



GOVERNMENT OF INDIA

Ministry of Railways

Guidelines for Rigid Catenary Overhead Conductor System
for use in Tunnels
and Retractable Rigid Overhead Conductor System in
Sidings/Depots

INSTRUCTION No. TI/IN/0041

Issued by:

Traction Installation Directorate,
RESEARCH DESIGNS & STANDARDS ORGANISATION,
MANAK NAGAR,
LUCKNOW – 226 011.

(For official use only)

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1. TITLE: Guidelines for Rigid Catenary Overhead Conductor System for use in Tunnels and Retractable Rigid Overhead Conductor System in Sidings/Depots.

2. BACKGROUND: A Rigid Overhead Conductor-rail System (ROCS) should be generally used in following cases:

- i) Normally in tunnels of length more than 750m or where the provision of ATD is difficult.
- ii) Where the head room/height of the tunnel is not sufficient for conventional OHE,
- iii) Stations/Any other location for improved electrical clearances.
- iv) RRCS (Retractable Rigid Conductor-Rail System) can be used in Maintenance Depots, Coal sidings/other sidings for overhead loading under SILO in electrified territory and container handling tracks..

Conventional OHE requires substantial space above the train under the overhead structure to maintain Electrical clearance from 25kV live conductor.

In ROCS catenary is not required, thus requiring less space above the train & there is no pushup which helps to achieve improved electrical clearances as compared to conventional OHE. As there is no mechanical tension in the system, a ROCS does not require tensioning devices, thus more space is available. There is no push off and pull off. The stagger is simply achieved by moving the conductor rail clamp in across-track direction on the cantilever arm to set the required stagger, allowing better clearances than a conventional OHE cantilever. It has several other advantages over conventional OHE which are enumerated below.

a) More Current Carrying Capability

With large cross section conductor bar profile it can permit high current which can go in excess of 5000 Amps.

b) No Risk of Breaking-off, More Security

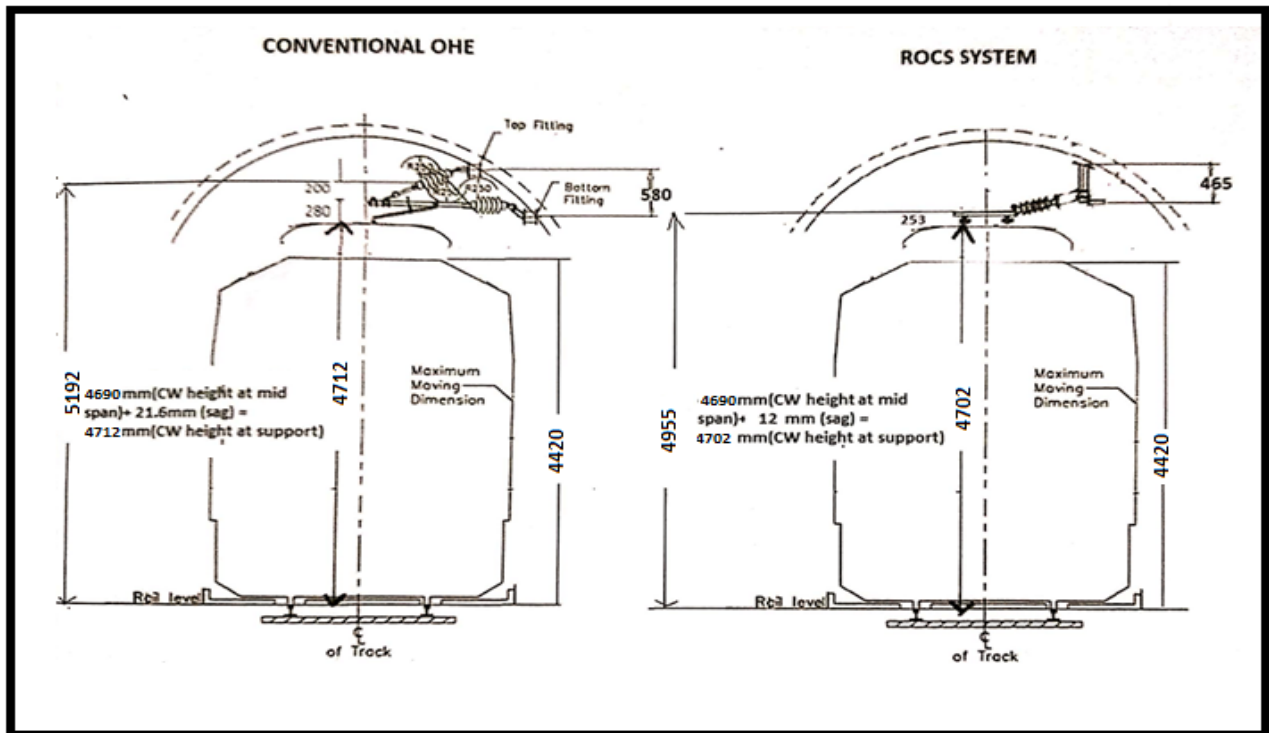
As there is no stress/tension, it allows more contact wire wear without risk of breaking-off in rigid catenary system, the only limitation is that the pantograph should not touch the conductor bar profile.

c) Easy Operation and Maintenance

As the contact wire allows more wear and its installation and replacing is easy in rigid catenary system, the maintenance cost is greatly reduced. The periodic tightening of the joint plates bolts and the cleaning of the insulators are almost the only maintenance operations.

d) Less Tunnel Clearance, Less Construction Cost

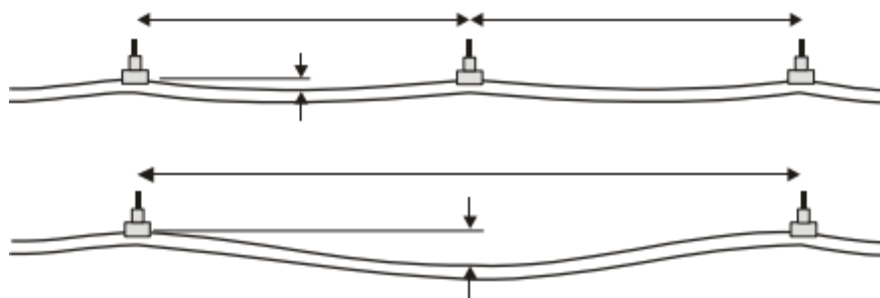
Rigid catenary system reduces tunnel clearance against standard catenary system, so the construction cost is less. A comparative analysis of ROCS and Conventional OHE reveals that, the height of topmost charged point in case of ROCS is 4955mm (4690 mm C.W. height for Rolling stock height of 4420mm+12mm sag+253mm support bracket charged portion)for single track as against topmost charged point in case of flexible OHE which is 5192 mm(4690mm C.W. height+21.6mm sag for 27m span+280 encumbrance for 27m span length(min. Allowed in IR)+200mm(ST height))i.e there is expected to be 237mm reduction in height (5192-4955) of topmost charged point considering same Rolling stock and contact wire height at mid span. The sketch is given below:



Arrangement of Overhead equipment in Conventional and ROCS System

- e) In conventional OHE contact wire is usually mounted with a tensile stress of 1000kgf, which reduces its mechanical strength. This fact, as well as the frequent short circuits caused by the load or internal/external factors, increases the risk of the contact wire breakage, entanglement of the pantographs and long restoration time for the OHE breakdown. With rigid catenary, all these risks disappear.
- f) The Aluminum conductor rail cross section is normally 2214mm.
- g) Also the maintenance costs is one of the advantages of this system as higher wear of the contact wire is allowed, its replacement is not so frequent. On the other hand, the time required to carry out this operation is less and many times it is not necessary to replace the complete section, as in the conventional contact wire, and only the affected sector will be repaired.
- h) The damages produced by short circuits or earth fault can be repaired very fast, replacing a short stretch of the contact wire (1 or 2 metres), without any consequences in the current supply and traffic can be permitted in a few minutes.
- i) In the case of rupture /breakage of an insulator, the deflection at this point would allow trains to run slowly.

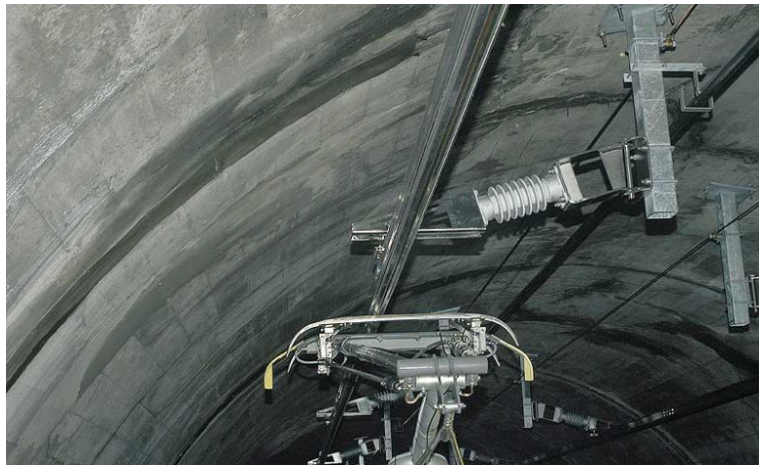
SUPPORT BREAKING EFFECT



- j) The speed potential of ROCS installed in India is currently 135 KMPH. The following table gives the speed limit with reference to span length.

Speed Limit	Span length
80kmph	12m
95kmph	11m
120kmph	10m
>120kmph	8m

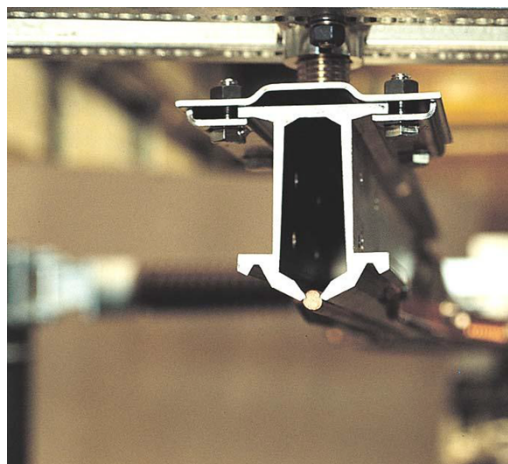
3. **DESCRIPTION OF ROCS SYSTEM:** Rigid Overhead Conductor System (ROCS) uses a rigid conductor instead of a flexible wire for electric power collection. ROCS has a rigid conductor rail installed overhead. A copper contact wire is inserted in the conductor rail and the Pantograph on the rolling stock collects power from this rigid conductor. The rigid overhead conductor is a piece of Aluminium rail which is fixed to the tunnel ceiling with the help of a cantilever arrangement. This aluminium rail is manufactured in 10 to 12 metre long pieces and then these pieces are joined together to form a continuous conductor all along the railway track. Contact wire is inserted into the groove of these aluminium rails so that the contact of the pantograph remains with the copper contact wire.



ROCS with Cantilever Arrangement

4. Components of Rigid Overhead Conductor System:

4.1 Conductor Rail: Conductor rail is generally made up of Aluminium alloy by extrusion moulding process in 10m to 12m long sections. The lower side of the Rail has ribs on both sides for the contact wire insertion device which is used for inserting contact wire into conductor rail. To avoid bi-metallic corrosion, the conductor rail profile design must not allow any condensation water to drip along profile and come in contact with copper-profile interface.

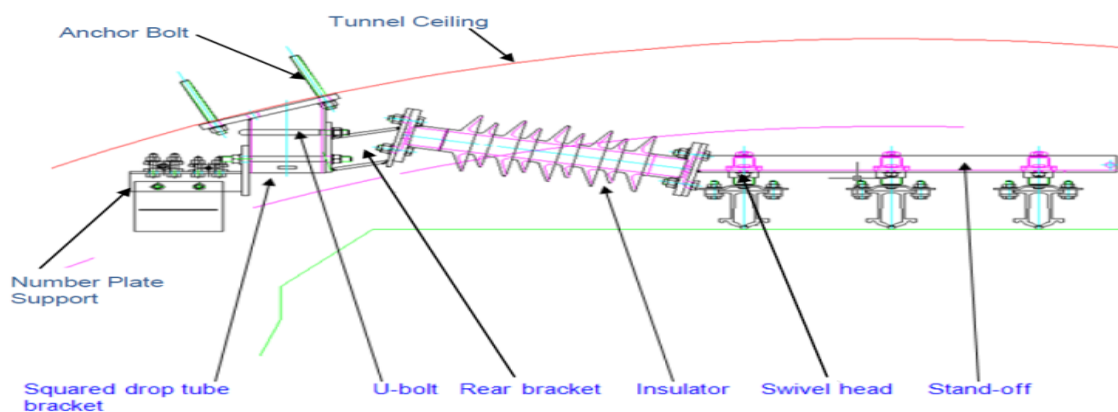


CONDUCTOR RAIL

4.2 Cantilever Support Bracket:

Cantilever support Bracket is installed to hold the aluminum conductor rail. The support is fixed to the tunnel ceiling at one end and the conductor rail is suspended from the free end; thus it forms a cantilever arrangement. These cantilever supports are placed at regular interval of 8 to 12m (depending on the train speed) to hold the rigid aluminum conductor rail. The sections of conductor rail are joined together through interlocking joints and continuous conductor length is made by adding one conductor rail after the other. Due to the temperature variation in the surrounding environment, the aluminum conductor rail tends to expand or contract. If the conductor rail is fixed or clamped at every support and no movement is allowed, stresses will be developed inside the rigid conductor rails. This may lead to un-even contact or even failure of the rail. Therefore, the linear (also called longitudinal) movement of the rigid conductor rail shall be allowed to accommodate the expansion and contraction caused by temperature variations.

The support structure is also termed as **ROCS Support Bracket**. The distance between two consecutive ROCS support brackets is known as span length.



Various components of Support Bracket

The ROCS support bracket has following components:

4.2.1 Drop Tube

This is a rectangular tube, made of galvanized steel, which is fixed to the tunnel ceiling by mechanical anchor bolts (described in Para 4.5). The rest of the bracket components are assembled on the drop tube. The top plate of the drop tube has to be flat or inclined as per the tunnel surface; flat for box tunnel and inclined to suit bored tunnel. The distance of drop tube from the track centre axis is fixed. It is designed such that the drop tube doesn't interfere with the rolling stock kinematic envelope and satisfies all the electrical and mechanical clearances as per IRSOD(BG)- Revised, 2004.

4.2.2 Number Plate Support

All support locations are given an identification number so that it is easier to locate any support. This number is printed on a plate which is called as number plate for that location. All number plates are retro-reflective so that they are easily visible even in low lights. This number plate is fixed on the support bracket through the Number Plate Support.

4.2.3 Rear Bracket

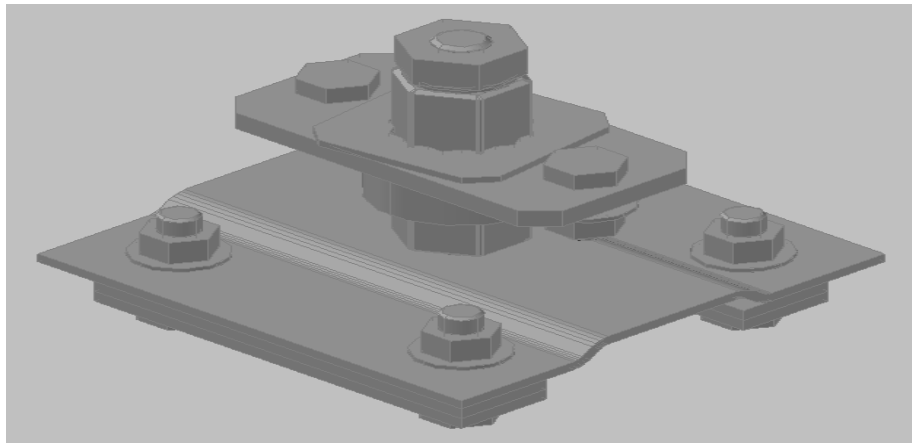
This component is fixed to the drop tube through nut bolt and backing angle or through U-bolts. This can be rigid or hinged type.

4.2.4 Standoff Bracket

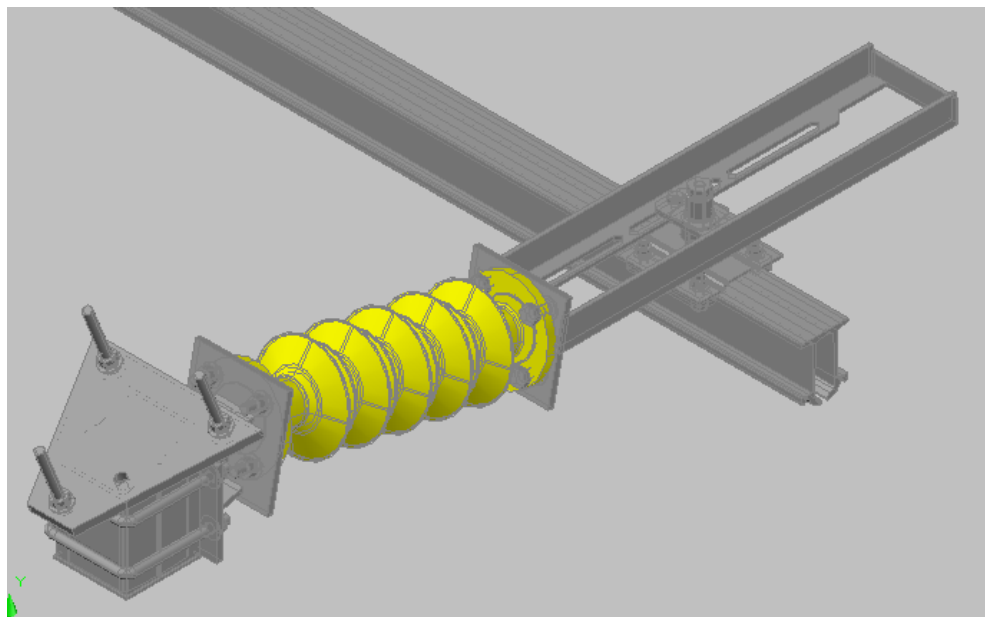
This component is attached to the insulator through nut bolts. It is also known as cross arm. This has a long slot inside which provides the required stagger of $\pm 200\text{mm}$ from the track centre axis. The length of the standoff bracket varies as per the requirement or site conditions. Like in case of overlaps, since parallel CRs are installed, the length of stand off bracket is lesser than the normal. Standoff bracket is live.

4.2.5 Swivel Head

This is placed in the slots provided in the standoff bracket and can glide along these slots to achieve the stagger of $\pm 200\text{mm}$. The main role of the swivel head is to hold the conductor rail. It has a clamp which holds the CR top surface and thus provides support for the entire CR length. If the rear bracket is hinged, no movement is required in swivel head. But if rear bracket is fixed, gliding arrangement is made available in swivel head so that CR can freely move due to temperature variations. The swivel head also allows $\pm 25\text{mm}$ vertical adjustment of contact wire height for fast & easy adjustment during maintenance.



SWIVEL HEAD



Swivel Head placed in Standoff bracket and holding the Conductor Rail

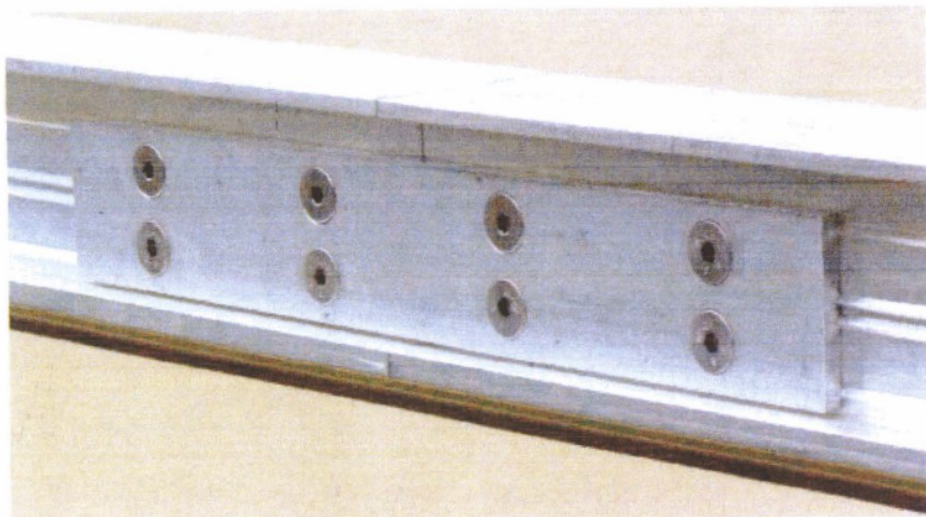
4.2.6 Insulator

An insulator is provided to isolate the live conductor rail system from the earth. The insulator can be of porcelain or a composite insulator made of silicon. Composite silicon insulators are light in weight and smaller in length; and also offer better handling, storage and maintenance. On the other hand, porcelain insulators are cheaper, have lesser diameter. Composite Insulator shall be in accordance with RDSO specification TI/SPC/OHE/INSCOM/1071 Rev-01 and Porcelain Insulator shall be in accordance with TI/SPC/OHE/INS/0070 with A & C Slip 1 & 2. Nominal creepage length shall be 1050mm minimum.

4.3 Interlocking Joint: Interlocking joints are used for interconnection of two conductor rails. Interlocking joints are made up of same alloy as that of conductor rail and have similar physical properties. Generally the rails will be delivered and installed in lengths of 10-12m according to span distance as per line speed. These rails are made continuous by Splices/Rail Joints. The conductor Rail Joint consists of inner and/or outer plates. The plates with their large contact surfaces ensure the current transmission between the rail and the joint and are also used for accurate mechanical fixing and fastening of the conductor rail. The interlocking joints have 4 screw connections on each plate i.e. total 8 screw connections per joint. This allows faster construction and repair.



INTERLOCKING JOINT



4.4 Contact wire: Contact wire is made up of hard drawn grooved copper with round bottom. contact wire is inserted inside the conductor rail profile and it is not mechanically tensioned.



CONTACT WIRE

4.5 Anchor Bolt: Anchor bolt is used to support ROCS bracket to the tunnel ceiling. These bolts are generally used to fix drop tube. Anchor bolt is hot dipped galvanised type mechanical anchor. Suitable design chemical anchors may also be used.



Anchor Bolt

4.6 Expansion Overlaps: Continuous length of rigid conductor system is formed by joining sections of aluminium conductor rail. But it is not feasible to keep on joining the sections as length increases by adding one conductor rail after the other, the expansion and contraction of the conductor rail due to the temperature variation also increases. Hence, it becomes cumbersome to handle or accommodate that change in the length of the conductor rail. Therefore, an overlap after a certain distance is added so that the expansion and contraction is within controlled limits and this is called as expansion overlap. In addition, the protruding ends of the conductor rail (CR) are slightly bent up to ensure smooth pantograph movement along the parallel CRs. To ensure electrical continuity, the parallel CRs are connected with copper cables long enough to accommodate the expected movement of the respective CR sections due to temperature variations. Expansion overlaps are arranged in parallel overlapping conductor rails. The distance between two consecutive expansion overlap is called tension length which is normally 500 meter. Other tension lengths may also be allowed when justified by design in accordance with operating temperature range. Expansion overlaps are used for low speed (<120km/h) and are of two types:

4.6.1 Insulated overlap: There is no electrical continuity between the parallel conductor rails at the expansion overlap. Insulated overlap is often used as an isolation point between two elementary sections. The sectioning of ROCS will be realized by insulated overlaps. The clearance between two OCS is 400/500 mm.



OVERLAP

4.6.2 Un-insulated overlap: In un-insulated overlap electrical continuity between parallel conductor rails is maintained through jumper connections. Two flexible copper jumper wires, size of which is selected in such a way that the current flows easily from one conductor rail to another conductor rail. The clearance between two OCS is 200 mm.

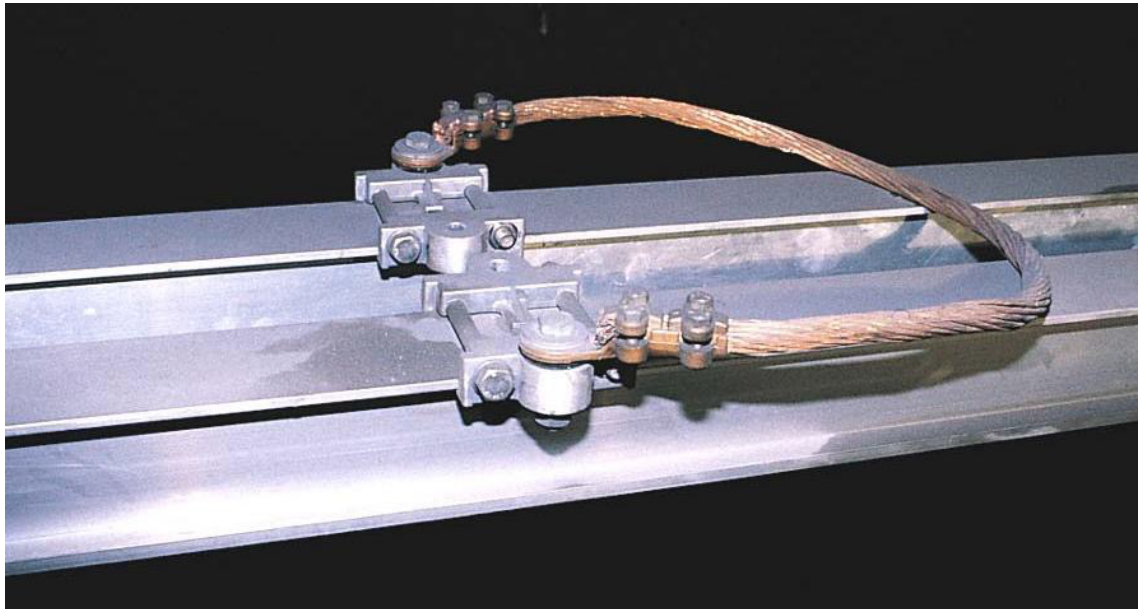
4.6.3 Expansion Joints: For higher speed applications (>120km/h), in-line expansion joints will be used as parallel CR type overlap do not provide compliant current collection at higher speeds.

4.7 Jumpers:

Jumpers are used in ROCS at three locations:-

1. Uninsulated overlaps
2. Turnouts
3. Feeding points

Un-Insulated Overlap jumper and Turn out jumper is the copper jumper of size 150/130 sq mm which provide the continuity between the two parallel Aluminium conductors rails. Two flexible copper jumper wires, each with a maximum cross section of 150 mm² can be attached.



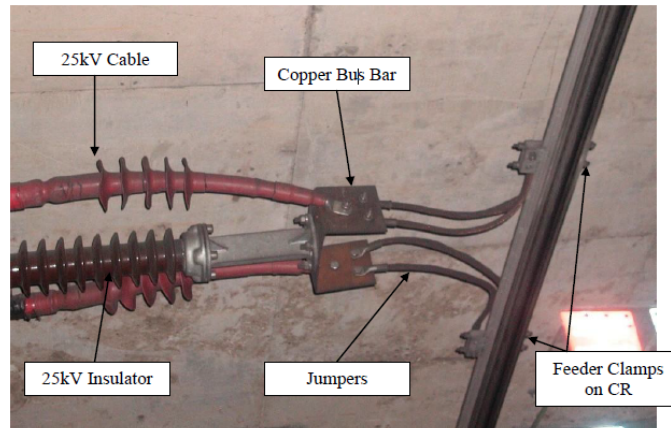
JUMPER

4.8 Feeder & Jumper

A cable which supplies power to the ROCS (or flexible OHE wire) is known as a feeder. Generally, 25 kv Cables shall conform to IEC-60840 with specified Voltage as 26/45kv(52kv) grade, 240sq.mm copper cable is used for power feeding. The power cables are terminated on the conductor rail with the help of feeder clamps.

The feeding is done through two numbers of 25kV flexible copper cables (240 rnm² single core, armoured copper cable). Each cable has a continuous current rating of 560 A. so the total capacity of 2*240 mm² connection is 1120 A. Both the cables are then terminated on a copper busbar mounted on an insulator, 4x150 sq.mm Copper Jumpers will then connect the bus bar to the CR through the feeder clamp. The feeder clamp has the capability to clamp flexible copper jumper up to 150mm². The flexible copper jumper are 1m long, sufficient to accommodate CR movement due to thermal expansion or contraction.

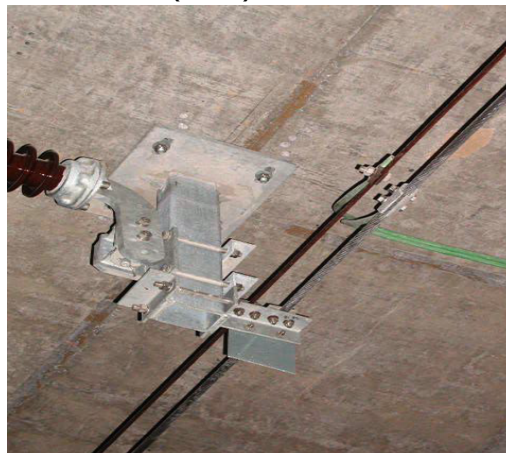
The 25kV feeder cables cannot be terminated directly on to the conductor rail as they are armoured cables and are not very flexible; hence they cannot accommodate thermal expansions and contractions of the conductor rail. There is a danger of possible breakage of the joint if they are terminated directly on the conductor rail.



25 kV Feeder Cable Termination at ROCS

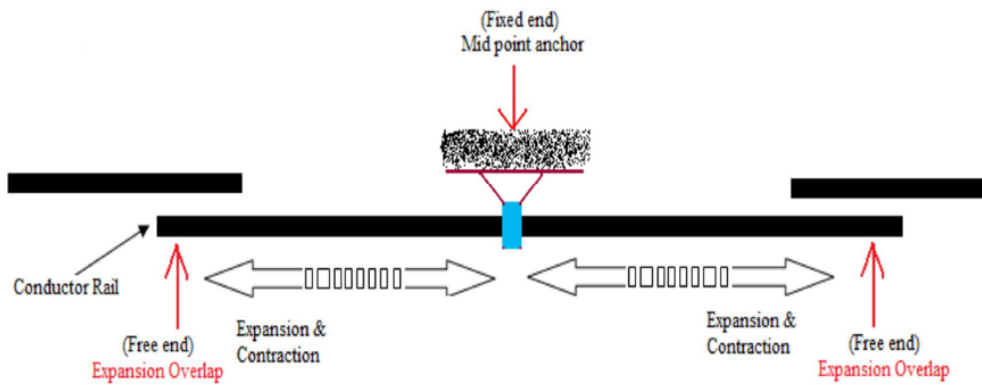
4.9 Over head protection conductor (OPC)

All the ROCS supports bracket are earthed. There is a continuous 70 sq.mm bare copper stranded or equivalent Aluminum conductor which runs all along the ROCS and it is clamped to each and every ROCS support bracket. This conductor is known as overhead protection conductor (OPC). At frequent interval Overhead protection conductor is connected to the Tunnel earth wire (TEW).



RC and OPC

4.10 Anti-creep Anchor: Anti-creep anchor is also called mid-point anchor. The mid-point or anti-creep anchor is installed in the middle of the tension length i.e. almost at the centre of two consecutive expansion overlaps. It ensures that equal expansion or contraction takes place on its both sides. The rigid overhead conductor system is not mechanically tensioned but some forces are developed inside the conductor rails because of temperature variations and pantograph movements. The midpoint anchor stabilises the various forces exerted on a conductor rail section within two expansion joints.

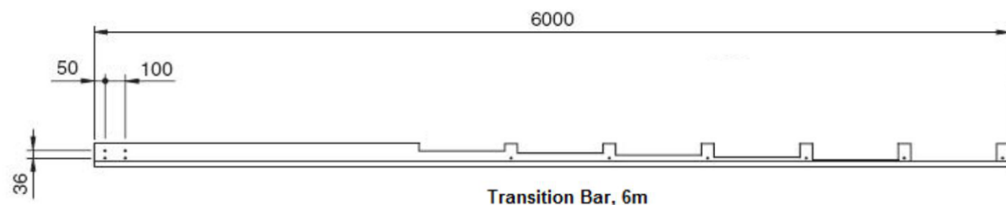


Mid point anchor arrangement

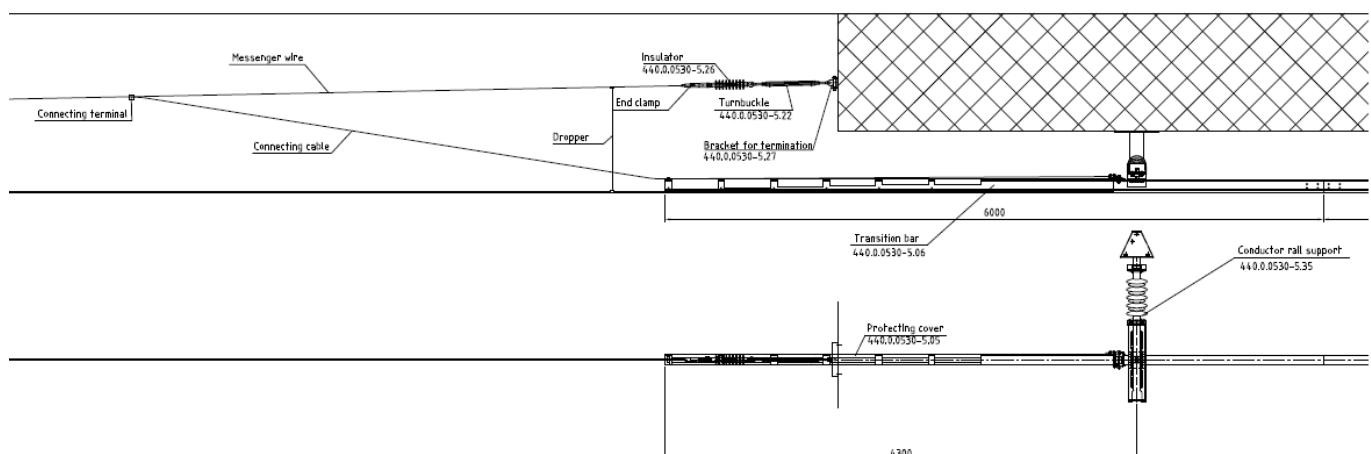
4.11 Transition Element

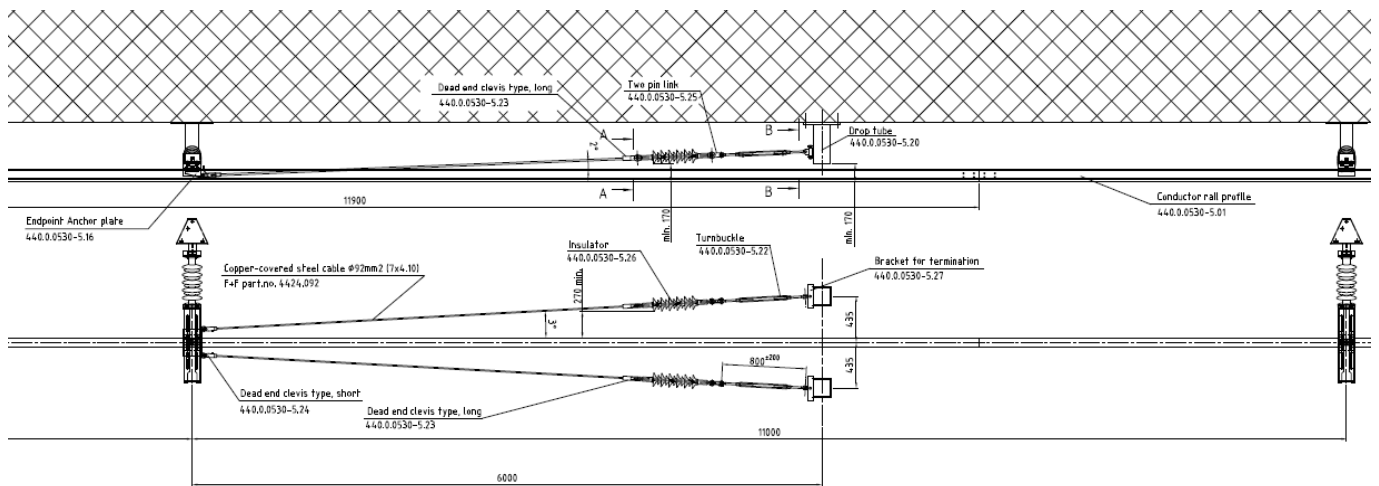
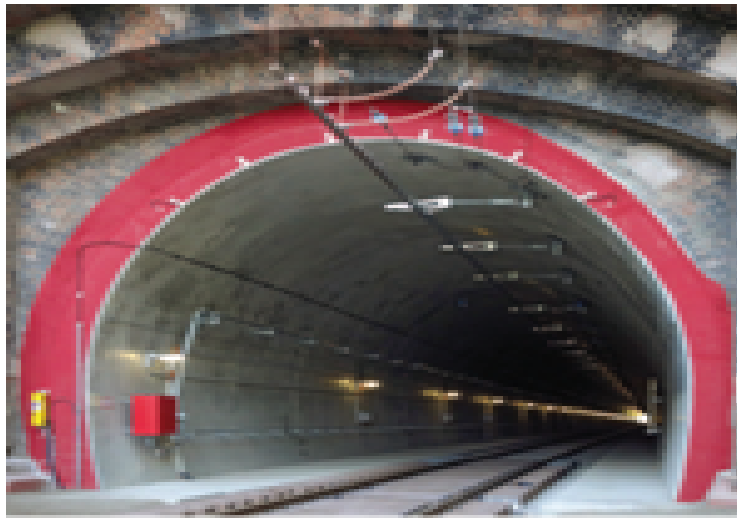
It is arrangement of joining ROCS with flexible OHE whenever elevated track enters into underground tunnel or vice-versa. At the junction point of flexible OHE and the ROCS system, there will be a sudden change in the stiffness of the contact wire. The flexible OHE contact wire is tensioned but not rigid; whereas the contact wire of ROCS is not tensioned but clamped in rigid CR.

The movement of pantograph will not be smooth during the transition from flexible OHE to ROCS or vice versa due to this sudden change in the contact wire stiffness. Thus, there shall be a gradual equalization of the difference in stiffness between the flexible OHE contact wire and the ROCS contact wire to assist a smooth transition of pantograph. This is achieved by using the transition bar at the junction point. Transition bar is a piece of CR with cut outs. These cut outs provide more flexibility and the transition bar acts as a shock absorber- There are six out-cuts in the transition bar profile of progressively increasing depth.



At the junction point between flexible OHE and the ROCS system, the tensioned contact wire from Flexible OHE enters the ROCS system through the transition bar & anchor bar and gets terminated inside the ROCS system. The anchor bar is a normal conductor rail section only but it is provided with 11 - M10 bolts, one M10 bolt at a gap of every 1m. The anchor bar is followed by the end point anchor arrangement. The endpoint anchor takes the tensile force of the contact wire entering the conductor rail and leads it into the civil structure. This means that with the exception of the transition section, the contact wire in the conductor rail is not subjected to tensile forces.





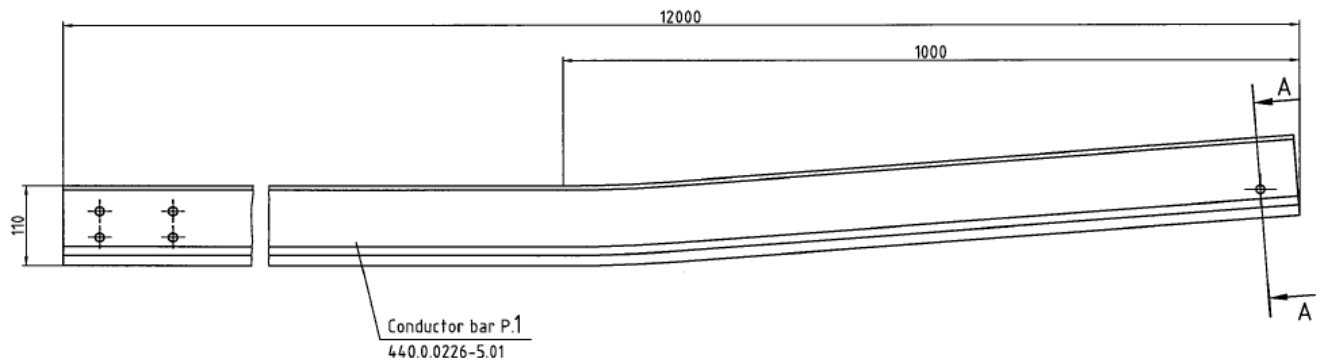
4.12 Section Insulators: Section insulators are provided to insulate the rigid overhead conductor of one elementary section from the rigid overhead conductor of the adjacent elementary section such as at track cross-overs. When the pantograph of a rolling stock passes from one track to another along a cross-over/turnout, current collection changes from one conductor rail system to other and therefore the runners of the section insulators overlap with contact wire so that there is no arcing. Sectional insulators are generally made up of Poly Tetra Fluro Ethylene (PTFE) fibre glass.



Section Insulator

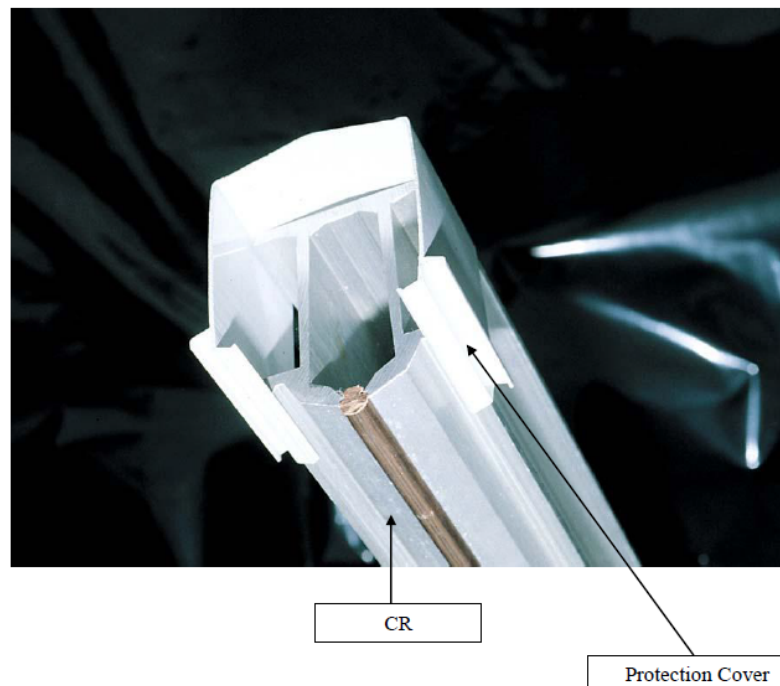
4.13 End Section:

End section is used at the expansion overlaps in the parallel CR arrangement. To maintain smooth transition of the pantograph from one CR to the other parallel CR, the last one metre of the CR is bent up. This ensures evenness when pantograph leaves the contact of the ending CR and makes contact with the starting CR placed parallel.



END SECTION

4.14 Conductor Rail Protection Cover: There may be a possibility of water leakage through nearest water body in tunnel. Even though aluminium conductor rail is very robust to withstand climatic conditions, water seepage on the conductor rail may cause problems. To avoid this risk, tunnel mouths and local moisture points, conductor rails are provided with a protective plastic cover. This protective plastic cover is very lightweight and has almost no or zero effect on the sag of the conductor rail.

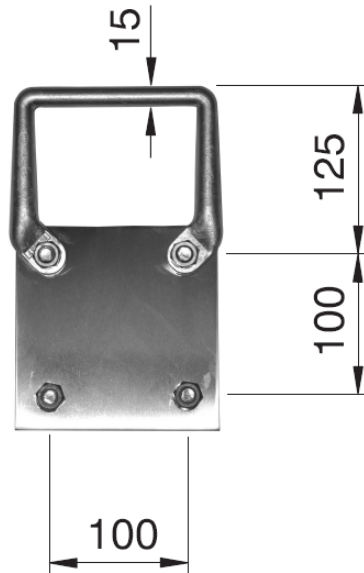


PROTECTION COVER WITH CONDUCTOR RAIL

4.15 Earthing Clamp

For any kind of maintenance activity on ROCS, we switch off the system first. Then the discharge rods are connected on ROCS at the both ends of the section where work has to be done to ensure that the system has been completely grounded and no charge exists on the rigid conductor system. The other end of the discharge rod is

connected to the track rail or nearest earth point. Earthing clamps are fitted on the CR at the both ends of a tension length. These clamps provide proper fixing for the discharge rod. Discharge rod cannot be fitted anywhere directly on the conductor rail.



5.0 RETRACTABLE RIGID CATENARY SYSTEM (RRCS) UNDER THE SILO

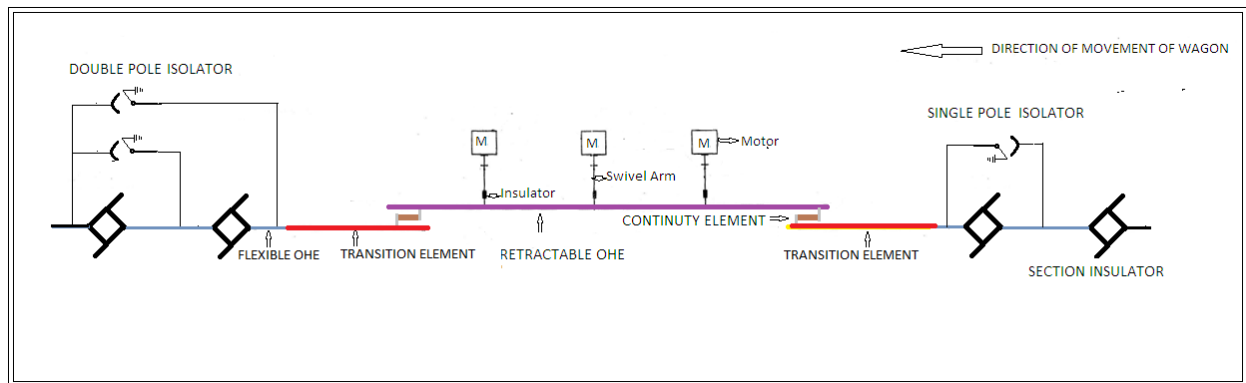
Under Mission 100% Electrification to eliminate Diesel Locomotive and reduce traction bill by means of saving of HSD oil, Retractable Rigid Catenary System (RRCS) is required for loading of Coal, Iron Ore etc under SILO.

5.1 Objective:

- (i) To provide a solution for facilitating overhead loading under SILO at freight terminals in electrified territory.
- (ii) To minimize the rake loading time thereby improving wagon turnaround and optimum utilization of crew / assets.
- (iii) Minimize damage to OHE during loading in wharf system.
- (iv) Compliance of National Green Tribunal (NGT) guidelines for minimizing pollution during loading.

5.2 Schematic Arrangement of RRCS in Railway Sidings/Maintenance Depots:

Swinging of bracket assemblies with conductors towards structures up to 70 degree parallel to the track from centre line of the structures with the help of Motor and crane/lifter arrangement, so that maintenance or top loading with the help of cranes/lifter can be done. RDSO vide letter no TI/OHE/GA/2017/07 date 18.09.17 has issued General arrangement for RRCS as below:



5.3 Components of Retractable Rigid Catenary System :

- (i) Combination of Section Insulators, SP Isolator with earthing heel, DP Isolator with earthing heel have been used for creation of 2 neutral sections at both end of loading zone and yard line.
- (ii) Transition Element: This is rigid type and will not be swivelling. UIOL has been created between the 'Transition element' & 'Retractable Rigid OHE'.
- (iii) Retractable OHE: Conductor Rail assembly, Hard Drawn Copper Contact wire, swivelling type OHE bracket assembly with insulators for supporting conductor rail assembly, motor gear unit to facilitate rotation of the swivelling type OHE bracket, jumpers, etc.
- (iv) Control System to control the operation of motor, Isolator & audio-visual signals and other controls as per the system requirement.
- (v) Earthing and Bonding: All metallic structures, OHE structures, Isolators have provision of Earthing & Bonding as per code.
- (vi) An Ariel Protection Cable (APC) will interconnect all swing arms together in order to keep equi-potentiality on any point of retractable rigid conductor system (RRCS). APC will be connected on each end to the Silo main earthing points/buried rail.

5.4 Safety Aspect:

- (i) For the safety of working personnel in loading area, audio-visual signal provided before energisation of the loading area.
- (ii) Motor operation is locked after retracting the OHE in either position.
- (iii) Loco with raised pantograph in the overlap zone is not allowed during operation of isolator with earthing heel.
- (iv) Isolator must be opened before swinging of RRCS OHE.
- (v) Suitable arrangement to prevent the falling of loading/foreign material on the OHE should be ensured.
- (vi) The normal position of the swivelling type rigid OHE should always be kept in position away from the track, i.e. not above the centre of track. 'ON' position is desired only for passage of locomotive.

5.5 Operation of 25KV Retractable Rigid Catenary System:

The following sequence should be followed for operation of RRCS:

- a) Initially, the position of the swiveling type rigid OHE will be away from the track. Electric loco approaching loading area/ maintenance depot shall be stopped before entry point of loading area/maintenance depot which will be before single pole Isolator. At the Entry point a sensor or Indicator (engine stop board) shall be provided.
- b) Retractable Rigid OHE shall be allowed to rotate forward over the track with the help of motorized arrangement.
- c) Both the Isolator shall be switched-on (First Single Pole Isolator and then Double Pole Isolator) to make the OHE between the isolators live at 25 kV. Before

energisation of OHE an audio visual signal shall indicate the energisation of OHE under the loading area.

- d) Then, electric loco will be moved through the loading area/maintenance depot (i.e. through energized Retractable OHE).
- e) The loco will stop outside of loading area and beyond the double pole isolator so that the pantograph will remain in energized OHE even after the opening of the double pole isolator and the first empty wagon is positioned below the chute for filling of wagon/maintenance.
- f) Retractable Rigid OHE will now be de-energized and earthed through Isolators (First Double Pole Isolator and then Single Pole Isolator) and discharge rod may be additionally provided. After Retractable OHE de-energized it will be moved back.
- g) Commencement of maintenance or loading shall be interlocked with the traversing mechanism of the RRCS. After completion of rake loading, the traversing chute will be retracted back automatically to parking position.

6.0 Guidelines: Following guideline should be followed for provision of Rigid Catenary in Tunnels and Retractable Rigid Catenary in Sidings and Depots having less clearances:

General:

- 6.1 All necessary measures must be taken to prevent electro-chemical corrosion between the contact wire and its supporting structure.
- 6.2 Contact wires according to RDSO specifications no. ETI/OHE/76 (6/97) or latest should be passed through the conductor rail.
- 6.3 If possible, the contact wire must be installed without joints for each continuous rail section (i.e. between two expansion joints).
 - Contact wire interruptions / joints are permitted if:
 - These are essential for construction reasons.
 - A segment of contact wire requires replacement due to damage.
 - In case of interruptions in the contact wire, completely smooth transitions must be ensured at the joint between new and old wire. A gap of no more than 1mm is allowed at the joint between new and old wire.
 - At points where the contact wire is interrupted, it must be secured by bolting through the conductor rail.
- 6.4 By means of constructional measures, it may be ensured that there is no sagging or upward deflection at the rail joints. Each rail joint connection (pair of connecting plates) shall not have more than 8 fasteners / screws to minimise installation and repair/renewal time.
- 6.5 The clamp for the contact wire must be designed so that it corresponds to contact wire as per RDSO specifications. The rail profile must not allow condensation water to come in contact with contact wire – profile interface to avoid corrosion.
- 6.6 Contact wire Gradient with respect to track should be according to EN 50119.
- 6.7 A suitable continuous transition between the rigid overhead conductor rail system and the flexible catenary must be provided for the transition from the catenary to the overhead conductor rail. Hard points must be avoided.
- 6.8 In the area of the transition the contact line must be supported so that the tensile forces can be adequately absorbed and the contact line is installed in the conductor rail without tension. Transition elements must be covered with plastic caps to protect against birds and water.
- 6.9 Minimum Vertical & lateral Electrical Clearances between live bare conductor/pantograph & structure should be as per IRSOD (BG) Revised-2004 with A&C.

- 6.10 Earthing and Bonding should be carried out as per Earthing and Bonding Code ETI/OHE/71(11/90) or latest.
- 6.11 Composite Insulator shall be in accordance with RDSO specification TI/SPC/OHE/INSCOM/1071 Rev-01 and Porcelain Insulator shall be in accordance with TI/SPC/OHE/INS/0070 with A & C Slip 1 & 2. Nominal creepage length shall be 1050mm minimum. The composite insulator with 1600mm creepage distance may be used where ESDD ≥ 0.3 mg/cm² with approval of PCEE's as per directives issued by Railway Board vide letter no. 2002/Elect(G)/161/21 Vol.II dated 04.07.2012.
- 6.12 All the items like - transition element, rigid rail, Drop arms, Bracket assembly, control system, motor for swiveling arrangement or any other sub assemblies should be of appropriate design already working in India/abroad.

ROCS inside Tunnels

- 6.13 On double track section, the support structures on the two tracks must be mechanically and electrically separated. The support structures must be arranged on the outsides of the double track if space allows in order to avoid blocking of both tracks in case of work. Support structures should have swiveling cantilever or swivel head with gliding arrangement.
- 6.14 Attachment on the roof of tunnel should be designed for additional loads due to adjacent defective support structures. Collapse of an adjacent support structure or detachment of the overhead conductor rail from two adjacent mounts (left/right or 2 on one side) must not result in failure of a support structure.
- 6.15 M16 or higher size stainless steel bolts (min. A4) as per RDSO Specification No. TI/SPC/OHE/Fasteners/0120 Rev. 1 or its equivalent standard must be used for fastening to the tunnel roof. For fastening in rock or masonry-lined tunnel roofs, appropriate strength considerations must be made and pull-out tests for critical areas must be carried out. The torques on the bolts must be considered in the design. Care must be taken that there is a good contact surface between the mounting plate and the bolts and nuts.
- 6.16 The torques for all fasteners must be stated. Depending on the requirements, fasteners must be secured against loosening. This must be specified by the supplier.
- 6.17 For grouting OHE fixtures on tunnel wall/ceiling/face, normally M20 grade of concrete/Epoxy resin should be considered in the design and depth of bolts may be upto 500mm. In the lined tunnels, stubs for supporting OHE cantilever assembly should be provided on both sides of the tunnel, opposite each other. This would facilitate restoration of OHE in the event of damage to stubs on one side. Similarly spare stub bolts for drop arm arrangement hanging from roof/ceiling of tunnel should also be provided on each location. For determination of bond stress between rock and grout and between grout and ragged type bolt "pull out test" shall be done as per IS 11309 latest version.
- 6.18 The height and stagger of the contact wire must be able to be adjusted quickly without the use of special tools and without additional load on the fastening bolts and support structures. The swivel head / CR clamp must allow ± 25 mm vertical adjustment.
- 6.19 The support structures must be equipped with appropriate terminals which enable the installation of an adequate electrical connection to the earth conductor. The height differences between support structures must comply with EN 50119.
- 6.20 Material for Support structure like drop arm, cantilever assembly, base plate etc. should be conforming to IS -2062:2011 and fabrication should be as per IS:800-2007 latest version or its equivalent.
- 6.21 Mid Point anchor must be designed such that the static electrical clearances and the pantograph clearances are met.

Retractable Rigid Conductor System:

In addition to general guidelines following guidelines should also be followed for Retractable OHE.

6.22 While approving the design of RRCS, following should be ensured:

- (i) If the environment is dusty as the loading/unloading of metallic/coal or other mining product is involved and to be loaded, adequate electrical clearance must be ensured. Also the sidings may be in open area and the OHE will be affected by wind and therefore proper locking arrangement is required so that OHE is locked in both normal and swivelled position and the required electrical clearance are maintained.
- (ii) The system should have suitable alarm to pre-warn when the OHE is energized and the alarm goes off only when OHE is de-energised and earthed so that safety of workmen is ensured.
- (iii) Suitable earthing arrangement should be in place for which inspection of the open line authorized representative and sanction of EIG to ensure compliance of statutory electrical safety is ensured. EIG may be requested to prescribe suitably periodic statutory inspection by his representative to ensure sustained compliance. It would be a good practice to incorporate provision of earthing rod additionally as backup in the working rules or SOP.
- (iv) The standard operating procedure needs to be specified and approved by PCEE of Zonal Railway as no. of different personnel are involved namely railway staff of operating and electrical/mechanical department and staff of siding owner.
- (v) Drawings for system design involving OHE arrangement and loading arrangement should be approved by PCEE of Zonal Railways/authorized representative and siding owners authorized personnel.

6.23 The detailed proposal/scheme with detailed design ensuring safety, operability and maintainability for specific sidings/depots/tunnels should be implemented with the approval of the PCEE of concerned Zonal Railway.

7.0 Technical Documentation

7.1 General

The following requirements may be specifically regulated in the contract. The technical documentation which is submitted by the supplier or manufacturer in the context of the qualification process must contain at least the following elements:

7.2 Detailed system description, design and drawings of the ROCS/RRCS system and its components as given below:

1. Relevant international /National standard followed for Basic design data, Inspection& acceptance criteria.
2. Details of General Arrangement of ROCS/RRCS like Material, size, permissible continuous current carrying capacity, short time rating, thermal time constant of conductors, permissible maximum temperature for continuous & short time rating, relevant standard references, permissible tensile stress, Breaking load & factor of safety for conductors & fittings , allowable wear of contact wire, permissible condemning diameter of the contact wire etc.
3. Design details of Tension length, Spans, Stagger, Height of Contact Wires, Wind Load & Electrical Clearances (Longitudinal/ Lateral & Vertical - Static & Dynamic).
4. Electrical clearances of pantograph from adjacent structures, in dynamic condition of train under design wind conditions.
5. Design details of Temperature rise in all type of bare conductors, insulated conductors (Cables), for continuous and short time intervals.
6. Tolerances and limit of construction, operation and maintenance.

7. Any other Details.
8. General Arrangement and Part Drawings of following:
 - (a) Contact wire, Conductor Rails
 - (b) Drop arms, Insulators, Jumpers, Expansion joints
 - (c) Insulated Overlaps, Un-insulated Overlaps.
 - (d) Turnouts & Crossover arrangements.
 - (e) Anti-Creep Arrangement
 - (f) Termination Arrangement
 - (g) Anchoring Arrangement
 - (h) Neutral Section and Section Insulator
 - (i) Transition section Arrangement.
 - (j) Earthing and Bonding Arrangement.
 - (k) Any other relevant drawing.

7.3 Creepage lengths/Air Gap of the various insulators.

7.4 FEA, STADPRO reports and design calculations for

- Supporting structures with approved partial factors (support structures, fastening bolts)
- Catenary – Conductor rail transitions
- Sagging
- Support point distances

7.5 List of systems implemented in India and foreign countries with details of the approved speeds for the route.

7.6 Installation and maintenance instructions

7.7 Statement of times for the replacement of components.

7.7 Any other Information.

7.2 Tunnels

Following details other than general requirements shall be submitted to the concerned Railway Authority for approval for **Rigid OHE arrangement in tunnels**:

- (a) Layout Plan of the ROCS in tunnels.
- (b) Drawing of transition arrangement from Flexible OHE to Rigid OHE.
- (c) Specification and Drawings of Components of ROCS.
- (d) Earthing and bonding requirement of components of the system duly considering Railway directives.
- (e) Cable routing/Installation Plan/drawing.
- (f) Schedule of type tests for the components and Assembly to be specified.
- (g) Electrical clearances from the live ROCS system and pantograph to the structure
- (h) Protection system for safety of operation and personnel.
- (i) Design details and drawings of the Structure and Foundations of the ROCS system.

7.3 Sidings/Depots

Following details other than general requirements shall be submitted to the concerned Railway Authority for approval for **Retractable Rigid OHE arrangement at sidings/Depots**:

- (a) Layout Plan of the RRCS at sidings /Depots.
- (b) Drawing of transition arrangement from Flexible OHE to Rigid OHE.
- (c) Specification and Drawings of Components of RRCS.
- (d) Power Supply arrangements.

- (e) Standby power supply for the control system & Standby arrangement for Motor failure.
- (f) Pollution Degree for components, Fire Retardant Class for Cables, sleeves, MCB, connectors etc.
- (g) Earthing and bonding requirement of components of the system duly considering Railway directives.
- (h) Cable routing/Installation drawings.
- (i) Schedule of type tests for the components and Assembly to be specified.
- (j) Electrical clearances from the live RRCS system and pantograph to the earthed structure.
- (k) Protection system for safety of operation and personnel.
- (l) Design details and drawings of the Structure and Foundations of the ROCS system.

8.0 Acceptance Process

For acceptance of a system, the following steps must be performed and documents provided. Special environmental conditions should be defined by the project.

- 8.1 Record of static measurements (must be available prior to acceptance and must be carried out before the contact line is switched on), e.g.
 - Heights of the contact wire at support points.
 - Support point distances / span length.
 - Stagger.
 - Electrical clearances (static to earth).
 - Evidence of electrical connection (continuity test).
 - IR value test.
- 8.2 Acceptance inspection of the system by the Railways and contractor, important points for inspection:
 - Installation of return and earth conductor (if part of design).
 - Compliance with the electrical clearances at critical points as per approved drawings.
 - Complete and correct installation of components as per approved drawings.
 - Inspection of weak points and excessive wear:
 - Expansion joints
 - Section insulators
 - Transitions
 - Turnouts & cross-overs
 - Stability of fixed points(civil structures).
 - Tightness/Completeness of electrical connectors.
 - The contact wire is correctly clamped in the conductor rail.
 - The conductor rail, expansion joints and all moveable components can move freely according to the expected longitudinal expansion.
 - The contact wire does not have any irregularities /gap which are smaller than the permissible gradients.
 - Contact wire interruptions are smooth and bolted.
- 8.3 Testing of ROCS/RRCS in Dynamic condition should be done to check proper current collection at permissible speed of track.
- 8.4 The following documentation (DIGITAL & PRINTED VERSION(Two copy)) must be submitted on completion of the system.
 - Description of system.
 - Location plan / Layout.
 - Schematic and detailed drawings of each components /parts.
 - Earthing and bonding scheme.

- Installation and maintenance instructions.
- List of components with part nos and qty(Inventory List).

8.5 Training

- The Manufacturer must carry out training of IR personnel according to the specifications of the tender.
- The supplier shall submit the digital and printed versions of the training documents.
- RDSO/IR reserves the right to use the documents for further internal training.

9.0 References:

- DMRC Manual
- Document for procedure of safety certificate and Technical Clearance of Metros
- Railway Board Letter No..2003/RE/161/1 Vol-III Pt dated 10.08.2017 regarding approval for adoption of OHE arrangement with Retractable Rigid Catenary Scheme (RRCS) for use in Railway freight/coaching terminals.
- RDSO letter no. TI/OHE/GA/2013 dated 22.10.13 - recommendations for provision of Rigid Catenary in tunnels.
- RDSO letter no. TI/OHE/GA/2017 dated 18.09.17 - guidelines no. TI/MI/0044 (09/2017) Rev-1 dated 18.9.17 incorporating scheme of Retractable Rigid Catenary System for overhead hopper/chute/crane loading/ unloading of rakes in electrified sidings issued to Zonal Railways.
- Railway Board letter No. 2013/Elect(G)/148/1 dated 15.07.19.
- Railway Board letter No. 2009/Elect(G)/184/1 dated 17.06.20.
