disconnection to minimize the risk of loss of train shunt.

(iii) In single rail track circuits, in the event of a break in the uninsulated rail, very heavy current will flow through the track relay as well as the equipment at the feed point. To avoid this, the uninsulated rails of the adjacent tracks shall be cross bonded at intervals of not more than 100 meters. In case the track circuit is less than 100 meters, the cross bonding shall be provided on the uninsulated rail at either end of the track circuit. (Ref: Drg no. 17-D3)

(iv) On single line track circuited sections, a continuous earth wire is provided on the traction mast capable of carrying full traction return current. The uninsulated rail shall be connected to each of the traction masts by a structure bond, which shall be riveted at both ends. The arrangement for Double Line and Single Line Sections is as illustrated in given at Drg No.17-D3.

(v) Typical bonding examples with single rail track circuits are shown in Drg No.17-D3.

(d) Double Rail Track Circuits

(i) No structure bonds, cross bonds or connections to earth wires or return conductors shall be connected to the running rails where double rail track circuits are in use. If necessary, an impedance bond must be specially installed to provide a neutral point for these connections.

(e) Types of Bonds in RE Area

(i) Rail Joint Bonds: Rail joints in track circuited areas shall be bonded using two 8 SWG bare galvanized steel wires or copper bonds/steel wires or flats secured by means of channel pins or welding/riveting. The S&T department is responsible for the installation and the maintenance of all rail joint bond.

(ii) Rail bonds and Cross bonds: Where rail bonds and cross bonds are required for traction return purposes they shall be installed by and remain the responsibility of the electrical department.

(iii) The longitudinal bonding on a non track circuited track adjacent to a track circuit shall be extended for a distance of 50 meters beyond the track circuit.

(iv) In addition, the two rails of the non-track circuited track outside any track circuit or in between two track circuits shall be bonded together immediately after the block joints.

(v) It is essential that the traction return and track circuit bonding is maintained in its design condition. The SSE/JE (Traction) and SSE/JE (Signal) of section will arrange for physical inspection at six months intervals to ensure conformity with approved Bonding Plan. In the event of faulty connection or bond being found immediate remedial action will be taken to restore system Integrity. The results of the joint inspections shall be entered in a register maintained by the SSE/JE (Signal) and put up within a month for the scrutiny of the Sr. Divisional Signal and Telecommunication Engineer/Sr.Divisional Electrical Engineer (OHE). Responsibility of maintenance of traction bonds is with electrical department.

(vi) Detailed instructions for bonding of track are given in the AC Traction Manual.

Section 6: Axle Counters - General

17.6.1 Axle Counter consists of track device (axle detector) mounted on the rails, track side electronic equipment provided near the track and connected with track device & evaluator. Evaluator monitors the counts of track device(s) to give clear/occupied indication. Evaluator/track side electronic equipment may be kept in relay room or site.

(a) Digital Axle Counters of approved type may be used in lieu of track circuits to prove the clearance of a portion of track.

(b) Axle Counters may also be provided in lieu of conventional track circuits for block working, viz. Intermediate Block Signalling, Automatic Signalling, Block Working controlled by track circuits, etc.

(c) Digital Axle Counter (DAC) may be preferred on girder bridges in lieu of DC track circuits.

17.6.2 Typical usage of Axle Counters is for following applications:

(a) Intermediate Block Stop Signalling.

(b) Automatic block signaling.

(c) Station Section having poor drainage, flood prone sections.

(d) Block Section Proving of Clearance (BPAC).

(e) Tracks having problem of rust.

(f) Tunnels and bridges as per site requirement.

17.6.3 **Trolley Suppression**

Axle counter shall not count standard 4 spoke wheels of push trolleys.

Note: In those sections where certain models of Motor/Light motor/Moped/Scooter trolley in use which may not get detected shall be taken care of, by suitable provisions in Station Working Rules, working Time tables and subsidiary Rules. Such Trolleys shall be run as per GR 15.25 for working of Motor trolleys.

Section 7: Installation of Axle Counters

17.7.1 The installation of Axle Counters shall be done as per prescribed installation guidelines of OEM and approved pre-commissioning checklist.

17.7.2 The important features of the installation procedure are:

(a) **Trolley Suppression:** On sections where trolleys are in operation and existing axle counters do not have inbuilt trolley suppression arrangement, the arrangement shall be provided to prevent the operation of system by insulated trolleys. Trolley suppression arrangement shall be closed track circuit and track devices shall be fixed on rails within the boundaries of track circuit. It is possible to dispense with the provision of trolley suppression arrangement for track devices provided on point zone portion by using approved circuits for this purpose. On sections where non-metallic wheels are used, trolley suppression arrangement can be dispensed with.

Note: In future, digital axle counters having inbuilt provision of trolley suppression shall only be provided.

(b) The distance between the two adjacent axle detectors of different axle counters shall be at least 2 meters or as specified in OEM manuals, so as to minimise mutual interference.

(c) To protect axle detectors against damage (from hanging parts of moving trains), deflectors shall be provided, on both sides of the axle detectors on single line and one side on double line.

(d) The track side electronic equipment shall be housed at a location close to the axle detectors so that the length of cable between the track side electronic and the axle detectors is minimum and does not exceed the limit recommended by the manufacturer. The equipment shall be placed at a level well above the flooding level of the area.

(e) The incoming cables from axle detectors and evaluator may first be terminated on a cable distribution board to provide facility for testing.

(f) Wherever applicable, the transmitter and receiver coil cables between axle detector and associated track side electronics shall be laid in different pipes as prescribed by OEM.

(g) Ensure minimum of 400 mm Sleeper spacing & packing of sleepers in between track device (sensor) are fitted & fitting do not vibrate under train movement & packing of the same shall be done, if required

(h) Track side electronic equipment shall be operated from Central power supply like DC–DC converter of approved type preferably used for feeding evaluator with adequate battery backup. At remote locations track side electronic equipment may be provided with separate power supply. The input power supply shall have a maximum ripple of 50 mV peak to peak/10 mV rms.

(i) The evaluator shall be installed preferably in a relay room or at a location which is not accessible to unauthorised persons. Equipment shall be installed at a high level, well above the flooding level of the area and protected from rain water. It shall be fixed on a separate shelf away from signalling relays. As far as possible, it shall be located away from any source of heavy electromagnetic interference like industrial machinery, motor/generator or welding plants, etc.

(j) The power to evaluator is fed from a power supply like DC-DC converter of approved type with adequate battery backup. Each evaluator shall be provided with a separate DC-DC converter for better availability. The input power supply shall have a maximum ripple of 50 mV peak to peak/10 mV rms.

(k) All lead connections to and from battery and DC-DC converter shall have adequate current capacity to ensure that the voltage drop does not exceed 0.2 V. These connections at terminals shall be secured properly and should preferably be made through lugs to give firm contact.

(l) Connections between battery, battery charger and DC-DC converter shall not be bunched with any other wires. These wires shall preferably be laid at least 150 mm from any other bunch of wires. Positive and negative wires shall be twin twisted to avoid interference pick up especially when the lead wires are long.

(m) Where ever Integrated power supplies are provided, power for axle counter shall be taken from nominated DC-DC module.

(n) Redundancy in train detection devices may be provided for all train detection device in Block section and at vulnerable Track sections within station section. Redundant system shall be independently powered through independent power source and separate cable.

17.7.3 **Communication Media**

(a) The quad cable or PIJF Telecom Cable used with axle counters shall be of approved type. The Transmission loss, cross talk measurements shall be within limits specified for the axle counter to be installed. Optical Fibre Cable (OFC) may also be used for communication with suitable interfaces.

(b) All precautions prescribed for laying and installation of communication cables shall be strictly followed.

17.7.4 **Axle Counter Resetting - Block Section/Intermediate Block Signalling/ Automatic Signalling:**

(a) Preparatory reset arrangement shall be provided, so that whenever the axle counter shows fault condition; the same can be reset by the on duty Assistant Station Master/Station Master (ASM/SM), after ensuring that the monitored portion is clear of vehicles.

The following precautions shall be followed for resetting.

(i) Once the Axle Counter has failed and the concerned signal cannot be taken off, the on duty Assistant Station Master (ASM) of Train dispatching station shall positively verify the clearance of the block section with the on duty Assistant Station Master (ASM) of Train receiving station by exchange of private numbers and record the same in Train Signal Register (TSR) by both the stations. After ensuring that the block section is clear of vehicles, Axle Counter`s reset operation shall be initiated by cooperative effort between the ASM`s of the dispatching and the receiving stations.

(ii) The circuitry shall be such as to obviate the possibility of the resetting by the dispatching/receiving station independently.

(b) The reset box shall be operated by a key which shall be kept locked in a separate box kept in the ASM's office. Each and every operation of the reset button shall be counted on a non-resettable type counter and shall be recorded in the Train Signal Register by both the ASMs, indicating the movement before and after the operation of the reset button. During inspection of the stations the Signal and Traffic Inspecting officials shall specifically checkup and ensure that the system of exchange of private number is being followed meticulously.

(c) The procedure of resetting, verification of clearance of concerned axle counter section from any obstruction/vehicles before resetting is initiated and piloting of the first train shall be clearly laid down in the Station Working Rules.

17.7.5 **Axle Counter Resetting - Station Section:** Where Axle Counter is provided in station section, the following procedure shall be followed for resetting:

(a) **For Point zones/Loop lines/Sidings**:- Once the Axle Counter has failed and is showing fault condition, the on duty Assistant Station Master (ASM)/Station Master (SM) shall first arrange to verify that line on which train is to be received is physically clear of any obstruction. Such physical verification of failed Track section shall be done through Line verification box (LV box) which shall be installed close to the line to be verified. The resetting shall be cooperative and done jointly by the on duty ASM along with another Operating Staff, who shall verify physical clearance of Line and operate the line verification box for the failed Track section of axle counter.

(b) **For Main line/Run through lines**:- Preparatory Reset arrangement along with arrangements mentioned at (a) above, shall be provided.

(c) The reset box shall be operated by a key which shall be kept locked in a separate box secured in the ASM's office. Each and every operation of the reset button shall be recorded in the Train Signal Register by the ASM and during inspection of the station; the Signal and Traffic inspecting officials shall specifically check up the procedures being followed in respect of the above resetting device and ensure that laid down procedure for resetting is being followed.

(d) This procedure of ensuring that the monitored portion is free of any vehicle before resetting is done, shall be clearly laid down in the Station Working Rules.

(e) The first train after the reset operation may be either received on calling-on signal or piloted as per the extant rules after verification of the clearance of the reception line.

Note:- An overview of Axle Counter resetting arrangements mentioned above, is given below.

S. No.	*Line/Section (1)*	*Type of Reset (2)*	*To be applied by (3)*	*Axle Counter status after application of Reset (4)*
1	***Block Section**/ Automatic Signalling Section/ IB Signalling section*	*Preparatory Reset*	*On duty ASMs at both ends of Block Section*	*After operation in Column (3) and axle counter will show 'clear' only after tallying 'count in' with 'count out' by the passage of first Train.*
2	*Station Section (a) Main line/ Run through lines*	*Preparatory Reset*	*On duty ASM and another operating staff*	*-do-*
	(b) Point zones/ Loop lines/Sidings	*Conditional Reset*	*On duty ASM and another operating staff*	*Will show 'clear' after operation in Column (3)*
***For Station Section:** Once the axle counter has failed and is showing fault condition, the first train shall be piloted as per extant rules, after verification of the clearance of the reception line. After the piloted train has cleared the portion being monitored by the axle counter, the axle counter may be reset. The reset device shall be operated by a key which shall be kept locked in a separate box in the SMs office. Whenever, it becomes necessary to operate the reset device, the resetting shall be done jointly by the on duty ASM along with another Operating staff.*				

17.7.6 If Axle Counter cannot be reset, due to any reason or it fails again after resetting, it should be treated as failed and the Signalling maintenance staff should be advised immediately for rectification.

Note: Both the words namely; Assistant Station Master/Station Master (ASM/SM) are used synonymously.

Section 8: Maintenance of Axle Counters

17.8.1 Maintenance of axle counters shall be done as per RDSO's guidelines and maintenance recommendations of equipment manufacturers.

(a) In case of double rail mounted track devices there shall be no differential creep between the two rails of the track to the extent as to alter their inter distance beyond the permissible tolerance, it is, therefore, necessary that 4 rail lengths on either side shall be well anchored.

(b) Anchoring of track on either side of the rails where track devices of axle counters are fixed, shall be closely watched by the Permanent Way staff to ensure that there is no differential creep.

(c) Tie Tamper shall not be used for 4 sleepers on either side of the track devices. Incidentally they should be manually maintained.

(d) Replacement of components of Axle Counters shall be done with utmost care and as per technical manuals of OEMs. As a general rule, any maintenance activities in track device area, like, ballast packing & rail changing etc. that require disconnection of track devices and adjustments of axle counter parameters shall not be done in working system. Where required, maintenance staff shall take proper disconnection, duly de-energizing the related sections of Axle Counters from CT rack/disconnection terminals before starting indoor/outdoor maintenance activities. Once work is completed the section should be connected/energised following all precautions related to resetting, checking of parameters as stipulated and physical clearance of track section before reconnection. Activities like measurement of parameters, cleaning etc. which does not interfere with working of system, may be carried without disconnection.

(e) Periodic preventive checks by maintenance staff shall be done to ensure that track device/axle detector is properly fitted at site and fixing nuts/bolts are properly tight and intact. Connections of track device cables are also proper. Any damage/irregularity noticed in nuts/bolts/cables near the trackside shall be immediately attended by duly disconnecting the associated track section while attending the same for damages/irregularities.

(f) Wherever feasible, it is desirable to monitor working of axle counters through Dataloggers with a suitable interface.

		Note: This chapter has under mentioned Annexures
S.No.	*Annexure No.*	*Description*
1	*17-A1*	*Measurement of Stray Direct Current before Installation of DC Single Rail Track Circuits*

		Note : This chapter has under mentioned Maintenance Schedules in Appendix I
S.No.	*Annexure No.*	*Description*
1	*17-MS1*	*Maintenance Schedule of Track Circuit Test Record Card*
2	*17-MS2*	*Maintenance Schedule of DC Track Circuit*
3	*17-MS3*	*Maintenance Schedule of Track Circuit – AFTC*
4	*17-MS4*	*Maintenance Schedule of Analog (Universal Axle Counter (UAC))*
5	*17-MS5*	*Maintenance Schedule of Digital Axle Counter (DAC)*
6	*17-MS6*	*Maintenance Schedule of Multi Section Digital Axle Counter (MSDAC)*

		Note: This chapter has under mentioned Drawings in Appendix II
S.No.	*Drawing No.*	*Description*
1	*17-D1*	*Drawing for Track Lead Cable Connections*
2	*17-D2*	*Track Circuit Bonding Diagram for Typical 4 Road Station (Double line)*
3	*17-D3*	*Cross Bonding in Double line and Single line Track Circuits, Earth Wire in Single line*

Measurement of Stray Direct Current before Installation of DC Single Rail Track Circuits

1.0 Before installing a DC Track Circuit in areas, which are to be AC Electrified, stray Direct Current tests shall be carried out so as to ensure that DC Track Relays shall not operate with the stray currents.

2.0 These Tests shall be carried out only on non-electrified sections.

3.0 If there are already existing track circuits in the area, these shall be disconnected to safeguard against false readings being recorded in case of leakage of Block Joints.

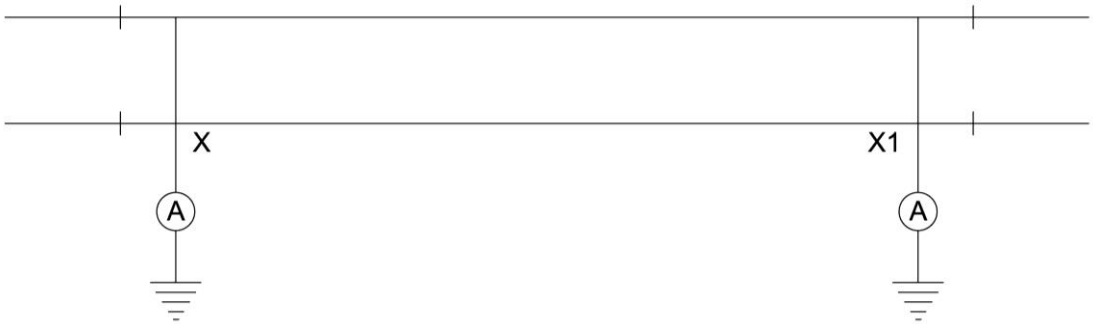
4.0 The length of the track required being track circuited should be insulated by means of Block Joints on either end of the rails. The rail joints in the track-circuited length may or may not be bonded for purpose of these tests.

5.0 electing a suitable earth, which shall not exceed 5 ohms in resistance, test shall be carried out.

6.0 A suitable type of milli-volt meter and milli-ammeter shall be used for recording voltages.

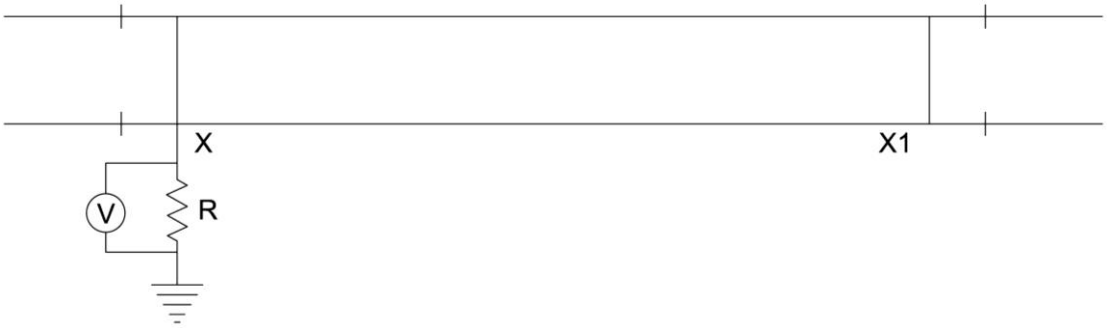
7.0 These stray current and rail earth voltage measurements shall be recorded in accordance with the diagram for measurements indicated below:

FIG. 1 Measurement of Stray Current



Note: For measurement of stray current set up the circuit as shown above and measure the current simultaneously.

FIG.2 Measurement of Rail-Earth Voltage



Note: Where 9 ohms, 4 ohms or 2.25 ohms relays are used, use 9 ohms, 4 ohms or 2.25 ohms resistance and measure the voltage once at 'X' and next at 'XV'.

8.0 These measurements shall be recorded at different periods of the day - one in the morning, one in the afternoon and one in the evening. These tests shall be extended for three days.

9.0 Where stray current/voltages are observed, the length of the Direct Current track circuit shall be cut down so as not to exceed the following limits for each length of Track Circuit:

(a) The Rail-Earth voltage as measured across 9 ohms, 4 ohms, or 2.25 ohms shall not exceed 0.1 V.

(b) The total stray current as measured shall not exceed 100 mA. Where all track circuits to be installed on the line are less than 100 meters long, the highest acceptable figure of stray current is 10 mA.