

Guidance Document

M8012

Track Handbook 12 Composite Conductor Rail Installation and Maintenance

Document M8012 2013

Issue No.: A2

Issue date: February 2013
Review date: February 2018

MAYOR OF LONDON

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1 Purpose

- 1.1 This Track Handbook describes the installation, inspection and maintenance techniques to be used with composite conductor rail (CCR) so that these activities may be undertaken both correctly and safely.
- 1.2 This Track Handbook is intended to support the application of LU Category 1 standards, in particular S1162, 1-163 and 1-164.
- 1.3 Where any conflict arises between this Track Handbook and any LU Category 1 standard, the latter shall prevail.

2 Scope

- 2.1 The scope of this Track Handbook is to provide guidance for the methods and tools to be used when working with CCR. It covers the installation of CCR, its insulator supports, ramps, anchors, slipper runs, safety blocks and associated components and equipment, in conjunction with both new work and maintenance.
- 2.2 This Track Handbook has been written exclusively for the types of CCR used on LU infrastructure at the time of writing. Specifically these are Brecknell Willis No.6 and No.7u. In the event that other types of CCR are introduced, this document will be amended as necessary.

Note: A booklet (BW10831) describing the Brecknell Willis CCR system, detailing its components and setting out basic inspection and maintenance procedures, is available from Brecknell Willis. It is compatible with this Handbook. In addition it includes a list of drawings.

3 Configuration and installation

3.1 General description of system

Power is supplied to LU trains by two conductor rails running along the track. The positive conductor rail is located outside the four-foot adjacent to one of the running rails; the negative conductor rail is located on the centreline between the running rails.

CCRs are joined using fishplates secured by MGL pins. The fishplated joints are similar electrically and mechanically to the plain rail, so no additional strengthening or electrical bonding is necessary.

Rail lengths begin and end with fabricated steel ramps to guide the train's collector shoes onto and away from the conductor rails. The stainless steel contact face is of a similar material to the conductor rail's wearing cap.

In order to prevent trains gapping at junctionwork special conductor rail configurations may be required. Negative splays and positive side-entry ramps may be used only if unavoidable and necessary to increase the train's collector shoes' contact with the conductor rails. These configurations must be carefully positioned relative to the track alignment to ensure correct pick up of the train's collector shoes.

Slipper runs are fitted in junctionwork where negative shoes are required to cross over the running rails.



Depot exit tracks may have low-negative-shoe detector rails fitted to detect any badly adjusted negative shoes, which are dangerously low and out of gauge, before the train goes into service.

Cabled connections to the conductor rail are required at specific places, typically for sub-station feeders or for continuity. A copper/aluminium bi-metallic adaptor plate is bolted to the conductor rail using terminal fishplates. The adaptor arrangement is suitable for the connection of a standard LU phosphor bronze cable lug.

The maximum and minimum spacings of insulators supporting CCR are shown in standard S1162.

Beside staff walking routes, or where passengers might approach the conductor rails, protection planking is fitted around the sides of the rail to protect against accidental contact. Protection planking is not specifically fitted to take account of actions in the event of an emergency.

Every rail length is anchored to prevent permanent movement along the track. The rail anchors are mounted to react against 2, 4 or 6 insulators dependent on section length and are normally located at the mid-point of the length.

3.2 Component identification

This section covers the identification of the various CCR components used on LU infrastructure.

There are two CCR systems used on the Underground. The Brecknell Willis No.6 rail has been widely used for a number of years. The Brecknell Willis No.7u is more recent: it has a larger cross-sectional area and is termed extra low loss, ELLCCR. The principles and components for both are similar, but specific to each system and not interchangeable.

The stainless steel cap has a 5mm nominal thickness with a central groove of 0.3mm $\pm$ 0.2mm. Ramps have a 10mm thick stainless steel cap.

Both rails may have to be pre-curved, depending on track radius.

3.2.1 No.6 CCR

The No.6 rail consists of an aluminium core with two stainless steel 'J' sections clamped around the head of the core and welded down the centre. The rail comes in 15m lengths, with an 80mm foot. Weight is 17.5kg/m with an electrical resistance of 6.6 micro-ohms/m.

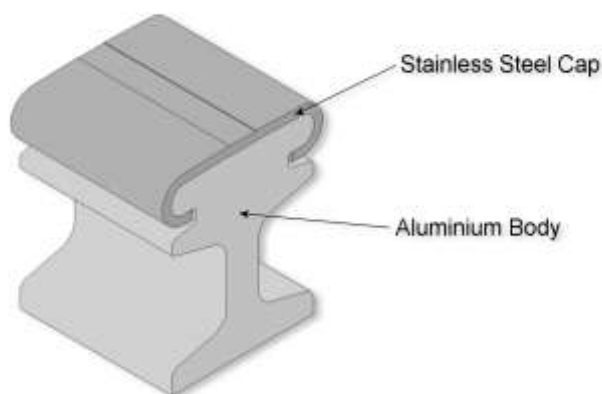


Figure 1 – No.6 CCR

3.2.2 No.7u CCR

The No.7u ELLCCR is similarly constructed, but with a larger aluminium section for lower electrical resistance. The rail comes in lengths of 15m, with a 124mm foot. Weight is 24.7kg/m with an electrical resistance of 4.4 micro-ohms/m.

This larger rail is used in areas where high conductivity is required.

3.2.3 Fishplated joint

The fishplated joint allows two CCRs to be joined together. The joint consists of two extruded aluminium fishplates, four MGL pins & collars and contact grease. No.6 rail joints use ½" (12mm) steel MGL pins and No.7u uses ⅝" (16mm) diameter steel MGL pins. When correctly assembled the joint provides a connection as strong and electrically conductive as the plain rail.

3.2.4 Insulator assembly

There are two types of insulator: GRP (variants for No. 6 and No 7u CCR) and porcelain (No. 6 only). There are also special insulators available to accommodate the wider foot on ramps. GRP is now the preferred material.

The insulator supports are modular assemblies consisting of a nylon anti-friction pad over the insulator, nylon sheath (No.6 CCR only), nylon packers and square-spigotted baseplate locating it, screwed to the sleeper. There are several styles of insulator and baseplate which may be mixed and matched to give the correct positive or negative rail height with any type of sleeper or track format. Resilient pads are used when mounting on concrete.

3.2.4.1 GRP insulator

Owing to the different foot widths there is a specific GRP (Glass Reinforced Plastic) insulator for each type of rail. Both are approved for use in an underground environment, and have a fitted height of 85mm(the baseplate provides the variable overall required height). The profile offers a long tracking distance, with integral ears to locate the rail foot.



Figure 2 – GRP insulator

3.2.4.2 Porcelain insulator

There are porcelain insulators in four fitted heights, 85, 95, 100 and 120mm as marked on the side. These all consist of a glazed porcelain body with a cemented-on, galvanised, cast-iron cap.



Figure 3 – Porcelain insulator

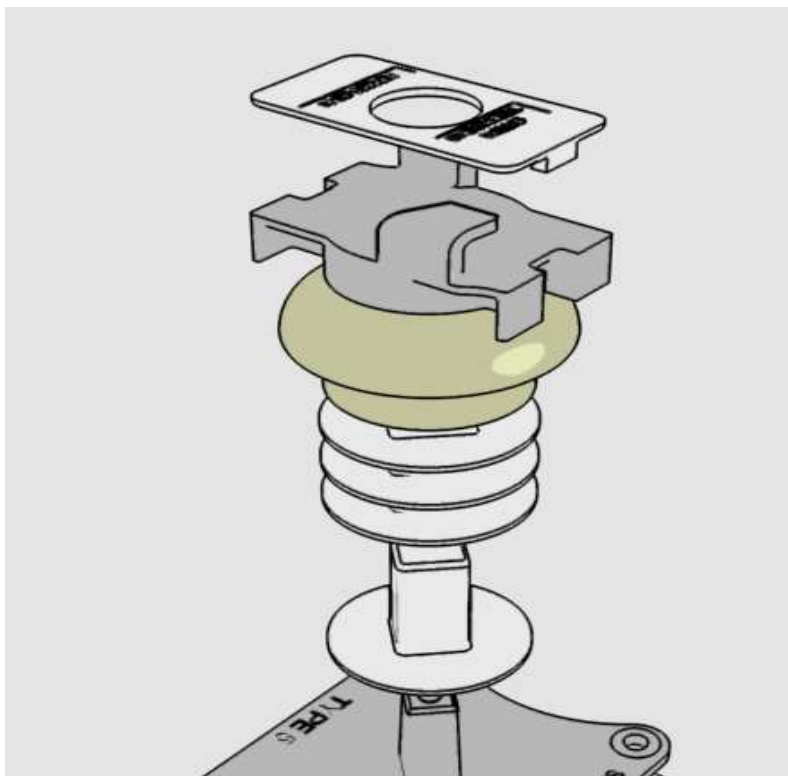


Figure 4 – Insulated support assembly (No.6)

3.2.4.3 Baseplate

Galvanised, cast-iron baseplates are screwed to the bearers or sleepers, with insulators located over their spigots. Baseplate types vary in both height and hole patterns to suit both the No.6 and No.7u CCR and for a variety of applications. The fitted height is indicated by the type number, e.g. for No.6:

- Type 5 (152mm x 184mm hole centres with 4 fixing holes);
- Type 5-d (210mm hole centres with 2 fixing holes);

and for No.7u:

- Type 55 (152mm x 184mm hole centres with 4 fixing holes).

The type number is cast into the baseplate for easy identification.

3.2.4.4 Base sheath

The No.6 has a nylon sheath shaped to fit over the square spigot of the baseplate to protect the insulator from direct rubbing on the rough-cast surface. Note that the No.7u does not use a base sheath.

3.2.4.5 Anti-friction pad

The 5mm thick nylon anti-friction pad sits in slots on top of every insulator cap to support the CCR off the insulator, reducing sliding wear. There is therefore no requirement for a steel shim between the rail and the insulator cap.

3.2.4.6 Packer

The 4mm thick nylon packers allow the rail height to be adjusted during installation and maintenance. The packers sit over the baseplate spigot. When installed on new track choose the insulator and baseplate combination to be fitted at the correct rail height, allowing for downwards adjustment with future running rail wear. The maximum number of packers to be fitted is 4 giving the maximum height adjustment of 16mm.

3.2.4.7 Fixings

The baseplate mounts on the sleeper, bearer or concrete plinth with screw fixings of various types, in 10mm, 12mm or ½” diameters. There are various types including:

- square or hexagon head coachscrews into wood directly, or plastic inserts cast-in or pushed-in to concrete,
- Excalibur bolts directly into pre-cast or drilled holes in concrete sleepers,
- male or female, steel or stainless steel, threaded fixings or plastic inserts cast-in to concrete plinth or slab track.

3.2.4.8 Support packers

Some situations may require a height adjustment between that available by mix & matching. Galvanised steel packer plates under the baseplate, in a variety of thicknesses (3, 5 or 9mm) up to a total thickness of 25mm, together with longer screw fixings may be provided to suit.

3.2.4.9 Resilient pad

Where the baseplate is mounted on concrete a resilient pad (nominal thickness 3mm) is fitted between the two for a more secure fixing, protecting the baseplate and concrete. There are styles for each baseplate hole format: all are approved for use in an underground environment.

3.2.5 Ramp designs

Ramps for the BW CCRs are steel fabrications with a 10mm thick stainless contact face, profiled to a parabolic curve. Installation requires no special components as they mount on standard insulators and are fixed with standard fishplated joints. They are relatively high resistance to reduce arcing, so cabled connections cannot be made to ramps and there is no provision for this. There is a low speed and high speed profile for each rail type.

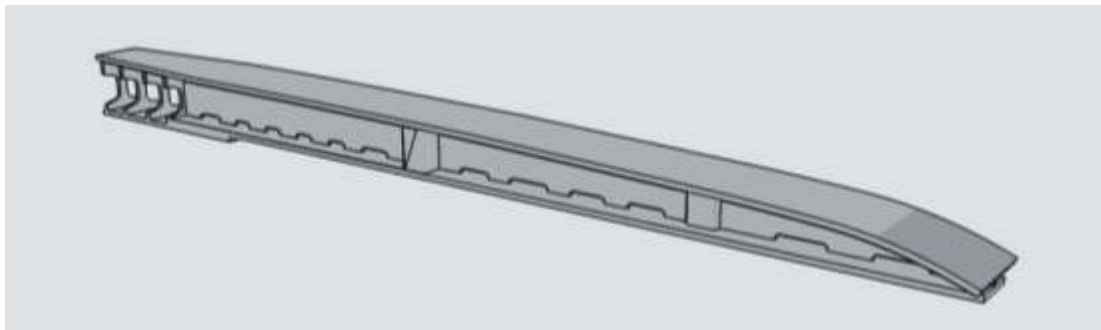


Figure 5 – Typical fabricated ramp



3.2.5.1 Low speed ramp

Low speed ramps are 1675mm long x 140mm wide. Used in depots, areas with speeds below 60km/h and on mainline trailing ramp situations where speeds are below 100km/h. These ramps are designed and approved for use with one insulator support. The insulator should be placed in accordance with the design engineer's requirements.

3.2.5.2 High speed ramp

High speed ramps are 3050mm long x 140mm wide. They are used on mainline as leading ramps or areas of two-way running above speeds of 60km/h. They are also used as trailing ramps in areas with speeds above 100km/h. Insulators should be placed in accordance with the design engineer's requirements. These ramps are designed and approved for use with one insulator support positioned towards the toe of the ramp. Note that a Victoria Line high speed ramp has been specially designed with a longer conductor rail joint to allow electrical connections to be made to the ramp.

3.2.5.3 Fat ramp

A fat ramp is a high speed ramp with a 50mm wider contact plate (190mm wide) which mounts directly to negative splays, allowing shoe contact deeper in towards the switch tip, but avoiding the points machinery.

3.2.5.4 Negative splayed ramp

The negative splayed ramp is a low speed ramp profile built into a negative splay connecting to two plain splay rails. It may be used in some smaller turnouts to allow shoe contact deeper in towards the switch tip, but avoiding the point machinery.

3.2.6 Negative splay

If there is a risk of gapping negative splays may be used at junctionwork for improved shoe contact to reduce gapping. They are steel fabrications of similar construction to the ramps, to connect standard CCR at three points in a 'Y' format inside the turnout. Owing to electrical clearance and maintainability concerns for switch motors and mechanisms, negative splays are no longer a preferred arrangement.

Negative splays are carefully chosen and positioned to suit each turnout format. As they are relatively high resistance, cabling arrangements must never allow continuous traction current through a negative splay.

If no risk of gapping is present negative splays should not be used.

3.2.7 Side-entry ramp

Side-entry ramps to the positive conductor rail are used only if gapping is a problem. A plain conductor rail is modified with a fabricated steel ramp attached to the side. Side-entry ramps are specifically designed and positioned for each switch type.

3.2.8 Mid-point anchor

A single mid-point anchor assembly consists of four anchor clamp blocks and two MGL pins. There are two styles of block to fit the No.6 and No.7u rails' different foot widths.

Pairs of anchor blocks are fitted on opposing sides of two adjacent insulators and fixed with MGL pins (size M12) or bolts and locking nuts. This single assembly is

used on rail lengths up to 55m long. Two assemblies are used for lengths from 55m to 150m on four insulators. Three assemblies are used for lengths over 150m long on six insulators.

A mid-point anchor is fitted at the middle of the equivalent rail length (see standard S1162 for explanation of “equivalent”), allowing balanced thermal expansion and contraction away from it, but preventing the whole rail length from migrating along the track.

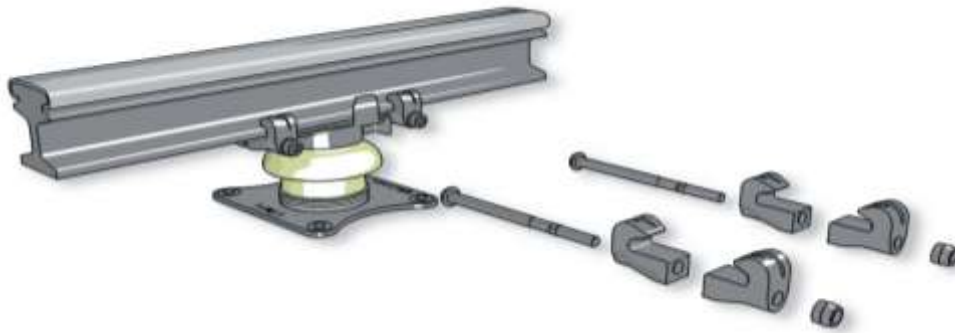


Figure 6 – Mid-point anchor assembly

3.2.9 Cable terminals

For connection to standard LU phosphor bronze lugs, the cable terminal adaptor can be used. There is an adaptor for each rail type. This consists of two special drilled fishplates, two M24 bolts, washers & self-locking nuts, bi-metallic plate and conductive grease.

The lugs are bolted to the rail via the bi-metallic plate and fishplates. For corrosion protection it is important to install the bi-metallic plate the correct way round, i.e. similar metal of plate to similar metal of component. All mating surfaces are to be coated with contact grease.

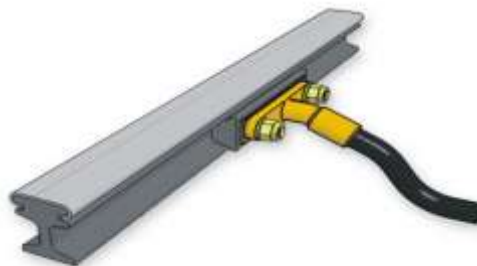


Figure 7 – Cable terminal assembly (other lug configurations are available)

3.2.10 Bus-bars

Bus-bars are used to electrically connect two negative, splayless floater rails, where there is not enough room to make a normal cable jointed termination. They are aluminium fabrications where a flat plate is welded to a fishplate piece. Two opposing fabrications are MGL-pinned to the rails and the interlocking plates bolted with threaded fasteners. They are mounted at the end where the rails converge towards each other and must be configured so as not to pass a continuous traction current.

3.2.11 Slipper runs

Slipper runs are planks screwed through spacer blocks to sleepers in the 'four foot' to guide badly adjusted negative shoes over the running rails at junctionwork. They come in different lengths depending on the turnout geometry. Their configuration and material is as in steel conductor rail layouts.

3.2.12 Safety blocks

Safety blocks are pre-cast concrete cradles that sit under the conductor rail and clear of it, with an ear coming up each side. They are intended to prevent the conductor rail from being continuously tipped over by broken shoe gear hanging off to the side of the rail. Standard S1162 allows their omission in the case of CCR as long as the insulators provide restraint to the foot of the CCR. Where fitted, they are on the nearest available sleeper next to every ramp and at 400m maximum intervals.

3.2.13 Low negative shoe detector rail

Low negative shoe detector rails are installed at the exit from depots and are intended, as their name suggests, to detect low negative shoes. They are designed to be installed at a lower level than the normal height of the negative conductor rail. At this height, any negative shoe which touches the detector rail is too low to enter service on the running lines and the signalling system will trigger and prevent the train leaving the depot.

A low negative shoe detector comprises a 2160mm length of CCR with a low speed ramp attached to either end. The head of the rail needs to be maintained at between 11mm and 15mm above the head of the running rails and, to achieve this low setting, the three insulator assemblies which support the detector rails are located between sleepers on galvanised steel brackets fastened to the two adjacent sleepers. The detector rail is anchored at its centre position with an anchor block on both sides of the centre insulator assembly.

Figure 8 shows a low negative shoe detector rail assembly. Figure 9 shows the support plate for the insulators and the rail anchor arrangement which is peculiar to this rail.



Figure 8 – Low negative shoe detector rail



Figure 9 – Low negative shoe detector rail with middle insulator mounted on a special bracket. Note the anchors on either side of the insulator

3.3 Delivery to depot or storage site

For LU both No.6 rails and No.7u rails are 15m long, packaged in bundles, secured with tension bands and protected at the ends by metal shields. Each bundle must be lifted by a suitably rated crane and lifting beam that is a minimum of 6m long with at least three equally-spaced slinging points.

Note: Owing to its lightness, care must be taken to avoid crippling CCR when handling or transporting it.

The bundles must be stacked tidily on timber bearers distributed evenly along the rail length at between 2m and 4m intervals. Bundles may be stacked up to eight high, provided that the load is well distributed on a level base by use of heavy timbers or sleepers and the base is sufficiently substantial. Each layer must be separated by timber bearers positioned vertically above the lower row.

Other components may arrive in wooden boxes or pallets suitable for fork-lift truck, each with a maximum weight of one tonne. The size, weight and description of the components contained in each box should be detailed on a packing list.

The storage area must be fully secure, with regard to the value of the components. In addition, materials of a hazardous nature must be stored separately in accordance with the instructions supplied with the hazard data sheets.

3.4 Delivery of components to trackside

Rail and components must be suitably distributed along the appropriate track prior to any installation activities. The detail of this is dependent upon whether the installation is done during a possession or during engineering hours.

3.4.1 Rail distribution

Rail would normally be accurately placed in position along the track. If it is located in the four-foot in a tunnel it should be on the dark side, furthest from tunnel lighting, to allow for safer, emergency, track-bound, egress from a train.

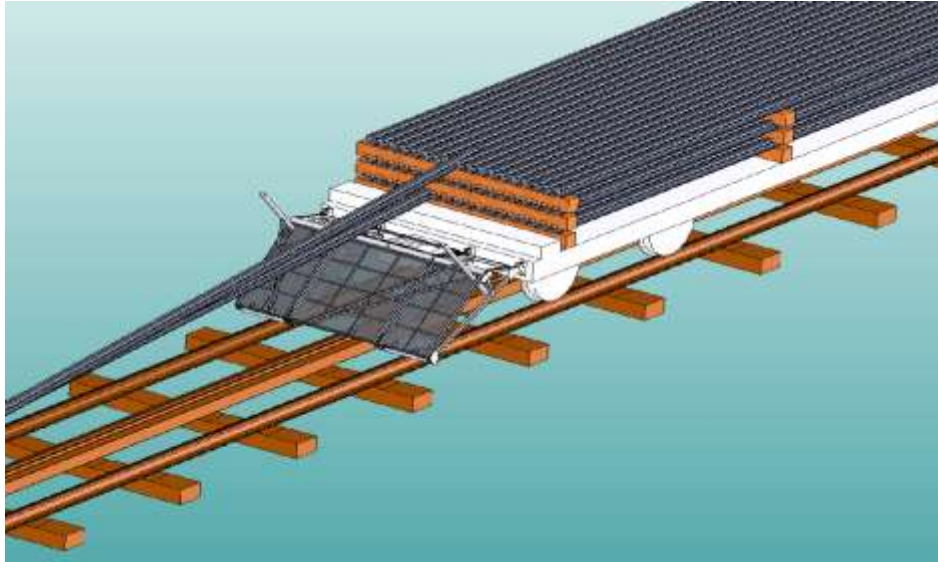


Figure 10 – Wagon fitted with unloading ramp

Rail will be carefully stacked on suitable flat-bed, low-loader or wagon and taken to the track location by special rail train. The rails will be off-loaded either singly or in pairs (depending on whether just positive or negative, or both are being installed) in line, end to end. A special unloading ramp as shown above will speed trackside distribution. For details of this procedure, refer to specific method statements concerning this operation.

3.4.2 Component distribution

Other CCR components may be delivered along the track in approximate position of installation from a train or track trolley.

3.5 Marking out the system

Careful marking out of the system is important as it highlights problems and interferences.

The conductor rail layout drawings should be used to show ramp positions, mid-point anchor locations and conductor rail in relation to the track.

The junctionwork drawings should be more detailed, giving ramp locations, mid-point anchor locations, bolted joint locations and insulator positions.

3.5.1 Marking out for plain line

The first stage of marking out is to identify the location of the ramp ends. These positions are shown on the layout drawing. Once located on the track each ramp end should be marked on the adjacent running rail with a vertical (white) stripe.

The locations of the bolted joints between the ramp and the conductor rail should also be marked on the adjacent rail with a vertical (white) stripe. This stripe should be



1675mm back from the first (white) stripe for low speed ramps or 3050mm for high speed ramps.

The insulator for the ramp should also be positioned at this time by marking on the adjacent running rail with a (yellow) vertical line. The insulator for the ramp should be positioned to allow freedom of movement under expansion and contraction of the conductor rail.

Once the ramp ends are marked the remaining conductor rail joints can be marked. This must be done precisely to avoid significant cumulative error further along. The intervals will be according to the standard rail length being installed. The length between the ramp bolted joint and the final bolted joint marked (or closure length) should be greater than 4.5m. If this is not the case then the last standard rail should be shortened to give a closure length of at least 4.5m.

While marking out the bolted joint positions the insulator positions can also be marked using the (yellow) marker paint. Insulators should be positioned to avoid conductor rail bolted joints and short sleepers. Insulators should be positioned in accordance with LU standards. At least two insulators should be installed under a closure length.

Insulators should not be located on running rail joint sleepers. CCR joints, anchors or ramp ends should be at least 1m away from running rail bolted joints.

Except within junctionwork and at conductor rail gap locations the positive and negative conductor rail insulators must not be on the same sleeper.

Where existing sleepers are to be used, they should be examined for signs of decay, splitting or loose fastenings. If sleepers are found to be suspect, they should be ignored and an adjacent good sleeper used for mounting. If several sleepers together are unsuitable they must be replaced.

Also if possible, place insulators away from continuously wet or dripping areas.

The maximum length of CCR in underground locations starting 55m inside a tunnel portal is 900m. The absolute maximum length for CCR elsewhere is 300m.

3.5.2 Marking out for junctionwork

Junctionwork installations will usually have a site-specific conductor rail layout drawing showing insulators, rail joints and ramp positions dimensioned to crossing features such as switch toes or crossing noses.

From the drawing, transfer measurements to the track using the same reference points. Mark on the running rails with a (white) vertical stripe where the ramp tips fall. Then mark a second (white) line, 1675mm for low speed or 3050mm for high speed, behind the first to show the bolted joint position.

Mark the rail joint positions according to the drawing or in standard rail lengths, as appropriate, up to the final closure rail. If the closure rail is under 4.5m the previous standard rail will need to be cut back to give a closure of at least 4.5m.

Once all the joints are positioned the insulator positions can be marked. Positions are usually also shown on the layout drawing, to be marked off on the corresponding sleeper using a (yellow) line. Where dimensions are not shown use the same rules for marking insulator positions as on plain line.

Check insulator positions for clashes with rail joints or other junctionwork equipment and move as necessary. Mark-up the layout drawing for future reference.