

PART 2: EMPLOYER'S REQUIREMENTS

CHAPTER 10: TRACTION OVERHEAD EQUIPMENT

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Note: These specifications are the bare minimum requirement, PST Contractor must verify the design and should fulfil while selecting system/equipment/component & executions. The final requirements of the specifications will depend upon the simulation studies and based upon that the PST contractor has to provide the material over and above to these specifications which shall be finally approved by Engineer / Employer.

1. GENERAL

1.1. Description

In BI-RIDE, Two Corridors, from Benniganahalli to Chikkabanavara (corridor-2), from Rajanukunte to Heelalige (corridor-4) and Soladevanahalli depot are planned for commissioning.

Benniganahalli to Chikkabanavara (Corridor-2), Soladevanahalli depot –:

The Benniganahalli to Chikkabanavara (incl. Soladevanahalli depot), Corridor-2 is 29.05 km long and consists of elevated & At-grade sections. There are a total of 16 stations. In corridor 2, Yesvantpur & Benniganahalli are interchange stations for Corridor 1 and corridor 4 respectively. There is a depot at Soladevanahalli catering to both the corridors 2 & 4 through the interchange at Benniganahalli.

Rajanukunte to Heelalige - Corridor 4:

The Rajanukunte to Heelalige, Corridor-4 is 47.15 km long and consists of Elevated & At-grade sections. There are a total of 24 stations. In corridor 4, Yelahanka & Benniganahalli are interchange stations for Corridor 1 & corridor 2 respectively.

Traction Overhead Equipment:

Design Verification, Supply, Installation, Testing and Commissioning of 25 kV AC flexible Overhead Equipment (OHE) System for Elevated At-grade section including Ramp and Depot is in the scope of this tender.

In depot, OHE will be regulated tramway type except at test track, where OHE will be same as that of main line i.e., Conventional OHE. In Inspection Bay, Retractable OHE type OHE shall be provided on either side of the platform.

1.2. Description of Alignment

1.2.1 Alignment

The Alignment of both Corridors are taken from Civil tender and are for reference purpose for preparation of Layout Plan. Any further changes in alignment will be incorporated into LOP and the same will be done by PST contractor.

1.2.2 Details of Curves

1.2.2.1. Horizontal Curves

The details of horizontal curves are shown in the Alignment drawings, Or it will be made available as per site conditions during interface meeting with the civil engineering contractors.

1.2.2.2 Transition Curves

All curves are provided with transition curves. While calculating the versine, the length of curve is considered from the start of transition curve on one end till the end of transition curve at the other end, and the radius of the curve is considered uniform. In other words, the radii at the transition portion are not considered. The versine calculated after ignoring the above radii, will not be significantly different from the versine values, if calculated with transition curves and in any case, will result in a better OHE Design only.

1.3.2.3 OHE Supports

The flexible OHE is required to be provided on sections on Viaduct & At-grade (together called as Main Line) and in Depots and approaches there to.

In the viaduct portion of Main line section, the traction overhead equipment will be supported from galvanized steel IR masts/portals/Tubular Poles, fastened to the parapet with the help of galvanized steel base plates and bolts and nuts.

At at-grade portion of Main line, OHE will be supported from galvanized steel structures (IR masts / IR portals) via grouting in foundations.

In stations, the traction overhead equipment will be supported on drop-arms attached to the roof trusses (for separate platforms for UP & Down lines) & if required OHE will be supported by individual IR masts at Island Platforms, suitably.

In the case of at-grade sections and in the Depot, the traction galvanized steel structures (IR masts / IR portals) will be provided with concrete foundations. The girders of the viaduct, the structural members of the station roof truss wherefrom the traction overhead equipment is supported, and the concrete foundations in 'at-grade' sections, will suitably consider the loads arising out of the traction overhead equipment.

1.3.2.4 OHE Layout Plans

The OHE Layout Plans considering the latest track alignment as of now, will be issued to the successful bidder as 'Good for Construction' drawings. Any subsequent modifications to the Layout Plans, arising out of changes in the track alignment, locations of cross-over etc, will be carried out by the PST Contractor and accordingly, revisions to Layout Plans will be made.

1.2.3 Soladevanahalli Depot

Soladevanahalli Depot is located at grade, adjacent to Soladevanahalli Station and is connected to Viaduct at the end of Corridor-2 after Chikkabanavara station. It has the following tracks:

- Covered stabling tracks
- Inspection tracks
- workshop track
- Pit Wheel Lathe track
- P-way engineering lines
- Tower Wagon shed
- Auto coach washing plant track
- Test Track etc.,

For the main tracks entrance in the depot and for the test track conventional OHE (messenger wire and contact wire) will be used. For the other tracks OHE will be regulated tramway type. In Inspection Bay for the lines with Roof platforms, OHE will be of Retractable OCS type, balance IBL lines shall be of regulated tramway.

For electrical protection from 25 kV supply OHE of staff working in inspection bay lines & internal

cleaning shed of depot, an interlocking system shall be installed. This fail-safe interlocking will be made in such a way that till the OHE supply of these sheds is not deenergized isolator at will remain open, no staff can enter on roof platform or operate the EOT cranes.

Arrangement of visual and audio indication shall also be provided to indicate whether the OHE of these sheds are dead (deenergized) or live (energized).

1.3. Stations

1.3.1 Corridor-2

The following table shows the list of Stations in Corridor-2.

S.No.	Station Name	Chainage (m)	Station Type
1	Benniganahalli	0-575	Elevated
2	Kasturi Nagar	1+094	Grade
3	Sevanagar	3+106	Grade
4	Banaswadi	4+152	Grade
5	Nagavara	7+133	Grade
6	Kanakanagar	8+582	Grade
7	Hebbal	10+930	Grade
8	Mathikere	15+669	Elevated
9	Yesvantpur	16+900	Elevated
10	Shettyhalli	20+327	Grade
11	Myadarahalli	23+280	Grade
12	Chikkabanavara	24+500	Grade
13	Soladevanahalli depot	26+883	Grade

Table 1 List of Stations – Corridor-2

1.3.2 Corridor-4

The following table shows the list of Stations in Corridor-4.

S.No.	Station Name	Chainage (m)	Station Type
1	Heelalige	0-132	Grade
2	Singena Agrahara	3+000	Grade
3	Huskur	5+068	Grade
4	Ambedkar Nagar	7+950	Grade
5	Karmelaram	9+626	Grade
6	Belanduru	13+812	Grade
7	Marathahalli	15+875	Elevated
8	Doddanekundi	18+408	Grade
9	Kaggadasapura	20+750	Grade
10	Benniganahalli	22+295	Elevated
11	Channasadra	24+107	Grade
12	Horamavu	26+178	Grade

S.No.	Station Name	Chainage (m)	Station Type
13	Hennur	27+582	Grade
14	Thanisandra	30+620	Grade
15	RK Hegde Nagar	32+116	Grade
16	Jakkur	33+891	Grade
17	Yelahanka	37+233	Elevated
18	Muddanahalli	42+250	Grade
19	Rajankunte	45+875	Grade

Table 2 List of Stations – Corridor-4

1.4. Meteorological conditions

For meteorological conditions, please refer conditions specified in General Specifications.

2. BASIC DESIGN CRITERIA**2.1. Basic parameters**

2.1.1 The Overhead Equipment (OHE) is designed considering the following basic parameters:

- 2.1.1.1. Track gauge : 1676 mm
- 2.1.1.2. Types of Points and Crossings : 1 in 12 for mainline & 1 in 8.5 for ML scissor
: 1 in 12 for test track & 1 in 8.5 for others (depot)
- 2.1.1.3. Curves
- a). Minimum radius of curvature on Main line : 200 m
 - b). Minimum radius of curvature in depot/workshop/car shed : 175 m
- 2.1.1.4. Gradient
- a). Maximum gradient of track on main line : 4%
 - b). Maximum gradient of track in depot : 4%
- 2.1.1.5. The salient design parameters adopted are as follows:
- a). Maximum span
 - At-grade : 63 m
 - Viaduct : 47.5 m
 - b). Minimum height of Contact Wire at Support
 - for Regulated OHE (with pre-sag) : 5.10 m
 - for unregulated OHE : 5.20 m
 - in car sheds/depots : 5.20 to 5.50m
 - c). Pre-sag of contact wire at mid span : 1/1000 of span length
 - d). Maximum gradient of contact wire
 - on main line : 4 mm/m
 - on sidings : 6 mm/m

2.2. Span and stagger

2.2.1 Span

Spans must allow the spark-less current collection at all permissible speeds in all weather conditions and different conditions of track. Spans must allow the spark-less current collection at all permissible speeds on the entire stretch of track and under weather conditions permitting train operation. Therefore, the main consideration for selection of spans is that the contact wire must be in the working zone of the pantograph under the worst operating conditions. Factors which affect the determination of span of overhead equipment are:

- Blow off - of OHE, Db
- Stagger effect, Ds
- Versine effect, Dv
- Displacement of mast due to permanent load and wind load, Dm
- Pantograph sway, Dp
- Cantilever swivelling allowance, Dsa
- Stagger construction tolerance, De

2.2.1.1. Maximum span in straight alignment

For calculating the maximum span, the factors mentioned above are considered and it is ensured that contact wire is contained within the working zone of pantograph.

A. Tangent track: Staggers on opposite side of Pantograph center line.

$Db + Ds + Dm + Dp + Dsa + De < \text{Pantograph half working width}$ (versine effect can be ignored for radius $\geq 7,500$ m)

Wind blowing towards outside of the curve (for curve with radius ≥ 2000 m)

$Db + Ds - Dv + Dm + Dp + Dsa + De < \text{Pantograph half working width}$ Wind

blowing towards inside of the curve (for curve with radius ≥ 2000 m) $Db - Ds$

$+ Dv + Dm + Dp + Dsa + De < \text{Pantograph half working width}$

B. Curved track (with radius < 2000 m): Staggers considered on same side of Pantograph centre line

For masts on curves with radius less than 2000m, the staggers are considered on same side (towards outside curve) with value of staggers almost equivalent to the versine to limit the mid-span offset. Hence, maximum spans on these curves are increased and the maximum limit is governed by the versine. By providing staggers equivalent to versine mid-span off-set of very less value can be achieved and hence spans can be increased. Also, by providing staggers equal to versine, in the same direction, the maximum blow-off the wires will be at the centre of span i.e. $L/2$ (where L = Length of span) and stagger effect will be negligible.

SPAN & STAGGER SUMMARY				
SNO	RADIUS (m)	SPAN (m)	STAGGER S1 (m)	STAGGER S2 (m)
1	R >= 7500	47.5	0.2	-0.2
2	7500 > R >= 5000	45	0.2	-0.2
3	5000 > R >= 4000	44	0.2	-0.2
4	4000 > R >= 3500	43	0.2	-0.2
5	3500 > R >= 3000	42	0.2	-0.2
6	3000 > R >= 2500	41	0.2	-0.2
7	2500 > R >= 2000	41	0.15	-0.15
8	2000 > R >= 1500	40	0.2	-0.2
9	1500 > R >= 1000	38	0.2	0.2
10	1000 > R >= 900	38	0.25	0.25
11	900 > R >= 800	38	0.25	0.25
12	800 > R >= 700	38	0.3	0.3
13	700 > R >= 600	34	0.3	0.3
14	600 > R >= 500	34	0.3	0.3
15	500 > R >= 400	30	0.3	0.3
16	400 > R >= 300	26	0.3	0.3
17	300 > R >= 175	20	0.3	0.3

Table 3 Span and stagger Summary for main line (Viaduct)

SPAN & STAGGER SUMMARY				
SNO	RADIUS (m)	SPAN (m)	STAGGER S1 (m)	STAGGER S2 (m)
1	R >= 7500	63.0	0.200	-0.200
2	7500 > R >= 5000	58.5	0.250	-0.200
3	5000 > R >= 4000	54.0	0.250	-0.200
4	4000 > R >= 3500	54.0	0.250	-0.150
5	3500 > R >= 3000	49.50	0.200	-0.100
6	3000 > R >= 2500	49.5	0.200	-0.150
7	2500 > R >= 2000	45	0.150	0.150
8	2000 > R >= 1500	40.5	0.200	0.200
9	1500 > R >= 1000	40.5	0.200	0.200
10	1000 > R >= 900	36	0.200	0.200
11	900 > R >= 800	36	0.200	0.200
12	800 > R >= 700	36	0.250	0.250
13	700 > R >= 600	31.5	0.250	0.250
14	600 > R >= 500	31.5	0.300	0.300
15	500 > R >= 400	27	0.250	0.250
16	400 > R >= 300	22.5	0.250	0.250
17	300 > R >= 175	18	0.250	0.250

Table 4 Span and stagger Summary for main line (At-Grade)

Radius (m)	Span (m)	Stagger, S1(m)	Stagger, S2(m)
Infinity>R>=5000	40	0.200	-0.200
5000>R>=2000	40	0.200	-0.200
2000>R>=1000	40	0.200	0.200
1000>R>=800	36	0.200	0.200
800>R>=700	36	0.250	0.250
700>R>=600	35	0.250	0.250
600>R>=500	35	0.300	0.300
500>R>=400	31	0.300	0.300
400>R>=300	27	0.300	0.300
300>R>=200	22	0.300	0.300
200>R>=100	15	0.300	0.300

Table 5 Span and stagger summary for depot

Note: However, on Mainline the span may have to be reduced as per site constraints.

2.2.2 Stagger

2.2.2.1 The Overhead Equipment (OHE), containing the Messenger wire and the contact wire, is normally kept in a vertical plane, i.e., the messenger wire above the contact wire. While the Messenger wire stagger is adjusted by means of the position of the messenger clamp on the cantilever, the contact wire stagger is adjusted by means of steady arm fixed to registration arm. In straight alignment, the contact wire (and the messenger wire) is staggered, alternatively, at each support to a maximum of $\pm 200\text{mm}$, from the pantograph axis. In the case of a curved track, a maximum stagger of 300 mm is provided in the direction away from the center of curve, from the pantograph axis.

2.2.2.2 In the insulated and un-insulated overlaps, both on straight tracks as well as on curves, special values of staggers are chosen for the in-running and the out-of-run OHE, to ensure adequate clearances and smooth transition of current collection from one OHE to the other. The special values of stagger are shown in the typical drawings showing insulated and un-insulated overlaps: KRDD01-TDR-GEN-GEN-OCS-DWG-00003 & KRDD01-TDR-GEN- GEN-OCS-DWG-00002.

2.3 Pre-sag versus Span

2.3.1 The contact wire is designed to have a specified pre-sag at mid span. Provision of pre-sag is achieved by suitably adjusting the lengths of droppers.

2.3.2 Overhead catenary system designed with a pre-sag of $L/1000$, along with other improvements (increasing of push up and reducing of pre-sag) on the design parameters, has been found suitable for speeds up to 200 kmph.

2.4 Conductor Tensions

In all elevated sections of the two corridors Overhead Conductor of 120 sq.mm messenger wire and 150 sq.mm contact wire will be used with conductor tensions of 1500kgf each.

The following conductor tensions are adopted.

Messenger wire	...	1500 kgf (regulated)
Contact wire	...	1500 kgf (regulated)
Anticreep wire	...	1300 kgf at 35°C

- 2.4.1 The use of a higher conductor tension of 1500 kgf in the messenger and contact wire ensures a better current collection performance. The mechanical interaction between the contact wire and the pantograph plays an important role in the phenomenon of current collection. The pantograph exerts an upward pressure on the contact wire, which tends to hog the contact wire. At the same time, the contact wire tends to sag by its own unsupported weight and the pre-sag provided. The sag of the contact wire will depend upon the tension in the contact wire. The net result of this pantograph - contact wire interaction will play a vital role in the flow of current from the contact wire to the pantograph. A combination of higher tension in the contact wire and a specified pre-sag, helps to contribute better current collection at higher design speeds.

3 FEEDING AND SECTIONING

3.1 Traction feeding arrangements: Corridor-2

3.1.1 Benniganahalli to Chikkabanavara

- 3.1.2 The Traction Power for Benniganahalli to Chikkabanavara: Corridor-2 is derived from Traction Substation, proposed to be located at Benniganahalli, Mathikere & Soladevanahalli.

3.2 Feeding Post: Corridor-2

Benniganahalli to Chikkabanavara: Corridor-2

Feeding Post for Corridor-2 is located at Mathikere. Power for 25 kV Traction will be transported from the TSS (Mathikere) to a suitable feeding point on the flexible OHE, via feeder cables. The Supply, Installation, Testing and Commissioning of Feeding Posts on the Mainline and 25 kV Feeder Cables, Return Cables and C&M Cables between the TSS and the Feeding Point on the Mainline, is within the Scope of this Contract.

The function of feeding post is to extend the 25 kV Power Supply from TSS to OHE. Normally it contains 4 no's of feeds, 2 for Up line & 2 for down line with a Short Neutral Section in between.

3.3 Sectioning arrangements: Corridor-2

The Corridor also has sectioning arrangements (SP) at Benniganahalli & Soladevanahalli to isolate the feed of Mathikere on either side.

The function of Sectioning Post is to segregate the power supply feeds from adjacent substations, since the 2 feeds will have a phase difference between them and cannot be coupled together. The Sectioning Post will have a Short Neutral Section (SNS) in front of it and the OHE on either side of the Neutral Section will not be bridged under normal operation. Under N-1 scenario (i.e. failure of one TSS) bridging interrupters (normally open) provided at SP are closed to extend the feed between the two sections.

To facilitate isolation of faulty sections, without disrupting power supply to healthy sections, and to facilitate power shutdown to be affected on the sections of traction overhead equipment, the corridors will further be sectionalised, by providing sub sectioning posts (SS) and Sub- sectioning and Paralleling posts (SSP's) as follows:

The Traction Sectioning Diagram for Corridor 2: vide drawing no. KRDD01-TDR-CR02-GEN- OCS-SEC-00002 shall be referred.

There is a crossover present between

- Corridor-1 & Corridor-2 at Yeshwantpur.

These are for intra movement of Rolling stock of across the corridors without any hassle. Hence Sectioning arrangement is made accordingly.

3.4 Traction feeding arrangements: Corridor-4

3.4.1 Rajanukunte to Heelalige

The Traction Power for Corridor-4 is derived from Traction Substation, proposed to be located at Yelahanka & Benniganahalli.

3.5 Feeding Post: Corridor-4

- 3.5.1 Feeding Post for Corridor-4 is located at Yelahanka & Benniganahalli. Power for 25 kV Traction will be fed from the TSS to a suitable feeding point on the flexible OHE, via feeder cables. The Supply, Installation, Testing and Commissioning of Feeding Posts on the Mainline 25 kV Feeder Cables, Return Cables and C&M Cables between the TSS and the Feeding Point on the Mainline, is within the Scope of this Contract.

3.6 Sectioning arrangements: Corridor-4

The Corridor also has sectioning arrangements (SP) at Thani Sandra to isolate the feed of Yelahanka & Benniganahalli from either side.

- 3.6.1 To facilitate isolation of faulty sections, without disrupting power supply to healthy sections, and to facilitate power shutdowns to be affected on the sections of traction overhead equipment, the corridors will further be sectionalized, by providing sub sectioning posts (SS) and Sub- sectioning and Paralleling posts (SSP's) as follows:
- 3.6.2 The Traction Sectioning Diagram for Corridor 4: Rajanukunte to Heelalige vide drawing no. KRDD01-TDR-CR04-GEN-OCS-SEC-00002 shall be referred.

There are crossovers present between

- Corridor-2 & Corridor-4 at Benniganahalli.
- Corridor-1 & Corridor-4 at Yelahanka.

These are for intra movement of Rolling stock of across the corridors without any hassle. Hence Sectioning arrangement is made accordingly.

3.7 Feeding Arrangement Soladevanahalli Depot Corridor-2

Soladevanahalli depot shall be fed from the TSS located inside depot.

Feeding post in the depot shall segregate the power to Depot lines, typical drawing is referred here KRDD01-TDR-CR02-SLD-OCS-SEC-00001.

Also, there is a provision for back feed of supply from Main Line in case of outage of Depot TSS outage.

To achieve this, a neutral section arrangement is proposed between Main Line & Depot so that main line supply can be extended to depot in case of emergency & vice versa.

3.8 Need for Neutral Sections

- 3.8.1 The Single-Phase Traction Power from two adjacent Substations may have a phase difference between them. To segregate the power supply feeds from adjacent Substations, Neutral Sections are provided on the flexible OHE. Normally, the OHE on either side of the Neutral Section will not be bridged. 01 no. of short Neutral Section on each line is proposed.

3.9 Short Neutral Section Assembly

- 3.9.1 General arrangement of Short Neutral Section is shown in typical drawing No. KRDD01-TDR-GEN-GEN-OCS-DWG-00025.

3.10 Neutral Sections

Rolling Stock - The Electric Multiple Units, operating on the line will pass the Neutral Section, under their own momentum. Special track side equipment located at a pre-determined distance from the centre line of the Neutral Section operates to switch off the power supply to the EMU. Thereafter, the EMU moves under its own momentum, with the pantographs raised. After negotiating the Neutral section, the power to the EMU is switched on, again by the operation of track side equipment. The location of track side equipment, the mounting of the corresponding car-borne equipment and their operation will have to be suitably co-ordinated between the Rolling Stock manufacturer, signalling contractor and the track contractor.

4 CLEARANCES**4.1 Kinematic Envelope**

- 4.1.1 The Schedule of Dimension, for Broad Gauge 1,676 mm Rail, adopted by BI-RIDE BSTP provides the Kinematic Envelope of the vehicles as per SOD.
- 4.1.2 The effect of superelevation on the Kinematic envelope should also be considered, the data for which is contained in the SOD.

4.2 Structure Gauge

- 4.2.1 The Structure Gauge provides for adequate clearance over the Kinematic envelope. The structure Gauge, as provided for in the Schedule of Dimensions Gauge 1,676 mm Rail, adopted by BI-RIDE BSTP, should be fully respected.
- 4.2.2 The Structure Gauge for stations with side platforms, stations with Island platform, for tracks outside stations and the effect of cant on the Structure Gauge, are all defined in the SOD. These requirements are to be fully respected for support arrangements etc. for OHE, outside as well as inside stations.

4.3 Electrical Clearances

- 4.3.1 The Electrical clearances (values in mm), as specified in the Schedule of Dimensions (latest), Gauge 1,676 mm shall be adopted. The OHE and power supply designs consider these clearances.
- 4.3.2 Minimum vertical distance between any live bare conductor (overhead equipment or pantograph) and any earthed structure or other bodies (rolling stock, over bridges, signal gantries etc.).

(i). when the conductor is at rest..... 320 mm (long time clearance)

(ii). when the conductor is not at rest..... 270 mm (short time clearance)

Note:

A minimum vertical distance of 340 mm shall normally be provided between rolling stock and contact wire to allow for a 20 mm temporary raising of the tracks during maintenance. Wherever the allowance required for track maintenance exceeds 20 mm the vertical distance between rolling stock and contact wire shall correspondingly be increased.

- 4.3.3 Minimum lateral distance between any live bare conductor (overhead equipment or pantograph) and any earthed structure or other bodies (rolling stock, over bridges, signal gantries etc.)

(i). when the conductor is at rest..... 320 mm (long time clearance)

(ii). when the conductor is not at rest.....220 mm (short time clearance)

- 4.3.4 Height of contact wire:

Minimum height from rail level to the under-side of live Conductor wire:

(i). Under bridges & tunnels.....4800 mm

(ii). In the open (Elevated & at grade sections).....5100 mm

(iii). in running and carriage sheds wherever staff are expected to work on the roof of rolling stock.....5200 mm

Note: -

(a). For the movement of over-dimensional consignments of any height the contact wire height specified in 4.3.2 (i) above, shall be increased by the difference between the height of the consignment contemplated and 4.41m. In case such an over dimensional consignment is moved at speeds not exceeding 15 km/h and is also specially escorted by authorised railway staff, the derived height of contact wire may be reduced by 50 mm.

(b). On curves, all vertical distances specified in item 4.3.2 above, shall be measured above level of the inner rail, increased by half the super-elevation.

- 4.3.5 Maximum variation of the live conductor wire on either side of the centre line or track under static conditions.

(i). On straight track.....±200 mm

(ii). On curves ±300 mm

Note: These limits would not apply to special locations like insulated overlaps, Neutral Sections and out of run wires.

4.4 Pantograph

- 4.4.1 The OHE design shall allow for running of pantograph with the following or similar characteristics.

Total width of pantograph with Insulated horns	: 2030mm
Upward static thrust	: 70 to 90 N
Maximum uplift of contact wire, in normal running track	: 150mm
Maximum operating speed	: as per BSTP SOD
Type of pan strips	: Metallized Carbon

These parameters are subject to minor changes and will be confirmed by Rolling Stock Contractor during interface.

Bi-RIDE

5 GENERAL ARRANGEMENT OF OHE

5.1 Normal spans

- 5.1.1 The general arrangement of OHE, regulated, in normal spans, is shown in typical drawing KRDD01-TDR-GEN-GEN-OCS-DWG-00010.

In tangent tracks, the contact wire is given a stagger of ± 200 mm with respect to the track vertical axis. The messenger wire is kept just above the contact with the same stagger.

However, on curves, having super elevation, the pantograph axis and the track vertical axis are separated at contact wire level by an amount equal to:

$$S = \frac{(\text{super elevation} \times \text{contact wire height})}{\text{track gauge}}$$

The contact wire as well as the messenger wire is given stagger 300 mm towards the outer rail of the curved track with respect to panto axis.

5.2 Insulated Overlaps

- 5.2.1 The General arrangement of OHE, in 4 span insulated overlaps, is shown in typical drawing KRDD01-TDR-GEN-GEN-OCS-DWG-00003. The insulated overlap is made up of 4 spans. Viewed in the normal direction of traffic, the OHE located on the left-hand side, directly gets anchored later while the one located on the right-hand side crosses first the left-hand equipment and gets anchored. This arrangement is called a normal overlap with 4 spans. The arrangement is briefly shown below in figure 2

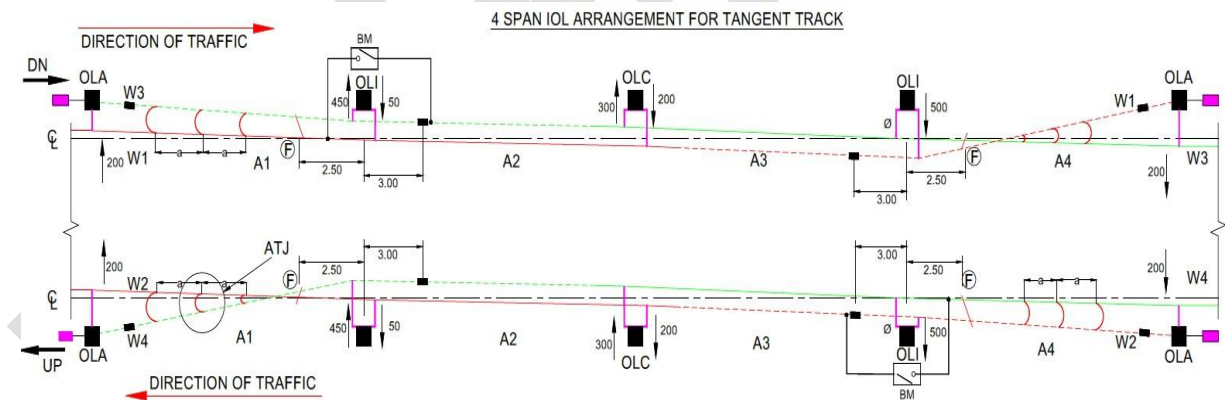


Figure 1 Normal Insulated Overlap with 4 Spans

- 5.2.2 On the contrary, viewed in the direction of traffic, the left-hand side OHE first makes an overlap while the right-hand side OHE later crosses the left-hand OHE, in the overlap arrangement, called 'Reversed overlap with 4 spans'. The arrangement is shown briefly in the figure 3 below:

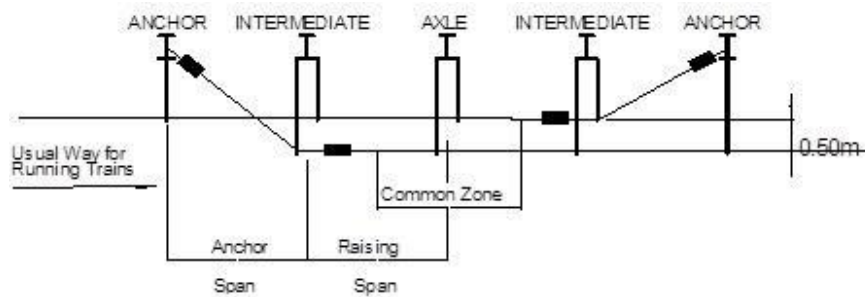


Figure 2 Reversed Insulated Overlap with 4 Spans

- 5.2.3 The number of spans of insulated overlap is subjected to change with curvature of the track.
- 5.2.4 Since the OHE's on either side of the insulated overlap belong to different elementary sections, it will be necessary to maintain a minimum clearance of 500 mm between the two OHE's. In addition to this cut in insulators are provided on the messenger wires and contact wire near the intermediate masts of insulated overlaps. General arrangement of cut-in insulators on OHE at overlaps is included in typical drawing KRDD01-TDR-GEN-GEN-OCS-DWG-00003. This is achieved by adoption of suitable staggers.
- 5.2.5 At every insulated overlap, it would be necessary to provide a switch (an interrupter) depending upon the sectioning arrangement finalised. Under normal operating conditions, the switch may remain closed thereby maintaining continuity of supply and it could be opened depending upon the operation/maintenance requirements.
- 5.2.6 The location of the IOL has been designed to maintain 160 m (6 Coaches length + margin) between them and signals. However, during the settle down of the OHE facilities, the location of the IOL shall be coordinated with the signalling contractor.
- 5.2.7 Additionally, caution boards should also be provided to guide to where to stop the train before signal.

The PST Contractor shall interface with Signalling Contractor for provision of signal away from Insulated Overlap, FP, SP, Neutral Section etc.

5.3 Un-insulated overlaps

- 5.3.1 While the requirement of insulated overlaps is dictated by the operation/maintenance needs, the un-insulated overlaps have necessarily to be introduced in the OHE, since the lengths of conductors have a definite maximum value, dictated by the size of drums, transportation, handling etc. Generally, an overlap will have to be introduced in OHE, every 1000 m to 1300 m, which again will depend upon various other parameters like maximum permissible tension length from considerations of temperature variations, station locations, points and crossings etc.
- 5.3.2 The layout of un insulated overlap is similar to what has been adopted for the insulated overlap, except that in the un insulated overlap the separation between the two OHE's can be reduced to 200mm (unlike 500mm in the case of insulated overlap), since both the sections of OHE on either side of the un insulated overlap belong to the same elementary section and there is need only for mechanical clearance between the sections and not electrical clearance. The continuity is achieved by providing jumpers.
- 5.3.3 The un-insulated overlaps can be either 'Normal' or 'Reversed'. The arrangement of 'Normal' un-insulated overlap is shown in figure 4 and that of a 'Reversed' uninsulated overlap is shown in figure 5

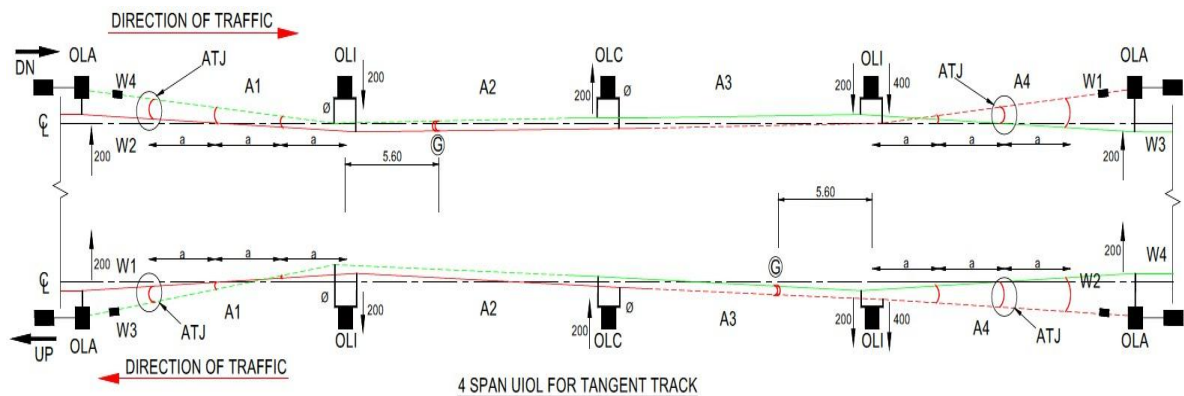


Figure 3 Normal Un-insulated Overlap by means of 4 spans

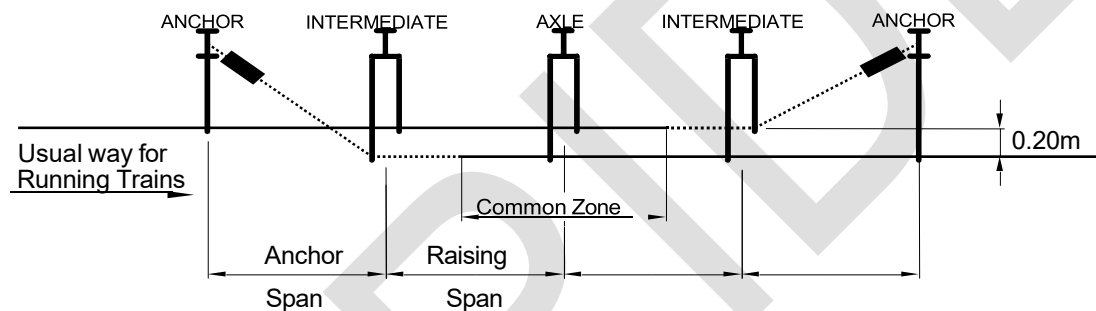


Figure 4 Reversed un-insulated Overlap by means of 4 spans

5.3.3 The details of arrangements, including values of staggers adopted, are shown in the typical drawing KRDD01-TDR-GEN-GEN-OCS-DWG-00002.

5.4 Automatic Tensioning Devices

5.4.1 As mentioned earlier, the Messenger wire and contact wire are each given a tension of 1500 kgf. This tension must be maintained at this value, irrespective of the variations in the conductor temperatures.

5.4.2 This is achieved by providing Automatic Tensioning Devices (ATD), on either end of each tension length. When the tension length is less than 700 m, ATD could be provided at one end and the other end of the tension length could be fixed without an ATD. This will be termed as a half-tension-length and is provided depending upon the exigencies in the layout of OHE. Normally the tension length varies up to 1300-1400 m and ATD's are provided at either end of the tension length. The ATD's used shall be either of 5 pulley block type or of spring type. Normally 5 pulley block type ATD shall be provided at At-Grade & depot & Spring type ATD shall be provided on the viaduct. However, at critical location, where any remote possibility of ATD falling accidentally on the below road traffic or higher tension lengths etc; Spring type ATD shall be provided. Spring type ATD shall also be provided on the ramps, where there is limited height available for counterweight movement. Use of spring type ATDs shall be approximately 20% of the total number of ATDs, used overall in the system. However actual will be worked out during detailed design stage as per the approved Layout Plan.

5.4.3 The scope will also include temperature marking on the masts for corresponding tension lengths.

5.4.4 Automatic Tensioning Device

5.4.4.1 Pulley Block Type ATD for Conductor Tensions 1500 kgf each

The 5-pulley-block ATD has a mechanical advantage of 5. With tensions of 1500 kgf in each conductor (i.e. messenger wire and contact wire), the total weight of the counterweight assembly would be

$$\frac{1500 \times 2}{5} = 600 \text{ kgf.}$$

A Mesh cage to be provided to prevent the theft of Counterweights.

The arrangement of counterweight assembly is shown in typical drawing no. KRDD01-TDR- GEN-GEN-OCS-DWG-00005. The counterweight assembly must be provided with a special anti-shoot arrangement, which prevents the counterweight from falling on to the track or to the ground. In case of any eventuality due to snapping of the stainless-steel wire rope or due to any other reason, hot dip galvanised protective mesh cage to be provided to avoid falling of counterweights.

5.4.4.2 The movable pulley of the 5-Pulley ATD has a range of travel of 0.85 metres in the horizontal direction. This means, the counterweights can have a maximum vertical travel of $5 \times 0.85 = 4.25$ metres. While the counterweights will be free to move over the above 4.25 metres in sections at-grade, the free vertical travel of counterweights in sections on viaduct, is reduced by the parapet height. Hence, Spring Type ATD shall be used on Viaduct which enhances the visual appeal & eliminates the limitation on maximum tension length on Viaduct.

5.4.4.3 Considering safety allowances, the maximum half tension length of OHE is 700 m, where the BWA termination is At-Grade & Spring Type on viaduct. For the above dimensions PST Contractor shall do necessary interface with Civil Contractor.

5.4.4.4 X-Y charts

With the increase or decrease in the conductor temperature, the conductor expands or contracts respectively, and as a result the movable pulley moves towards or away from the fixed pulley (i.e., towards or away from the anchor mast), causing the counterweights to travel downwards or upwards. The extent of movement of counterweight depends upon the expansion or contraction of OHE conductors. It is very important to ensure that under the extreme conditions, the counterweight assembly maintains a predetermined minimum mechanical clearance, from the bottom muff or the top anchor point. This can be ensured by maintaining pre-determined clearance of bottom of counterweight assembly from the muff (designated Y) and pre-determined distance between the axes of fixed pulley and movable pulley (designated as X). Given the maximum permissible value of travel of counterweight from the bottom most position to top-most position, the values of X and Y can be calculated for various tension lengths i.e., the distances between the fixed point of the OHE (FTA or ACA) and the location (BWA) where the ATD is provided. PST Contractor shall prepare and submit the detailed X-Y chart during construction for Client review.

5.4.5 Spring Type ATD

Spring type automatic tensioning devices use force coming from spring instead of counterweights. Comparing to the standard tensioning counterweight system, it is very compact and is lighter in terms of overall weight.

The Spring type ATD system can use linear spring or coil spring type design. The system shall be proven and in service. The Indicative drawing is attached in tender drawings KRDD01-TDR- GEN-GEN-OCS-DWG-00004.

This is for reference only; PST Contractor shall take approval from Engineer In charge before giving clearance for undertaking the manufacturing.

5.5 Anticreep Arrangement

5.5.1 As explained in 5.4 above, the tension length is provided with ATD on either end. With this arrangement, the catenary system could move in the direction of traffic, due to the interaction between the pantograph and the contact wire, unless the catenary system is 'fixed' at some point. To arrest this movement, the catenary is fixed at the midpoint of the tension length. This arrangement is called 'anti-creep arrangement' or 'mid-point arrangement'.

5.5.2 The cantilever at the Anticreep central location is provided with a suitable clamp wherein, apart from the normal messenger wire, one more messenger wire is provided and this second messenger wire, called the Anticreep wire, is anchored on masts on either side of the central mast. The catenary is thus fixed at this location, called the 'Anticreep'. Anti Slip arrangement is to be provided at ACC location (PG Clamps on either side of ACC of suitable sizes) to arrest the movement of contact wire, as required.

5.5.3 A typical 'Anticreep arrangement' drawing is shown in Drawing No. KRDD01-TDR-GEN-GEN-OCS-DWG-00012.

5.6 Termination and Anchoring arrangements

5.6.1 The Messenger wire and contact wire are linked together by a balancing plate, before anchoring to an OHE mast, through an ATD or otherwise. The balancing plate enables the tension to be equally distributed between the messenger wire and the contact wire. In special cases, the messenger wire and contact wire may be anchored separately on the OHE mast but ATD cannot be provided at such anchor location.

5.6.2 The OHE masts where the OHE conductors are terminated, are provided with a guy-rod which gets anchored on a concrete foundation (in the case of at-grade locations) or to a specially designed base plate connected by bolts to the parapet (in the case of viaduct locations) or into dwarf mast, the following typical drawings show the arrangements:

KRDD01-TDR-GEN-GEN-OCS-DWG-00026: Typical Arrangement for base plate for anchor on viaduct

KRDD01-TDR-GEN-GEN-OCS-DWG-00004 & KRDD01-TDR-GEN-GEN-OCS-DWG-00005 :
: Typical OHE termination Arrangement

5.7 Points and Crossings

5.7.1 The location of obligatory structures to support the catenary system of the main line and that of the turn-out equipment, together with their arrangement on the cantilevers, is of vital importance. Basically, the arrangement must ensure.

- That the current collection is smooth and without any sparking, and That under normal, as well as worst conditions, there is no likelihood of the overhead equipment getting entangled with the pantograph.

It is, therefore, of prime importance that the design principles at the points and crossings are strictly observed and implemented.

5.7.2 The principles of design of OHE at turnouts, crossovers and diamond crossing, for regulated OHE, are shown in typical drawing No. KRDD01-TDR-GEN-GEN-OCS-DWG-00001 & KRDD01-TDR-GEN-GEN-OCS-DWG-00013.

5.7.2.1 Turnouts

Overlap type arrangement is adopted depending upon the span and the type of equipment.

5.7.2.2 Crossovers

In this case also, overlap type arrangement is adopted depending upon the span.

5.7.2.3 Diamond Crossings

The Span on either side of the crossing will govern the type of arrangement to be used for wiring the diamond crossing.

6 CANTILEVER ARRANGEMENTS

6.1 Single cantilever on normal mast

6.1.1 The general arrangement of cantilever on a normal mast (both conventional & tramway) is shown in typical drawing no. KRDD01-TDR-GEN-GEN-OCS-DWG-00010, 00011 & 00030. Modular cantilever or SIC (Single Insulated) cantilevers of suitable design other than what is specified above shall be considered, which shall be approved by Engineer / Employer on receipt of Vendor proposal.

Preference would be given to the already proven design & successfully used in Metros / RRTS system.

6.1.2 The Modular cantilever should be of superior design and have a proven service record in similar metro rail system. It should be corrosion resistant and light weight. Part details of typical modular cantilever is shown in drawing no. KRDD01-TDR-GEN-GEN-OCS-DWG-00030.

6.1.3 PST Contractor must commit for availability of the adequate supply of spares of the material and unconditional support during the operational period i.e. even after completion of DLP, AMC & up to the life span of minimum 30 years. An undertaking to this effect should be submitted by the PST Contractor.

6.1.4 The modular type design should be with a smaller number of fittings. The number of fitting (including tubes, insulators & droppers) for the cantilever should be as small as it can be. Suitable locknuts and split pins shall be used on cantilever fasteners. Usage of Beta pins should be avoided.

6.1.5 All fastenings shall be so designed that these are easy to install and maintain.

6.1.6 The typical nominal diameter of the tube shall be:

Stay Tube: 55mm OD

Bracket Tube: 70mm OD

Register Tube: 55mm OD

The PST contractor should submit the detailed stability analysis of the various tubes considering the load of catenary wire 120 sq.mm and contact wire 150 sq.mm. Higher tube sizes should be

adopted based on stability analysis, if found necessary.

Very high pollution levels from industry, sea salt and spray should be considered. For testing RDSO Specification No. TI/SPC/OHE/MCS/0150 or equivalent EN/IEC standards shall be referred considering the catenary size of 120 sq.mm. The PST Contractor must demonstrate and certify a minimum service life of 30 years for the cantilever assembly.

6.2 Multiple brackets on normal mast

The arrangement of typical assemblies with multiple OHE's on normal mast is shown in typical drawing. No. KRDD01-TDR-GEN-GEN-OCS-DWG-00016 & KRDD01-TDR-GEN-GEN-OCS- DWG-00032.

6.3 Arrangement for Mounting Multiple Cantilevers on Mast / Drop arm

These are the small parts of steel provided in the OHE mast for the provision of multiple brackets. Normally these items are required at the location of overlap mast, obligatory structure. These should be made of steel and confirm to Bureau of Indian Standard specification IS: 2062, IS: 800 and IS: 808 all latest versions and it should be hot dip galvanized as per the RDSO specification No. ETI/OHE/13(4/84). The galvanization shall not be less than 1000gm/m².

6.4 Cantilevers on drop arms

6.4.1 In stations or yards, where the space available between the tracks does not permit location of independent masts, then the OHE is supported by means of cantilevers mounted on drop arms suspended from portal booms or truss (station roof).

6.4.2 Typical arrangement of cantilevers on drop arms from portals or station roof trusses, is shown in typical drawing No. KRDD01-TDR-GEN-GEN-OCS-DWG-00014, KRDD01-TDR-GEN-GEN- OCS-DWG-00015 & KRDD01-TDR-GEN-GEN-OCS-DWG-00031.

Drop arm support from the station roof truss is to be provided by the station building contractor, PST contractor shall interface for its provisions.

6.5 Arrangement for Catenary system / Overhead conductors from under the roof at stations

These are the small part of the steel as per the typical drawing no. KRDD01-TDR-GEN-GEN- OCS-DWG-00014 & 00015. This is also known as DA in Indian railway. The DA should be Rolled Steel Joists (RSJ) or Broad Flange Beams (BFB) type. The DA should confirm to Bureau of Indian Standard specification IS: 2062, IS: 800 and IS: 808 all latest versions and it should be hot dip galvanized as per the RDSO specification No. ETI/OHE/13(4/84). The galvanization shall not be less than 1000 gm/m².

6.6 Bolts, nuts and washers

The Anchor U-Bolts for the indigenous fittings should meet RDSO specification TI/SPC/OHE/Fasteners/0120, latest version for Steel fasteners & Stainless-Steel fasteners for 25 kV AC Traction OHE.

All bolts, nuts, washers and split pins shall be used as per approved drawings and should only be procured from approved vendors. Proper identification marks should be there to identify the make of the nut, bolts and washers.

All SPS, nuts, bolts, washers etc should be suitable for very high pollution zone. Grade of all steel nuts, bolts, washers should be 8.8.

7 OVERHEAD CATENARY SYSTEM

7.1 Contact Wire

The contact wire shall be of 150 sq.mm flat bottom Silver bearing Grooved Copper conductor (CU Ag0.1). Contact wire shall conform to EN 50149 (latest revision) or specification approved by Engineer / Employer.

Contact wire of 107sq.mm hard-drawn copper shall be used in Depot.

The contact wire shall be tested, checked and results shall be confirmed in accordance with EN 50149 and RDSO Specification no. ETI/OHE/76(6/97).

7.2 Messenger wire

The Messenger wire shall be 120 sq.mm Magnesium Copper BZ II stranded conductor conforming to RDSO Specification no. ETI/OHE/50(6/97) or DIN 48201-2 or equivalent international standard.

The messenger wire shall be tested, checked and results shall be confirmed in accordance with RDSO Specification no. ETI/OHE/50(6/97) or equivalent international standard.

The messenger wire will be protected with an insulated cover (MVLC) to avoid faults caused by birds at stations & at portal locations & also at crossings like FOB, ROB etc.,

7.3 Bridle wire

Bridle wire shall be of cadmium copper, consisting of 37 strands each of 1.1 mm diameter with a nominal cross section of 35 sq. mm and overall diameter of 7.7 mm. The Bridle Wire shall conform to Indian Railway's RDSO specification ETI/OHE/50, Latest version, for cadmium copper conductor.

7.4 Droppers

The contact wire is suspended from the messenger wire by means of suitable droppers.

Suitable current carrying droppers, at least 12 sq.mm, with proper clamping arrangement to be utilised, in consultation with Engineer in Charge. Preference would be given to the already proven & successfully used in earlier phases Metro / RRTS System. The fastening arrangement shall be provided with locking arrangement to withstand vibrations. Typical arrangement is shown in tender drawing no. KRDD01-TDR-GEN-GEN-OCS-DWG-00021.

In addition, the Register arm of the cantilever assembly is supported from the bracket tube by means of a stainless-steel dropper, called "inclined dropper".

Droppers shall be tested, checked and results shall be confirmed in accordance with EN 50119 and RDSO Specification no. TI/SPC/OHE/Fitting/0130(10/13) as applicable.

7.5 Jumpers

7.5.1 Three sizes of jumpers will be used in the OHE.

26 sq.mm jumper of annealed copper, consisting of 19 strands, each strand containing 7 wires each of 0.5 mm diameter, with a nominal Cross Section of 26 sq.mm and diameter of 7.5mm. This is used as In-span jumper. "C / H" jumpers shall be provided at every 200 m. (KRDD01- TDR-GEN-

GEN-OCS-DWG-00018).

Jumper of same cross-section, but two number ("F" jumper) will also be used at IOL locations on both the termination spans. Typical arrangement is shown in tender drawing no. KRDD01- TDR-GEN-GEN-OCS-DWG-00019.

2x164 sq.mm jumper of annealed copper with suitable crimped PG clamps on both catenary and contact wire, is used as Continuity jumper. (KRDD01-TDR-GEN-GEN-OCS-DWG-00017).

2x164 sq.mm jumper with suitable crimping arrangement, shall be used for jumper connections between various current carrying equipment as decided by Engineer in Charge.

75 sq.mm Jumper connection to 25 kV potential transformers & 42 kV Lightning Arrester shall confirm to RDSO Specification.

Anti-theft jumper of 50 mm sq. nominal, 19/1.8 mm in size shall be used in out of run wire of conventional OHE and anti-creep wire as an anti-theft measure.

All Jumpers shall relate to bimetallic strip where two different metals are connected.

The length of jumpers should be calculated based on the clearances required after considering the movement of conductors: catenary wire and contact wire, due to temperature variation, etc at all locations.

Each Jumper of switching posts, section insulators should be supported on at least two no of pedestal insulators in such a manner that loose/hanging jumpers are avoided. No separate payment shall be made for pedestal insulators required for jumper assembly installation.

For all continuity jumper connections, the crimping arrangement of suitable thermal and current carrying capacity will be used. Wherever crimping is unavoidable, prior approval of Engineer In charge will be taken.

7.6 Other conductors and cables

7.6.1 Feeder wire

2 x 145 sq.mm feeder wires shall be used, as required, on the Overhead Catenary System with due approval from Engineer in Charge.

7.7 Insulated Sleeves (MVLC)

Insulated sleeves (openable) along with shrouds shall be provided on catenary wire at portal locations. Similar arrangement shall also be done on catenary wire near cantilever assembly at platform area and other bird infested locations to prevent damage due to short circuits caused by birds. The sleeve shall be of proven and type tested with a third-party laboratory.

7.8 Overhead Protection Conductor (OPC)

The OPC shall be of 93.3 sq.mm ACSR conductor & shall run on the mast at the highest point on the mast all along the entire corridors (Mainline + Depot (all lines) + Sidings). It is provided at station area on the support provided by the civil contractor on each station trusses. An ACSR conductor, consisting of 7 steel wires each of 2.5 mm diameter and 12 aluminium wires also of 2.5mm diameter each, with a nominal cross section of 93.3 sq.mm shall be used as OPC. The overall diameter of the conductor is 12.5 mm. The ACSR conductor shall conform to Bureau of Indian Standard specification IS: 398 (Part II)-Latest Revision.

7.9 Buried Earth Conductor (BEC)

The BEC shall be of 93.3 sq.mm ACSR conductor & shall run on the cable trough / bracket throughout the entire corridor (Mainline). An ACSR conductor, consisting of 7 steel wires each of 2.5 mm diameter and 12 aluminium wires also of 2.5 mm diameter each, with a nominal cross section of 93.3 sq.mm shall be used as BEC. The overall diameter of the conductor is 12.5 mm. The ACSR conductor shall conform to Bureau of Indian Standard specification IS: 398 (Part II)- Latest Revision.

Every mast on Main line (At-grade) shall be connected to OPC at the top & to BEC at the bottom.

Every mast on Main line (Viaduct) shall be connected to OPC. BEC

shall not be used in Depot.

7.10 Return conductor (RC)

All aluminium conductor (SPIDER) consisting of 19 strands each of 3.99 mm diameter, with a nominal cross section of 233 sq.mm(min) is used as Return Conductors.

The overall diameter of conductor is 19.9 mm. The SPIDER conductor shall conform to Bureau of Indian Standards, specification IS:398 (Part I)-Latest Revision. However, size shall be as per simulation study results.

RC shall run on the masts at all locations on the entire corridor through clamping. In station areas, return conductor will be supported by the support provided by civil contractor on each station trusses.

OPC & RC shall be taken through super mast or by the provision of pedestal supports at the sensitive locations such as at double & triple cantilever assemblies', BM's, isolators, FPs, Neutral Section locations etc., to meet the long-term clearance of live to earth if required. No separate payment shall be made for pedestal supports / super masts required for this purpose.

RC shall be provided on Main line only, shall not be provided in Depot & sidings.

7.11 Large Span Wire

Large Span wire shall conform to Latest RDSO standard.

7.12 Moveable / Retractable Overhead Catenary System

The Moveable/Retractable Overhead Catenary system is like the Normal Rigid Overhead Catenary system but can be retracted from its mean position. In Mass rapid transit system, it is used in depots for the lines where maintenance of the roof equipment like Air conditioner, Pantograph of the Rolling Stock, etc. is done.

SL NO.	SPECIFICATION	VALUE
1	Standard	As per proven system and equivalent standards
2	Type	Used in existing Metro / RRTS depots (Aluminium conductor rail)
3	Conductor rail cross section (min.)	2200 sq.mm

4	Nominal voltage at 50 Hz (line to earth)	25 kV
5	System voltage can go up to	As per EN 50163
6	Creepage distance of insulator	1600 mm
7	Ambient temperature	45°C
8	Environmental conditions	Heavy Air Pollution
9	Basic wind speed	33 m/s
10	Max. temperature of contact wire	80°C
11	Maximum train speed	15 kmph
12	Contact wire as per EN 50149	Cu-ETP. 107 sq.mm.

The Moveable/Retractable OCS is installed in the Maintenance shed portion i.e. Inspection Bay of the depot. Moveable/Retractable OCS is connected to the Tramway OHE of depot through the Transitional element. The AC supply of 25 kV is feed through the Double pole isolator provided outside the inspection / Maintenance shed like the normal inspection shed. The Double pole isolator used in the Retractable OCS system is like the double pole isolator used in the OHE yard. The double pole isolator feeds the supply to transition element. The transition element is further connected to the retractable OCS through the movable joints. The Motors are provided at the support locations of the Retractable OCS system.

Advantages of the Retractable Overhead Catenary System are:

- No vertical obstruction to maintenance personnel while working on the roof of the train.
- Physical separation of the Retractable OCS from the charged section to ensure the safe working condition.
- Possibility of the minor Maintenance like replacement of the pantograph, other roof mounted devices in the inspection line itself by use of cranes, without taking the train to the workshop tine.

The retractable OCS system is used in the Inspection Bay Lines in the Depots. Rigid OCS is hanged from several swiveling jib arms/ Cantilever. Some of the Swiveling arms/ Cantilever are motorized whereas others are not. To ease the Rolling Stock roof maintenance operation, the retractable OCS enables:

1. **In Normal position:** The arrival and departure of trains by electrical traction inside the building, the train electric motors testing, pantograph testing, and other operation requiring overhead contact line.
2. **In "Retracted" position:** Any maintenance work on the roof of the rolling stock can now be done easily by means of roof working platforms, lifting platforms or baskets, or gantry crane on the total length of the workshops.
3. The swiveling action to retract the OCS is only possible when following safety conditions are met:
 - a. Power supply of the Retractable OCS is switched off.
 - b. Foot bridge access can be provided only after the switch off Retractable OCS Power supply.
 - c. Gantry crane can move only when the power supply of Retractable OCS is switched off and the Retractable OCS has been retracted.

	Messenger/Anti- Creep Wire	Contact Wire (main line)	Contact Wire (depot)	OPC	Buried/Structure Earth Conductor	Drop Wire	Copper Bridle Wire	In-Span Jumper	Feeder Wire	Continuity Jumper Wire G JUMPER	Continuity Jumper Wire at PT / LA / CVS
Material	Cu-Mg BZ II	Cu-Ag0.1	Cu-ETP	ACSR	AAC	Bronze, 12B	Cadmium Copper	Annealed copper	Electrolytic Copper	Annealed copper	Annealed copper
Cross Section (sq. mm)	116.99	150	107	93.3	237.6	12 (min)	35	26	145	164	75
Diameter (mm)	14.0	14.50	12.24	12.50	19.95	5	7.7	7.5	15.7	18.35	12.7
Made of	19 strands x 2.80 mm diameter	Solid conductor with identification groove	Hard drawn grooved copper	7 steel wires and 12 aluminium wires each of 2.5 mm	19/3.99	7x0.65 + 42x0.54	37/1.1	19/7/0.5	37/2.24	37/7/0.9	37/7/0.61

Approximate Linear Weight (Kg/m)	1.060	1.3335	0.9515	0.437	0.654	0.103	0.319	0.246	1.29	1.465	0.67
Breaking Stress* (kgf)	6890	5341	3812	4610	3643	708	As per standard	As per standard	As per standard	As per standard	As per standard
Coefficient of Linear	17×10^{-6}	17×10^{-6}	17×10^{-6}	18×10^{-6}	23×10^{-6}	-	17×10^{-6}	17×10^{-6}	17×10^{-6}	17×10^{-6}	17×10^{-6}
	Messenger/Anti-Creep Wire	Contact Wire (main line)	Contact Wire (depot)	OPC	Buried/Structure Earth Conductor	Drop Wire	Copper Bridle Wire	In-Span Jumper	Feeder Wire	Continuity Jumper Wire G JUMPER	Continuity Jumper Wire at PT / LA / CVS
Expansion per K											
Equivalent Copper Conductivity (%)	Minimum 36 m / Ωmm^2	97%	97%	61% (Alu.)	61%	72%	80%	100%	98.9%	100%	100%
Resistivity at 20°C in $\Omega \cdot \text{m}$	2.778×10^{-8}	1.777×10^{-8}	1.777×10^{-8}	-	-	-	-	-	-	-	-
Specification	DIN 48200-2, 48200-3, 48201-2.	EN 50149 Flat bottom	EN 50149	IS 398 (Part-II)	IS 398 (Part-I)	TI/SPC/OHE/Fittings/0130(10/13)	ETI/OHE/50	DIN 43138 or RDSO equivalent	NFC 34-110-3 or RDSO equivalent	NFF 55-681 or RDSO equivalent	NFF 55-681 or RDSO equivalent

Table 8 OHE Conductor Details

Note: GTP of all the above conductors shall be approved by Engineer / Employer.

Bi-RIDE

8 INSULATORS

8.1 Cantilever Insulators

Silicone composite insulators, conforming to latest RDSO specification TI/SPC/OHE/INSCOM/1071 latest version shall be used as stay tube insulators and Bracket insulators on the cantilever. The composite insulators have the following distinct technical advantages.

- Superior pollution performance
- Impact Resistance
- Higher mechanical reliability
- Better dielectric characteristics
- Low leakage current and power loss
- Light weight
- Better aesthetics

Composite type stay tube and Bracket tube insulators shall be used in mainline and depot. The creepage distance of insulators should be 1600mm.

To avoid failures of the bridging of insulators due to birds, circular discs made of cast acrylic sheet or as per specification specified by Engineer In charge shall be provided on the HT side of stay tube and bracket tube insulators.

Before insulators are used in bracket assemblies or dispatched from the Contractor's Depot to work site for erection, they shall be tested as specified for routine mechanical test. NO chipped or cracked insulators shall be installed. All insulators shall be cleaned before offering complete wired sections for inspection and testing.

8.2 Tensioning Insulators

Cut-in-insulators and termination insulators on the OHE system consisting of catenary and messenger wire, shall be of silicon composite type conforming to latest RDSO specification. The creepage distance of insulators should be 1600mm.

8.3 Post Insulators

The insulator shall conform to the latest RDSO Specification. The creepage distance of insulators should be 1600mm.

8.4 Light weight Section Insulators (Main Line)

8.4.1 Section insulators are deployed when it is necessary to electrically separate one section of the OHE from another. The normal section insulator assembly consists of a Tensioning Insulator (9 tonne) on the catenary wire and an arrangement involving copper runners and sectioning insulator on the contact wire. The above arrangement provides the necessary insulation between adjacent sections of the OHE.

8.4.2 Section Insulators specially to meet the following requirements, are used on the OHE.

- Light weight
- Better current collection
- Long Life permitting many panto-passages per day.
- Less maintenance. The skids do not require frequent checks and adjustments thereby permitting the Section Insulators to be left unattended for long periods.
- Usable at higher speeds up to 120 kmph. In reverse direction, it shall be up to 100 kmph.

8.4.3 The use of section insulator has been restricted to places in Main lines where insulated overlap assembly is not possible and in sidings and depot lines.

8.4.4 Section Insulator should be used at least 5 years in any metro / railway / RRTS system.

8.4.5 The PST Contractor should give 5 years warranty for section insulator.

8.4.6 The metallic part forming the air gap in the section insulator assembly shall have smooth surface.

Sr. No.	SPECIFICATION	VALUE
1	Standard	RDSO Spec no. TI/PC/OHE/LWTSI/0060 and IEC 61109 / IEC 60507 / EN 50119
2	Type	Silicone Composite insulator, for 150 sq.mm contact wire (Cu-Ag0.1) and 120 sq.mm messenger wire (BZ II)
3	Nominal voltage at 50 Hz (line to earth)	25 kV
4	System voltage can go up to	EN 50163
5	Creepage distance of insulator	1600mm
7	Air Gap	220 mm
8	Maximum working load	26 kN
9	Min. Breaking load	80 kN
10	Shed and sheath material of insulator	Made of HTV type silicon rubber having silicon content between 40-50% and preferably alumina tri hydrate as filler
11	Core material of the insulator	Boron free, electrically corrosion resistant grade fibre reinforced epoxy resin rod having at least 70% fibre by weight
12	Dry condition of flashover	78.3 kV
13	Wet condition flashover	64.5 kV

8.5 Section Insulators (Depot, Tramway OHE)

SL NO.	SPECIFICATION	VALUE
1	Standard	RDSO Spec no. ETI/OHE/27(8/84) with A & C Slip No-1
2	Type	Composite insulator, for 107 sq.mm contact wire (Cu-ETP)
3	Nominal voltage at 50 Hz (line to earth)	25 kV
4	System voltage can go up to	EN 50163
5	Creepage distance of insulator	1200 mm/1600 mm (As per Availability)

8.6 Short Neutral Section (SNS) what is the length

SL NO.	SPECIFICATION	VALUE
1	Standard	RSDO Spec. TI/SPC/OHE/SNS/0000 and IEC 61109 / IEC 60507 / EN 50119
2	Type	NS25 or equivalent suitable for 150 sq.mm contact wire (Cu-Ag0.1) and 120 sq.mm messenger wire (BZ II)
3	Speed Potential	120 kmph (min.)
4	Application	Outdoor
5	Neutral Section Insulator	Glass fibre rods covered by virgin PTFE (self-cleaning ability under rainwater and a low wear rate). The rods can be turned 4 times after permitted wear on one side to guarantee a live time of 2 – 4 million passages of pantographs.
6	Material	Copper runners and stainless-steel arching horns
7	Breaking Load	>80 kN per Insulator rod and 120 kN for neutral section (no sliding until full breaking load of contact wire)
8	Bending strength of insulator rod	350 Nm
9	Spark extinguishing	100% when locomotive is not switched off while passing neutral section
10	Creepage distance (insulator rod as well as NS insulator)	2500 mm
11	Power frequency withstand voltage dry	>600 kV for insulator rod and >500 kV for Neutral Section insulator
12	Power frequency withstand voltage wet	>395 kV for insulator rod and >300 kV for Neutral Section insulator
13	Lightning impulse withstand voltage dry	>950 kV for insulator rod and >800 kV for Neutral Section insulator
14	Power frequency pollution withstand voltage as per IEC 507 (224g/m ³)	>60 kV for both
15	Insulation resistance	>1.2 GΩ for both
16	Leakage current	<120 μA for both
17	Arc withstand property	10 kA / 0.15 s for neutral section
18	Water absorption	No water absorption
19	Vibration performance	Resistant against vibrations
20	Wearability	>2x10 ⁶ passage for insulator rod and >5x10 ⁶ passage for neutral section insulator
21	Service life	>20 years (without considering the aging and wear resistance at direct sliding of the insulator)

9 OHE SUPPORTS

9.1 Independent masts (Depot Tramway)

- 9.1.1 Broad Flange Beams (BFB), Fabricated B-Series Structures of IR design are used as independent masts. BFB's and B- Series Structures of Indian origin shall confirm to Bureau of Indian Standard specifications IS: 2062, IS: 800 and IS: 808, all latest versions.
- 9.1.2 The independent mast supporting the OHE, will be grouted in a foundation at ground level. The Erection contractor will have to prepare drilling schedule to provide the necessary drilled holes on the masts to meet the requirements, for mounting cantilevers, anchor fitting, number plates etc. Drilling will have to be done before galvanizing.
- 9.1.3 The Steel masts shall be hot dip galvanized in accordance with Indian Railway's RDSO specification ETI/OHE/13(4/84), latest version. The galvanization shall not be less than 1000gm/m².

The mast at-grade shall be embedded in a concrete foundation, according to specifications and grouted.

9.2 Independent Masts (Conventional Main Line)

The flexible OHE is required to be provided on sections on Viaduct & At-grade (together called as Main Line) and in Depots and approaches there to.

In the viaduct portion of Main line section, the traction overhead equipment will be supported from galvanized steel IR masts/portals, fastened to the parapet with the help of galvanized steel base plates and bolts and nuts.

Considering the beautiful landscape & pleasant weather of Bengaluru, type of mast that shall be provided on Main Line supporting OHE shall be aesthetically appealing & meeting the landscape of the city as well.

At at-grade portion of Main line, OHE will be supported from galvanised steel structures (Tubular poles / IR masts / IR portals / Tubular Portals) via grouting in foundations.

In the case of at-grade sections and in the Depot, the traction galvanised steel structures (Tubular poles / IR masts / IR portals / Tubular Portals) will be provided with concrete foundations.

The type of mast that shall be used on Main line should be of proven system & already in service in the existing Metros / RRTS systems.

9.3 Portals (Depot & Main Line)

- 9.3.1 Indian Railways RDSO type N, O, P, R, BFB portals may be used in yards, depots & mainline / sidings.
- 9.3.2 On Viaducts, the portals must be provided with base plates to enable the uprights to be fastened to the parapet. Locations to be interface with Civil Contractor.
- 9.3.3 Wherever multitrack portals are used in Yards / Depot, OHE's nearest to the uprights will be supported by cantilevers mounted on the portal uprights. OHE's relating to intermediate tracks shall be supported by means of drop-arm attached from underside of such portal. A typical

general arrangement of cantilevers on Portals is shown in drawing no. KRDD01-TDR-GEN- GEN-OCS-DWG-00031

9.3.4 For portal, only factory fabricated galvanised uprights of portal shall be erected.

9.4 Blanketing of masts and portals:

To avoid / prevent bird nesting, blanking of B-series mast (by SS / PVC mesh) and portals to be provided. Blocking of hollow Drop Arm (DA) supports by GI sheet to be provided at all locations in station area. In addition, proper blanking by SS sheets to be provided at structures within bird menace areas. Mast drilling schedule should have a provision for fixing of GI sheet blankets.

9.5 Earthing of masts and portals:

Earthing of OHE masts and structures shall be done with the help of OPC and BEC (with suitable T- connector) that are laid on Main Line. OPC is connected to every mast through clamping.

10 OHE FOUNDATIONS

10.1 General

At 'At-grade', concrete foundations shall be used for supporting the OHE masts and portals. The foundations shall be generally in accordance either with RDSO drawings or the design approved by Engineer / Employer.

10.2 Design Principles of OHE Foundations

10.2.1 The concrete foundations shall withstand safely, the vertical loads and the bending moments arising parallel and perpendicular to the track. The principal loads which are required to the reckoned while arriving at the vertical loads and bending moments are

- Weight of the OHE, weight of cantilevers including insulators etc., weight of any equipment such as isolator, interrupter etc. on the structure, weight of structure itself.
- Radial forces arising out of the pull-on contact wire, messenger wire, anti-creep wire, feeder, etc. and the bending moments occurring on the top of foundation due to such radial forces.
- Wind forces, due to wind blowing parallel or perpendicular to the track, on conductors, cantilevers, pole-mounted equipment and on the structure, itself.
- In addition, weight of a man standing on the cantilever shall also be considered for calculating the bending moments and direct load. However, when the effect of full wind is taken in the calculations, for any case of load combination, the effect of the weight of a man standing on the cantilever need not be considered, as an addition. In other words, the more severe case between the two alternatives viz. (a) without man and with wind and (b) with man and with reduced (20%) wind load, shall be considered.

10.2.2 The foundations designed shall be checked for safety against Seismic forces (Zone II) in accordance with IS:1893-2002 or Latest Version.

10.3 Types of foundations

10.3.1 The following types of foundations are used

- a). Side Bearing: This type is generally used in level grounds, cutting and good consolidated embankments with sufficient shoulder width.

b). Side gravity: This type is used in good, consolidated embankments, where the shoulder with is insufficient.

c). Pure gravity: This type is used in unconsolidated banks and in ash filled areas.

d). New Pure gravity: This type is used in consolidated banks and in ash filled areas. This is a modified and economical.

e). Cylindrical: These are recently being implemented in IR Projects. These are economical & time saving. Already approved type of cylindrical foundations that are being followed in Indian railway projects can be used. Any new case obtained on account of change in soil type or soil bearing pressure etc., for which approval is to be taken from Engineer / Employer.

f.) In those areas, where black cotton soil is encountered, special Black Cotton soil foundations may be used.

The decision to go with conventional foundations or cylindrical foundations or a combination of both lies with Engineer/Employer.

10.4 Soil pressure

10.4.1 Soils are classified in accordance with their capability to withstand the mechanical forces to which they are subjected. They are generally defined in terms of maximum permissible pressure which could be withstood by them.

10.4.2 Three types of soil are considered

a). Normal Soil: Maximum permissible pressure is 0.11Mpa to 0.22MPa

b). Rocky Soil: Maximum permissible pressure is 0.5MPa to 1.0Mpa, for soft rock and 2.4Mpa for hard rocks

c). Loose Soil: Maximum permissible pressure is 0.06MPa.

Contractor shall get soil testing done to verify soil bearing at a stretch of not more than 2 km of OHE foundations and wherever soil strata changes.

10.5 Concrete Mix

10.5.1 Concrete for foundations shall be of nominal mix of grade M-20 obtained by mixing cement, coarse aggregate, fine aggregate and water in accordance to IS:456-2000.Latest Version.

10.5.2 For grouting, muffing and embedding of structures, in foundations and for cable trenches at switching stations, nominal mix concrete M-20 shall be used, in accordance with IS:456-2000. Latest Version.

Concrete Poles shall be grouted with dry sand. The core hole after sand grouting shall be sealed with a 10cm layer of Bitumen before Muffing is provided to prevent any ingress of water into the Core hole.

10.5.3 In judging the acceptability of the materials, quality of concrete & the method of work, the Engineer will generally observe the provisions of the "IS code of practice for Plain & Reinforced

Concrete, IS:456-2000 or latest. The crushing strength of concrete shall not be less than the limits mentioned below (as per IS-456:2000 or latest):

Grade of concrete	At 28 days age
M15	15 N/sq.mm
M20	20 N/sq.mm

Test Specimen of work tests shall be taken at the site of work from mixture of concrete ready for pouring into the foundation hole. All tests shall be carried out in accordance with IS:516-1989 or latest. The sample of concrete from which test specimens are made shall be represent the entire batch. Age is reckoned from the day of casting.

The indicative compressive strength of 15 cm cubes at 7 days shall normally be 67% of same value at 28 days for every 50 cubic meter

10.6 Anchor blocks

10.6.1 Use of concrete anchor blocks shall be in accordance with Indian Railway's RDSO drawings or the design approved by Engineer / Employer.

10.7 Equipment pedestals

10.7.1 Pedestals for Control and Monitoring panels at grade, where required, shall be of mass concrete M-15 in accordance with IS:456-2000.Latest Version.

10.8 Details of Cements to be used

Ready Mix Concrete (RMC) is preferred for civil works.

10.9 Sampling of the cubes

Testing of cement concrete cube as per IS 516:1959

Normal cube size is 6x6x6 inches i.e., 15.24x15.24x15.24 cm

11 BOLTED BASE MASTS / PORTALS

11.1 Base plates

11.1.1 As already stated, the OHE structures and portal uprights to be located on the viaduct parapet are required to be provided with steel base plates, welded to the structure/upright. The typical arrangement of base plates for structures/uprights and for anchor on viaduct, are shown in drawings KRDD01-TDR-GEN-GEN-OCS-DWG-00026. It should be ensured that the steel used for base plates shall be of weldable quality. Nut along with check nut should be provided for fixing the structure with base plate on to the U bolt provided in Viaduct.

11.2 Anchor bolts (if required)

Anchor bolts, suitably designed, to transmit the mechanical forces from the structure to parapet, shall be provided by the viaduct contractor (see interfacing document) at the time of casting and

installation of parapets. It is important that these anchor bolts are provided, strictly in accordance with design (bolt diameter, spacing etc.), failing which could lead to problems in installation of structure / uprights on viaducts.

Note: The nuts, locknuts and washers etc. as required will be supplied by PST Contractor for completion of Job.

12 TRACTION RETURN CURRENT CIRCUIT

12.1 Longitudinal Continuity

Longitudinal continuity in the traction return circuit must be ensured.

The return path is:

- Primarily, made up by the Return conductor followed by Rails, OPC, BEC. In

addition, cabling is necessary to link:

- The tracks to the Traction Sub-Station
- Each track to the others as per approved Earthing and Bonding plan.

These cables make up the return links. The traction current return circuit must have minimum equal number of conductors to that of 25kV feeding conductors for each feeding zone. Any additional number of return conductors decided by Engineer In-Charge, shall also be provided.

In electrification at 25 kV AC., the traction return circuit must be as closely linked as possible to the earth.

The longitudinal continuity of the return circuit must be such that it provides the shortest, most direct path to the Traction Sub-Station with the least impedance possible.

12.1.1 Turnouts

To ensure proper bonding in the switch gear, the return circuit is made up of an association of longitudinal and transverse connections.

12.2 Integral Transverse Links (ITL)

12.2.1 ITL Plate shall be made of GI / Aluminium alloy plate with holes drilled as per typical drawing No. KRDD01-TDR-GEN-GEN-OCS-DWG-00020.

12.2.2 Integral Transverse Links (ITL) shall be provided, to establish interconnection between BEC, RC, OPC and track at appropriate locations. ITL should be provided on approx. every km (max). The interval of ITL to be reduced to 500 m in area where hospital is in close vicinity of 200 m.

12.2.3 Connections between aluminium conductors and copper terminals or between copper conductors and aluminium terminals will be made by means of bimetallic connections. Wedge type PG to be used for cable connection at OPC / RC and other end of cable to be connection with ITL.

12.2.4 The Integral Transverse Links (ITL) provides the necessary transverse connection between the various paths carrying the return current. At ITL locations the OPC, BEC, RC and Rail are connected.

12.2.5 The aim of Integral Transverse Links is to:

BI-RIDE (BSTP/PST – C2 & C4)

- Reduce the rail/earth voltages (Touch Potential)
- Ensure sharing of return current between different tracks and return conductor
- Equalise the potential of the two rails of the same track (for rails not fitted with TC)
- Link electrically sidings and main track
- Interconnect certain parts of the switchgear to provide a better return path

12.2.6 ITL shall be realised by crossing cable (2x240 / 2x400 mm² Aluminium 3.3kV insulated cables), connected to up and down tracks.

12.2.7 The chainage of ITL locations required for 25kV traction system shall be decided with the consultation of the signalling contractor, to

- Finalise the ITL locations based on signalling plans and track circuiting diagrams

The PST Contractor shall interface with the Signalling Contractor to finalise the locations.

12.2.8 It may be noted that drilling of holes is not permitted in the head hardened rails. All connections to rails must be done by cad-welding.

12.2.9 All connections to ITL from BEC, OPC, RC to be with AI cable in Rail corridor.

12.2.10 The connections to ITL coming from OPC / RC / Rail / BEC shall meet the respective sizes accordingly.

Note:

1. Head hardened rails is being used for Main line C-2 & C-4.
2. Entry, Exit & Test track inside depot will be head hardened rails. All other tracks inside Depot will use 880 grade (Non- Head hardened) rails.

13 EARTHING AND BONDING

13.1 General

13.1.1 In sections where the tracks are laid 'at grade', bonding and earthing arrangements, as adopted on the Indian Railways, should be provided with the provision of OPC instead of structure bond. However, in sections where the tracks are laid on viaduct, suitable arrangements will have to be made to ensure.

- a safe low resistance path for the return current from the rail to earth and back to traction substation.

- Avoidance of dangerously high 'touch potentials' along the viaduct portion.

13.1.2 The European Norms EN 50122-1 and 50122-2 and Bureau of Indian Standards specification IS: 3043, shall be followed for the earthing and bonding arrangements.

13.2 Buried Earth Conductors and connections

13.2.1 The following earth conductors will be provided as part of the OHE.

1 run of 93.3 sq.mm Aluminium stranded conductor per track shall be provided both for elevated & At-grade section of both corridors.

13.2.2 The following connections are established or are required to be established by means of suitable cables / conductors, through appropriate terminals and connecting plates.

13.2.2.1. Connections established by the Viaduct Contractors:

(a). A non-structural earthing re-bar (T20) is provided by the Viaduct contractor inside each Pier Cap. An Earth plate is also provided, and an internal connection is established between the earthing re-bar and the Earth plate.

(b). Similarly, a non-structural earthing re-bar (T20) is provided inside the girders. Earth plates are provided at appropriate locations, as per design, based on the type of girders used for construction of Viaduct. For illustration, the Earthing on Viaduct adopted for Connections to be established by Contractor

13.2.2.2. Connections to be established by PST Contractor

(a). Connection between the various Earth plates provided on the pier / girder etc shall be connected suitably by means of flexible connectors. This will ensure a continuity of earth connection between the various components of viaduct.

(b). Connection between the Buried Earth Conductor and Earth plate provided on the girders shall be established by the PST Contractor. This connection must be at the rate of one at each end of span i.e. 4 per span. In addition, the end segments of each span are to be connected to the earth plates on pier cap.

(c). Connection between Buried Earth Conductor and all metallic structures like the platform canopy, foot bridges etc, shall be established by PST Contractor.

(d). Integral Transverse Links (ITL) shall be provided, to establish interconnection between Earth conductor and track at appropriate locations. Earth conductor to Rail connection shall be provided through Al cable of 93 sq. mm.

(e). Connections between aluminium conductors and copper terminals or between copper conductors and aluminium terminals will be made by means of bimetallic connections.

(f). In Depots, there will not be installed Buried Earthing Cable. Therefore, OPC will be provided and connected to Earth Pits.

(g). Buried Earth Conductor shall be connected to Main Earth Terminal (MET) inside to each ASS.

(h). Isolator / BM masts at Feeding Post, SP, switching stations etc., shall be connected to Buried Earth conductor.

13.2.2.3. The following Earthing drawings may be referred to

PIER / PILE Earthing Arrangement	KRDD01-TDR-GEN-GEN-TPS-DWG-00001
TYPICAL INTEGRATED EARTHING SCHEME - EARTHING & BONDING ARRANGEMENT AT VIADUCT	KRDD01-TDR-GEN-GEN-TPS-DWG-00002
TYPICAL EARTHING ARRANGEMENT OF U GIRDER	KRDD01-TDR-GEN-GEN-TPS-DWG-00003
TYPICAL INTEGRATED EARTHING SCHEME - NOISE BARRIER EARTHING ARRANGEMENT AT VIADUCT	KRDD01-TDR-GEN-GEN-TPS-DWG-00004
TYPICAL CABLE BRACKET ARRANGEMENT ON VIADUCT	KRDD01-TDR-GEN-GEN-TPS-DWG-00005
TYPICAL CABLE SUPPORT ARRANGEMENT BELOW VIADUCT FOR CABLE ENTRY	KRDD01-TDR-GEN-GEN-TPS-DWG-00006

TYPICAL CUTOOUT ARRANGEMENT ON PARAPET FOR CABLE ENTRY TO VIADUCT	KRDD01-TDR-GEN-GEN-TPS-DWG-00007
GENERAL ARRANGEMENT OF EARTHING AT STATION CANOPY	KRDD01-TDR-GEN-GEN-TPS-DWG-00008
GENERAL ARRANGEMENT OF EARTHING AT I GIRDER	KRDD01-TDR-GEN-GEN-TPS-DWG-00010

13.3 Bonding

- 13.3.1 Apart from the bonding between earth conductors and non-current carrying metallic objects, as visualised above, it may be necessary to provide longitudinal track bonds and transverse bonds in non-track-circuited areas, to ensure a longitudinal continuity for the traction return current. These arrangements, as described in para 12 above, will require to be finalised, in co-ordination with the Signalling Contractor.
- 13.3.2 All connections to head-hardened rails shall have to be made by means of cad-welding and not by drilling holes in the rail webs. Cad welding shall conform to IEEE 837 or equivalent standard and shall be done by an approved agency. Locations of cad welding will be as per approved Earthing and Bonding Plan.
- 13.3.3 The PST Contractor shall ensure and do the continuity of track by Cad welding. Necessary interface shall be done with track contractor in this regard.

13.4 Lightning Protection

The primary purpose of a lightning arrester is to protect the system from getting damaged by the over-voltages caused due to lightning strokes and switching surges. Lightning arresters absorb the energy and reduce the over voltage in the system.

13.4.1 Protective Provisions on the Overhead Contact Line System

At each feeding point, at the ends of the feeding sections and dead-end feeders, at the coupling points and at the equipment locations, lightning arresters shall be installed. Additional arresters are recommended for line sections often hit by lightning strikes at the endangered positions.

The arresters are preferably fitted at the height of the overhead contact line so that the electrical connection can be installed in a short, straight way.

Moreover, at At-grade locations the arresters are to be connected to the earth electrodes directly. An Earth pit must be provided at the locations where LA is present. Two connections are to be made one from LA to earth pit & another from LA to BEC. In case of viaduct, the arrester is to be connected directly to the earth plate present on Pier cap & another to BEC.

For reference Sectioning diagram may be referred:

KRDD01-TDR-CR02-GEN-OCS-SEC-00002, KRDD01-TDR-CR04-GEN-OCS-SEC-00002.

13.4.2 Protective Provisions in the Substations

Overvoltage protection is achieved by protecting the feeder cables and the return cables in the substations by way of arresters or surge protective devices.

The connecting cables of the arresters and the surge protective devices shall be as short as possible, and they should be short circuit proof.

14 ELECTROMAGNETIC INTERFERENCE

14.1 General

The 25kV Single phase AC Electrification system is likely to cause electromagnetic interference in

the adjacent installations. The PST Contractor shall follow the requirements indicated in IEC61000-5 installation and Mitigation Guidelines wherever applicable.

14.2 Electro-Magnetic Compatibility Control Plan

- 14.2.1 An EMC Control Plan shall be submitted by the PST contractor as specified in the Employer's Requirements: General Specification for review by the Employer.
- 14.2.2 The EMC control plan shall include measures to reduce conducted, induced and radiated emissions to acceptable levels as specified by EN50121:2006. The plan shall specify measures to increase immunity of the system and all its subsystems.
- 14.2.3 The Plan shall specify basic protective measures proposed for all electrical and electronic subsystem and components and specify measures to be adopted for selected subsystems and components.
- 14.2.4 The Plan shall analyse EMI and EMC impacts on the design of the system, all other train-borne equipment and track-side equipment as well as the general environment. Attention should also be paid to additional requirements in grounding, bonding, and shielding, filtering and cabling arrangements.
- 14.2.5 The PST Contractor is required to conduct full EMI tests at locations adjacent to television and radio transmission stations airport, and other transmitting commercial stations to be agreed with the Employer. These tests shall include simulated fault conditions.
- 14.2.6 The radiated emissions shall not exceed the levels permitted by the relevant standards.
- 14.2.7 Conductive emissions shall be below the levels deemed by the signalling equipment to the satisfaction of the Employer. This condition shall be met by each individual piece of equipment.
- 14.2.8 Power cables and data cables shall be physically separated from each other. A power cable shall be located and arranged such as to minimize electrical induction or interference to train control and communication circuits because of traction, auxiliary or other currents, both static' transient or flowing.

14.3 Inter-system EMI

The PST Contractor shall ensure that all equipment's are designed and constructed in accordance with the latest issues or version of internationally recognized EMC standards, including but not limited to CISPER, EN50082, EN50121(1-5), EN 50123, EN 50155, IEC 60571-1, IEC61000, or equivalents, to ensure proper functioning.

14.4 Safety-related System Interference

(a). Special attention must be given to the interface with safety-related operations and equipment such as the signalling and telecommunication systems. Special tests must be designed to ensure that the full range of emissions, whether conducted, induced, or radiated, individually or in combination with one another conform to the specific requirements of these safety related systems. Adequate safety margin must be ensured between the immunity levels of these safety-related systems and the emission levels of the system specified by prevailing international standards.

(b). The subsystems and components which could possibly give rise to the level of emissions under both normal and fault conditions (conducted, induced or radiated) that may, affect the safety –related systems must be identified. The quantified risk assessment must be carried out as part of Hazard Analysis to determine the probabilities and effects of such interference. Measures

must be taken to reduce emissions. The reliability of subsystems as well as the additional measures, e.g. filter, must be investigated.

(c). The probabilities of various conditions which could lead to an unsafe operation must be determined. An appropriate technical construction file suitable for safety audit must be developed to demonstrate EMC compliance to the Employer. The PST contractor shall note that the signalling contractor shall be responsible for determining the limits of interference for both the trackside and train-borne Signalling equipment, to ensure safe operation of the trains, high frequency radiated coupling through common mode, differential-mode, or ground loop mechanisms.

14.5 Environmental EMC

(a). The equipment shall not produce significant interference with aeronautic equipment, radars, global positioning system, tracking systems, radio, television, tape recorders or players, heart pacemakers, radar, computer systems, magnetic media, portable and cellular telephones pagers, etc.; in the train or external audible systems as per International Standard EN50121(1- 5). This includes action by static electricity, magnetic fields and electric fields.

(b). Effect of emission on explosive or volatile/flammable material must be considered. BS6656:2002 (Assessment of inadvertent ignition of flammable atmospheres by radio- frequency radiation-guide) and other related standards shall be adhered to.

(c). Effect of low frequency magnetic field produced by traction currents of BI-RIDE grounding system as well as electrolytic weakening of structures shall be taken care of.

14.6 Guidelines

IEC61000-5 installation and Mitigation Guidelines must be observed wherever applicable.

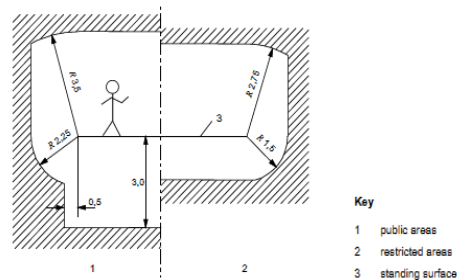
15 PUBLIC PROTECTION

15.1 General

In station buildings, on roads and foot bridges shall be fitted with special equipment, if the safe distance of 3.50 m regarding 25kV is not reached for the public or non-authorised personnel. The provisions of EN 50122-1 and 50122-2 shall be complied with.

The requirements for protective screening and barriers for standing surfaces in public areas are based on the requirements of EN 50122-1. Based on EN 50122-1, the standing surfaces above live parts on the outside of vehicles or above live parts of an overhead contact line system shall be of solid barrier design.

The requirements for protective screening and barriers for standing surfaces in restricted areas are mainly based on EN 50122-1. For standing surfaces above live parts on the outside of vehicles or above live parts of an overhead contact line system, the protection shall be of solid barrier construction. The length of the solid barrier, protecting the standing surface, shall correspond to the pantograph zone and shall extend beyond the live parts of an overhead contact line.



15.2 Mechanical Protection

Station buildings and bridges shall be equipped with horizontal or vertical awnings made up with meshes.

15.3 Electrical protection

All main parts of station buildings and bridges as well as catenary poles, as beams, girders, abutments and handrail and mechanical protection (awnings) have to be connected to earth and to over-head protection cable (as applicable).

15.4 Danger plate and caution notice

A "Caution Notice" at every station warning the commuters that the station is electrified on 25kV is also fastened.

Caution boards should also be provided to guide Train Operator where to stop the train before signal to prevent stopping of trains at Insulated Overlap locations.

To warn Project / O&M staff to come in proximity of charged electrical panels and other assets, Danger Notices shall be provided as per Rule 18 of CEA (Regulations for Safety) 2010 or latest amendment.

All the Boards such as number plate, caution board on mast, caution board at neutral section etc. should be as per latest RDSO drawing to be used. However, these drawings can be different as per the site conditions. These drawings should be approved by Engineer / Employer before the provision.

15.5 Numbering plate

Numbering plates are fastened on the track side of poles, they are implemented by means of:
An enamelled plate fastened on the pole by means of four bolts and intermediate lead washer

Fluorescent figures on the enamelled plate of different colour.

In accordance with RDSO standards. RDSO drawing no ETI/OHE/P7503 or Latest Specification for retro reflective number plates may be followed.

15.6 Nuts, Bolts & Washer

All nuts, bolts & washer used for commissioning of 25 kV Traction system shall be Galvanised steel and stainless steel except in special application.

All the nuts, bolts & washers used of Galvanized steel or stainless steel for 25kV ac shall be as per RDSO specification No. TI/SPC/OHE/Fasteners/0120, Latest Version.

15.7 Safety Screen Panel

The Safety Screen panels is normally provided at the location of DA in platform area. Normally Safety Screen shall be provided at the locations either in different elementary sections in the same structure or less clearance locations and on the masts where equipment's (LA, PT / CVS) are installed on. For more details, please refer tender drawings for switching stations.

16 SPECIAL EQUIPMENTS**16.1 Catenary Monitoring System**

16.1.1 Catenary Monitoring System continuously monitors the tensile forces in the contact wire and catenary wire and acquires and evaluates the sensor information. The status of the overhead contact line and the location of selected damage events can be detected quickly and precisely, thereby increasing the availability of the system. The function of CMS should be:

- Status monitoring of the overhead contact line
- Detection of tensile forces in the catenary system
- Detection of wire ruptures (contact wire profile/shape)
- Detection of significant changes in the tensile forces attributable to external influences.

16.1.2 The Catenary monitoring system installed in the automatic tensioning device.

16.1.3 The salient features of the CMS are as below: -

- Self-monitoring
- Contactless measuring method
- Reliable detection of faults with indication of location
- Low space requirement
- Immediate detection of faults
- Speedy rectification of damage
- No flood of data but event – driver alarm and fault messenger.

16.1.4 The CMS should be in working condition in any Railway of the world. The firm should give an undertaking that their product is defect free. The PST contractor should give the 05 years warranty for catenary monitoring system. Preference would be given to the design already proven & successfully used in Metros/ RRTS/ railways. PST contractor will integrate CMS with SCADA system.

16.2 Wind Speed Sensor

16.2.1 The speed of trains shall be restricted to 40Kmph on platform when wind speed is more than 70Kmph but less than 90Kmph. When wind speed exceeds 90Kmph, the train movement on platform shall be halted and stationary trains shall not be started till wind speed is below 90Kmph.

16.2.2 To ensure compliance of the above condition, Wind Speed Anemometers are to be provided. Wind Speed Anemometer should provide real time wind speed which can be monitored locally and remotely through SCADA.

16.2.3 Wind speed sensor specifications:

1. Output - DIGITAL ASCII / RS485 MODBUS RTU (0 TO 60 m/s) with option for 4-20mA output
2. Range - 0-110MPH

3. Accuracy	-	+/- 2%
4. Resolution	-	0.01 m/s
5. Operating voltage	-	12-30 VDC
6. Current Draw	-	Same as sensor output
7. Warm up time	-	3 seconds minimum
8. Operating Temperature	-	-40°C to +75°C
9. Size of Probe	-	7" diameter x 8 ¹ / ₂ "long
10. Weight	-	1 lb
11. Ultrasonic output rate	-	0.25, 0.5, 1, 2 or 4 Hz

16.2.4 The sensor is a two-wire sensor using the red wire for power and the black wire for the output signal. The sensor should relate to the power turned off.

16.2.5 The sensor comes with a stainless-steel elbow that can be mounted on a 1" diameter tube. The sensor is mounted parallel to the ground surface.

16.2.6 The wind speed sensor or anemometer produces a sine wave voltage signal with a frequency that changes linearly with the wind speed. The frequency is transformed into a 4-20mA sensor signal output.

16.2.7 The signals of wind speed sensor should be integrated in OCC through RTU via the SCADA System. Each wind speed sensor shall be provided with the necessary auxiliary contacts and internal wiring to permit remote control and indication.

16.2.8 Preference would be given to the design already proven & successfully used in other Metros / RRTS systems.

16.2.9 The total number of locations to install the wind speed sensors shall be decided during detailed engineering stage.

16.3 Earthquake Sensor

16.3.1 Earthquake Warning System Specification

1. No of proposed nodes	-	Three (02) (1 no. in each RSS)
2. Connectivity	-	LAN
3. Individual Nodes	-	Seismic Warning System (SWS) (Accelerometer + Seismic Data Acquisition System) with LAN Connectivity
4. Alarm Generation	-	On thresholding (Programmed PGA Value, resolution 0.05g)
5. Data Packet	-	Containing timing and data values
6. Central Recording System	-	Recording and alert packet generation at Central Control Room

16.3.2 Specifications of Seismic Warning System (SWS)

16.3.2.1. Sensor

1. Type	-	Force Balance Accelerometer
2. Component	-	Three (Tri-Axial)
3. Full Scale Range	-	± 1g (Capability to adjust ± 2g also)
4. Frequency Response	-	DC to 100 Hz
5. Operating temperature	-	-10°C to 50°C

- | | | |
|---------------------------|---|--------------------------------|
| 6. Cross-Axis sensitivity | - | <1% |
| 7. Dynamic Range | - | >130dB |
| 8. Connection | - | Military style metal connector |

16.3.2.2. Seismic Data Processing Unit

- | | | |
|--|---|--|
| 1. No. of Channel | - | Three (Programmable) |
| 2. Recording Mode mode | - | User Selectable Continuous and Triggering |
| 3. Sampling Mode | - | Programmable |
| 4. Timing | - | GPS timing unit |
| 5. System Triggering | - | amplitude Triggering, STA/LTA Triggering |
| 6. Alarm Logic | - | Programmable up to 3 (One for each channel) |
| 7. Alert signal (PGA) (Minor and Major alarm as per PGA) | - | On exceeding Peak Ground Acceleration |
| 8. Connectivity | - | Ethernet |
| 9. Data Storage | - | Internal in GB |
| 10. Software | - | Data viewing software |
| 11. Date Downloading | - | Using IP address (to be provided by client) Over Ethernet connectivity |
| 12. Pre-event memory | - | Programmable up to 100 sec |
| 13. Post-event memory | - | Programmable up to filling of internal memory |

The signals of Earthquake sensor should be integrated in OCC through RTU via the SCADA System. Each Earthquake sensor shall be provided with the necessary auxiliary contacts and internal wiring to permit remote control and indication.

Earthquake warning system requirements:

The following shall be considered for reporting / detection of occurrence of earthquake.

S.N.	PGA value	Earthquake Severity	Alarms
1	0.0-0.039 g	Low	Only Visual
2	0.039-0.18 g	Moderate	Both Visual & Audio
3	Above 0.18 g	Strong	Both Visual & Audio

Earthquake Warning System: -

The PST contractor shall propose the locations of installing the system for proper monitoring of condition of earthquake for the entire line and Depot. The rating and selection of equipment and their interface shall be developed according to the requirements and subject to Employer's review and consent. The requirements given in specifications for Earthquake Sensors are generic in nature. The basic requirement is to detect even feeble Earthquake and generate an alarm in OCC, with one seismic sensing node shall be provided at OCC & with minimum 2 no's seismic sensing nodes in the field, all duly integrated in one network, & all strategically located.

II. Earthquake Zone: 2 (Bengaluru)

III. Seismic Survey – The PST contractor shall be responsible for carrying out seismic survey

from some authorized agency to capture real time data of seismic noise required for parameterization of earthquake sensors for selection of proposed locations of required Earthquake sensors with details of foundation and room requirements housing the Earthquake sensor at respective locations. The civil activity for this work is of specialized nature, hence all civil works to be in the scope of the contract. The seismic survey report with recommendations on basis of land feasibility and arresting a complete route network of proposed complete corridors and selection of locations for deployment of earthquake sensor system, shall also be got reviewed from Government Seismology Department.

IV. Healthy status of Each Node – Whenever any node becomes faulty, or breaks communication, then change of colour of that node and visual indication/ display should appear on screen in OCC. Also, screen colour should change as per PGA value of event. Whenever any event occurs then its PGA value, time & date should appear on the screen.

V. Remote access of Earthquake Warning system – The PST contractor should make arrangement in the system to facilitate OEM for remote access for carrying out any modification/ rectification work remotely for the system functional requirements, without access to the metro SCADA System. The system should be designed to meet functional requirements and operation should be user friendly.

16.4 Thermal Imaging System

16.4.1 General

The Thermal Imaging System shall be portable equipment, which is handy and simple to use with interactive menu.

16.4.2 Specifications

The system shall have following specifications:

- The Thermal Imaging System shall have an infrared image resolution of 240x180 (43200) pixels.
- The Thermal sensitivity of the system shall be 0.05°C.
- The camera should be capable to measure temperature in two range: -20°C to 120°C and 0°C to +65°C.
- The image frequency (thermal) shall be 60Hz.
- The Thermal Imaging System shall have a Touch screen LCD display for user interface and displaying thermal/visual/ PIP and fused images.
- The camera must have video recording and video output facility with following functions:
 - Non-Radiometric IR Video Recording.
 - Non-Radiometric IR Video Streaming.
- The camera must have Bluetooth and Wi-Fi facility.
- The camera should have facility to connect through Wi-Fi with I-Phone, I-Pad or any android based phone for remote control of the camera/streaming of images.
- The camera should have MSX facility for crisp and clear thermal images.
- The Thermal imaging system shall also have an inbuilt digital camera for capturing visual images with built in LED light.
- There shall be provision for overlaying infrared picture on the normal picture (PIP) and shall have facility to blend the thermal and digital images.
- The system shall have a laser locator for association of the hot or cold spot in the infra red image with the physical target. The laser locator shall be activated with a control button for the same.
- The infrared camera shall have 3 spot meters and 3 boxes with max, min and average and auto hot and cold spot markers.
- The storage temperature range of the Thermal Imaging System shall be up to 70°C and the

- operating temperature range shall be up to 50°C.
- The Thermal imaging camera shall bear a warranty of 2 years from the date of supply and the manufacturer shall have service set-up in India. The detector of the camera shall bear a warranty of minimum 5 years.

17 BRIEF DISCUSSION OF DEPOT OHE (TRAM OHE)

The Depot OHE shall be of Tramway type except on Entry-Exit line and Test Track, where conventional OHE is to be provided.

The Tramway OHE cantilever arrangement shall be as per RDSO drawing no. ETI/OHE/G/04204. The RDSO standards for fitting and tubes of cantilever shall be referred. 107 sq. mm contact wire shall be used as per RDSO standard ETI/OHE/42 with all latest correction slips in depot.

In Depots, 5 pulley type ATDs shall be used as a tensioning device with 1000 kgf tension in each wire. Counterweights shall be galvanised.

Bridle wire for Tramway OHE shall be of cadmium copper, conforming to Indian Railway's RDSO specification ETI/OHE/50, Latest version, for cadmium copper conductor. The bridle wire shall be supported by HDC dropper wire as per IR design.

Insulator: -Composite type stay tube and Bracket tube insulators shall be used in depot cantilevers. Creepage distance of insulators shall not be less than 1600mm.

The Section Insulator in tramway OHE shall be provided as per RDSO drawing no. ETI/OHE/G/04207 Sh-1. The sectioning insulator/core insulator of section insulator shall be composite type with minimum 1050 mm creepage distance.

The Overhead Protection conductor (OPC) of 93.3 sq.mm, ACSR shall be used for earthing of Masts, Drop Arms at IBLs, SBLs and their sheds as well. Each Tension length of OPC shall be connected to minimum two earth stations.

Earthing of Overhead equipment in depot shall be done as per approved earthing and bonding drawing.

The depot feeding post shall have provision of three different feed i.e. from feeding RSS, from main line OHE (up and down line) and from Depot ASS. The feeder protection relay i.e. Distance, overcurrent and earth fault shall be provided. The necessary interlocking shall also be provided as per requirement of employer.

The sectioning in various lines shall be provided for electrical isolation. Each elementary section must have redundant power supply arrangement by the means of cables or bridging isolators. The sectioning diagram shall be approved by Engineer/Employer.

The real time status of each elementary section (coloration) shall be displayed in depot control centre by the means of SCADA. LED screen shall be displayed for showing the status.