LIST OF TI's RECEIVED FROM RDSO

Sl.No.	TI No.	Date Issued	Subject
1	TI/IN/0001	27.05.1994	Instruction for Booster Transformer & return conductors in 25 KV AC traction system.
2	TI/IN/0002	01.01.1997	Guidelines for design of fixed compensation for improving power factor at 25 KV, 50 Hz Traction sub-station.
3	TI/IN/0007	17.09.2001	Action taken by Division/Zone in case of porcelain insulator failure.
4	TI/IN/0008	28.09.2001	Instruction for use of cupper cross feeders at switching station.
5	TI/IN/0009	01.10.2001	Instruction for splicing of 19/3.99 mm Aluminium conductor (spider).
6	TI/IN/0011	15.12.2005	Guidelines operating procedures of TSS in Mumbai area.
7	TI/IN/0012	13.12.2005	Instruction for action to be taken for failure prone insulators, insulators suspected to be failure prone and those to retained in service.
8	TI/IN/0013	19.12.2005	Action to be taken by Divn/OHE depots for handling of composite insulators.
9	TI/IN/0014	03.04.2007	Instructions for use of DRPC on Indian Railways.
10	TI/IN/0015	01.02.2010	Application of lubricant on SS wire rope used with ATD
11	TI/IN/0016	01.05.2008	Guidelines for parallel operation of traction transformer on IR.
12	TI/IN/0017	15.07.2008	Guidelines on protection scheme with parallel operation of 2×21.6 MVA traction transformer
13	TI/IN/0018	09.02.2009	Application of existing panto flash over relay at TSS for single line section on IR.
14	TI/IN/0019	29.09.2009	Instruction for load profile, current & voltage harmonics measurement & recording in 25 KV AC traction sub-station.
15	TI/IN/0020	01.12.2009	Instruction for timely replacement & upgradation of computers at RCC of traction SCADA system on IR.
16	TI/IN/0021	01.01.2010	Instruction for increasing data transfer sped of the traction SCADA system on IR from 600/1200 bps to min. 9600 bps.
17	TI/IN/0022	01.02.2010	Setting guidelines for traction transformer & 25 KV shunt capacitor bank protection relay developed as per RDSO specification no. TI/SPC/ PSI/ PROTCT/6070(09/08) for 25 KV AC TSS.
18	TI/IN/0023	23.02.2010	Instructions for operating RTUs with power supply of 110 V DC (in place of 240 V AC) for existing traction SCADA system on IR.
19	TI/IN/0024	07.06.2010	Instruction for monitoring & analysis of Feeder Circuit Breaker Tripping for 25 KV AC Traction systems.
20	TI/IN/0025	01.08.2010	Technical Instructions for improving reliability of traction SCADA systems on IR
21	TI/IN/0026	10.07.2003	Protection scheme and relay setting guidelines for 25 KV AC traction sub-station provided with 30 MVA traction transformer
22	TI/IN/0027	25.10.2010	Technical instructions on maintenance practices to be adopted for numerical type microprocessor based protection relay modules for 25 KV AC traction system on Indian Railways
23	TI/IN/0028	01.12.2010	Implementation of feeder circuit breaker backup feature in different makes/types of feeder protection modules provided in C & R panels as per old RDSO Spec. No. ETI/PSI/65 (01/97).
24	TI/IN/0029	01.04.2011	Technical instructions on important aspects of relay settings of Vectorial Delta-I relays as per RDSO Specification No. TI/SPC/PSI/PROTCT/1982.
25	TI/IN/0030	02.08.2011	Technical instructions related to the installation and commissioning of the 42 KV metal oxide gapless lightning arr-esters provided on traction systems on Indian Railways.
26	TI/IN/0031	02.04.2013	Setting up of earth stations at Switching stations
27	TI/IN/0032	26.02.2020	Special maintenance instruction for setting up earthing station at switching posts (SSP & SP).
28	TI/IN/0035	01.09.2017	Testing of OHE structure Foundation
29	TI IN 0038	01.02.2019	for Earthing on various types of Bridges

30	TI IN 0039 - Rev 0	01.01.2019	Making non-standard holes in Steel structure
31	TI IN 0040 - Rev 0	01.11.2019	Cleaning of 25kV composite insulators
32	TI IN 0041	22.09.2020	Rigid catenary system in Tunnels & retractable OHE in sidings or depots
33	TI IN 0042	23.10.2020	OHE guidelines to increase speed potential to 160kmph on NDLS-HWH & NDLS-BCT routes
34	TI IN 0043 - Rev 1	25.02.2022	PSI guideline to increase speed potential to 160 kmph
35	TI IN 0044 - Rev 0	21.02.2022	Procedure for acceptance of new item or design or spec for 25kV & 2x25kV system
36	TI IN 0045 - Rev 0	10.01.2023 (withdrawn)	Guideline for hotline cleaning of insulators
37	TI IN 0047	12.06.2023	OHE design in concourse area for station development projects
38	TI IN 0048	19.04.2024	Cyber Security in the existing SCADA Sytems.
39	TI IN 0049	22.04.2024	Relay setting instruction of Delta-I and backup DPR on diff load
40	TI IN 0050	27.06.2024	Relay setting instruction of Feeder protection & shunt capacitor bank protection relay on load
41	TI IN 0051 - Rev 1	24.10.2025	Relay setting guidelines for traction transformer, feeder protection & shunt capacitor bank protection relay for 2x25 kV AC traction system
42	TI IN 0051 - Rev 0	24.06.2024	Instruction for handling of 25kV Porcelain insulators

MASTER COPY

मूल प्रति

INSTRUCTION FOR BOOSTER TRANSFORMER /RETURN CONDUCTORS IN 25 kV AC TRACTION SYSTEM –NORMS TO BE ADOPTED

The norms which are to be followed for the provision of BT & RC in the 25 kV electrified section are given below. The letter from Director (OF) , DOT, Sanchar Bhavan , New Delhi addressed to CGM, RE project circle ,DOT, Nagpur is at Annexure –I. Method of calculation for induced voltage in Telecom line due 25 Kv OHE is at Annexure-II. Soil resistivity which plays an important role in electromagnetic induction has also been given in table form indicating the mutual impedance in ohm/km, to be adopted in the calculation of induced voltage.

No. 88/RE/141/4 New Delhi, dated. 27.5.94.

General Manager (Electrical),
General Manager (S&T)
All Zonal Railways except N. F. Railway.

Sub: Booster transformers/Return Conductors in Electrified territories - norms to be satisfied.

****

The matter regarding norms to be satisfied for providing booster transformers (BT) and return conductor (RC) while electrifying Railway tracks had been under consideration with the Department of Telecommunications (DOT) for some time. The Railways' view-point that the standards prescribed in the International Telegraph and Telephone Consultative committee (CCITT) Directives are required to be followed and the norms accordingly revised and all concerned advised has been accepted by the DOT. The DOT has also accepted the principle that Railways will provide protective works for existing installations of DOT while for their future installations, the DOT itself would take necessary measures for protection. A copy of DOT's letter No. 114/2/92/TPL (CF) dated 17.05.1994 in this regard is at Annexure-I.

The revised norms required to be satisfied are: -

i) The longitudinal induced voltage on DOT lines due to railway electrification shall not exceed 60V under normal working conditions and 430 V under faulty conditions.

ii) The limit of 5 V shall be applicable only for transverse induced voltage on the DOT lines.

iii) The rail screening factor shall be 0.28 where all four (4) rails are conducting on a double track section.

The methodology for calculating the longitudinal induced voltage and the length of parallelism of DOT overhead lines with the 25 kV a.c. 50 H_z single phase traction overhead equipment for various soil resistivities based on the above norms is at Annexure - II.

Taking into account the revised norms, the need for continuing the BT/RC in all sections wherever provided should be reviewed in consultation with the General Manager of the concerned Telecommunications circle to determine the sections in which the BT/RC can be dispensed with altogether. To start with the sections where the voltage profile of the OHE is poor - particularly where two streams of traffic meet say like at Bhusaval- Should be reviewed first and thereafter the other. The sections over which BT/RC are proposed to be removed may perhaps be utilised as spares or in those sections where essentially required. It is desired that action be initiated immediately required. It is desired that action be initiated immediately and completed by 30.09.1994 and a completion report sent to this office.

The receipt of this letter may please acknowledged.

Enc.: Two

Sd.(Noel Lobo Prabhu)
Adviser (Electrical)
Railway Board

Copy to:

General Manager/CORE/Allahabad together with copy in each of the above Annexures. The BT/RC shall be provided in accordance with the revised norms only. The requirement of BT/RC in the sections being electrified and to be electrified may be determined in consultation with the Chief General Manager/Telecommunication, RE Project/Nagpur to determine the sections where BT/RC is needed and this office advised. The BT/RC removed by the various Zonal Railways may perhaps be utilised for these sections where BT/RC is essentially needed . The estimate of various projects may be reviewed and recast/revised as needed. The action taken in the matter be advised to this office . The receipt of this letter may please be acknowledged.

Enc.: Two

Sd.(Noel Lobo Prabhu)
Adviser (Electrical)
Railway Board

Annexure 'I'

Sanchar Bhavan
20, Ashoka Road,
New Delhi - 110 001.

No. 114/2/92/TPL/(CX) May 17,1994.

The Chief General Manager Telecom.
RE Project Circle,
Nagpur - 440 010.

1.0 Recommendations of the Technical committee.

A Technical Committee consisting of following members form DOT and Railways was constituted in December, 1992 to study the requirement of BT/RC, as well as payment to DOT for protective works due to Railway Electrification.

1. Sh. A.K. Trikha, Advisor (P), DOT.
2. Sh. M.V. Bhaskara Rao, CGM/REPC, Nagpur.
3. Dr. D. P. S. Seth, Dy. Dir. General, (TX), DOT.
4. Sh. N. K. Goel, EDRE (S&T), Railway Board.
5. Sh. Lobo Prabhu, Director (TI), RDSO, Lucknow.
6. Sh. M. L. Gambhir, Director (Tele), RDSO, Lucknow

2.0 The recommendations of the Technical Committee have been examined in the Telecom Commission and the following guidelines, approved by the Telecom Commission, is furnished below for information and necessary action.

1. The following guidelines will be a decision factor for providing booster transformer by the Railways:

a) The voltage on DOT Lines due to Railway Electrification should not exceed 60 volts longitudinal voltage and 5 volts as transverse voltage under faulty conditions as per CCITT recommendation.

b) Railway Reduction Factor for the new schemes can be taken as 0.28 where all the four Rails are conducting under the following condition:

i) The Rails have been provided with bonded joint and not mechanical bonds.

ii) After the Railways Electrification work is completed, if on actual measurements, the Railway Reduction Factor as observed is not more than 0.28. In all other cases, RRF will be taken as 0.44.

No overhead alignment should exist within 50 meters from the railway track in electrified sections due to static charging by higher working voltage.

III) For the purpose of trunk diversion for protection, the cash component and 50% of the stores component of the overhead alignment, considering as if this alignment is to be provided new along the railway track, may be taken for the purpose of calculating the cost of protective works. The cost of cash component and 50% of stores component should be after surrender of railway circuits due to railway electrification. The cost of transferring the circuits on the microwave/PCM etc. should be taken as the lower of the two options for payment by Railways to DOT.

IV) The committee recommends that the track sections will be categorised into rural and urban areas for the purpose of protective works. Urban and rural will be identified as per the norms laid down in the consensus report.

3.0) Further, it is also clarified that Railways will provide the protective equipment only for the existing installations and not for future installations.

Sd. (P. GANESH)
DIRECTOR (OF)

Copy to:

1) Shri. N. K. Goel, Executive Director, RE (S&T), Railway New Delhi for information.

2) Shri. R. Lalwani, DDG (LL) T.E.C., New Delhi.

3) Shri. T. K. Sampath Kumar, DDG (ML), DOT, New Delhi.

Annexure -II

INDUCED VOLTAGE ON TELECOMMUNICATION LINES DUE TO 25 kV ELECTRIFICATION

INDUCED VOLTAGE ON TELECOMMUNICATION LINES

IV = $2\pi f$ m I L K volt, where

f = frequency of inducing current in H_z

I = Inducing current in Ampere.

m = Modulus of mutual inductance per unit length in Henry per km between. the OHE and telecom. lines with earth return

L = Length of parallelism in km.

K = Screening factor.

For the frequency of 50 H_z, the mutual impedance for a given earth resistively. $2\pi f$ m has been taken from the mutual impedance graph and the same is denoted as M.

Therefore,

IV = M (Mutual. Impedance in ohm per km)

X L (Length of parallelism in km)

X K (Screening factor)

X I (Circuit current in A)

= ML X 600 X 0.28

= 168 ML

Where, K = 0.28 Rail Screening factor for double line section.

I = 600 A.

If M is the mutual impedance in ohm/1000 m ,then

IV = 168 X ML

If IV = 60 V, then

$$ML = \frac{60}{168} = 0.3571428$$

$$\text{or L in km} = \frac{0.3571428}{M \text{ (Mutual impedance for 1000 m.)}}$$

TABLE FOR PERMITTED LENGTH OF PARALLELISM FOR 60V. INDUCED VOLTAGE AT DIFFERENT SOIL RESISTIVITIES

Distance from OHE in meter	M in ohm/km.	Length of O/H in km	Length of cable in km. (Cable S/F 0.8)
SOIL RESISTIVITY (ohm. Cm.)	500		
35.0	0.12500	2.857	3.57
50.0	0.10500	3.401	4.25
100.0	0.06500	5.49.5	6.87
200.0	0.03500	10.204	12.76
300.0	0.02200	16.234	20.29
400.0	0.01300	27.473	34.34
500.0	0.00820	43.554	54.44
600.0	0.00550	64.935	81.17
700.0	0.00380	93.985	170.48
800.0	0.00290	123.153	153.94
900.0	0.00220	162.338	202.92
1000.0	0.00180	198.413	248.02
SOIL RESISTIVITY (ohm. Cm.)	1000		
35.0	0.14500	2.463	3.08
50.0	0.12500	2.857	3.57
100.0	0.08500	4.202	5.25
200.0	0.04900	7.289	9.11
300.0	0.03300	10.823	13.53
400.0	0.02150	60.611	20.76
500.0	0.01450	24.631	30.79
600.0	0.01100	32.468	40.58
700.0	0.00760	46.992	58.74
800.0	0.00590	60.533	75.67
900.0	0.00450	79.365	99.21
1000.0	0.00360	99.206	124.01
SOIL RESISTIVITY (ohm. Cm.)	3000		
35.0	0.18000	1.984	2.48
50.0	0.15500	2.304	2.88
100.0	0.11000	3.247	4.00
200.0	0.07500	4.762	5.95
300.0	0.05500	6.494	8.17
400.0	0.04800	8.306	10.38
500.0	0.03300	10.823	13.53
600.0	0.02600	13.736	17.17
700.0	0.02100	17.007	21.26
800.0	0.01600	22.321	27.90
900.0	0.01400	25.510	31.89
1000.0	0.01100	32.468	40.58

TABLE FOR PERMITTED LENGTH OF PARALLELISM FOR 60 V. INDUCED VOLTAGE AT DIFFERENT SOIL RESISTIVITIES

Distance from OHE in meter	M in ohm/km.	Length of O/H in km	Length of cable in km. (Cable S/F O.8)
SOIL RESISTIVITY (ohm. Cm.)	5000		
35.0	0.19500	1.832	2.29
50.0	0.17500	2.041	2.55
100.0	0.13000	2.747	3.48
200.0	0.09000	3.968	4.96
300.0	0.07000	5.102	6.38
400.0	0.05500	6.494	8.12
500.0	0.04500	7.937	9.92
600.0	0.03500	10.204	12.76
700.0	0.02900	12.315	15.39
800.0	0.02500	14.286	17.86
900.0	0.02100	17.007	21.26
1000.0	0.01700	21.008	26.26
SOIL RESISTIVITY (ohm. Cm.)	10000		
35.0	0.21600	1.653	2.07
50.0	0.19500	1.832	2.29
100.0	0.14500	2.463	3.08
200.0	0.10500	3.401	4.25
300.0	0.08500	4.202	5.25
400.0	0.07000	5.102	6.38
500.0	0.06000	5.952	7.44
600.0	0.05200	6.868	8.59
700.0	0.04400	8.117	10.15
800.0	0.03700	9.653	12.07
900.0	0.03200	11.161	13.95
1000.0	0.02800	12.755	15.94
SOIL RESISTIVITY (ohm. Cm.)	20000		
35.0	0.23000	1.553	1.94
50.0	0.21500	1.661	2.08
100.0	0.17000	2.101	2.63
200.0	0.12500	2.857	3.57
300.0	0.10500	3.401	4.25
400.0	0.09000	3.968	4.96
500.0	0.07500	4.762	5.95
600.0	0.06600	5.411	6.76
700.0	0.06000	5.952	7.44
800.0	0.52000	6.868	8.59
900.0	0.04800	7.440	9.30
1000.0	0.04200	8.503	10.64

TABLE FOR PERMITTED LENGTH OF PARALLELISM FOR 60 V. INDUCED VOLTAGE AT DIFFERENT SOIL RESISTIVITIES

Distance from OHE in meter	M in ohm/km.	Length of O/H in km	Length of cable in km. (Cable S/F O.8)
SOIL RESISTIVITY (ohm. Cm.)	30000		
35.0	0.25000	1.429	1.29
50.0	0.22500	1.587	1.38
100.0	0.18000	1.984	2.48
200.0	0.14000	2.551	3.18
300.0	0.11500	3.106	3.88
400.0	0.10000	3.571	4.04
500.0	0.09000	3.968	4.85
600.0	0.07800	4.579	5.16
700.0	0.07000	5.102	6.28
800.0	0.06400	5.580	6.87
900.0	0.05700	6.266	7.86
1000.0	0.05200	6.868	8.56
SOIL RESISTIVITY (ohm. Cm.)	50000		
35.0	0.26000	1.374	1.72
50.0	0.24000	1.488	1.80
100.0	0.20000	1.786	2.20
200.0	0.15500	2.304	2.88
300.0	0.13000	2.747	3.40
400.0	0.11500	3.106	3.88
500.0	0.10000	3.571	4.40
600.0	0.09000	3.968	4.96
700.0	0.08400	4.252	5.42
800.0	0.07800	4.579	5.78
900.0	0.07000	5.102	6.82
1000.0	0.06600	5.411	6.96

GUIDELINES FOR DESIGN OF FIXED SHUNT COMPENSATION FOR IMPROVING POWER FACTOR AT 25 kV. 50 H_Z TRACTION SUBSTATION

1.0 INTRODUCTION:

The traction load unlike the industrial loads is of frequently and rapidly varying nature. The variations ranging from no load to short time overloads. The traction system is also subjected to frequent short circuit primarily due to earth faults. The harmonics generated by the electric locomotives particularly the thyristor locomotives are quite high with odd harmonics dominating and producing a severe distortion of voltage wave . The instantaneous power factor of traction loads (electric locomotives) is usually lagging—being poorer at light loads. The average power factor being generally in the range of 0.7 and 0.8 lagging.

The lagging power factor of the traction loads is not welcomed by the state Electricity Boards and in the recent past the trend has been to raise the penalty level for poor power factor from 0.8 to 0.9. On account of the stiff penalty being imposed by the supply authorities for power factor below this level , it has become essential for the Railways to take measure for improving the power factor of the traction loads. Drawl of leading KVAR to compensate/partially compensate the lagging KVAR of traction loads by providing shunt compensation is by far the most common method employed. While the best place for installation of power factor compensation equipment is at the load itself. Some compensation at the traction substation becomes inevitable particularly since most of locomotives of Indian Railways are not provided with any such compensation.

2.0 Chargeable power factor and metering arrangement:

The overall chargeable power factor over the billing period as calculated by the Electricity Boards is different from the instantaneous power factor reflected at the point of metering which is continuously varying. This chargeable power factor not only depends on instantaneous power but also on the method of calculating the chargeable power factor from the metering registers installed at the traction substations.

A fixed shunt compensation which continuously draws a leading kVAR reduces the cumulative kVAh by reducing the net (lagging) kVAR of the load. Thus as long as this is true an improvement in chargeable power results. However, during periods of prolonged no load/low load, the leading kVARh drawn by capacitor bank will get recorded in different fashions depending upon the type of metering systems installed. The electronic meters now available have facility of recording the leading kVARh and lagging kVARh separately and therefore depending upon whether the advantage of drawing the excess leading kVARh by the consumers (Railways) has to be reflected in calculating the chargeable power factor will depend upon the method used for calculating the chargeable power factor. Three possible methods for calculating the chargeable power factor can be employed:

The most common method of calculating the chargeable power factor is:-

I) Chargeable power factor = $\frac{\text{Skwh}}{\text{SkVAh}}$

(The kVAh meter rotates in same direction irrespective of drawl of leading or lagging kVARh).

OR

Where separate registers for leading & lagging kVARh are provided.

$$\text{Chargeable power factor} = \frac{\text{S kwh}}{\sqrt{(\text{Skwh})^2 + (\text{S lagging kVARh})^2 + (\text{Sleading kVARh})^2}}$$

As excessive leading kVARh increases the denominator, a reduction in chargeable power factor could result with excessive compensation. This method of calculating chargeable power factor, therefore discourages drawl of excessive leading kVARh.

II) Chargeable power factor = $\frac{\text{S kwh}}{\sqrt{(\text{SkWH})^2 + (\text{S lagging kVARh})^2}}$

OR

Where kVARh meter stops rotating while drawing leading kVARh

Chargeable power factor = $\frac{\text{S kwh}}{\text{S kVAh}}$

This method of calculating chargeable p.f. neither penalises nor gives benefit for drawl of excessive leading kVARh.

III) Chargeable Power factor = $\frac{\text{S kwh}}{\sqrt{(\text{kwh})^2 + (\text{S lagging kVARh})^2 - (\text{S leading kVARh})^2}}$

OR

Where kVAh meter rotates in opposite direction while drawing leading kVARh.

Chargeable power factor = $\frac{\text{S kwh}}{\text{S kVAh}}$

This method of calculating chargeable power factor gives benefit for drawing excessive leading kVARh.

3.0 Methods used for improving power factor:

3.1 Fixed shunt capacitor:

The simplest and the most common method employed at present is to install fixed shunt compensation equipment at the traction substation. The compensation improves power factor by reducing the net lagging kVAR drawn by traction load thus avoiding the payment of low power factor penalty. The other incidental benefit acrued are by way of reduction in maximum demand charges, improvement in the voltage and reduction in transformer losses.

3.1.1 Problems associated with fixed shunt compensation:

(i) Traction load is continuously varying, the compensation has to be therefore truely dynamic which fixed capacitor can not provide thus resulting into under/over compensation at times.

(ii) Excessive compensation may sometimes (depending upon the extent of overcompensation) lead to deteriorate in chargeable power factor if chargeable power factor is calculated according to method I.

(iii) Changing the capacity to meet changed requirement of compensation disturbs the capacitor bank configuration & is therefore not always possible to implement. In larger bank using series reactor this may not be possible at all from consideration of rating of existing equipment and resonance.

To overcome some of the above drawbacks it is suggested that:

(a) Bank rating should be fixed on the basis of load pattern over the billing period instead of average load.

(b) While it is possible to improve chargeable power factor to desired value of method II &III is followed, it may some times be not possible to improve the chargeable power factor to desired value particularly in lightly loaded traction substation if chargeable power factor is calculated by method I, in which case one of the following two alternative may be considered.

(i) As changing the rating of fixed shunt compensation could be tricky smaller capacitor bank (around 500 kVAR) without series reactor could be tried in the interim period till the load fully builds up at the traction substation.

(ii) If penalty limits of p .f are too stringent e.g. 0.95 & load pattern at traction substation is likely to change, use of dynamic compensation may be resorted to.

3.2 Switched Shunt capacitors:

Where load pattern at a traction substation is fairly stable and has rather fixed periods of no load/low load , the chargeable p.f. can still be improved even if calculated using method I provided the shunt capacitors are switched off during such no load/low load periods. Such switching off / on has to be limited to not more 1-2 operation / day if reliability of capacitors is not to be launched. Such switching on / off can be activated either automatically using a combined time of the day / load current check or done manually through RCC.

3.3 Multistage Switching of Shunt capacitors:

Changing the kVAR rating of the capacitor bank by switching in/out branches of capacitor bank is not suitable for traction application as traction load fluctuates widely & is rather difficult to predict. The switching operation may also be too large for reliability of compensation equipment & the system. Moreover, on account of increased in rush current while switching on a parallel branch of capacitor, the circuit breaker shall be subjected to very heavy duty particularly if the polarity of the branches are in opposition. Considering these aspects it is considered that this current will not be suitable for traction application.

3.4 Thyristor switched capacitor (TSC) :

If the load at the traction substation fluctuates considerably and there are prolonged periods of light load. The fixed shunt capacitor bank would be ineffective in providing desired improvement in power factor, though the improvement in M.D. would still take place. Thyristor switched capacitor banks (Flg. 1.0) can in such cases be used with advantage. In this scheme 2 or 3 capacitor banks each controlled by thyristors connected in circuit during both positive and negative half cycles. All switching on should take place when the voltage across the thyristors is zero to obtain almost transient free switching. As the capacitor while switching off is left with a trapped charge. The voltage across thyristors will alternate between zero and twice the peak phase voltage. Besides the capacitors will start discharging when switched off. A transient free switching will therefore, require two conditions to be met-

i) The thyristors must be gated at a positive or negative crest of supply voltage and

ii) The capacitors must be precharged or topped up for the loss of charge with the same polarity.

(The pre- charged voltage = $\frac{n^2}{2}$ Vp
$n - 1$

Where n = $\sqrt{\frac{XC}{XL}}$, Vp - Peak phase voltage

Xc = Capacitor reactance, and

X1 = Reactance of damping reactor used for keeping di/dt within capability of thyristors.

Appropriate circuitry to pre charge the discharged capacitor has also to be provided to avoid large switching transients and premature failure of capacitor.

Disconnection is affected by withdrawing the firing pulses at natural current zero. The current is sinusoidal and contains no harmonics.

The degree of flexibility with given number of parallel branches (i.e. maximum number of steps) is maximum if no two capacitor bank branches have equal value however no grounds of economy equal values of capacitance is only adopted. The response time of such an arrangement is quite good (roughly about 2 cycles) but the compensation is in discreet steps as large number of banks if provided in parallel would complicate the schemes and add to a very high cost of the installation.

3.5 Thyristor controlled reactor with fixed capacitor banks:

In this scheme (Fig. 2.0) two oppositely poled thyristors conduct on alternates half cycles of the supply frequency. If thyristors are gated into conduction precisely at the peaks of the supply voltage, full conduction results in the reactor and the current is the same as though the thyristors controller were short circuited. The current is essentially reactive, lagging the voltage by nearly 90 degree. If gating in delayed by equal amounts on both thyristors a series of current wave forms is obtained. By varying the conduction angle, the amount of lagging reactive power can be controlled. Equal conduction angles of the two oppositely poled thyristors. Introduces odd harmonies will incorporate harmonic filters to keep the total harmonic distortion within limits. During light loads the capacitive power requirement would be very less, therefore, the reactor would be working with almost full conduction resulting into considerable energy losses. The arrangement would however give a step less control of the reactive power with a very high response time the order of 1.5 cycles. Combination of TSC and TCR can also used suit the application.

4.0 Calculation of rating of fixed shunt compensation:

4.1 Based on average load:

A rough method for calculating the requisite rating for a fixed compensation for a heavily loaded traction substation involves calculation of an average demand which can be approximated as:

$$\text{Average demand in kW} = \frac{\text{Monthly average energy consumed}}{\text{Number of hours in a month}}$$

The rating of the shunt compensation for getting a desired power factor is given by:-

Capacitate kVAR= Average demand in kW (tan Ø 1-tan Ø 2)

Where, Ø 1 = initial power factor angle
Ø 2 = improved power factor angle

While this method gives the reasonable idea of the compensation needed in case of heavily loaded traction substation, the method is likely to give quite eroneous result for traction substations which are very lightly loaded where excess leading kVAR drawn by the shunt compensation would complicate the metering. Therefore in order to taken the varying nature of traction load into account and whether the chargeable power factor is to be calculated over the billing period , it is necessary to take the above aspects into consideration for fixing the load of the shunt compensation.

4.2 Based on load pattern and method of calculating chargeable power factor:

As illustrated in para 5.0 the calculation of rating of shunt compensation on the basis of average loads could even lead to power factor poorer than before. It is therefore essential that the rating is related to the load patterns and not with average load. It must be understood that a particular kVAR rating of fixed shunt compensation is best suited only for the designed load pattern. If the load pattern changes markedly particularly in regard to periods of no load/ low load and peak loads. The rating may become unsuitable for getting the desired compensation. The shunt compensation therefore can be employed with advantages only in cases where the load patterns are reasonably stable and traction substation is well loaded. Where these conditions are not met with a fixed shunt compensation may not give the desired results and may even lead to poor chargeable power factor.

The procedure takes into account the fluctuating traction load, varying instantaneous power factor and simulates the reading which may get recorded in different registers of different metering system on the basis of which chargeable power factor is calculated for working out the optimum rating of the shunt compensation a number of iterations have to be performed on the load pattern. This procedure therefore necessarily requires calculations be computer. A programmer module in C++ has been designed to help enable this calculation being performed by persons not familiar with computer working by following simple screen prompts.

5.0 Illustrative examples:

To Illustrate the above aspects two examples –one relating to load pattern (I) for typically lightly loaded traction sub-station and another for load pattern(II)for a

reasonably loaded traction substation has been considered . It is assumed that these load patterns are representative of the entire billing period . If this is not so several representative load patterns prevailing in the billing period can also be considered in the simulation . The following data has entered for the purpose of above illustrations.

i) Load pattern over the billing Period for all the days in a month……. Pattern (I)

ii) Load pattern over the billing Period for all the days in a month…… Pattern (II)

iii) Desired power factor 0.9

The result of the simulation for the two load patterns is tabulated below:-

LOAD PATTERN (I) (LIGHTLY LOADED TRACTION SUBSTATION)
Existing chargeable power factor = 0.79

TABLE –I

Methodology for calculating chargeable power factor	Optimum rating of fixed shunt compensation	Likely actual chargeable power factor after installation of compensation .	Remarks
I	100 kVAR	0.802 lagging	Not possible to improve chargeable p.f. beyond 0.80 by fixed shunt compensation.
II	400 kVAR	0.90 lagging	Chargeable p.f. will improve beyond 0.90 with increase in rating beyond 400 kVAR.
III	1000 kVAR	0.90 lagging	Chargeable p.f will improve beyond 0.90 will increase in rating beyond 1000 kVAR.

As against these if capacitor rating is designed based average load the chargeable power factor with different methodology will be as under:

TABLE –II

Methodology for calculating chargeable power factor	Optimum rating of fixed shunt compensation	Likely actual chargeable power factor after installation of compensation.	Remarks
I	400 kVAR	0.78 lagging	Chargeable p.f will deteriorate below 0.78 with increase in rating beyond 400 kVAR.
II	400 kVAR	0.90 lagging	Chargeable p.f will improve beyond 0.90 with increase in rating beyond 400 kVAR.
III	400 kVAR	0.84 lagging	Chargeable p.f will improve beyond 0.84 with increase in rating beyond 400 kVAR

Table- II gives an idea of how the chargeable power factor will look like if rating of fixed shunt compensation is increased. When chargeable power factor is being calculated on the basis of method I. From this it will be seen that the chargeable power factor deteriorates form the existing chargeable power factors with increased rating of shunt compensation. This explains the deterioration of power factor reported by some Railways at some of the traction substation where a over rated shunt compensation has been installed.

Similar information for the loaded traction substation [Pattern (II)] is shown in Table - III. From this it would be seen that there is an improvement in power factor with increased rating of shunt compensation.

LOAD PATTERN (II) (REASIONABLY LOADED TRACTION SUBSTATION)

Existing chargeable power factor = 0.82

TABLE –III

Methodology for calculating chargeable power factor	Optimum rating of fixed shunt compensation	Likely actual chargeable power factor after installation of compensation .	Remarks
I	1800 kVAR	0.90 lagging	Chargeable Power factor will improve beyond 0.90 with increase in rating beyond 1800 kVAR.
II	1450 kVAR	0.90 lagging	Chargeable p.f will improve beyond 0.90 with increase in rating beyond 1450 kVAR.
III	1600 kVAR	0.90 lagging	Chargeable p.f will improve beyond 0.90 with increase in rating beyond 1600 kVAR

6.0 Harmonics:

Percentage of individual current hormone present in the traction system as measured during 1990-1992 is given below:-

Percentage current harmonic

Zone Harm. No.	Eastern		Northern		Central		Southern		Western	
	A	B	A	B	A	B	A	B	A	B
3rd	18	18	19	17	19	17	19	19	18	18
5th	8	8	9	7	9	8	9	8	9	9
7th	4	4	5	4	6	5	8	7	5	5
9th	3	2	3	3	4	3	4	3	4	4
11th	2	2	3	3	-	-	2	2	3	2

A- Load current range 200-300 A: B-Load current range 300-400 A

Typical value of current harmonics for the load current range 200 –400A has been considered for designing the capacitor bank:

3rd harmonic	=	20%
5th ,,	=	10%
7th ,,	=	8%
9th ,,	=	4%
11th ,,	=	3%

In addition to the above 20% safety margin has also been taken into account while designing the actual rating of capacitor bank.

7.0 Rating of the shunt capacitor bank:

Considering reasonably loaded traction substation as indicated in load pattern (II) and the methodology for calculating changeable power factor as II the optimum rating of fixed capacitor bank is 1450 kVAR.

Assuming 10% extra for the future growth of load. kVAR capacity of the capacitor bank at 25 kV = 1.1x 1450= 1600 kVAR.

Capacitive reactance of 1600 kVAR
Cacpitor bank at 25 kV $= \frac{1000 \times kV^2}{kVAR}$ $Xc = \frac{kV^2 \times 1000}{kVAR}$

= 390.63 ohm.

7.1 Series reactor rating:

In order to avoid resonance at all odd harmonics the minimum value of series reactor reactance (XL) should to be 12% of the capacitive reactance (Xc).

Moreover, to keep the effective capacitive reactance same as 390.63 ohm. the capacitive reactance of capacitor bank should be increased by the same amount of the series rector reactance.

The value of series reactor reactance. XL = 0.13Xc

And (Xc - XL) = 390.63 ohm

$\therefore Xc = \frac{390.63}{(1 - 0.13)}$

= 449 ohm

and XL = 0.13 x 440 ohm.

= 58.37 ohm.

7.2 Actual rating of capacitor bank with series reactor:

Taking into account the fluctuations of incoming supply voltage and the voltage rise at no load due to capacitor , the voltage class of the capacitor bank should be calculated taking the bus voltae as 28 kV.

Current drawn by capacitor- reactor

Circuit at fundamental frequency = $\frac{28000}{(Xc - XL)}$

$= \frac{28000}{(449 - 58.37)}$

= 71.68 Amps.

Voltage across the capacitor bank at fundamental frequency.

Vcf = Icf x Xc
= 71.68 x 449
= 32184 Volts.

Taking the average load current of 336 A corresponding to the load pattern (II) (8.39 MVA load), the individual harmonic current is:

Harm No.	Harmonic current (In)	Distribution factor (pc)	Actual harmonic current through capacitor bank
3	I 3 - 80.64 A	0.46	Ic 3 - 37.10 A
5	I 5 - 48.38 A	0.134	Ic 5 - 5.36 A
7	I 7 - 32.26 A	0.126	Ic 7 - 4.06 A
9	I 9 - 16.13 A	0.119	Ic 9 - 1.92 A
11	I 11 - 12.10 A	0.115	Ic 11 - 1.39 A

7.2.1 Voltage rise due to harmonic currents:

i) 3rd harmonic voltage across the capacitor bank:

Vc3 = $\frac{Xc}{3}$ x Ic3

= $\frac{449}{3}$ X 37.1

= 5552.6 Volts

ii) 5^{th} harmonic voltage across the capacitor bank.

$$Vc5 = \frac{Xc}{5} \times Ic5$$
$$= \frac{449}{5} \times 6.48$$
$$= 581.9 \text{ Volts}$$

iii). 7^{th} harmonic voltage across the capacitor bank.

$$Vc7 = \frac{Xc}{7} \times Ic7$$
$$= \frac{449}{7} \times 4.06$$
$$= 260.4 \text{ Volts}$$

iv) 9^{th} harmonic voltage across the capacitor bank.

$$Vc9 = \frac{Xc}{9} \times Ic9$$
$$= \frac{449}{9} \times 1.92$$
$$= 95.8 \text{ Volts}$$

v) 11^{th} harmonic voltage across the capacitor bank.

$$Vc11 = \frac{Xc}{11} \times Ic11$$
$$= \frac{449}{11} \times 1.39$$
$$= 56.74 \text{ Volts}$$

Total harmonic voltage across the capacitor bank.

$$= \sqrt{V^2c3 + V^2 c5 + V^2 c7 + V^2c\,9 + V^2\,11 + }$$

$$= \sqrt{(5552.6)^2 + (581.9)^2 + (280.4)^2 + (95.8)^2 + (56.74)^2}$$

$$= 5590.22 \text{ Volts.}$$

Final voltage across the capacitor bank.

$$Vcf + Vchar. = 32184 + 5590.22$$

$$= 37774.22 \text{ Volts. Say 40 kV}$$

\ kVAR capacity of the capacitor bank at 40 kV

$$= \frac{kV^2 \times 1000}{Xc} = \frac{(40)^2 \times 1000}{449}$$

$$= 3564 \text{ kVAR}$$

7.3 Rating of the series reactor:

Voltage across the series reactor

$$VL\ max = XL \times \sqrt{I^2cf + 9\ I^2c3 + 25\ I^2\ c5 + 49\ I^2c7 + 81\ I^2c9 + 121\ Ic11}$$

$$= 58.37 \sqrt{(71.68)^2 + 9(37.1)^2 + 25\ (6.48)^2 + 49\ (4.06)^2 + 81\ (1.92)^2 + 121\ (1.39)^2}$$

$$= 58.37 \times 141.12$$

$$= 8237.32 \text{ Volts.}$$

$$Ic\ max = \sqrt{I^2cf + I^2c3 + I^2c5 + I^2\ c7 + I^2c9 + I^2c11}$$

$$= \sqrt{(71.68)^2 + (37.1)^2 + (6.48)^2 + (4.06)^2 + (1.92)^2 + (1.39)^2}$$

$$= 81.108 \text{ A}$$

\ kVAR rating of the series reactor = VL max x Ic max x 10^{-3}

$$= 8237.32 \times 81.108 \times 10^{-3}$$

$$= 668 \text{ kVAR.}$$

Inductance of the series reactor.

$$L = \frac{XL}{2pf} = \frac{58.37}{100\ p} \times 10^3 \text{mH} = 185.8 \text{mH}$$

8.0 Resonant Frequency:

i) Source reactance. Xs

Assuming Sc fault level on 132 kV side of traction substation 2000 MVA.

\ Source reactance on 132 kV side = $(132)^2 / 2000 = 8.71$ ohm.

\ Loop reactance on 132 kV side = 2 x 8.71 ohm.

\ Reflected reactance on 25 kV side $Xs = 17.42 \times (27/132)^2$
$= 0.625$ ohm

ii). Transformer Impedance:

132/25 kV. 13.5 MVA transformer with 12% impedance has reactance value:

$$Xt = \frac{12 \times (27)^2}{100 \times 13.5}$$

$= 6.48$ ohms.

iii) Equipment circuits of traction power supply circuit:

Where,

In	-	Harmonic current at nth harmonic
Xs	-	Source reactance.
Xt	-	Transformer reactance.
Xc	-	Capacitive reactance.
XL	-	Series reactor reactance.
Icn	-	Capacitor current at the nth harmonic.
Ps.Pc	-	Distribution factors.

$In = Icn + Isn$

$$Icn = \frac{(Xs + Xt)}{(Xs + Xt + XL) - Xc/n^2} In = Pc.\ In$$

$$Isn = \frac{(XL - Xc/n)^2}{(Xs + Xt + XL) - Xc/n^2} In = Ps.\ In$$

Capacitor bank will have two types of reactances:

i) Parallel resonance will occur at.

$(Xs+Xt+XL-Xc / n^2) = 0$

i.e. $n = \sqrt{\frac{Xc}{(Xs+ Xt+ XL)}}$

$= \sqrt{\frac{449}{(0.826 + 6.48 + 58.37)}}$

$= \sqrt{449 / 65.475}$

$= 2.62$

$fc = 2.62 \times 50 = 131\ H_z$

ii) Series resonance will occur at:

$(XL-Xc/n^2) = 0$

i.e.n $= \sqrt{Xc/XL}$

$= \sqrt{449/58.37}$

$= 2.77$

$fc = 2.77 \times 50 = 138.50\ H_z$

Harmonic current distribution between supply and capacitor bank.

N	Ps	pc
1	1.0185	0.0185
2	1.152	0.152
3	0.544	0.456
4	0.81	0.19
5	0.85	0.15
6	0.866	0.134
7	0.874	0.126
8	0.878	0.122
9	0.881	0.119
10	0.883	0.117
11	0.885	0.115

It is clear from the enclosed graph for harmonic current distribution to supply circuit and capacitor bank circuit V/s frequency that when harmonic current distribution factor p s is less than 1 higher harmonic current is decreased by capacitor bank and when it is more than 1 higher harmonic current is amplified with the shunt capacitor bank.

Therefore the resonant frequency of the capacitor bank with the system should be in the range between 50 H_z and 140 H_z to avoid amplification of harmonic current at 3rd and other higher harmonics.

Therefore it is recommended to use 13 to 15% reactor in series with capacitor bank to make the capacitor reactor bank inductive in the frequency area above the 3rd harmonic.

It is also recommended that whenever a capacitor unit is found defective it is necessary to cut of the whole capacitor bank from the circuit with the help of circuit breaker instead of removing the defective unit and putting the capacitor bank with reduced capacity again into service. This is required because the total Capacitive reactance Xc will increase and the resonant frequency will become higher and this will cause the amplification of high harmonic current.

8.0 Capacitor bank inrush currents:

The energizing of a capacitor by closing a circuit breaker produces an inrush current which is a function of the voltage the capacitances of the circuit the values and location of the inductances in the circuit the charges on the capacitor at the time the circuit is closed and the dumping of the switching transients. The inrush current can be calculated by knowing the network impedances and calculations of inrush current are usually made on the assumptions that the capacitor bank has no initial charge and that the circuit is closed at a time which produces the maximum inrush current.

a) Connection of a single bank:

$$I = \sqrt{2\mu} \sqrt{C1/(Lo + L1)}$$

$$f = 1\ \mu\ 2\pi \sqrt{C1\,(Lo + L1)}$$

b) connections when one bank is already connected:

$$I = \sqrt{2\mu} \sqrt{\frac{C1\,C2}{C1+C2)(L1+L2)}}$$

$$f = \frac{1}{2\mu \sqrt{\frac{C1C2\,(L1+L2)}{(C1+C2)}}}$$

$$s = \sqrt{2\mu} / (L1 + L2)$$

Where

μ = System voltage.

I = Inrush current peak.

f = inrush current frequency.

s = inrush current rate-of-rise.

Lo = Source inductance including transformer.

L1 = inductance in series with switched cap. bank 1.

L2 = inductance in series with switched cap. bank 2

C1 = capacitance of switched capacitor bank 1

C2 = capacitance of switched capacitor bank 2

The value of the overcurrents due to switching operations should be limited to a maximum of 100 times the rated current (rms value) of the capacitor bank.

9.0 Maximum permissible switching voltages.

The residual voltage on a capacitor bank prior to energization shall not exceed 10% to the rated voltage of the capacitor bank. The energization of a capacitor bank by a restrike-free circuit breaker usually causes a transient oveeroltage the first peak of which does not exceed 2/2 times the applied voltage (rms. Value) for a maximum duration of 1/2 cycle. However the switching surge voltage should not normally exceed 70 kV peak.

10.0 Restrike-free circuit breakers:

Circuit breakers suitable for capacitor switching i.e. restrike-free circuit breakers shall be used for controlling the capacitor banks. While selecting the circuit breaker, It should be ensured that the circuit breaker can take a minimum of 140% of the capacitor bank current continuously.

****

LOAD PATTERN – (1)

ANNEXURE-I

TIME	KW	PF.	TIME	KW	PF.	TIME	KW	PF.
00 00	1220.0	0.7	08 00	50.0	0.7	16 00	50.0	0.7
00 10	1800.0	0.7	08 10	1000.0	0.7	16 10	4000.0	0.8
00 20	1950.0	0.7	08 20	1500.0	0.7	16 20	3000.0	0.75
00 30	3000.0	0.75	08 30	2000.0	0.75	16 30	4000.0	0.8
00 40	3500.0	0.8	08 40	500.0	0.7	16 40	2500.0	0.75
00 50	2000.0	0.75	08 50	500.0	0.7	16 50	7000.0	0.8
01 00	900.0	0.7	09 00	50.0	0.7	17 00	1000.0	0.7
01 10	50.0	0.7	09 10	50.0	0.7	17 10	500.0	0.7
01 20	50.0	0.7	09 20	50.0	0.7	17 20	1000.0	0.7
01 30	50.0	0.7	09 30	50.0	0.7	17 30	500.0	0.7
01 40	50.0	0.7	09 40	50.0	0.7	17 40	50.0	0.7
01 50	50.0	0.7	09 50	50.0	0.7	17 50	50.0	0.7
02 00	50.0	0.7	10 00	50.0	0.7	18 00	1220.0	0.7
02 10	50.0	0.7	10 10	50.0	0.7	18 10	1800.0	0.7
02 20	50.0	0.7	10 20	50.0	0.7	18 20	1950.0	0.7
02 30	50.0	0.7	10 30	50.0	0.7	18 30	3000.0	0.75
02 40	50.0	0.7	10 40	50.0	0.7	18 40	3500.0	0.8
02 50	50.0	0.7	10 50	50.0	0.7	18 50	2000.0	0.75
03 00	50.0	0.7	11 00	50.0	0. 7	19 00	900.0	0.7
03 10	50.0	0.7	11 10	500.0	0.5	19 10	50.0	0.7
03 20	50.0	0.7	11 20	2500.0	0.75	19 20	50.0	0.7
03 30	50.0	0.7	11 30	500.0	0.7	19 30	50.0	0.7
03 40	50.0	0.7	11 40	50.0	0.7	19 40	50.0	0.7
03 50	50.0	0.7	11 50	50.0	0.7	19 50	50.0	0.7
04 00	50.0	0.7	12 00	50.0	0.7	20 00	50.0	0.7
04 10	200.0	0.7	12 10	50.0	0.7	20 10	50.0	0.7
04 20	1000.0	0.7	12 20	50.0	0.7	20 20	50.0	0.7
04 30	50.0	0.7	12 30	50.0	0.7	20 30	50.0	0.7
04 40	50.0	0.7	12 40	50.0	0.7	20 40	50.0	0.7
04 50	50.0	0.7	12 50	50.0	0.7	20 50	50.0	0.7
05 00	50.0	0.8	13 00	50.0	0.7	21 00	50.0	0.7
05 10	1000.0	0.8	13 10	1000.0	0.7	21 10	50.0	0.7
05 20	5000.0	0.8	13 20	1000.0	0.7	21 20	50.0	0.7
05 30	4500.0	0.8	13 30	800.0	0.7	21 30	50.0	0.7
05 40	6000.0	0.8	13 40	250.0	0.7	21 40	50.0	0.7
05 50	8000.0	0.8	13 50	1000.0	0.7	21 50	50.0	0.7
06 00	7000.0	0.85	14 00	50.0	0.7	22 00	50.0	0.7
06 10	9000.0	0.85	14 10	50.0	0.7	22 10	200.0	0.7
06 20	12000.0	0.85	14 20	50.0	0.7	22 20	1000.0	0.7
06 30	11000.0	0.85	14 30	50.0	0.7	22 30	50.0	0.7
06 40	13000.0	0.75	14 40	50.0	0.7	22 40	50.0	0.7
06 50	18000.0	0.7	14 50	50.0	0.7	22 50	50.0	0.7
07 00	20000.0	0.7	15 00	50.0	0.7	23 00	50.0	0.7
07 10	50.0	0.7	15 10	50.0	0.7	23 10	1000.0	0.7
07 20	50.0	0.7	15 20	50.0	0.7	23 20	5000.0	0.8
07 30	50.0	0.7	15 30	50.0	0.7	23 30	4500.0	0.8
07 40	50.0	0.7	15 40	50.0	0.7	23 40	6000.0	0.8
07 50	50.0	0.7	15 50	50.0	0.7	23 50	8000.0	0.8

LOAD PATTERN – (1I)

ANNEXURE-II

TIME	KW	PF.	TIME	KW	PF.	TIME	KW	PF.
00 00	5000.0	0.8	08 00	8000.0	0.8	16 00	10000.0	0.85
00 10	9000.0	0.8	08 10	9000.0	0.8	16 10	5000.0	0.8
00 20	1000.0	0.85	08 20	10000.0	0.85	16 20	5000.0	0.8
00 30	12000.0	0.85	08 30	5000.0	0.8	16 30	8000.0	0.8
00 40	5000.0	0.8	08 40	8000.0	0.8	16 40	10000.0	0.85
00 50	8000.0	0.8	08 50	10000.0	0.85	16 50	8000.0	0.8
01 00	10000.0	0.85	09 00	5000.0	0.8	17 00	5000.0	0.8
01 10	8000.0	0.8	09 10	7000.0	0.8	17 10	6000.0	0.8
01 20	9000.0	0.8	09 20	8000.0	0.8	17 20	8000.0	0.8
01 30	10000.0	0.85	09 30	10000.0	0.85	17 30	10000.0	0.85
01 40	5000.0	0.8	09 40	5000.0	0.8	17 40	5000.0	0.8
01 50	3000.0	0.75	09 50	6000.0	0.8	17 50	6000.0	0.7
02 00	1000.0	0.7	10 00	10000.0	0.85	18 00	2000.0	0.75
02 10	500.0	0.7	10 10	10000.0	0.85	18 10	1500.0	0.7
02 20	50.0	0.7	10 20	8000.0	0.8	18 20	50.0	0.7
02 30	4000.0	0.8	10 30	6000.0	0.8	18 30	50.0	0.7
02 40	5000.0	0.8	10 40	1000.0	0.7	18 40	4000.0	0.8
02 50	10000.0	0.85	10 50	1000.0	0.7	18 50	8000.0	0.8
03 00	8000.0	0.8	11 00	50.0	0.7	19 00	10000.0	0.85
03 10	10000.0	0.85	11 10	50.0	0.8	19 10	5000.0	0.8
03 20	12000.0	0.85	11 20	8000.0	0.8	19 20	8000.0	0.8
03 30	10000.0	0.85	11 30	10000.0	0.85	19 30	10000.0	0.85
03 40	5000.0	0.8	11 40	12000.0	0.85	19 40	15000.0	0.85
03 50	7000.0	0.8	11 50	10000.0	0.85	19 50	12000.0	0.85
04 00	10000.0	0.85	12 00	5000.0	0.8	20 00	8000.0	0.8
04 10	5000.0	0.8	12 10	9000.0	0.8	20 10	9000.0	0.8
04 20	5000.0	0.8	12 20	10000.0	0.85	20 20	10000.0	0.85
04 30	8000.0	0.8	12 30	12000.0	0.85	20 30	5000.0	0.8
04 40	10000.0	0.85	12 40	5000.0	0.8	20 40	8000.0	0.8
04 50	8000.0	0.8	12 50	8000.0	0.8	20 50	10000.0	0.85
05 00	5000.0	0.8	13 00	10000.0	0.85	21 00	5000.0	0.8
05 10	6000.0	0.8	13 10	8000.0	0.8	21 10	7000.0	0.8
05 20	8000.0	0.8	13 20	9000.0	0.8	21 20	8000.0	0.8
05 30	10000.0	0.8	13 30	10000.0	0.85	21 30	10000.0	0.85
05 40	5000.0	0.8	13 40	5000.0	0.8	21 40	5000.0	0.8
05 50	6000.0	0.8	13 50	3000.0	0.75	21 50	6000.0	0.8
06 00	2000.0	0.75	14 00	1000.0	0.7	22 00	10000.0	0.85
06 10	1500.0	0.78	14 10	500.0	0.7	22 10	10000.0	0.85
06 20	50.0	0.7	14 20	50.0	0.7	22 20	8000.0	0.8
06 30	50.0	0.7	14 30	4000.0	0.8	22 30	6000.0	0.8
06 40	4000.0	0.8	14 40	5000.0	0.8	22 40	10000.0	0.7
06 50	8000.0	0.8	14 50	10000.0	0.85	22 50	1000.0	0.7
07 00	10000.0	0.8	15 00	8000.0	0.8	23 00	50.0	0.7
07 10	5000.0	0.8	15 10	10000.0	0.85	23 10	50.0	0.7
07 20	8000.0	0.8	15 20	12000.0	0.85	23 20	8000.0	0.8
07 30	10000.0	0.85	15 30	10000.0	0.85	23 30	10000.0	0.85
07 40	15000.0	0.85	15 40	5000.0	0.8	23 40	12000.0	0.85
07 50	12000.0	0.85	15 50	7000.0	0.8	23 50	10000.0	0.85

III-3

MASTER COPY
मूल प्रति

1.0 SCOPE

This instruction stipulates the action to be taken **by DIVISIONS / HEAD QUARTERS as applicable** in case of a failure of 25kV solid core porcelain insulator. This instruction shall be applicable separately for each type of insulator.

2.0 GENERAL INSTRUCTION

Whenever there is a failure of 25kV solid core porcelain insulator, the following actions are to be taken **by DIVISIONS.**

i) Check for the cause of the failure. If the failure is due to external reasons such as

a) Monkey / Vulture electrocution
b) Pantograph entanglement
c) Short circuit by Snake, Stray wire etc.
d) Tree falling
e) Stone throwing by miscreant
f) Brake Block hitting the mast
g) Bad weather (Thundering & Lightning)
h) Potential Difference at FP
i) Pollutant deposition
j) Contact wire / Catenary reason or
k) Any other external reason

then no investigation of failure is required. If the failure is due to material defect , then further analysis is required as given below:-

ii) Check whether the insulator belongs to the batch and make which are to be replaced advised vide Instruction No. TI/IN/0005/Rev. 0. If so, then replacement of insulator is required as already advised.

iii) Check whether the insulator belongs to the batch and make which are suspect for failure proneness as advised vide Instruction No. TI/IN/0006/Rev. 0. If so, action is to be taken as advised in the above Instruction.

iv) If the make and batch of the failed insulator is not applicable to any of the categories (ii) & (iii) above, then the action to be taken by the following appropriate agency will be as under:

A) BY THE DIVISIONS:

a) Check whether any insulator failure of the same make and batch due to material defect has been recorded within a period of previous one year from the date of current failure. If no failure due to material defect has been recorded, then no action is to be taken but they are to be kept under close watch till the next failure of same make and batch of the insulator due to material defect. **The failed insulator need not be sent to RDSO for investigation.**

b) If the current failure is the second case due to material defect within a period of previous one year, then 5 insulators of the same batch and make are to be removed from the vicinity of the location of failures. They are to be sent to RDSO for conducting requisite test. Based on the test results, decision will be taken by RDSO to retain or replace the make and batch concerned and advice will be given to all concerned.

B) BY THE HEAD QUARTERS

c) Check whether any insulator failure of the same make and batch due to material defect has been reported by any Division in the Railway within a period of previous one year from the date of current failure. If no failure due to material defect has been reported, then no action is to be taken.

d) If the current failure is the second case due to material defect within a period of previous one year reported by any Division in the Railway, not necessarily from the same Division which reported the earlier failure, then the situation shall be considered serious. Any one Division where the failure occurred shall be instructed to remove 5 insulators of the same batch and make from the vicinity of the location of failures. They are to be sent to RDSO for conducting requisite test. Based on the test results, decision will be taken by RDSO to retain or replace the make and batch concerned and advice will be given to all concerned.

3.0 DEVIATION FROM THE INSTRUCTION

If any deviation is sought from the above procedure, complete details may be submitted to RDSO and specific exemption may be obtained on case to case basis.

4.0 This supersedes all the instructions issued earlier regarding the failure of insulators.

****

1144

Government of India
Ministry of Railways
Research Designs & Standards Organisation
Manak Nagar, Lucknow – 226011

MASTER COPY

मूल प्रति

INSTRUCTION NO. TI/IN/0008 Rev. 0

INSTRUCTIONS FOR USE OF COPPER CROSS FEEDERS AT SWITCHING STATIONS.

1. **Objective** : Use of copper cross feeder in place of aluminium cross feeder (spider) to improve the reliability of the system.

2. **Back Ground:** On 25 kV ac traction system, failures of 19/3.99 mm aluminum cross feeder due to industrial pollution, corrosion and bimetallic action etc. may take place thereby affecting the reliability of the system. Therefore, to avoid failures of cross feeders of aluminum conductor (Spider) and thereby to improve the reliability of the system only 37/2.25 mm, 150 mm^2 stranded copper conductor should be used as cross feeder. Aluminium conductor (Spider) wherever exists as cross feeder should be replaced with copper cross feeder.

3. The arrangement of copper cross feeders are indicated in the following drawings which should be followed:

i) ETI/OHE/G/05121 Sh. No.1 Rev C	General arrangement of connection to OHE by copper cross feeder (150).
ii) ETI/OHE/G/05122 Sh. No.1 Rev C	General arrangement of connection at switching station on double track section by copper cross feeder (150).
iii) ETI/OHE/G/05123 Sh. No.1 Rev C	General arrangement of connection at switching station on multiple track section by copper cross feeder (150).
iv) ETI/OHE/G/05121 Sh. No.3	General arrangement of connection to composite OHE by copper cross feeder .
v) ETI/OHE/G/05122 Sh. No.3	General arrangement of connection at switching station on double track section for composite OHE by copper cross feeder .
vi) ETI/OHE/G/05123 Sh. No.3	General arrangement of connection at switching station on multiple track section for composite OHE by copper cross feeder .

4. It should be ensured that the cross feeders are without any joint (splicing)in between.

5. **Agency for implementation .**

Railways and RE Project units.

****

III-5

MASTER COPY
मूल प्रति

Government of India
Ministry of Railways
Research Designs & Standards Organisation
Manak Nagar, Lucknow – 226011

INSTRUCTION NO.TI/IN/0009 Rev. 0.

INSTRUCTIONS FOR SPLICING OF 19/3.99 mm ALUMINIUM CONDUCTOR (SPIDER).

1. **Objective-** To evolve proper procedure for splicing the aluminium conductor (Spider).

2. **Background:-** On 25 kV ac traction system 19/3.99 mm aluminium conductor (Spider) has been used as cross feeder, along track feeder and return conductor. The spider conductor is not required to be used as cross feeder now but along track feeder still exists.

3. The correct method to splice the conductor (Spider) is to use repair sleeves as per drawing no. ETI/OHE/P/1610-1 or equivalent drawing of the source approved by CORE/ALD. No other method of splicing the conductor shall be resorted to.

4. Agency for implementation:

Railways and RE Project units.

----------x----------

MASTER COPY
मूल प्रति

Guideline Operating Procedures of TSSs in Mumbai Area.

(Ref. Interlocking Scheme by RDSO drawing no.TI/DRG/PSI/INTERLOCK/RDSO/00001/05/0)

1. Normally, both incoming line circuit breakers CB 1 & 2 shall remain closed and 110 KV bus coupling circuit breakers CB- 3 will be in open position.
2. Power supply to traction over head equipments shall be fed through any one of two transformers by closing its respective HV and LV transformer Circuit Breakers. At a time, only one transformer will be in service. Other transformer, not on load, can be kept as
   a. Hot standby, by closing its HV side transformer Circuit Breaker and keeping LV transformer Circuit Breaker open.

   OR

   b. Dead, by keeping both HV & LV transformer Circuit Breaks in open position. However, each transformer shall feed load periodically at regular intervals.

3. Bus coupler is provided on 25 kV side with Circuit Breaker CB - 8. This shall normally be closed for feeding the OHE in either side of IOL from any of the transformers.

4. In case of outage of one feeder and transformer on other bay at a particular time, power supply can be restored through healthy transformer from other feeder by operation of 110 KV bus coupler Circuit Breaker CB – 3.

5. **Extension of 25 KV supply in case of outage of one complete TSS.**

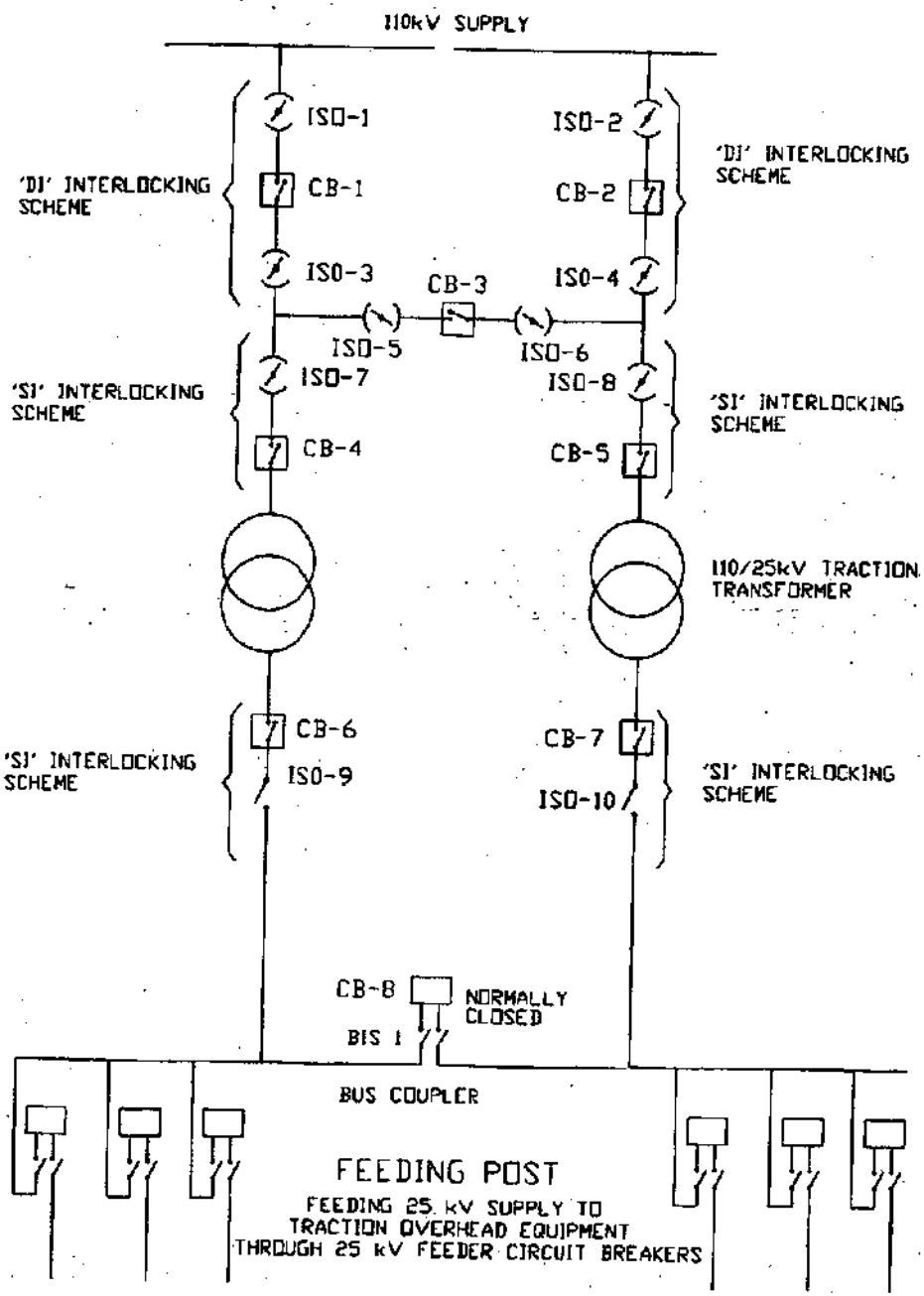
   a) In the event of failure of any TSS, supply from adjoining TSS may be extended up to the IOL of failed TSS by closing the bridging CB at the SP on either side of failed TSS. Bus coupler CB no. 8 at the failed TSS shall be kept in open position along with LV transformer CB 6 & 7 at the failed TSS in open position. However, this will necessiate lower panto / raise panto of the trains in front of failed TSS, if it is not provided with neutral sections.

   b) Otherwise, supply may be extended over complete zone of failed TSS from any of the adjoining TSS i.e. from SP to SP. Bus coupler CB no. 8 at the failed TSS shall be kept in close position along with LV transformer CB 6 & 7 at the failed TSS in open position. In this case no lower panto / raise panto is required, however the OHE voltage and load has to be closely monitored.

6. **For paralleling of nominated Traction Sub Stations**

   a) Energize the OHEs of concerned TSS zone up to SP locations and then close the bridging CBs at SP location.

   b) Energize the OHE of one TSS zone. Extend the supply by closing bridging CB at SP and feeder CB & bus coupler CB at the next TSS. Then close LV transformer Circuit Breaker at other Traction Sub Station to make parallel operation of the two TSSs.



INTERLOCKING SCHEME- EXPLANATORY NOTES:

1. CB-1 AND CB-2 ARE 110 kV INCOMING LINE CIRCUIT BREKERS AND CB-3 IS BUS COUPLER CIRCUIT BREAKER.
2. CB-4 AND CB-5 ARE 110kV SIDE TRANSFORMER CIRCUIT BREAKERS.
3. CB-6 AND CB-7 ARE 25kV SIDE TRANSFORMER CIRCUIT BREKERS.
4. CB-8 IS 25kV CIRCUIT BREAKERS FOR BUS COUPLER.
5. ISO 1 2 3 4 7 8 9 & 10 ARE ASSOCIATED ISOLATORS
6. ISO 5 6 ARE 110 kV BUS COUPLER ISOLATORS.
7. BIS 1 IS 25 kV BIPOLE ISOLATOR FOR BUS COUPLER.
8. SI INTERLOCKING SCHEME REFERS TO CIRCUIT BREAKER INTERLOCKED WITH ONE ASSOCIATED ISOLATOR.
9. DI INTERLOCKING SCHEME REFERS TO CIRCUIT BREAKER INTERLOCKED WITH TWO ASSOCIATED ISOLATORS.
10. DI INTERLOCKING SCHEME IS TO BE PROVIDED ON 110 kV SIDE INCOMING LINE CIRCUIT BREKERS CB-1 AND CB-2 & 110kV BUS COUPLER CB-3 AND INTERLOCKING OF CIRCUIT BREAKERS TO BE DONE WITH ASSOCIATED DOUBLE ISOLATORS.
11. SI INTERLOCKING SCHEME IS TO BE PROVIDED IN HV & LV SIDE TRANSFORMER CIRCUIT BREAKERS WHERE INTERLOCKING OF CIRCUIT BREAKER ARE TO BE ENSURED WITH SINGLE ASSOCIATED ISOLATORS.
12. SI INTERLOCKING SCHEME IS TO BE PROVIDED FOR BUS COUPLER. INTERLOCKING OF CIRCUIT BREAKER SHALL BE DONE WITH ASSOCIATED BIPOLE ISOLATOR.
13. SI INTERLOCKING SCHEME IS ALSO TO BE PROVIDED AT 25kV FEEDER CIRCUIT BREAKER INTERLOCKING SHALL BE DONE WITH RESPECTIVE ASSOCIATED BIPOLE ISOLATORS.
14. THE KEY CODES ADOPTED FOR BREAKERS TO BE INSTALLED AT A SUB-STATION SHALL BE NON INTERCHANGEABLE SO THAT NO NAL OPERATION IS POSSIBLE.
15. LOCK MEANT FOR MOUNTING ON ISOLATOR SHALL BE A BOLT TYPE LOCK
16. INTERLOCKING SCHEME PROVIDED WITH CIRCUIT BREAKER FOR ITS INTERLOCKING WITH ISOLATOR SHOULD BE SUCH THAT THE OPERATION OF ISOLATOR SHALL NOT BE POSSIBLE UNLESS THE CIRCUIT BRAKER IS LOCKED IN OPEN POSITION. OPERATION OF CIRCUIT BREAKERS SHALL NOT BE POSSIBLE UNLESS THE ASSOCIATED ISOLATORS ARE LOCKED IN EITHER CLOSE OR OPEN POSITION.
17. THE REQUIREMENT OF INTERLOCK FOR THE ARRANGEMENT SHOWN IN THE DRAWING SHALL BE
    a) SI INTERLOCKING SCHEME - 05 SETS + ADDITIONAL FOR FEEDER CB's
    b) DI INTERLOCKING SCHEME - 03 SETS
18. PLEASE REFER GUIDE LINE OPERATING PROCEDURES FOR TSS OPERATION IN MUMBAI AREA (TI/IN/11 REV. 0)

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE WITHOUT PRIOR CONSENT IN WRITING."

SCHEME OF INTERLOCKING ARRANGEMENT OF 25 kV CIRCUIT BREAKER AT TRACTION SUB STATION FOR MRVC

DTI - 1

ADE - 1

REF:- ETI/PSI/5212 MOD B

CROSS REF:-

DATE	MOD.	NATURE OF MOD	INITIAL

R.D.S.O.

	DATE	NAME
DR	28-03-79	Sd/-
TC	20-10-81	Sd/-
CH	05-11-81	Sd/-

TI/DRG/PSI/INTERLOCK/RDSO/00001/05/0

SCALE:- NTS

SUB-SCALE:-

MASTER COPY
मूल प्रति

1.0 OBJECTIVE:

1.1 Zonal Railways have reported a large number of failures of porcelain insulators over the last five years .The data has been analyzed by RDSO & it has been found that out of total failures reported by zonal Railways, 372 failure are on **MANUFACTURING** account. The failures on manufacturing account have been thoroughly studied & it has been found SER,CR & E.Rly have maximum failures.

1.2 To reduce the on line failures, RDSO has issued instructions from time to time for replacement /retention of insulators. However, this time failure pattern of last five years & result of tensile load test conducted at RDSO have been analyzed. This instruction stipulates the action to be taken by **RAILWAYS** for replacement/retention of certain makes and batches of 25 kV solid core porcelain insulators. This outcome of the analysis is given in following paras :

2.0 "FAILURE PRONE BATCHES":

2.1 Based upon the failure pattern of last 5 years & result of tensile load testing done at RDSO, on the insulators received from Railways, the insulators belonging to the following batches have been declared as "FAILURE PRONE" batches.

Make	Type of insulator	Batches
MPL	Stay arm Insulator	1966, 1968 & 1969 (For undivided S.E.Rly only)
	Bracket insulator	1960, 1968 & 1975 (For undivided S.E.Rly only)
GDR	Bracket insulator	1966
	9-tonne insulator	All batches
JSI	9-tonne insulator	5/96, 12/96, 2/97, 1/97
	Bracket insulator	2/89

WSI	Bracket insulator	9/88
	Stay arm Insulator	9/88
	9-tonne insulator	1/89
MIL	9-tonne insulator	10/87, 12/87, 11/2000
W.G	9-tonne insulator	1982
BHEL	Bracket Insulator	6/82

Table-I

2.2 ACTION TO BE TAKEN:

The replacement of the entire batch of such insulator as given in Table-I may be done. Please note that MPL make insulators should be replaced by all divisions of undivided S.E.Rly only & not by other Railways. If no failure of the above batches is noticed on the Railways, the details of such batches should be submitted to RDSO and **specific exemption** may be obtained on case-to-case basis.

3.0 "SUSPECTED TO BE FAILURE PRONE BATCHES":

3.1 **Based upon the failure pattern of last 5 years, those batches of wherein at least 4 insulators have failed during the last 5 years have been declared as "suspected to be failure prone batches"**., as given in Table-II.

Make	Type of insulator	Batches
NGK	9 Tonne	1980
JSI	9-tonne insulator	2/96

Table-II

3.2 ACTION TO BE TAKEN:

If any failure of above mentioned batch of insulator has occurred on manufacturing account, 10 healthy insulator of that batch should be removed from the vicinity of failed insulator and sent to RDSO for testing. Based upon the results of the tests conducted by RDSO the decision for replacing or retaining that particular batch shall be taken by RDSO and advised to all concerned.

4.0 ""MAKES, TYPES & BATCHES TO BE RETAINED IN SERVICE

4.1 The under mentioned makes, types & batches of 25 kV solid core porcelain insulators were declared either "failure prone" or suspect batches" earlier. Based upon the failure pattern of last five years & on the result of tests conducted at RDSO, these make, type & batches MAY BE RETAINED in service.

Make	Type of insulator	Batches
MPL	9-tonne	All
	Stay arm	All batches, However for S.E.Rly, all batches except 1966,1968 &1969.
	Bracket	All batches, However for S.E.Rly, all batches except 1960,1968 &1975.
JSI	9-tonne insulator	3/98
	Bracket insulator	1/90
	Stay arm insulator	1/94
GDR	Stay arm insulator	1965, 1966
WSI	Bracket insulator	8/88
MIL	9-tonne insulator	1/88

Table -III

4.2 ACTION TO BE TAKEN:

These batches should be retained in service. However, if there is more than one failure on manufacturing account of any batch among that listed in Table -III & of batches other than those given in Table I & II, in the Railway, then the situation should be considered serious. The divisions where the failure occurred, shall be instructed to removed 10 insulators of the same batch and make from the vicinity of the location of failures. They are to be sent to RDSO for conducting requisite tests. Based on

the test results, decision will be taken by RDSO, to retain or replace the make and batch concerned and advice will be given to all concerned.

5.0 Failures per 1000 insulators :

One more study has been carried out to find out those make and type of insulators, having failure of more than 1 insulator per 10,000 insulators. Apart from the make and type already covered in above study, the following make & type of insulators, given in Table IV, should be replaced with new insulators as their population is very less but per 10,000 insulator is more than 1.0

Make	Failure per 10,000 insulator	
	9 T	Stay
CGEC	2.52	
FP	9.62	
Siemen	47.06	
WG	44.64	
Japan	2.09	
BICC	5.49	
ENG		1.19
SMC		1.04

The current population of insulators of these make may be advised to RDSO by Railways.

6.0 DEVIATION FROM THE INSTRUCTION

If any deviation is sought from the above procedure, complete details may be submitted to RDSO and specific exemption may be obtained on case-to-case basis.

7.0 GENERAL INSTRUCTION :

7.1 Railways are reporting failures of porcelain insulators on account of manufacturing & external reasons to RDSO. The external reasons details

submitted by Railways have been studied by RDSO & it has been found that the external failures are mainly on following accounts.

a) **Pantograph entanglement**
b) **Short circuit by Snake, Stray wire, monkey/vulture/birds etc.**
c) **Tree falling.**
d) **Stone throwing by miscreant**
e) **Mast hitting by brake block/road vehicle, open door wagon etc.**
f) **Bad weather (Thundering & Lightning)**
g) **Potential Difference at FP**
h) **Pollutant deposition**
i) **Derailment / accident etc.**
j) **Any other external reason.**

7.2 Whenever, there is failure of 25 kV solid core porcelain insulator, then check, whether the failure is due to any one of the above external reasons. If so, then the Railways have to certify that the failures are due to external reasons & it is not on account of manufacturing. It will help in identifying the insulator failure pattern & corrective action can be taken accordingly.

8.0 ***This supersedes all the instructions issued earlier regarding the replacement of insulators***

☺☺☺☺☺☺☺

Government of India, Ministry Railways
Research Designs & Standards
Organisation,
Manak Nagar, Lucknow– 226 011

सत्यमेव जयते

Telephone:91-0522-2465765
Fax : 91-0522-2465765
Email:dti5rdso@gmail.com
dirti1@rdso.railnet.gov.in

सं./No: RDSO-TI0LKO(OHE)/42/2020-O/o PED/TI/RDSO दिनांक/Date: 19.06.2023

Principal Chief Electrical Engineer,

1. Central Railway, 2nd floor, Electrical Branch, Parcel Office Bldg. Mumbai - 400 001.
2. Eastern Railway, Fairlie Place, Kolkata-700 001
3. East Central Railway, Hajipur (Bihar).844101
4. East Coast Railway, B-Rental Colony, Chandrashekharpur, Bhubaneshwar (Orissa)-751 023
5. Northern Railway, Baroda House, New Delhi - 110 001
6. North Central Railway, Block-A, Subedarganj, Prayagraj 211 033.
7. North Eastern Railway, Gorakhpur (UP).220 055
8. Northeast Frontier Railway, Maligaon, Guwahati - 781011.
9. North Western Railway, Jaipur (Raj.) – 302017.
10. Southern Railway, Park Town, Chennai - 600 003 (TN)
11. South Central Railway, Rail Nilayam, Secunderabad – 500 371
12. South Eastern Railway, Garden Reach, Kolkata-700 043.
13. South East Central Railway, Bilaspur (Chhattisgarh).4950 04
14. South Western Railway, DRM's Office, Hubli (Karnataka)
15. Western Railway, Churchgate Stn. Bldg, Mumbai - 400 020.
16. West Central Railway, Jabalpur-482 001 (M.P)
17. Central Organisation for Railway Electrification, 1, Nawab Yusuf Road, Civil Lines, Prayagraj-211001.
18. Konkan Railway Corporation Limited, Belapur Bhavan, Plot No 6, Sector 11, CBD Belapur, Navi Mumbai – 400614.
19. Metro Railway, Kolkata, Metro Bhavan, 33/1, J L Nehru Road, Kolkata-700031.
20. Director General, IRIEEN, Post Box 233, Nashik Road-422101.
21. Chairman and Managing Director, IRCON, Room No. 505, Palika Bhawan, Sector -13, R. K. Puram, New Delhi-110066.
22. Managing Director, DFCCIL, 5th Floor, Pragati Maidan, Metro Station Building Complex, New delhi-110 001.
23. Chief Executive Officer, Railway Energy Management Co. Ltd, Ground Floor, Central Wing, Sector 29, Gurgaon-122001.
24. Director Technical, MRVC, 2nd Floor, Churchgate, Mumbai-400020.
25. ED (Electrical), RVNL, 1st Floor, August Kranti Bhavan 'B' Block, BhikaJi Cama Place, R K Puram, New Delhi-110066.
26. Chairman and Managing Director RITES LTD, Shikhar, Plot No.01, Sector 29, Gurgaon, Haryana, India-122001.

विषय/Sub: Instruction No. TI/IN/0013, Rev-02 for Handling of 25 kV Composite Insulator.

The revised Instruction No. TI/IN/0013, Rev-01 for handling of 25 kV Composite Insulator was issued by RDSO in April-2023. The same has been reviewed and revised as Instruction No. TI/IN/0013, Rev-02 by adding illustration. This supersedes the earlier issued Instruction No. TI/IN/0013, Rev-0 and TI/IN/0013, Rev-01.

A copy of revised Instruction No. TI/IN/0013, Rev-02 is enclosed herewith for reference and necessary action please.

This issues with the approval of competent authority.

संलग्नक: यथोक्त

Digitally Signed by Arvind Kumar
Date: 19-06-2023 17:52:03
Reason: Approved

(अरविन्द कुमार/Arvind Kumar)
निदेशक/कं.सं-1/ Director/TI-1
कृते महानिदेशक/कं.सं/For Director General/TI

Copy to: Executive Director, EEM, Railway Board, Rail Bhavan, New Delhi- 110001-for kind information please.

सत्यमेव जयते

भारत सरकार GOVERNMENT OF INDIA

रेल मंत्रालय MINISTRY OF RAILWAYS

25 केवी कंपोजिट इंसुलेटर के संभालने (हैंडलिंग) के लिए निर्देश
INSTRUCTION FOR HANDLING OF 25 KV COMPOSITE INSULATORS

सं. टी0 आई0/आई0एन0 / 0013 (06/2023), संशोधन 02

No. TI/IN/ 0013 (06/2023), Rev 02

जारीकर्ता/ISSUED BY:

कर्षण संस्थापन निदेशालय

TRACTION INSTALLATION DIRECTORATE,

अनुसन्धान अभिकल्प और मानक संगठन

RESEARCH DESIGNS & STANDARDS ORGANISATION,

मानक नगर लखनऊ-226011

MANAKNAGAR, LUCKNOW-226011

(केवल आधिकारिक प्रयोग के लिए/ For official use only)

Ajay	19.06.23	15.6.23
Prepared By SSE(D)/TI	Checked By ADE/TI-1	Issued By DTI-1

1.0 SCOPE :

This IN (Instruction) stipulates the action to be taken for handling of 25 kV Composite Insulators over IR. This version of IN (Instruction) shall superseded the older version issued in Dec.2005 and April 2023.

2.0 OBJECTIVE:

The composite insulators have been inducted in the Indian Railways traction network due to its inherent property of performing in severe polluted conditions. The performance not only depends upon the quality of the manufactured product but also on the manner in which the user handles these insulators when it is received in the Railway's premises , until it is put into service (in line).

Since the composite insulators have silicon rubber as a component, they are much more flexible and fragile than the solid core porcelain insulators. Thus special care needs to be taken during handling of these insulators.

Although, Composite Polymer Insulators are unbreakable when compared to Porcelain Insulators but the Composite Polymer Insulators are not damage-proof because any sharp edge / uneven flooring while storage / Stone / Nails on the Wooden Box etc. can damage the Silicon Rubber Covering on the Core, which may not be visible through naked eyes & it will lead to moisture ingress , which can deteriorate the life of these Insulators.

3.0 GENERAL INSTRUCTION:

This IN (Instruction)) elaborates the various stages through which the insulator passes from the production line to the actual service in line. Various stages are as under:-

i. Receiving, unpacking & storage.
ii. Transport to construction site.
iii. On-site handling.
iv. Installation by TRD staff/Contractors.
v. Conductor stringing & cantilever assembly.
vi. Final inspection before energization.
vii. Care during maintenance.

3.1 RECEIVING, UNPACKING AND STORAGE

3.1.1 Transportation vehicle unloading should be done without using any type of Hook or Metal equipment which can damage outer carton box of the packing / inner skin of the Insulator.

3.1.2 On receipt of composite insulator at the store of user, the crate should be carefully inspected for any sign of damage.

3.1.3 No Sharp Blade or Knife with more than 10 mm blade length should be used to open the sealed Carton Boxes to avoid any cut / damage on the Polymer / Silicon Shed / Core of the Insulators. It is preferred to use only some nib type sharp edge tool of max 10 mm nib length to open the sealed carton Boxes.



3.1.4 After inspection, the insulators should be packed in original packing and preferably be stored in original packing.

3.1.5 Alternatively, Insulators can also be or placed on a suitable designed racks, so that sheds of the insulators do not bend and remain straight.

3.1.6 Carton packing Boxes should be put one over other in a proper row and in such a way to avoid any damage of Boxes and Composite Insulators due to extra weight burdens.

3.1.7 The stacking & storage of insulators should be proper, i.e. one insulator overthe other at 90° should be avoided.

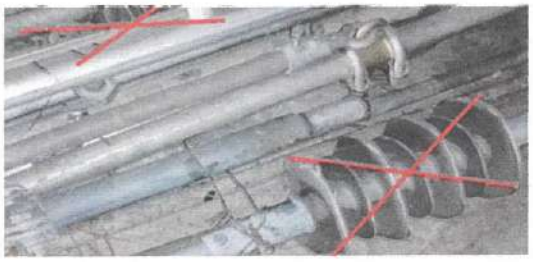






3.1.8 They should be stored in a dry, covered area preferably within the packing, raised off the ground on wooden Pallets. Lids of the packing should remain sealed to prevent entry of rodents.

3.1.9 Under no circumstances Composite Insulators should be stored / placed close to the Metal Items / any other type of Sharp Object to avoid any damage on the Core / Rubber of the Composite Insulators.

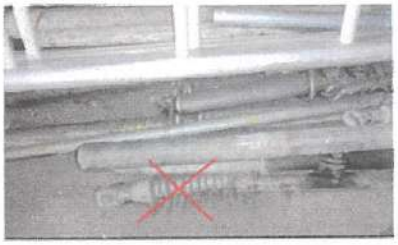


3.1.10 The storage area should be free from oil or other petroleum derivative products.

3.1.11 After pre-installation test as per RDSO's SMI No. TI/MI/0042, Rev-01 or latest on the Insulators, the same should be repacked in the Carton Boxes as per Original Packing till the final Installation at the site / exact location.

3.1.12 To avoid any damage on the Insulators, it is preferred that the Insulators should be unpacked only at the time of Installation and should not be stored / kept up without packing under any circumstances.

3.1.13 Composite Polymer Insulators should only be installed at site directly (as per same procedure followed for Porcelain Insulators) and should not be loaded or transported to any site after assembly on Cantilevers. Due to mis-handling of naked Polymer Insulators without packing may lead to damage on Silicon Rubber Covering, which will affect the performance of the Insulators.



3.1.14 Composite Insulators having gap between Metal fitting and Rubber should not be used.

3.2 TRANSPORT TO CONSTRUCTION SITE

Whenever possible, the insulators should be transported to site in their original (closed) packing. However, if this is not possible, they should be transported neither loosely nor without sufficient protection and the insulators should not be tied down or bound together with

chain or ropes.

3.3 ON SITE HANDLING

Upon arrival at site, the packing should again be carefully checked. If any sign of breakage or rough treatment is evident, each insulator-shed should be carefully examined for evidence of damage.

It is recommended that a temporary reusable packing system should be adopted to provide the adequate protection to these insulators.

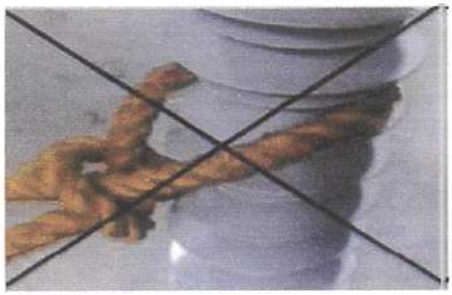
3.4 INSTALLATION

Prior to installation, the insulators should once again be thoroughly examined for any damage. Units displaying hit marks, cuts or damage of sheds of the composite material should be set aside for expertinspection. In case exposure of the fiber glass core is noticed, however small, the insulator should immediately be discarded from the lot and should not be installed on line.

If the insulators are dirty & require cleaning, they should be cleaned as per RDSO Instruction No. TI/IN/0040, Rev-0 or latest.

While installing these insulators, care should be taken that lifting lines or ropes are not attached to the metal end fittings of the insulators and not to the sheds or FRP rod.

The ladder / person should not rest on the rest-portion of the insulator.



3.5 CONDUCTOR STRINGING

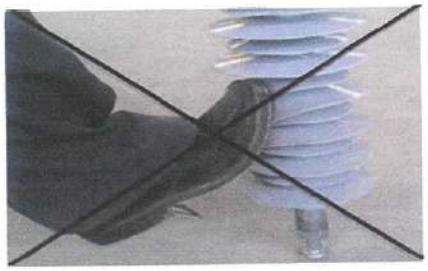
During conductor stringing operation, the insulators should not be subjected to bending loads & torsioning loads.

3.6 CARE DURING MAINTENANCE

i. During Installation and maintenance of the Composite Insulator or any other OHE

maintenance, only authorized Persons / Skilled Labour should be allowed.

ii. Special care needs to be taken while undertaking OHE maintenance near the composite insulator area and the staff working on the cantilever and on OHE overhead line should not damage the sheds of these insulators by standing or resting the ladder on these insulators.





iii. This needs to be monitored while Installation of Insulators.

3.7 FINAL INSPECTION BEFORE LINE ENERGIZATION

On undertaking a final inspection prior to commissioning of a line, composite insulators should be examined for any of the following.

i. Physical damage like Broken & torn sheds.

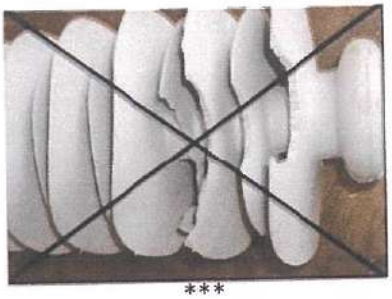
ii. Damage to the end seals where the rod enters the metal fitting.

iii. If any cuts, Damage on Sheds or Core is observed on the Composite Polymer Insulators then the same should be set aside for expert & complete Inspection.

iv. A misalignment of the metal fitting which would indicate that the insulator has been subjected to, or is being subjected to a torsional stress.

v. Splitting of the sheath resulting in exposure of FRP rod or core.

vi. If exposure of Fibre glass Core is observed at any surface of the Insulator, then it should be replaced immediately.



***

112-4

MASTER COPY

टेलीफोन / Tele : 2451200(PBX)
2450115 (DID)
Extn.: 42586
फैक्स / Fax : 91-0522-2465763

भारत सरकार – रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
लखनऊ – 226 011
Government of India-Ministry of Railways
Research designs & Standards Organisation
Lucknow-226 011

No.TI/PSI/DRPC/DEV/07

Date: 03-04-2007

REGD POST

Chief Electrical Engineer

1- Central Railway, Parcel Bldg. CST, Mumbai.
2- Eastern Railway, Fairlie Place, kolkata-700001
3- East Central Railway, hajipur-844101
4- East Coast Railway, B-2, BDA Rental Colony, Chandrashekharpur, Bhubaneshwar
5- Northern Railway, Baroda House, New Delhi-110001
6- North Central Railway, Allahabad
7- Southern Railway, Park Town, Chennai-400001
8 South Central Railway, Rail Nilayam, Secunderabad.
9- South Eastern Railway, Garden Reach, Kolkata-700 043
10- South East Central Railway, Bilaspur
11- South Western Railway, Hubli
12- Western Railway, Churchgate, Mumbai-400 020
13- West Central Railway, DRM Office, Jabalpur
14- Central Organisation for Railway Electrification (CORE), Nawab Yusaf Road, Civil Line, Allahabad.

Sub : Instructions for use of Dynamic Reactive Power compensation.

Ref : This office letter No. TI/PSI/STATCON/DEV/06 dtd. 22.09.06

Vide reference to above please find enclosed herewith instruction No. TI/IN/0014 for use of dynamic reactive power compensation equipments.

Encls : as above

(Sumit Bhatnagar) 3.4.07
For Director General/TI

MASTER COPY

Effective from 03-04-2007	Instruction No. TI/IN/0014	Instruction for use of DRPC

Government of India



Ministry of Railways
Research Designs & Standards Organisation
Manaknagar, Lucknow-226011

Instructions

For use
Of
Dynamic reactive Power compensation
On IR

1.0 Scope

This Instruction stipulates the action to be taken by Zonal railways / CORE as applicable in case of providing dynamic power factor compensation equipment.

2.0 Objective and background

These guidelines will help in deciding the correct capacity of dynamic and fixed compensation to be provided for a particular TSS.

Traditionally fixed HT capacitors with 13% detuned reactor are being used for compensation of lagging reactive MVARs. However Railways may still end up having poor PF due to methodology adopted for calculation of PF i.e. addition of leading MVAR generated under over compensated situation arising due to light/no load conditions with fixed compensation method. Moreover the fixed capacitors connected to traction circuit with light load results into over voltages besides other limitations like generation of switching surges due to capacitor switching.

Railways shall have to interact with the respective supply authorities for getting the details of method for calculation of chargeable power factor being followed in their trivector meter. Proper study in terms of load variation pattern, harmonics content in the system, statutory requirement and tariff applicable etc. should be done at the time of considering installation of DRPC.

2.1 Limitations of fixed capacitor banks for PF Improvement

Although using fixed capacitor banks for PF improvement is the simplest and most cost effective method however it has got some limitations e.g.

a. Provision of large size fixed capacitor banks for PF correction under no load or light load condition may create high voltages in the system. The over voltages generated due to switching in of capacitor banks under lightly loaded conditions should be recorded/ measured. Theoretically the rise in voltage on account of capacitor bank can be calculated by formula given below.

$$\%\,\Delta V = \frac{KVAR_{cap} \times Z_{tx}(\%)}{kVA_{tx}}$$

Where $\%\,\Delta V$ = percent voltage rise
$MVAR_{cap}$ = Capacitor bank rating
Z_{tx} = Traction Transformer Impedance (%)
kVA_{tx} = Traction Transformer rating

b. Under the no load/less load condition leading to over correction there will be losses due to flow of leading reactive current in the transformer windings.

c. Another disadvantage of using capacitor banks without proper series reactor is that the reactance of a capacitor bank decreases as the frequency increases, this causes the bank to act as a sink or trap for higher harmonic currents from the surrounding customer and/or utility system. The effect is increased current, increased heating and dielectric stresses that could lead to capacitor bank failure.

d. Switching on of HT capacitor banks results into over voltage switching transients of approximately 1.4 to 2.0 times the system voltage while switching off of capacitors puts stress on circuit breakers and possible damage to CB due to re-strike of arc.

In view of the above drawbacks it is difficult to achieve PF above 0.9 lagging using fixed capacitors. Recently in many states e.g. Orissa, West Bengal, Jharkhand, Tamilnadu, MP, Karnataka etc. rebate/incentive is being offered by electricity utilities for achieving PF

above 0.9 up to unity. Due to the fast varying traction loads it is difficult to maintain this near unity PF simply using fixed capacitor banks hence to cater to this problem Dynamic reactive power compensation (DRPC) is the solution in such cases.

3.0 General instructions for adopting DRPC

The use of Dynamic Reactive Power Compensation shall be beneficial for Railways under following conditions

3.1 When tariff gives incentive/rebate for achieving PF above 0.9 upto unity, which is not advisable to achieve by using fixed capacitor banks due to problems of over correction in condition of light /no load (Such incentive is available in states like MPSEB, TNEB, and KSEB etc.)

3.2 As already pointed out above the fixed capacitor bank compensation leads to over compensation and leading PF under no/light load conditions, earlier the electricity boards were ignoring this leading MVAR and treated it as unity PF while calculating the PF and maximum demand energy charges and some of them were even subtracting the leading MVAR for calculating apparent power in the formula for chargeable PF. However in the year 2000 some utilities like MPSEB changed the calculation method to calculate the chargeable PF and started treating the leading MVAR similar to lagging MVAR for calculation of PF. This resulted in poor chargeable average PF and increase in MVA reading for Railways.

Although from 1.1.05, this problem was sorted out as MPSEB agreed not to consider the leading MVAR similar as lagging MVAR as a temporary measure, however they have advised railways to provide Dynamic reactive power compensation (DRPC) equipment at TSS to avoid the over compensation. Meanwhile as reported by S.Rly, ECoR other utilities like TNEB, CSEB have also adopted the similar stand of adding (and not neglecting) leading MVAR while calculating apparent power for chargeable PF.

3.3 When tariff is penalizing for values of PF lower than 0.9 or above which is difficult to maintain with fixed compensation under all load conditions especially at substations where variation in loads are more.

4.0 Reactive Compensation method

The reactive compensation Methods may be divided into following broad categories

(i) HT capacitors with 13% detuned reactors presently in use on IR. They also act as passive filters for filtering of harmonics but cannot fully eliminate all harmonics.

(ii) Static VAR compensators (SVC): The Static VAR compensators use power electronic switching devices to control capacitive or inductive energy into the power system. Commonly available SVC configurations are

a. Thyristor switched capacitors (TSC).
b. Thyristor controlled reactors with passive filters (TCR).
c. TSC with TCR and passive filters to eliminate harmonics.

(iii) Self commutated VAR generators: The fast switching power electronic devices are used to act either as voltage or current fed inverter to inject required amount of leading/lagging reactive MVAR into the system. These are also known as active filters for power quality correction and are widely used in various configurations like shunt, series or combined use of shunt and series as UPQC.

At present two methods of dynamic PF correction are in use on Indian railway traction application namely:

a. Thyristor switched capacitors (TSC).
b. IGBT based STATCOM.

The calculation methodology for fixed and variable reactive compensation MVAR required to fully neutralize lagging MVAR to achieve near unity PF in both the above methods is explained in annexure IV with the two TSS sample data calculations.

4.1 **Guidelines for deciding MVAR rating of dynamic and fixed compensation**

4.1.1 The required reactive power compensation should be worked out based on typical load curve and the desired power factor improvement carefully as per RDSO instruction no. TI/IN/002 "Guidelines for shunt compensation for improving power factor at 25 Kv traction substation (September 96).

4.1.2 The energy parameters are to be recorded and tabulated every 15 minutes (or even less depending upon integration/window period followed by different utilities). The data obtained is to be utilized to make load distribution curves from fixed part which can cater to base load or minimum load on the TSS and additional variable / dynamic portion to compensate maximum load conditions. By providing variable compensation, the improvement in average power factor can be worked out by integrating the apparent and active powers during the various periods.

4.1.3 The load factor which is the ratio of summation of average kva-hr and maximum demand kva-hr be calculated for each TSS, generally load factor of a traction sub station varies from 25% to 45%. TSS with low load factor (i.e. wide variation of load) shall need more variable/dynamic compensation out of total reactive compensation required.

4.1.4 Average PF is measured on the basis of MVARh and MVAh for the period of 1 month and hence even if total lagging MVAR are not fully compensated for smaller period (less than window period adopted by utilities) it may not result in major deterioration of PF or MD however the exact tariff conditions may be verified in this regard.

4.1.5 While calculating total compensation MVAR required take into account tariff conditions for billing MD, CD e.g. In most of the states chargeable MD is taken as 70-80% of CD or recorded MD, whichever is higher.

4.1.6 The MVAR data collected for sufficient period should be used in determining following: -

1) The fixed compensation shall be used to maintain the p.f. of about 0.99 under no-load / minimum load condition. This is intended to take care of the base load of the sub-stations which also comprises of lighting / signaling transformers, no load magnetizing current of main transformer and DRPC's transformers etc.
   Summarily install LT/HT fixed capacitors of required capacity to cater the base load and rest compensation capacity by providing DRPC. The minimum requirement of fixed compensation for a typical TSS may be of the order of 600-1200 kVAR.
2) Rating of total reactive compensation required is to be based on maximum MVAR requirement occurred. Hence while calculating total MVAR compensation required as well as base load requirement of MVAR compensation, short duration peaks for maximum or minimum can be ignored. After study of such peaks for 1-2 months decide about MVAR requirement taking into account long duration uncompensated lagging MVAR which may increase MD. During the calculation the seasonal variations may also be taken into account in the load pattern and it will be better if load variation detail of different seasons are analyzed.

4.2 As already explained that presently two methods are being used for Dynamic Reactive Power Compensation.

1) If the compensation is done by Thyristor Switched capacitor Bank, the capacity of fixed capacitors will be equal to minimum required MVAR to compensate the base load. And as TSC type compensation generates capacitive MVAR only and not lagging reactive MVAR, the required variable compensation will be

= Total required max. MVAR compensation - Required min. MVAR compensation to be provided by fixed HT capacitor banks.

2) If the compensation is done by STATCOM, the capacity of fixed HT capacitors will be sum of 50% capacity of total required variable compensation and minimum required MVAR compensation. Moreover as STATCOM type compensation can generate capacitive as well as reactive MVAR, thus the required variable compensation will be equal to 50% capacity of total required variable compensation.

(i) Required capacity of fixed HT capacitor = Minimum required MVAR (Base load) + 50% capacity of total required variable compensation

(ii) Required capacity of variable compensation through STATCOM= 50% capacity of total required variable compensation

The case studies of two TSS having different load pattern is given in Annexure III as example. For the sake of simplicity, MVA, MVAR, and PF variation only for 24 hours has been shown. The Railways may take help of reputed outside agencies to undertake recording of energy/load measurements for calculating the total reactive compensation requirement.

5.0 The design considerations of Sub-components of complete DRPC system

5.1 Calculation For Fixed Cap with 13% detuned reactor.

Fixed compensation capacity requirement will be available in kVAR as described above.

Thus Required Capacitive reactance, $A = KV^2 \times 1000/kVAR$

In order to limit the over voltages limit the inrush current and to avoid resonance at all odd harmonics a series reactor is provided in series with capacitor bank. The reactor provided shall be 13% of the value of capacitor bank rating. In no case the value of X_L/X_C should be 11.1% as this is the resonance frequency for the third harmonics. Similarly ratio of X_L/X_C = 4% and 2% should be avoided to over come any resonance at 5th or 7th harmonics.

The value of inductive reactance of the series reactor can be given by the following expression:-

$$X_L = 0.13 X_C$$

However $(X_C - X_L) = A$

$\therefore X_C - 0.13\ X_C = A$

thus $X_C = A / (1-0.13)$

Required capacitive reactance $X_C = 1.149A$

and Rating of series reactor -:

$$X_L = 0.13\ X_C$$
$$= 0.13 \times 1.149A$$

Required inductive reactance $X_L = 0.149A$

(For more details please refer this office Instruction No. IN 0002 Rev. 1)

5.2 Calculation For TSC and STATCOM sub-components

5.2.1 *Rating of LT Capacitor*

The capacitor should be capable to take care of the voltage 1.6 times of system voltage. As the voltage across the capacitor at fundamental frequency may be 1.29 times the rated system voltage and there will be voltage rise due to harmonic current also.

5.2.2 *Rating of Series Reactor for each arm of LT capacitor*

The ratio of the inductor reactance to the capacitor reactance at network frequency should be 13%

5.2.3 *Rating of Transformer*

Required Rating of reactive compensation = **X** MVAR at **27 kV**.

Consider 10% extra for future addition on account of increase in load.
Thus revised Rating of reactive compensation will be=**1.1 X** MVAR at **27 kV**.

As it is desired that capacitor shall satisfactorily operate continuously at rated Voltage and shall withstand 30% over current due to over voltages, harmonics and transient over current

Thus required new reactive compensation = **1.1 X** x **1.3** MVAR
The new MVAR rating will be = **1.43 X** MVAR

Thus required rating of transformer will be = 1.43 x **X** kVA

$\cong$ 1.50 x **X** kVA

For IGBT based STATCOM system also same methodology for rating of step down transformer may be adopted.

5.2.4 General guidelines for Rating of Thyristor & IGBT Modules

The selection of power modules for any application is subject to the considerations of:

- Voltage capacitance,
- Current carrying capacity under realizable cooling conditions and with reference to the switching frequency
- Safe operating areas (SOA) and
- Critical rate of rise of on-state current (di/dt)

The most important characteristics of power modules will deteriorate when the temperature rises. For this and few other reasons, the determination of the maximum operating temperature is critical.

Under no circumstances, the maximum ratings for blocking voltage, peak current, junction temperature and safe operating area as indicated in the datasheets be exceeded, which might occur during any static or dynamic operation. The same goes for the limit values of module case parameters (e.g. isolation voltage, vibration strength, climate persistence, assembly instructions).
It must be ensured that the specific semiconductor module approved by RDSO prior to type testing should only be used, at the time of supply and commissioning of the system.
The selection of a suitable power electronic device for a specific application is a complex exercise however now various websites like www.semisel.semikron.com offer online solutions for selection of correct rating and type of module, which can also be explored.
The design of the complete dynamic compensation system shall be modular. There are different capacity semiconductor power modules available, hence capacity of each module should be verified as per the design drawings approved by RDSO prior to type testing. The

rating of each module or step in the existing TSC based DRPC systems is 100 KVAR. Similarly, existing IGBT based STATCOM, each module is of 150 KVAR.

5.2.5 Features of APFC relays/ controllers

In TSC systems microprocessor DSP based APFC relays controls the power factor of the installation by giving signals to switch ON or OFF power factor correction capacitors. It is the brain of control circuit and controls firing of thyristors to switch on/off the capacitors based on zero differential voltage switching.

Calculation of power parameters is based on stored sampled data of voltage and current inputs using a fast sampling rate ADC. The fundamental component of voltage and current is extracted using fast Fourier transform techniques. Generally the APFC are capable of displaying various power parameters like true RMS values of V & I, power, Energy, MD and harmonics etc. These are also provided with different serial communication ports, data loggers, soft touch control keypads, self-check and protection features

When the power factor falls below setting, the capacitors are switched on either First in First out (FIFO) or First in Last Out (FILO) sequence. The capacitors controlled by the APFC must be switched on/off in linear sequence. To prevent over correction hunting, a dead band is provided. This setting determines the range of phase angle over which the controller does not respond; only when the PF goes beyond this range, the controller acts. When the load is low, the effect of the capacitors is more pronounced and may lead to hunting. Under current blocking (low current cut out) shuts off the controller, switching off all capacitors one by one in sequence, when load current is below setting. Special timing sequences ensure that capacitors are fully discharged before they are switched in. This avoids dangerous over voltage transient. The solid state LCD displays various functions that the operator should know and also indicate each capacitor switching stage.

5.3 In addition to above, the following design calculations may be verified with the supplier at the time of commissioning of DRPC system.

- Reactive power compensation requirement for various load patterns.
- Parallel resonance frequencies and inrush current calculation for each combination of capacitor arm in TSC system.
- Data of harmonic measurement carried out by supplier before and after installation of DRPC.
- Selection of Switchgear based on above calculations.
- Design of panel cooling system.
- Calculation for transformer terminal voltage at leading PF.
- Calculation for short circuit effect (Electro Dynamic forces developed) on Bus bars.
- Voltage drop calculation of Bus Ducts.
- Protection for Transformer, IGBT/Thyristor panel, IGBT/Thyristor module etc.
- Structure design for Transformer & IGBT/Thyristor panel.
- Foundation design calculation.

Effects of harmonics and lagging MVAR drawn by load needs to be studied separately for deciding on dynamic compensation because adoption of modern power quality correction techniques can simultaneously act for PF and harmonics corrections. Moreover it must be ensured that DRPC system does not increase the existing harmonics level due to switching of its own power electronic devices.

At present only few systems of dynamic reactive compensation are working on Indian Railways namely TSC systems at Bhadli (CR) and Makshi (under commissioning) and STACON based systems at Lasalgaon , Pimperkheda (CR), while some more systems are either in planning stage or under commissioning hence performance of the systems installed need to be evaluated by Railways in terms of initial cost, losses, system output and maintainability of the systems as per the Para 14.0 of RDSO specification no. TI/SPC/PSI/DRPC/0050 regarding Capitalization of losses & benefits.

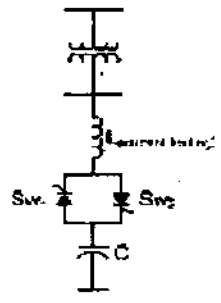
Annexure-I

Operating principal Thyristor-Switched Capacitors

It is a well known fact that conventional contactor or breaker switching systems are not suitable for improving p.f at places where the load is of fast variable nature. Therefore, electric traction always faces the problem of low p.f. Since frequent switching of H.T. capacitors is not possible, hence it is necessary to inject the required amount of capacitive current through thyristor switched LT capacitors at 433 V. Static compensators of the TSC type have the features of stepwise control, average delay of one half a cycle (maximum one cycle), and no generation of harmonics since current transient component can be attenuated effectively.

The basic scheme of a static compensator of the thyristor-switched capacitor (TSC) is as below:

25 kV single phase traction supply is stepped down to 433 volts through step down transformer. On the LT side of the transformer; the capacitors, which are split up into appropriately small steps, are connected and individually switched in and out using bi-directional thyristor switches. Switching of these thyristors is controlled by an automatic power factor correction relay. This relay is fed with current and voltage inputs through proper CTs and PTs for p.f. sensing of the load. the relay will determine the correct amount of capacitors required at any time for maintaining target p.f. by switching in and out the capacitors accordingly.



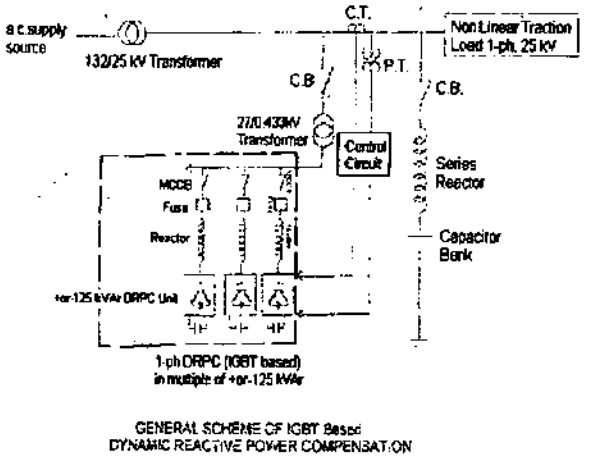
The thyristor-switched capacitor configuration.

Each single-phase branch consists of two major parts, the capacitor C and the thyristor switches. In addition, there is an inductor L, whose purpose is to limit the rate of rise of the current through the thyristor, to prevent resonance with the network and to prevent any inrush current produced by a firing pulse out of time. To connect each branch, a firing pulse is applied at the thyristor gate, when the capacitor voltage and the network voltage have the same value (this Zero differential voltage is sensed using a comparator circuit connected across the thyristor). In this way, a soft connection is obtained. The voltage across the capacitor will increase starting from zero without distortion, following a sinusoidal waveform, and after the half cycle is completed, the capacitor voltage will have the reverse voltage, and the thyristor automatically will block. In this form of operation, both connection and disconnection of the branch will be soft, and without distortion. If the firing pulses, and the voltage *at zero value* are properly adjusted, neither harmonics nor inrush currents are generated,

Annexure-II

Operating principle of IGBT based Self-commutated VAR compensator

The Self-commutated VAR compensator is basically meant for stepless (smooth) and dynamic reactive compensation of a given load reactive power demand and is hence used in shunt with the load. Self-commutated VAR compensators capable of generating or absorbing reactive power without requiring large banks of capacitors or reactors ,instead it uses a capacitor with a regulated dc voltage. Self-commutated compensators are used to improve voltage regulation, correct power factor. The compensator uses pulse width modulated (PWM) voltage source converters (VSCs) based on IGBTs as the self-commutated power device.



GENERAL SCHEME OF IGBT Based DYNAMIC REACTIVE POWER COMPENSATION

The VSC is a boost converter with output DC voltage greater than peak of the supply voltage. The fundamental component of PWM voltage reacts with the input supply voltage to produce the desired capacitive or inductive current. The load current feed back from a load CT is given to the VSC, which calculates the reactive current component. The fundamental component of the PWM voltage is dynamically adjusted to offer exact compensation for the calculated reactive current component of the load current. This relieves the source from supplying any reactive current/VAR. Neglecting the internal power losses of the overall converter, the control of the reactive power is done by adjusting the amplitude of the fundamental component of the voltage.

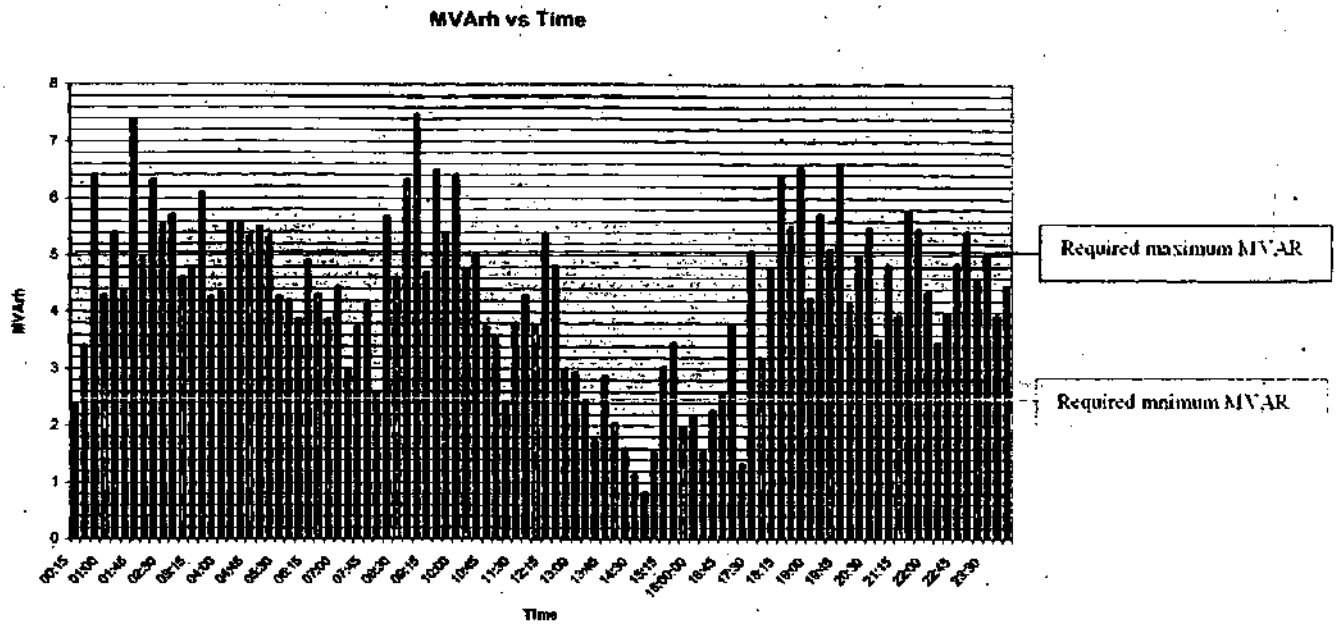
Its principle of operation is similar to the synchronous machine. The concept of STATCOM is very simple but it is difficult to implement.

The IGBT based VSC generates an AC voltage, which is in phase with the network voltage. This VSC & network, they are connected through a series reactor or transformer leakage reactance. The current flows through the reactor lags/leads the network voltage, depending on the direction of current. When the voltage generated by VSC is greater than the network voltage, leading reactive current is drawn from the network and then STATCOM acts as a capacitor and when the network voltage is greater than the VSC voltage, a lagging current is drawn from the network and then STATCOM acts as a reactor.

Annexure-III

Typical load variation pattern of Heavy Loaded TSS

Time	MVARh	PF	MVAh	12:30	4.8031519	0.815	8.289
00:15	2.3458363	0.838	4.299	12:45	2.9926536	0.833	5.409
00:30	3.4078002	0.851	6.489	13:00	2.9239967	0.825	5.174
00:45	6.3998779	0.818	11.126	13:15	2.4365635	0.852	4.654
01:00	4.2943325	0.85	8.152	13:30	1.7601286	0.834	3.19
01:15	5.394757	0.825	9.546	13:45	2.8769704	0.856	5.565
01:30	4.3760727	0.847	8.232	14:00	2.0387891	0.816	3.527
01:45	7.3840135	0.796	12.199	14:15	1.6080685	0.847	3.025
02:00	4.9714153	0.828	8.866	14:30	1.148476	0.846	2.154
02:15	6.3291812	0.812	10.844	14:45	0.8205915	0.898	1.865
02:30	5.5472464	0.827	9.867	15:00	1.5360452	0.819	2.677
02:45	5.7106662	0.825	10.105	15:15	3.0392116	0.843	5.65
03:00	4.6015037	0.841	8.505	15:30	3.467876	0.799	5.767
03:15	4.77218	0.832	8.602	15:45	1.9621979	0.861	3.858
03:30	6.0799161	0.819	10.596	16:00:00	2.1814162	0.779	3.479
03:45	4.2676948	0.823	7.513	16:15:00	1.5403252	0.855	2.97
04:00	4.3508587	0.845	8.136	16:30	2.2639931	0.833	4.092
04:15	5.55666	0.826	9.858	16:45	2.5943315	0.848	4.895
04:30	5.5702418	0.82	9.732	17:00	3.7601884	0.81	6.412
04:45	5.3201414	0.814	9.159	17:15	1.3194306	0.838	2.418
05:00	5.5123522	0.824	9.729	17:30	5.0688917	0.802	8.486
05:15	5.3183965	0.813	9.134	17:45	3.1743505	0.825	5.617
05:30	4.2648638	0.827	7.586	18:00	4.7858748	0.792	7.839
05:45	4.1949238	0.829	7.501	18:15	6.3934782	0.79	10.428
06:00	3.8746684	0.826	6.874	18:30	5.4848224	0.793	9.003
06:15	4.9008476	0.821	8.584	18:45	6.557607	0.792	10.741
06:30	4.3070339	0.822	7.563	19:00	4.2406413	0.82	7.409
06:45	3.8700324	0.848	7.302	19:15	5.718658	0.799	9.51
07:00	4.4385524	0.825	7.854	19:30	5.0953294	0.812	8.73
07:15	2.996323	0.82	5.235	19:45	6.6111056	0.794	10.875
07:30	3.7428601	0.828	6.675	20:00	4.1410501	0.82	7.235
07:45	4.1336344	0.797	6.844	20:15	4.9688777	0.815	8.575
08:00	2.5722506	0.809	4.376	20:30	5.4773307	0.822	9.618
08:15	5.6715357	0.791	9.27	20:45	3.5195403	0.846	6.601
08:30	4.581787	0.797	7.586	21:00	4.8067499	0.831	8.641
08:45	6.3235338	0.796	10.447	21:15	3.9336432	0.816	6.805
09:00	7.4711027	0.783	12.011	21:30	5.7763793	0.819	10.067
09:15	4.6897468	0.806	7.923	21:45	5.4569138	0.82	9.534
09:30	6.4945895	0.797	10.753	22:00	4.3470473	0.821	7.614
09:45	5.401078	0.813	9.276	22:15	3.461088	0.818	6.017
10:00	6.4126622	0.808	10.884	22:30	3.9654488	0.805	6.684
10:15	4.7743053	0.829	8.537	22:45	4.8402805	0.823	8.521
10:30	5.0149553	0.819	8.74	23:00	5.4260616	0.809	9.231
10:45	3.7377122	0.823	6.58	23:15	4.55496	0.827	8.102
11:00	3.565543	0.832	6.427	23:30	5.0464795	0.823	8.884
11:15	2.4249243	0.832	4.371	23:45	3.9393287	0.836	7.179
11:30	3.803296	0.827	6.765	00:00	4.4624911	0.838	8.178
11:45	4.2995051	0.823	7.569				
12:00	3.7674313	0.832	6.791	max=	7.4711027		
12:15	5.3852475	0.806	9.098	min=	0.8205915	Average=	4.3016143



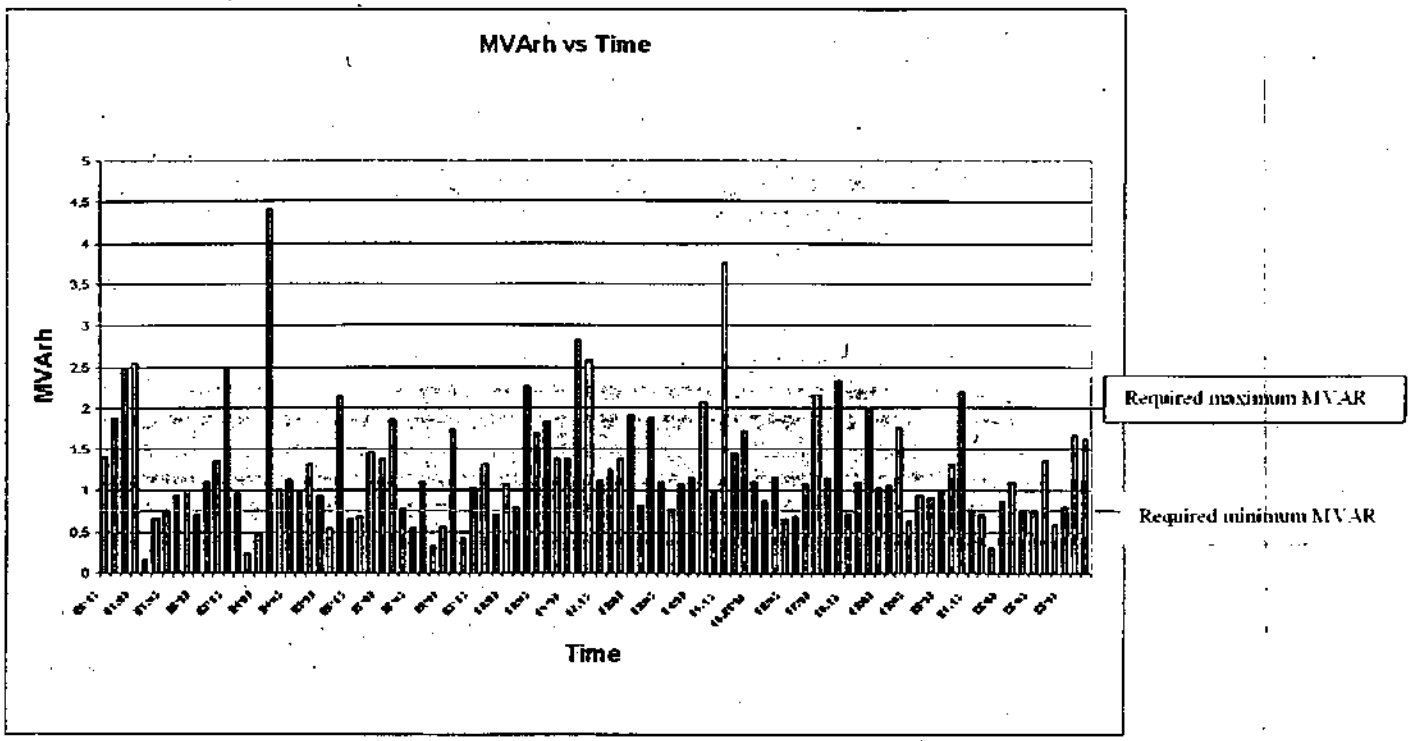
As the total required compensation for this particular TSS is approx. 5.7 MVAR and the minimum required compensation (base load) is 2.4 MVAR.

Case-I : If we adopt TSC type compensation method, the capacity of Fixed HT capacitor will be 2.4 MVAR and capacity of Thyristor switched LT capacitor will be 3.3 MVAR.

Case-II : If we adopt STATCOM type compensation method, the capacity of Fixed HT capacitor will be {(2.4 + 50% of 3.3 MVAR) = 4.05 MVAR} and capacity of STATCOM will be 50% of 3.3 MVAR = ± 1.65 MVAR. Because when STATCOM generate lagging reactive MVAR of its total capacity the total compensation will be equal to (4.05- 1.65)=2.4 MVAR and when it generates leading/capacitive MVAR of its total capacity the total compensation will be equal to (4.05 + 1.65)=5.7 MVAR, thus total variable compensation is for 3.3 MVAR i.e. from 2.4 MVAR to 5.7 MVAR.

Typical load variation pattern of Lightly Loaded TSS

Time	MVARh	PF	MVAh	12:30	1.2328822	0.809524	2.1
00:15	1.4177447	0.9142857	3.5	12:45	1.3964218	0.911765	3.4
00:30	1.8761663	0.9130435	4.6	13:00	1.8973657	0.818182	3.3
00:45	2.4718414	0.5666667	3	13:15	0.8306562	0.971429	3.5
01:00	2.5455844	0.6363636	3.3	13:30	1.8761712	0.913043	4.6
01:15	0.1732051	0.5	0.2	13:45	1.0954441	0.935484	3.1
01:30	0.6557438	0.9545455	2.2	14:00	0.7745967	0.875	1.6
01:45	0.7416199	0.9642857	2.8	14:15	1.0816649	0.857143	2.1
02:00	0.9380832	0.9130435	2.3	14:30	1.161895	0.6875	1.6
02:15	0.9591663	0.9166667	2.4	14:45	2.0566975	0.678571	2.8
02:30	0.7141428	0.9615385	2.6	15:00	0.9797959	0.92	2.5
02:45	1.0954451	0.9354839	3.1	15:15	3.7456641	0.452381	4.2
03:00	1.3527749	0.90625	3.2	15:30	1.4496662	0.8915	3.2
03:15	2.4959968	0.8541667	4.8	15:45	1.7175564	0.84375	3.2
03:30	0.9643651	0.8235294	1.7	16:00:00	1.0954441	0.935484	3.1
03:45	0.2236068	0.6666667	0.3	16:15:00	0.8717798	0.9	2
04:00	0.4795832	0.9166667	1.2	16:30	1.148917	0.941176	3.4
04:15	4.4215382	0.7424242	6.6	16:45	0.6557471	0.954545	2.2
04:30	1.0198039	0.9259259	2.7	17:00	0.6855681	0.958333	2.4
04:45	1.1313709	0.9393939	3.3	17:15	1.0770356	0.933333	3
05:00	0.9797959	0.92	2.5	17:30	2.1563877	0.897959	4.9
05:15	1.3228757	0.75	2	17:45	1.161895	0.875	2.4
05:30	0.9380832	0.9130435	2.3	18:00	2.3345197	0.912281	5.7
05:45	0.5385165	0.9333333	1.5	18:15	0.714147	0.961538	2.6
06:00	2.1330761	0.895833	4.8	18:30	1.1135529	0.9375	3.2
06:15	0.6557471	0.954545	2.2	18:45	1.9899767	0.833333	3.6
06:30	0.6855681	0.958333	2.4	19:00	1.0392335	0.928571	2.8
06:45	1.4594513	0.918919	3.7	19:15	1.0583041	0.931034	2.9
07:00	1.3964218	0.911765	3.4	19:30	1.7663524	0.902439	4.1
07:15	1.8520259	0.75	2.8	19:45	0.6244998	0.95	2
07:30	0.7745967	0.875	1.6	20:00	0.9380856	0.913043	2.3
07:45	0.5385178	0.933333	1.5	20:15	0.9110524	0.97619	4.2
08:00	1.0954449	0.764706	1.7	20:30	0.9797898	0.71429	1.4
08:15	0.3316628	0.833333	0.6	20:45	1.3228757	0.75	2
08:30	0.5567764	0.9375	1.6	21:00	2.1908901	0.304348	2.3
08:45	1.7435596	0.9	4	21:15	0.7416169	0.964286	2.8
09:00	0.4123104	0.888889	0.9	21:30	0.7	0.96	2.5
09:15	1.0392335	0.928571	2.8	21:45	0.3	0.8	0.5
09:30	1.3048274	0.8235	2.3	22:00	0.8717798	0.9	2
09:45	0.714147	0.961538	2.6	22:15	1.0954441	0.935484	3.1
10:00	1.0816649	0.857143	2.1	22:30	0.754986	0.965517	2.9
10:15	0.8062254	0.969697	3.3	22:45	0.7483306	0.866667	1.5
10:30	2.2449918	0.866667	4.5	23:00	1.3527749	0.90625	3.2
10:45	1.6970551	0.894737	3.8	23:15	0.5916103	0.944444	1.8
11:00	1.8330294	0.909091	4.4	23:30	0.8062254	0.969697	3.3
11:15	1.3747721	0.909091	3.3	23:45	1.6733193	0.891892	3.7
11:30	1.3964218	0.911765	3.4	00:00	1.6248096	0.885714	3.5
11:45	2.8284258	0.851852	5.4				
12:00	2.5690433	0.896552	5.8	max=	4.4215382		
12:15	1.1313703	0.939394	3.3	min=	0.1732051	Average=	1.2656963



As the total required compensation for this particular TSS is approx. 2.0 MVAR and the minimum required compensation (base load) is 0.75 MVAR.

Case-I : If we adopt TSC type compensation method, the capacity of Fixed HT capacitor will be 0.75 MVAR and capacity of Thyristor switched LT capacitor will be 1.25 MVAR.

Case-II : If we adopt STATCOM type compensation method, the capacity of Fixed HT capacitor will be {(0.75 + 50% of 1.25 MVAR) = 1.375 MVAR} and capacity of STATCOM will be 50% of 1.25 MVAR = ± 0.625 MVAR. Because when STATCOM generate lagging reactive MVAR of its total capacity the total compensation will be equal to (1.375- 0.625)=0.75 MVAR and when it generates leading/capacitive MVAR of its total capacity the total compensation will be equal to (1.375 + 0.625)=2.0 MVAR, thus total variable compensation is for 1.25 MVAR i.e. from 0.75 MVAR to 2.0 MVAR.

112-5

Telegram : 'RAILMANAK', Lucknow
Telex : 0535 - 2424 RDSO -IN
Fax : 91-0522-2465763
Telephone :91-522-2465765, Rly. 42805
E-Mail: dti5@rdso.railnet.gov.in

भारत सरकार – रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
लखनऊ – 226011
Government of India - Ministry of Railways
Research Designs & Standards
Organisation LUCKNOW - 226011

सत्यमेव जयते
MASTER COPY

TI/OHE/SSWR/2010

Dated: 29.01.2010

Chief Electrical Engineer,

1 South Eastern Railway, Garden Reach, Calcutta-700 043.
2 Eastern Railway, Fairlie Place, Calcutta-700 001.
3 Northern Railway, Baroda House, New Delhi - 110 001.
4 Southern Railway, Park Town, Madras- 600 003.
5 South Central Railway, Rail Nilayam, Secunderabad – 500371
6 Western Railway, Churchgate, Bombay - 400 020.
7 Central Railway, Mumbai CST – 400 001.
8 South West Railway, DRM's Office, Hubli (Karnataka)
9 West Central Railway , Jabalpur
10 East Coast Railway, Bhubaneshwar
11 East Central Railway, Hajipur
12 North Central Railway, Block-A, Subedarganj Rly Stn, Allahabad.211 033
13 South East Central Railway, Bilaspur-495004
14 North Eastern Railway, Gorakhpur

Sub: Instructions for application of lubricant on stainless steel wire rope

---

Please find enclosed instruction no. TI/IN/0015 Rev "0" for application of lubricant on stainless steel wire ropes used with auto tensioning devices for implementation.
Zonal Railways are requested to adopt the application methods suggested in the instruction and provide **half-yearly** feedback to RDSO in the following format.

Rly.	Divn	Section	Nature of pollution (Marine, industrial, chemical or non-polluted)	Frequency of application (Scheduled POH/AOH/ quarterly or half-yearly)	Method used for application of lubricant during service/AOH/ POH	Type of ATD	Observations/ remarks

(B. S. Bodh) 29/1/2010

Encl: as above

For Director General/TI

SE/Doc

MASTER COPY

INSTRUCTION NO. TI/IN /0015



GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

INSTRUCTION FOR APPLICATION OF LUBRICANT ON WIRE ROPE USED WITH AUTO TENSIONING DEVICES

Jan 2010

Issued by:

T.I. DIRECTORATE
RESEARCH DESIGNS & STANDARDS ORGANISATION
MANAK NAGAR , LUCKNOW 226 011

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
RESEARCH DESIGNS & STANDARDS ORGANISATION
MANAK NAGAR , LUCKNOW 226 011

INSTRUCTION NO. TI/IN/0015 REV '0'

INSTRUCTION FOR APPLICATION OF LUBRICANT ON WIRE ROPE USED WITH AUTO TENSIONING DEVICES

1.0 General:

Lubrication is recommended for the maintenance of wire ropes & this is indicated in para 6.8 of RDSO specification No. TI/SPC/OHE/WR/1060. The lubrication of wire rope is a field; where from considerable amount of savings can be achieved by ensuring that the ropes are correctly lubricated. A rope is fully protected when each individual wire in it is lubricated. It is essential that the lubricant reaches deep into layers to avoid inter layer abrasion.

When wire rope passes around sheaves or drums, wires and strands move relative to each other to compensate for the difference in their diameters i.e. between inside and outside of each layer in the rope. Abrasion occurs between the wires as they move over the pulley (smaller the sheave diameter, the greater is the adjusting movement and thus more rapid is the wear). Every wire of the rope must be free to move and adjust, unless it is lubricated, this essential movement/adjustment cannot take place.

Lubricant protects the wire rope from external corrosion. Fatigue life of rope is greatly extended by proper lubrication, when the wires can move freely to equalize the stress distribution.

2.0 Objective:

The lubrication applied during manufacturing of ropes (before stranding and closing) is adequate only for initial storage and for the early stage of the rope's working life (one year from date of manufacture), to reduce internal abrasion, exclude external moisture and to avoid corrosion. It must be supplemented at regular intervals during service to prevent deterioration of wire ropes.

3.0 Methods for Application of Lubricant: Method of application of lubricant on the wire rope depends upon the viscosity of the lubricant, length of rope involved and limitation of space constraints for on line application.

3.1 Existing Practice on IR : Application of lubricant in field during service is normally accomplished by any one of following methods.

1. **SWABBING:** A rag is dipped in the lubricant and is used to swab the lubricant on to the rope as shown in Fig 1. The lubricant may also be applied by hand with leather gloves. Leather is preferred to canvas because of its greater protection and less penetration of grease.

Fig-1

2. **BRUSHING:** The brush is dipped into the lubricant and applied as shown in Fig.-2.



Fig.-2.

3. **POURING AND DRIPPING :** Lubricant is poured or dripped on the portion of the rope passing over the sheave as shown in Fig-3.

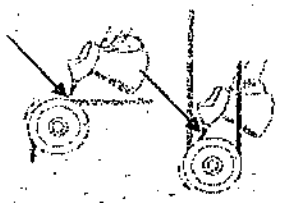


Fig.-3

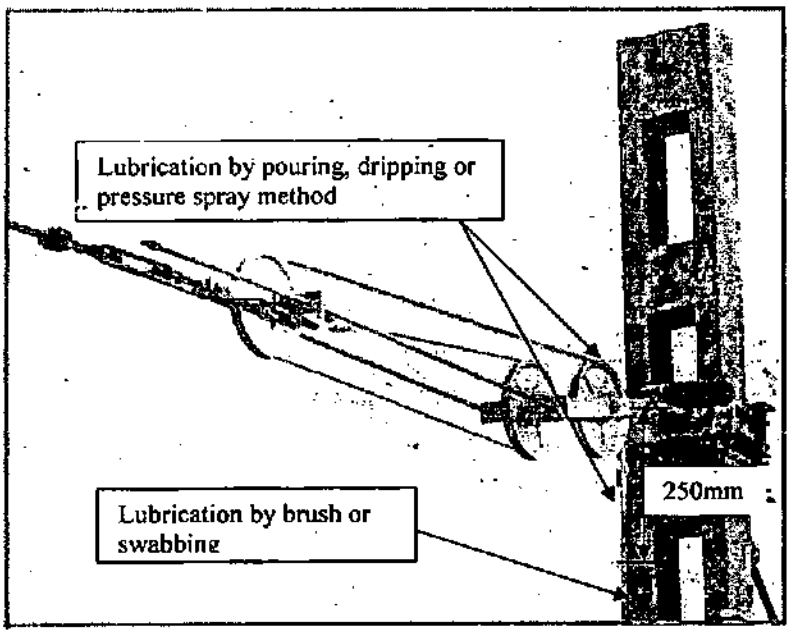
3.2 Recommended Practices during AOH:

3.2.1 To ensure proper lubrication of each wire & strand of wire rope, it is recommended that lubricant is applied with adequate pressure.

3.2.2 The surface of the ropes usually gets covered with dirt, dust or other material during storage and in service. This covering prevents lubricants being applied in the field from penetrating into the wires of the rope. Therefore, ropes should be dried and cleaned prior to lubrication. For this purpose, a jet of air and wire brushing methods for drying and cleaning of wire rope during AOH can be used .

3.2.3 In the field, during AOH the straight portion of the rope towards counter weight (leaving 250mm vertical length of rope from center line of mast side pulley towards counter weight) shall be lubricated with lubricant "Balmerol Rope Lube 1000" by brush/swabbing".

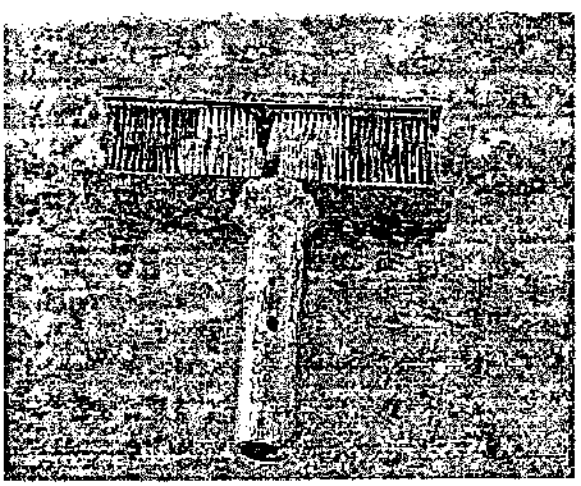
3.2.4 Lubricant shall also be applied on the portion of rope passing over drum or pulley and upto 250 mm towards counter weight by pouring, dripping or pressure spray method. Location of bent is usually the location where rope's wire starts breaking due to inter layer abrasion. Rope shall slowly wound and unwound on and off the pulley several times, to work the lubricant. This can be achieved on line by using spring balance.

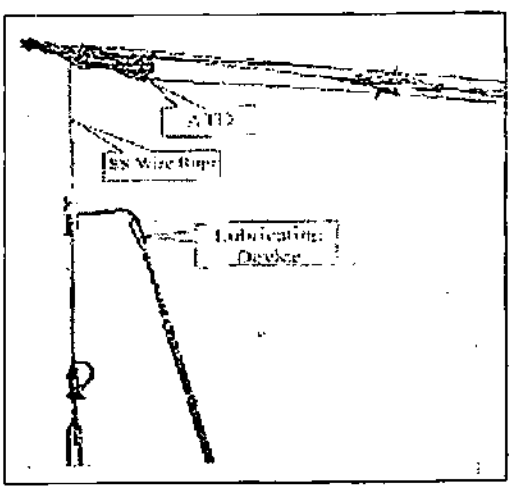


3.2.5 Re-lubrication of stainless steel wire ropes should be carried out regularly right from the beginning of the service life of the rope and not after the first damage has been ascertained. Frequency of application of lubricant may be decided based upon field experience. However, at present RDSO recommends applying the lubricant annually.

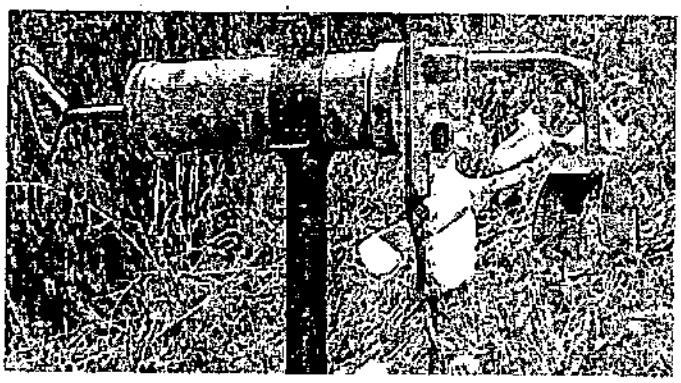
3.2.6 **Equipments recommended for lubrication during AOH:**

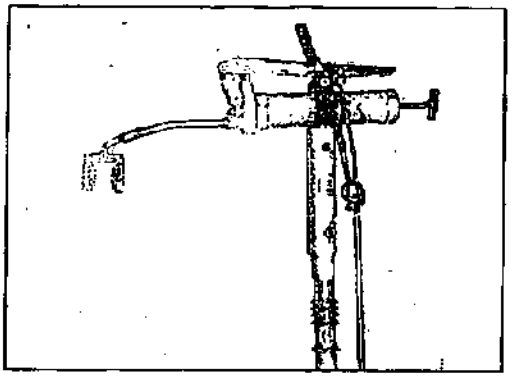
(A) **Wire brushes** recommended for lubrication of straight portion of wire rope in field. Brush and grease gun is fixed through nuts and bolts on an insulated link puller which can be operated from ground by a nylon rope attached to the grease gun.



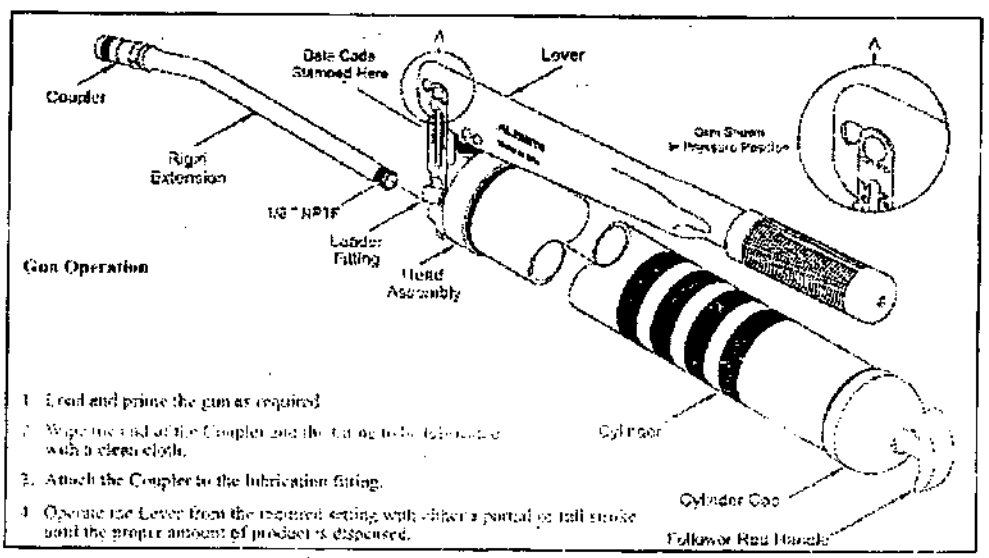


(B) **Spray Guns:** SS wire rope over the pulley can be lubricated using grease gun with a guide to seat over the pulley. The grease gun can be operated from ground by a nylon rope attached to the grease gun.



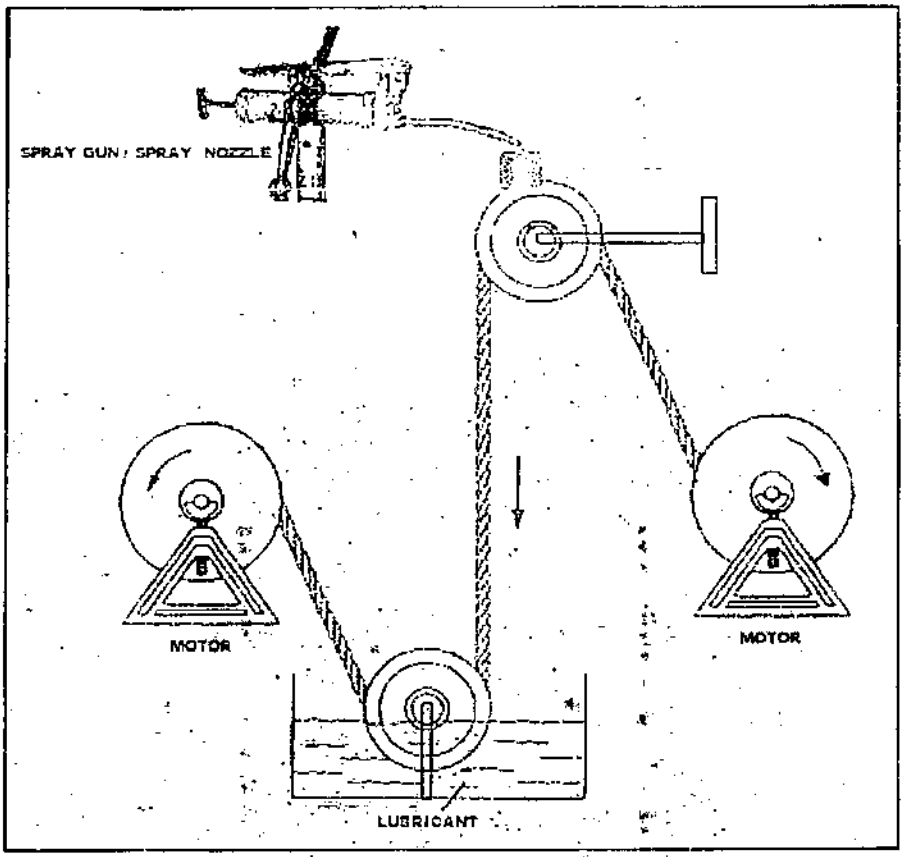


C) **Lever operated Grease Guns:** Recommended for lubricating the wire rope passing over the sheave during AOH.



3.3 **Recommended Practices for lubrication during POH:** Following methods of lubrication can be adopted for lubricating the wire rope during POH.

3.3.1 Ropes should be dried with a jet of air and cleaned with wire brushing methods before being lubricated. Thereafter, the rope should be passed under the pulley submerged in the lubricant, so that lubricant reaches to all the wires. Lubricant can also be applied through spray gun or spray nozzle on the rope passing over the pulley. One of the arrangements may be as shown below.



4.0 Importance of foot patrolling record

4.1 The service life of ropes is directly proportional to the effectiveness of the method used and the amount of lubrication reaching on working parts of the rope. Regular inspection of the rope with frequent application of lubricant produces better results. Proper lubrication and protection of wire rope along with proper alignment is instrumental in increasing its efficiency and ensuring longer service life. In this regard, the record of foot patrolling carried out by TRD staff is quite useful, wherein the staff check the movement of ATD with the help of spring balance and record the status of movement.

4.2 Railways to ensure that foot patrolling is being regularly carried out and abnormalities observed by foot patrolling staff are noted by depot incharges & corrective action taken on priority. The abnormality & its compliance report should also be scrutinized by concerned Sr. DEE/TRDs from time to time.

(3)

CARRIAGE DIRECTORATE
COMPUTER WING

(113)

COVERING LETTER

Instructions

SUBJECT: SCANNING/DIGITISATION/INDEXING OF OFFICIAL DOCUMENTS OF DIFFERENT DIRECTORATES OF RDSO

1	NAME OF THE DIRECTORATE	Traction Installation Directorate (T.I. Dte.)
2	NAME OF THE SUB-DIRECTORATE/SECTION	Doc Cell
3	NAME & DESIGNATION OF THE SCANNING-CORDINATION OFFICER/STAFF	T. Hasan / A.K. Sareen
4	NAME OF THE RECORD/FILE/ DOCUMENT/SPECIFICATION etc. AND ITS VOLUME/VERSION	Instructions (I.N)
5	TOTAL NO OF PAGES/IMAGES	30 Nos pages (5 nos documents of back side)
6	NAME,SIGNATURE AND DESIGNATION OF THE HANDING OVER RDSO OFFICIAL	A.K. Sareen, SE/Doc A.K. Sareen 03/09/10
7	NAME,SIGNATURE AND DESIGNATION OF THE TAKING OVER CMC OFFICIAL	3/09/10
8	DATE OF HANDING OVER FILE/DOCUMENT etc.	03-09-10
9	FIELDS FOR INDEXING	
	1 Type of Document (File/ DRAWING/TECHNICAL CIRCULAR/MODIFICATION SHEET/SPECIFICATION/NP)	
	2 Document No.	
	3 SUBJECT	Instruction
	4 SUB-SUBJECT	
	5 VOLUME	
	6 Sr. No.	From ____ To 30
	7 DATE OF CREATION OF FILE	
	8 Dealer	
10	DATE OF RECEIVING BACK THE DOCUMENT	
11	NAME, SIGNATURE AND DESIGNATIONOF THE RDSO OFFICAL RECEIVING BACK THE DOCUMENT AFTER SCANNING (No of papers to be checked by department)	
12	REMARKS/FEEDBACK IF ANY (Quality of documents to be checked by department and certified)	
13	CATEGORY OF DOCUMENTS A) COMPUTER GENERATED GOOD QUALITY B) COMPUTER GENERATED (DOT MATRIX) C) TYPE WRITTEN D) HAND WRITTEN	

113-1 MASTER COPY

TRACTION INSTALLATION DIRECTORATE

सत्यमेव जयते

GOVRNMENT OF INDIA
MINISTRY OF RAILWAYS

Instruction No. TI/IN/0016(5/2008)

for

PARALLEL OPERATION OF TRACTION TRANSFORMERS ON INDIAN RAILWAYS

May 2008

ISSUED BY

TRACTION INSTALLATION DIRECTORATE
RESEARCH DESIGNS AND STANDARDS ORGANISATION
(MINISTRY OF RAILWAYS)
MANAK NAGAR, LUCKNOW-226 011

GUIDE LINES FOR PARALLEL OPERATION OF TRACTION TRANSFORMERS ON INDIAN RAILWAYS

The satisfactory parallel operation of transformers is dependent upon five principle characteristics; that, any two transformers which it is desired to operate in parallel should possess:

1. Identical turn ratios and voltage ratings.
2. Equal percentage impedances.
3. Equal ratios of resistance to reactance
4. Same polarity.
5. Same phase angle shift.
6. Same phase rotation

For single phase transformers, only the first four conditions apply, as there is no phase rotation or phase angle shift due to voltage transformation.

1.0 Turn Ratio

The turn ratio of the transformer should be identical on each taps.

If the turn ratios are not same a circulating current will flow even at no load. A circulating current in the transformer windings of the order of, say 5 % of the full load current of the lowest rating of transformer may generally be allowed in the case of modern transformers without any fear of serious overheating occurring.

Transformers designed with RDSO specifications have tolerance of ± 0.5% variation in turn ratio. This will result into total 1% variation in voltage between two LT windings which corresponds to 270 volts.

The circulating current will be approx. 270/(4+4) = 33.75 Amps which is less than 40Amps i.e. 5% of rated current of 21.6 MVA transformer.

Similarly, for 13.5 MVA rating transformers the circulating current is (270/(6.75+6.75)) =22 Amps, which is less than 25A, the 5% of the rated current.

Hence, same rating transformers procured as per RDSO specifications may be paralleled. For paralleling of dissimilar transformers, above guideline may be followed.

2.0 Percentage impedance:

If the percent impedance or the ratios of resistance to reactance are different there will be no circulating current at no load, but the division of load between the transformers when applied will no longer be proportional to their KVA

ratings. In the simplest case viz. of two transformers of the same output operating in parallel, the % impedance must also be identical if the transformers are to share the total load equally. However, good paralleling is considered attainable when the % impedance of two winding transformers is within 7.5% of each other.

RDSO specification specifies tolerance in percentage impedance ± 0.5 which amount to total variation of 8 %, hence paralleling can be done.

3.0 R/X ratio:

In power transformers of normal design the ratio of resistance to reactance (R/X) is generally sufficiently small to make the requirement of equal ratios of negligible importance in paralleling. When it is desired to parallel transformers having widely different impedances, reactors in series is placed with the transformer whose impedance is lower. It should have a value sufficient to bring the total effective %impedance of the transformer plus the reactor upto the value of the % impedance of the second transformer.

4.0 Polarity of the transformers needs to be checked before connecting them in parallel.

5.0 Conclusion: Transformers with same rating and built to the RDSO specifications are suitable for parallel operations.

5.1 Precautions:

1. Ratings of the transformer should be identical and for dissimilar ratings circulating current should be less than prescribed limits.
2. It is preferable to parallel transformers with closest turn ratio and percentage impedance.
3. Connecting two transformers in parallel will result in a combined impedance which is less than either of the components (paralleling two identical transformers result in a combination which has an impedance of half that of each, individually), the primary result of this is to increase the fault level of the LV bus bar. Care must therefore be taken to ensure that the fault capability of the LV switchgear is not exceeded and suitable protection scheme is implemented.

References

1. The J&P Transformer book, twelfth edition, A Practical Technology of power transformer by Martin J.Heathcote.
2. M/s ABB instruction leaflet on Parallel Operation of Transformers, Technical Data 1LUS010001-LFE Rev 5, October 15 ,2003.

टेलीफोन/Tele : 2451200 (PBX)
2450115 (DID)
फैक्स/Fax : 91-0522-2458500

सत्यमेव जयते

भारत सरकार - रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
लखनऊ - 226 011

Government of India-Ministry of Railways
Research Designs & Standards Organisation
Lucknow - 226 011

ISO 9001 REGISTERED
DNV
MGMT. SYS.
RvA C024
DNV Certification B.V., The Netherlands

No. TI/PSI/PROTCT/CONVEN/08 Date: 15.07.2008

Chief Electrical Engineer

1. Central Railway, Parcel Buldg. CST, Mumbai.
2. Eastern Railway, Fairlie Place, kolkata-700001
3. East Central Railway, Hajipur-844101
4. East Coast Railway, B-2, BDA Rental Colony, Chandrashekharpur, Bhubaneshwar
5. Northern Railway, Baroda House, New Delhi-110001
6. North Central Railway, Allahabad
7. Southern Railway, Park town, Chennai-600003
8. South Central Railway, Rail Nilayam, Secunderabad.
9. South Eastern railway, Garden Reach, Kolkata-700 043
10. South East Central Railway, Bilaspur
11. South Western Railway, Hubli
12. Western Railway, Churchgate, Mumbai-400 020
13. West Central Railway, DRM Office, Jabalpur
14. North Eastern Railway, Gorakhpur-220055
15. Central Organisation for Railway Electrification (CORE), Nawab Yusuf Raod, Allahabad.
16. Director, IRIEEN, Post Box No. 233, Nasik Road-422101

Sub: Guide lines on protection scheme for parallel operation of two 21.6 MVA traction transformers at a traction sub-station.

Ref : i) Railway Board letter No. 2003/R.E./161/1 dated 19.05.2008
ii)Railway Board letter No. 2002/R.E./161/8 dated 26.12.2007 addressed to CEE/NCR and copy to MD/RVNL, GM CORE, ED/TI/RDSO & CEEs all Zonal Railways.
iii) This office letter of even number dated 08.05.2008.

Please find enclosed herewith "Guide lines on protection scheme for parallel operation of two traction transformers of 2x21.6 MVA capacity". Following relays of M/s ASHIDA, Thane for traction transformer and feeder protection developed (type testing completed) for MRVC project are having all the features as stipulated in the guidelines.

OC + REF protection module for transformer comprising of IDMT, instantaneous, Definite time elements.	Type: ADR-221B
Integrated feeder protection module comprising of 3-zone DPR, WPC, Instantaneous & Definite time OCR elements etc.	Type: ADR-219B

Other relay manufacturers are also being approached for development of numerical relay modules and such relays may also be recommended for use in future subject to the design drawings and type tests clearance from RDSO.

17.7.08
(Sumit Bhatnagar)
For Director General/TI

Encl: As above

Copy to: The Secretary (RE), Railway Board, Rail Bhawan, New Delhi.



सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Instruction No. : TI/IN/0017 (July/2008)

GUIDELINES ON PROTECTION SCHEME WITH PARALLEL OPERATION OF 2 x 21.6 MVA TRACTION TRANSFORMERS

RESEARCH DESIGNS AND STANDARDS ORGANISATION
LUCKNOW-226 011

PREFACE

The power requirement to be fed into OHE from traction substations is meant to meet the loads arising from higher train density, train loads and speeds. The traction substations have been upgraded from 10 MVA capacity in early sixties to 21.6/30 MVA (ONAF) as of now. Increase in the transformer capacity has been with same percentage impedance to maintain regulation. As the ohmic value of transformer impedance decreases, elevated fault level on 25 kV bus may lead to damages during faults at the bus or on OHE within 10 km of TSS.

Numerical relay module (i.e. consisting of DPR, OCR, and WPC), used for feeder protection, clears fault in approximate 90 to 110ms (i.e. relay +Master trip relay + CB operating time). The IDMT relay on transformer LV&HV as backup protection relays will operate at about 470 to 570 ms on LV and 870 to 970 ms on HV side for faults at 25 kV bus. The operating time of IDMT relays can be reduced by using numerical relays with fine steps of TMS setting, and is thus recommended for parallel operation of two 21.6 MVA transformers at a TSS.

This report covers the time coordination of protective relays, requirement of additional relays and the obligations to employ numerical relays for protection where parallel operation of two 21.6 MVA traction transformer at a TSS is unavoidable.

The recommendations regarding protection relay settings are based on calculations & field data available. Relay settings proposed vide these guidelines have been kept on safer side and depending upon load pattern, trippings may increase on some sections initially. Based upon field experience and feedback received from Railways adjustments will be feasible.

1.0 INTRODUCTION

With the increase in transformer capacity from 13.5 MVA to 30 MVA without changing its percentage impedance, the fault current for LV bus faults has increased from 4.0 kA to 9.0 kA. Similarly the maximum fault current at LV bus with 2 transformers of 21.6 MVA rating connected in parallel shall be approximately 12 kA. These values are summarized below for various combinations.

Transformer Rating (12.5% impedance)	Prospective maximum fault current (neglecting source / earth resistance) at 25 kV bus
13.5 MVA	4 kA
21.6 /30 MVA (ONAF)	6.4 kA
30/40 MVA (ONAF)	8.9 kA
two 21.6 MVA in parallel	12.8 kA

Specification have been issued for 30/40 MVA (ONAF) transformers for future needs however, where due to non availability of 30/40 MVA transformers, parallel operation of 21.6 MVA transformers has been adopted by Zonal Railways or is so contemplated, protection scheme shall include the following.

2.0 The present protection scheme at 25 kV TSS comprises:

(a) Numerical feeder protection module comprising DPR (distance protection relay), Instantaneous OCR (over current relay), WPC (Wrong phase coupling relay) and. Local breaker backup or trip fail element, PT fuse failure relay & Auto reclosure element.
(b) Vectorial Delta-I relay.
(c) Differential protection for transformer.
(d) REF protection for transformer.
(e) IDMT OCR on LV & HV side of transformer & instantaneous OCR on transformer HV side, and
(f) Panto flash over relay

2.1 Existing protection at 25 kV TSS envisages instantaneous operation (without any additional time delays) for the main feeder protection relays (DPR, OCR) to clear faults in 90-110 ms (20 to 40 ms for DPR+ 10 ms for master trip relay (MTR) + 60 ms for CB). The backup IDMT relays on transformer LV & HV can clear the close-up faults in 470 to 570 ms and 870-970 ms respectively. But for fault current of around 12kA on 25 kV during parallel operation of transformer, a preliminary thermal study has shown that 67 sq mm catenary wire may become soft or even part, in case fault is not cleared within 300 ms. However, the best clearing time of back up feeder protection in present arrangement is at least 470 ms (400 ms for IDMT + 10 ms for MTR + 60 ms for CB), thus making the instrument stability of OHE a suspect.

2.2 In this background the protection scheme is amended such that fault must be cleared in 250-300 ms by back up protection provided by LVCB IDMT relay. The time reduction in backup IDMT relays is possible by having fine settings of TMS in the range of 0.01 to 0.1 in steps of 0.01.

3.0 The following protection elements & relays are recommended:

Recommended protection elements	Qualifying Remarks
Transformer & Feeder back up protection	
a) REF & OC protection relay for transformer : i) Numerical IDMT over current relays on transformer HV & LV with fine TMS setting of 0.01 to 0.1 in steps of 0.01 & instantaneous over current element on transformer HV side ii) Restricted earth fault protection relay on transformer HV & LV side. iv) Auxiliary relays for transformer alarm contact multiplication.	Fine steps of TMS setting are required to have time grading of 250 to 300 ms (LVCB IDMT) and 500-600 ms (HVCB IDMT) as backup protection for 25 kV close in OHE faults for main feeder protection.
b) Differential protection module i) Biased differential protection relay ii) Auxiliary relays for transformer trip contact multiplication.	No change in the present protection scheme for individual traction transformer is required and separate differential and auxiliary relays with trip contact multiplication for each transformer will be used.
OHE / Feeder protection relays	
a) Numerical integrated traction feeder protection module	
i) 2- Zone parallelogram characteristic distance protection element ii) Wrong phase coupling protection element iii) Definite time OCR element iv) Instantaneous over current protection element v) PT fuse failure element vi) Auto reclosure function element vii) Trip fail element	Second zone of distance protection is an additional protection element proposed for back up of zone-1. The feeder protection instantaneous OCR element is presently set at 200% of the transformer full load current. However, for far end faults on feeder, the reach of OCR is limited, hence as a backup protection, 2 zone DPR with settable time delay is proposed to be provided in place of single zone DPR. The definite time OCR is also an additional protection element proposed to be provided as a backup protection for Instantaneous OCR.

b) Vectorial Delta-I relay	Presently Delta-I relay as per RDSO specification No. TI/SPC/PSI/ PROTCT/1982 is not mandatory. This relay was developed to provide protection against high resistive faults as well as backup of DPR and OCR. However, it is now proposed to make it mandatory for parallel operation of transformers.
c) Panto flash over protection relay	No changes in present protection scheme.

3.1 The protection modules shall have features of event and fault waveforms recordings with time stamping for post fault analysis, retrievable through serial communication port with the help of computer / laptop or other specified tools.

4.0 Relays setting guidelines

4.1 Transformer protection

4.1.1 IDMT over current relay HV side

The function of this protection element is to act as a backup protection to the LVCB relays. The reach of this relay should be as much as possible, however to utilize the over load capacity of traction transformer the current setting of the relay should be selected to correspond to 160% of the rated current of the traction power transformer. The setting on the relay side may be calculated by formula given below:-

$$\text{Relay setting} = \frac{1.6 \times I_{pri}}{\text{CT ratio}} \text{ A}$$

$$\text{Setting in \%} = \frac{\text{Relay setting}}{5} \times 100\ \%$$

The TMS of this relay may be selected such that the relay operating time obtained is 500 ms to 600 ms for a fault occurring on LV bus.

4.1.1.1 TMS calculation

Calculate the fault current at LV bus considering the source impedance and single transformer impedance

$$\text{Fault current at LV bus} = \frac{\text{No load bus voltage (= 27 kV)}}{\text{Source impedance + transformer impedance (ohm)}} \text{ A}$$

$$\text{HV side source impedance} = \frac{kV^2_{pri}}{\text{Fault level at primary bus at TSS in MVA}} \quad \Omega$$

Reflected impedance on LV bus

$$= \text{HV side Source impedance} \times \frac{kV^2_{sec}}{kV^2_{pri}} \quad \Omega$$

$$\text{Impedance of transformer at 27 kV base} = \frac{kV^2_{sec} \times \%\ \text{impedance of transformer}}{\text{transformer MVA} \times 100} \quad \Omega$$

$$\text{Plug setting multiplier} = \frac{\text{Fault current at LV bus} \times (kV_{sec} / kV_{pri})}{1.6 \times I_{pri}}$$

From IDMT curve (3 sec at 10 time of setting), choose the suitable TMS for getting the relay operating time 500 to 600 ms at calculated plug setting multiplier.

4.1.2 Instantaneous over current relay

The instantaneous element may be set to correspond to a current of 1.25 times the fault current on the LV bus. The setting is proposed to avoid this relay operation for LV bus fault.

Current setting

$$= 1.25 \times \text{fault current at LV bus} \times (kV_{sec}/kV_{pri}) \times (1/\text{CT ratio}) \quad A$$

$$\%\ \text{Current setting} = \frac{\text{Current setting}}{5} \times 100\ \%$$

4.1.3 Restricted earth fault relay (HV & LV) & transformer differential protection

There shall be no change required and these relay settings should be calculated as per earlier setting guide lines issued by RDSO vide letter No ETI/SS/7 Dated 22-04-88.

4.1.4 IDMT relay on transformer LV side.

The function of this relay is to act as a back- up protection to the feeder protection relays. The reach of the relay should be as much as possible. However to obtain grading in current between HV & LV IDMT, the current setting of the relay should be selected to correspond to 150% of the rated current of the traction transformer.

$$\text{Relay setting} = \frac{1.5 \times I_{sec}}{\text{CT ratio}} \quad A$$

$$\text{Setting in \%} = \frac{\text{Relay setting}}{5} \times 100\ \%$$

The TMS of IDMT relay should be selected such that the relay operating time obtained is 250 ms to 300 ms for a fault occurring on LV bus.

4.1.4.1 TMS calculation

Refer to the fault current at LV bus considering the source impedance and single transformer impedance as already calculated in clause 3.1.1.1 above.

The Plug setting multiplier of LVCB IDMT shall be calculated as under.

$$\text{Plug setting multiplier} = \frac{\text{Fault current at LV bus}}{1.5 \times I_{sec}}$$

From IDMT curve (3 sec at 10 time of setting), choose the suitable TMS for getting the relay operating time 250 to 300 ms at calculated plug setting multiplier.

4.2 Feeder/OHE Protection

4.2.1 Instantaneous OCR element

This protection element provides primary protection to the catenary on earth faults in the vicinity of the feeding post. The current setting of the relay should be corresponding to about 220% of the continuous current rating of the single traction transformer. Assuming that a factor of 1.10 will account for the CT & relay errors and relay transient over reach, the relay will allow loads of about 220/1.10 i.e. 200% of rated load current of a single transformer.

4.2.2 Definite time OCR element

This protection element provides back up protection to Instantaneous OCR & DPR. The current setting of the relay should be corresponding to 180% of the continuous current rating of single

traction transformer. The relay operating time may be selected between 200-250 ms to avoid the transient tripping during simultaneous switching on of locos/EMUs.

4.2.3 Distance protection relay

4.2.3.1 Zone-1 setting.

There shall be no change required and these relay settings should be calculated as per earlier setting guide lines issued by RDSO report No. TI-35(7/95) July 1995 and revision to this report issued vide letter No TI/PSI/PROTCT/STATIC/07 dated 23.4.07

4.2.3.2 Zone-2 setting.

The zone-2 element of distance protection shall act as a backup protection for primary zone-I protection with comparatively higher resistive reach in comparison to zone one resistive and OCR reach.

Forward reactance (X_F) setting

X_F for zone 2 is to be taken as 1.25 times the value of X_F selected for zone1.

Forward resistance (R_F) setting

$$\text{Calculate the peak load impedance } Z_{PL} = \frac{25000 \times \text{CT ratio}}{1.5 \times I_{sec} \times \text{PT ratio}} \quad \Omega$$

In order to accommodate CT, PT & relay errors and to enhance the resistive reach as compared to zone-I

$$Z = 90\% \text{ of } Z_{PL}$$

To obtain the R_F setting a factor 0.5812 is to be multiplied to Z (as per RDSO report No. TI-35(7/95) July 1995).

$$R_F = 0.5812 \times Z \quad \Omega$$

Reverse reactance (X_B) setting.

The same value may be used as mentioned for Zone –1 setting.

Backward resistance (R_B) setting

It is should be of the same value as R_F.

Time setting

The operating time of the Zone-2 protection element may be set at 300-400 ms.

4.2.4 WPC, PTFF, Trip fail, Auto reclosure & Delta-I relay

For setting of these relay refer the existing RDSO setting guideline for feeder protection module & Delta-I relay, circulated to Zonal Railways vide RDSO report No. TI-35(7/95) July 1995 and revision to this report issued vide letter No. TI/PSI/PROTCT/STATIC/07 dated 23.4.07.

113-3

टेलीफोन 2465763(क)
फैक्स 91&0522&2465763
Telephone : 2465763 (O)
Fax DOT : 91-0522-2465763
E-mail : dti3@rdso.railnet.gov.in

सत्यमेव जयते

भारत सरकार रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
मानक नगर,लखनऊ – 226 011
Government of India, Ministry of Railways
Research Designs & Standards Organisation
Manak Nagar, Lucknow – 226 011

No. TI/PSI/PROTCT/FLASH/09

Date: 09.02.2009

Chief Electrical Engineer

i) Northern Railway, Baroda House, New Delhi - 110 001
ii) Central Railway, 2nd Floor, Parcel Office Building, CST Mumbai - 400 001
iii) Eastern Railway, Fairlie Place, Kolkata - 700 001.
iv) North Eastern Railway, Gorakhpur (UP)
v) Southern Railway, Park Town, Chennai - 600 003
vi) South Central Railway, Railnilayam, Secunderabad -500 371.
vii) South Eastern Railway, Garden Reach, Kolkata 700 043.
viii) South Eastern Central Railway, Bilaspur 495 004
ix) Western Railway, Churchgate, Mumbai - 400 020.
x) East Coast Rly, B-2, BDA Rental Colony, Chandshekharpur, Bhubaneswar
xi) East Central Railway, Hajipur (Bihar).
xii) North Central Railway, Near Rly Station, Allahabad.
xiii) South Western Railway, DRM Office, Bangalore.
xiv) West Central Railway, DRM Office, Jabalpur.
xv) Central Organisation for Rly Electrification, Nawab Yusuf Rd. Allahabad
xvi) Director, Indian Railway Institute of Electrical Engineering (IRIEEN), Post Box No. 233, Nasik Road-422101.

Sub: Instruction no. TI/IN/0018 (Feb/2009) for application of existing panto flash over relay at traction sub-station (TSS) for single line section on Indian Railways.

Please find enclosed herewith a copy of the instruction no. TI/IN/0018 (Feb/2009) for application of existing panto flash over relay at 25 kV ac traction sub-station (TSS) with single line section on Indian Railways for your kind information and necessary action please.

9.2.09
(Sumit Bhatnagar)
For Director General/TI

Encl : As above

Copy to:
ED/EE(M)
Room No. 102-A, Railway Board.

MASTER COPY

TRACTION INSTALLATION DIRECTORATE

सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Instruction No. TI/IN/0018 (Feb/2009)

For

APPLICATION OF EXISTING PANTO FLASH OVER RELAY AT TRACTION SUB-STATION (TSS) FOR SINGLE LINE SECTION ON INDIAN RAILWAYS

February 2009

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization
(Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 Scope

This instruction stipulates the action to be taken by Zonal Railways / CORE as applicable for use of existing panto flash over relays of M/s Ashida (type: APFO/1) and M/s Alind (type:TVG-124) make at 25 kV, ac traction sub-station (TSS) with single line section.

2.0 Background

A specification no. TI/SPC/PSI/PROTCT/2983 for Panto flash over relay was developed by RDSO in 1998 for double line section to prevent the flashovers at FP insulated over lap (IOL) when electric locomotives enter from live to dead OHE. At present the panto flashover relays of M/s Ashida and M/s Alind make are already provided at number of TSS with double line sections.

Northern Railway requested to study the application of existing panto flash over relay for single line section of 25 kV ac traction system also. In this regard it is observed that the existing panto flashover relay as developed for double line section as per RDSO specification no. TI/SPC/PSI/PROTCT/2983 can also be used for single line sections also as per logic and connection diagram explained in this instruction.

3.0 Working of Panto flash over relay

3.1 Whenever there is tripping of circuit breaker due to fault on one of the sides of the FP IOL and a electric train enters from live to dead section of the FP IOL, there shall be a heavy flash over when the panto leaves the IOL. Depending upon the intensity of current being drawn by the panto at that point of time, the extent of damage would be cutting of a few strands of catanery or parting of the OHE.

3.2 The various types of faults which can cause CB tripping are as follows

a) A permanent fault, and the CB is unable to hold.

b) A transient fault which may not reappear on the reclosure of the Circuit Breaker.

c) An intermittent fault which may go on reappearing within short intervals (like a tree swinging and touching the OHE)

3.3 If there is a permanent fault on one side of the TSS resulting in tripping of any one of the CBs and pantograph bridges the IOL form the live end, the second feeder CB shall also trip under the normal fault conditions. In such an event there shall be no possibility of any damage to OHE due to flashover.

3.4 In case of transient faults, the quick reclosure of CB may obviate the problem but if the reclosure is delayed, the possibility of flashover will continue to exist.

3.5 The situation is worse in case of intermittent faults since in case of CB tripping a second time the TPC will go in for an fault isolation which will require some time. If in the intervening period, a train enters the insulated overlap, when there was no fault on the other side of the OHE, heavy flashover will take place which may cause extensive damage to OHE.

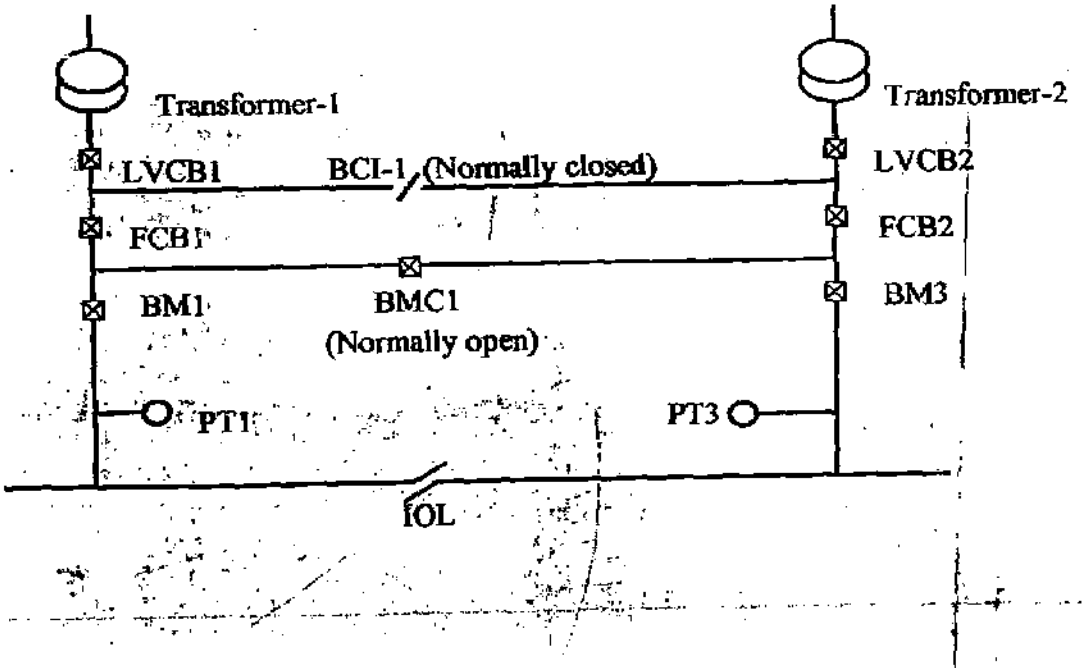
3.6 Logic for various conditions like status of different switching devices, PT's can be used by a microprocessor based relay to detect the eminent condition of flashover over IOL and other FCB can be tripped.

3.7 In case any side of the overlap is dead, due to any of the feeder breakers being tripped, the PT output at that side gets dipped considerably. If PT delivers a normal output on dead line, which can only be due to bridging of the live line by the panto, the relays sense this as an abnormal condition and release trip command to the feeder breaker, parallely disabling auto reclose scheme, to prevent auto reclosing of this dead line.

3.8 Under extended feed condition i.e. in case the feed is extended to the failed TSS, the relay shall be disabled. This shall be recognised by the relay from the status of feeders and interrupters.

4.0 Working logic for panto flashover relay for use in single line section is given below:

4.1 Schematic lay out arrangement of TSS for single line section



4.2 Logic chart of panto flash over protection relay for single line section

(When the panto bridges the IOL momentarily)

S. No.	FCB1	FCB2	BM1	BM3	BMC1	PT1	PT3	Relay operation	Supply Feed condition
1	1	0	1	1	0	1	1	Relay shall Trip	Normal
2	0	1	1	1	0	1	1	Relay shall Trip	Normal
3	*	*	0	*	*	*	*	Relay shall not Trip	Extended
4	*	*	*	0	*	*	*	Relay shall not Trip	Extended
5	*	*	*	*	1	*	*	Relay shall not Trip	Extended

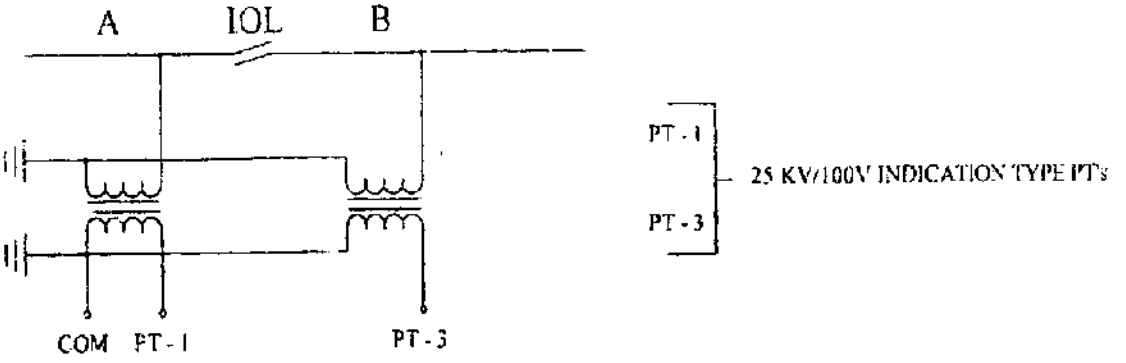
1- Denotes Breaker or Interrupter closed / PT delivers output

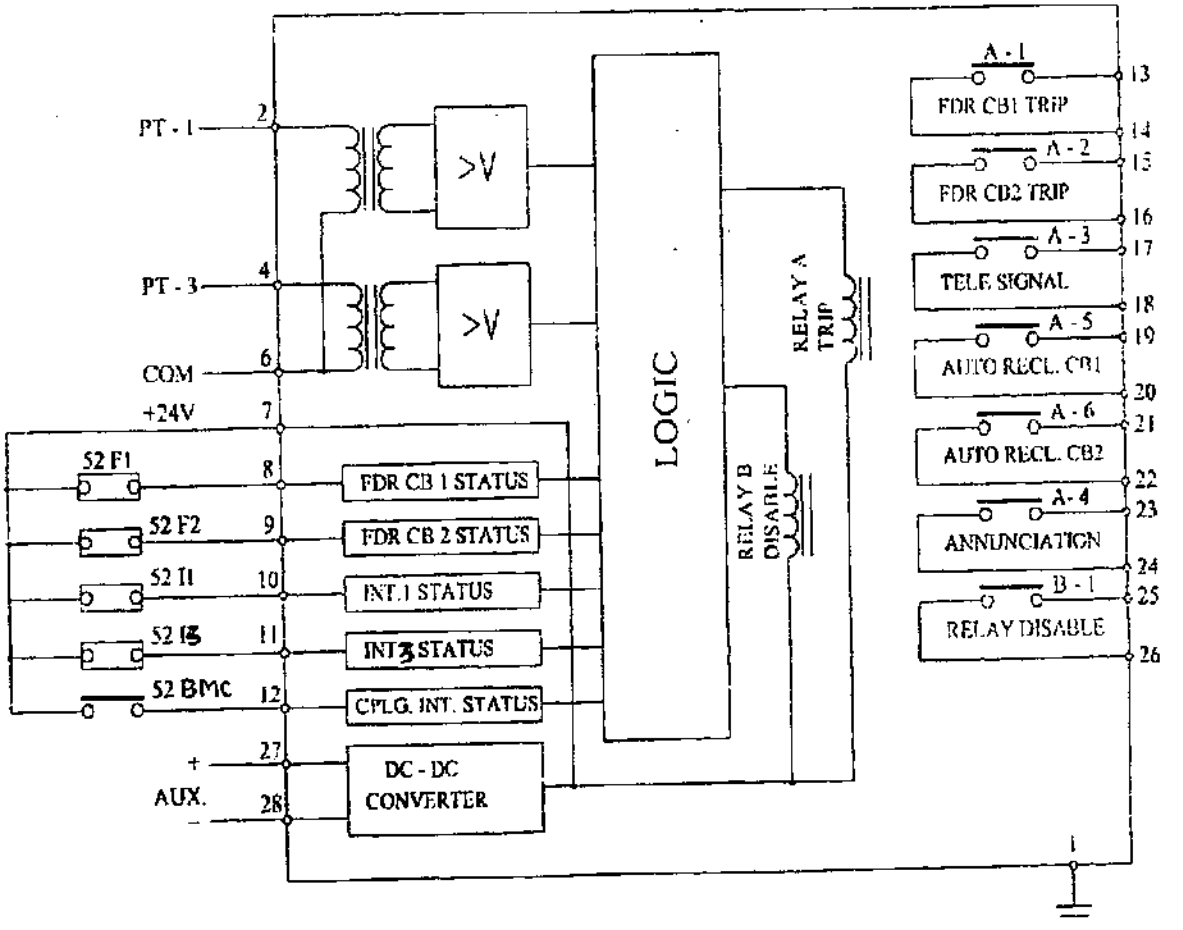
0- Denotes Breaker or Interrupter tripped

*- Denotes 1 or 0 status need not be cared or considered.

5.0 Connection diagram of panto flash over relay for single line section

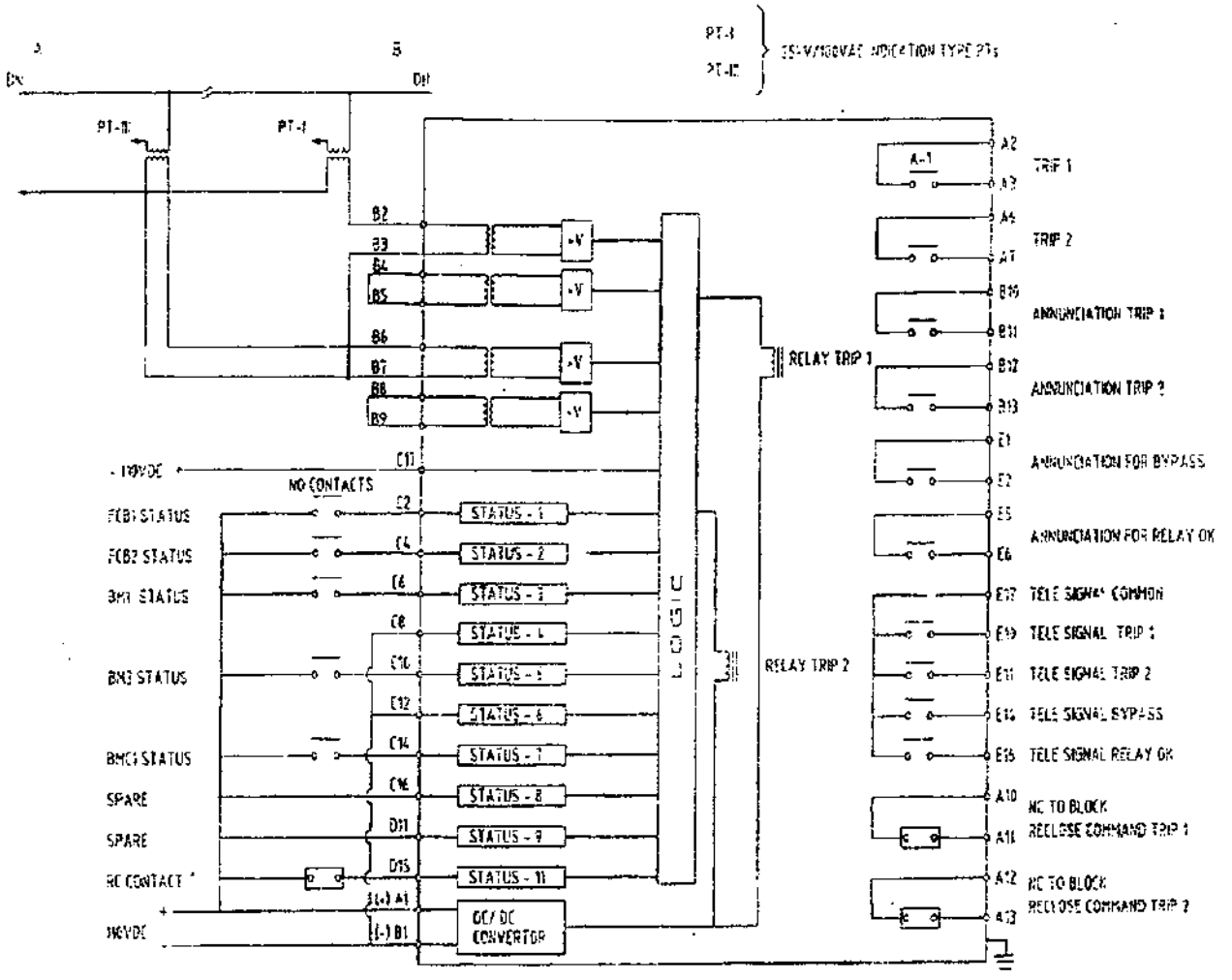
5.1 M/s ALIND make (Type – TVG 124) panto flash over relay





5.2 M/s ASHIDA make [Type APFO / 1(Logic-1)] panto flash over relay

ELECTRICAL CONNECTION OF APFO/1 (LOGIC-1) OF CONVENTIONAL 25KVAC TRACTION SYSTEM.



The connections as explained above may be adopted for using the existing relays for the single line section. In case of any further clarifications relay manufacturers may also be consulted.

6.0 References

M/s ASHIDA & M/s ALIND letter Nos. AEPL/0811/359/L dated 28th November 2008 & DD/EC/FR-4/01/0080/1187 dated 9th September 2008 respectively regarding the use of same panto flash over realy as approved for double line section in single line section.

113-4

टेलीफोन 2465763(क)
फैक्स 91&0522&2465763
Telephone : 2465763 (O)
Fax DOT : 91-0522-2465763
E-mail : dti3@rdsc.railnet.gov.in

सत्यमेव जयते

भारत सरकार रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
मानक नगर लखनऊ – 226 011
Government of India, Ministry of Railways
Research Designs & Standards Organisation
Manak Nagar, Lucknow – 226 011

TI/ PSI/HARFIL/DEV/09 Dt: 29.09.09

Chief Electrical Engineer,

1. South Eastern Railway, Garden Reach, Kolkata-700 043
2. Eastern Railway, Fairlie Place, Kolkata-700 001
3. Northern Railway, Baroda House, New Delhi - 110 001
4. Southern Railway, Park Town, Chennai - 600 003 (TN)
5. South Central Railway, Rail Nilayam, Secunderabad – 500 371
6. Western Railway, Churchgate Stn. Bldg, Mumbai - 400 020
7. Central Railway, 2nd floor, Electrical Branch, Parcel Office Bldg. Mumbai - 400 001
8. South West Railway, DRM's Office, Hubli (Karnataka)
9. West Central Railway , Jabalpur (MP)
10. East Coast Railway, B-Rental Colony, Chandrashekharpur, Bhubaneshwar (Orrisa)
11. East Central Railway, Hajipur (Bihar)
12. North Central Railway, Block-A, Subedarganj, Allahabad 211 033
13. South East Central Railway, Bilaspur (Chattisgarh)
14. Northeast Frontier Railway, Guwahati
15. North West Railway, Jaipur (Raj.)

Sub: TI/IN/0019 (09/09) rev.'0' "Instruction for Load profile, current & voltage harmonics measurement and recording in a 25 KV ac traction substation".

Please find enclosed herewith the "Instruction for Load profile, current & voltage harmonics measurement and recording in a 25 KV ac traction substation". It is advised to go-through the instructions and record the parameters. The data generated shall be useful in future for dealing with the different tariff conditions, if imposed by utilities related to the limits on harmonic distortion etc.

29.9.09
(Sumit Bhatnagar)
for Director General,TI

Encls: As above

MASTER COPY

INSTRUCTION No. TI/IN/0019(09/09) rev.0

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

सत्यमेव जयते

INSTRUCTION
FOR
LOAD PROFILE, CURRENT & VOLTAGE HARMONICS MEASUREMENT
AND
RECORDING IN 25 KV AC TRACTION SUBSTATION

SEPTEMBER' 2009

ISSUED BY

TRACTION INSTALLATION DIRECTORATE
RESERARCH DESIGNS & STANDARDS ORGANISATION
LUCKNOW – 226 011

Load profile, current & voltage harmonics measurement and recording in a 25 KV ac traction substation

1.0 Introduction

With the introduction of new electricity act 2003, lots of changes had taken place in the power sector in India e.g. open access facility in transmission and distribution sectors, bigger role of central & state regulatory commissions for consumer grievances and enforcement of performance, power quality parameters for all concerned. Instructions related to generation, transmission, distribution, grid operations and metering etc. are now being issued by different authorities like CEA, CERC and state regulatory commissions in the form of codes, guidelines and regulations. The documents like supply codes, grid connectivity guidelines etc. refers to the power quality parameters & their limits to be maintained by the power supply licensee's and the consumers. Summary of some regulations issued by CEA & state regulatory commissions is placed at Annexure – III for reference.

In addition to the above, some Railways have reported that their respective utilities start charging for low PF/MD penalties by implementing logic of addition of leading kVAR.

In order to respond for such conditions it becomes necessary to evaluate the effect of various tariff conditions on the traction bill (e.g. treatment to leading kVAR, low PF & MD penalties, incentives for high PF etc.). This requires accurate analysis of load variation & power quality data at TSS.

Railways may also record short term voltage variations (sag, swell etc.) and capacitor switching transient wave forms depending upon local conditions e.g. equipment failures suspected on account of wide voltage fluctuations, size of capacitor bank, load pattern etc.

During the process of development of Dynamic reactive compensation systems RDSO with the assistance of different vendors collected load variation and other Power Quality related data from various TSS on IR and based on these following recommendations/guidelines have been made. Railways may also offer their suggestions to improve these guidelines based on the field experience.

2.0 Scope of the measurement and recording at a TSS

Initially online measurements and data logging may be carried out at one TSS which is considered representative of a particular area/division and following parameters measurement & recording must be ensured.

2.1 RMS voltage, Current, Active, Reactive, Apparent Power & Energy and Harmonics at HV side of Traction Transformer (Location-1 as shown in Annexure-II) if TSS has got facility & access of HV side measurement through a step-down PT at 110/√3 V and suitable CT secondary current 5A otherwise at LV side –(Location 2 as shown in Annexure-II).

2.2 The preferable location of measurement is at the HT side which is also the point of common coupling (PCC) with the utility.

2.3 RMS Current and Reactive power delivered at 25KV by existing capacitor bank if any (Location 3 as shown in Annexure-II).

2.4 Logging of Fundamental & Individual Harmonic Currents and Voltage preferably up to minimum 25th Harmonics should be ensured. The measurement of harmonics and analysis should generally be in accordance with IEEE 519 guidelines.

2.5 The measurements should be recorded with or without existing Capacitors banks (if feasible) preferably spread over a week duration. A sample format of data to be recorded is shown in Annexure-I

2.6 The possible location and arrangements are depicted in pictorial form in Annexure-II. The results obtained must be analyzed correctly in terms of the location of the measurements e.g. the measurements recorded at location 2 and 4 shall provide the compensated and uncompensated readings respectively.

2.7 The continuous readings of V, I, kW, kVA, kVAR and PF must be finally available in data spreadsheet for desired time duration and scale for analysis. While preparing the load pattern graphs the minimum time interval should be selected based on the window period adopted by the utilities (generally 15 minutes) for calculation of apparent power, MD and average chargeable PF. The recording time interval should be adjustable to accommodate any special tariff condition and to clearly understand the load variation.

2.8 Voltage harmonic distortion of supply voltage (THD) at Point of common coupling (PCC) without traction load should be measured to get full idea of harmonic pollution already present at PCC.

3.0 Requirements of Power Quality analyzer & Data logger Instrument

3.1 The equipment should be portable facilitating easy field testing.

3.2 The equipment should have both measurement, display and recording facilities and it should be able to record sampled data.

3.3 The CT/PT output should be connected to the equipment with or without any interface depending upon the type of equipment.

3.4 The equipment must be able to measure and record minimum up to 25th harmonic current & voltage distortion (individual as well as total).

3.5 The equipment should be capable of continuously logging all voltage and current waveforms on internal memory of at least 8 GB. The data should be stored with suitable Data Compression Technology.

3.6 The equipment with modem communication features should have wide bandwidth, high sampling rate for accurately capturing waveforms, at high resolution and fast data storage.

3.7 The equipment should have suitable LCD type user interface/ display arrangement and it should be supplied with data analysis software (including any other support software to clearly depict recorded data as bar graphs, vectors and lists). It should also support variety of display formats like numeric, wave, bar, trend or their combinations etc.

3.8 The equipment should have necessary communication interface to collect the data from the devices to the central processing computer, by means of GPRS, Modem or Ethernet connection.

3.9 The equipment should be capable of providing the following system parameters continuously

(a) Active power and energy i.e. KWh
(b) Reactive power and energy, KVARh
(c) Apparent power and energy, KVAh
(d) Power Factor
(e) Current and voltage Harmonics (individual as well as total).

4.0 Analysis of the data recorded

Railways shall have to analyze the data to calculate the requirement of reactive compensation. In addition any violation of tariff condition on account of pf, MD and power quality parameters like harmonic distortion must also be examined.

ANNEXURE-I

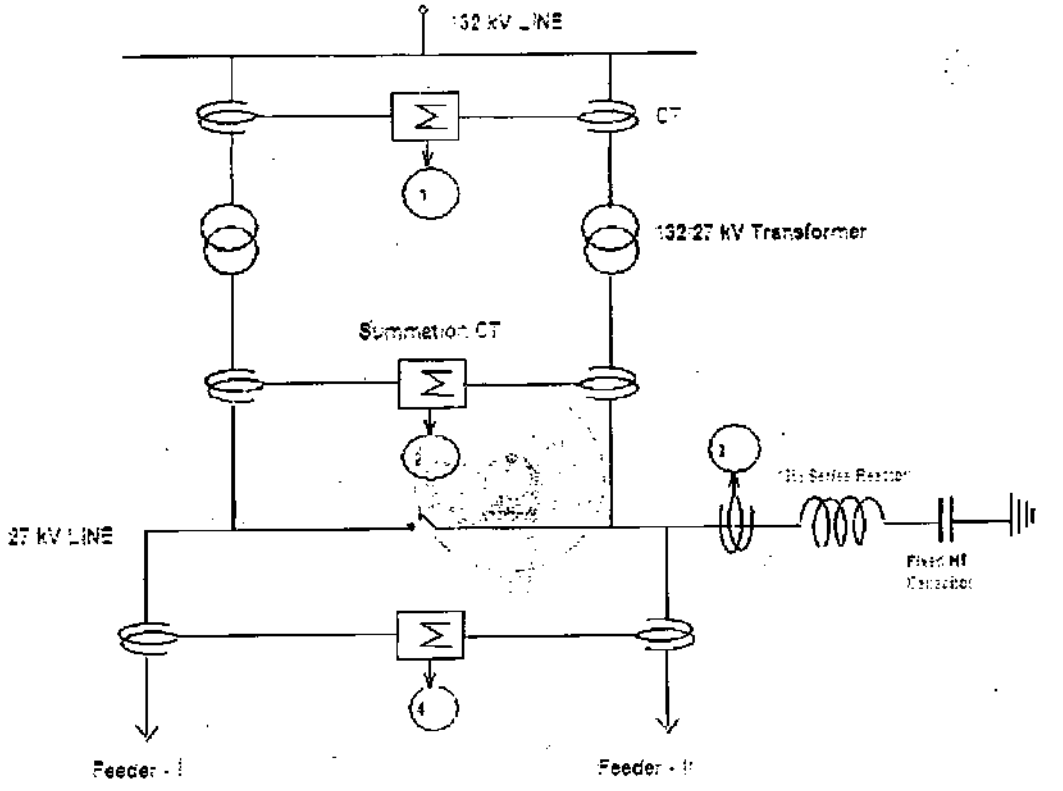
Sample format of data recording

Date	Time	Frequency	V_{rms}	V_{THD}	A_{rms}	A_{THD}	kW	kW-hours	kVAR	kVAR-hours	kVA	kVA-hours	Power Factor
		Hz	V	%	A	%	kW	kWh	kVAR	kVARh	kVA	kVAh	

THD :- Total Harmonic Distortion

Pl note that generally all the instruments record individual harmonic current and voltage components up to 25th or higher order however columns are not shown in above table due to space constraint.

ANNEXURE-II



General Scheme for Load profile, current & voltage harmonics measurement and recording in a 25 KV ac traction substation

Annexure-III

Regulations, Codes and guidelines on limits of harmonic distortion in different states

<table>
<tr><th></th><th>Supply/Distribution Code summary</th></tr>
<tr><td>CEA</td><td>Technical standards for connectivity to the grid regulations-2007 dt 21-02-2007
• THD for voltage not to exceed 5% at PCC. Individual harmonic distortion not to exceed 3%.
• THD for current not to exceed 8% at PCC.</td></tr>
<tr><td>Rajasthan</td><td>The Rajasthan Electricity Regulatory Commission (Transmission Licensee's Standards of Performance) Regulations, 2004
&
"Rajasthan Electricity Regulatory Commission (Rajasthan Electricity Grid Code) Regulations 2008"
• Harmonic measurement shall conform to IEC Std. 1000-4-7 or IEEE Std. 519
• The Total Harmonic Distortion (THD) determined in accordance with IEC Std. 1000-4-7 shall not exceed 1% at the inter-connection point of EHV system in the Final Phase. The measurement should be taken at 10 minutes interval and shall last for 1 week per site. Licencee shall measure the THD at strategic such inter-connection points which it consider prone to harmonic voltage generation at regular interval of 6 months. RVPN shall intimate the programme to RVUN or Distribution Licensee as the case may be at least 7 days in advance and their representative may be present during such measurements. Wherever THD exceeds the limit or individual harmonics exceed 0.5%, RVPN shall measure harmonics with and without load/generating station to ascertain the origin.
CURRENT UNBALANCE
• Current unbalance shall not be more than 3%. Current unbalance shall apply on all the feeders of a voltage class emanating from a sub station taken as a group. In case of railway traction it shall apply on 3 sub stations in a row taken as a group. Distribution Licencee shall be given at least 12 hours to remedy current unbalance. Failure to meet this criterion shall be discussed in committee proposed under grid code and remedial measures agreed there on.
• As per clause 6.6.4.3 of grid code Voltage and Current Harmonics:
Voltage Harmonics: The maximum limit of total harmonic distortion for voltage shall be:-
<table>
<tr><th>Nominal System Voltage</th><th>Total Harmonic Distortion (THD)</th><th>Individual harmonic of any particular frequency</th></tr>
<tr><td>400 kV</td><td>2.0%</td><td>1.5%</td></tr>
<tr><td>220 kV</td><td>2.5%</td><td>2.0%</td></tr>
<tr><td>132 kV</td><td>3.0%</td><td>2.0%</td></tr>
</table>
Current Harmonics: The total harmonic current drawn from the transmission system at any point shall not exceed 8% of the fundamental frequency current.</td></tr>
</table>

Maharastra	**MAHARASHTRA ELECTRICITY REGULATORY COMMISSION** **Maharashtra Electricity Regulatory Commission (Electricity Supply Code and Other Conditions of Supply) Regulations, 2005** **12. Power factor / Harmonics** 12.1 It shall be obligatory for the consumer to maintain the average power factor of his load at levels prescribed by the Indian Electricity Rules, 1956 with such variations, if any, adopted by the Distribution Licensee in accordance with Rule 27 of the Indian Electricity Rules, 1956 and in accordance with the relevant orders of the Commission. Provided that it shall be obligatory for the HT consumer and the LT consumer (Industrial and Commercial only) to control harmonics of his load at levels prescribed by the IEEE STD 519-1992, and in accordance with the relevant Orders of the Commission. 12.2 The Distribution Licensee may require the consumer, within a reasonable time period, which shall not be less than three months, to take such effective measures so as to raise the average power factor or control harmonics of his installation to a value not less than such norm, in accordance with Regulation 12.1 above: 18 Provided that the Distribution Licensee may charge penalty or provide incentives for low /high power factor and for harmonics, in accordance with relevant Orders of the Commission.
MP	**MADHYA PRADESH ELECTRICITY REGULATORY COMMISSION (PERFORMANCE STANDARDS) REGULATIONS, 2004 (REVISION- I, 2005)(No.RG-8 (I) of 2005)** • Licensee shall monitor harmonics at regular interval at strategic points in respect of HT consumers, which it considers prone to harmonic voltage generation and ask the user to comply with the specified standards. • The harmonic currents drawn by various consumers shall be measured and its records shall be maintained. The following is a non-exhaustive list of harmonic generating equipment: a) Salient pole synchronous generating units b) Transformers operated with core saturation c) Rolling mills d) Induction furnaces e) Welding equipment f) Static power loads incl. computers & television sets g) Inverters/Power Rectifiers h) Railway Traction Loads • The Distribution licensee shall follow the Voltage and Current Harmonics distortion limit as specified by the Authority in the Grid Connectivity Standards applicable to the Distribution Systems. **Madhya Pradesh Electricity Grid Code (Rev-I), 2005** • Discoms and Open access users shall ensure that their loads do not affect STU system in terms of causing any:

	1. Unbalance in the phase angle and magnitude of voltage at the interconnection point beyond the limits prescribed by Transmission Performance Standards. 2. Harmonics in the system voltage at the interconnection point beyond the limits prescribed by Transmission Performance Standards. **MADHYA PRADESH ELECTRICITY REGULATORY COMMISSION (TRANSMISSION PERFORMANCE STANDARDS) REGULATIONS, 2004 (Revision 1, 2005) (No.RG-9 (I) of 2005)** • Harmonic measurement shall confirm to IEC Std. 1000-4-7 or IEEE Std. 519. The Total Harmonic Distortion (THD) in voltage waveform determined in accordance with IEC Std. 1000-4-7 shall not exceed 1% at the interconnection point of EHV system. • The measurement should be taken at 10 minutes interval and shall last for 1 week per site. State Transmission Utility /Transmission Licensee shall measure the THD at strategic such interconnection points which it consider prone to harmonic voltage generation at regular interval of 12 months. • State Transmission Utility /Transmission Licensee shall intimate the programme to Generating Companies or Licensee as the case may be at least seven (7) days in advance and their representative may be present during such measurements. State Transmission Utility /Transmission Licensee will compile a list of all metering points, which are prone to harmonic generation for taking remedial measures.
Tamil Nadu	**Tamil Nadu Electricity Supply Code as amended upto 31.7.2008** • Additional charges on harmonic dumping, the consumer shall provide adequate harmonic suppression units to avoid dumping of harmonics into distribution system. • Licensee may provide suitable metering equipments to measure harmonic level, consumer failing to provide harmonic suppression shall be liable to pay compensation.
Chattisgarh	**"Chhattisgarh State Electricity Supply Code-2005"** Para 6.47 **Harmonics** If the licensee detects and proves to the consumer that the consumer's system is generating harmonics above acceptable limits, the licensee may ask the consumer to install appropriate harmonic filter within a reasonable period of time . The tolerance limits of harmonic injections are as follows:- EHT – THD – 3%, HT – 4%, LT – 6%
Punjab	Punjab State Electricity Regulatory Commission (Electricity Supply Code and Related Matters), Regulations, 2007 **Harmonics** (a) The Licensee will monitor harmonics in respect of those EHT/HT consumers, which it considers prone to generation of harmonic currents and.

	require such consumers to comply with standards as may be specified by the Commission. (b) The harmonic currents generated by a consumer will be jointly measured by the Licensee and the consumer and its record maintained. (c) Consumers contributing harmonic distortion in excess of the specified standards will be liable to pay penalty, as may be specified by the Commission.
Delhi	**DERC supply code and performance standards** **Harmonics** Requirements will be specified separately at an appropriate time after conducting a detailed study.

Note: (1) The above details have been collected from the information available on the websites of respective Electricity regulatory commissions.

(2) The Railways have to interact with their respective utilities/regulatory commissions for latest amendments/ revisions to the guidelines/codes.

113-5

MASTER COPY

TRACTION INSTALLATION DIRECTORATE

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Instruction No.-TI/IN/0020 (12/2009)

Instructions for timely replacement & up-gradation of Computers at Remote Control Centres of traction SCADA systems on IR

December 2009

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization
(Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 **Scope:** This instruction stipulates the action to be taken by Zonal Railways to up-grade the work station at Remote Control Centres by timely replacement of computers.

2.0 **Background:** In some of the SCADA systems having old RCC computers, Railways has been reporting problems like MMI refreshing taking time, MMI hanging on changing the windows quickly or appearance of double windows, Hard disk memory limitations and non compatibility with the latest versions of software applications and updates of the SCADA software etc.

3.0 In addition to above, problems on account of delays in repairing of the old computers due to non availability of requisite parts, non functioning of printers and other peripheral devices due to in-compatible/ obsolete drivers, and severe constraints are being observed in the overall SCADA system performance.

4.0 **Up gradation and timely replacement of RCC computers**

To ensure reliable & required optimum performance of SCADA system following instructions/ criteria should be followed for timely up-gradation and / or replacement of RCC computers.

4.1 The SCADA software at RCC is a graphical User Interface (GUI) based application and its efficient working requires large RAM sizes on PC's workstations.

4.2 The life of the PC's and computer has been stipulated by the Railway Board's letter No. 2002/ACII/1/10(Vol-II) dated 24-5-2006 (RBA No. 25/2006) and revised on 25-02-2009 vide RBA No. 13/2009. The same should be adhered to for timely planning the replacement & up-gradation.

4.3 The specification of the computer hardware and software are changing very fast due to rapid technological developments taking place in this field e.g. after every 2-3 years, the new Microsoft windows OS are released, similarly the memory size required for using the different application software is also increasing rapidly and hence the peripheral & interfacing devices like DVD drives, HDD, printers and other communication devices are also required to be updated very fast.

4.4 SCADA vendors keep on updating their software in line with the new operating systems, application development tools, interfacing software and higher & more efficient product design requirements. The new versions of the SCADA software may require higher level of hardware configurations for proper running of the application and configuration with latest data cards thereby necessitating up gradation or replacement of the computers.

4.5 In this regard Railways are advised to review the specifications of the existing computers of SCADA systems and plan either replacement or up gradation of the systems. The basic configuration of the RCC computers is given in the RDSO specification for complete SCADA systems which is the minimum requirement for satisfactory functioning however as the computer models and capabilities are changing rapidly it is advised to opt for the best possible and available configurations to avoid obsolescence. The Railways may refer to the Web sites of the approved makes of the computers i.e. IBM, DELL, HP etc. as mentioned in the SCADA specification.

4.6 The motherboard and the RAM should be examined prior to deciding for the up gradation of the computers.

All components and peripherals inside the computer are connected to Motherboard either directly or indirectly. Their specification indicate the type of processor that can be used, the maximum amount of RAM that can be fitted & the requirement of number of USB ports, hard drive sockets, sound features and so on. Each motherboard has a socket which dictates what type of CPU's can be fitted therefore if Mother board is not having the additional slots for RAM or graphic cards the up gradation of the computer shall not be possible.

4.8 Upgrading the RAM of the system may be one of the easiest and cheapest hardware modifications that can be done to speed up the computer. Computers motherboard determines the type of RAM that can be used. Now a days for desktop PCs DDR2 RAM with DIMM (dual in-line memory module) sockets is used. DDR, DDR2, and DDR3 are different types of SDRAMs requiring different pin counts of DIMM sockets. In new computers RAM sizes of higher than 4 GB are common.

4.9 It may be noted that minimum 512 Mb RAM is essential to efficiently run most of the SCADA application software. If mother board does not support even this size of RAM then it is advisable to replace the computer. If higher memory RAM is available in the market and existing Motherboard supports the same, it can be preferred and provided.

*****

(4)

CARRIAGE DIRECTORATE
COMPUTER WING

(114)

Instructions

COVERING LETTER

SUBJECT: SCANNING/DIGITISATION/INDEXING OF OFFICIALDOCUMENTS OF DIFFERENT DIRECTORATES OF RDSO

1	NAME OF THE DIRECTORATE		Traction Installation Directorate (T.I. Dte)
2	NAME OF THE SUB-DIRECTORATE/SECTION		Doc Cell
3	NAME & DESIGNATION OF THE SCANNING-CORDINATION OFFICER/STAFF		T Hasan / A.K. Sareen
4	NAME OF THE RECORD/FILE/ DOCUMENT/SPECIFICATION etc. AND ITS VOLUME/VERSION		Instructions (IN)
5	TOTAL NO OF PAGES/IMAGES		Nos Pages List of Documents on back side
6	NAME,SIGNATURE AND DESIGNATION OF THE HANDING OVER RDSO OFFICIAL		A.K. Sareen / SE/Doc A.K. Sareen 03/09/10 SE/Doc
7	NAME,SIGNATURE AND DESIGNATION OF THE TAKING OVER CMC OFFICIAL		03/09/10
8	DATE OF HANDING OVER FILE/DOCUMENT etc:		03/09/10
9	FIELDS FOR INDEXING		
	1	Type of Document (File/ DRAWING/TECHNICAL CIRCULAR/MODIFICATION SHEET/SPECIFICATION/NP)	
	2	Document No.	
	3	SUBJECT	Instructions
	4	SUB-SUBJECT	
	5	VOLUME	
	6	Sr. No.	From_____ To_____
	7	DATE OF CREATION OF FILE	
	8	Dealer	
10	DATE OF RECEIVING BACK THE DOCUMENT		
11	NAME, SIGNATURE AND DESIGNATIONOF THE RDSO OFFICAL RECEIVING BACK THE DOCUMENT AFTER SCANNING (No of papers to be checked by department)		
12	REMARKS/FEEDBACK IF ANY (Quality of documents to be checked by department and certified)		
13	CATEGORY OF DOCUMENTS A) COMPUTER GENERATED GOOD QUALITY B) COMPUTER GENERATED (DOT MATRIX) C) TYPE WRITTEN D) HAND WRITTEN		

SCAN DONE

MASTER COPY

TRACTION INSTALLATION DIRECTORATE

सत्यमेव जयते

GOVERNMENT OF INDIA,
MINISTRY OF RAILWAYS

Instruction No. TI/IN/0021 (01/2010)

Instructions for increasing data transfer speed of the traction SCADA system on IR from 600/1200 bps to minimum 9600 bps

Jan' 2010

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization
(Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 Scope: This instruction stipulates the action to be taken by Zonal Railways for modification of existing low speed (600/1200 bps) data transfer communication system to high speed data transfer communication system capable of achieving minimum 9600 bps. Railways may plan this work in consultation with S&T department.

2.0 Background: At present ITU-T V-23 half duplex, multi-drop FSK modems are used at RCC and remote posts i.e. RTU. The data transfer takes place at 600/1200 bps speed and due to slow speed of communication, Railways face following problems.

- Time taken for up-dation is quite high especially when no. of retries is needed due to noisy communication channel.
- The analogue signal on copper wires between station hut and RTU-modem is affected by EMI.
- Due to slow speed, some features such as Auto Fault Localization (AFLN) are not in function.
- With modern numerical relays available, SCADA system can be interfaced with protection relays to obtain fault data like impedance values, voltage & current waveforms however higher data transfer speed is required.
- Updating of the information available in field e.g. current, voltage, power, energy & PF etc to RCC at faster rate can provide better analysis of data.

3.0 Development of High Speed Data Transfer Communication System (HSDTCS):

To overcome the above problems, RDSO designed and developed a new communication scheme in consultation with S&T department. The main objectives of new communication scheme were to.

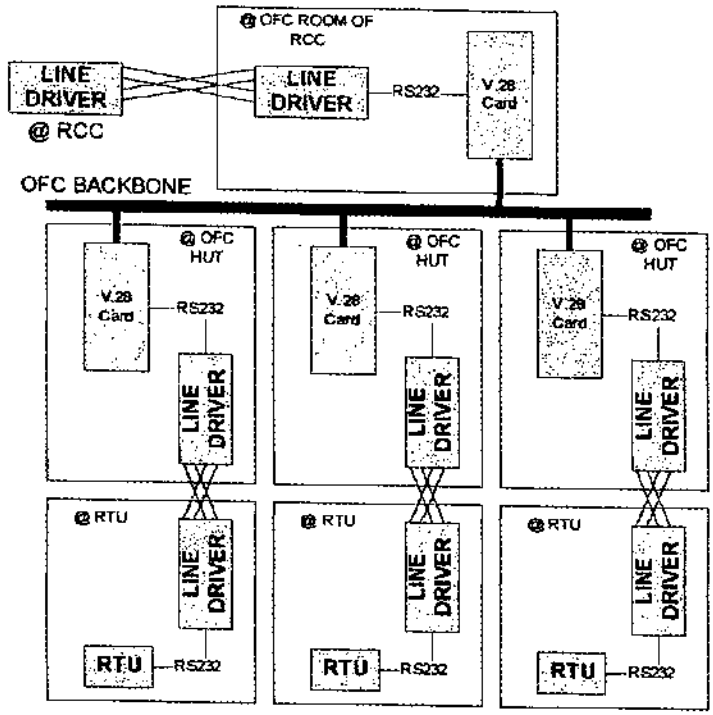
i. To achieve minimum 9600 bps data transfer rate.
ii. Avoid multiple conversion of signal from A to D and then D to A thereby reducing chances of noise generation.
iii. Digital data transmission from RCC to RTUs thereby reducing chances of EMI substantially.
iv. V-23 modems are now slowly getting obsolete so alternate development was considered necessary.

The trials as per this new scheme have now been conducted successfully in Ambala Division of NR after which a report No. TI/REPORT/00077 (02/2009) on HSDTCS was prepared and same has been accepted by Railway Board vide letter No. 2006/Elect(G)/170/2 dated 13.05.2009.

4.0 Communication Setup

The communication setup for implementing high-speed communication was achieved through the use of line drivers/ digital short haul modems and V.28 cards (slow speed data interface as per IRS-TC-68). The V.28 cards are installed in the MUX units of S&T department. These cards provide RS232 signal interface, which is then connected to the line driver installed alongside the OFC equipment. The line drivers enable RS232 communication over distances of up to 4 -5 kms depending upon the condition of cables. Another line driver installed at RTU location receives these signals and converts it back to RS232 signal levels, which is then connected to the RTU.

The arrangement of new communication scheme is depicted below.



5.0 Implementation of the new communication scheme-Steps to be taken by Railways

5.1 The work of increasing the data transfer rates as per this instructions may be got done only from RDSO approved sources of SCADA system or from OEMs.

5.2 Although all new PC based SCADA systems as per RDSO specification No. TI/SPC/ RCC/SCADA/0990 supports operation at higher data transfer rates with changes in settings & configurations however, Railways shall have to confirm from SCADA OEM that their system software at RCC and RTU firmware and hardware supports data transfer rate of 9.6 kbps through serial data port.

5.3 Obtain the make/ type of MUX equipment at RCC end and at station huts from S&T department. Check availability of V-28/ slow speed data interface cards in the MUX as per IRS/TC-68 and plan quantities accordingly.

5.4 Railways shall confirm from S & T department that vacant slot is available for providing V-28 cards in the MUX equipment at headquarter and all station huts.

5.5 Railways shall have to mention the following technical details while preparing specifications for the work.

5.5.1 Technical details of MUX equipment at both headquarter (RCC) and station huts to be provided by S&T department.

5.5.2 Make/ type and quantities of V-28 (slow speed data interface as per IRS-TC-68) cards required if not provided in MUX.

5.5.3 The distance of each post from the station hut to decide the correct line drivers or short haul modem.

5.5.4 The available ac and dc supply voltage levels at station huts, RTU and RCC for selection of suitable line driver/ short haul modem.

5.6 RDSO had conducted trials by using line drivers operating at 240 V ac (use of UPS was made to prevent interruptions in trial) for both at RCC and at station huts however it is recommended to select line drivers / short haul modems suitable for working at 48 V dc for station huts and RTUs while in RCC and at head quarter MUX 240 V ac operated units may be used.

5.7 If the operating voltage of line driver/ short haul modem is different than the available dc supply at any place then suitable dc-dc converters should be included in the scope.

5.8 The successful implementation of the scheme shall depend on the quality of line drivers/ short haul modems hence it shall be mentioned in the work specification that overall performance of the system including all sub-components like line drivers/short haul modems shall be of the vendor undertaking the work of up-gradation.

5.9 Railways shall also include a clause for warranty and AMC for a minimum period of 1 & 2 years respectively covering the all up graded system components.

5.10 The methodology of switching over from existing communication channel to the new channel should be decided in consultation with the vendor and local conditions and it is advisable to switchover in gradual manner.

5.11 All other general terms condition of contracts may be decided by Railways as per the extant rules.

5.12 The work content shall be for erection, testing, commissioning of the new communication channel in association with Railways engineers including measurement of dB levels, noise and data capture using software tools as part of system integration.

5.13 It is recommended that Railways shall keep provision of spare V-28 cards and line drivers/ modems to avoid any delay in restoration of the system.

5.14 The work shall include that, on completion, vendor shall provide time calculations to find out the overall improvement in the system performance. In addition vendor shall also jointly verify the increase in data transfer speed by using oscilloscope. It may however be noted that there will not be a direct relation in terms of improvement in data transfer speed of the system and update times because of line driver/short haul modem turnaround times.

6.0 Modifications at RCC and RTU level may include

6.1 RCC Level

The SCADA system at RCC may have to be modified to include another communication channel. For this purpose, the existing communication processors at RCC may be augmented with additional RS232 ports. The SCADA software shall then have to be reconfigured, with the RTUs to communicate on the new line over SPORT protocol, operating at 9600 baud.

6.2 RTUs Level

The configuration of the existing RTUs at each location shall have to be modified to run over SPORT protocol and at 9600 baud rate. The existing modems will be replaced with line drivers as shown in above figure.

All the changes in the RTU wiring done by the vendor shall be by using standard wiring practices and circuit diagrams shall be provided to the Railways.

7.0 The trials were conducted by RDSO as a project for 3 posts of Ambala division and RDSO specification for this trial, copy of LOA, joint performance report , photographs of the trial and technical details of the equipment is enclosed herewith as Annexure-I to V for reference purpose.

MASTER COPY

TRACTION INSTALLATION DIRECTORATE

सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Instruction No. TI/IN/0022 (February/2010)

Setting guide lines for traction transformer & 25kV shunt capacitor bank protection relay developed as per RDSO specification no. TI/SPC/PSI/PROTCT/6070(9/08) for 25 kV ac traction sub-station

February 2010

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization (Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 INTRODUCTION

The existing specification no. ETI/PSI/65(1/97) of control and relay panel incorporating static type relays for 25kV ac traction sub-station has been superseded by new RDSO specification no. TI/SPC/PSI/PROTCT/6070(9/08) in March 2009. As per this specification all the protection relays are of numerical type and additional three stage definite time over current protection element have also been included on primary and secondary side of transformer to utilize the over load rating of traction power transformer at the same time providing adequate protection against overloading as per the defined overloading cycle of traction power transformers.

The numerical type protection relays also have features to set the various parameters in fine steps for achieving better coordination between different protection relay elements.

In view of the above, new setting guidelines for transformer protection relays and 25kV shunt capacitor bank has been prepared. These setting guide lines shall provide the method of calculations only, for other general parameters and relay setting procedure reference to the operation & commissioning manual of relay manufacturer shall have to be made.

2.0 Relays setting guidelines for transformer protection

2.1 IDMT over current relay HV side

The function of this protection element is to act as a backup protection to the LVCB relays. The reach of this relay should be as much as possible, however to utilize the over load capacity of traction transformer the current setting of the relay should be selected corresponding to 190% of the rated current of the traction power transformer. The setting on the relay side may be calculated by formula given below:-

$$\text{Relay setting in Amp. } (I_{set}) = \frac{1.9 \times \text{Rated transformer primary (HV) current } (I_{pri})}{\text{CT ratio}}$$

$$\text{or relay setting in \% } = \frac{(I_{set})}{5} \times 100$$

The TMS should be selected such that the relay operation must be achieved in between 500 to 600 ms for a fault occurring on LV bus.

2.1.1 TMS (Time Multiplier Setting) calculation

Calculate the fault current at LV bus considering the source impedance and single transformer impedance

$$\text{Fault current at LV bus} = \frac{\text{No load bus voltage (= 27 kV)}}{\text{Source impedance + transformer impedance}} \quad \text{A}$$

$$\text{HV side source impedance} = \frac{kV^2_{pri}}{\text{Fault level at primary bus at TSS in MVA}} \quad \Omega$$

Reflected impedance on LV bus =

$$= \text{HV side Source impedance} \times \frac{kV^2_{sec}}{kV^2_{pri}} \quad \Omega$$

$$\text{Impedance of transformer at 27 kV base} = \frac{kV^2_{sec} \times \%\ \text{impedance of transformer}}{\text{transformer MVA} \times 100} \quad \Omega$$

$$\text{Plug setting multiplier} = \frac{\text{Fault current at LV bus} \times (kV_{sec} / kV_{pri})}{1.9 \times I_{pri}}$$

अ. अ. मा. स.

From IDMT curve of (3 sec at 10 time of setting), choose the suitable TMS for getting the relay operating time of 500 to 600 ms at calculated plug setting multiplier or calculate TMS by formula given below:

$$t = \frac{TMS \times a}{[I/I_{set}]^b - 1}$$

Where a&b are constant a = 0.14, b = 0.02
t = Operating time in second
TMS = Time multiplier setting
I = Measured current by relay
I_{set} = Set current in amp

2.2 Instantaneous over current relay

The instantaneous OCR element shall be set to correspond to a current of 1.25 times the fault current on the LV bus. The factor 1.25 is proposed to avoid this relay operation for fault at LV bus.

Current setting in A

$$= 1.25 \times \text{fault current at LV bus} \times (kV_{sec}/kV_{pri}) \times (1/\text{CT ratio}) \quad A$$

$$\text{or \% Current setting} = \frac{\text{Current setting in A}}{5} \times 100\ \%$$

2.3 Restricted earth fault relay on (HV & LV) & transformer differential protection

The current setting of the relay should correspond to 10 % of the rated current of traction power transformer.

REF setting in Amp (I_{ref})

$$= \text{(Transformer rated current on LV \& HV side} \times 10/100)/ \text{CT ratio}$$

$$\text{\% setting} = (I_{ref} / \text{CT secondary}) * 100$$

2.4 IDMT relay on transformer LV side.

The function of this protection element is to act as a backup protection to the feeder protection relays. The reach of this relay should be as much as possible. However to obtain grading in current between HV & LV IDMT and utilization of transformer over load capacity the current setting of the relay should be selected corresponding to 180% of the rated current of the traction power transformer. The setting on the relay side may be calculated by formula given below:-

$$\text{Relay setting in amp}(I_{set}) = \frac{1.8 \times \text{Rated transformer secondary (LV side) current}\ (I_{sec})}{\text{CT ratio}} \quad A$$

$$\text{or Setting in \%} = \frac{(I_{set})}{5} \times 100\ \%$$

The TMS of this relay shall be selected such that the relay operating time must be achieved in between 250 - 300 ms for a fault occurring on LV bus.

2.4.1 TMS calculation

Calculate the fault current at LV bus considering the source impedance and single transformer impedance, for calculation refer the clause (2.1.1) above.

The Plug setting multiplier of LV IDMT shall be calculated as under.

$$\text{Plug setting multiplier} = \frac{\text{Fault current at LV bus}}{1.8 \times I_{sec}}$$

From IDMT curve (3 sec at 10 time of setting), choose the suitable TMS for getting the relay operating time of 250 to 300 ms at calculated plug setting multiplier or calculate TMS by formula given below:

$$t = \frac{TMS \times a}{[I/I_{set}]^b - 1}$$

Where a&b are constant a = 0.14, b = 0.02
t = Operating time in second
TMS = Time multiplier setting
I = Measured current by relay
I_{set} = Set current in amp

2.5 Definite time over current protection element setting

Three stage definite times over current relay is proposed to utilize the overload capacity of traction transformer and also protect the transformer against over loading beyond the permissible time limits. The setting of each stage for HV and LV side are separately given below:

2.5.1 Current and time setting of definite time over current relay on transformer LV side

अ अ. भा. से.

Stage setting	Current Setting	Operating Time
OL1	110% of Full Load	5 Minutes
OL2	140% of Full Load	2 Minutes
OL3	170% of Full Load	1 Minutes

The Rated LV current of transformer seen by relay (I_{LV}) in amp

= Transformer LV rated current/CT ratio

Stage 1 Overload setting in amp =

110% of rated transformer LV current **(OL1)** $= 1.1 \times I_{LV}$

or % Setting = OL1 x 100 / Rated CT Secondary

Stage 2 Overload setting in amp =

140% of rated transformer LV current **(OL2)** = $1.4 \times I_{LV}$

or % Setting = OL2 x 100 / Rated CT Secondary

Stage 3 Overload setting in amp =

170% of rated transformer LV current **(OL3)** = $1.7 \times I_{LV}$

or % Setting = OL3 x 100 / Rated CT Secondary

2.5.2 Current and time setting of definite time over current relay on transformer HV side

Stage	Current Setting	Operating Time
OL1	120% of Full Load	6 Minutes
OL2	150% of Full Load	3 Minutes
OL3	180% of Full Load	2 Minutes

The rated HV current of transformer seen by relay (I_{HV}) in amp

= Transformer HV rated current / CT ratio

Stage 1 Overload setting in amp =

120% of rated transformer HV current **(OL1)** = $1.2 \times I_{HV}$

or % Setting = OL1 x 100 / Rated CT Secondary

Stage 2 Overload setting in amp =

150% of rated transformer HV current **(OL2)** = $1.5 \times I_{HV}$

or % Setting = OL2 x 100 /Rated CT Secondary

Stage 3 Overload setting in amp =

180% of rated transformer HV current **(OL3)** = $1.8 \times I_{HV}$

or % Setting = OL3 x 100 / Rated CT Secondary

2.5.3 Repeated over load protection

As per the RDSO specification of the traction transformers, the traction transformer can be overloaded 150% for 15 minutes and 200% for 5 minutes; two consecutive overloading on transformer is only permitted after the interval of 3 hours, to take care the defined transformer over loading cycle the other definite time OCR i.e post over load protection element is also proposed as under.

i) **HV side**

Current setting

Current setting in Amp (I_{HVpost})

= Transformer HV rated current * 1.10 / CT ratio

or % Current setting = I_{HVpost} x 100 /5

Time setting

Time setting is to be kept at 70 sec

Post over load time reset setting

Reset time is to be set at 3 Hours

ii) **LV side**

Current setting

Current setting in Amp (I_{LVpost})

= Transformer LV rated current / CT ratio

or % Current setting = I_{LVpost} x 100 /5

Time setting

Time setting is to be kept at 60 sec

Post over load reset time setting

Reset time is to be set at 3 Hours

2.5.4 The above proposed settings of current and time are on the safer side and are therefore much less than the overloading permitted by the transformer manufacturers because the overloading on the traction transformers is generally for very short durations and for allowing errors in the CT/PT measurements. However based on the field experience Railways may suggest to RDSO any changes if considered necessary.

2.6 Biased differential protection

The biasing and operating current setting of the numerical type differential protection relay should be calculated as follows:

(a) The percentage biased setting should be so chosen that the relay remains inoperative on differential currents resulting from (1) tap changing of traction transformer, (2) mismatch in CT ratios and (3) difference in CT saturation levels under through fault conditions. Percentage mismatches resulting from factors (1) and (2) may be calculated from actual data and an allowance of 7.5 to 15% may be made for factor (3).

(b) The operating current setting may be taken as 40%. If mal operations of the relay are observed on through faults and magnetizing inrush (switching in of power transformer), a higher setting may be considered.

2.6.1 Calculation of ICT multiplication factor setting

This factor is used to neutralize the effect of transformer bushing CTs ratio corresponding to transformer primary and secondary rated current, as the output current (CT secondary) shall be same to avoid the mal function during normal operating condition. The ICT multiplication factor individually for HV & LV shall be calculated by formula given below:

$$\text{ICT multiplication factor} = \frac{5 \times \text{Bushing CT ratio}}{\text{Transformer rated current in Amp}}$$

2.6.2 Bias & operating current setting calculation

Calculate the transformer HV current at lowest tap position i.e. -15%

$$= \frac{\text{Rated transformer MVA} * 1000}{(\text{Rated primary voltage in kV} - 15\% \text{ of rated primary voltage})} \text{ Amp}$$

$$\text{Current read by relay} = \frac{\text{HV current at lowest tap in amp} * \text{ICT multiplication factor}}{\text{HV bushing CT ratio}}$$

$$\text{Spill over Current in amp} = \text{Current read by relay} - 5$$

$$\text{Percentage differential bias current} = \frac{\text{Spill over current in amp} * 100}{(\text{Current read by relay} + 5) / 2}$$

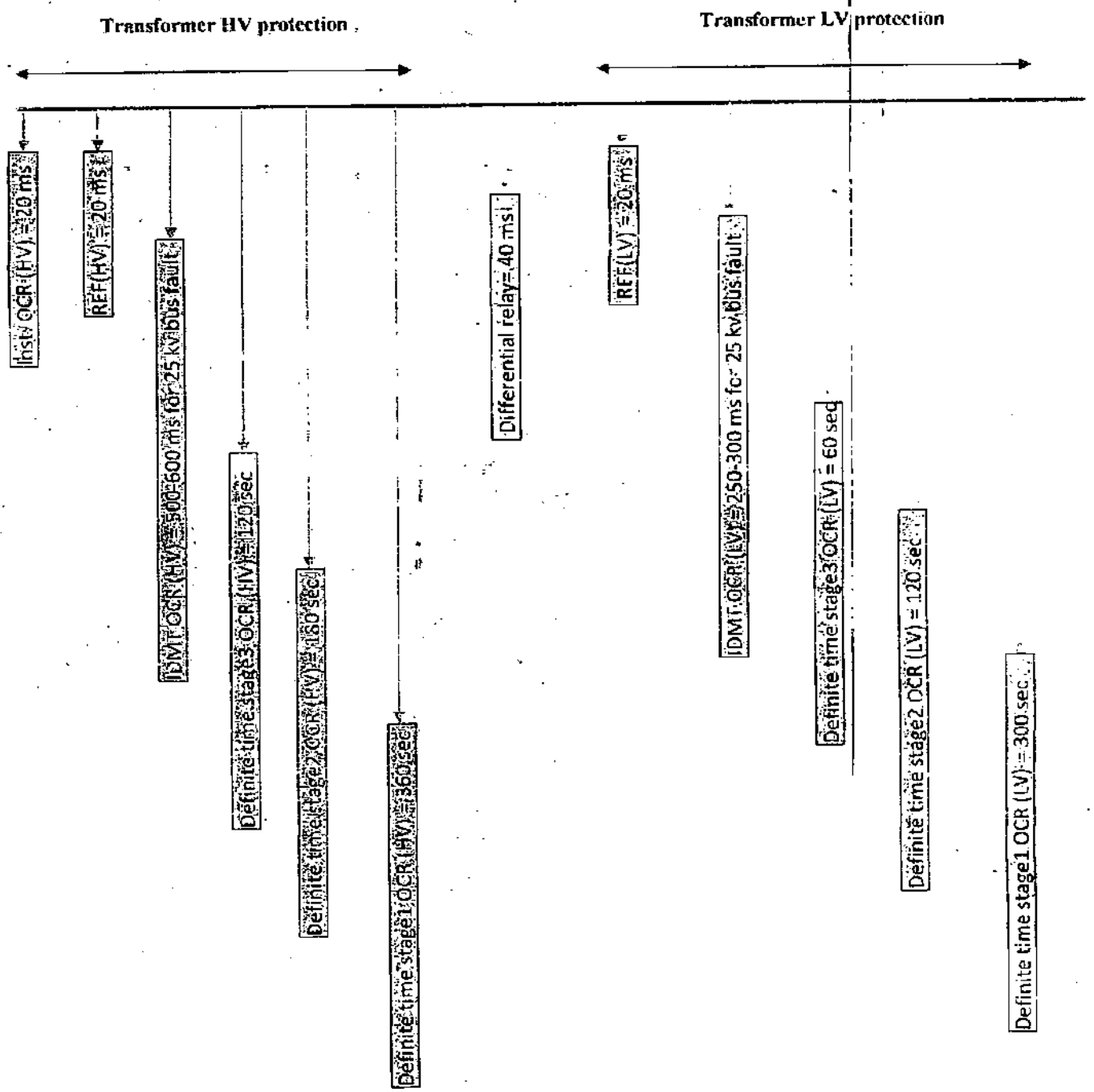
To allow the relay and CT errors, the % differential current further increased by a factor of 1.25.

The operating current shall be set at 40% of transformer rated current.

3.0 The summary of transformer protection IDMT & definite time OCR relays setting is as under

Relay element	HV side		LV side	
	Current setting in % of transformer rated current	Time setting	% Current setting of transformer rated current	Time setting
REF	10	Instantaneous i.e. 20ms	10	Instantaneous i.e. 20ms
IDMT	190	500-600ms as per curve for bus fault	180	250-300ms as per curve for bus fault
Stage-1 OCR	120	360 sec	110	300 sec
Stage-2 OCR	150	180 sec	140	120 sec
Stage-3 OCR	180	120 sec	170	60 sec
Post over load	110	5 sec	100	5 sec

4.0 Graphical depiction of time coordination of transformer protective relays



5.0 Sample calculation for transformer protection relay setting

The following assumptions are made for sample calculation:

a. Traction power transformer

i) Traction transformer rating = 21.6 MVA
ii) % impedance = 12.5
iii) No load primary voltage, V_{PO} = 132 kV
iv) No load secondary voltage, V_{SO} = 27 kV
v) Rated secondary current, I_{Sec}

$$I_{Sec} = \frac{21.6\ MVA}{27\ KV} = 800\ Amp$$

vi) Rated primary current, I_P

$$I_P = I_S \times V_{SO} / V_{PO} = 800 \times 27 / 132 = 163.6\ Amp$$

b. CT ratio

i) 27 kv side ..... 750 / 5
ii) 132 kv side ..... 200 / 5

(5. Bushing CT ratio

i) 27 kv side ..... 1600 / 5
ii) 132 kv side ..... 330 / 5

d. Fault MVA

10000 MVA at 132kv base voltage

5.1 Low (25kv) voltage side

5.1.1 Restricted earth fault relay

Current setting in amp, I_{ref}

$$= \frac{800 \times 10}{100 \times 750/5} = 0.53\ Amp$$

Setting in % = 0.53 / 5) * 100
= **10.6 % i.e. 10%**

5.1.2 IDMT over current relay

5.1.2.1 Current setting

$$= \frac{800 \times 180}{100 \times 750/5} = 9.6 \text{ Amp}$$

Setting in % $= (9.6 / 5) * 100$
$= 192\ \%$

5.1.2.2 TMS setting

Source impedance, Z_{source} at 132kv base

$$= \frac{(132)^2}{10000} = 1.74\ \Omega$$

Loop impedance = 2 x 1.74 = 3.48 Ω
Source impedance as seen from the 25 kv bus

$$= 3.48 \times \frac{(27)^2}{(132)^2} = 0.146\ \Omega$$

Impedance of traction transformer at 27 kv base, $Z_{transformer}$

$$= \frac{(27)^2 \times 12.5}{21.6 \times 100} = 4.21\ \Omega$$

Total impedance, Z = 0.146 + 4.21 = 4.36 Ω

Fault current for 27 kV bus fault, I_f

$$= \frac{27000}{4.36} = 6192 \text{ amp}$$

Fault current reflected to secondary side of CT

$$= 6192 \times 5/750 = 41.28 \text{ amp}$$

To achieved the operating time 300 ms for bus fault, the TMS setting should be

$$\frac{300}{1000} = \frac{TMS \times 0.14}{[41.28/9.6]^{0.02} - 1}$$

$$\frac{300}{1000} = \frac{TMS \times 0.14}{1.03 - 1}$$

TMS = 0.0642 i.e. the available setting on the relay 0.07

5.1.3 Current and time setting of definite time over current relay

5.1.3.1 Stage 1 OCR

Current setting in amp, I_{OCR1}

$$= \frac{800 \times 110}{100 \times 750/5} = 5.87 \text{ Amp}$$

Setting in % = (5.87 / 5) * 100
= **117 %**

5.1.3.2 Stage 2 OCR

Current setting in amp, I_{OCR2}

$$= \frac{800 \times 140}{100 \times 750/5} = 7.47 \text{ Amp}$$

Setting in % = (7.47 / 5) * 100
= **149 %**

5.1.3.3 Stage 3 OCR

Current setting in amp, I_{OCR3}

$$= \frac{800 \times 170}{100 \times 750/5} = 9.07 \text{ Amp}$$

Setting in % = (9.07 / 5) * 100
= **181 %**

5.1.3.4 Post over load

Current setting in amp,

$$= \frac{800 \times 100}{100 \times 750/5} = 5.33 \text{ Amp}$$

Setting in % = (5.33 / 5) * 100
= **107 %**

5.2 High voltage side

5.2.1.1 Restricted earth fault relay

Current setting in amp

$$= \frac{163.6 \times 10}{100 \times 200/5} = 0.41 \text{ Amp}$$

setting in % = (0.41 / 5) * 100
= **8 %**

5.2.2 IDMT over current relay

5.2.2.1 Current setting

$$= \frac{163.6 \times 190}{100 \times 200/5} = 7.75 \text{ Amp}$$

Setting in % = (7.75 / 5) * 100
= **155 %**

5.2.2.2 TMS setting

Fault current for 27 kv bus fault, I_f

$$= \frac{27000}{4.36} = 6192 \text{ amp}$$

Fault current seen at HV side

$$= 6192 \times \frac{27}{132} = 1266 \text{ amp}$$

Fault current reflected to secondary side of CT

$$= 1266 \times 5/200 = 31.66 \text{ amp}$$

To achieved the operating time 600 ms for bus fault, the TMS setting should be

$$\frac{600}{1000} = \frac{TMS \times 0.14}{[31.66/7.75]^{0.02} - 1}$$

$$\frac{600}{1000} = \frac{TMS \times 0.14}{1.029 - 1}$$

TMS = 0.12

5.2.3 Current and time setting of definite time over current relay

5.2.3.1 Stage 1 OCR

Current setting in amp, I_{OCR1}

$$= \frac{163.6 \times 120}{100 \times 200/5} = 4.9 \text{ Amp}$$

Setting in % = (4.9 / 5) * 100
= **98 %**

5.2.3.2 Stage 2 OCR

Current setting in amp, I_{OCR2}

$$= \frac{163.6 \times 150}{100 \times 200/5} = 6.13 \text{ Amp}$$

Setting in % = (6.13 / 5) * 100
= **123 %**

5.2.3.3 Stage 3 OCR

Current setting in amp, I_{OCR3}

$$= \frac{163.6 \times 180}{100 \times 200/5} = 7.36 \text{ Amp}$$

Setting in % = (7.36 / 5) * 100
= **147 %**

5.2.3.4 Post over load

Current setting in amp,

$$= \frac{163.6 \times 110}{100 \times 200/5} = 4.5 \text{ Amp}$$

Setting in % = (4.5 / 5) * 100
= **90 %**

5.3 Biased differential protection

5.3.1 Calculation of ICT multiplication factor

LV Bushing CT multiplication factor

$$= \frac{5 \times 1600/5}{800}$$

$$= 2$$

HV Bushing CT multiplication factor

$$= \frac{5 \times 330/5}{163.6}$$

$$= 2.02$$

5.3.2 Bias setting calculation

Calculate the transformer HV current at lowest tap position i.e. -15%

$$= \frac{21.6 * 1000}{112.2} = 192.5 \text{ Amp}$$

$$\text{Current read by relay} = \frac{192.5 * 2.02}{330/5} = 5.89$$

Spill Over Current in amp = 5.89 – 5

$$\text{Percentage differential current} = \frac{0.89 * 100}{(5.89 + 5)/2} = 16.34\%$$

To allow the relay and CT errors, the % differential current further increased by a factor of 1.25.

% biased setting = 1.25 x 16.34
= 20.43% i.e. 20%

6.0 Setting guide line for 25 kV shunt capacitor bank protection relay

6.1 IDMT Over current relay

6.1.1 Current setting

Calculate the capacitive reactance at rated voltage

$X_C = kV^2 * 1000 / KVAr \quad \Omega$

Calculate the effective reactance of complete capacitor & reactor unit

$X_{Cl} = X_C - 0.13\ X_C \quad \Omega$

Calculate the KVA_R capacity of bank at 25 kV

KVAr rating at 25kv system voltage

$KVA_r = (25)^2 * 1000 / X_{Cl}$

Calculate the rated current of capacitor bank at system voltage 25 kV

$$\text{Capacitor bank current in amp, } I_{cap} = \frac{\text{KVAr}}{\text{Rated system voltage in kV}}$$

To accommodate the CT and relay errors, the 10% higher value of above calculated current is recommended for setting of relay.

$$\text{Current setting of IDMT relay in amp } (I_{relay}) = \frac{1.10 \times I_{cap}}{\text{CT ratio}} \text{ Amp}$$

$$\text{Setting in \%} = \frac{\text{Current seen by relay } (I_{relay})}{\text{CT secondary}} \times 100$$

6.1.2 TMS setting

Calculate the fault current after reactor and select the suitable TMS to achieve the operating time of 500 ms.

$$\text{Fault current} = \frac{27000}{\text{Source Z + transformer Z + Reactance of reactor}} \text{ Amp}$$

$$\text{Plug setting multiplier} = \frac{\text{Reflected fault current to relay side}}{\text{Set current of IDMT relay } (I_{relay})}$$

From IDMT curve (3 sec at 10 time of setting), choose the suitable TMS for getting the relay operating time of 250 ms at above calculated plug setting multiplier or calculate TMS by formula given below:

$$t = \frac{TMS \times a}{[I/I_{set}]^{b} - 1}$$

Where a & b are constant a = 0.14, b = 0.02
t = Operating time in second
TMS = Time multiplier setting
I = Measured current by relay
I_{set} = Set current

6.2 Over voltage relay

6.2.1 Over voltage setting

The over voltage relay shall be set at 10% higher than the rated nominal no load voltage of traction transformer.

$$\text{Setting in volt } (V_{o/v}) = \frac{1.1 \times \text{Rated nominal no load voltage of traction transformer}}{\text{PT ratio}} \text{ V}$$

$$\text{Setting in \%} = \frac{\text{Setting in volt } (V_{o/v})}{\text{Rated PT secondary voltage}} \times 100$$

6.2.2 Time multiplier setting (TMS)

Calculate the plug setting multiplier by formula given below:

$$\text{Plug setting multiplier} = \frac{\text{Setting in volt } (V_{o/v})}{\text{Rated PT secondary voltage}}$$

Form IDMT curve 7sec at 1.5 times, select the suitable TMS for above calculated plug setting multiplier to obtain the operating time of approximately 1 second.

6.3 Under voltage relay

6.3.1Under voltage setting

The under voltage relay shall be provided to cut off the shunt capacitor bank from power supply when 25 kV supply fails or low voltage occurrs. The bank should not be put back in to system again before it is totally discharged. To fulfill this requirement a timer is also provided in the closing circuit, it is generally inbuilt with numerical relay, timer setting shall be set at 10 minutes. As the lowest permissible voltage in IR traction is 17.5kV, hence the under voltage relay shall be recommended to be set at 17.5kV.

$$\text{setting in volt } (V_{U/v}) = \frac{17500\ V}{\text{PT ratio}}\ V$$

$$\text{Setting in \%} = \frac{\text{Setting in volt } (V_{u/v})}{\text{Rated PT secondary voltage}} \times 100$$

6.3.2 Time multiplier setting (TMS) setting

Calculate the plug setting multiplier by formula given below:

$$\text{Plug setting multiplier} = \frac{\text{Setting in volt}}{\text{Rated PT secondary voltage}}$$

From IDMT curve 5sec at 0 Voltage; select the suitable TMS for above calculated plug setting multiplier to obtain the operating time of approximately 1 second.

6.4 Current unbalance relay

6.4.1 Current setting

This protection element is provided for internal faults in the capacitor units. At present as per RDSC specification No. ETI/PSI/67(11/96) A & C slip No. 7, each capacitor unit of 220 kVAR is rated for 8 kV, and its construction comprises of number of elements in parallel & individually protected by internal fuses. In case of failure of the element and therefore blowing of the internal fuse the voltage across the remaining healthy elements of affected and other units increases. The neutral unbalance current protection should be set so that it trips if the ratio of *the voltage across healthy elements in parallel to the failed elements in one unit* and *rated voltage of healthy element* is above 1.7. The manufacturer of the HT capacitor bank should provide the calculation for the above

based on the internal design of the capacitor unit. Generally the unbalance current generated after failure of 7-10 elements may cause the voltage appearing on the remaining healthy elements to 150-175% of the rated voltage which may damage the healthy capacitor element. A sample results of unbalance current and voltage rise produced due to failure of number of internal elements is placed at Annexure-I for reference.

$$\text{Set current in amp, } I_{UB} = \frac{\text{Recommended unbalance current}}{\text{NCT ratio}}$$

$$\text{Setting in \%} \quad \frac{I_{UB}}{\text{Rated CT secondary}} \times 100$$

6.4.2 Time setting

The time setting shall be kept at 200–400 ms.

7.0 Sample calculation for capacitor bank protection relay setting

7.1 Assumption

The following assumptions are made for sample calculation:

a. **Shunt capacitor bank rating** = 5500 KVAr at 40 kV

b. **NCT ratio** = 2/1

c. **PT ratio** = 27500/110

d. **Fault MVA** = 10000 MVA at 132kV base voltage.

e. **CT ratio** = 100/5

7.2 IDMT Over current relay

7.2.1 Current setting

Calculate the capacitive reactance at rated voltage

$X_C = 40^2 * 1000 / 5500$

$= 290.91 \ \Omega$

Calculate the effective reactance of complete capacitor & reactor unit

$X_{C1} = 290.91 - 0.13 * 290.91$

$= 253.09 \ \Omega$

Calculate the KVAr capacity of bank at 25 kV

$KVA_r = (25)^2 * 1000 / 253.09$

$= 2469.47$ KVAr

Rated current of capacitor bank at system voltage 25 kV

$$\text{Capacitor bank current in amp, } I_{cap} = \frac{2469.47}{25} = 98.77 \text{ amp}$$

To accommodate the CT and relay errors, the 10% higher value of above calculated current is recommended for setting of relay.

$$\text{Current setting of IDMT relay in amp } (I_{relay}) = \frac{1.10 \times 98.77}{100/5} = 5.43 \text{ Amp}$$

$$\text{Setting in \%} = \frac{5.43}{5} \times 100$$

= 108.65 i.e. 109 %

7.2.2 TMS setting

$$\text{Fault current} = \frac{27000}{4.36 + 37.82} = 640 \text{ Amp}$$

(Source and traction transformer impedance 4.36 ohm as calculated above for traction transformer setting)

$$\text{Plug setting multiplier} = \frac{640 * 5 / 100}{5.43} = 5.89$$

To achieve the operating time 500 ms for fault after shunt reactor, the TMS =

$$\frac{250}{1000} = \frac{TMS \times 0.14}{[33/5.43]^{0.02} - 1}$$

$$\frac{250}{1000} = \frac{TMS \times 0.14}{1.0367 - 1}$$

TMS = 0.0656 i.e. 0.07

7.3 Over voltage relay

7.3.1 Over voltage setting

$$\text{Setting in volt } (V_{os}) = \frac{1.1 \times 27500}{27500/110} = 121 \text{ Volt}$$

$$\text{Setting in \%} = \frac{121}{110} \times 100 = 110\%$$

7.3.2 Time setting

$$\text{Plug setting multiplier} = \frac{121}{110} = 1.1$$

Form IDMT curve 7sec at 1.5 times, at 1.2 times of setting the operating time is 17 sec at TMS 1. To achieve the operating time 1 sec.

$$\text{TMS setting} = \frac{1}{17} = 0.058 \text{ i.e } 0.06$$

7.4 under voltage relay

7.4.1 under voltage setting

$$\text{setting in volt } (V_{U/v}) = \frac{17500}{27500/110} = 70 \text{ volt}$$

$$\text{Setting in \%} = \frac{70}{110} \times 100 = 63.64\ \% \text{ i.e. } 64\%$$

7.4.2 TMS setting

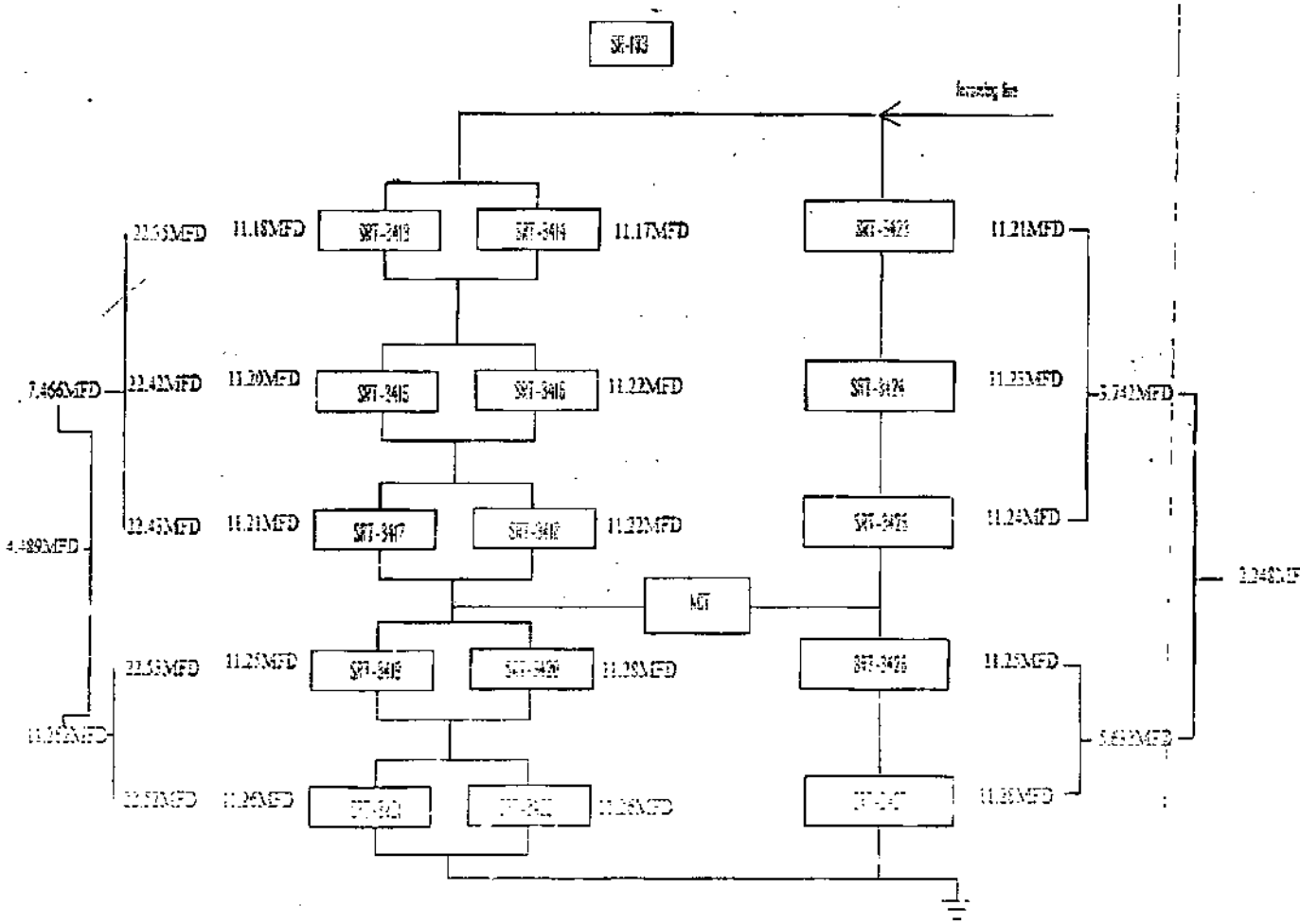
Calculate the plug setting multiplier by formula given below:

$$\text{Plug setting multiplier} = \frac{70}{110} = 0.64$$

Form IDMT curve 5sec at 0 Voltage; at 0.64 times of setting the operating time is nearly 9 sec at TMS 1. To achieve the operating time 1 sec.

$$\text{TMS setting} = \frac{1}{9} = 0.11$$

7.5 Current unbalance relay



TOTAL BANK CAPACITANCE = 6.717 MFD

BANK RATING = 5300 KVAR

7.5.1 Current setting

A sample result of unbalance current & voltage rises on healthy element and units of a capacitor bank vendor are given below:

X	In(A)	Vu/Vuo	Vel/Velo	Iu(A)
0	0.000	1.00	1.00	27.50
1	0.065	1.00	1.06	27.14
2	0.137	1.01	1.12	26.73
3	0.219	1.01	1.19	26.27
4	0.312	1.02	1.28	25.74
5	0.419	1.03	1.37	25.14
6	0.543	1.04	1.48	24.44
7	0.689	1.05	1.61	23.62
8 trip	0.863	1.06	1.76	22.64
9	1.073	1.07	1.95	21.46
10	1.333	1.09	2.18	19.99
11	1.662	1.11	2.47	18.14
12	2.094	1.14	2.86	15.70
13	2.638	1.18	3.38	12.38
14	3.536	1.24	4.13	7.58

X – Number of failed elements.
In(A) – Neutral current in Amps.
Vel – Voltage across healthy element in parallel to failed element.
Velo – Rated voltage of healthy element.
Vu – Voltage across healthy unit in series with failing unit.
Veo – Rated voltage of healthy unit.
Iu(A) – Unit current in amps.

As per the above sample result, it is seen that with the failure of 8 elements resulting voltage appeared across healthy elements parallel to failed elements is 1.76 times of rated voltage, the unbalance current above number of elements failure is 0.863 amps. This is the sample results only, it may vary manufacturer to manufacturer, therefore approach to capacitor bank manufacturer for actual permitted unbalance current.

$$\text{Set current in amp, } I_{UB} = \frac{0.863}{2/1} = 0.4315 \text{ amp}$$

$$\text{Setting in \%} \quad \frac{0.4315}{1} \times 100 = 43.15\% \text{ i.e. } 43\%$$

7.5.2 Time setting

The time setting shall be kept at 200-400 ms.

114-3

टेलीफोन / पीबीएक्स 2451200(PBX)
2450115 (DID)
Extn.: 42806
फैक्स / Fax: 91-0522-2465763
e-mail: dtiprotection@gmail.com

भारत सरकार – रेल मंत्रालय
अनुसंधान अभिकल्प एवं मानक संगठन
लखनऊ – 226 011
Govt of India- Ministry of Railways
Research Designs and Standard Organisation
Lucknow-226011

MASTER COPY

BY REGISTERED POST

TI/RCC/SCADA/SPC/10

Dated: 23.2.2010

Chief Electrical Engineer

1.	Central Railway, 2nd floor, Parcel Office Building CST, Mumbai-400001	022-22620867
2.	South Eastern Railway, Garden Reach, Calcutta-700 043	033-24503643
3.	Eastern Railway, Fairlie Place, Calcutta-700 001.	033-22300446
4.	Northern Railway, Baroda House, New Delhi-110001	011-23387198
5.	Southern Railway, Park Town, Chinnai- 400 003.	044-25353690
6.	South Central Railway, Rail Nilayam, Secunderabad	040-27825243
7.	Western Railway, Churchgate, Bombay - 400 020.	022-22073829
8.	South West Railway, DRM's Office, Hubli (Karnataka)	080-2282787
9.	West Central Railway , Jabalpur	0761-2628133
10.	East Coast Railway, Bhubaneshwar	0674-2302524
11.	East Central Railway, Hajipur	06224-274459
12.	North Central Railway, Block-A, Subedarganj Rly Stn, Allahabad.211 033	0532-2560934
13.	South East Central Railway, Bilaspur-495004	07752-414627

Sub-Instructions for operating RTUs with power supply of 110 Vdc (in place of 240 Vac) for existing traction SCADA system on IR

Ref: RDSO's instruction No. TI/IN/0023(02/2010)

Please, find enclosed herewith the copy of above instructions for information and implementation.

23/2/2010
(Sumit Bhatnagar)
for Director General/TI

Encl. As above

SE/DOC

MASTER COPY

TRACTION INSTALLATION DIRECTORATE

सत्यमेव जयते

GOVERNMENT OF INDIA,
MINISTRY OF RAILWAYS

Instruction No. TI/IN/0023 (02/2010)

Instructions for operating RTUs with power supply of 110 V DC (in place of 240 V ac) for existing traction SCADA system on IR

Feb- 2010

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization
(Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 **Scope:** This instruction stipulates the action to be taken by Zonal Railways for operation of Remote Terminal Units (RTU) at TSS, SP/SSP of 25 KV SCADA systems as per RDSO's specification TI/SPC/RCC/SCADA/0990 (5/07) with Amendment No.1. on 110 V dc supply only. The dc supply system has got many obvious advantage over the ac supply system for control in terms of reliability & lesser damage to electronic components.

2.0 **Background:** Remote Terminal Units (RTU) at TSS, SP/SSP of 25 KV SCADA system as per RDSO's specification TI/SPC/RCC/SCADA/0990 (5/07) with Amendment No.1.system are having provisions for operation on both 240 V ac and 110 V dc power supplies. RTU normally operates on 240 V ac and in case of failure of ac supply, changeover to 110 V dc supply takes place.

2.1 Operation of RTU on 240 V ac supply some time affects the performance of RTUs due to:

- The ac supply to RTU is taken from the 25 kV ac traction supply which is having high harmonic contents.
- Switching surges, fault currents and transients in ac supply cause failures in power supply units of RTU.
- Poor power quality of ac supply for RTU affects the life of power supply unit and other components of the RTUs.
- Indian Railways have been reporting number of failures in power supply cards/ modules and other electronic equipment.

3.0 Operation of RTU at only 110V dc power supply:

To overcome the above problems and to enhance the performance of SCADA system; RDSO advised Northern Railway to conduct trials at Lucknow and Ambala division using only 110 V dc supply of RTU for the period of more than three months and to monitor the performance. Satisfactory performance has been reported so far from there. The SCADA vendors were also consulted and their responses have been affirmative.

3.1 SCADA system developed & implemented for Mumbai area as per RDSO specification no. TI/SPC/RCC/SCADA/1080(9/08) with amendment no.1 (7/09) is having provision of 110Vdc power supply. The system is working without any problem for last few months.

3.2 Based on above it is now recommended to all the Zonal Railways to shift the existing SCADA RTUs on 110Vdc system in a gradual manner. This should be

started from RTUs where power supply/card failures are more and complete the entire RTUs in a time bound schedule.

4.0 Modifications at RTUs:

4.1 Disconnect the 240V ac power supply to RTU and confirm that the PSU automatically changes over to 110V dc. In case of any difficulty, the OEM/ AMC personnel must verify the availability of 110Vdc output before permanent disconnection of 240 Vac input.

4.2 Battery ratings of traction installation are more than sufficient and battery charger keeps them at a floating charge, still it is recommended to keep watch on battery condition.

4.3 Monitor the performance of operation of SCADA system and keep the records of card failures prior to & after implementation of the changes.

4.4 Performance reports / feedback may please be sent to RDSO for further analysis and improvements in RTU designs.

*****

दूरभाष 2465763(दू)
फैक्स 91&0522&2465763
Telephone : 2465763 (O)
Fax DOT : 91-0522-2465763
E-mail : dti3@rdso.railnet.gov.in

सत्यमेव जयते

भारत सरकार रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
मानक नगर, लखनऊ – 226 011
Government of India, Ministry of Railways
Research Designs & Standards Organisation
Manak Nagar, Lucknow – 226 011

No. TI/PSI/PROTCT/CONVEN/08 Date: 01.06.2010

Chief Electrical Engineer,

1- Central Railway, Parcel Buldg. CST, Mumbai.
2- Eastern Railway, Fairlie Place, kolkata-700001
3- East Central Railway, Hajipur-844101
4- East Coast Railway, B-2, BDA Rental Colony, Chandrashekharpur, Bhubaneshwar
5- Northern Railway, Baroda House, New Delhi-110001
6- North Central Railway, Allahabad
7- North Eastern Railway, Gorakhpur
8- South Central Railway, Rail Nilayam, Secunderabad.
9- South Eastern railway, Garden Reach, Kolkata-700 043
10- South East Central Railway, Bilaspur
11- South Western Railway, Hubli
12- Western Railway, Churchgate, Mumbai-400 020
13- West Central Railway, DRM Office, Jabalpur
14- North East Frontier Railway, Maligaon, Guwahati
15- Southern Railway, Park Town, Chennai - 400001
16- Central Organisation for Railway Electrification (CORE), Nawab Yusuf Raod, Allahabad.

Sub: Instruction no. TI/IN/0024 for Monitoring and Analysis of Feeder Circuit Breaker Tripping for 25kV ac Traction system.

Please find enclosed herewith a copy of Instruction no. TI/IN/0024 for Monitoring and Analysis of Feeder Circuit Breaker Tripping for 25kV ac Traction system for your kind information and necessary action please.

(Sumit Bhatnagar)
for Director General/TI

Encl: as above

Copy to:

EDEE (M),
Room no. 102A, Rail Bhawan,
Railway Board, Ministry of Railway,
New Delhi-01

Traction Installation Directorate

सत्यमेव जयते

Government of India
Ministry of Railways

Instruction No. TI/IN/0024

For
Monitoring & analysis of Feeder Circuit Breaker Tripping for 25kV ac Traction systems

June, 2010

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization (Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 Scope

This instruction stipulates the action to be taken by Zonal Railways for monitoring & analysis of feeder CBs tripping and also suggests relevant check points for system improvements.

2.0 Background

In conventional 25 kV ac traction system, two feeder circuit breakers feed the traction power to the OHE on both sides of the TSS. As per the tripping data analyzed over the years, it is learnt that maximum numbers of faults occur on OHE only. With continuous increase in the number of trains at any time in the feeding zone due to increase in traffic density and automatic signaling, even a small interruption of traction supply results in to number of trains losing punctuality. The problem of signal getting blank is also observed if IPS (Integrated Power Supply) is not provided by signaling department. It is therefore essential to analyze the feeder CB tripping as a preventive and corrective action to ensure better reliability of OHE (traction power).

3.0 Analysis of faults on OHE

3.1 Every fault results in to flow of heavy current causes stress in the overhead equipment (OHE). The damage is more in case of arcing faults wherein cutting of some strands of catenary wire, pitting of contact wire and flashing / breakage of insulators shed etc. may also result.

3.2 Repeated transient faults occurring at same location may finally result in breakage of catenaries / contact wires or insulators resulting in permanent breakdown of OHE.

3.3 In case of permanent faults due to failure of any equipment e.g. insulators, substation/switching post equipment, lightening arresters and OHE breakdowns etc. feeder CB trips. The single shot auto re-closer automatically closes the CB after nearly 500 ms and it trips again and relay locks out. It is easier to locate such faults as in most of the cases damage is visible.

3.4 Traction Power controllers reclose the CB with different combinations of system configurations so as to identify & localize the faulty section.

3.5 It is observed from the details of feeder CB trippings as provided by Railways, that large number of tripping are of transient in nature i.e. CB holds after re-closing. Likely reasons of transient tripping attributed by Railways are tabulated as under. The

remarks/remedial measures to be adopted by Railways have been suggested against each to minimize the tripping.

Likely reasons of transient tripping	Remarks/Remedial measures
Suspected bird/monkey/snake faults	RDSO has issued drawing of anti- climbing arrangement of OHE mast vide RDSO letter no. TI/OHE/INS/GEN/08 dated 03.11.2008 which should be adopted to reduce such menace.
Over loading on TSS (feed extension or low incoming voltage)	• Record loading data at TSS. Refer to RDSO instruction TI/IN/0019 (09/09) • Analyze voltage profile, whether voltage is falling below the minimum permissible limit. • Long term planning of feeding zone rationalization. • Consider options of ONAF, higher capacity & parallel operation of transformers.
Tree touching	• There are instructions for tree trimming before onset of monsoon
Flash overs on insulators / tracking & bad weather/extreme pollution conditions	• Minimum creepage distance of insulators has been increased from 840 mm to 1050 mm. • Ensure that insulators of correct type &creepage distance are provided based on the pollution level (calculation of ESDD) as per the policy directives issued from Rly. Bd./RDSO from time to time.
Faults on the roof or on HT side equipment of Loco	• Feeder CB tripping time with modern numerical relays is 100-110 ms (*50-40 ms for relay+ 60 ms for CB+ 10ms for MTR*). • The loco CB time (for both DJ and VCB types) is nearly same or more than this therefore even in case of fault in Loco HT equipment like transformer, bushing etc. TSS CB tripping may occur. • Tripping due to loco should be dealt as per Para 20521 of ACTM Vol-II Part-I and close interaction of TPC with TLC should be ensured.
Fault created by foreign materials like small wires etc.	Provision of standard jalis and boards on ROB & FOB apart from maintenance precautions taken at the time of birds nesting periods can reduce the problem.

3.6 There are some cases reported by Railways wherein a persistent arcing fault on OHE results in to severe damage to system e.g. melting of insulators or ferrous fittings etc. Such incidences occur mainly due to high resistive faults, which should be analyzed in detail as elaborated in Para 5.0 below.

3.7 In addition to above from the CB tripping data received from Railways, it is observed that large number of feeder CB tripping results if it is feeding to a nearby loco shed, long siding or a large yard.

3.7.1 In order to reduce tripping of feeder CB's, under these situation some Railways have provided separate feeder breakers for loco sheds/yards at the nearest switching post however as no time delay (grading) is permitted in distance protection both the feeder CB's connected in series trip simultaneously. However in such cases auto re-closer function in the CB feeding the loco shed/yards should be kept off so that it remains open while main feeder CB should reclose for identifying faults in loco sheds/yards. After confirming the cause of tripping by TPC from loco shed/yard, the CB may be closed.

3.7.2 Other possible options for this problem may be provision of a separate CB in the TSS and feeder line for loco sheds/yards based on techno economic considerations.

4.0 Use of numerical protection relays for fault analysis

Before 2009 the protective relays developed by RDSO for 25kV feeder protection were electromagnetic / static / microprocessor type, in these types of relays event recording, display of current, voltage, resistance & reactance parameters of fault was either not available or not standardized, however with the development of numerical type relays as per latest specification following features have been standardized:

4.1 Capability to store maximum 10 numbers of latest fault events with date and time stamping. Each event comprise of 45 pre and 5 post-fault waveforms.

4.2 Facility to retrieve the following data from relay through serial communication port for analysis:

- Peak, average and RMS value of fault current and voltage
- Fault clearing time
- R-X and phase angle
- Percentage harmonics analysis of fault current

4.3 Display of Voltage, current and R-X value of 5 latest faults with date and time on relay LCD display.

Railways should make use of above features to the maximum extant for fault analysis purpose.

5.0 High Impedance or High resistive faults

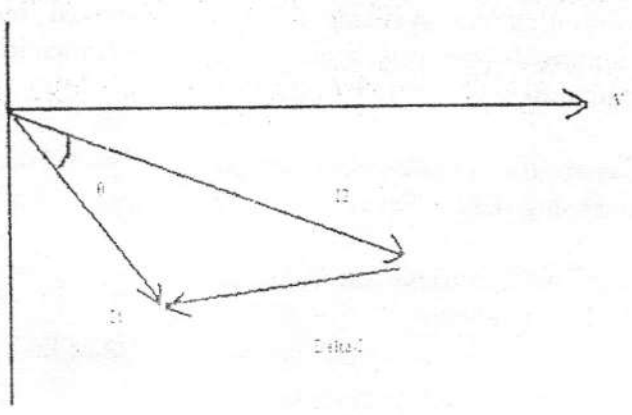
There are two characteristics of such faults on OHE i.e. low fault currents and arcing. Arcing is the result of air gaps due to the poor contact made with the ground or a grounded object

The high impedance of the fault does not result in a substantial increase in current and due to this fault cannot be reliably detected & cleared using conventional protection relays like OCR & DPR.

5.1 To clear the high resistive faults scalar Delta-I relay was developed in 1998 and subsequently in order to increase its sensitivity, in place of scalar characteristics Vectorial type relays were developed in 2003 as per RDSO specification no. TI/SPC/PSI/PROTCT/1982, which should be provided by Railways.

5.2 Δ-I relay monitors the vectorial difference between base current and fault current in pre defined time interval (generally 2-3 cycle), if vectorial difference is more than set current and other conditions are satisfied then relay executes trip command. By using Vectorial Δ-I relay the failure of OHE due to high resistive fault may be minimized.

Vectorial delta-I relay characteristic



I_1 and I_2 are two consecutive current values seen by Vectorial Δ I relay

5.3 RDSO has circulated setting guidelines for ΔI relay vide letter No.TI/PSI/PROTCT/STATIC/07 dated 23.04.2007 which should be followed. Main features of this protection relay are:

(a) It is a backup protection of DPR or OCR. Its operating time is above 200 ms. In view of this all cases wherein it has operated must be carefully examined for any possibility of fault in the system or mal-operation of the relay or tripping due to in correct setting. There are cases reported by Railways wherein this relay operates along with the DPR which means either the ΔI relay is not having correct setting or DPR operation might have resulted due to culmination of high resistive fault in to a solid earth fault after damage to the system or equipment.

(b) The suggested settings of Delta-I current are based on practical experiences however Railways must critically review and suggest any changes if required for increasing effectiveness of this protection.

(c) X-blinder value- This is the line reactance value monitored by relay and it does not trip if it is not less than the set value.

(d) There is a logic to differentiate between sudden rise in current due to load or fault i.e. generally load current has got high 3rd harmonics therefore for 3rd Harmonics contents < 15% relay trips for ΔI > 2A, however for 3rd Harmonics > 15% it automatically increases set value to ΔI > 4A. Thus in this way it analyses 2nd and 3rd harmonics level to distinguish between load & fault currents.

6.0 Important points for monitoring & analyzing faults on OHE

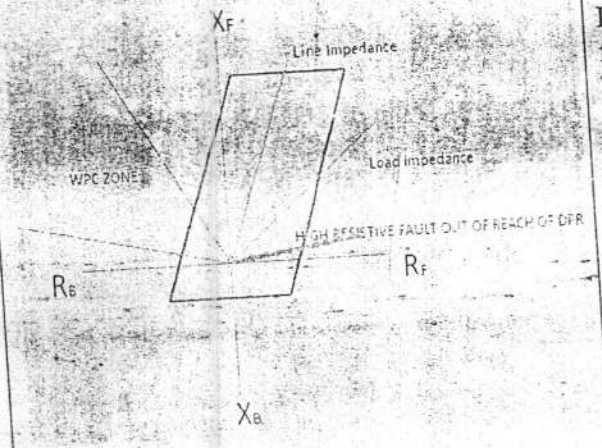
6.1 Transient faults

- Maintain the individual CB tripping detail history.
- Protection relay / element acted (DPR-{*OCR, WPC, PTFF*}, Panto flashover, Δ-I, BDMT etc.) should be clearly indicated for each tripping.
- If numerical type relays are provided for feeder protection the information as mentioned at Para 4.0 above must be retrieved. For each feeder, it should be stored chronologically in soft copies with date and location tags for analysis.
- Estimate the fault distance with the help of recorded reactance value i.e. X considering 0.38 Ω/km reactance for single line and 0.22Ω/km for double line sections.

- Compare the voltage, current, resistance & reactance of each tripping, if during transient tripping similar values of reactance are observed repeatedly for same CB, inspect the OHE surrounding the calculated fault distance (± 500 meters) and look for the flash mark on catenary and contact wire, cutting of catenary strands, flash mark / breakage on insulator shed, foreign material hanging on the catenary/ contact wire etc.

6.2 Additional important points for investigation of permanent faults resulting in to large scale damage to OHE or traction supply system

If relay has taken excessive time in clearing the fault or consequential damage to equipment/system is found to be substantial then following additional areas should also be studied to arrive at the root cause of problem.

Sr No.	Important points	Remarks
1	One of the most important reason of non/delayed operation of distance protection relays is that effective impedance (with predominantly resistive arc component) as seen by the relay falls outside the parallelogram characteristics as depicted in the diagram below. 	Condition/availability of earthing bonds at fault location should be checked. If possible earthing resistance can also be measured at fault location. The condition of bond joints with Rail should be carefully examined for signs of arcing, loose connections etc. If repeated cases of high impedance faults are observed from a single TSS then substation buried Rails and their connections to the Rails must also be checked.

2	Check how many times CB has been closed by TPC for fault localization. Repeated closing of CB under persisting fault condition may also result in to damage to system.	A fault localization control card should be readily available with TPC's in line with Para 20522 of ACTM Vol-II Part-I. While preparing the control card due consideration should be given to quick isolation of tripping prone loco sheds, yard lines.
3	Verification of the relay settings & calculations done earlier	Examine if in the recent past changes have been made in the feeding arrangements or layouts.
4	Distance of fault location from feeding post	Fault currents are more near to the feeding point.
5	Type of Delta I relay provided	Check whether scalar or vectorial Δ-I relay is provided. Vectorial Delta I relays as per RDSO specification no. TI/SPC/PSI/PROTCT/1982 are the latest and having better resolution.
6	Check the CB tripping time.	It should not be more than 60 ms.
	Testing of relays	Check functionality of relays at set values. Also check operating time of relay by secondary injection test kit. Features like Local Breaker Back up protection must also be checked. Find out errors, if any, in the relay operating values especially near boundary conditions. Examine the data recorded in relay (see Para 4.0 above).
7	Parallel operation of 2x21.6 MVA transformers	Parallel operation of 2x21.6 MVA transformers leads to nearly double the fault current for close in faults. New protection scheme suggested by RDSO vide TI/IN/0017 dated July 2008 should be adopted.

8	Feed condition (normal / extended) at the time of incidence.	If problem occurs in the extended feed zone verify the relay setting calculations carefully.
9	Power block status and its location.	There have been cases reported from some heavily loaded substations wherein power block of one subsector (i.e say DN line) between TSS & first SSP has resulted in to feeding of complete load current from single line OHE (i.e UP line in this case), thereby resulting in overloading and melting or damage to OHE/jumpers.
10	Flash overs due to breaking of load currents	If a moving loco/train crosses from the live section to dead section on an IOL at TSS/FP, the resulting flash over may cause parting of contact/catenary wires. Similar condition may occur on section insulators provided in yards or loco sheds especially under power block conditions. Even sudden lowering of the pantograph drawing heavy current may also result into arcing and damage to contact/catenary wires. Use of Panto flash over relays must be considered for all TSS/FP having IOL.

TRACTION INSTALLATION DIRECTORATE



GOVERNMENT OF INDIA,
MINISTRY OF RAILWAYS

Instruction No. TI/IN/0025 (08/2010)

TECHNICAL INSTRUCTIONS FOR IMPROVING RELIABILITY OF TRACTION SCADA SYSTEMS ON IR

Aug 2010

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization
(Ministry of Railways)
Manak Nagar, Lucknow – 226011

TI/IN/00-- Rev 0

Technical Instructions for improving reliability of traction SCADA systems on IR

1.0 Scope & objective: This technical Instruction is applicable to different types of SCADA systems provided on Indian Railways. Objective of this technical instruction is to improve the overall reliability of SCADA systems existing on Indian Railways by increasing awareness of the operating personals against any form of mal-operation of the system. These instructions should not be treated as the substitute of Annual Maintenance Contract (AMC), however, these shall help Railways in developing good operation & maintenance practices for SCADA system.

2.0 Development of SCADA system on IR: Prior to development of PC's, microprocessor based SCADA systems were commissioned in Indian Railways. Now most of them have been replaced with PC based SCADA systems running with proprietary SCADA software and protocols. The microprocessor based SCADA systems had its own limitations, like large size mimic diagram boards in RCC & their inability to implement difficult logics. Now a days PC based SCADA systems working on Railways proprietary SPORT (Standard Protocol for Railway Traction SCADA) Protocol have been made so intelligent & efficient that any logic can be easily implemented through user friendly SCADA software for control, monitoring and data acquisition.

Over the years there have been number of improvements in RTU designs as well, in terms of reduction in their size, reliability of electronic components, use of IED's in place of transducers etc.

The current specification for SCADA systems for traction is TI/SPC/RCC/SCADA/0990 (5/07) with amendment no. 1. Approximate break up of different types / legacies of SCADA systems working on IR is given below.

SN	Description & specification	Features	Approx. no. of systems	Approx. year of comm.
1	SCADA system for 25kV ac traction SCADA on IR. ETI/PSI/76(12/93)	• Proprietary protocols • Proprietary software and hardware	40 (Mostly under up gradation)	1994-2001
2	TI/SPC/RCC/SCADA/0986 for Standard SCADA for single 25 kV,	• CMC software • Hardware /RTU	6	2001-2005

	50 Hz ac Traction Power Supply	of any approved vendor • Standard Protocol 'SPORT'		
3	TI/SPC/RCC/SCADA/0990 (05/2007) with Amendment No.1 for Standard SCADA for single 25 kV, 50 Hz ac Traction Power Supply	• SCADA vendors/ OEM Hardware/RTU & own software with SPORT protocol	>12	2006 onwards
4	TI/SPC/RCC/SCADA/1080(9/08) with amendment no.1. Technical specification for SCADA for 25 kV 1 phase 50 Hz traction Power supply for Mumbai area.	• For Mumbai only • SPORT • IEC 60870-5-103 based communication between RTU's & numerical relays.	1	2009

3.0 Maintenance to SCADA systems: As explained above, IR is having a wide range of SCADA systems installed and also technical features of these systems varies widely, therefore, Railway Board & RDSO has time & again reiterated importance of proper un-interrupted maintenance support from OEM for all SCADA systems and in this regard instructions issued from Rly. Board & RDSO are tabulated as under.

SN	Railway Board /RDSO references	Subject
1	Letter No. 93/RE/220/3/Pt.I dated 21.11.2007	SCADA related TRD works: up gradation and AMC of existing SCADA system on IR.
2	Letter No. TI/RCC/SCADA/SPC/07 dated 15.06.2007	Issue of technical guide lines for awarding AMC of SCADA system.

3.1 SCADA System mainly consists of Remote Control Centre (RCC), Remote Terminal Units (RTU) & Communication Media and its reliability can be improved by following certain procedures, guidelines and taking some precautions against mal-operations of these sub- systems.

3.2 Railways should follow these instructions during operation & maintenance of SCADA system by themselves or through AMC.

4.0 Remote Control Centre:

4.1 General Instructions:

4.1.1 All the latest documents such as Technical Manuals, Operating Instruction, Troubleshooting manuals & specifications should be available at RCC.

4.1.2 Only licensed copies of Microsoft Windows operating systems along with service packs compatible to SCADA software should be used.

4.1.3 Only genuine Anti-virus software should be available and loaded on all computers. Operating system should be upgraded with latest available service pack by the SCADA vendor who has taken the AMC.

4.1.4 As the system is having redundancy in respect of server, FEP and MMIs, these can be connected with internet one by one for any available upgrades for operating system & Anti-virus software.

4.1.5 SCADA application software latest version should be available on CD-ROM and it should be loaded on all the computers.

4.1.6 Preferably on weekly basis hot & standby computers (Host and FEP) must be interchanged. By doing so, healthiness of system can be ensured.

4.1.7 Old PCs should be upgraded especially in respect of their RAM size. Latest available maximum RAM size compatible to PC may be opted. Refer RDSO's Instruction No.-TI/IN/0020 (12/2009) for timely replacement & up-gradation of Computers at Remote Control Centre of traction SCADA systems on IR.

4.1.8 Improper shut down of computers (i.e. Windows not shut down properly) should never be done as it results into lost data/ Windows files.

4.1.9 Scandisk & defragment utilities should be run at least once in a month on all computers.

4.1.10 Peripherals should not be unplugged from the computer when powered on.

4.1.11 'C' drive of computers should have minimum 600 Mb free memory space for its optimum performance, otherwise computers slow down considerably and may also hang.

4.1.12 All the program drives and software supplied originally on CD-ROM should be properly stored and readily available on demand.

4.1.13 Computer & accessories should be cleaned at least once in a month by using soft cloth & vacuum cleaner.

4.1.14 When SCADA application is running properly no other application like games, movies, spread sheet & word processor etc. should be run on same computer. It is also not recommended to load such applications on any work station/ FEP/ HOST.

4.1.15 Opening multiple instances/ Windows of the same application at a time should be avoided.

4.1.16 All the floppy, CD drives & USB drives should be disabled through software or it is preferable to protect the access of these drives through software lock.

4.1.17 The computers and its peripherals along with LAN Hub & master modem should be placed in such a way that a minimum space of nearly 20 cm is available for ventilation on back of the computer & devices.

4.1.18 All SCADA computers should be properly designated as per specification.

4.1.19 LAN switch/ hub should be kept at a place where it does not infringe the movement of personals.

4.1.20 Electrical and LAN connections including master modem should be checked periodically.

4.1.21 The LAN cables should be firmly cleated & its settings and connections should not be disturbed.

4.1.22 Power source circuits supplying to computers should be properly grounded as per IS: 3043 on earthing practices.

4.1.23 It is recommended that backup of data/entire folder of SCADA software configured for the project should be taken every month. For procedure of the same, the instructions of OEM or agency undertaking AMC should be followed. In exigencies this backup file may be used to restore the system.

4.1.24 Any error message such as debug error/ run time error on computer screen, should be saved by giving print screen command and pasting it in MS Paint by opening through start>programs>accessories>paint>edit>paste, File>save as. For any other type of on screen error messages etc., instruction of OEM or agency undertaking AMC should be followed.

4.1.25 Dead RTUs should be made Off SCAN to enhance the performance of the system.

4.1.26 The system should never be powered off suddenly when the application is running therefore healthiness of UPS & its battery set should be ensured. Working of both the UPS should be checked in presence of AMC personals at least once in a month at any convenient time by switching ‘off’ the power supply.

4.1.27 Unauthorized usage of system should not be permitted & different passwords for individual time users’ login should be created.

4.1.28 There should not be more than one project and its backup on host. More project/ application may create the confusion at the time of restoration etc. and may also affect the real time application running on the system due to memory space occupied on computer.

4.1.29 Error and temporary files generated on each computer should be got deleted periodically.

4.2 **Step by step procedure to start and shut down:**

There is a step by step procedure prescribed by the OEM to start and shut down the SCADA software. This should always be followed. As an example, the steps given below are for running & stopping of the SCADA application developed by M/s CMC.

The sequence for running the applications is as follows:

4.2.1 Start the Host application and wait till the message “This machine is Active Host” appears on the screen.

4.2.2 Start the MMI application and wait till the MMI displays its Active status on the Status bar of MMI.

4.2.3 Start the FEP application and wait till all the stations are polled.

4.2.4 Run the standby machines (Host and FEP).

The sequence for closing the application is as follows:

4.2.5 First close standby FEP then Active FEP,

4.2.6 Close all MMIs one by one

4.2.7 Close standby Host and then active host.

5.0 Remote Terminal Units:

5.1 **General Instructions:**

All manufacturers furnish installation, commissioning, upkeep & maintenance instructions. These should be readily available with maintenance staff and it should be referred to whenever required, however the following general instructions should be followed:

5.1.1 The RTU door should be properly locked and gaskets provided on the door should be available for proper sealing of the door.

5.1.2 RTU modules layout diagram should be available on the backside of the door within the RTU.

5.1.3 Various modules such as CPU, DI/ DO, AI, PSU & Modem etc. in RTU should be named.

5.1.4 Detailed maintenance instructions as issued by manufacturer should be got followed by agency undertaken AMC of complete SCADA system.

5.1.5 While inserting/ withdrawing components like modules or PCBs etc. power supply of RTU should be switched off.

5.1.6 RCC Host computer synchronizes RTU Clock periodically. If time drift displayed at RCC is more than 2 sec within half an hour period. Lithium battery of the CPU cards may require replacement.

5.1.7 Some times RTU response is same for any command due to malfunctioning. In this case RTU should be reset from RCC through reset command or if not successful then locally.

5.1.8 Under voltage and PT indication voltages at site should not be set by using any un-calibrated variable source and generally setting of any transducer should not be disturbed.

5.1.9 The CPU cards of different RTU's should not be swapped because every card is having station address link settings. If unknowingly different station address card is put, then in spite of communication OK, the telesignals, telecommand, analog data of wrong station may be displayed and in case of command execution, a wrong device may get operated.

5.1.10 Generally plunger of contactors should not be pressed manually to operate contactors directly when RTU is interfaced with field devices as it may damage contacts apart from causing unwanted operation of the field devices.

5.1.11 The RTUs where "energy meters" are used as IEDs, it should be ensured that CT by pass links are properly inserted before removing these devices. Similarly to make IEDs in circuit, be sure that CT bypass links are removed.

5.1.12 Lightning protection module (LPU) should never be bypassed. It may damage modem or entire RTU during lightning or voltage surges.

5.1.13 The fuses of BMs in control circuit should not be bypassed. These are protective devices. For close command fuse is provided but for trip command fuse is not required because even in case of emergency trip command should get executed.

5.1.14 No foreign material should be kept inside the RTU panel.

5.1.15 RTUs may be operated on 110 V dc in place of 240 V ac as per RDSO's instruction no. TI/IN/0023(02/2010 for existing traction SCADA system on IR.

5.2 **EMI precautions at RTU**

Possible sources of Electro-Magnetic interference at a TSS may be switching surges, fault currents, lightning apart from inductive equipment, e.g. coils of contactors, relays or solenoid valves or due to

two circuits sharing one cable, two adjacent cables susceptible to mutual interference via electromagnetic field, transformers and transmitters.

In view of the above following precautions should be taken:

5.2.1 Arrangement of the wiring at TSS/switching post should be such that all types of cable run separately i.e. power supply cables, data lines, analog signal lines and shielded signal lines should be separated from cables that are used to switch high currents or high inductive loads.

5.2.2 In TSS compound signal lines should not be laid parallel to power cables and ensure that distance to sources of interference (contactors, transformers) is 1metre minimum.

5.2.3 In case of conduit wiring, both ends of the metal ducts should be grounded.

5.2.4 All inactive metal parts should be grounded and make sure all connections to earth have good contact. All metal parts should be connected together such that they give good contact (broad earthing strips) with screw connections connected to ensure good contact, i.e. using lock washers or fan type lock washers.

5.2.5 The earthing connections of RTU body with earthing strip of control room & effective earthing resistance should be got checked periodically. Its value should not be > 2 Ω.

6.0 Communication Media:

6.1 For communication between the RCC and the RTU, 6 wires are generally used, 2 wires are for receive (Rx + & Rx-) and 2 are for send (Tx + & Tx-) and 2 as spare.

6.2 Instruction No. TI/IN/0021 (1/2010) for increasing data transfer speed of traction SCADA system on IR from 600/1200 to a minimum of 9600 bps may be referred for the implementation of new communication scheme for operation of SCADA on High Speed Data Transfer Communication System.

6.3 Present modems support 600 & 1200 bps speed. If OFC has been laid (between stations) it is recommended that master and slave modems should be tried to work on 1200 bps speed. However, if communication noise problem increases speed may be again set at 600 bps.

6.4 Tx and Rx wires should have crimped lugs and their connections should be checked at master & slave modem periodically.

6.5 Port monitor or any other similar utility software is generally installed in FEP which shows the data bits sent to & received from field. The analysis of this data can give exact cause of failure and useful for troubleshooting. This can be saved through file>save as> File name as per requirement.

6.6 It may be noted that Portmon application or similar utility should not be run continuously for more than three hours; otherwise it may cause the system to slow down. (It also depends on the storage capacity i.e. Hard Disk capacity. If this capacity is 500 GB or more then such utility software can be run for longer time.)

6.7 The exercise of tuning communication parameters should be carried out jointly with supplier's technical representative and S & T engineers normally at the time of commissioning of system. If retries to scan any particular RTU are more, communication parameters of that particular RTU should be checked thoroughly once again.

6.8 Regular checks on communication copper cable between RTU and Hut at station should be carried out with the help of S & T supervisors and the no. of joints in cable should be recorded jointly.

6.9 The acceptable and recommended range of standard parameters decided in consultation with Telecom Directorate of RDSO are enclosed as Annexure-I. The signal dB level should be checked at RCC & individual RTU modem terminals as per the requirements. Signal dB level should be measured by dB level meter keeping one RTU on line at a time and other RTUs in Off SCAN condition.

Annexure-I

Check list for checking health of communication channel for SCADA purpose (for each RTU)

SN	Description	Instruments	Value as RDSO		Remarks
			Acceptable range	**Recommended range**	
1.	Insulation resistance of cable at 500 V	Megger	**>10,000 MΩ/km**	**>10,000 MΩ/km**	As per SCADA spec. clause 4.2.1
2.	Trans signal from RCC Modem	dB level meter	**0 to -30 dBm**	**-3 to -20 dBm**	As per SCADA spec. clause 4.5.6 (vii)
3.	Receive signal at Modem		**0 to -43 dBm**	**-3 to -20 dBm**	As per SCADA spec. clause 4.5.6 (viii)
4.	Trans signal at OFC terminal near RCC		**0 to -30 dBm**	**-3 to -20 dBm**	As per Telecom Dte. Note no. STT/ DC/ MUX/ Prototest/ 245 dated 1.12.2005
5.	Receive signal at OFC terminal near to RCC		**0 to -30 dBm**	**-3 to -20 dBm**	
6.	Trans signal at OFC terminal near to switching post (stn)		**0 to -30 dBm**	**-3 to -20 dBm**	
7.	Receive signal at FC terminal near to switching post (stn)		**0 to -30 dBm**	**-3 to -20 dBm**	
8.	Trans signal at SWS (before connection to RTU is made)		**0 to -30 dBm**	**-3 to -20 dBm**	
9.	Receive signal at RTU		**0 to -30 dBm**	**-3 to -20 dBm**	
10.	Signal to noise ratio	SNR meter	**>20 dB**	**>20 dB**	

Traction Installation Directorate

सत्यमेव जयते

Government of India
Ministry of Railways

Instruction No. : TI/IN/0026

FOR

Protection scheme & Relay setting guideline for 25 kV, ac traction sub-station provided with 30MVA traction transformers

September 2010

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization (Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 Introduction

In order to meet the increased traction power requirement arising due to higher train density, train loads and speeds, RDSO issued technical specification number TI/SPC/PSI/30TRN/2070 (10/2007) for 30 MVA traction power transformers.

The comparison of 21.6 MVA & 30 MVA transformers is as under.

Transformer Rating (12.5% impedance)	Rated current in Amp	Prospective maximum fault current (neglecting source / earth resistance) at 25 kV bus
21.6 MVA (ONAN) / 30 MVA (ONAF)	800/ 1111	6.4 kA
30 MVA (ONAN) / 42 MVA (ONAF)	1111/ 1555	8.9 kA

Existing protection scheme (RDSO specification ETI/PSI/65(1/97)) and relay setting guide lines for transformer protection (issued vide letter Nos.ETI/SS/7 dated 22 April 1988) and ACTM relevant Para's were all based on 21.6 MVA traction power transformers.

This instruction now proposes to define protection scheme for TSS provided with 30 MVA traction transformers to provide.

(i) Optimum utilization of overload capacity of the traction transformer
(ii) Improvements in relay protection coordination.

1.1 Utilization of overload capacity of the traction transformer

1.1.1 The relay setting guidelines and protection relays provided as per old RDSO specification ETI/PSI/65(1/97) at 25 kV ac TSS does not allow to utilize the rated over load capacity of the traction transformer over 150% of transformer capacity while traction power transformers are designed to deliver 50% over load for 15 minutes and 100% over load for 5 minutes. The current setting of IDMT over current relay as per old specifications is adjusted at 150% of transformer rating i.e. above 150% of transformer loading it executes trip command to transformer CBs in around 3-4 second.

1.1.2 Moreover in the existing traction sub-stations provided with 21.6 MVA traction transformers no protective relays are provided to protect the transformer against over loading between 100 to 150 % of transformer rated load and the traction transformer is protected by only winding and oil temperature sensing relays provided with transformer tank.

1.1.3 In order to utilize the permissible over load rating of traction transformer between 150 to 200 % and protection against over load between 100 to 150%, three stage definite time OCR with independent setting of current and time for each stage is essential.

1.2 Improvements in relay protection coordination

1.2.1 The static type transformer protection relays (IDMT over current on HV & LV sides) as per earlier RDSO specification ETI/PSI/65(1/97) does not have current and TMS settings in fine steps.

1.2.2 This sometimes results in to tripping of HV, LV or both side breakers for some faults on OHE. Moreover there is no coordination between HV & LV side IDMT over current relays (both are set at 150 %) which sometime results in tripping of HV breaker which has to be reclosed only after manual resetting of the Inter trip relay (ITR) at TSS thereby affecting TSS supply.

1.2.3 In order to utilize the rated over load capacity of traction transformer by provision of additional definite time over current relays for over load protection an improvement in relay protection coordination is essential.

1.2.4 The fine steps and better coordination in setting parameters/zones amongst all relays provided at TSS can only be achieved by using more precision numerical type protection relays having fine steps of setting.

1.2.5 Advanced numerical protection relays for transformer (IDMT OCR, Definite time OCR, REF and Differential) have already been developed and being provided on IR as per new specification TI/SPC/PSI/PROTCT/6070(9/08).

2.0 Protection scheme at 25 kV TSS with 30 MVA traction transformer

2.1 The new specification no. TI/SPC/PSI/PROTCT/6070(9/08) for control and relay panel with numerical type relays for traction transformer protection has already been issued to Zonal Railways. Which also covers the protection requirements of 30 MVA traction transformer permitting utilization of the over load capacity of traction transformer.

2.2 It is advised to provide numerical relays & control and relay panels as per RDSO specification no. TI/SPC/PSI/PROTCT/6070(9/08) with 30 MVA traction transformers.

2.3 The relay setting guide lines for all the numerical type protection relays of above specification have been circulated by RDSO vide Technical Instruction No. TI/IN/0022 (2/10) which should be followed. The procedure for setting different parameters of relays shall be according to manufacturer's instruction manual, field requirement and actual equipment provided at TSS.

2.4 Setting guidelines issued vide RDSO letter No. TI/PSI/PROTCT/STATIC/07 dated 23-04-2007 for feeder protection shall continue to be followed. At present no additional protection for overloading of feeder is being proposed because it is assumed that at any time only one transformer is in service and feeding the up and down lines on both side of IOL, hence the

total current will be divided in four circuits and current in each circuit will be approximately 280 A in normal case and 560 A under maximum over loading (200%) of transformer, which is below the continuous rated current of catenary and contact wire (65 sq mm catenary & 107 sq mm contact wire). However during some unbalanced loading conditions or power block of any one line of any sub-sector within feeding zone of TSS, especially close to TSS, the total load current may flow in one line of sub-sector under power block, it may be more than the rated current of OHE. The policy of overload protection of OHE may be reviewed by RDSO based on the suggestions and experience generated by Railways in due course of time.

2.5 The 25 kV side CT are provided as per RDSO Spec No. ETI/PSI/90 (6/95) with A&C 1 to 7 where in CT Ratios of 750/5 and 1500/5 are available. It is recommended to use 1500/5 ratio in case of 30 MVA transformers as normal rated (permissible load) current are much higher than 21.6 MVA transformers.

2.6 The relay setting calculations of traction transformer and feeder protection relays should be done considering the actual parameters of given below equipment:

- Actual fault level at TSS.
- Bushing CTs ratio of 30 MVA transformers.
- CT ratio of HV and LV side.
- PT ratio.
- OHE configuration.
- Rating of traction transformer.

2.7 The transformer specification stipulates use of ONAF mode for 40 MVA output however the recommended settings of Definite time OCR elements for traction transformer protection shall not permit the operation of 30 MVA traction transformer in ONAF mode i.e. 40 MVA continuously. Hence during ONAF mode of operation, the setting of stage-1 definite time OCR on LV and HV side shall have to be reviewed.

Traction Installation Directorate

सत्यमेव जयते

Government of India

Ministry of Railways

Instruction No: TI /IN/0027

For

Technical Instructions on maintenance practices to be adopted for numerical type microprocessor based protection relay modules for 25 kV ac traction system on Indian Railways

October, 2010

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization (Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 Introduction

Protection relays are vital part of any power system and play an important role in minimization of damage to power system equipment by detecting and isolating the faulty equipment or section automatically in minimum possible time. Minimization of damages & safety of power supply equipment depend on relay characteristics, operating time, accuracy, sensitivity and reliability.

Electric traction load on Indian Railways system is increasing due to rise in number of trains, induction of higher power locomotives (fitted with state of the art traction converters capable of regenerating during braking) and running of faster and heavier trains. This trend has led to the reduction in the margin between the likely fault and the load currents and has further increased need for an effective, intelligent and faster protection system capable of ensuring reliable & uninterrupted traction power supply and with this objective development of numerical protection relays has gradually progressed on IR.

The purpose of this instruction is to develop awareness, knowhow and testing & maintenance procedures to be followed for numerical protection relays by Railways.

1.1 Development of traction protection relays on Indian Railways

Initially simple electro-mechanical type over current relays were considered adequate for protection of traction system and 25 kV ac traction only used distance (mho), over current, wrong phase coupling, restricted earth fault and differential type of electro-mechanical relays.

With the gradual shift in technology world over from the electro-mechanical technology to static technology IR also adapted such relays in late 1980's. Significant advances in the digital processor based techniques have now enabled development of new protective relays to suit the modern electric traction requirements and making their operations more effective, reliable and accurate. The processing power in the relays has grown phenomenally over the years to perform variety of complex integrated protection functions.

The milestones in the field of traction protection system on Indian railways in last 3 decades are given below:

Apr 1982	Auto reclosure with overriding scheme introduced
Aug 1984	Static relays were introduced superseding the electromechanical relays
Apr 1991	High speed single shot auto reclosure scheme introduced
Oct 1990	Development of parallelogram characteristics microprocessor based distance protection relays
July 1998	Development of high resistive fault selective relay (Delta-I) and Panto flashover protection relays
Nov 2000	Development of microprocessor based compact Control &Relay panel for trial.
2000	Development of protection scheme for Mumbai suburban area to isolate the minimum possible faulty sub sector automatically.
2005	Development of protection scheme for MRVC project in Mumbai sub urban area having all numerical relays, minimum subsector isolation and parallel operation

	of TSS.
2008	Development of numerical relays for all protection functions with reduced panel size
2009	Integration of numerical relay with SCADA RTU as per IEC 60870-5-103 protocol in Mumbai area.

1.2 Electromechanical and static relays

1.2.1 Electro-mechanical Relays

The operation of electromechanical relays depends on comparing the operating torque/force with restraining torque/force. These types of relays are now only preferred for simple protection functions because for each protection function separate element is essential, resulting in to very large control panel and wiring.

The limitations/demerits of electromechanical type relays are

- Integration of several protection functions in one relay is not possible.
- Implementation of complicated logic functions is difficult and requires lot of control panel wiring.
- More VA burden on CT & PT. Bulky in size and gets affected due to vibration & shock.
- Deterioration of relays characteristics with time requiring periodic maintenance & calibration.
- No ability of self check feature or redundancy of components.
- Non availability of features like communication & data storage.
- Operation affected due to distorted wave forms & harmonics.
- Fine steps of setting range are not possible.

1.2.2 Static type or solid state relays

In static relays the analogue measurement techniques are used and comparison of measured parameters is performed by electronic/magnetic/optical or other components without mechanical motion. Its functioning comprise of the analog voltage/current rectification, filtration to provide a conditioned input to the relay and relay measuring circuit by using discreet electronic components like comparators, transistors etc. The low level output is amplified to drive the output circuit providing the trip contacts.

The limitations/demerits of static relays are:

- Poor thermal stability i.e. operation and relay characteristics get affected with temperature. Frequent calibration is required due to ageing and drift effect.
- Fine steps of setting range are not possible due to limitation of voltage /current dividers, potentiometers etc.
- Multiple characteristics and integrated protection functions are not possible in a single unit.
- No digital data is available. Fault wave form recording, time stamping and digital communication are not possible.
- Sensitive to electrostatic discharge.

1.3 Microprocessor based numerical relays

Numerical relays are defined as relays which utilize software based numerical measuring techniques & digital microprocessor hardware for their operation. These are now being preferred for all complex protection, control and monitoring functions of power system. In these relays hard ware platform and soft ware library can be programmed for achieving different types of protection functions. The most important advantages of these types of relays are given below:

1.3.1 Multiple functions

These relays provide many functions like multiple setting groups, programmable and adaptive logics, self-monitoring, self-testing, sequence-of-events recording, fault data recording, oscillography and ability to communicate with other relays and computers.

1.3.2 Custom logic schemes

A major feature of microprocessor-based relays that was not available in previous technologies is the ability to allow users to develop their own logic schemes, including dynamic changes in that logic.

1.3.3 Panel space

Microprocessor-based protection systems require significantly less panel space than the space required by electromechanical and solid-state systems for similar applications due to integration of the hardware and the ability of using one physical device for performing multiple protection functions, such as, over current, multiple zone distance, PT fuse failure, Wrong Phase Coupling protections are combined in one relay module.

1.3.4 Burden on instrument transformer

Microprocessor-based relays place significantly less burden on instrument transformers (less than 0.3 VA) than the burden placed by the electromechanical relays (8-10 VA).

1.3.5 Sequence of events and oscillography

Sequence of events recording and oscillography are a natural by-product of microprocessor-based protection systems. These features make it possible to analyze the performance of relays as well as system disturbances at minimal additional costs.

1.3.6 Self monitoring and self testing

Another advantage of microprocessor-based relays is their ability to perform self-monitoring and self-testing functions. These features reduce the need for routine maintenance because the relays automatically alert the operators of the problem while detecting any functional abnormalities.

1.4 Working principles of Microprocessor based Numerical relays

1.4.1 The relay samples voltages and currents obtained from respective CT's or/and PT's. The levels of these signals are reduced by voltage and current transformers typically to 110V and 5A nominal values.

1.4.2 The outputs of instrument transformers are applied to the analog input subsystem of the relay. This subsystem electrically isolates the relay from the power system, reduces the level of the input voltages, converts currents to equivalent voltages and removes high frequency components from the signals using analog filter. The outputs of the analog input subsystem are applied to the analog interface, which includes amplifiers, multiplexers and analog-to digital (A/D) converters.
These components sample the reduced level signals and convert their analog levels to equivalent numbers that are stored in memory. The status of isolators and circuit breakers in the power system is provided to the relay via the digital input subsystem and are read into the microcomputer memory.
1.4.3 A relaying algorithm, which is a part of the software, processes the acquired information. The algorithm uses signal-processing techniques to estimate the magnitudes and angles of voltage and current phasors. These measurements are used to calculate other quantities, such as impedances. The computed quantities are compared with pre-specified thresholds (settings) to decide whether the power system is experiencing a fault or not. If it is, the relay sends a command to open one or more circuit breakers for isolating the faulted zone of power system.
1.4.4 The relay settings and other vital information are stored in non-volatile memory of the relay. Random-access memory (RAM) is used for storing data temporarily. The power supply to a relaying microcomputer must be available even when the system supply is interrupted.
1.4.5 The relay is isolated from the power system by using auxiliary transformers which receive analog signals and reduce their levels to make them suitable for use in the relays. The digital signals, also called binary or contact inputs are applied to the relay via optic isolators that ensure physical disconnection of the relay from the power system.
1.4.6 After being quantized by the A/D converter, analog electrical signals are described by discrete values of the samples taken at specified instants of time. These discrete numbers are processed by using numerical methods. For example, quantized values of current and voltage samples are used to estimate the magnitudes and angles of their phasors. Voltage and current phasors are further used to calculate impedances as seen from a relay location.
1.4.7 Microprocessor-based relays are called numerical relays specifically if they calculate the algorithm numerically. The signal and data flows in these relays are shown in Annexure-I &II.

1.5 Short comings of Numerical relays

While microprocessor-based relays have several advantages, they also have a few shortcomings which should be known to decide a correct maintenance strategy for these type of relays. Some of the areas of concern are listed below.

1.5.1 Short life cycle:-

Microprocessor-based devices, including the protection systems offer relatively short life cycles due to the pace of change in the field of electronics making the equipment/technology obsolete very fast. Similarly changes in the software used on the existing hardware platforms also become unavoidable after few years. On the positive side these changes effectively generate newer and better product designs.

1.5.2 Susceptibility to transients

Electromechanical relays were inherently immune to electrical transients such as EMI, RFI, etc. Early designs of relays using electronic devices were susceptible to incorrect operations due to transients but now latest designs include adequate counter measures like reduction in wiring lengths, proper design of enclosures, surge suppression for power supply as well as transducer inputs, use of line filters and proper shielding and grounding.

All the numerical microprocessor-based protection systems for IR are therefore being designed conforming to the IEC 61000 & 60255 series of standards providing reliability under difficult conditions.

1.5.3 Setting and testing complexities

Single numerical type relay module is designed to replace the functions of several solid-state or electromechanical relays apart from offering programmable functions that increase the application flexibility compared with the fixed function relays therefore there are significant number of settings to be done. The increased number of settings sometimes poses problems in managing the settings and in conducting functional tests.

It should however be appreciated that all the shortcomings listed above can be overcome by proper designing and management of the relays. It is now more or less concluded world over that the benefits of numerical relays far outweigh the shortcomings and the acceptance of numerical type microprocessor based protection systems has reached to almost all power applications including 25 kV ac traction.

2.0 Numerical microprocessor based protection relays on IR

2.1 Feeder (OHE) protection

- Numerical integrated Feeder protection module comprises of following functions:
  - Parallelogram characteristics distance protection with independent setting of R and X (Up to 3 Zones possible if as per RDSO spec No. TI/SPC/PSI/PROTCT/4050 is used).
  - Wrong phase coupling protection.
  - Instantaneous OCR (definite time OCR elements also if relays as per RDSO spec No. TI/SPC/PSI/PROTCT/4050 is used).
  - PT fuse failure indication/alarm and trip
  - Feeder breaker failure backup protection function
  - Single shot (2 shot for RDSO spec No. TI/SPC/PSI/PROTCT/4050) auto re-closure functions
  - Monitoring of CB trip circuit
  - Monitoring of SF-6 gas pressure low alarm.

- Delta-I relay: To provide protection against high resistive faults with fault current less than load current as a back up to feeder protection.

- Pantograph flash over protection relay: To provide protection against flash over at Insulated overlap in front of TSS, when Panto enters from live to dead section.

2.2 Traction transformer protection

- Transformer differential protection numerical relay module and contact multiplication function for transformer auxiliary trip i.e. PRD trip, winding and oil temperature high trip, buchholz trip etc.

- Transformer over current and REF protection modules for both HV and LV side separately comprising of instantaneous over current, IDMT over current, definite time over current and restricted earth fault along with monitoring of CB trip circuit, gas pressure low alarm and trip.

2.3 25 kV shunt capacitor bank protection

- IDMT Over current and neutral unbalance current protection module
- Over and under voltage protection module.

3.0 Maintenance practices for Numerical protection relays-General

3.1 The Railways should ensure that manufacturers operating, troubleshooting and maintenance manuals are readily available with the concerned technical persons.

3.2 RDSO has issued time to time relay setting guidelines which should be readily available. The present list of guidelines is placed at Annexure-III.

3.3 The relay setting procedures are defined by manufacturers in their manuals. Initially relay settings based on RDSO guidelines should be got done in presence of the technical representatives of the relay manufacturer however knowledge to change the same as and when required should be available with Railways.

3.4 The ACTM refers to Electro mechanical type of protection relays & recommends its calibration & maintenance accordingly. The ACTM guiding notes on Maintenance on Protective relays Para 20221 should be read with following clarifications:

3.4.1 20221-6 (a) In present designs there is no relay cover or dust proof gasket and the complete relay assembly is sealed. There is no need to either open the relay or even remove it from the panel only for cleaning purpose.

3.4.2 20221-6 (b) Manual operation of the relay to check the correctness of wiring of breaker tripping circuit and contact healthiness of internal trip relay should be verified. In case of numerical relays, this is generally done after entering in to the setting menu and enabling the trip test features for activating test button on the outside console of the relay. As such instructions in the manufacturer's operating manual should be followed.

3.4.3 20221-6 (c) There are no moving parts in the numerical relays therefore its settings do not get disturbed hence annual calibration is not necessary but as recommended in this Para Distance protection relay functionality should be verified using primary injection set which covers CT, PT and wiring connections etc. also.

3.4.4 20221-6 (d) As recommended secondary injection tests on all protection relays for verification of their operation & settings of all protection functions as mentioned in Para 2.0 above should be done annually. The major protection features of numerical relays are explained in 5.2.3 below.

3.4.5 20221-6(e) The overhauling or repair of numerical relays should not be attempted by Railways and OEM's should only be approached for this work. After attempting overhauling the functional, calibration & operating time tests should be carried out and a record should be maintained showing the date and results.

4.0 Installation and commissioning checks on numerical protection relays

4.1 The Para 20929 to 20942 of ACTM (Vol.-II, Part-I) must be ensured wherever applicable. However some additional checks are explained below.

4.2 Check the correctness of indication LEDs, display on LCD and terminals for annunciation & telesignalling by injecting the desired input to operate the protection function.

4.3 Check online & fault values of current, voltage, R, X etc. as applicable on relay display and compare with the actual injected values considering CT & PT ratio selected on the relay during secondary injection testing.

4.4 The functional verification, pickup, dropout and operating time tests should be carried out at the time of installation and commissioning of relays / panels. The errors in operating value and operating time should be within permissible limit as per RDSO specifications or latest type tests results done by RDSO.

4.5 Download the event and disturbance data stored in relay memory and compare with actual inputs applied to the relay. The time stamping done by the relay for particular event should also be verified.

4.6 Relay wiring should be done as per wiring diagrams provided by manufacturers based on RDSO approved design drawings of control and relay panels.

4.7 CTs, PTs and auxiliary dc supply to the relay should be connected with proper polarity. The correct values of CT & PT ratio should only be entered as per the procedure of relay setting defined by the manufacturer.

4.8 Ensure that the relay earthing terminal is always connected to the local earth bar provided in the control and relay panel.

4.9 The insulation resistance of the relay between all terminals shorted and relay cabinet should be measured by 1000 V Megger and it should not be less than 1Mega ohm.

4.10 The relay setting calculations should be done as per relevant RDSO relay setting guidelines considering the actual field parameters. However procedure for the same should be according to manufacturer's maintenance and commissioning manual.

4.11 The password protection is provided in the numerical relay for entering in setting mode. Only authorized Railway persons should have password for relay setting to avoid unauthorized changes.

5.0 Periodic maintenance checks on numerical protection relays

5.1 The numerical protection relays provide generally maintenance free operation under the normal environmental conditions. The relays also have got features of continuous monitoring of important internal components and indication on its display (along with telesignalling and annunciation contact) in case of failure of any critical component.

5.1.1 One LED is provided on front side of the relay to indicate the healthiness status of the relays. The telesignaling / annunciation contacts are also provided to transmit the relay fail to RCC through SCADA.

5.1.2 Whenever relay fail indication appears, note down the type / code on relay display. Subsequently replacement of the affected relay with healthy one should be ensured. The failure of relays should be informed to manufacturer. The failure should be reported to the RDSO clearly indicating make, specification, year of manufacturing, model, details of defects or problem observed and any failure investigation done by Railways independently or jointly with manufacturer.

5.2 The functional tests are to be carried out using secondary injection test kit annually as specified in the ACTM. The following parameters of the relay should be checked :

5.2.1 **Functionality of LEDs**

The healthiness of LEDs provided on the relay should be checked by operating the particular protection element for creating the operating conditions by injecting the operating values as per relay settings / apply the status input voltage at correct terminals of relay through secondary injection test kit.

5.2.2 **Check continuity of output tripping, annunciation & telesignaling contacts for each protection & status input functions**.

The continuity of tripping, annunciation and telesignalling contacts provided inside the relay should be checked by continuity tester at specified terminals after actuating the particular protection element one by one by injecting the operating value with the help of secondary injection test kit.

5.2.3 **Pickup, dropout and operating time of the protection elements**

The important features of main protection and monitoring elements available in the numerical type protection modules are explained below. During annual testing of the relays these should be checked. While testing operating & reset values along with time taken by the relay should be recorded.

5.2.3.**1 Feeder protection (RDSO specification TI/SPC/PSI/PROTCT/5070 or latest)**

(a) Numerical integrated feeder protection module comprising of DPR, WPC, OCR, PTFF, Auto reclosure & LBB

	Protection function	General logic / working / definition
i.	DPR element	
	Minimum operating current	The minimum operating current is current below which DPR element will not act even though the impedance seen by relay is inside the set parallelogram.
	Parallelogram characteristic	Inside the parallelogram boundary is the operating area of the DPR element, if impedance measured by relay falls inside the parallelogram and second harmonic contents less than set value then relay execute trip command.
ii.	WPC element	
	Impedance characteristic test	The WPC relay provides protection against wrong phase coupling of two TSSs supply connected with different phases. The relay should be actuated only, if all condition given below is satisfied: ✓ Measured impedance is in between low and high impedance settings. ✓ Impedance angle is in second quadrant within the set range. ✓ current more than the regenerative current setting.
	Angle test	
	Regenerative current immunity.	
iii.	Over current element	
	Current setting	This is a simple over current relay and initiates trip command when current seen by relay is above the set value.
iv.	PT fuse failure element	
	PT Fuse failure alarm & trip	The relay continuously monitors the feeder current and voltage and in case of PT fuse failure the voltage seen by relay falls close to zero and in most of the cases the load current remains above the set minimum operating current of DPR element, in this condition DPR element will be operated along with PTFF element. The logic of PTFF element is: (i) If voltage and current both are less than set value and CB is in close condition PTFF alarm LED (if provided) along with annunciation & telesignalling will result. (ii) If voltage is less than set value and current is more than set current, CB tripping will result with PTFF trip LED along with annunciation & telesignalling.

v.	Auto reclosure relay	
	Dead time test	Dead time is the time after which the relay executes close command.
	Reclaim time test	Reclaim time is the time after which executing the close command, if breaker again trips, the autorclosure is locked out.
	Auto reclosure bypassed on high set current	If current seen by relay is more than high set auto reclosure bypass current then auto reclosure action will not occur.
vi.	LBB trip	
	Local Breaker Back up	After executing the trip command by relay if concerned CB fails to open or operating current does not fall below the set value within the pre set time, then relay as a backup protection actuate another contact which can be utilized to trip another circuit breaker upstream e.g. LV CB of transformer.
vii.	Trip circuit supervision	
		Relays has got feature to monitor the continuity of trip coil circuit of concerned CB by sensing the 110V dc supply. In case of continuity break of the trip circuit, indication along with annunciation and telesignaling results.
viii.	Gas pressure low alarm and low pressure trip & lock status.	
	Contact multiplication	The contact multiplication for SF6 CB gas pressure status is inbuilt in relay module, which can be checked by giving the 110 V dc status at input terminal of relays provided for this purpose.

(b) Vectorial Delta-I type high resistive fault selective relay (RDSO specification No. TI/SPC/PSI/PROTCT/1982 or latest)

	Operating value test	
i.	Operating current	Relay monitors the vectorial difference between base and fault current in pre defined time interval and executes trip command when vectorial difference is more than set value, measured reactance less than the set value and 2nd harmonic content less than 2nd harmonic setting, the relay operation should take place after the set time delay. If 3rd harmonic content is more than set value then relay operates with higher vectorial difference current according to 3rd harmonic de-sensitivity setting.
ii.	Reactance value (X blinder setting)	

(c) Panto flashover relay (TI/SPC/PSI/PROTCT/2983 or latest)

	Operating logic and threshold voltage test	
i.	Logic test	Panto flashover relay is a logic based relay and operates only after all trip conditions are satisfied i.e. status of BMs, CBs and PT's (for trip logic refer the RDSO specification no. TI/SPC/PSI/PROTCT/2983) after which it executes the trip command. The relay also monitors the PT voltage level and gets activated only when PT voltage is more than set value.
ii.	PT Threshold operating Voltage level test	
iii.	Operating value for PT dead voltage	The PTs voltage continuously monitored by relay if PT voltage is less than set PT dead voltage, then relay display the PT is dead alongwith annunciation and telesignaling contacts.

5.2.3.2 Transformer protection relays (TI/SPC/PSI/PROTCT/6070 or latest)

(a) OC + REF Protection module

	Operating value and status input functional test	
i.	Inst. OCR element	This is a non directional over current relay and is provided on transformer HV side. It continuously monitors the CT current and actuate trip command when measured current is more than set current.
ii.	IDMT OCR element	The IDMT OCR is provided on both side of transformer, it provide protection to transformer against overloading as well as works as a backup protection to Feeder relays beyond the set current of IDMT element.
iii.	REF element	It is a current actuated relay used to provide the protection against internal fault of traction transformer.
iv.	Transformer Alarm status input	The contact multiplication for transformer alarms (Buchholz, Oil temperature, winding temperature, low oil level) status is available in the relay module hence no separate aux. relays is required for the same. The LED indications on front side of the relay and contacts for annunciation & telesignaling for above mentioned alarm contacts should be checked by giving 110V dc supply at correct terminal used for status input.
v.	Trip circuit supervision	Relays has got feature to monitor the continuity of trip coil circuit of concerned CB by sensing the 110V dc supply. In case of continuity break of the trip circuit, indication along with annunciation and telesignaling results.
vi.	Gas pressure low alarm and low pressure trip & lock status.	The contact multiplication for SF6 CB gas pressure status is inbuilt in relay module, which can be checked by giving the 110 V dc status at input terminal of relays provided for this purpose.

(b) Biased differential protection relay

Operating value and status input functional test		
i.	Bushing CT multiplication factor	The bushing CTs provided in the transformer do not match the same secondary current, so in order to match the same secondary current, external ICTs are used with static / electromagnetic type relays. Numerical differential relay have a settable HV & LV ICTs correction factor to match the same secondary current of HV & LV bushing CTs, hence no external ICTs is required.
ii.	Differential current test	The relay monitors the current difference between primary and secondary bushing CTs and initiate trip command when measured current difference is more than set differential current and second harmonic contents less than 15%.
iii.	Biased test	
iv.	Transformer trip status input	The contact multiplication for transformer auxiliary protection tripping (Buchholz, winding temperature, oil temperature, PRD Trip) are provided in the relay module hence no separate aux. relays is required for the same. The LED, contacts for annunciation & telesignaling provided on relay for transformer alarm contact multiplication should be checked by giving 110V dc supply at correct terminal used for status input.

5.2.3.3 25 kV shunt capacitor bank protection relays

i.	IDMT OCR	Check functionality
ii.	Current unbalance	
iii.	Under voltage	
iv.	Over voltage	
v.	Trip circuit supervision	Same as above
vi.	Gas pressure low alarm and low pressure trip & lock status.	Same as above

5.3 Check the on line & fault values of current, voltage, R, X etc. as applicable on relay display and compare with the actual injected values considering CT & PT ratio selected on the relay.

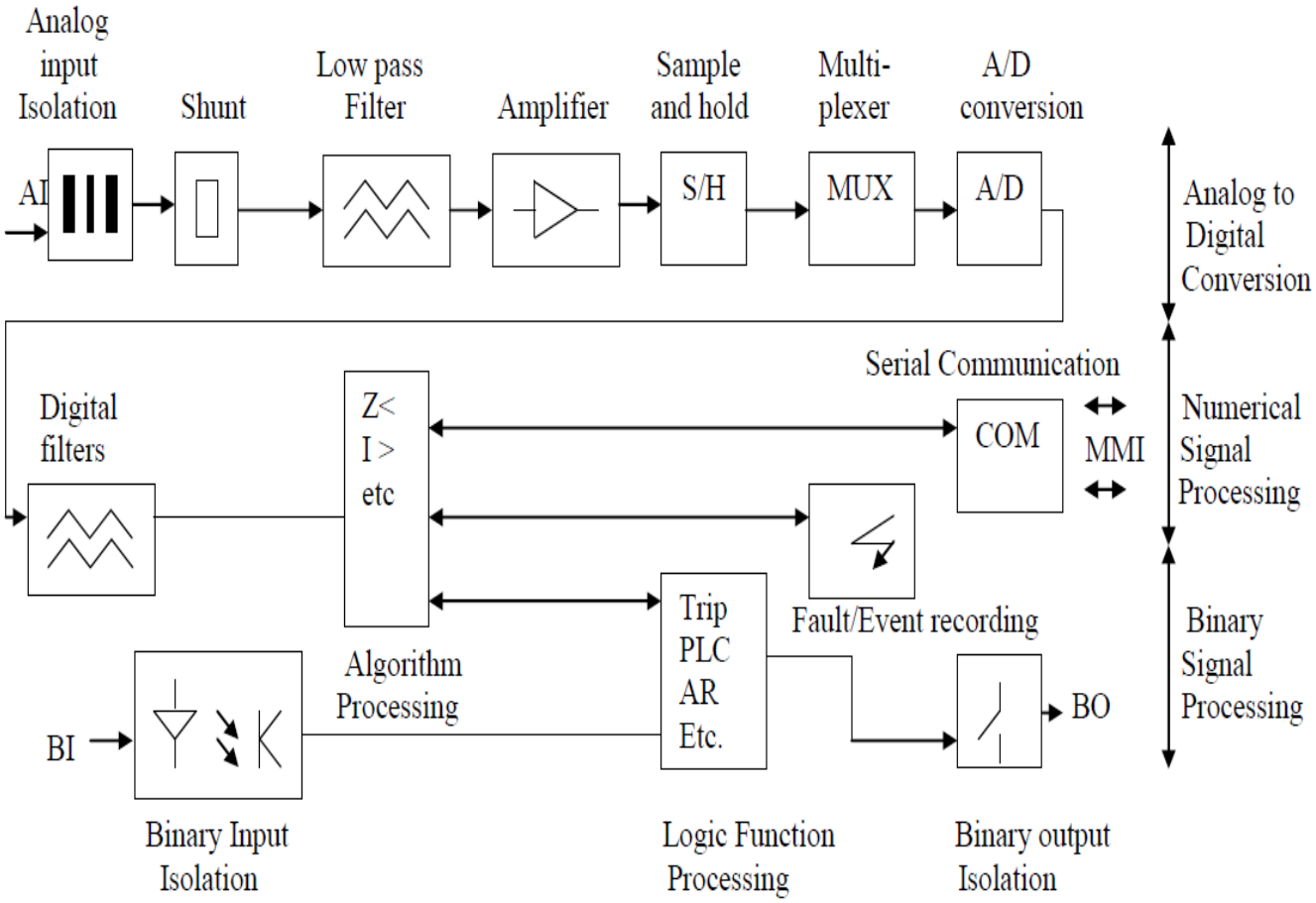
5.4 Download the event and disturbance data stored in relay memory and compare with actual inputs applied to the relay. The time stamped by relay for particular event should also be verified.

5.5 The insulation resistance of the relay between all terminals shorted and relay cabinet should be measured by 1000 V megger and it should not be less than 1 Mega ohm.

5.6 Date wise record should be maintained for all measured values, type of abnormality observed and action taken by Railways / manufacturers.

5.7 Numerical protection relays work based on the software loaded on them. It is therefore very important to keep record of any changes or up gradation done on the relay software by manufacturer. It should also be ensured that whenever changes in relay software are effected all functional tests on the relay (by secondary injection set) are repeated along with verification of relay settings.

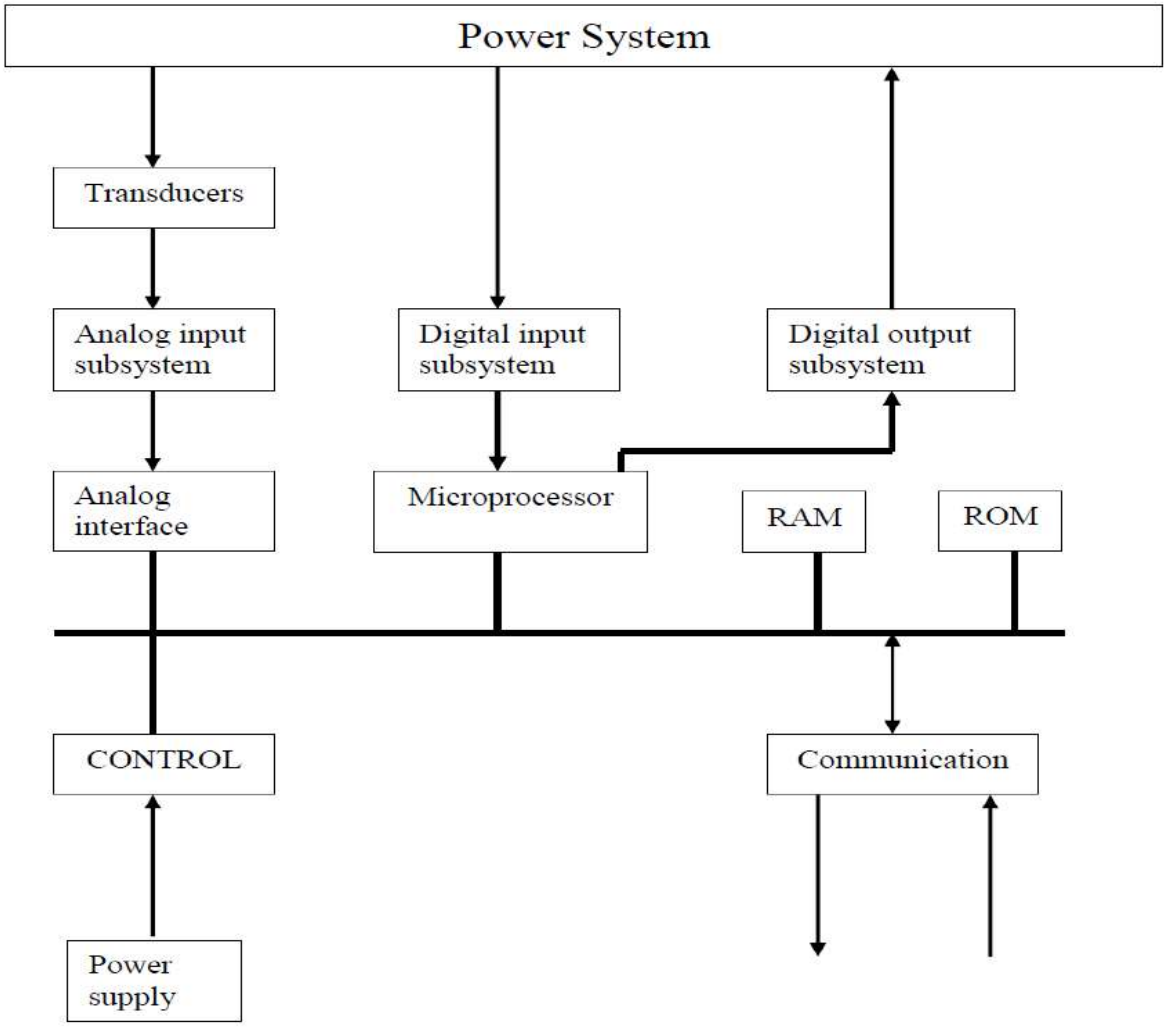
Annexure-I



Signal flow diagram of a numerical relay

Annexure-II

The block diagram of typical microprocessor-based relay is shown below.



Annexure – III

List of relay setting guidelines issued by RDSO

S.N.	Description	Document / letter no.	Date of issue
1.	Guide lines for calculating relay settings at ac traction sub-stations and setting posts	Letter No. ETI/SS/7	dated 22 April 1988
2.	Microprocessor based integrated feeder protection module type AZ 1114 for 25 kV ac traction sub-station	Report No. TI-35 (7/95)	July, 1995
3.	Amendment to report no. TI-35 (7/95)	Letter no. TI/PSI/PROTCT/STATIC/07	23.04.2007
4.	Guidelines on protection scheme with parallel operation of 2 x 21.6 MVA traction transformers	Instruction No. : TI/IN/0017 (July/2008)	Vide letter no. TI/PSI/PROTCT/CONVEN/08 Dated 15.07.2008
5.	Setting guide lines for traction transformer & 25kV shunt capacitor bank protection relay developed as per RDSO specification no. TI/SPC/PSI/PROTCT/6070(9/08) for 25 kV ac traction sub-station	Instruction No. TI/IN/0022 (February/2010)	Vide letter no. TI/PSI/PROTCT/CONVEN/08 Dated 02.02.2010
6.	Protection scheme & Relay setting guideline for 25 kV, ac traction sub-station provided with 30MVA traction transformers	Instruction No. : TI/IN/0026	

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS



TECHNICAL INSTRUCTION NO.TI/IN/P&S/0028

Implementation of Feeder circuit breaker backup feature in different makes/types of feeder protection modules provided in C&R panels as per old RDSO spec. No. ETI/PSI/65(1/97).

December, 2010

ISSUED BY

TRACTION INSTALLATION DIRECTORATE
RESEARCH DESIGNS AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW – 226011

1.0 Background:

In Northern Railways an incident of OHE break down occurred on 23-11-10 at Narela TSS wherein feeder CB did not clear the fault as MTR contacts were not passing feed. The traction transformers were operating in parallel condition (with extended feed conditions) without any improved protection scheme available (as per RDSO instructions TI/IN/0017) and as the fault was at the farthest end of extended feeding section (i.e. with not substantial fault current) the LVCB IDMT relays (set at 150 %) also failed to detect the same as total fault current is shared by both transformers.

The feature of Feeder breaker back up available in the modern numerical feeder protection relays was also not implemented there hence effectively no backup protection operated and extensive damage to OHE was resulted.

1.1 Introduction to Feeder breaker back up protection feature

This feature monitors the status of Feeder CB or magnitude of fault current after issue of trip command to feeder CB and issues a trip command for LVCB's after a lapse of set time delay, if either Feeder CB fails to open or fault current is not falling below the actuating value.

This feature has been defined in Para 6.1.7 of RDSO spec TI/PSI/SPC/PROTCT/5070 and Para 7.2.1.1 of RDSO spec TI/SPC/PSI/PROTCT/6070(3/09). Setting of time delay is explained in the amendment to the setting guidelines issued vide letter No. TI/PSI/PROTCT/STATIC/07 dated 23-04-07.

2.0 History of development of feeder protection modules

The different feeder protection modules developed by RDSO since 1995 along with their make & features are tabulated below.

Sl. No	Type	Year Of approval & RDSO specification	Make	Features
1.	AZ1114	1995 ETI/PSI/141(10/90)	M/s ALIND	Micro processor based design and integration of DPR, WPC, Inst. OCR & PTFF in one module.
2.	ADDR/1	2002 ETI/PSI/141(10/90)	M/s ASHIDA	• Micro processor based numerical design. • Integration of DPR, WPC, Inst OCR, PTFF, Auto reclosure, LBB (Local breaker backup) relay in one module.

				• Storage of 50 cycle fault current and voltage of latest 10 faults in relay memory.
3.	AZ1114+	2003 ETI/PSI/141(10/90)	M/s ALIND	• Micro processor based numerical design. • Integration of DPR, WPC, Inst OCR, PTFF, Auto reclosure, LBB (Local breaker backup) relay (only one trip contact for LBB). • Storage of 50 cycle fault current and voltage of latest 10 faults in relay memory.
4.	ADR 219A	2007 TI/SPC/PSI/PROTCT/5070 (5/2007)	M/s ASHIDA	• Development as per revised RDSO specification no. TI/SPC/PSI/PROTCT/5070. • Micro processor based numerical design. • Integration of DPR, WPC, Inst OCR, PTFF, Auto reclosure, LBB (Local breaker backup), and CB trip coil monitoring relay in one module. • Storage of 50 cycle fault current and voltage of latest 10 faults in relay memory.
5.	AZM1114+	2009 TI/SPC/PSI/PROTCT/5070 (5/2007)	M/s ALIND	• Development as per revised RDSO specification no. TI/SPC/PSI/PROTCT/5070. • Micro processor based numerical design. • Integration of DPR, WPC, Inst OCR, PTFF, Auto reclosure, LBB (Local breaker backup), and CB trip coil monitoring relay in one module. • Storage of 50 cycle fault current and voltage of latest 10 faults in relay memory.
6	ADR 219 B	2008 TI/SPC/PSI/PROTCT/4050 & Parallel operation of	M/s ASHIDA	• Development as per RDSO specification No. TI/SPC/PSI/PROTCT/4050 for Mumbai area.

		transformers vide letter no. TI/PSI/PROTCT/CONVEN/08 dated 15.07.2008.		• Micro processor based numerical design. • Integration of DPR, WPC, Inst OCR, PTFF, Auto reclosure, LBB (Local breaker backup), and CB trip coil monitoring relay in one module. The DPR is having 3 zone and 3 stage OCR . • Storage of 50 cycle fault current and voltage of latest 10 faults in relay memory.
7.	AZM1114 + (AN SERIES)	2010 TI/SPC/PSI/PROTCT/4050 TI/SPC/PSI/PROTCT/5070 (5/2007). & Parallel operation of transformers vide TI/PSI/PROTCT/CONVEN/08 dated 03.03.2010.	M/s ALIND	• Development as per RDSO specification No. TI/SPC/PSI/PROTCT/4050 for Mumbai area and also meets the revised RDSO specification no. TI/SPC/PSI/PROTCT/5070. • Micro processor based numerical design. • Integration of DPR, WPC, Inst OCR, PTFF, Auto reclosure, LBB (Local breaker backup), and CB trip coil monitoring relay in one module. The DPR is having 3 zone and 3 stage OCR . • Storage of 50 cycle fault current and voltage of latest 10 faults in relay memory.

3.0 Implementation of Feeder circuit breaker back up feature

3.1 All feeder protection modules being used in IR except S.No.1 (i.e. AZ1114 of M/s Alind) in table above are having this feature of Feeder circuit breaker back up protection.

3.2 Current specifications of feeder protection module (TI/SPC/PSI/PROTCT/5070(5/2007)) and control & relay panels (TI/SPC/PSI/PROTCT/6070(8/09)) are having this feature and all the panel drawings approved by RDSO includes its implementation.

3.3 Implementation of this feature was first referred by RDSO in amendment of setting guidelines issued by RDSO vide TI/PSI/PROTCT/STATIC dated 23-04-07 wherein it was suggested to carry out the wiring by taking the details from relay manufacturers.

3.4 It has been observed that number of Railways have still not implemented this feature in the wiring of old control & relay panels (as per old RDSO spc. ETI/PSI/65(1/97) or older specifications).

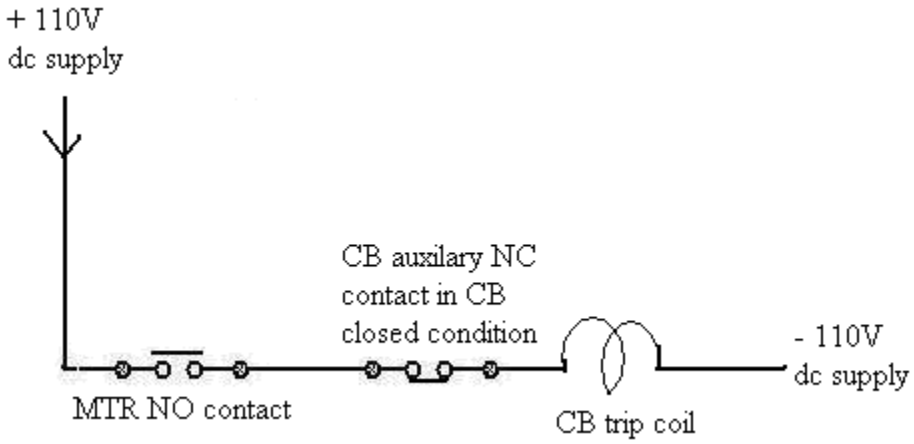
3.5 In view of the above it is again advised to implement this feature in different make/type of relays locally/by works using the required material only from the approved sources. If required, necessary technical assistance of relay or panel manufacturers may be taken. The wiring and other technical details are tabulated below.

Relay make/Type	**Scheme of implementation**
AZ1114+	-Wiring details given in **Annexure-I.** -Implementation shall require one additional auxiliary relay (Type: AEMS32 of M/s Alind or Type :AVAJS13 of M/s Ashida) for each feeder protection module for contact multiplication needed for trip, annunciation and telesignalling purposes.
AZM1114+	-Wiring details are given in **Annexure-II.**
AZM1114+ (AN series)	-Wiring details are as per the approved drawing of M/s Alind and enclosed as **Annexure-III.**
ADDR/1	-Wiring details are given in **Annexure-IV.**
ADR 219A	-Wiring details are as per the approved drawings of M/s Ashida and enclosed as **Annexure-V**
ADR 219B	-Wiring details are given in **Annexure-VI.**

4.0 Other important precautions for protection of 25 kV ac traction feeders

Some other important observations emerging out of the failure of the OHE at NDLS division of NR along with the actions to be taken by Railways are as under.

4.1 The simplified trip coil circuit is shown below. The NO contact of MTR and CB auxiliary NC contact are in series. When Feeder protection relay operates, MTR is actuated and it's NO contact closes thereby energizing the CB trip coil. As CB opens, its NC auxiliary contact should first open and break the inductive trip circuit current. If this NC interlock is sluggish and operates later then MTR NO contact (which also opens with the resetting of Feeder & MTR relays), MTR contact shall interrupt the inductive current and may get flashed as their breaking capacity is much lesser then CB contact.



4.2 The burning or flashing of Master Trip Relay contacts may be due to a short circuit in the trip coil circuit, CB trip coil failure and also due to opening of trip coil current by MTR contact instead of CB auxiliary contact as explained above.

4.3 The total resetting time of Feeder protection relay and MTR should be measured using a secondary relay test kit and same should be between 160-250ms. Similarly the CB NC interlock opening time should be checked for any spare interlock and same should not be more than 100 ms. In any case the time difference between the two should ideally be above 80-100 ms to avoid any possibility of opening of MTR contacts before CB auxiliary contact.

4.3.1 The Feeder protection relay resetting time can be adjusted by software hence if any such situation arises where the difference of 80 ms is not available then relay manufacturer should be advised to increase the relay reset time.

4.3.2 The condition of NC (Normally Closed) auxiliary interlock of CB provided in series with MTR (Master Trip Relay) NO (Normally Open) interlock should be checked visually for any sign of wear & tear, damage or sluggishness.

4.3.3 The rotary switch type auxiliary interlocks provided in Alind make CB's should be visually examined & attended/replaced on observing signs of loosening of insulated disks and holding bolts.

4.4 Railways replace complete control & relay panels as well as individual protection relays therefore it is recommended that before a new protection relay is provided in to the existing panel its specification should be thoroughly studied and thereafter implementation of all the features should be ensured at the time of wiring of the same in panel.

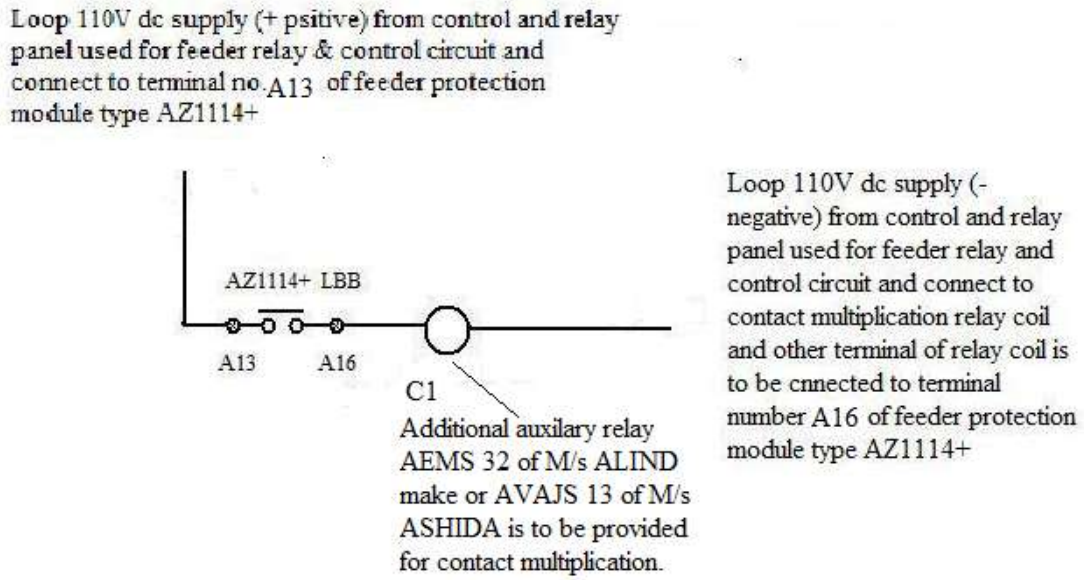
4.5 It has been observed that Railways generally decide parallel operation of 21.6 MVA transformers based on IDMT OCR (LVCB) tripping on overloading. In this regard it is recommended that a complete load pattern recording & monitoring should be carried out as per RDSO instructions TI/IN/0019.

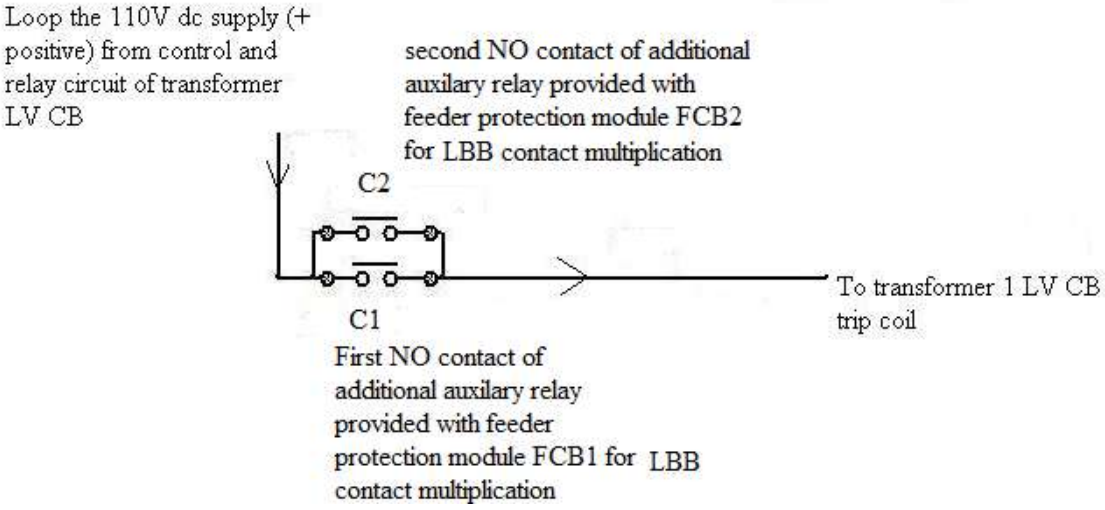
4.5.1 It is important to assess the magnitude and durations of overloading pattern because traction transformers can withstand overloads of 150% for 15 minutes & up to 200 % for 5 minutes and this feature can be utilized by adopting relays and panels for which refer new specification TI/SPC/PSI/PROTCT/6070 and setting guidelines issued vide TI/IN/0022.

4.5.2 Moreover traction transformers of 21.6 MVA can be continuously operated up to 30 MVA in ONAF mode.

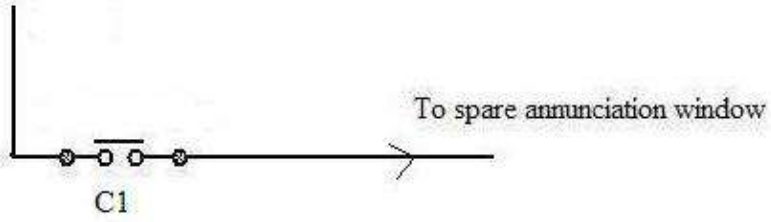
4.5.3 The decision of paralleling of transformers should be taken only after above possibilities have been fully explored.

ANNEXURE-I


Loop 110V dc supply (+ psitive) from control and relay panel used for feeder relay & control circuit and connect to terminal no. A13 of feeder protection module type AZ1114+
AZ1114+ LBB
A13
A16
C1
Additional auxilary relay AEMS 32 of M/s ALIND make or AVAJS 13 of M/s ASHIDA is to be provided for contact multiplication.
Loop 110V dc supply (- negative) from control and relay panel used for feeder relay and control circuit and connect to contact multiplication relay coil and other terminal of relay coil is to be cnnected to terminal number A16 of feeder protection module type AZ1114+

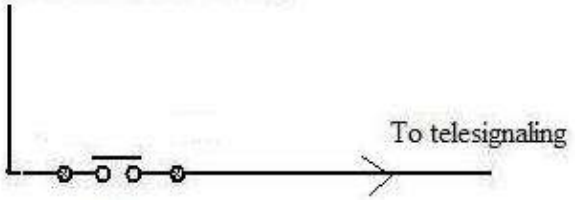

Loop the 110V dc supply (+ positive) from control and relay circuit of transformer LV CB
second NO contact of additional auxilary relay provided with feeder protection module FCB2 for LBB contact multiplication
C2
C1
To transformer 1 LV CB trip coil
First NO contact of additional auxilary relay provided with feeder protection module FCB1 for LBB contact multiplication

Loop the common output supply of annunciation window and connect to 3rd contact of multiplication relay.



3rd NO contact of additional auxilary relay provided with feeder protection module FCB-1 for LBB contact multiplication.

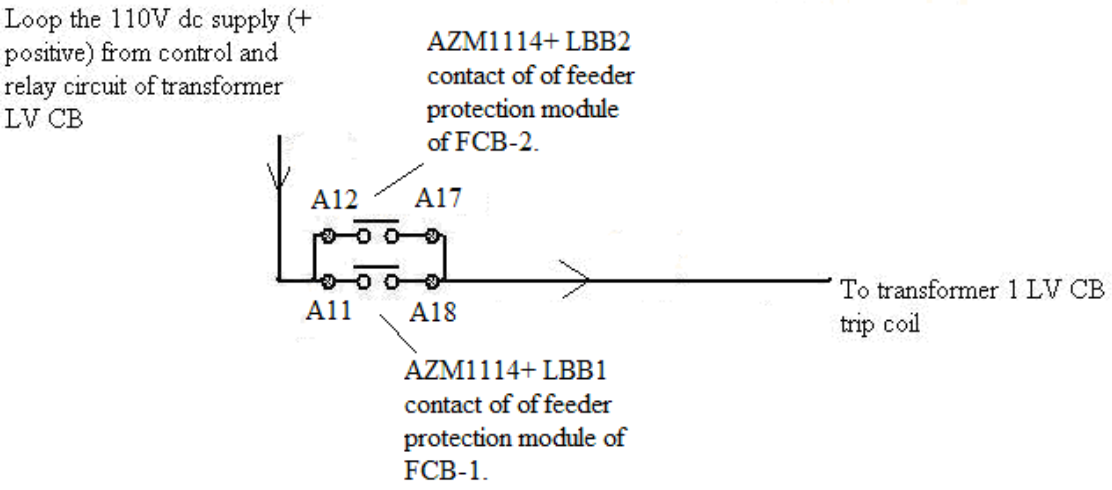
Loop the common supply of telesignaling and connect to 4th contact of contact multiplication relay

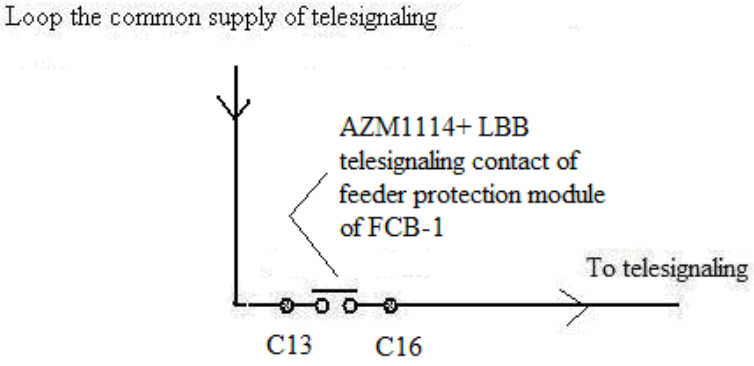


4th NO contact of additional auxilary relay provided with feeder protection module FCB-1 for LBB contact multiplication.

Note : Similar arrangement to be made for tripping, annunciation and telesignaling for feeder CB- 2 also.

ANNEXURE- II

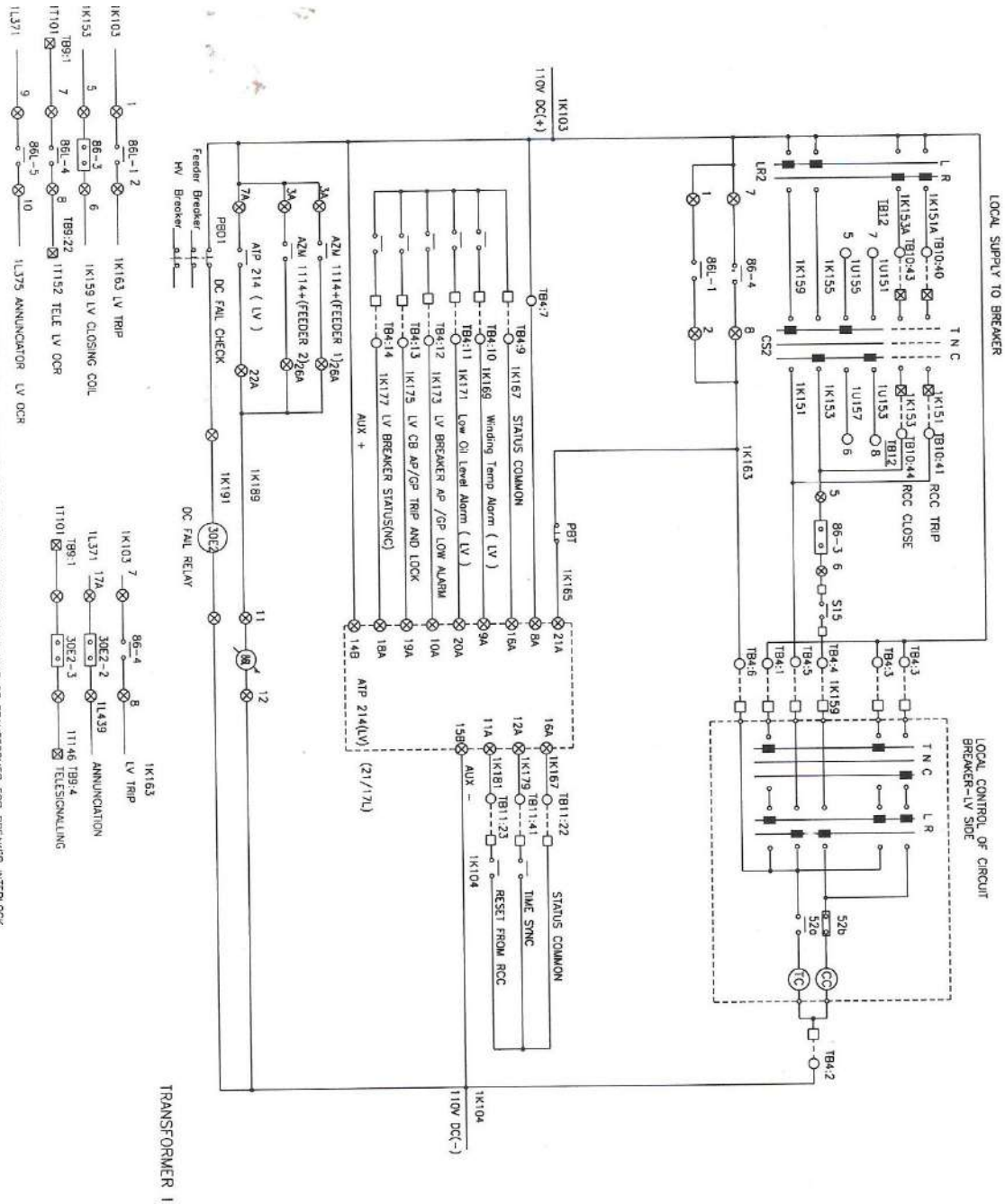


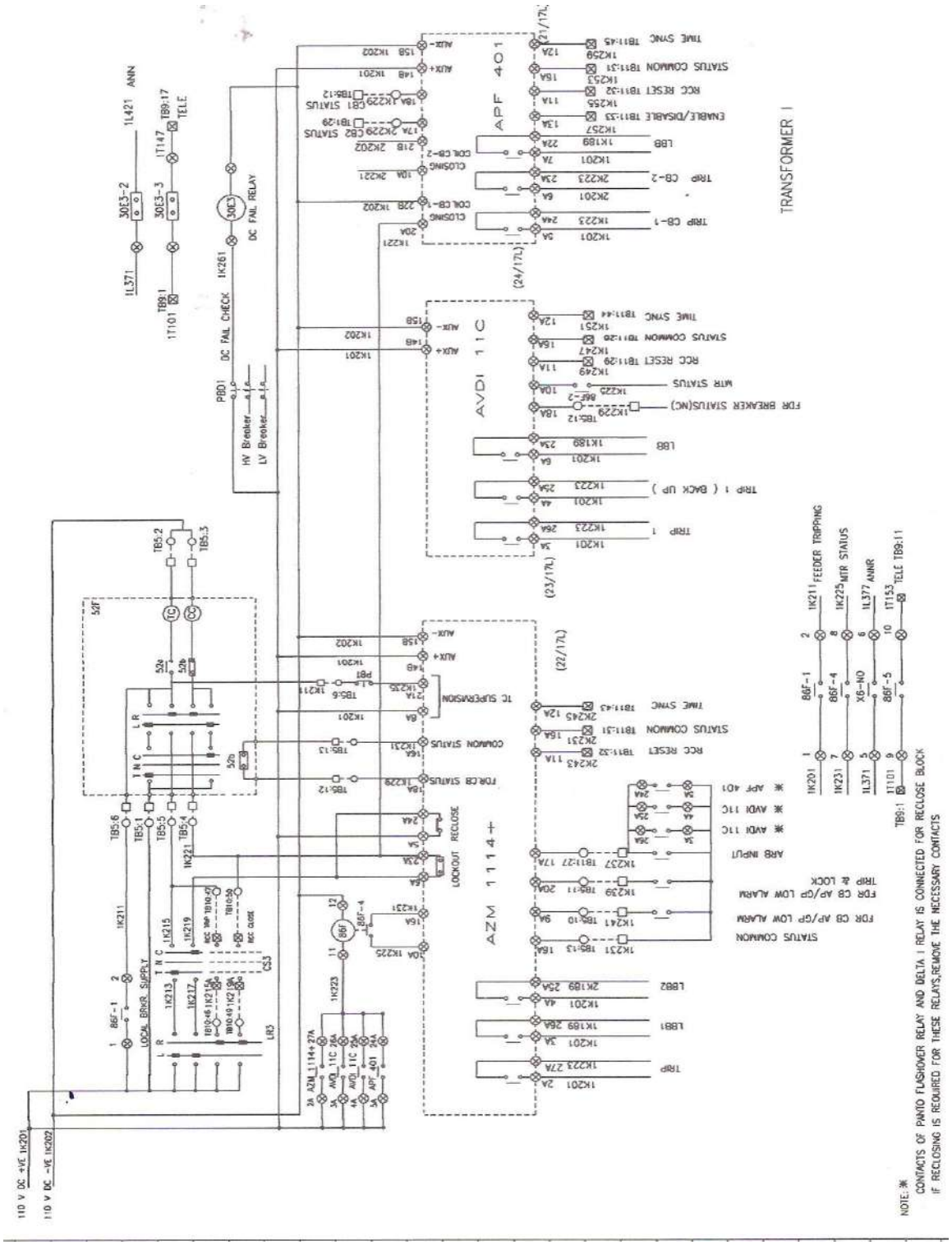


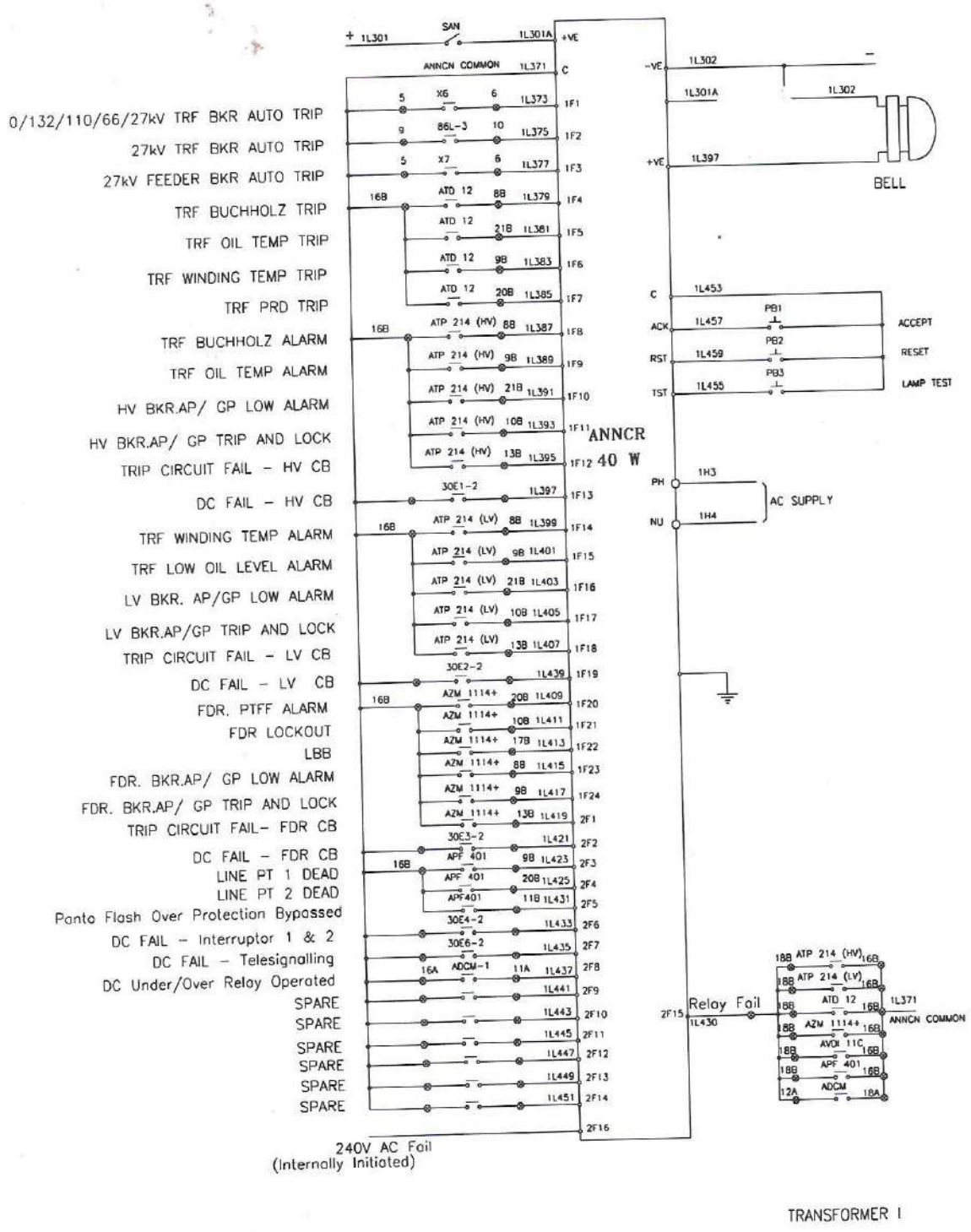
Note : 1 Similar arrangement to be made for tripping and telesignaling for feeder CB- 2 also.

2. AZM1114+ : contact for annunciation is not provided, if any other spare auxilary relay is available in the control and relay panel can be used for annunciation by contact multiplication of telesignaling contact of AZM1114+.

ANNEXURE-III

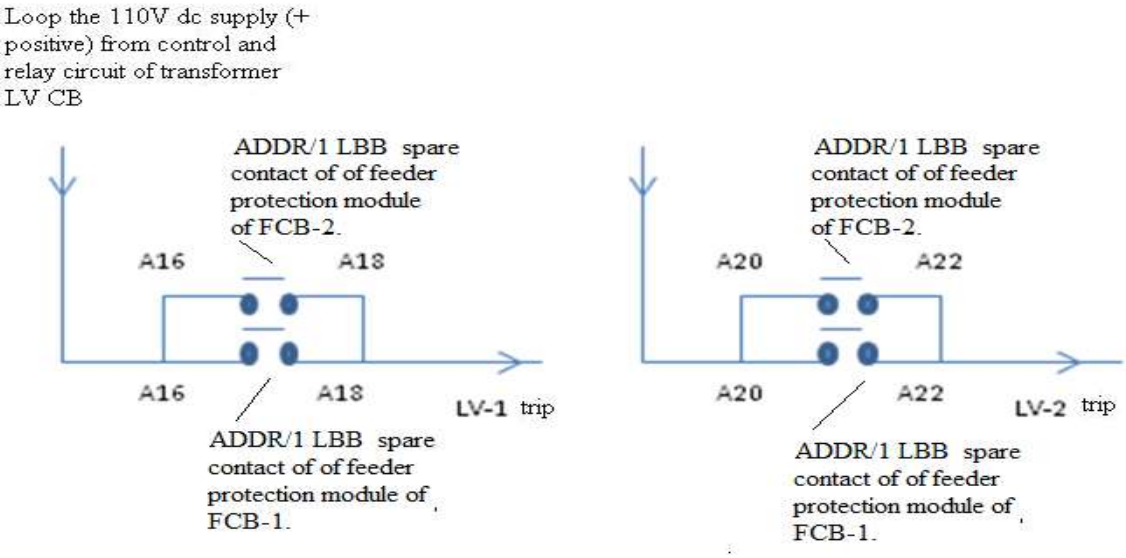


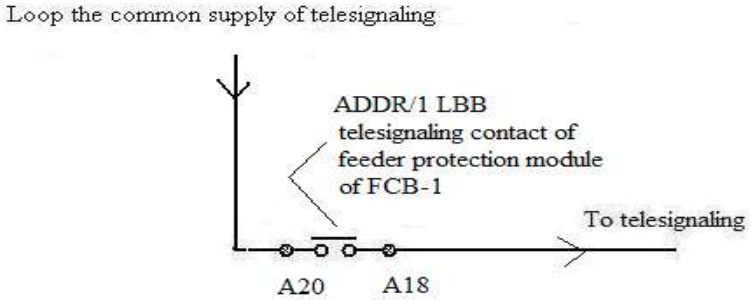

APF 401
AVDI 11C
AZM 1114+
TRANSFORMER I
TIME SYNC
STATUS COMMON
RCC RESET
ENABLE/DISABLE
LBB
TRIP CB-2
TRIP CB-1
TRIP 1 (BACK UP)
TRIP 1
MTR STATUS
FDR BREAKER STATUS(NC)
TC SUPERVISION
COMMON STATUS
FDR CB STATUS
LOCKOUT RECLOSE
ARB INPUT
FEEDER TRIPPING
MTR STATUS
ANNR
TELE
DC FAIL RELAY
DC FAIL CHECK
HV Breaker
LV Breaker
LOCAL BRKR SUPPLY
110 V DC +VE 1K201
110 V DC -VE 1K202
NOTE:*
CONTACTS OF PANTO FLASHOVER RELAY AND DELTA I RELAY IS CONNECTED FOR RECLOSE BLOCK
IF RECLOSING IS REQUIRED FOR THESE RELAYS,REMOVE THE NECESSARY CONTACTS

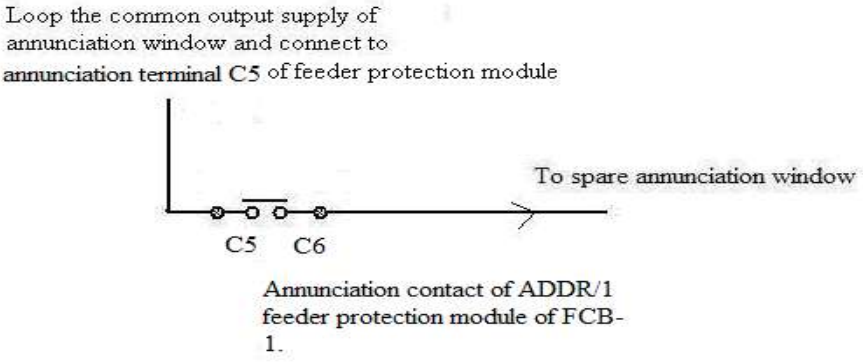

0/132/110/66/27kV TRF BKR AUTO TRIP
27kV TRF BKR AUTO TRIP
27kV FEEDER BKR AUTO TRIP
TRF BUCHHOLZ TRIP
TRF OIL TEMP TRIP
TRF WINDING TEMP TRIP
TRF PRD TRIP
TRF BUCHHOLZ ALARM
TRF OIL TEMP ALARM
HV BKR.AP/ GP LOW ALARM
HV BKR.AP/ GP TRIP AND LOCK
TRIP CIRCUIT FAIL – HV CB
DC FAIL – HV CB
TRF WINDING TEMP ALARM
TRF LOW OIL LEVEL ALARM
LV BKR. AP/GP LOW ALARM
LV BKR.AP/GP TRIP AND LOCK
TRIP CIRCUIT FAIL – LV CB
DC FAIL – LV CB
FDR. PTFF ALARM
FDR LOCKOUT
LBB
FDR. BKR.AP/ GP LOW ALARM
FDR. BKR.AP/ GP TRIP AND LOCK
TRIP CIRCUIT FAIL– FDR CB
DC FAIL – FDR CB
LINE PT 1 DEAD
LINE PT 2 DEAD
Panto Flash Over Protection Bypassed
DC FAIL – Interruptor 1 & 2
DC FAIL – Telesignalling
DC Under/Over Relay Operated
SPARE
SPARE
SPARE
SPARE
SPARE
SPARE
240V AC Fail
(Internally Initiated)
ANNCR
40 W
AC SUPPLY
BELL
ACCEPT
RESET
LAMP TEST
Relay Fail
ANNCN COMMON
TRANSFORMER I

TELE ATP 214 (HV)
1T101
22B
ATP 214 (HV) 1B 1T154 TB8:3 TELE BUCHOLZ ALARM
ATP 214 (HV) 2B 1T155 TB8:4 TELE OIL TEMP ALARM
ATP 214(HV) 27B 1T156 TB8:5 TELE HV CB AP/GP LOW ALARM
ATP 214(HV) 3B 1T157 TB8:6 TELE HV CB AP/GP TRIP & LOCK
ATP 214(HV) 26B 1T158 TB8:7 TELE IDMT
ATP 214(HV) 4B 1T159 TB8:8 TELE DEFINITE TIME OCR
ATP 214(HV) 25B 1T160 TB8:9 TELE INST. O/C
ATP 214(HV) 5B 1T161 TB8:10 TELE REF
ATP 214(HV) 24B 1T162 TB8:11 TELE RELAY FAIL
ATP 214(HV) 6B 1T163 TB8:12 TELE TRIP CKT FAIL
ATP 214(HV) 23B 1T164 TB8:13 TELE LBB
TELE ATP 214 (LV)
1T101
22B
ATP 214 (LV) 1B 1T165 TB8:15 TELE WINDING TEMP. ALARM
ATP 214 (LV) 2B 1T166 TB8:16 TELE LOW OIL LEVEL ALARM
ATP 214 (LV) 27B 1T167 TB8:17 TELE-LV CB AP/GP LOW ALARM
ATP 214 (LV) 3B 1T168 TB8:18 TELE-LV CB AP/GP TRIP & LOCK
ATP 214 (LV) 26B 1T169 TB8:19 TELE-IDMT
ATP 214 (LV) 4B 1T170 TB8:20 TELE DEFINITE TIME OCR
ATP 214 (LV) 5B 1T171 TB8:21 TELE REF
ATP 214 (LV) 24B 1T172 TB8:22 TELE RELAY FAIL
ATP 214 (LV) 6B 1T173 TB8:23 TELE TRIP CIRCUIT FAIL
ATP 214 (LV) 23B 1T174 TB8:24 TELE LBB
TELE ATD 12
1T101
22B
ATD 12 1B 1T175 TB8:26 TELE-BUCHOLZ TRIP
ATD 12 2B 1T176 TB8:27 TELE OIL TEMP TRIP
ATD 12 27B 1T177 TB8:28 TELE WINDING TEMP TRIP
ATD 12 3B 1T178 TB8:29 TELE PRD TRIP
ATD 12 24B 1T179 TB8:30 TELE RELAY FAIL
ATD 12 4B 1T180 TB8:31 TELE DIFFR. RELAY OPERATED
ATD 12 6B 1T181 TB8:32 TELE TRIP CIRCUIT FAIL
ATD 12 23B 1T182 TB8:33 TELE LBB
TELE AZM 1114+
1T101
22B
AZM 1114+ 6B 1T183 TB8:35 TELE TRIP CIRCUIT FAIL
AZM 1114+ 1B 1T184 TB8:36 TELE FDR AP/GP LOW ALARM
AZM 1114+ 2B 1T185 TB8:37 TELE FDR. CB AP/GP LOW TRIP & LOCK
AZM 1114+ 27B 1T186 TB8:38 TELE DP
AZM 1114+ 3B 1T187 TB8:39 TELE WPC
AZM 1114+ 26B 1T188 TB8:40 TELE INST. O/C
AZM 1114+ 4B 1T189 TB8:41 TELE PTFF TRIP
AZM 1114+ 25B 1T190 TB8:42 TELE ARB
AZM 1114+ 7B 1T191 TB8:43 TELE LOCKOUT
AZM 1114+ 5B 1T192 TB8:44 TELE RECLOSE
AZM 1114+ 23B 1T193 TB8:45 TELE LBB
AZM 1114+ 24B 1T194 TB8:46 TELE RELAY FAIL
AZM 1114+ 21B 1T195 TB8:47 TELE SOTF
ADCM
1T101 8
ADCM-2
9 1T196 TB8:49 TELE DC UNDER/OVER MODULE ACTED
TRANSFORMER I

ANNEXURE- IV

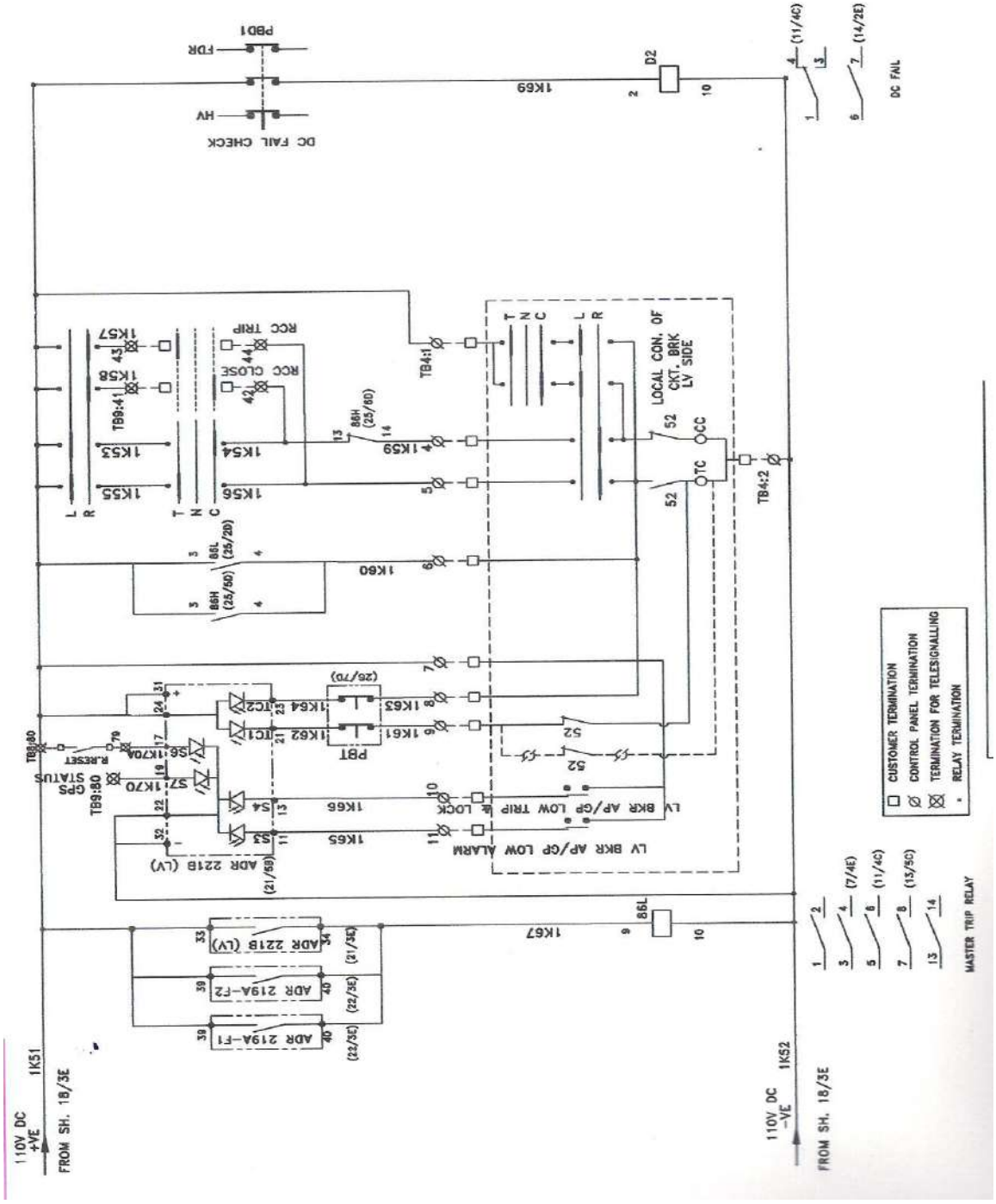


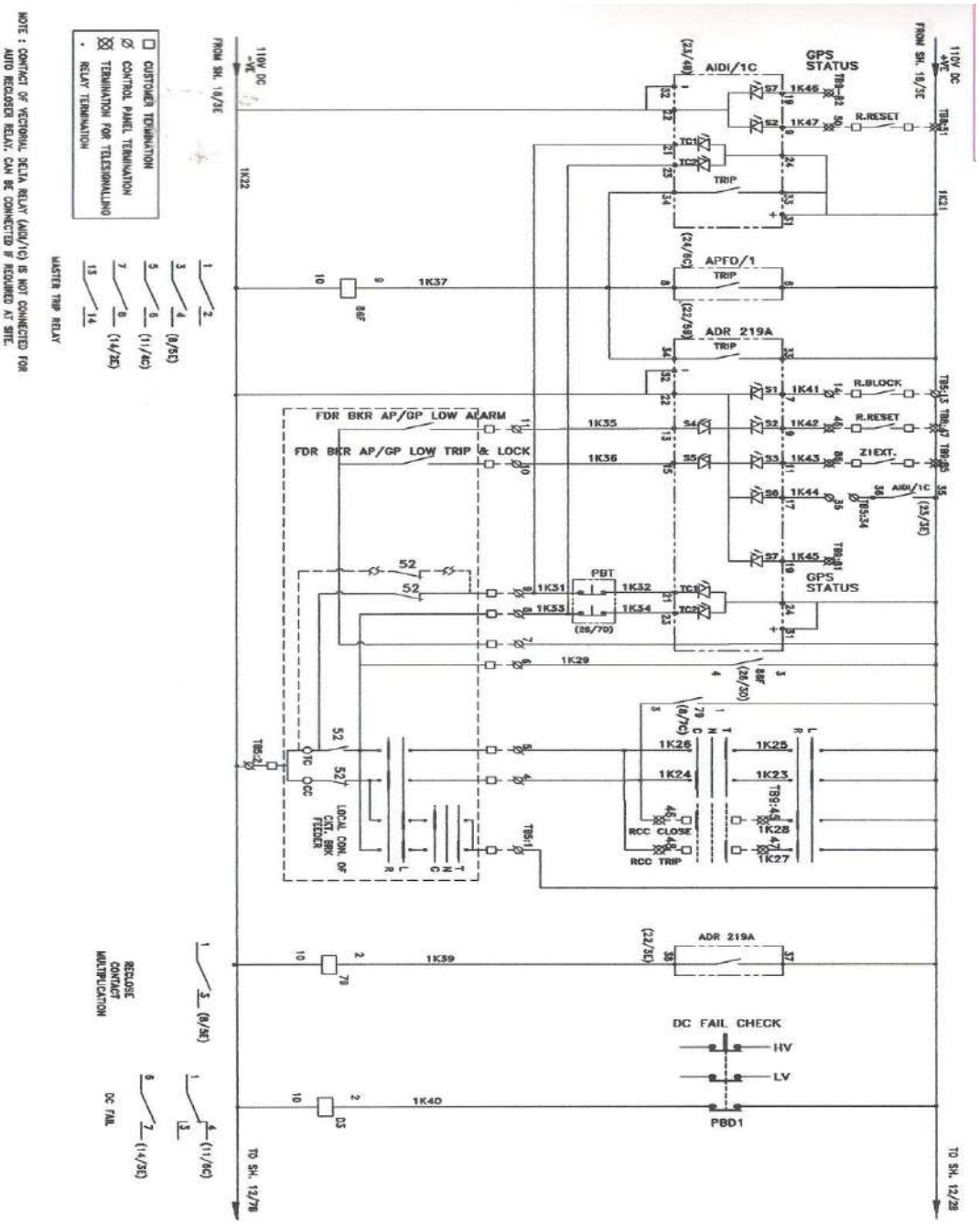


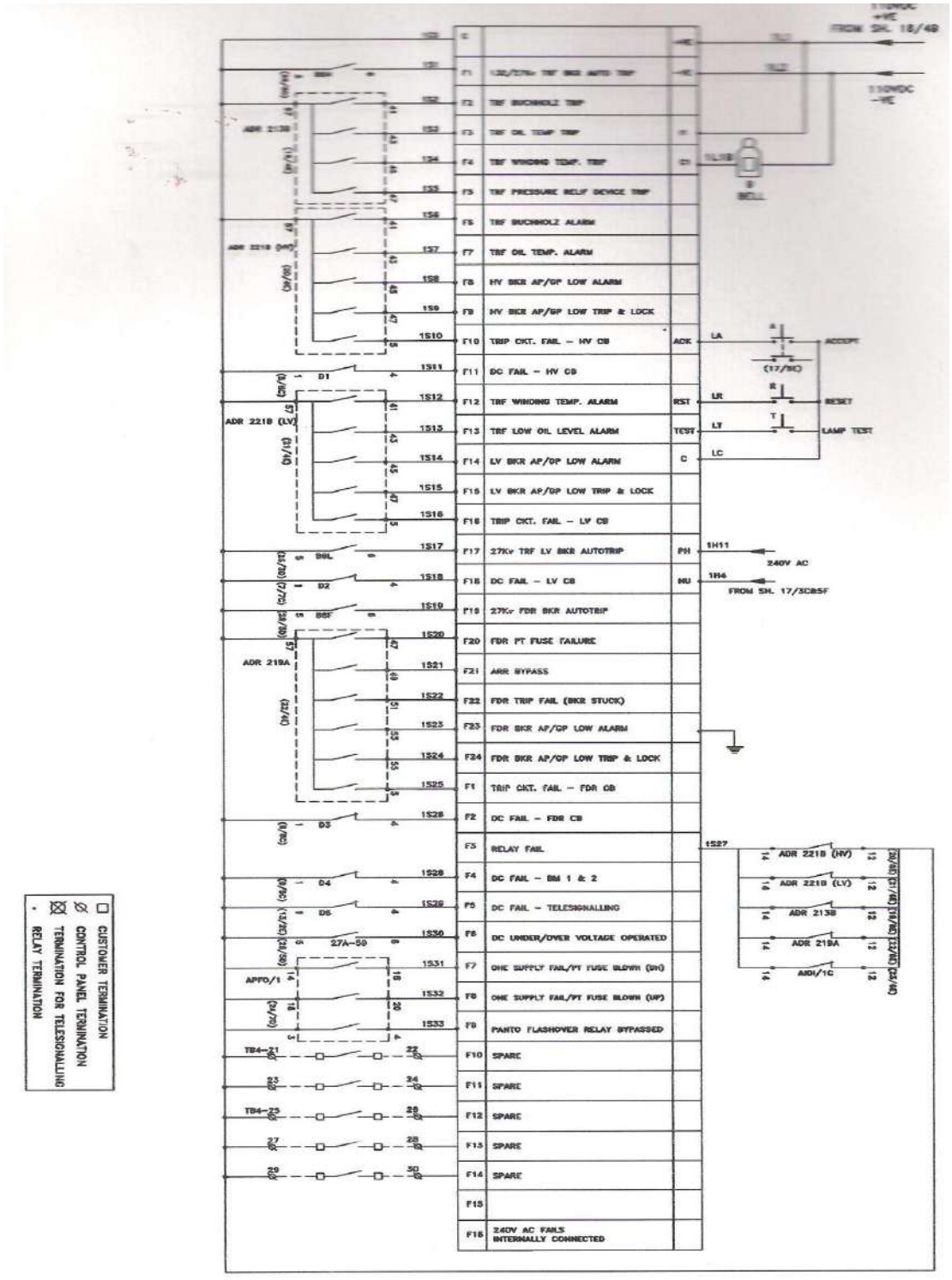


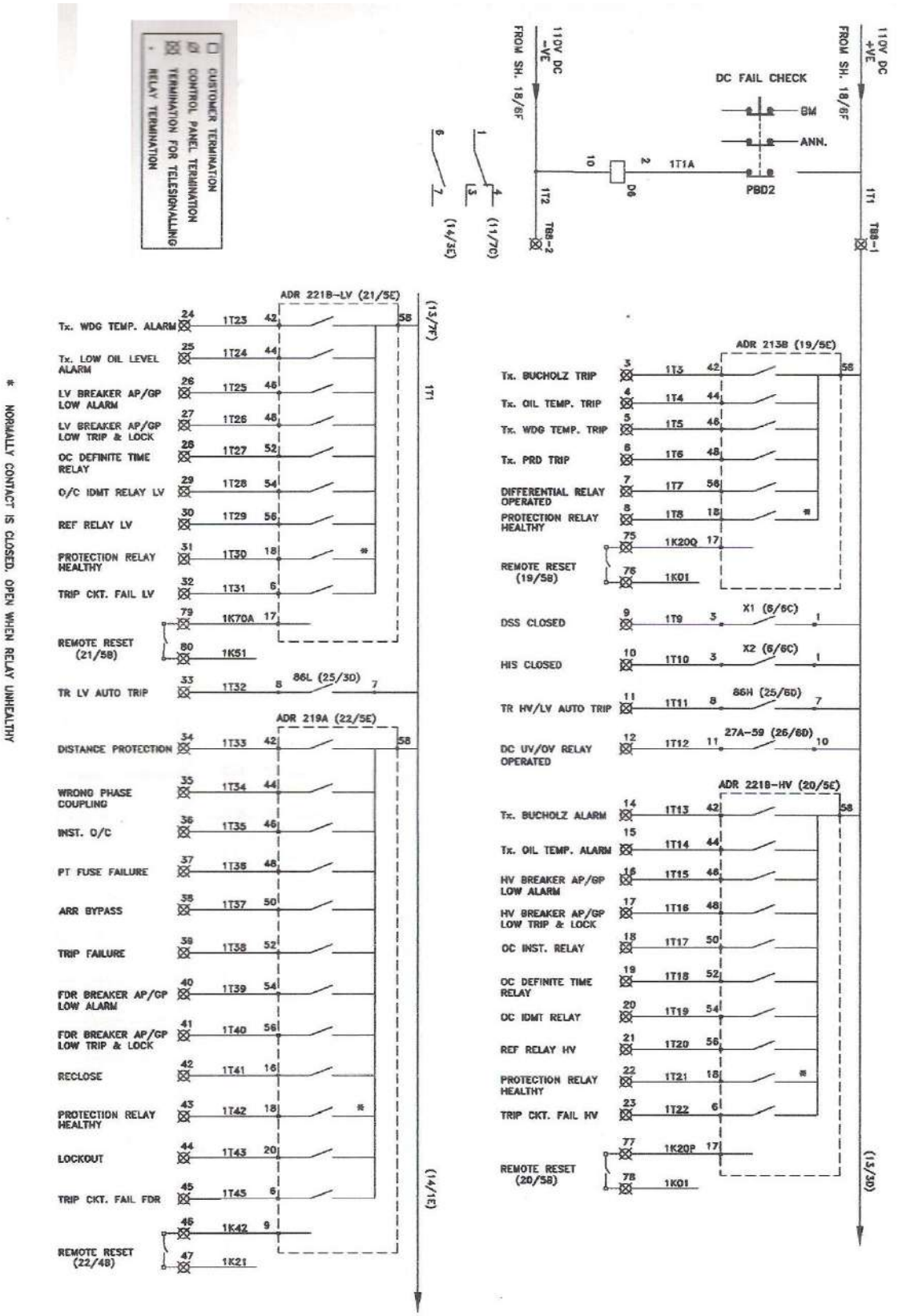
Note : Similar arrangement to be made for annunciation and telesignaling for feeder CB- 2 also.

ANNEXURE-V

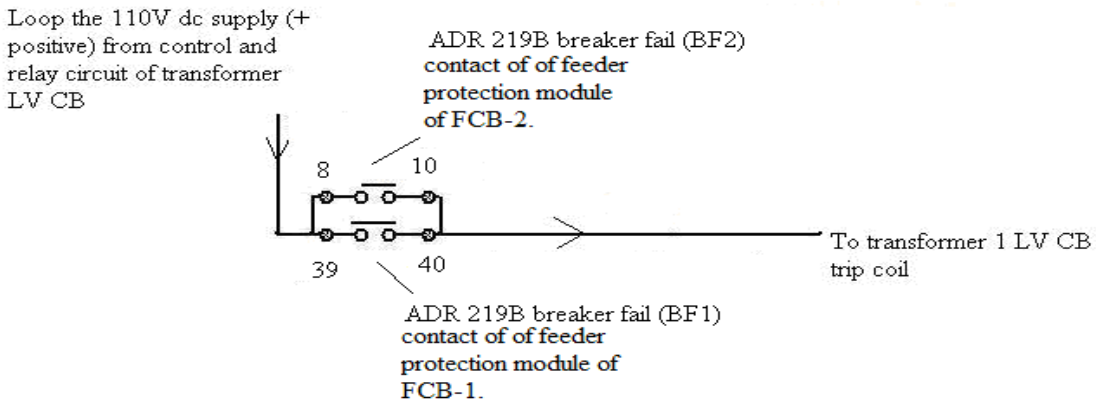

PBD1
FDR
HV
DC FAIL CHECK
1K69
D2
DC FAIL
RCC TRIP
RCC CLOSE
LOCAL CON. OF CKT. BRK LV SIDE
1K57
1K58
1K53
1K55
1K54
1K56
1K59
1K60
1K63
1K64
1K61
1K62
PBT
1K70A
1K70
1K66
1K65
LV BKR AP/GP LOW TRIP
LOCK
LV BKR AP/GP LOW ALARM
ADR 221B (LV)
1K67
ADR 219A-F2
ADR 219A-F1
CUSTOMER TERMINATION
CONTROL PANEL TERMINATION
TERMINATION FOR TELESIGNALLING
RELAY TERMINATION
MASTER TRIP RELAY
110V DC +VE
1K51
FROM SH. 18/3E
110V DC -VE
1K52
FROM SH. 18/3E

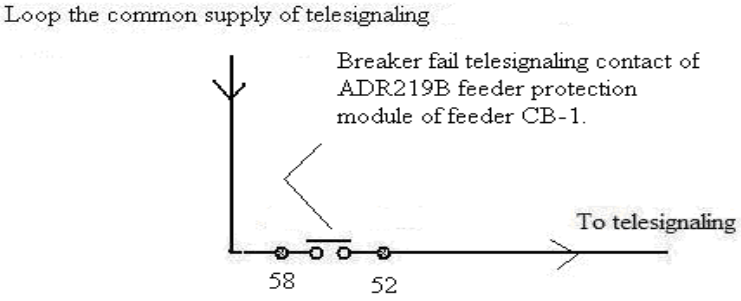

NOTE : CONTACT OF VECTORIAL DELTA RELAY (AIDI/1C) IS NOT CONNECTED FOR AUTO RECLOSER RELAY. CAN BE CONNECTED IF REQUIRED AT SITE.
CUSTOMER TERMINATION
CONTROL PANEL TERMINATION
TERMINATION FOR TELESIGNALLING
RELAY TERMINATION
MASTER TRIP RELAY
FROM SH. 18/3E
110V DC +VE
AIDI/1C
GPS STATUS
R.RESET
TRIP
APFD/1
ADR 219A
R.BLOCK
Z1EXT.
FDR BKR AP/GP LOW ALARM
FDR BKR AP/GP LOW TRIP & LOCK
PBT
1K22
1K21
1K37
1K35
1K36
1K41
1K42
1K43
1K44
1K45
1K31
1K32
1K33
1K34
1K29
1K26
1K25
1K24
1K23
1K28
1K27
1K39
1K40
52
86F
79
OTC
OCC
LOCAL CONT. OF CKT. BRK FEEDER
RCC CLOSE
RCC TRIP
DC FAIL CHECK
HV
LV
PBD1
RECLOSE CONTACT MULTIPLICATION
DC FAIL
TO SH. 12/7B
TO SH. 12/2B

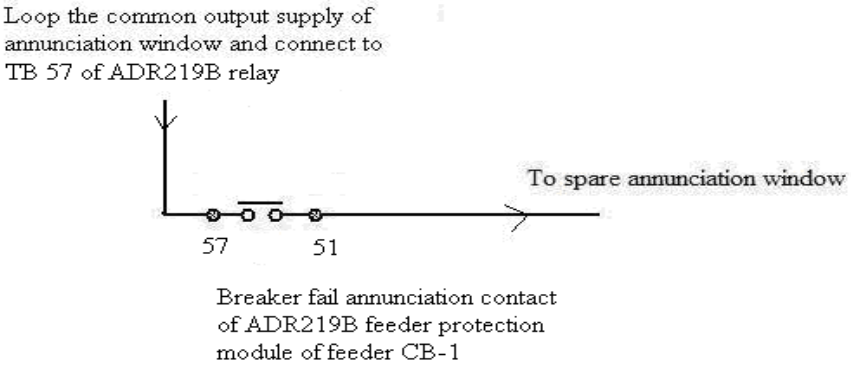

ADR 2138
ADR 2218 (LV)
ADR 219A
APFO/1
TB4-
F1 132/27Kv TRF BKR AUTO TRIP
F2 TRF BUCHHOLZ TRIP
F3 TRF OIL TEMP TRIP
F4 TRF WINDING TEMP. TRIP
F5 TRF PRESSURE RELIF DEVICE TRIP
F6 TRF BUCHHOLZ ALARM
F7 TRF OIL TEMP. ALARM
F8 HV BKR AP/GP LOW ALARM
F9 HV BKR AP/GP LOW TRIP & LOCK
F10 TRIP CKT. FAIL – HV CB
F11 DC FAIL – HV CB
F12 TRF WINDING TEMP. ALARM
F13 TRF LOW OIL LEVEL ALARM
F14 LV BKR AP/GP LOW ALARM
F15 LV BKR AP/GP LOW TRIP & LOCK
F16 TRIP CKT. FAIL – LV CB
F17 27Kv TRF LV BKR AUTOTRIP
F18 DC FAIL – LV CB
F19 27Kv FDR BKR AUTOTRIP
F20 FDR PT FUSE FAILURE
F21 ARR BYPASS
F22 FDR TRIP FAIL (BKR STUCK)
F23 FDR BKR AP/GP LOW ALARM
F24 FDR BKR AP/GP LOW TRIP & LOCK
F1 TRIP CKT. FAIL – FDR CB
F2 DC FAIL – FDR CB
F3 RELAY FAIL
F4 DC FAIL – BM 1 & 2
F5 DC FAIL – TELESIGNALLING
F6 DC UNDER/OVER VOLTAGE OPERATED
F7 ONE SUPPLY FAIL/PT FUSE BLOWN (UP)
F8 ONE SUPPLY FAIL/PT FUSE BLOWN (UP)
F9 PANTO FLASHOVER RELAY BYPASSED
F10 SPARE
F11 SPARE
F12 SPARE
F13 SPARE
F14 SPARE
F15
F16 240V AC FAILS INTERNALLY CONNECTED
ACK
RST
TEST
C
PH
NU
110VDC +VE
110VDC -VE
BELL
LA
ACCEPT
LR
RESET
LT
LAMP TEST
LC
1H11
240V AC
1H4
FROM SH. 17/3C&5F
1S27
ADR 2218 (HV)
ADR 2218 (LV)
ADR 2138
ADR 219A
AUDI/1C
27A-59
CUSTOMER TERMINATION
CONTROL PANEL TERMINATION
TERMINATION FOR TELESIGNALLING
RELAY TERMINATION


CUSTOMER TERMINATION
CONTROL PANEL TERMINATION
TERMINATION FOR TELESIGNALLING
RELAY TERMINATION
110V DC -VE FROM SH. 18/6F
110V DC +VE FROM SH. 18/6F
DC FAIL CHECK
BM
ANN.
PBD2
1T1A
1T2
1T1
TB8-2
TB8-1
D6
(14/5E)
(11/7C)
ADR 221B-LV (21/5E)
Tx. WDG TEMP. ALARM
Tx. LOW OIL LEVEL ALARM
LV BREAKER AP/GP LOW ALARM
LV BREAKER AP/GP LOW TRIP & LOCK
OC DEFINITE TIME RELAY
O/C IDMT RELAY LV
REF RELAY LV
PROTECTION RELAY HEALTHY
TRIP CKT. FAIL LV
REMOTE RESET (21/5B)
TR LV AUTO TRIP
86L (25/3D)
(13/7K)
ADR 219A (22/5E)
DISTANCE PROTECTION
WRONG PHASE COUPLING
INST. O/C
PT FUSE FAILURE
ARR BYPASS
TRIP FAILURE
FDR BREAKER AP/GP LOW ALARM
FDR BREAKER AP/GP LOW TRIP & LOCK
RECLOSE
PROTECTION RELAY HEALTHY
LOCKOUT
TRIP CKT. FAIL FDR
REMOTE RESET (22/4B)
(14/1E)
ADR 213B (19/5E)
Tx. BUCHOLZ TRIP
Tx. OIL TEMP. TRIP
Tx. WDG TEMP. TRIP
Tx. PRD TRIP
DIFFERENTIAL RELAY OPERATED
PROTECTION RELAY HEALTHY
REMOTE RESET (19/5B)
DSS CLOSED
HIS CLOSED
TR HV/LV AUTO TRIP
86H (25/6D)
DC UV/OV RELAY OPERATED
27A-59 (26/6D)
ADR 221B-HV (20/5E)
Tx. BUCHOLZ ALARM
Tx. OIL TEMP. ALARM
HV BREAKER AP/GP LOW ALARM
HV BREAKER AP/GP LOW TRIP & LOCK
OC INST. RELAY
OC DEFINITE TIME RELAY
OC IDMT RELAY
REF RELAY HV
PROTECTION RELAY HEALTHY
TRIP CKT. FAIL HV
REMOTE RESET (20/5B)
(15/3D)
* NORMALLY CONTACT IS CLOSED. OPEN WHEN RELAY UNHEALTHY

ANNEXURE- VI







Note : Similar arrangement to be made for tripping, annunciation and telesignaling for feeder CB- 2 also.

Traction Installation Directorate

सत्यमेव जयते

Government of India
Ministry of Railways

Instruction No. TI/IN/0029

For

Technical instructions
on important aspects of relay settings of Vectorial Delta-I relays
as per RDSO specification No. TI/SPC/PSI/PROTCT/1982

April, 2011

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization (Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 Introduction & background

Vectorial delta- I relays are being provided at 25kV ac traction sub-station in IR (as per the RDSO specification No. TI/SPC/PSI/PROTCT/1982(12/2003)) to detect the high resistive fault above the set Delta-I current, even though total fault current less than rated full load current of traction transformer and the same may also be considered as a backup protection to the main feeder protection module mainly DPR & OCR element.Recently some Railways have reported mal operation cases of vectorial delta-I relay, occurring when the feeding post Insulated Overlap (IOL) is bridged by a pantograph.

There is no auto recloser function provided with Delta-I relay in newly developed C&R panel as per RDSO spc. No. TI/SPC/PSI/PROTCT/6070(9/08), therefore this situation may sometime lead to flash over (caused by pantograph passing from live to dead section) as Panto Flash over relay may also fail to open the live section CB as explained in the following Para's of this instructions.

2.0 Developments and functioning of Vectorial Delta-I relay

2.1 RDSO developed scalar Delta I relay to specification No. TI/SPC/PSI/PROTCT/1981 in 1998.This relay used to detect scalar difference of two current samples for its operation. With the advancement of protection technology for high impedance earth faults, more accurate and reliable relay for such an application was developed in 2001 as per RDSO spec. No. TI/SPC/PSI/PROTCT/1982. In this type of relay vectorial difference of two current samples is used (vectorial difference of base load current and the fault current) for its operation.

2.2 The delta I relay works on the principle of Vectorial difference between the base load current and fault current. The relay has a feature to prevent unnecessary operation by the inrush current of power transformer and due to starting of multiple numbers of electric locos in the section. The inrush currents of power transformers contain significantly high 2^{nd} harmonics currents. If the 2^{nd} order harmonic component is larger than 15% of the fundamental components, the relay blocks out, thus preventing unnecessary operation of the relay.

2.3 The relay is operated by Vectorial delta I current at the same value as of setting current notwithstanding the magnitude of base current. There is a provision of differentiation between fault current and load current. The load current normally has got a high percentage of 3^{rd} harmonic distortion as compared to the fault current. The relay sensitivity restrains according to the de-sensitivity setting at set current when Vectorial delta I current include more than 15% of 3^{rd} harmonic current (generally set for 2 times of set vectorial Delta-I current).

2.4 Relay continuously monitors the reactance (X) of OHE at the fault point and ensure its operation only when X value is below the set value of X-blinder setting provided other conditions of relay operation are fulfilled.

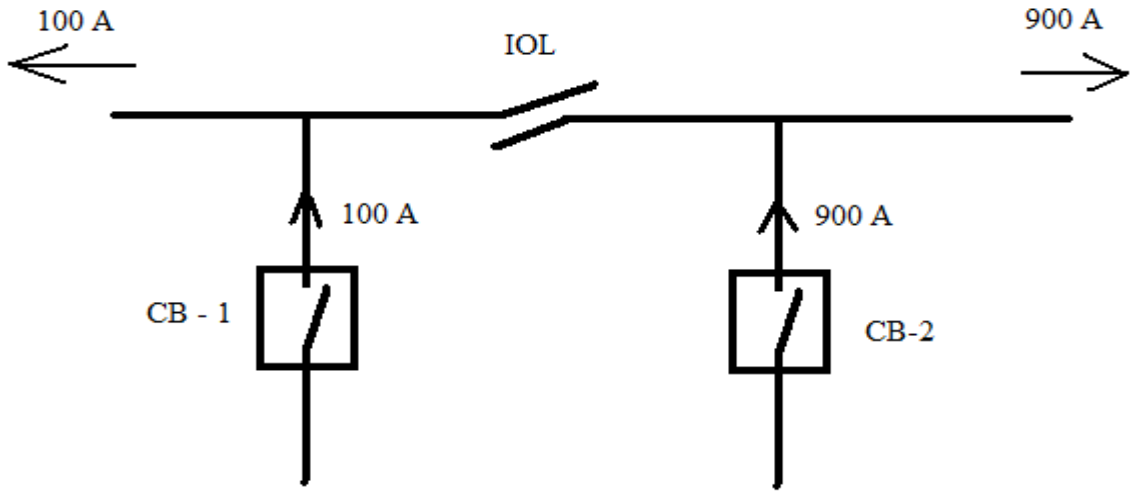
2.5 Delta-I relay is a backup protection function therefore its operating time (with settable time delays) is higher than the primary feeder protection relays.

3.0 Mal operation of Vectorial Delta I relay

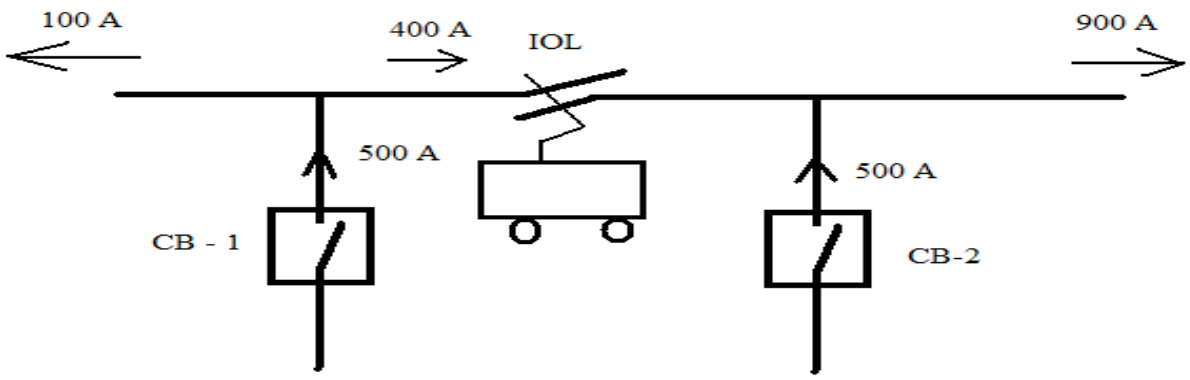
3.1 Delta I relay continuously monitors the vectorial difference between base current and fault current (vectorial difference between consuctive cycles), if vectorial difference is more than set current for set delay time and other condition for tripping also satisfy i.e. II^{nd} harmonic content less than 15% and value of X (reactance) is less than set value then relay initiate trip command.

The mal operation of vectorial Delta-I relay may result if such condition occur under normal load conditions.

3.2 Some mal operation incidences experienced by Zonal Railways and analyzed by RDSO have occurred when the loco pantograph bridges the IOL opposite FP/TSS and Delta I relay operates. This situation may arise when there is large difference in currents being fed by two feeder CB's on either side of the TSS i.e. in example shown below two feeder CB current are 100A and 900A.



3.2.1 When a loco pantograph bridges the IOL, both the feeder CB supplies are paralleled and redistribution of load currents take place wherein both the feeder CB currents are nearly equalized as depicted below. This causes sudden rise of CB-1 current from 100 A to 500 A. The vectorial difference may be higher than 400 A sufficient to trip the Delta-I relay.



3.2.2 As Delta-I relay is a backup protection provision of auto recloser is not provided. This may result in to flashover if Loco is moving from live to dead section. Even if auto recloser is activated with Delta-I relay it may not be able to prevent flashover under all conditions due to total auto recloser time of 600-700ms.

3.2.3 Panto flash over relay (with live CB tripping time of 100-110ms) may also get activated in this condition however it may also be not able to safeguard against the flashover under all conditions depending upon train speed & length of IOL.

3.3 Other cases of mal operation of Delta-I relay may be due to higher actuating Delta-I current on account of sudden variation in load current. The prevention against mal operation in such case is only restraint feature which increases the delta-I setting by 100% if 3rd harmonic content is above 15 % however 3rd harmonic content of traction load current varies widely and relay may still operate if actuating current is even more than 100% above the set value or 3rd harmonic content is less than 15% to initiate restraint action.

4.0 Performance review of Delta-I relays on IR

4.1 Tripping details and overall performance of Delta-I relays received in 2006-07 & 2010 and from Zonal Railways were analyzed for transient and high resistive fault tripping and following observations are made.

4.1.1 Tripping details of 5 Railways i.e. CR, SR, SCR, ER and WR were received in 2006-07. All Railways reported cases of Delta-I relay tripping without any fault noticed. One of the reasons for transient tripping is reported as sudden rise of load current by most of the Railways.

4.1.2 CR, SR and SCR respectively reported at least 4, 7 and 3 cases (suspected high impedance faults caused by bird faults, electrocution and insulator flashing) detected and cleared by Delta-I relay.

4.1.3 Overall performance submitted by 8 Zonal Railways (SR, SER, WR, WCR, NR, SWR, CR & SCR) was analyzed in 2010. The holding of TSS having Delta-I relay and its reported performance is as under:

Railway	Number of TSS	Number of TSS having Delta-I relay	Performance
SR	30	30	• At shoranur TSS 3 cases and 1 case at Kazhakuttam TSS of Delta-I not acted after tree fallen on OHE. • **Spurious tripping at Vridhachalam TSS & Relay dissconnected**. No spurious tripping at other TSS. • Sankaridrug TSS Delta-I acted after tree fallen on OHE. • Working satisfactory at other TSS.
SER	21	1	• No spurious tripping. • Performance satisfactory.

WR	26	15	• Although no spurious tripping reported. **Separate case of contact wire parting at IOL reported after mal operation of Delta-I.** • Performance satisfactory. Actual tripping on high resistive fault not available.
WCR	21	17	• **Spurious tripping at 4 TSS reportedly attended by firm.** • Working satisfactory at other TSS.
NR	11	11	• **No individual tripping, its always occur with DPR & OCR at BTR/TSS which means spurious operation.** • Working satisfactory at other TSS. • **Overall performance is under observation.**
SWR	2	1	• 7 times fault cleared by Delta-I relay. • No spurious tripping. • Performance satisfactory.
CR	36	36	• **Spurious tripping on 12 occasions & attended by firm.** • **At BDI/TSS 24 occasions where delta-I acted with DPR & OCR.** • Number of cases where Delta-I relay cleared the fault. • Performance is reported good at other TSS.
SCR	-	-	• **SEC division reported mal operation cases of Delta-I relay leading to contact wire parting at IOL opposite TSS.**

4.1.4 With above it is summarized that there have been reports of operation of this relay acting to detect and clear high impedance faults however there are cases of mal operation of Delta-I relays which can be addressed by reviewing its settings and at the same time.

5.0 Features & setting options of different make/models of Delta-I relays in service on IR

The different Delta-I relay developed by RDSO since 1999 along with their make & features are tabulated below.

Make / Type	Year of approval & RDSO specification	Features
M/s ALIND/ ADI -11	1999 TI/SPC/PSI/PROTCT/1981	• Monitors the scalar difference between base current and load / fault current with definite time interval and execute trip command if scalar difference more than set Delta-I current. • 3^{rd} harmonic restrain, if 3^{rd} harmonic contents in total current more than 15%, then relay will operate at 2 times of set current. • 2^{nd} harmonic blocking, if 2^{nd} harmonic contents in total

		current more than 15%, then relay will block the trip command. • Relay monitor the MTR status, if MTR status come within operating time of Delta-I relay, then relay is not executes trip command. • **Only Delta-I current setting is provided.** • No features of fault wave form recording and storage in relay memory.
M/s ALIND/ AVDI -11C	2004 TI/SPC/PSI/PROTCT/1982 (12/2003)	• Monitors the Vectorial difference between base current and load / fault current with definite time interval and execute trip command if vectorial difference more than set Delta-I current. • 3rd harmonic restrain, if 3rd harmonic contents in total current more than set value, then relay will operate at 2 times of set current. The 3rd harmonic percentage is settable from 5 to 50% in steps of 5%. • 2nd harmonic blocking, if 2nd harmonic contents in total current more than set value, then relay will block the trip command. The 2nd harmonic percentage is settable from 5 to 50% in steps of 5%. • Relay monitors the MTR status, if MTR status come within operating time of Delta-I relay, then relay is not executes trip command. • Delta-I current is settable from 1 to 6 A in steps of 0.1 A. • Forward and reverse reactance (X) is settable in the range of 0.5 to 30 ohm in steps of 0.01 ohm. • Additional time delay is settable from 0 to 250 ms in steps of 25 ms. • No features of fault wave form recording and storage in relay memory.
M/s ALIND/ AVDI -11C (AN SERIES)	2010 TI/SPC/PSI/PROTCT/1982 (12/2003)	• Monitor the Vectorial difference between base current and load / fault current with definite time interval and execute trip command if vectorial difference is more than set Delta-I current. • 3rd harmonic restrain, if 3rd harmonic contents in total current more than set value, then relay will operate at 2 times of set current. The 3rd harmonic percentage is settable from 1 to 100% in steps of 0.5%. • 2nd harmonic blocking, if 2nd harmonic contents in total

		current more than set value, then relay will block the trip command. The 2nd harmonic percentage is settable from 1 to 100% in steps of 0.5%. • Relay monitors the MTR status, if MTR status come within operating time of Delta-I relay, then relay is not executes trip command. • Delta-I current is settable from 0.5 to 10 A in steps of 0.1 A. • X blinder (reactance) is settable in the range of 0.0 to 99.99 ohm in steps of 0.01 ohm. • Additional time delay is settable from 0 to 1000 ms in steps of 10 ms. • Settable Delta-I cycle 20 to 100 ms in steps of 10 ms. • Settable 3rd harmonic de-sensitivity 0 to 100% in steps of 5%. • Provision of local breaker backup feature. • Event and Fault wave form recording and storage in relay memory.
M/s ASHIDA/ (AIDI/1C)	2004 TI/SPC/PSI/PROTCT/1982 (12/2003)	• Monitors the Vectorial difference between base current and load / fault current with definite time interval and execute trip command if vectorial difference more than set Delta-I current. • 3rd harmonic restrain, if 3rd harmonic contents in total current more than 15%, then relay will operate at 2 times of set current. • 2nd harmonic blocking, if 2nd harmonic contents in total current more than 15%, then relay will block the trip command. • Relay monitor the MTR status, if MTR status come within operating time of Delta-I relay, then relay is not executes trip command and not provided relay supplied after 2008, as this function is implemented software logic by monitoring the delta-I current within set delay time also. • Delta-I current is settable from 1 to 6 A in steps of 0.1 A. • X blinder (reactance) is settable in the range of 0.5 to 60 ohm in steps of 0.01 ohm and 0.04 to 60 ohm in steps of 0.01 ohm in relays supplied after 2008. • Additional time delay is settable from 0 to 300 ms in steps of 10 ms and 0-500 ms in steps of 20ms in relays supplied

		after 2008. • Settable Delta-I cycle 40 to 100 ms in steps of 20 ms and 20 to 100 ms in steps of 10 ms in relays supplied after 2008. • Settable 3rd harmonic de-sensitivity 0 to 1A in steps of 0.1A. • Event and Fault wave form recording and storage in relay memory.

6.0 Recommendations for setting of Delta-I relays

6.1 Existing setting guide lines of vectorial Delta – I relay

The existing guidelines were issued vide letter No.TI/PSI/PROTCT/STATIC/07 dt. 23-04-07. The highlights of this are as under.

6.1.1 Current setting of Delta-I relay is based on the assumption on number of locos entering or number of locos switched on simultaneously in the section causing sudden rise of load current to avoid the false tripping due to sudden rise of load current. The Delta-I current setting should be more than the sudden rise of load current. Assuming 2 numbers loco entering or switched on simultaneously in the section and considering load current of one loco as 150 A, setting of current was proposed as 300 A.

6.1.1.1 The setting should be done taking into account the correct CT ratio. It was also recommended that if relay gives more spurious tripping then next higher value may be selected.

6.1.2 The X-BLINDER setting is the reactance of OHE in ohms below which delta I relay shall pick up if other conditions like delta I, time delay etc. are met. Its calculation was recommended based on the OHE impedance from feeding TSS to adjacent feeding TSS considering the lowest OHE configuration (Single line OHE).

6.1.3 Second harmonic blocking & Third harmonic restraint feature setting features in different make/type of relays are explained in Para 5.0 above. Generally manufacturer set these parameters internally during relay manufacture. However some relay manufacturers made provision to set these parameters externally through knob or keypad. At present both 2nd harmonic block and 3rd harmonic restraint are set at 15 % with desenstivity set at 100% (meaning double the set delta-I current).

6.1.4 Additional time delay setting of 145 ms or higher was recommended. Moreover as the relay monitors the current samples continuously, this delta time setting i.e. time duration between the two samples was recommended as 60 ms.

6.2 Changes required to be done in settings of Vectorial Delta-I relay

In continuation of guidelines issued vide letter No. TI/PSI/PROTCT/STATIC/07 dt. 23-04-07, following changes are to be done in the setting guidelines of the Vectorial Delta-I relay for any two TSS where Delta-I relay tripping on spurious/unknown accounts are maximum. The performance should be watched and after getting a positive feedback from Railways these instructions shall be implemented for all substations.

6.2.1 Current setting of the Delta-I relay should be increased so as to correspond to 450A primary current (on 25 kV side) from existing value of 300A. This increase in relay setting has been decided based on the fault waveforms recorded by Delta-I relay spurious tripping cases at WR and SCR.

6.2.2 The setting of 3rd harmonic restraint should be done at 10% in place of 15%. This change in setting option is possible only in case of latest M/s Alind relay AVDI-11C and in all other models/makes this change shall require change in relay software which shall have to be got uploaded in the relay by relay manufacturers. This reduction in the 3rd harmonic restraint value has been taken after analysis of load data recorded at number of locations on IR (NR, ECR, WCR & NCR etc.) wherein it is observed that % of 3rd harmonic current in the load current varies in the range of 10 to 25% most of the time. By reducing the 3rd harmonic restraint it is expected that relay shall be better placed for not operating due to sudden load variations and situations like pantograph bridging the IOL.

6.2.3 3rd harmonic de-sensitivity factor should be set so as to increase the Delta-I setting by 200% (i.e. 3 times the set current value as against maximum 2 times setting done presently). This will also require change in relay software and up graded relay software shall have to be up loaded by relay manufacturers.

The above changes in setting are expected to substantially reduce cases of mal operation & spurious tripping.

7.0 Analysis of tripping caused by Vectorial Delta-I relays

Railways should examine and analyze cases of Delta-I relay tripping as explained below:

Sr. no.	Items relevant to Delta-I relay tripping analysis	Remarks and explanations
i.	Make, type & year of Delta-I relay	• Check whether scaler/vectorial type. Scaler types are more prone for maloperations.
ii.	Whether any fault located or not	• It should be clearly decided whether the relay operated due to some fault or it was a spurious tripping. This is important to judge & report the overall performance of the relay.
iii.	Past tripping History of the relay	• Past tripping history of the relay should be readily available for reporting to manufacturer & RDSO.
iv.	CT ratio	• The relay setting of Delta-I (in Amp) should properly corresponds to the correct actuating 25 kV side current therefore in relay setting calculation, put correct CT ratio as provided at respective TSS. • If CT ratio is settable in particular relay, then correct setting is also put in the relay.

v.	Download data, current and time. See fault current waveform.	• In old version relay, this feature is not available. Latest versions of relays are having features of recording and storage of latest 10 fault wave forms (50 cycles i.e. 45 before trip command is given by relay and 5 after trip command). • The tripping of Delta-I relay should be analyzed for Delta-I current, harmonics & operating time. • Check 3rd harmonic content is above/below set value and whether set delta-I current is increased as per setting of de-sensitivity. • Check power factor at the time of relay tripping and compare it with load power factor prevalent in previous cycles recorded. • Check timings of CB operation.
	Harmonic analysis of recorded fault current	
vi.	Whether any train at FP-IOL at the time of tripping	• Try to figure out if any spurious tripping are taking place at the time of any pantograph bridging the IOL opposite TSS. • Such cases are more likely where TSS/FP location is such that the feeding length or loading pattern on two sides of IOL widely varies e.g. presence of large yards, sheds & stations on one side as compared to other.
vii.	Any other feeder protection relay also tripping	• Generally Delta-I relay tripping should not accompany with DPR because it is a back up protection with time delay however if DPR picks up after giving the tripping command by Delta-I relay both can operate. • In most of the cases it may be spurious tripping of Delta-I therefore check its relay setting and time delay. • The setting and timing of DPR and CB may also be checked.

78

BR-77

SOUTH CENTRAL RAILWAY

CEE's Office,
4th Floor,
Rail Nilayam,
Secunderabad – 500 071.

NO. E.220/TRD/MI/VOL/IV/1856

Dt: 02-08-2011

Sr.DEE/TRD/SC, BZA,
Sr.DEE/RU,
Sr.DEE/M/HYB,
Sr.DEE/GNT
Dy.CEE/C/TRD/SC

Sub: Technical Instruction No. TI/IN/0030 for lightning arrester.

Ref: RDSO's Lr. No. TI/PSI/GAPLA/Policy/11 dated 06/12-05-2011. → Pkg - A IF. 77

***

With reference to above cited letter a copy of Technical Instruction No. TI/IN/ 0030 related to the installation and commissioning of the 42 kV Metal oxide gapless Lightinig Arrester provided on Traction systems on Indian Railways received from RDSO under the above reference is enclosed herewith for your reference.

Kindly acknowledge the receipt of this letter.

Encl: Technical Instruction No. TI/IN/0030 for lightning arrester.

(R.P.Prajapati)
Dy.CEE/TRD/HQ
For Chief Electrical Engineer.

O/C

हस्ताक्षर .....
Despatched
CEE/TRD/HQ
Initial .....

SSE/TRD Engg/HQ (Sri Quddus) for n.a.pl. मु वि इ./C.E.E
1/6/11 मु.वि.वि.इं./C.E.D.E.
उप मु.वि.इं./क.वि./Dy. CEE/TRD
अनुभाग/SECTION

टेलीफोन 2465763(क)
फैक्स 91&0522&2465763
Telephone : 2465763 (O)
Fax DOT : 91-0522-2465763
E-mail : dti3@rdso.railnet.gov.in

भारत सरकार रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
मानक नगर,लखनऊ – 226 011
Government of India, Ministry of Railways
Research Designs & Standards Organisation
Manak Nagar, Lucknow – 226 011

सत्यमेव जयते

TRD/Tech. (77)

NRD

No. TI/PSI/GAPLA/POLICY/11

Date : 06-05-2011

Chief Electrical Engineer,

1. South Eastern Railway, Garden Reach, Kolkata-700 043
2. Eastern Railway, Fairlie Place, Kolkata-700 001
3. Northern Railway, Baroda House, New Delhi - 110 001
4. Southern Railway, Park Town, Chennai - 600 003 (TN)
5. South Central Railway, Rail Nilayam, Secunderabad – 500 371
6. Western Railway, Churchgate Stn. Bldg, Mumbai - 400 020
7. Central Railway, 2nd floor, Electrical Branch, Parcel Office Bldg. Mumbai - 400 001
8. South West Railway, DRM's Office, Hubli (Karnataka)
9. West Central Railway , Jabalpur (MP)
10. East Coast Railway, B-Rental Colony, Chandrashekharpur, Bhubaneshwar (Orrisa)
11. East Central Railway, Hajipur (Bihar)
12. North Central Railway, Block-A, Subedarganj, Allahabad 211 033
13. South East Central Railway, Bilaspur (Chattisgarh)
14. Northeast Frontier Railway, Guwahati
15. North West Railway, Jaipur (Raj.)
16. Central Organization for Railway Electrification, Allahabad- 211001

pl circulate to all divisions of TRD.

SSE/PSI for n.a.pl

Sub: Technical instruction No. TI/IN/0030 for lightning arrester.

Please find enclosed here with the Technical instruction No. TI/MI/0030 related to the installation and commissioning of the 42 kV Metal oxide gapless Lightning Arresters provided on Traction systems on Indian Railways.

6.5.11
(Sumit Bhatnagar)
for Director General,TI

Encls: As above

Copy to :- ED/EE(M)/ Railway Board, New Delhi

For kind information please.

— Sd —
(Sumit Bhatnagar)
for Director General,TI

Encls: As above

महा प्रबन्धक का कार्यालय
Office of the General Manager
25 MAY 2011
व.म.वि.इं. विभाग
S.C.Rly., Secunderabad.

177
26/5/11

Government of India
भारत सरकार

सत्यमेव जयते

रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन .
मानक नगर,लखनऊ – 226 011

Ministry of Railways
Research Designs & Standards Organisation
Manak Nagar, Lucknow – 226 011

Technical Instruction No.: TI/IN/0030

Technical instructions related to the installation and commissioning of the 42 kV Metal oxide gapless Lightning Arresters provided on Traction systems on Indian Railways

Important points related to the installation and commissioning of the 42 kV Metal oxide gapless Lightning Arresters

1.0 Background

Functioning of the 42 kV lightning arresters (provided on 25 kV side) to a large extant depends upon its correct installation. Similarly it is important to understand the construction and working of the Lightning Arresters to fully appreciate its failure modes and importance of the installation and commissioning aspects. Failures of 42 kV LA's are on higher side as compared to the LA's provided on HV supply at TSS. Some failures of Lightning Arresters are reported from Railways however the failure investigation part is generally missing therefore investigation of failed LA's is also covered in this instruction.

1.1 Historical developments related to the provision of 42 kV class LA's over IR

1.1.1 Gapless Metal Oxide Lightning arresters are compulsorily provided at all the Traction substations and switching posts. The LA's provided at TSS are for protection of equipment there while LA's provided at SP/SSP mainly acts to divert travelling surges on OHE. Lightning Arresters provided at AT locations were gradually removed from 1982 onwards due to the reliability issues associated with them.

1.1.2 Subsequently instructions were issued to SER, ER, ECR & SECR in 1/2005 for providing LA's before selected lightning prone AT locations and furnish performance to RDSO for further study of the issues. Afterwards, based on encouraging results submitted by Railways extensive trials of LA's at selected AT locations under lightning prone areas were advised to all Railways in 9/2006 & reiterated in 7/2008.

1.1.3 After field trials in above 100 locations, SR suggested provision of an additional arcing horn (gapped at 165 mm) at 9 - Tonne insulator prior to DO fuse of AT lightning prone areas in 8/08. Reduction in the cases of DO fuse blowing cases was confirmed by S.Rly. Subsequently on advise of RB, RDSO examined the issue and submitted its recommendations of providing additional arcing horns and monitor its performance to RB on 1/2009 which was approved in 7/2009 and RDSO issued a scheme of providing arcing horn at 9-T insulator prior to AT, to all Railways in 2/2010 and periodical performance feedback was requested.

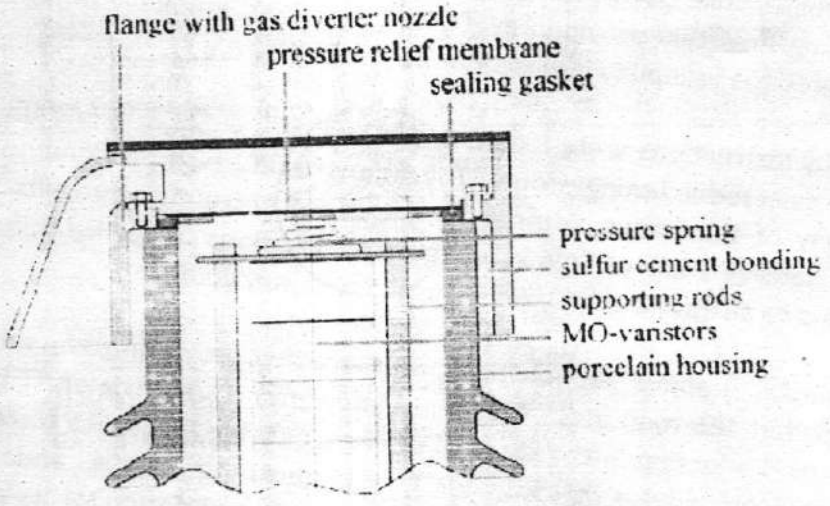
2.0 Other relevant RDSO documents and standards on LA maintenance

Document/Standard	Subject
RDSO specification No. TI/SPC/PSI/MOGLA/0100 (07/10)	Technical specification for metal oxide gapless type lightning arrester for use on 25 kV side of Railway traction substations and switching stations.
RDSO specification No. TI/SPC/PSI/LCMLA/0030 revision 1 (07/10)	Technical specification for leakage current monitor for lightning arresters.

RDSO Maintenance Instruction No. TI/MI/0041 Rev.1	Maintenance Instruction for lightning arresters.
IEC 60099-4	Metal oxide Surge arresters without gaps for a.c. system
IS 3070 part-III	Lightning arresters for alternating current system – specification – part 3: Metal oxide lightning arresters without gaps

3.0 Construction & working of the Lightning Arresters

A high voltage surge arrester basically consists of a stack of cylindrical MO elements kept together by a supporting structure and a housing. The main parts of arrester are its porcelain housing, Metal Oxide resistor blocks, pressure relief mechanism, spring mechanism to hold MO blocks and sealing arrangement as shown in the diagram below.



The general purpose of the housing is to:

(i) Protect the MO elements from environmental impacts such as humidity and pollution as well as damages due to transport,

(ii) Carry external forces, e.g. by conductor wires, wind or earthquake

(iii) Control the pressure relief behavior in case of electrically overloading the arrester,

(iv) Provide a dielectric strength (withstand voltage) above the protection level of the arrester and to

(v) Keep the stack of MO elements together by maintaining a certain pressure within the stack.

A very important part of above design MO surge arresters with respect to safety and reliability is the sealing and pressure relief system. The sealing system is designed to prevent ingress of moisture for the whole lifetime of LA i.e. 15 years. Similarly the

porcelain housing is designed to withstand the internal pressure and arc heat and remain mechanically undamaged during flow of short circuit current and pressure relief.

3.1 Failure modes of Lightning arresters

Most of the LA failures are caused by deficiency of the sealing system due to transportation damage or perishing of rubber sealing gasket due to ageing. Another mode of failure may be, stressing the arrester above its specification, e.g. by direct lightning strokes with extremely high currents or by voltage transfer.

In case of an arrester failure and internal short circuit, the pressure relief system must release the pressure inside the housing which is caused by the arc heat before the housing is violently destroyed by the pressure shock wave. Furthermore, the pressure relief forces the arc out of the housing to prevent from further pressure built-up and burning of the internal parts and housing.

It must be noted that failure of an arrester is a very rare event. Gapped SiC (Silicone carbide) surge arresters used to fail quite frequently and these are now mostly replaced by modern Metal Oxide gapless surge arresters, failure rates of which are considered much lower.

Under normal circumstances (@ operating voltage, without presence of surge) a very low leakage current flows through the LA however with the ingress of moisture and deterioration of MO blocks it goes on increasing finally causing its short circuiting (due to internal losses & heat generation).

4.0 Important points related to the Installation & commissioning of Lightning Arresters

4.1 National/international earthing codes, standards & manuals stipulate requirements for good earthing for lightning surge arresters as explained below.

- IEEE- 80 Clause 17.7 stipulates that "Surge arresters should always be provided with a reliable low-resistance ground connection. Arresters should be connected as close as possible to the terminals of the apparatus to be protected and have as short and direct a path to the grounding system as practical. While many utilities provide separate ground leads from arresters mounted on metal structures, other utilities use the arrester mounting structures as the surge arrester ground path because the large cross section of the steel members provides a lower resistance path than a copper cable of the usual size. In these cases it is important to ensure adequate electric connections from the structure to both arrester ground lead and ground grid; and also to be sure that the steel cross sectional area is adequate for conductivity, and that no high resistance is introduced into joints from paint films, rust, etc."

- Article 280 of National Electricity code (NEC) of NFPA 70 also defines installation of the surge arresters i.e. Para 280.12 *Routing of Surge Arrester Grounding Conductors*- "The conductor used to connect the surge arrester to line, bus, or equipment and to a

grounding conductor connection point as provided in 280.21 shall not be any longer than necessary and shall avoid unnecessary bends." Size of the lead prescribed is not less than 6 AWG Cu or Al.

- IE rules (Para 92- 2) also recommend that the earthing lead for any lightning arrestor shall not pass through any iron or steel pipe, but shall be taken as directly as possible from the lightning-arrestor to a separate earth electrode and/or junction of the earth mat already provided for the high and extra high voltage sub-station subject to the avoidance of bends wherever practicable.

- Code for Earthing Traction Power Supply Installation" vide Appendix III of ACTM Vol-II part-II (ETI/PSI/120(2/91)) clearly states the earthing arrangements of LA at TSS, SSP/SP which should be followed.

4.2 Higher grounding resistance causes large voltage drop when lightning discharge current passes through it thereby stressing the insulation voltage withstand capabilities of Surge arrester.

4.2.1 The length of HV and earth connection leads need to be short and as straight as practical in order to minimize the loop inductance and ensure minimum voltage drop across the leads. The inherent resistive and inductive impedance in the leads increases the effective residual voltage seen by the equipment being protected. This issue is particularly sensitive for protection from fast-front over voltages. Therefore it is important to keep these lead lengths short and free of inductive loops.

4.3 The cross-sectional area of the connecting leads is determined more by mechanical than by electrical requirements. Due to the very short time of discharge current flow, power or energy consumption in the conductor plays lesser role even though the currents may be high. If LA's are placed on an insulating base (as recommended in RDSO specification for Traction Installation also) then it is connected to earth by a 35 mm^2, 1100 volts grade, unarmored PVC insulated copper cable This arrangement has got advantage of measurement of leakage currents for condition monitoring however this lead introduces an inductance in to the lightning discharge circuit.

4.4 In Railway traction installations like SP, SSP and AT's where LA's are fitted on gantries & masts, length and connection of grounding leads is very important

4.5 Maximum permissible earthing resistance at AT locations is 10 Ω as compared to 0.5 & 2 Ω at TSS & SP/SSP.

It is therefore recommended that if it is decided to provide LA at AT location then a separate earthing pit should be provided and LA earthing lead should be directly connected to this independent earthing and bonding it to the earthing arrangement at AT location as per Para 11 of the Code for Earthing Traction Power Supply Installation" vide Appendix III of ACTM Vol-II part-II (ETI/PSI/120(2/91)) to achieve earthing resistance comparable to SP/SSP.

4.6 While storing and transporting Lightning Arresters it should be ensured that these are kept vertical with porcelain sheds pointing downwards to prevent any ingress of moisture inside. In any case, the precautions specified by the manufacturer for transportation and storage should strictly be followed as porcelain-housed arresters are very sensitive to transportation stress, which often represents the highest mechanical stress during an arrester's lifetime.

5.0 Failure investigation of the Lightning Arresters

A format recommended for failure investigation of LA's is given below:

	Check points	Remarks
1	Location of LA (TSS/SP/SSP or at AT)	• Check that there are no repeated failures from same location. If so check earthing and connections to LA.
2	Weather conditions at the time of LA failure	• Most of the LA failures occur during rainy (lightning) season however failure even during dry conditions must be jointly recorded with the manufacturer.
3	Make & year of manufacturing and commissioning	• Ascertain age of LA, compare from codal life. • Repeated failures of one particular make, batch of LA's. Report to manufacturer & CORE/Ald. • Failure immediately after installation may be either due to poor quality of LA or installation related issues.
4	Earthing Resistance at the point where LA's earth terminal is connected	• Check from records & whether it is a high earth resistance area. Any special efforts done to reduce earth resistance.
5	Length of Earthing lead from LA's to Earth terminal	• Connections should be as short as possible.
6	Size/cross section of Earthing conductor used as earthing lead for LA's	• As per LA specifications and Para 7.6 & 8.3.3 of Code for Earthing Traction Power Supply Installation" vide Appendix III of ACTM Vol-II part-II (ETI/PSI/120(2/91)).
7	Distance of LA's from earth terminal	• Connections to earth should be as short as possible.
8	Distance of failed LA at SP/SSP from TSS	• LA's at SP/SSP are practically protecting OHE.
9	Last values of following measurements (i) Total leakage current of LA (ii) Resistive leakage current. (iii) Surge counter readings	• Check for any trends of deterioration in condition of LA. • Review the threshold (limiting values) of resistive leakage current for replacement.

10	Any flash mark observed at the site on LA/Mast etc.	• Signs of a direct lightning strike on or near the LA location.
11	Bonding condition (whether any flash mark observed)	• Signs of a direct lightning strike on or near the LA location.
12	Whether LA was with or without insulating base	• It is important to have a proper connecting lead for LA's with insulating base.
13	Whether burst or simply earth	• Cases of LA bursting indicate failure of its pressure relief mechanism & should therefore be informed or recorded in the joint minutes with the manufacturer. • Instead of bursting of housing, opening of the top cover indicates that its pressure relief mechanism worked.
14	Any flashing marks on the outer surface of the porcelain LA housing	• Check record of cleaning done on housing.
15	Condition of its electrical terminal connections at top (live) & bottom (to earth/surge counter/leakage current meter)	• Look for any breakage, flashing signs.
16	Joint report with the manufacturer	• If failed LA is not burst then break open it in presence of manufacturer and check signs of water leakage up to MO blocks and damage/condition of MO blocks.

टेलीफोन 2465763(क)
फैक्स 91&0522&2465763
Telephone : 2465764 (O)
Fax DOT : 91-0522-2465763
E-mail : dti3@rdso.railnet.gov.in

सत्यमेव जयते

भारत सरकार रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
मानक नगर,लखनऊ – 226 011
Government of India, Ministry of Railways
Research Designs & Standards Organisation
Manak Nagar, Lucknow – 226 011

TI/PSI/DRG/TSS-SPC/POLICY/11 Dated, the 3rd April, 2013

To,
The Chief Electrical Engineer,
All Zonal Railways.

Sub: Special Maintenance Instruction No. TI/SMI/0031, for setting up Earthing Station at Switching Posts (SSP & SP)
Ref: Item No. 337 of 58th ESC meeting held at Jaipur

Augmentation of Earthing & Bonding Practices (Item No. 337) was discussed & deliberated in the 58th Electrical Standards Committee Meeting held at North Western Railway, Jaipur on 28 & 29.09.2012. It was decided to strengthen the Earthing system.

2. In existing Earthing system, there are no direct earth connections between rail and earth, except at the Feeding posts. The design philosophy assumes that the Rails are naturally at ground potential and the structures get earthed by connecting to Rails.

Present connection at Feeding Post has been described in the RDSO's Drawing No. ETI/PSI/203 for 'Typical Earthing Layout of a Feeding Station'.

2. The immediate concerns arising out of this arrangement are the rising of Rail potentials which affect efficacy of existing protection scheme leading to unsafe Rail system.

It was decided to create Earthing Stations at about 10 km separation to create positive, strong and deliberate 'maintenance free Earth connection' to improve system resilience.

3. Accordingly a trial was conducted at Lucknow SSP in Lucknow Division of Northern Railway with maintenance free Earth Electrodes, Earth conductivity enhancement material (non-leachable, non-corrosive, environmentally benign), Special fastening system. The Bond between Buried Rail and Earth Electrodes have been made using exothermic weld for achieving better rail to earth connectivity.

4. Special Maintenance Instruction No. TI/SMI/0031, covering methodology to create Earth Station, at Switching Posts (SSP & SP) has been prepared and is being issued for the use of Zonal Railways as well as Electrification Projects.

5. It is advised to implement the subject 'Special Maintenance Instruction', in a time bound manner, as it is essentially required for the safety of OHE Equipment and human being working near the electrified track.

Encl. As stated above.

3.4.2013
(J. N. Lal)
Director General (TI)

033.

uf

सत्यमेव जयते

Government of India
Ministry of Railways

SPECIAL MAINTENANCE INSTRUCTION

No. TI/SMI/0031

SETTING UP EARTHING STATION

AT

SWITCHING POSTS

(SSP & SP)

Research Designs & Standards Organisation
Manak Nagar,
Lucknow – 226011.

April, 2013

SPECIAL MAINTENANCE INSTRUCTION

FOR

SETTING UP EARTHING STATION

AT

SWITCHING POSTS (SSP & SP)

1.0 INTRODUCTION

With advances in track technology the Rail is no longer at ground potential which has been the assumption of existing Earthing Code ETI/PSI/120 & ETI/OHE/71. The structures have been conventionally bonded to the Rail with belief that the structure would be grounded through the Rail. Whereas, now Rail sees earth through the structures many-a-times with increasing rail-formation insulation.

The immediate concerns which arise are the rising of Rail potentials, affect on the efficacy of existing protection scheme and safety of Rail vehicles.

Thus, it was decided to create Earthing stations at about 10 km separation (for sake of convenience, this can be sited close to Switching Posts). Idea is to create positive, strong and deliberate maintenance free earth connection to improve system resilience.

58th Electrical Standards Committee Meeting held at North Western Railway, Jaipur. Item No. 337 on the subject `Augmentation of Earthing & Bonding Practices' identified need of strengthening the Earthing system. It was deliberated in length.

Accordingly, a trial was conducted at Lucknow SSP in Lucknow Division of Northern Railway (during January, 2013) with standard maintenance free components to create the Earthing Station, to verify the practicality of instructions. Drawings prepared at RDSO by the Traction Installations Directorate, using components, extant practices and documents.

2.0 REFERRED DOCUMENTS

2.1 Signal Specification for maintenance free Earthing System: RDSO/SPN/197 2008.

2.2 Specification for Exothermic Welding of Traction Installation Directorate: TI/PSI/OHE/EXOTHRMBOND/0100 (04/10)

2.3 Earthing and Bonding Code No. ETI/PSI/120 & ETI/OHE/71.

2.4 RDSO Drawing No: ETI/PSI/0212-1 for buried rail.

2.5 Existing Arrangement for Earthing the Tracks

There are no direct earth connections except at the Feeding posts. The design philosophy *assumes* that the Rails are naturally at ground potential and the structures get earthed by connection to the Rails.

Present connection at Feeding Post has been described in ETI/PSI/203. It is seen that following are main components of the present Feeding Post Earthing Station.

2.5.1 BURIED RAIL
Acts as maintenance free Earth Bus.

2.5.2 EARTHGRID
Connects various ground Electrodes and reduces the possibility of higher Step Potential.

2.5.3 EARTH ELECTRODES

Couple the Buried Rail to parent earth and hence bring it to earth potential.

It may be noted that in conventional electrification which uses a running Rail for return circuit, one end of Transformer's secondary is connected to this Earthing system, thereby making full traction current flow through this system. It may be further noted that full load current would not necessarily take:

Running Rail>Buried Rail>Transformer.

Some current can as well get to the transformer from

Earth Electrode>Earth Grid>Transformer.

For Single Wire Earth Return Circuits (SWER), to which conventional electrification deployed on IR belongs, good galvanic coupling with parent earth is a pre-requisite. Unfortunately, the continued dependence on mild-steel Electrodes, even though galvanised, places infrastructure in precarious position, as life of conventional Electrode is usually below ten years. It is hence imperative to move to solutions which are inherently maintenance free. Further, salt/charcoal mix leaches out easily, reducing soil conductivity drastically with passage of time. Thus it can be noted that Electrode corrodes fast and conductivity enhancement material also leaches out after some time.

It is hence imperative to use Electrode system which can last for 40-50 years and earth conductivity enhancement material which does not leach and is environmentally benign.

Thus, all new works must veer towards maintenance free components which meet practical operating and ambient conditions.

3.0 DESIGN OF THE EARTHING STATION

Two Earthing Stations in front of Switching Station, one either side of the UP and Dn track, shall be provided for. This has been done to reduce the length of the flats connecting the running Rails to Buried Rail.

3.1 GENERAL ARRANGEMENT

13 meters Long released Rail is used to create an Earth station. Two maintenance free Earth Electrodes with Earth conductivity enhancement material (non-leachable, non-corrosive, environmentally benign) shall be provided at each end of the Rail. Thus the Buried Rail would be configured as Earth Bus.

3.2 DESIGN

It is noted that -

- Conventional MS Fasteners fail to provide maintenance free and low resistance, durable connections and are prone to relatively faster corrosion.

- Special fastening systems which use Tinned Copper Bush are maintenance free, with low contact resistance, corrosion resistant, lesser prone to loosening due to vibration, higher productivity and ease of use, are now widely used in advanced Railways like German National Railways (Deutsche Bahn) and SNCF (French Railways), besides Bangalore Metro and other major Railroads & Metros. Such systems have already been adopted by Signal Department on Indian Railways for about 2-3 years (can be studied on AFTC Project being executed by IRPMU and North Central Railway).

  It is, hence ,decided to use such fastening systems for design of maintenance free Earth Stations.

3.2.1. A trench, of size about 0.6 m x 15 m, with a depth of about 1 m from the ground level is dug on the track side.

3.2.2. At a distance of about 1.5 meters from either ends of the Buried Rail, two holes are drilled.

3.2.3. At a distance of approximately 200 mm, Earth pits are dug on either end, Maintenance Free Earthing is provided as described in RDSO's Drawing No. TI/DRG/PSI/E.STN/00001/13/0.

3.2.4 Preparation of Earth Bus

Holes are drilled in the Rail (to be used as Buried Rail) using Rail drilling machine (as mentioned in the Railway Board letter no. 2006/RE/220/1 dated 28.04.2008 for High Productivity Tools). A tinned Copper Bush (one end with Flange) is inserted in these holes. After insertion of the Bush, with appropriate tool, free end of the Bush is swaged so that the Bush takes shape of a hollow Rivet and gets in permanent electrical contact.

(ii) The Rail, duly prepared, is lowered in to the trench.

(iii) The Electrodes are exothermically welded to the Rail as described in RDSO's Drawing No. TI/DRG/PSI/E.STN/00001/13/0.

(iv) 19 mm holes are drilled on the web of running Rail and tinned Copper Bushes provided as on the Buried Rail.

(v) Connections between the running Rail and the Buried Rail are made with two GI Flats of size 50 x 6mm. interconnecting between the main running rail and a 13 m. section of Buried Rail on the track side, as per RDSO's Drawing no. TI/DRG/PSI/E. STN/00001/13/0.

The connection between the Buried Rail and Earth Electrodes of respective Earth Pits on both sides is done through 50 x 6 mm GI flat by using Exothermic weld.

3.3 RESULTS

3.3.1 TRACK NORTH SIDE

Soil resistivity 33.96 Ω meter.

Sl.No.	Description	Earth resistance value
1.	Resistance of Running track without Earthing station	2.47 Ω
2	Resistance of Earth Pit	2.69 Ω
3.	Resistance of Running track with connection of the Buried Rail	1.36 Ω
4.	Resistance of Running track with connection of both end Buried Rail	1.36 Ω

3.3.2 TRACK SOUTH SIDE

Soil Resistivity 23.55 Ω meter.

Sl.No.	Description	Earth Resistance value
1.	Resistance of Running track without connection Earthing station	1.55 Ω
2.	Resistance of Earth Pit	2.48 Ω
3.	Resistance of Running track with connection of the Buried Rail	1.09 Ω

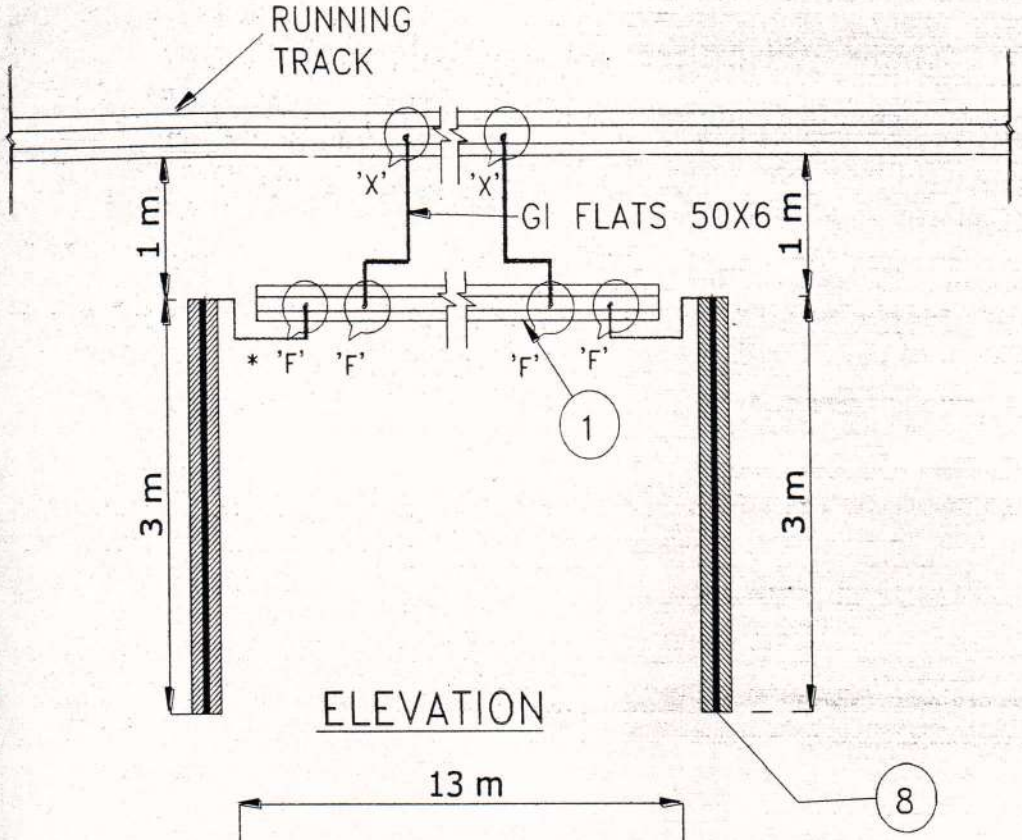
4.	Resistance of Running track with connection of both end Buried Rail	1.04 Ω

Equipment used for measurement of Earth resistance M/s FLUKE make Advance Earth/ Ground Tester Model 1625 (Calibration status: valid up to 17.12.2013).

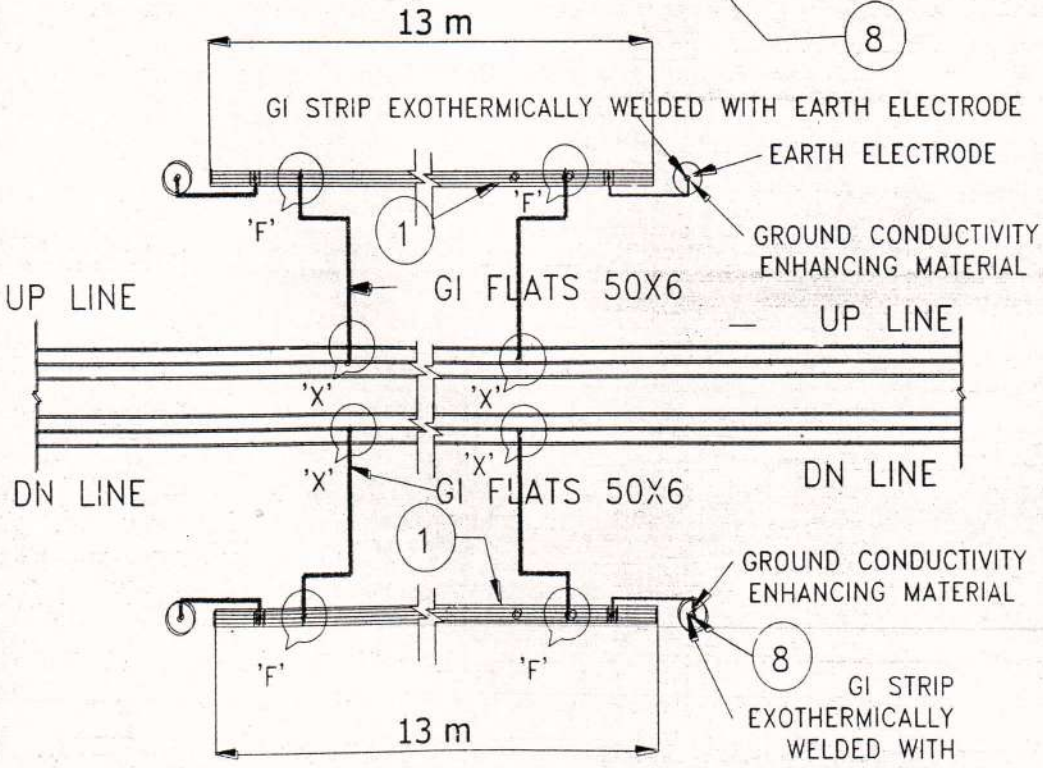
*****

(* FOR DETAILS 'X' KINDLY REFER SH 2/4 (PAGE 9/11) OF SMI No. TI/SMI/0031)

(* FOR DETAILS 'F' KINDLY REFER RDSO DRAWING No. ETI/PSI/0212-1)

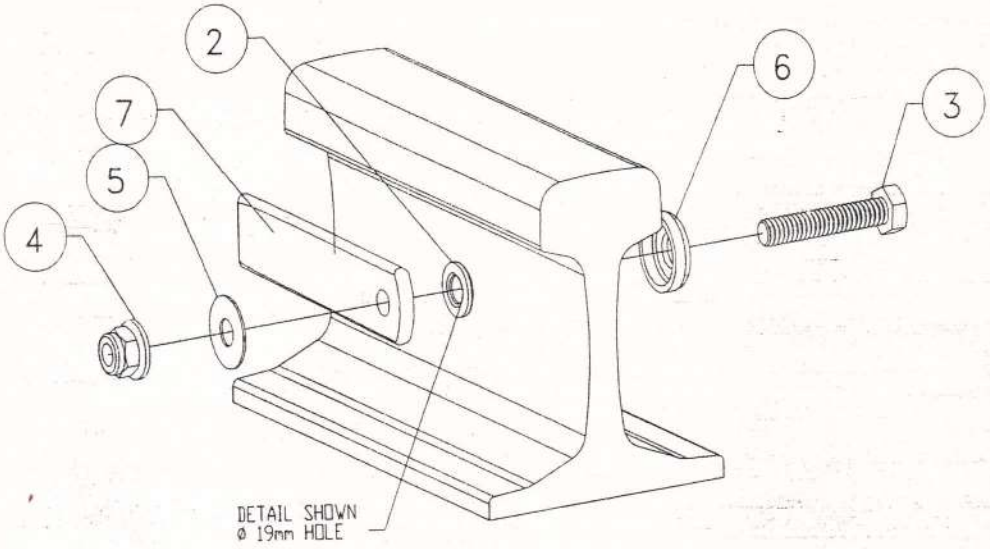


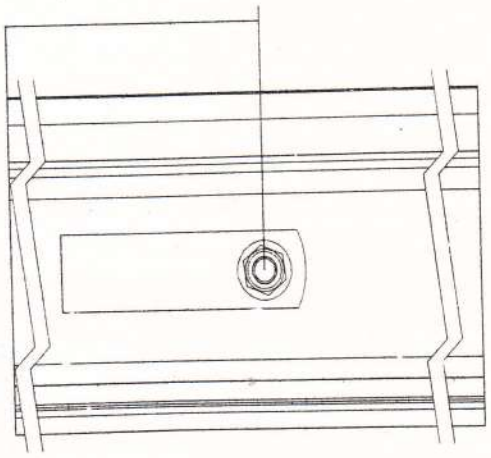
ELEVATION

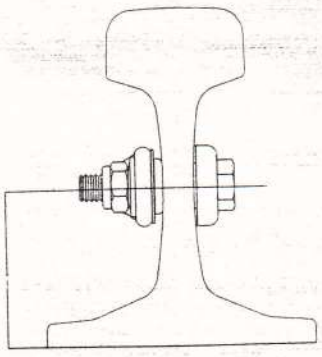


PLAN

TI/DRG/PSI/E.STN/00001/13/0 | SH 1/4







DETAIL OF X

NOTES:-

THE SYSTEM HAVE FOLLOWING BROAD COMPONENTS

1.0 RAIL CONTACT SYSTEM (FASTENING)

1.1 RAIL CONTACT SYSTEM SHALL BE IN LINE WITH THE DRAWING;VARIATIONS NEEDED TO MEET SPECIFIC REQUIREMENTS ARE ACCEPTABLE AS LONG AS DESIGN PHILOSOPHY REMAINS THE SAME.

1.2 ALL COMPONENT OF RAIL CONTACT SYSTEM SHALL BE PROCURED FROM THE SAME VENDOR. RAIL CONTACT SYSTEM SHOULD HAVE BEEN USED SUCCESSFULLY FOR SIIGNAL OR TRACTION APPLICATIONS ON A RAILWAY AND CERTIFICATE TO BE AVAILABLE.

1.3 RAIL CONTACT SYSTEM SHOULD HAVE BEEN EVALUATED FOR USE IN HIGH VIBRATION CONDITIONS.

1.4 CONTACT TO HAVE BEEN TESTED FOR SHORT CIRCUIT WITHSTAND ABILITY OF AT LEAST 6000 A AVERAGE CURRENT FOR 10 CYCLES (200 MS).

1.5 CONTACT RESISTANCE REQUIRED IS 5 MICRO OHMS.

1.6 SALT MIST TEST AS PER APPROPRIATE INTERNATIONAL STANDARD TO BE CARRIED ON THE RAIL CONTACT SYSTEM

2.0 EARTHING SYSTEM

THE EARTH ELECTRODE SHALL BE MADE OF HIGH TENSILE LOW CARBON STEEL CIRCULAR RODS, MOLECULARLY BONDED WITH COPPER ON OUTER SURFACE TO MEET THE REQUIREMENTS OF UNDERWRITERS LABORATORIES (UL) 467-2007 OR LATEST. SUCH COPPER BONDED STEEL CORED ROD IS PREFERRED DUE TO ITS OVERALL COMBINATION OF STRENGTH, CORROSION RESISTANCE, LOW RESISTANCE PATH TO EARTH AND COST EFFECTIVENESS.

2.1 THE EARTH ELECTRODE SHALL BE UL LISTED AND OF MINIMUM 17.0 MM DIAMETER AND MINIMUM 3.0 MTRS. LONG.

2.2 THE MINIMUM COPPER BONDING THICKNESS SHALL BE OF 250 MICRONS.

2.3 MARKING: UL MARKING, MANUFACTURER'S NAME OR TRADE NAME, LENGTH, DIAMETER, CATALOGUE NUMBER MUST BE PUNCHED ON EVERY EARTH ELECTRODE.

2.4 EARTH ELECTRODE CAN BE VISUALLY INSPECTED, CHECKED FOR DIMENSIONS AND THICKNESS OF COPPER COATING USING MICRON GAUGE. THE SUPPLIER SHALL ARRANGE FOR SUCH INSPECTION AT THE TIME OF SUPPLY, IF SO DESIRED. (SPECIFICATION OF SIGNAL DIRECTORATE, RDSO's SPECIFICATION No. RDSO/SPN197 2008 CAN BE REFERRED)

3.0 CONDUCTIVITY ENHANCEMENT MATERIAL

EARTH ENHANCEMENT MATERIAL IS A SUPERIOR CONDUCTIVE MATERIAL THAT IMPROVES EARTHING EFFECTIVENESS, ESPECIALLY IN AREAS OF POOR CONDUCTIVITY (ROCKY GROUND, AREAS OF MOISTURE VARIATION, SANDY SOILS ETC.). IT IMPROVES CONDUCTIVITY OF THE EARTH ELECTRODE AND GROUND CONTACT AREA. IT SHALL HAVE FOLLOWING CHARACTERISTICS-

3.1 SHALL MAINLY CONSIST OF GRAPHITE AND PORTLAND CEMENT. BENTONITE CONTENT SHALL BE NEGLIGIBLE.

3.2 SHALL HAVE HIGH CONDUCTIVITY, IMPROVES EARTH'S ABSORBING POWER AND HUMIDITY RETENTION CAPABILITY.

3.3 SHALL BE NON-CORROSIVE IN NATURE HAVING LOW WATER SOLUBILITY BUT HIGHLY HYGROSCOPIC.

3.4 SHALL HAVE RESISTIVITY OF LESS THAN 0.2 OHMS-METER. RESISTIVITY SHALL BE TESTED BY MAKING A 20 CM. CUBE OF THE MATERIAL AND CHECKING RESISTANCE OF THE CUBE AT THE ENDS. THE SUPPLIER SHALL ARRANGE FOR SUCH TESTING AT THE TIME OF SUPPLY, IF SO DESIRED. NECESSARY CERTIFICATE FROM NATIONAL/INTERNATIONAL LAB FOR THE RESISTIVITY SHALL ALSO BE SUBMITTED.

3.5 SHALL BE SUITABLE FOR INSTALLATION IN DRY FORM OR IN A SLURRY FORM.

3.6 SHALL NOT DEPEND ON THE CONTINUOUS PRESENCE OF WATER TO MAINTAIN ITS CONDUCTIVITY.

3.7 SHALL BE PERMANENT & MAINTENANCE FREE AND IN ITS "SET FORM", MAINTAINS CONSTANT EARTH RESISTANCE WITH TIME.

3.8 SHALL BE THERMALLY STABLE BETWEEN -10° C TO +60° C AMBIENT TEMPERATURES.

3.9 SHALL NOT DISSOLVE, DECOMPOSE OR LEACH OUT WITH TIME.

3.10 SHALL NOT REQUIRE PERIODIC CHARGING TREATMENT NOR REPLACEMENT AND MAINTENANCE.

3.11 SHALL BE SUITABLE FOR ANY KIND OF ELECTRODE AND ALL KINDS OF SOILS OF DIFFERENT RESISTIVITY.

3.12 SHALL NOT POLLUTE THE SOIL OR LOCAL WATER TABLE AND MEETS ENVIRONMENTAL FRIENDLY REQUIREMENTS FOR LANDFILL.

3.13 SHALL NOT BE EXPLOSIVE.

3.14 SHALL NOT CAUSE BURNS, IRRITATION TO EYE, SKIN ETC.

3.15 MARKING: THE EARTH ENHANCEMENT MATERIAL SHALL BE SUPPLIED IN SEALED, MOISTURE PROOFS BAGS. THESE BAGS SHALL BE MARKED WITH MANUFACTURER'S NAME OR TRADE NAME, QUANTITY ETC. (SPECIFICATION OF SIGNAL DIRECTORATE, RDSO's SPECIFICATION No. RDSO/SPN197 2008 CAN BE REFERRED).

4.0 FOR BURIED RAIL DRAWING No.ETI/PSI/0212-1 TO BE REFERRED.

5.0 EXOTHERMIC WELDING TO BE DONE ACCORDANCE WITH TI/PSI/OHE/EXOTHRMBOND/0100(04/10). IT IS PREPARED TO USE REMOTE IGNITION SYSTEM FOR PERSONNEL SAFETY.

6.0 COMPONENTS FOR ITEMS AT 2.0, 3.0 AND 5.0 TO BE PROCURED FROM SAME VENDOR TO ENSURE CONSISTENCY IN QUALITY.

REF.	DESCRIPTION	QUANTITY	REMARKS
1.	13M LONG RAIL (52kg OR 60kg AS AVAILABLE)	2 Nos.	
2.	TIN PLATED COPPER BUSHES	4 Nos.	
3.	M-12 BOLTS (STAINLESS STEEL)	4 Nos.	
4.	NUTS	4 Nos.	
5.	PLAIN WASHER	4 Nos.	
6.	LOCK WASHER (SPRING STEEL)	4 Nos.	
7.	GALVANIZED IRON FLAT SIZE OF 50X6 MM	28 m	
8.	COPPER BONDED CARBON STEEL EARTH ELECTRODE Ø 17.2 mm, 3 m LONG	4 Nos.	

SCHEDULE OF MATERIAL FOR MARKED 'F' (REFER RDSO DRAWING No. ETI/PSI/0212-1

REF.	DESCRIPTION	QUANTITY	REMARKS
1.	20 Ø COPPER RIVET	16 Nos.	
2.	M-16 BOLTS HRH 210/45 COMPLETE WITH 1 NUT, 1 LOCK NUT AND 1 FLAT WASHER	8 Nos.	

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

DRAWING FOR TYPICAL EARTHING STATION AT SWITCHING POST (SSP AND SP)

DTI/PSI 3.4.13

ADE/PSI 03.04.2013

REF:-

CROSS REF:-

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.	3.4.2013	
TC.		
CK.		

TI/DRG/PSI/E.STN/00001/13/0

SCALE:- N.T.S

SUB SCALE:-

SUB SCALE:-

SH 4/4

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS



सत्यमेव जयते

TECHNICAL INSTRUCTION NO. TI/IN/0035

Technical Instruction for Testing of OHE structure's Foundation

September, 2017

ISSUED BY

TRACTION INSTALLATION DIRECTORATE
RESEARCH DESIGNS AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW – 226011

	Prepared By	Checked By		Approved By
Signature				
Date	15.9.17	15.09.2017	15.09.2017	15/9/2017
Designation	SSE/TI-CIVIL	Dir./TI-CIVIL	Dir./TI-OHE	Sr.ED/TI

1.0 Scope:

1.1 In order to validate the design of OHE structure's Foundation this Technical Instructions based on IEC 1773-1996 & additional requirements has been prepared. This Technical Instruction will be applicable for testing of new design of OHE Structure's foundations. OHE structure may be installed either with grouting in core hole or erected with base plate.

1.2 This instruction is not applicable for the following clauses of IEC-1773

(i) Clause 4.1(a): To verify design methodologies.
(ii) Clause 4.1(b): To verify construction procedures.
(iii) Clause 4.1(c): To established geotechnical design parameter and/or a design methodology for a specific application.
(iv) Clause 4.1(e): To determine the average failure load and coefficient of variation of the design type in specified soil conditions.
(v) Clause 4.1.2: Reduced scale tests

2.0 Background: Indian Railway have been using parallelepiped type side bearing, side gravity, Pure gravity, dry black cotton and wet black cotton soil foundation etc. Recently RDSO has developed design of cylindrical type of foundations as an alternative to conventional side bearing & side gravity and also developed design of foundation on rock soil.

Validation of the new design of foundations is required by conducting load test.

3.0 Objective: The objective of this document is to frame instructions for testing of new design OHE mast foundation as per IEC 1773-1996 (herewith after mentioned as IEC -1773). IEC 1773 provide procedures which apply to the investigation of the load carrying capacity and/ or the load response (Settlement or tilt) of the foundation as an interaction between the foundation and the surrounding soil. In additional to this, test for crack in the foundation, angular rotation of the foundation and test with broken wire condition are included.

4.0 Minimum Requirement for the Testing of OHE Mast foundation as per RDSO design of foundation:

(a) Foundation will be casted as per relevant RDSO drawing.
(b) Foundation is projected above the ground level as per the concern drawing.
(c) Depth of loose soil 500mm below the ground level will be considered as ineffective depth.

5.0 Instructions: IEC -1773 should be complied. However, following clauses of IEC-1773 are brought out specifically for complying during the tests and relevant record of the same shall be made part of the test preparation plan and find test report:

SN	Clause no. of IEC 1773-1996	Heading
I	Clause 4	Categories of tests (Note: Clause 1.2 above)
II	Clause 5	Geotechnical data
III	Clause 6	Foundation Installation
IV	Clause 7	Test Equipment. It includes following: (i) Clause 7.1: Load application, Special note should be taken for Safety measure as per last Para of Clause 7.1

		(ii) Clause 7.2 : Test loading arrangement (iii) Clause 7.3:Reference Beam- Design test (iv) Clause 7.4: Displacement measurement device- Design test (v) Clause 7.6: Calibration of measuring instruments
V	Clause 8	Test procedures. It includes following: (I) Clause 8.1: Number of Test shall be decided by Railway Authority (ii) Clause 8.3: Loading procedure, as per Table 1 (Loading schedule) shall be complied however, Note given under table-1 will also be applicable .Test loading shall be done up to as agreed by the Railway Authority. Bending Moment and SBC reference shall be considered as per the relevant RDSO drawings. (iii) Test recording: Each test shall be recorded in a typical format of table D.1 of ANNEX-D of IEC 1773 and ANNEX A, B & C as attached herewith. (iv) The record of design test shall be as per sub clause 8.4.1 of IEC - 1773
VI	Clause 9	Test evaluation
VII	Clause 10	Acceptance criteria
VIII	clause 11	Test report

6.0 Acceptance Criteria of settlement of foundation: Compliance of the settlement value of foundation should not exceed the maximum permissible value of 5mm.

7.0 Test requirement and acceptance criterion for test of crack: Crack in foundation shall be checked by normal magnifying glass as below:

(a) At each stage of loading, observation for cracks on the surface of the foundation would be made. To have proper observation of any crack a thin layer of Plaster of Paris would be applied on the top of the foundation. The detail of the crack i.e. Length, width and location would be recorded.

(b) Observe the separation of the mast from the core concrete with respect to zero load.

(c) Observe, if any failure of the mast or the foundation.

(d) Observe, if any, heaving of the soil around the foundation.

(e) For the purpose of acceptance criteria, non-appearance of any crack or excessive strains in concrete or no failure of the mast up to 2D(2xDesign load) at least 3 samples. In case one of the 3 samples fails, repeat test would be done for 2 more samples in the repeat test shall pass. Appearance of any hair cracks which closes on the removal of the load will be considered as a crack since it is foundation; it may permit the entry of water.

8.0 Test requirement and acceptance criteria for test of broken wire condition: For broken wire condition for 2500 kg, 1.25x2500=3125 kg, 1.5x2500=3750 kg impact of sudden load considered for testing. Passing criteria as per 6.0 & 7.0 should be complied.

9.0 Test requirement and acceptance criteria for test of Tilting or inclination: In case of tilting or inclination, considered permissible limit is 0.2 degree and tilting shall be restore back after removal of imposed load. Passing criteria includes above clause 7.0 also.

10.0 Test requirement and acceptance criteria for test of rotation: Test of rotation about vertical axis of the foundation should not exceed 1degree.

11.0 Testing Report of Safe bearing Capacity: Following parameters shall be mentioned:

(a) Safe bearing capacity of soil shall be calculated as plate load test given IS: 1888-2002 (Method of load test on soil).

(b) If soil fails, in shear before 50mm settlement, then ultimate bearing capacity, safe bearing capacity including factor of safety (minimum 2.5),and value of settlement on which soil is failed in shear shall be mentioned. The value of settlement on which safe bearing capacity of soil has been determine shall be mentioned.

(c) If soil fails in shear after 50mm settlement, then ultimate bearing capacity in shear & safe bearing capacity including factor of safety (minimum 2.5) and the safe bearing capacity of soil on the basis of settlement shall be mentioned. The value of settlement on which safe bearing capacity of soil has been determine shall be mentioned.

(d) The calculation as per the formula for footing settlement, figures drawn base on the referred figure-5 & figure-6mantioned in the clause 5.2 and 5.3 of IS: 1888-2002 shall be made part of the test report.

(e) During testing of foundation value of settlement which arises during determination of safe bearing capacity of soil should not exceed the limit.

(f) The value of safe bearing capacity shall be determine on the basis of least value of two criteria (i) shear failure of soil (ii) settlement of foundation.

12.0 Any deviation from this Technical Instruction & IEC 1773 shall be brought out by the test executing authority acceptance of deviation shall be by competent Railway Authority.

13.0 After conducting the above mentioned test the design shall be reviewed with respect to the test result obtained at site by competent authority.

14.0 Codal Reference: The followings IS Codes and standard railway manuals are referred for prepared this document.

(a) IEC1773 Code for practice for Overhead lines – Testing of foundation for structures.

(b) IS 1904—1986- Code of practice for Design and construction of foundation in soil (Settlement check criteria)

(c) IS 8009-1998- Code of practice for calculation of settlement of foundation

(d) IS 6403-1997 –Code of practice for Determination of bearing capacity of shallow foundation (SPT calculation)

(e) IS: 1888-2002 (Method of Load Test on soil)

Test recording form

ANNEX –A

Location				Date														Drawing reference			
Foundation Type				Test Foundation No.																	
					Foundation Displacement													Inclination Observed by instrument "Total station"		Rotation Observed by Instrument "Total station"	
% of total load	Clock time	Elapsed time	Required load	Dynamometer	Load side				Track side				Along the track								
					Gauge 1		Gauge 2		Gauge 3		Gauge 4		Gauge 5		Gauge 6						
					Initial Reading		Initial Reading		Initial Reading		Initial Reading		Initial Reading		Initial Reading						
		min	kN	kN	Reading 1	change	Reading 2	change	Reading 3	change	Reading 4	change	Reading 5	change	Reading 6	change					
																	Reading Before Commencement of Load test	Change	Reading Before Commencement of Load test	Change
0																					
25																					
50																					
70																					
80																					
90																					
100																					
150																					
0																					
Settlement as per clause 6.0																					

Typical test recording form for Brocken wire Condition

ANNEX –B

Conclusion of load testing

ANNEX –C

Conclusion of Load Testing of Mock up Foundations																
S.No.	IR Chainage Location	Applicable Drawing	Type of Area	Depth of Foundation (m)	Load Considerations		Observation on Tilt of Foundation by Dial Gauge Arrangement								Inclination observed by Total Station	
							Maximum Horizontal change in readings observed by Dial Gauges (at Load % of Approved Designed load)				Maximum Vertical Change in Readings observed by Dial Gauges (at load % of Approved Designed load)				Maximum Inclination Observed	
							At 120% Load		At 130% Load		At 100% Load		At 150% load		Initial Value	Final Value
					Designed Load P (in Kg/KN)		Value (in mm)	Direction of Movement	Value (in mm)	Direction of Movement	Value (in mm)	Direction of Movement	Value (in mm)	Direction of Movement	at 0% Load	at 150% Load

Settlement is calculated as : (Final level at 150% load) - (Initial level at 0% load)

If the value is positive(+),it indicates that the foundation has settled down and if it is negative (-)value,it indicates that the foundation has lifted up.

दक्षिण मध्य रेलवे
SOUTH CENTRAL RAILWAY

मु.वि.इं.कार्यालय CEE's Office,
चौ.मं.,'सी'.ब्लॉक. 4th Floor, 'C' Block'
रेल निलयम 'Rail Nilayam',
सिकंदरावाद Secunderabad - 071.

सं. ई .**No.E.220 /TRD / MI-SMI/ Vol.V.** दि. **Dt:25.03.2019.**

Sr.DEE/TRD/BZA, SC,
Sr.DEE/TR/GTL, HYB,
Sr.DEE/GNT.

विषय:**Sub**: Technical Instruction " TI/IN/ 0038" for Earthing on various type of bridges.
संदर्भ:**Ref**: RDSO letter No: TI/ CIV/ MS/ 2019.; Dt: 19-03-2019.

****

A copy of RDSO letter under reference on the above subject matter is enclosed herwith for information and necessary action.

संलग्न Encl : जैसा कि ऊपर As above.

25/3/19

(आर.वी. वी सुब्रमण्यम)
(R.V. V.SUBRAHMANYAM)
सहायक कार्यकारी विधुत इंजीनियर/क.वि./प्र.का
AEEE/TrD/HQ
For Principal Chief Elec. Engineer.

S.No. 33

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

सत्यमेव जयते

TECHNICAL INSTRUCTION NO. TI/IN/0038

Technical Instruction for Earthing practices on various types of Bridges

February, 2019

Jointly Issued By

TRACTION INSTALLATION DIRECTORATE
&
BRIDGE & STRUCTURE DIRECTORATE

RESEARCH DESIGNS AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW – 226011

	Prepared By		Checked By			Approved By
Signature						
Date	28.2.19		28.02.2019	28-02-19	8/3/19	2/3/19
Designation	SSE/TI-CIVIL	SSE/B&S	DTI-C	DTI-2	Dir/B&S/SB	PED/TI

Scanned by CamScanner

1.0 **Scope:** Earthing practices to be followed on various types of bridges.

2.0 **Background:** Railway Board, vide letter no 2014/RE/161/19/Vol-I dated 10.09.18 directed RDSO for issuing the comprehensive guidelines for earthing practices on various types of bridges.

3.0 **Objective:** Main objective is to prevent non-standard practices in the field during electrification and maintenance. These guidelines also will be of use by the Railways in granting permission to Electrification agencies & Maintenance Organizations for making connections/ welding/ drilling hole etc on Bridge structures for the purpose of earthing & bonding. It will benefit the Electrification agency for appropriately submitting the proposal to approving authority and getting faster approval.

4.0 **Applicability:** Earthing & Bonding over various types of Bridges.

5.0 **Technical Instructions:** Following guidelines will be applicable for provision of Earthing & Bonding over various type of Bridges:

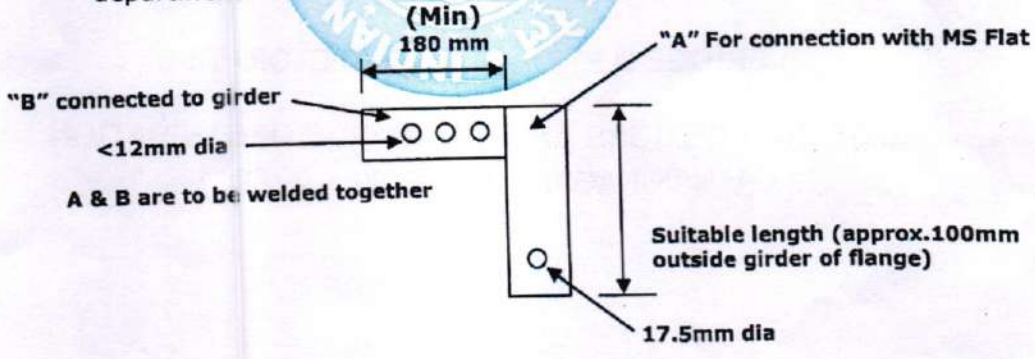
(i) **No holes by gas cutting** shall be made in steel parts of any type of bridges.

(ii) **No holes by any means** shall be made in the web of the steel girder of any type of bridges.

(iii) Following process can done over steel parts of the bridges with the permission of competent authority of engineering department by submitting proposal with sketch:

a. Circular Holes (not more than 12mm in diameter) by **drilling.**

b. **L–shape** steel Part shall be used for weld joint to the steel part of bridges. Welded part shall be painted as per the guidelines of engineering department.



(iv) The attachment through welding or drilling of holes (hole diameter less than 12mm) shall be done in the End-portion of the bridge span beyond the support bearings i.e. the connection/attachment shall not be done within the **effective-span** of the bridge.

(v) Provisions available in the Bridge drawing for Earthling & Bonding connections shall for welding/bolting.

(vi) Earthing & Bonding code shall be implemented.

Scanned by CamScanner

भारत सरकार - रेल मंत्रालय - अनुसंधान अभिकल्प और मानक संगठन,मानकनगर, लखनऊ-226011
Government of India - Ministry of Railways
Research Designs & Standards Organisation, Manak Nagar, Lucknow - 226011

बीएसएनएल/BSNL:91-522-2465731
रेलवे/Railway: 42804, फैक्स/Fax : 91-522-2465731
ईमेल/E-mail: dtiohed.rdso@gmail.com

TI/CIV/MS/2019

Dated: 19.03.2019

To,
Chief Electrical Engineer,

(01) मध्य रेलवे, टरमिनस षियाजी छत्रपति बिल्डिंग, आफिस पार्सल तल–2, मुम्बई–400 001.
(02) पूर्व रेलवे, फेयरली प्लेस, कोलकाता – 700 001.
(03) पूर्व मध्य रेलवे, हाजीपुर, बिहार – 844 101.
(04) पूर्व तटीय रेलवे, भुवनेष्वर, उड़ीसा – 751 017.
(05) उत्तर रेलवे, बढ़ौदा हाउस, नई दिल्ली – 110 001.
(06) उत्तर मध्य रेलवे, इलाहाबाद – 211 033.
(07) उत्तर पूर्व रेलवे, गोरखपुर – 273 001.
(08) उत्तर फ्रांटियर रेलवे, मालेगॉव – 781 011.
(09) उत्तर पष्चिम रेलवे, जयपुर – 302 006.
(10) दक्षिण रेलवे, पार्क टाउन, चेन्नई – 600 003.
(11) दक्षिण पूर्व रेलवे, गार्डनरीच, कोलकाता – 700 043.
(12) दक्षिण पूर्व मध्य रेलवे, बिलासपुर – 495 004.
(13) दक्षिण पष्चिम रेलवे, डीआरएम आफिस, हुबली – 580 020.
(14) पष्चिम रेलवे, चर्चगेट, मुम्बई – 400 020.
(15) पष्चिम मध्य रेलवे, जबलपुर – 482 001.
(16) केन्द्रीय रेल विद्युतीकरण संगठन, 1, नवाब युसुफ रोड, इलाहाबाद – 211 033.
(17) प्रबन्ध निदेषक, कोंकण रेलवे, प्लॉट न0–।।, सीबीडी, बेलापुर भवन, नवी मुम्बई – 400 614.
(18) प्रबन्ध निदेषक, डीएफसीसीआईएल, लिमिटेड, 5वॉ तल, प्रगति मैदान, मेट्रोस्टेषन बिल्डिग कॉम्प्रलेक्स, नई दिल्ली – 100 001.
(19) प्रबन्ध निदेषक, रेल विकास निगम लिमिटेड, प्लॉट न0 25, प्रथम तल, अगस्तकांति भवन, बिकाजीकामा पैलेस, नई दिल्ली – 100 001.
(20) प्रबन्ध निदेषक, इरकॉन साकेत, सी–4, जिलाकेन्द्र, नई दिल्ली – 110 017.
(21) Konkan Railway Corporation Limited, Belapur, Navi Mumbai-400614.

Sub: Technical instruction"TI/IN/0038" for Earthing on various type of bridges.
Ref: Railway Board letter No. 2014/RE/161/19/Vol-1, dated 10.09.2018

As directed by Railway Board vide reference above, comprehensive guideline "Technical Instruction No. TI/IN/0038" for earthing on steel bridges have been prepared jointly by TI and B&S directorate and is hereby issued for RE works. Instructions for RCC/PSC Bridges shall follow.

This is issued with the approval of competent authority.

19/03/2019
(Radhey Shyam)
[निदेशक (क0स0सिविल) /Director(TI/Civil)]
[कृतेमहानिदेशक (क0सं0)/For Director General(TI)]

Copy:- (i) ED/B&S, RDSO- For information please.
(ii) Secretary Railway Electrification (RE) Railway Board , New Delhi-110001
(iii) Secretary (Electrical) Railway Board, New Delhi -110001

CEDE
Useful. Pl send to CORE, RVNL, Constt. & Dize for implementation.
AP 20-3

Scanned by CamScanner

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

सत्यमेव जयते

TECHNICAL INSTRUCTION NO. TI/IN/0039

Technical Instruction for making of non-scheduled holes in steel structures of Traction Installation

January , 2019

ISSUED BY

TRACTION INSTALLATION DIRECTORATE
RESEARCH DESIGNS AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW – 226011

	Prepared By	Checked By		Approved By
Signature				
Date	26-12-2018	26.12.2018	26.12.2018	26.12.18
Designation	SSE/TI-CIVIL	Dir./TI-CIVIL	Dir./TI-OHE	ED/TI

Scanned by CamScanner

1.0 **Scope:** Instructions for non-schedule holes in steel structures of Traction Installation.

2.0 **Background:** CPD/RE/SC informed RDSO regarding non-standard practice of making hole in the portal/TTC leg by drilling or gas cutting.

3.0 **Objective:** To avoid weakening of the structures due to non-standard practices.

4.0 **Instructions:** Instructions for provision of non-schedule holes in steel structures:

(i) Schedule of holes in the steel structure's RDSO drawings comply the requirements of IS: 800. Non-schedule holes can be made in the steel structure subject to the compliance of this IS.

(ii) 'Over size holes' and 'short & long slots holes' as mentioned in IS: 800 are not permitted for making non-schedule hole in steel structures. Only "standard clearance hole" are permitted as per clause 10.2.1 table-19 of IS: 800-2007 specifying the clearances for fastener holes.

(iii) Making holes by hand flame cutting, gas cutting and punching are not permitted.

(iv) Portal upright legs are made of L-angels. Holes are not drilled in these L-angles. A plate having hole is welded for Bond connection. If Bond is to be connected at non-scheduled location, then similar plate (with predrilled hole) should be welded at appropriate place for making bond connection.

(v) Clause 7.3.2 of IS:800-2007, *Effective Sectional Area:* Except as modified in 3.7.2 (Class 4), the gross sectional area shall be taken as the effective sectional area for all compression members fabricated by welding, bolting and riveting so long as the section is semi-compact or better. Holes not fitted with rivets, bolts or pins shall be deducted from gross area to calculate effective sectional area.

(vi) *Clause 8.6.2 of IS:800-2007, Sectional Properties 8.6.2.1 The effective sectional area*: of compression flanges shall be the gross area with deductions for excessive width of plates as specified for compression members and for open holes occurring in a plane perpendicular to the direction of stress at the section being considered (see 8.2.1.4).

(ix) *Clause 10.2.4 of IS: 800-2007, Edge and End Distances 10.2.4.1:* The edge distance is the distance at right angles to the direction of stress from the centre of a hole to the adjacent edge. The end distance is the distance in the direction of stress from the centre of a hole to the end of the element.

(x) *Clause 13.3 of IS: 800-2007, Detail Category*: This clause not applicable.

(xi) *Clause 17.2.4.2 of IS: 800-2007, Punching*: Guideline of punching as per this clause is not applicable. Punching is not permitted.

(xii) 17.5mm Ø hole/holes shall be drilled in channel of TTC upright at a spacing of 200mm or a plate having pre-drilled hole of 17.5mm Ø shall be welded with angles of portal upright for bonding at height of 350mm (approx.) from the top of embedded length.

Scanned by CamScanner

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS



Instruction for cleaning of 25 kV Composite Insulators used in Indian Railways Traction system

No. TI/IN/0040 Rev. '0'

(November, 2019)

ISSUED BY

TRACTION INSTALLATION DIRECTORATE
RESEARCH DESIGNS AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW – 226011

Prepared By	Checked By	Issued By
2.11.19	02/11/19	2.11.19
JE/D/TI	ADE/TI	JDTI-1

1.0 Scope:

This instruction covers the guidelines for cleaning of 25 kV Composite Insulators used in Indian Railways Traction System. By cleaning of Composite Insulator failure on account of external reason may be avoided.

This instruction has been prepared on the basis of comments/suggestions received from the manufactures of Composite Insulators and Zonal Railways.

2.0 Objective:

Composite insulator performs service in OHE system under significantly adverse condition like higher degree of surface contamination including open environmental stresses such as rain, fog/ mist, UV and humidity. Surface contamination adversely affects the electrical properties of Composite Insulators which stimulates external Flashover.

This Instruction will be helpful in avoiding external failure of Composite insulators on account of surface contamination.

3.0 General Instruction:

For cleaning of 25 kV Composite Insulators installed in polluted/heavily polluted area, following schedule shall be followed:

SN.	Type of Insulator	Pollution level	Periodicity
1.	Stay Arm Insulator	Polluted Area/ Heavily Polluted Area	Once in a year
2.	Bracket Tube		
3.	9-Tonne		
4.	Sectioning		

4.0 Method:

(i) Composite Insulator shall be cleaned with DRY SOFT COTTON CLOTH to remove the dust/pollution from the insulator.

(ii) No water, detergents, any solvents and abrasive materials should be used for cleaning as use of such material leads to deterioration of electrical properties thus causing failure.

5.0 Precautions:

Please note that purpose of cleaning of Composite Insulator is only removal of dust/pollutants or any other deposition that adversely affects the electrical properties of Composite Insulators hence Care should be taken that during dry cleaning, the insulator should not be rubbed excessively to make it bright.

***

Prepared By	Checked By	Issued By
2.11.19	02/11/19	2.11.19
JE/D/TI	ADE/TI	JDTI-1

GOVERNMENT OF INDIA

Ministry of Railways

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

INSTRUCTION No. TI/IN/0041

Issued by:

Traction Installation Directorate,

RESEARCH DESIGNS & STANDARDS ORGANISATION,

MANAK NAGAR,

LUCKNOW – 226 011.

(For official use only)

SEPTEMBER, 2020

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

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

i) Normally in tunnels of length more than 750m or where the provision of ATD is difficult.

ii) Where the head room/height of the tunnel is not sufficient for conventional OHE,

iii) Stations/Any other location for improved electrical clearances.

iv) RRCS (Retractable Rigid Conductor-Rail System) can be used in Maintenance Depots, Coal sidings/other sidings for overhead loading under SILO in electrified territory and container handling tracks..

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

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

a) More Current Carrying Capability

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

b) No Risk of Breaking-off, More Security

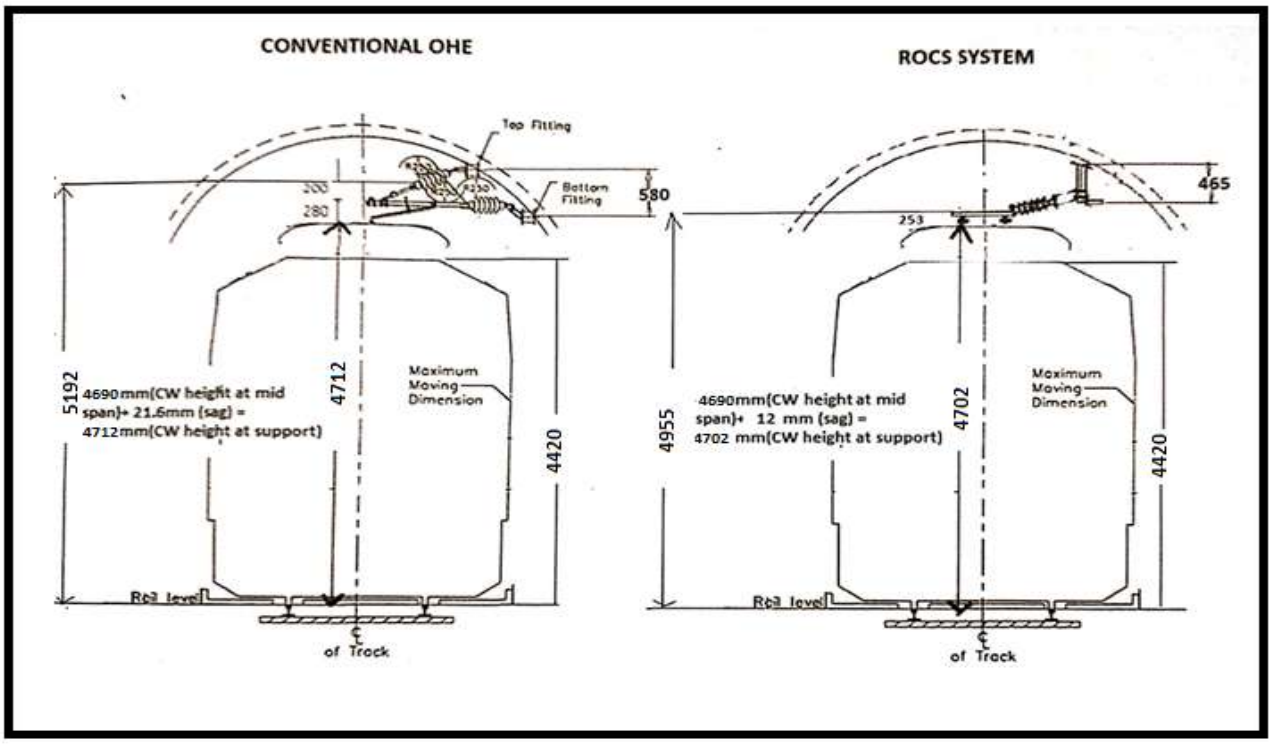
As there is no stress/tension, it allows more contact wire wear without risk of breaking-off in rigid catenary system, the only limitation is that the pantograph should not touch the conductor bar profile.

c) Easy Operation and Maintenance

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

d) Less Tunnel Clearance, Less Construction Cost

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



Arrangement of Overhead equipment in Conventional and ROCS System

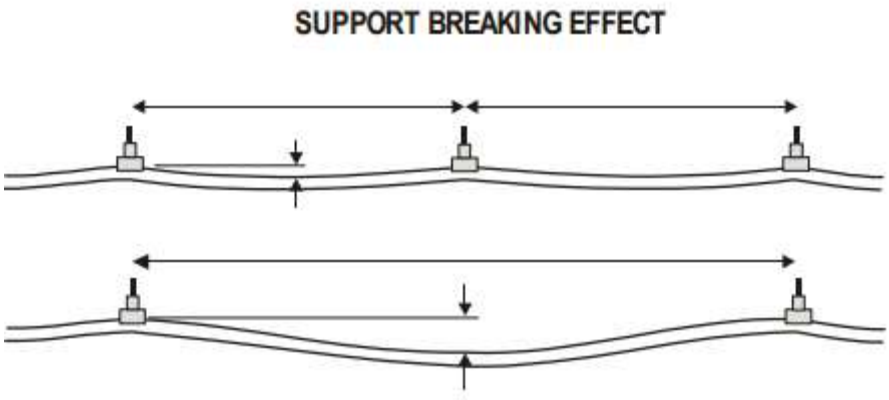
e) In conventional OHE contact wire is usually mounted with a tensile stress of 1000kgf, which reduces its mechanical strength. This fact, as well as the frequent short circuits caused by the load or internal/external factors, increases the risk of the contact wire breakage, entanglement of the pantographs and long restoration time for the OHE breakdown. With rigid catenary, all these risks disappear.

f) The Aluminum conductor rail cross section is normally 2214mm.

g) Also the maintenance costs is one of the advantages of this system as higher wear of the contact wire is allowed, its replacement is not so frequent. On the other hand, the time required to carry out this operation is less and many times it is not necessary to replace the complete section, as in the conventional contact wire, and only the affected sector will be repaired.

h) The damages produced by short circuits or earth fault can be repaired very fast, replacing a short stretch of the contact wire (1 or 2 metres), without any consequences in the current supply and traffic can be permitted in a few minutes.

i) In the case of rupture /breakage of an insulator, the deflection at this point would allow trains to run slowly.



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

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

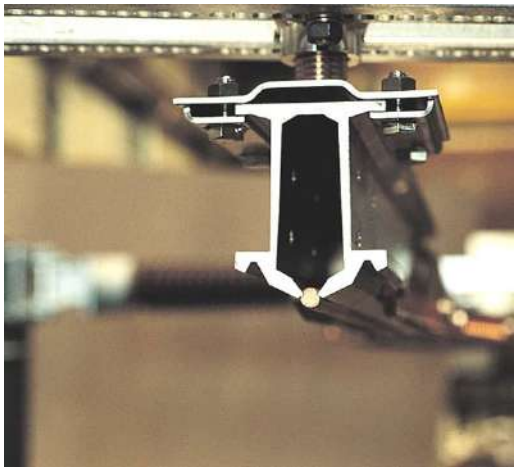
3. DESCRIPTION OF ROCS SYSTEM: Rigid Overhead Conductor System (ROCS) uses a rigid conductor instead of a flexible wire for electric power collection. ROCS has a rigid conductor rail installed overhead. A copper contact wire is inserted in the conductor rail and the Pantograph on the rolling stock collects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



ROCS with Cantilever Arrangement

4. Components of Rigid Overhead Conductor System:

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

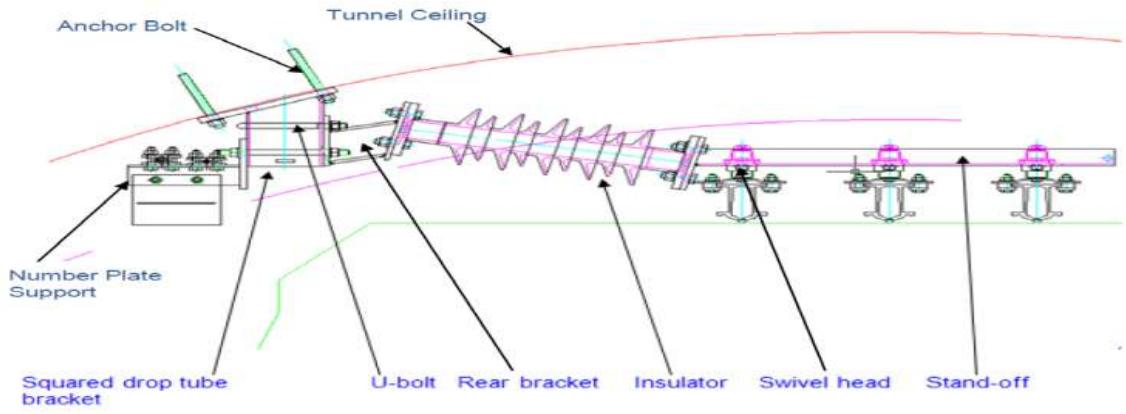


CONDUCTOR RAIL

4.2 Cantilever Support Bracket:

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

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



Various components of Support Bracket

The ROCS support bracket has following components:

4.2.1 Drop Tube

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

4.2.2 Number Plate Support

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

4.2.3 Rear Bracket

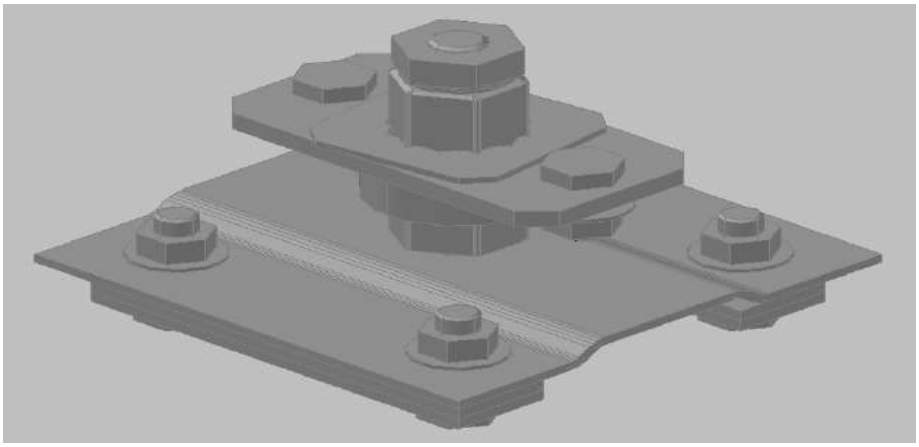
This component is fixed to the drop tube through nut bolt and backing angle or through U-bolts. This can be rigid or hinged type.

4.2.4 Standoff Bracket

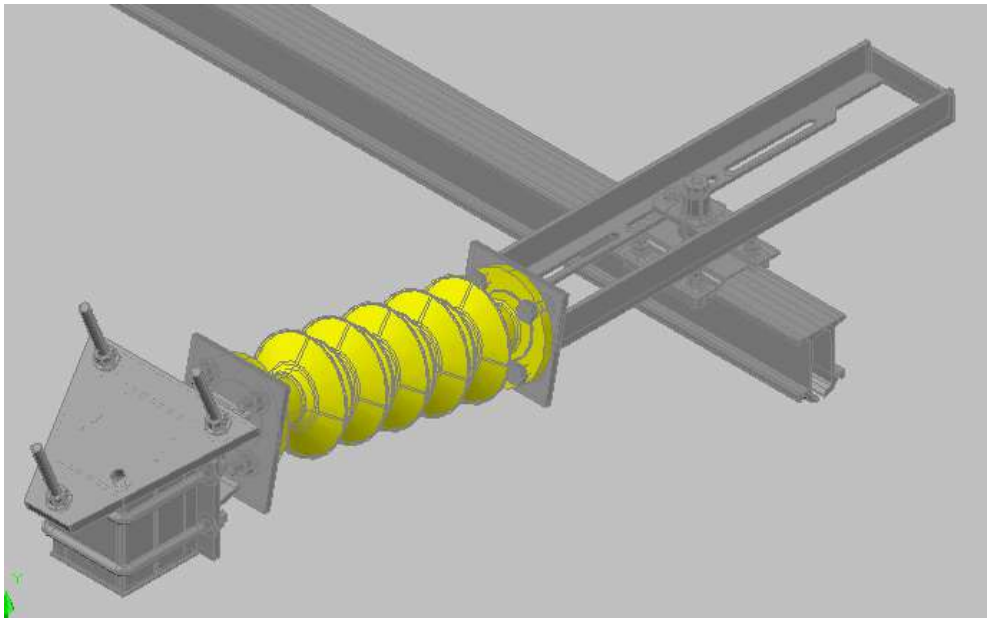
This component is attached to the insulator through nut bolts. It is also known as cross arm. This has a long slot inside which provides the required stagger of ±200mm from the track centre axis. The length of the standoff bracket varies as per the requirement or site conditions. Like in case of overlaps,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

4.2.5 Swivel Head

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



SWIVEL HEAD



Swivel Head placed in Standoff bracket and holding the Conductor Rail

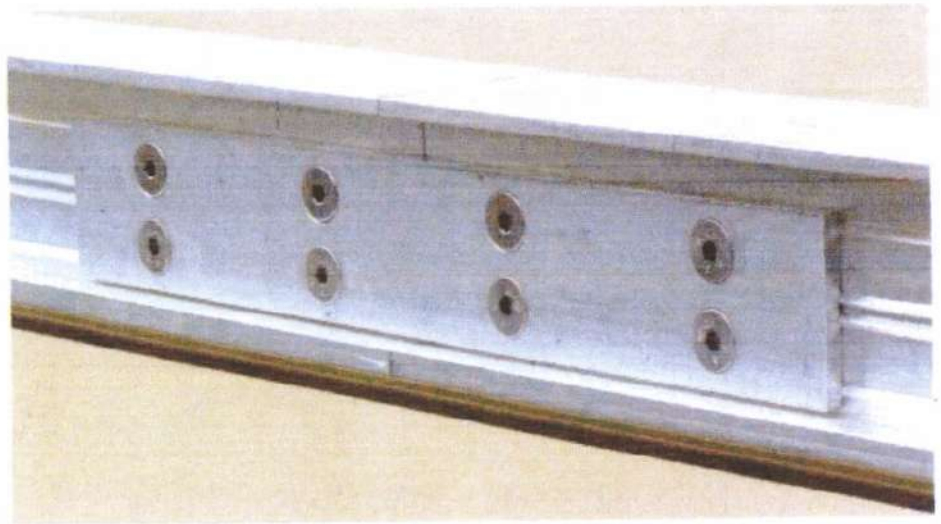
4.2.6 Insulator

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

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



INTERLOCKING JOINT



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



CONTACT WIRE

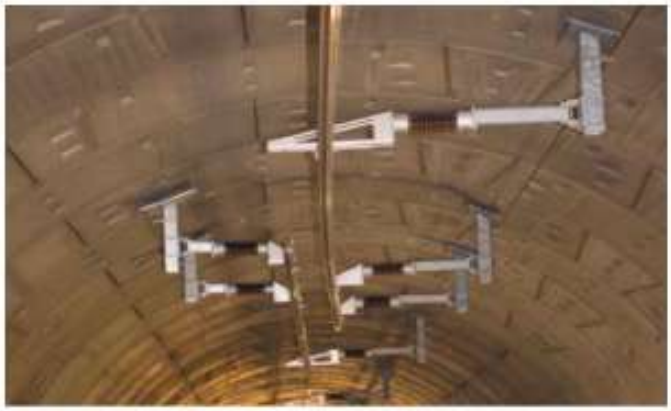
4.5 Anchor Bolt: Anchor bolt is used to support ROCS bracket to the tunnel ceiling. These bolts are generally used to fix drop tube. Anchor bolt is hot dipped galvanised type mechanical anchor. Suitable design chemical anchors may also be used.



Anchor Bolt

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

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



OVERLAP

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

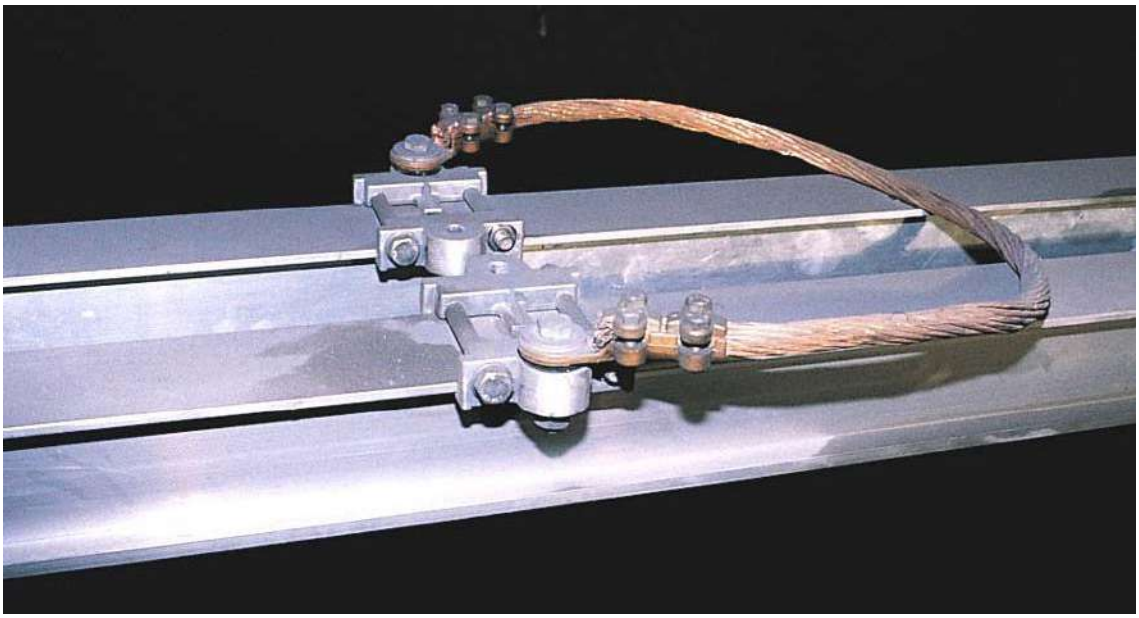
4.6.3 Expansion Joints: For higher speed applications (>120km/h), in-line expansion joints will be used as parallel CR type overlap do not provide compliant current collection at higher speeds.

4.7 Jumpers:

Jumpers are used in ROCS at three locations:-

1. Uninsulated overlaps
2. Turnouts
3. Feeding points

Un-Insulated Overlap jumper and Turn out jumper is the copper jumper of size 150/130 sq mm which provide the continuity between the two parallel Aluminium conductors rails. Two flexible copper jumper wires, each with a maximum cross section of 150 mm^2 can be attached.

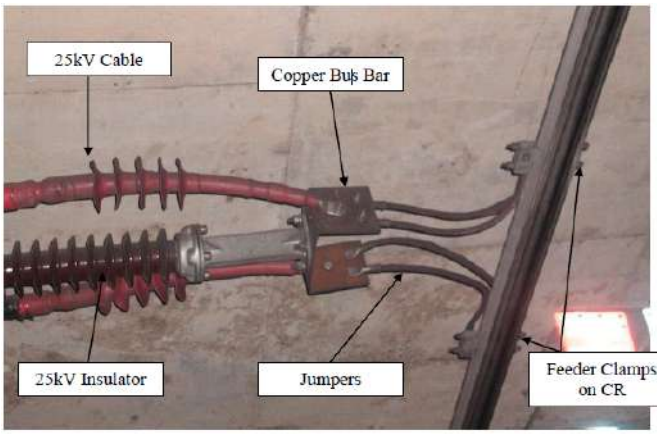


JUMPER

4.8 Feeder & Jumper

A cable which supplies power to the ROCS (or flexible OHE wire) is known as a feeder. Generally, 25 kv Cables shall conform to IEC-60840 with specified Voltage as 26/45kv(52kV) grade, 240sq.mm copper cable is used for power feeding. The power cables are terminated on the conductor rail with the help of feeder clamps.
The feeding is done through two numbers of 25kV flexible copper cables (240 rnm^2 single core, armoured copper cable). Each cable has a continuous current rating of 560 A. so the total capacity of 2*240 mm^2 connection is 1120 A. Both the cables are then terminated on a copper busbar mounted on an insulator, 4x150 sq.mm Copper Jumpers will then connect the bus bar to the CR through the feeder clamp. The feeder clamp has the capability to clamp flexible copper jumper up to 150mm^2. The flexible copper jumper are 1m long, sufficient to accommodate CR movement due to thermal expansion or contraction.

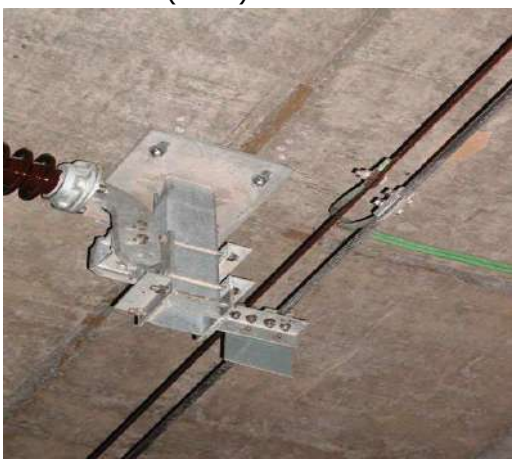
The 25kV feeder cables cannot be terminated directly on to the conductor rail as they are armoured cables and are not very flexible; hence they cannot accommodate thermal expansions and contractions of the conductor rail. There is a danger of possible breakage of the joint if they are terminated directly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



25 kV Feeder Cable Termination at ROCS

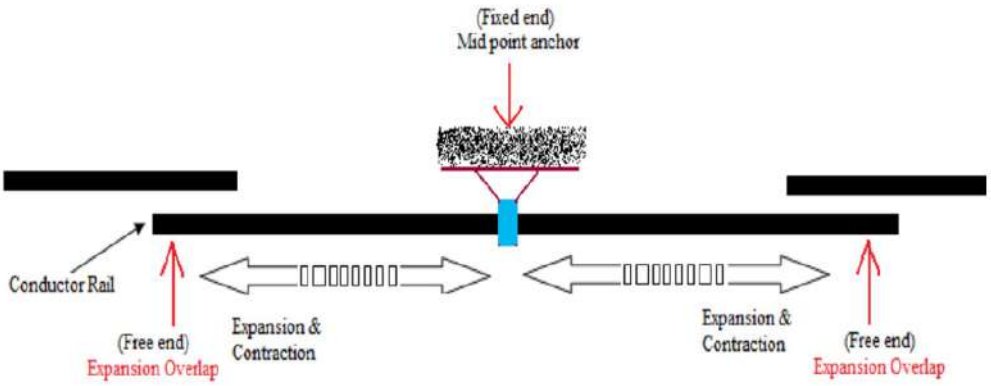
4.9 Over head protection conductor (OPC)

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



RC and OPC

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

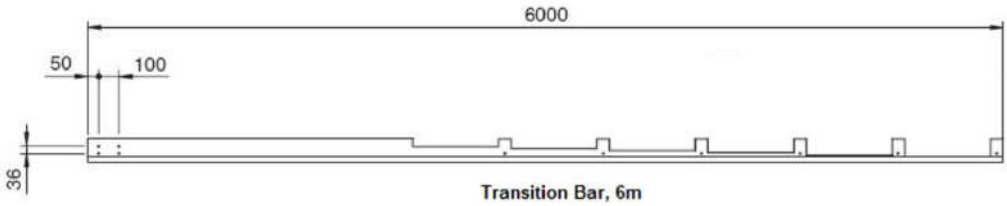


Mid point anchor arrangement

4.11 Transition Element

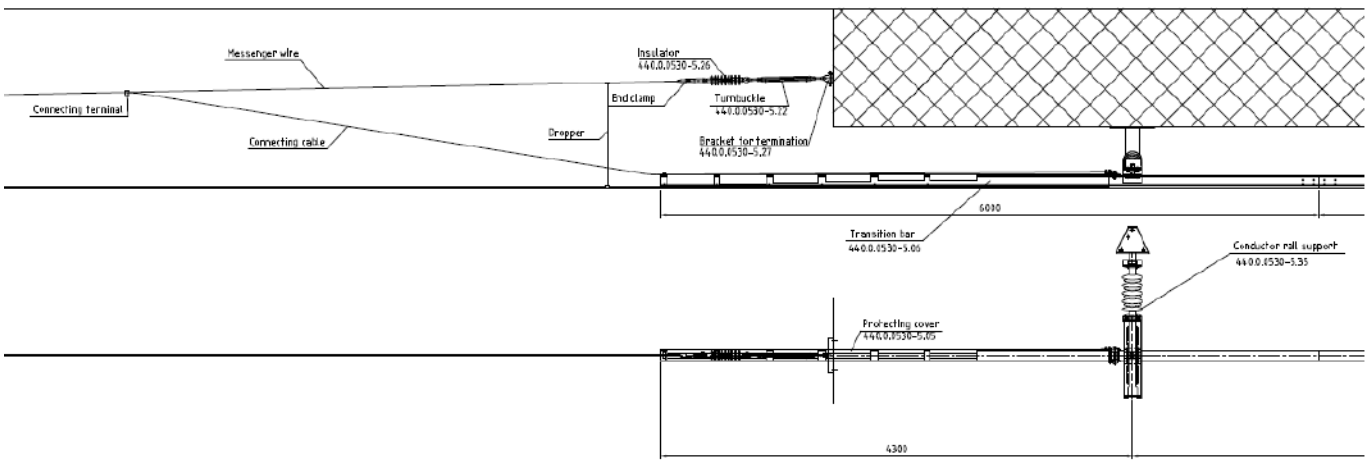
It is arrangement of joining ROCS with flexible OHE whenever elevated track enters into underground tunnel or vice-versa. At the junction point of flexible OHE and the ROCS system, there will be a sudden change in the stiffness of the contact wire. The flexible OHE contact wire is tensioned but not rigid;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

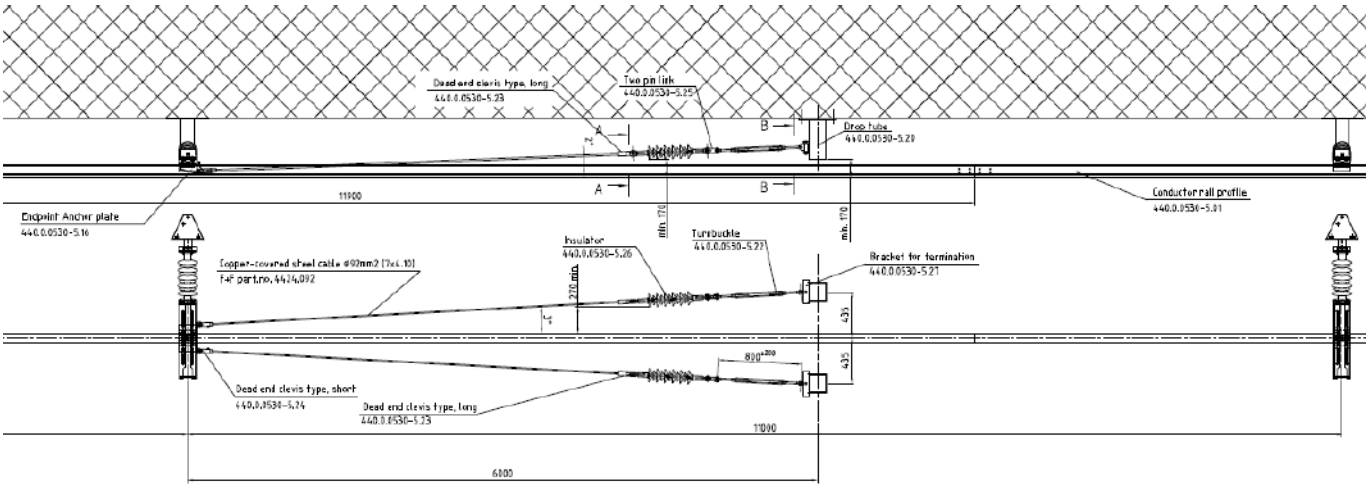
The movement of pantograph will not be smooth during the transition from flexible OHE to ROCS or vice versa due to this sudden change in the contact wire stiffness. Thus, there shall be a gradual equalization of the difference in stiffness between the flexible OHE contact wire and the ROCS contact wire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



Transition Bar, 6m

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







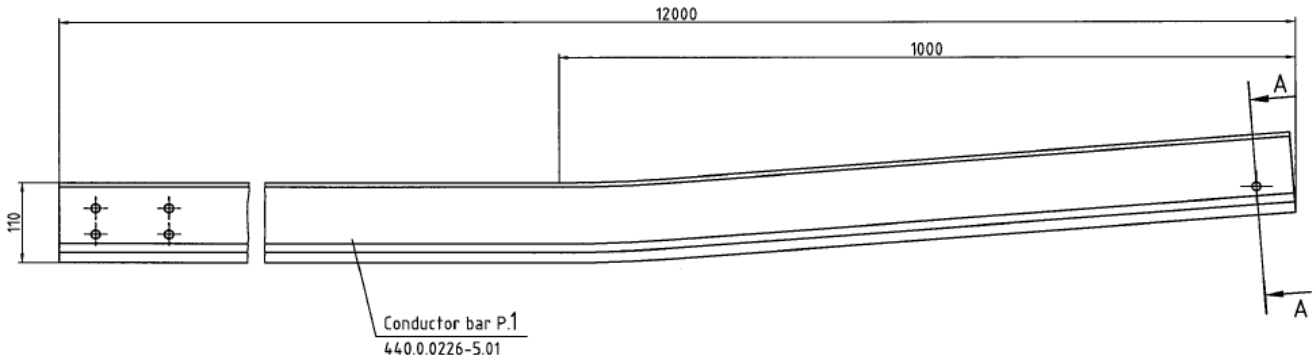
4.12 Section Insulators: Section insulators are provided to insulate the rigid overhead conductor of one elementary section from the rigid overhead conductor of the adjacent elementary section such as at track cross-overs. When the pantograph of a rolling stock passes from one track to another along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



Section Insulator

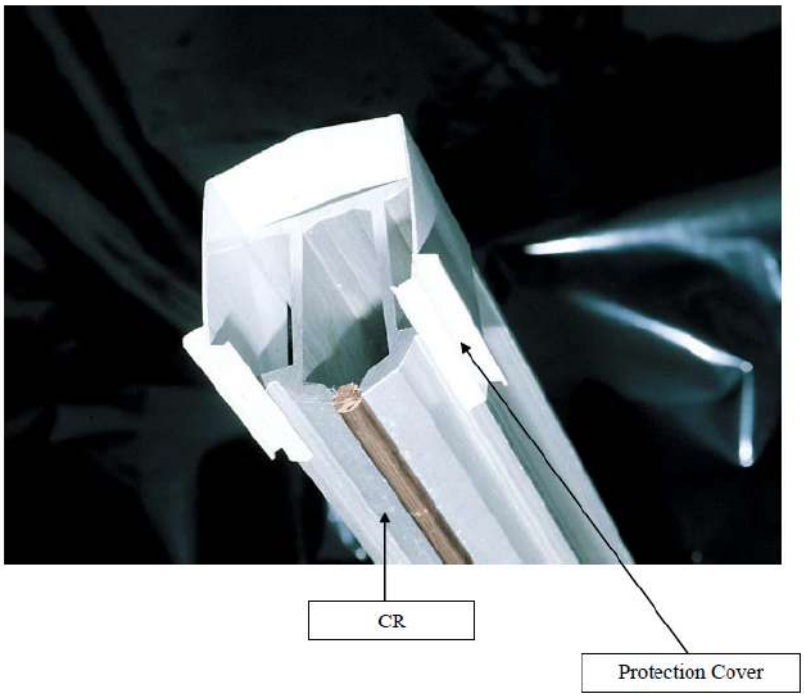
4.13 End Section:

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



END SECTION

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

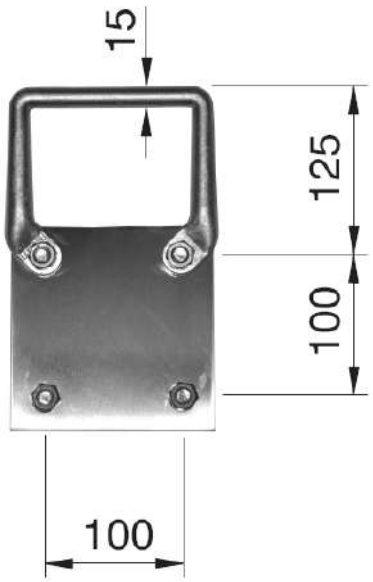


PROTECTION COVER WITH CONDUCTOR RAIL

4.15 Earthing Clamp

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

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



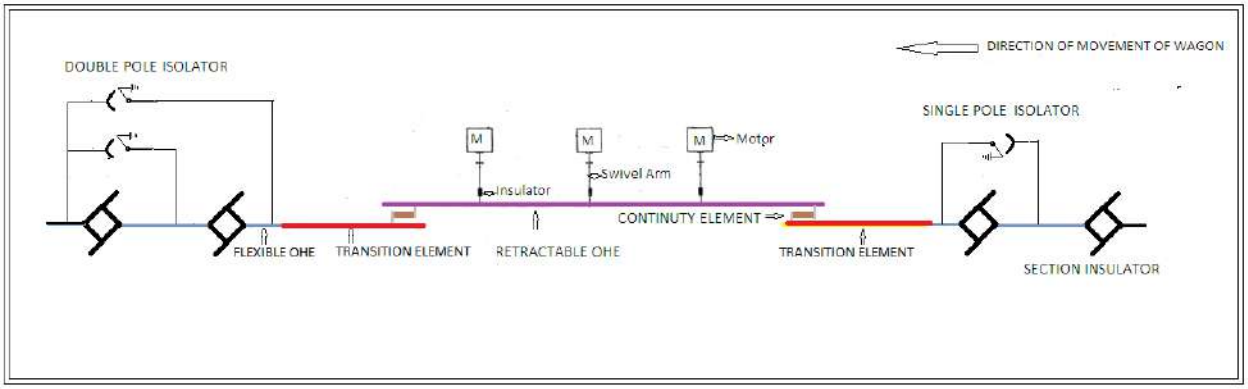
5.0 RETRACTABLE RIGID CATENARY SYSTEM(RRCS) UNDER THE SILO

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

5.1 Objective:

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

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



5.3 Components of Retractable Rigid Catenary System :

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

5.4 Safety Aspect:

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

5.5 Operation of 25KV Retractable Rigid Catenary System:

The following sequence should be followed for operation of RRCS:

a) Initially, the position of the swiveling type rigid OHE will be away from the track. Electric loco approaching loading area/ maintenance depot shall be stopped before entry point of loading area/maintenance depot which will be before single pole Isolator. At the Entry point a sensor or Indicator (engine stop board) shall be provided.

b) Retractable Rigid OHE shall be allowed to rotate forward over the track with the help of motorized arrangement.

c) Both the Isolator shall be switched-on (First Single Pole Isolator and then Double Pole Isolator) to make the OHE between the isolators live at 25 kV. Before

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

d) Then, electric loco will be moved through the loading area/maintenance depot (i.e. through energized Retractable OHE).

e) The loco will stop outside of loading area and beyond the double pole isolator so that the pantograph will remain in energized OHE even after the opening of the double pole isolator and the first empty wagon is positioned below the chute for filling of wagon/maintenance.

f) Retractable Rigid OHE will now be de-energized and earthed through Isolators (First Double Pole Isolator and then Single Pole Isolator) and discharge rod may be additionally provided. After Retractable OHE de-energized it will be moved back.

g) Commencement of maintenance or loading shall be interlocked with the traversing mechanism of the RRCS. After completion of rake loading, the traversing chute will be retracted back automatically to parking position.

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

General:

6.1 All necessary measures must be taken to prevent electro-chemical corrosion between the contact wire and its supporting structure.

6.2 Contact wires according to RDSO specifications no. ETI/OHE/76 (6/97) or latest should be passed through the conductor rail.

6.3 If possible, the contact wire must be installed without joints for each continuous rail section (i.e. between two expansion joints).

- Contact wire interruptions / joints are permitted if:
- These are essential for construction reasons.
- A segment of contact wire requires replacement due to damage.
- In case of interruptions in the contact wire, completely smooth transitions must be ensured at the joint between new and old wire. A gap of no more than 1mm is allowed at the joint between new and old wire.
- At points where the contact wire is interrupted, it must be secured by bolting through the conductor rail.

6.4 By means of constructional measures, it may be ensured that there is no sagging or upward deflection at the rail joints. Each rail joint connection (pair of connecting plates) shall not have more than 8 fasteners / screws to minimise installation and repair/renewal time.

6.5 The clamp for the contact wire must be designed so that it corresponds to contact wire as per RDSO specifications. The rail profile must not allow condensation water to come in contact with contact wire – profile interface to avoid corrosion.

6.6 Contact wire Gradient with respect to track should be according to EN 50119.

6.7 A suitable continuous transition between the rigid overhead conductor rail system and the flexible catenary must be provided for the transition from the catenary to the overhead conductor rail. Hard points must be avoided.

6.8 In the area of the transition the contact line must be supported so that the tensile forces can be adequately absorbed and the contact line is installed in the conductor rail without tension. Transition elements must be covered with plastic caps to protect against birds and water.

6.9 Minimum Vertical & lateral Electrical Clearances between live bare conductor/pantograph & structure should be as per IRSOD (BG) Revised-2004 with A&C.

6.10 Earthing and Bonding should be carried out as per Earthing and Bonding Code ETI/OHE/71(11/90) or latest.

6.11 Composite Insulator shall be in accordance with RDSO specification TI/SPC/OHE/INSCOM/1071 Rev-01 and Porcelain Insulator shall be in accordance with TI/SPC/OHE/INS/0070 with A & C Slip 1 & 2. Nominal creepage length shall be 1050mm minimum. The composite insulator with 1600mm creepage distance may be used where ESDD $\geq$ 0.3 mg/cm^2 with approval of PCEE's as per directives issued by Railway Board vide letter no. 2002/Elect(G)/161/21 Vol.II dated 04.07.2012.

6.12 All the items like - transition element, rigid rail, Drop arms, Bracket assembly, control system, motor for swiveling arrangement or any other sub assemblies should be of appropriate design already working in India/abroad.

ROCS inside Tunnels

6.13 On double track section, the support structures on the two tracks must be mechanically and electrically separated. The support structures must be arranged on the outsides of the double track if space allows in order to avoid blocking of both tracks in case of work. Support structures should have swiveling cantilever or swivel head with gliding arrangement.

6.14 Attachment on the roof of tunnel should be designed for additional loads due to adjacent defective support structures. Collapse of an adjacent support structure or detachment of the overhead conductor rail from two adjacent mounts (left/right or 2 on one side) must not result in failure of a support structure.

6.15 M16 or higher size stainless steel bolts (min. A4) as per RDSO Specification No. TI/SPC/OHE/Fasteners/0120 Rev. 1 or its equivalent standard must be used for fastening to the tunnel roof. For fastening in rock or masonry-lined tunnel roofs, appropriate strength considerations must be made and pull-out tests for critical areas must be carried out. The torques on the bolts must be considered in the design. Care must be taken that there is a good contact surface between the mounting plate and the bolts and nuts.

6.16 The torques for all fasteners must be stated. Depending on the requirements, fasteners must be secured against loosening. This must be specified by the supplier.

6.17 For grouting OHE fixtures on tunnel wall/ceiling/face, normally M20 grade of concrete/Epoxy resin should be considered in the design and depth of bolts may be upto 500mm. In the lined tunnels, stubs for supporting OHE cantilever assembly should be provided on both sides of the tunnel, opposite each other. This would facilitate restoration of OHE in the event of damage to stubs on one side. Similarly spare stub bolts for drop arm arrangement hanging from roof/ceiling of tunnel should also be provided on each location. For determination of bond stress between rock and grout and between grout and ragged type bolt "pull out test" shall be done as per IS 11309 latest version.

6.18 The height and stagger of the contact wire must be able to be adjusted quickly without the use of special tools and without additional load on the fastening bolts and support structures. The swivel head / CR clamp must allow ±25mm vertical adjustment.

6.19 The support structures must be equipped with appropriate terminals which enable the installation of an adequate electrical connection to the earth conductor. The height differences between support structures must comply with EN 50119.

6.20 Material for Support structure like drop arm, cantilever assembly, base plate etc. should be conforming to IS -2062:2011 and fabrication should be as per IS:800-2007 latest version or its equivalent.

6.21 Mid Point anchor must be designed such that the static electrical clearances and the pantograph clearances are met.

Retractable Rigid Conductor System:

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

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

(i) If the environment is dusty as the loading/unloading of metallic/coal or other mining product is involved and to be loaded, adequate electrical clearance must be ensured. Also the sidings may be in open area and the OHE will be affected by wind and therefore proper locking arrangement is required so that OHE is locked in both normal and swivelled position and the required electrical clearance are maintained.

(ii) The system should have suitable alarm to pre-warn when the OHE is energized and the alarm goes off only when OHE is de-energised and earthed so that safety of workmen is ensured.

(iii) Suitable earthing arrangement should be in place for which inspection of the open line authorized representative and sanction of EIG to ensure compliance of statutory electrical safety is ensured. EIG may be requested to prescribe suitably periodic statutory inspection by his representative to ensure sustained compliance. It would be a good practice to incorporate provision of earthing rod additionally as backup in the working rules or SOP.

(iv) The standard operating procedure needs to be specified and approved by PCEE of Zonal Railway as no. of different personnel are involved namely railway staff of operating and electrical/mechanical department and staff of siding owner.

(v) Drawings for system design involving OHE arrangement and loading arrangement should be approved by PCEE of Zonal Railways/authorized representative and siding owners authorized personnel.

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

7.0 Technical Documentation

7.1 General

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

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

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

7. Any other Details.

8. General Arrangement and Part Drawings of following:

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

7.3 Creepage lengths/Air Gap of the various insulators.

7.4 FEA, STADDPRO reports and design calculations for

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

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

7.6 Installation and maintenance instructions

7.7 Statement of times for the replacement of components.

7.7 Any other Information.

7.2 Tunnels

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

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

7.3 Sidings/Depots

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

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

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

8.0 Acceptance Process

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

8.1 Record of static measurements (must be available prior to acceptance and must be carried out before the contact line is switched on), e.g.

- Heights of the contact wire at support points.
- Support point distances / span length.
- Stagger.
- Electrical clearances (static to earth).
- Evidence of electrical connection (continuity test).
- IR value test.

8.2 Acceptance inspection of the system by the Railways and contractor, important points for inspection:

- Installation of return and earth conductor (if part of design).
- Compliance with the electrical clearances at critical points as per approved drawings.
- Complete and correct installation of components as per approved drawings.
- Inspection of weak points and excessive wear:
  - Expansion joints
  - Section insulators
  - Transitions
  - Turnouts & cross-overs
- Stability of fixed points(civil structures).
- Tightness/Completeness of electrical connectors.
- The contact wire is correctly clamped in the conductor rail.
- The conductor rail, expansion joints and all moveable components can move freely according to the expected longitudinal expansion.
- The contact wire does not have any irregularities /gap which are smaller than the permissible gradients.
- Contact wire interruptions are smooth and bolted.

8.3 Testing of ROCS/RRCS in Dynamic condition should be done to check proper current collection at permissible speed of track.

8.4 The following documentation (DIGITAL & PRINTED VERSION(Two copy)) must be submitted on completion of the system.

- Description of system.
- Location plan / Layout.
- Schematic and detailed drawings of each components /parts.
- Earthing and bonding scheme.

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

8.5 Training

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

9.0 **References:**

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

****

File No.RDSO-TI0LKO(OHE)/96/2020-O/o PED/TI/RDSO

भारतसरकार - रेलमंत्रालय - अनुसंधानअभिकल्पऔरमानकसंगठन,मानकनगर,लखनऊ-226011
Government of India - Ministry of Railways
Research Designs & Standards Organisation, Manak Nagar,
Lucknow – 226011

बीएसएनएल/BSNL:91-522-2465731
रेलवे/Railway: 42804, फैक्स/Fax : 91-522-2465731
ईमेल/E-mail: dtiohed.rdso@gmail.com

No. RDSO-TILKO(OHE)/47/2020-O/o PED/TI/RDSO Dated, the 23rd October, 2020

Principal Chief Electrical Engineer & CAO,

(i) Northern Railway, Baroda House, New Delhi - 110 001.
(ii) North Central Railway, Allahabad-211 015.
(iii) East Central Railway, Hajipur-844 101.
(iv) Eastern Railway, Fairlie Place, Kolkata-700 001.
(v) Western Railway, Churchgate, Mumbai-400 020.
(vi) West Central Railway, Jabalpur- 482 001.
(vii) Central Organisation for Railway Electrification, Nawab Yusuf Road, Allahabad-211000.

विषय/Sub:OHE guidelines for Zonal railways for increasing speed potential to 160kmph on NDLS-HWH (including Kanpur-Lucknow) & NDLS-BCT (incl. Vadodara- Ahmedabad) route

संदर्भ/Ref :(i) Railway Board Letter No.. 2001/Elect(G)170/I Pt-III dated 07.08.2020
(ii) Railway Board Letter No. 2001/Elect(G)170/I Pt-II dated 16.10.2020
(iii)VC held with Railway Board, concerned Zonal Railways and RDSO on 31.07.2020 & 29.08.2020
(iv)Meeting held with Railway Board at RDSO on 12.09.2020 & 17.10.2020

In compliance to Railway Board letters referred above, Technical Instruction No. TI/IN/0042 for "OHE guidelines for Zonal railways for increasing speed potential to 160kmph on NDLS-HWH (including Kanpur-Lucknow) & NDLS-BCT (including Vadodara- Ahmedabad) route" has been prepared and enclosed herewith

This is issued with the approval of PED/TI/RDSO.

(Bhardwaj Chaudhary)
Executive Director/TI
[कृते महानिदेशक(कर्षण संस्थापन)/For Director General(TI)]

Signed by Bhardwaj Chaudhary
Date: 23-10-2020 16:44:38
Reason: Approved

Encl: As above

Copy to:

1. ED/EEM/Railway Board – for kind information please.
2. EDRE/Railway Board - for kind information please.

GOVERNMENT OF INDIA

Ministry of Railways

OHE GUIDELINES FOR

INCREASING SPEED POTENTIAL TO 160KMPH

ON

NDLS-HWH & NDLS-BCT ROUTES

INSTRUCTION No. TI/IN/0042

Issued by:

Traction Installation Directorate

RESEARCH DESIGNS & STANDARDS ORGANISATION

MANAK NAGAR

LUCKNOW – 226 011

(For official use only)

OCTOBER,2020

TITLE: OHE GUIDELINES FOR ZONAL RAILWAYS FOR INCREASING SPEED POTENTIAL TO 160KMPH ON NDLS-HWH (INCL. KANPUR-LUCKNOW) & NDLS-BCT (INCL. VADODARA- AHMEDABAD) ROUTE

INSTRUCTION NO.: TI/IN/0042

	PREPARED BY		CHECKED BY	APPROVED BY
Signature				
Date	23.10.2020	23.10.2020	23.10.20	23/10/20
Name	ANURADHA SRIVASTAVA	MUKESH KUMAR	BHARDWAJ CHAUDHARY	SUNIL KUMAR
Designation	SSE/OHE DESIGN	SSE/CIVIL	EDTI	PED/TI

ASSISTED BY:

i) Shri Shrikant Saroj, Senior Section Engineer,

ii) Shri Bikesh Kumar, Senior Section Engineer,

iii) Shri Sujeet Kumar, Senior Section Engineer,

iv) Shri Dalip Singh Meena, Senior Section Engineer,

v) Shri Dharmraj, Junior Engineer

OHE GUIDELINES FOR ZONAL RAILWAYS FOR INCREASING SPEED POTENTIAL TO 160KMPH ON NDLS - HWH(INCL. KANPUR - LUCKNOW) & NDLS-BCT (INCL. VADODARA - AHMEDABAD) ROUTE

1.0 OHE GUIDELINES

In reference to Railway Board letter No.2001/Elect(G)170/1 Pt-III dated 07.08.2020, letter No.2001/Elect(G)170/1 Pt-II dated 16.10.2020 & VC held with Railway Board, concerned Zonal Railways and RDSO on 31.07.2020 & 29.08.2020, the final scheme/guidelines regarding up-gradation of OHE for increasing the speed potential to 160 KMPH in the territories of NR, NCR, ECR, ER, WR & WCR on NDLS-HWH & NDLS-BCT routes has been prepared and detailed below for ready reference to Railways.

1.1 OHE Structure:

1.1.1OHE mast & foundation of existing NDLS-HWH & NDLS-BCT section was designed for 1000/1000 kgf tension with OHE only/ OHE+ RC/OHE+ Earth wire/OHE+ RC + Earth Wire, mostly with 112.5 kgf/m^2 wind pressure and in some portion near Kolkata with 150kgf/m^2. Zonal Railways should check suitability of existing mast & foundation with OHE and earth conductor for increased tension of 1200/1200 kgf in OHE against Employment Schedule Drg No. ETI/C/0730 - Sheet-2 (Annexure-1) for 112.5kgf/m^2 Wind Pressure.
Alternatively for easy and convenient calculation, Excel sheet for checking suitability of mast & foundation with Instruction for checking Suitability of Mast and Foundation (Annexure-2) has been shared to Zonal Railways on 01.09.2020 & one correction was intimated on 24.09.2020. The suitability of existing mast should be checked and if existing mast is found unsuitable, OHE should be shifted on new feeder mast. If the existing mast is found suitable, the OHE can remain on existing mast and only feeder wire will be erected on new feeder mast.

PORTAL: Portal Structure has been checked for suitability with increase in tension in OHE from 1000/1000kgf to 1200/1200kgf, with Feeder wire and AEC. The existing portal has been found suitable for following loading:

SN	Type of Portal	Wind pressure KGF/M^2	Suitability with 1000/1000kgf Tension in OHE	Suitability with 1200/1200kgf Tension in OHE
1.	N Type	112.5	4 Track (8 OHE) + 2 feeder wire + 2AEC + 2 BWA	4 Track (6 OHE)+ 2 feeder wire + 2AEC + 2 BWA

		150	-Do-	4 Track (5 OHE)+ 2 feeder wire + 2AEC + 2 BWA
2.	O Type	112.5	6 Track (12 OHE) + 2 feeder wire + 2AEC + 2 BWA	6 Track (10 OHE)+ 2 feeder wire + 2AEC + 2 BWA
		150	-Do-	-Do-
3.	R Type	112.5	8 Track (16 OHE) + 2 feeder wire + 2AEC + 2 BWA	8 Track (14 OHE)+ 2 feeder wire + 2AEC + 2 BWA
		150	-Do-	8 Track (12 OHE)+ 2 feeder wire + 2AEC + 2 BWA

Zonal Railways are advised to check the existing loading of the Portal Structure and accordingly erect the feeder wire and AEC on the Portal if loading margin is available as given in the above table.

If loading goes beyond as given in the above table, separate Feeder mast and its foundation should be selected from Employment Schedule as per RDSO Drawing No. TI/DRG/CIV/FEEDER-ES/RDSO/00001/20/0 Sheet 1 & 2 (Annexure - 3A & 3B). 25kV Feeder wire (All Aluminum spider conductor of size 234 sq. mm) arrangement on separate mast for up and down tracks separately should be provided as per Drawing No. TI/DRG/OHE/FEEDER/RDSO/00001/19/0 (Annexure-3).

1.1.2 Feeder Line :

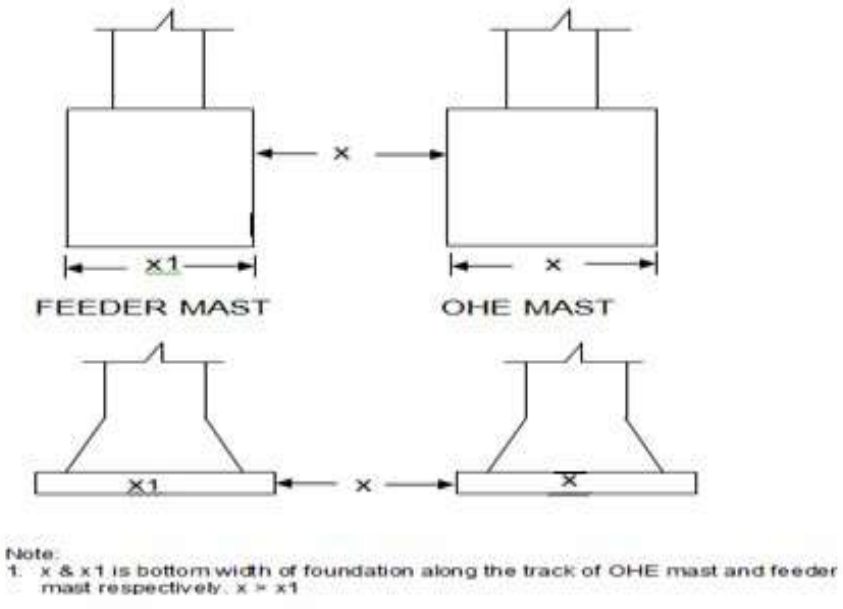
Feeder line has been designed, keeping in the view the provision for shifting the OHE on it in future. In this way, the feeder Mast will carry the OHE, AEC and feeder wire, after expiry of the codal life of the existing suitable mast which will presently carry the OHE and AEC. However wherever the existing mast has been found to be unsuitable for load of OHE with 1200/1200 kgf tension and AEC, the new feeder line mast will carry the OHE, AEC and feeder wire.

In this way it is needless to say that the feeder line should be constructed in such a way that it can be utilised as the OHE mast in future hence its pegging plan and Lay out plan should be made accordingly.

25kV Feeder line arrangement on separate mast for up and down tracks separately should be provided as per Option 1 or Option 2 as given in para 1.1.3.

Implantation of Feeder masts should be chosen as per para no 20.1 and 20.2 of Appendix-I of ACTM Vol.-II Part II with latest ACS.

The horizontal spacing (along the track) between Feeder mast foundation and existing OHE mast foundation should be as per drawing given below:



Feeder wire termination should be as per RDSO Drawing No.RE/33/G/05145-1-Rev.A (Annexure-4).

1.1.3 Feeder Line Employment Schedules

There are two design options for constructing Feeder line:

Option I:

(Feeder Mast and Foundation is designed for load of OHE configuration of 65 mm^2 /107 mm^2 catenary/contact wire with 1200/1200 kgf tension in contact wire and catenary wire, AEC 92$mm^2$and Feeder wire 234 mm^2)

New Feeder mast designed for OHE, feeder wire & Arial earth conductor should be provided as per employment schedule Drg No. TI/DRG/CIV/ES/RDSO/00004/19/0 (Sheet-I to III) for 1200/1200 kgf Tension, 155 kgf/m^2 wind pressure attached as Annexure-5, 6 & 7 for implantation of 2.8m, 3.8m & 4.85m respectively.

Similarly for 178kgf/m^2 wind pressure zone (Kolkata Region) new feeder mast should be provided as per employment schedule Drg No. TI/DRG/CIV/ES/RDSO/00004/19/0 (Sheet-IV to VI) for 1200/1200 kgf Tension attached as annexure 8, 9 & 10 for implantation of 2.8m, 3.8m & 4.85m respectively.

New feeder mast will carry the OHE, feeder wire on super mast and aerial earth conductor as per Drawing No. TI/DRG/OHE/FEEDER /RDSO/00002/19/0 (Annexure-11) wherever existing mast is found unsuitable. In this drawing the Feeder wire has been shown erected on the opposite side of the track/OHE for ease of execution of work.

Provision of feeder wire required for 2X25kV system in station areas, for 3rd & 4th line, under FOB , ROB & at places where clearance from other track is very less (Near DFCCIL track etc.), feeder wire may be provided towards OHE side on supermast. In places where clearance is very low, 25kV feeder cable of suitable size of voltage grade 26kV/45kV (52kV) as per IEC 60840 for 600 amp current carrying capacity as used in Metros may be provided.

Implantation of new feeder line mast should be chosen as per para no 20.1 and 20.2 of Appendix-I of ACTM Vol.-II Part II with latest ACS.

The new Feeder line spans should be chosen from respective Employment Schedule. In case new foundation is infringing with the old OHE mast foundation, the new feeder line span can be reduced to nearest lower value of the permissible span. The two consecutive spans shall not normally differ by more than 18m as per Para 5.5 of ACTM Vol. II Part-II.

Option II:

(Feeder Mast and Foundation designed for load of OHE configuration of 125mm^2/150 mm^2 catenary/contact wire with 1500/1500 kgf tension in contact and catenary wire, AEC and Feeder wire 288 mm^2)

This option should be adopted for providing Feeder mast & foundation suitable for higher size of OHE conductors (125/150 sq.mm Catenary/Contact wire) with 1500/1500kgf tension, higher size feeder wire (288 mm^2) and AEC (92mm^2).

New Feeder mast designed for OHE, feeder wire & Arial earth conductor should be provided as per employment schedule Drg No. TI/DRG/CIV/ES/RDSO/00004/20/0 (Sheet - I to III) for 1500/1500 kgf Tension, 155 kgf/m^2 wind pressure attached as Annexure-12, 13 & 14 for implantation of 2.8m, 3.8m & 4.85m respectively.

Similarly for 178kgf/m^2 wind pressure zone (Kolkata Region) new feeder mast should be provided as per employment schedule Drg No. TI/DRG/CIV/ES/RDSO/00004/20/0 (Sheet-IV to VI) for 1500/1500 kgf Tension attached as annexure - 15, 16 & 17 for implantation of 2.8m, 3.8m & 4.85m respectively.

New feeder mast will carry the OHE, feeder wire on super mast and aerial earth conductor as per Drawing No. TI/DRG/OHE/FEEDER/ RDSO/00002/20/0 (Annexure-18), wherever existing mast is found unsuitable. In this drawing the Feeder wire has been shown erected on the opposite side of the track/OHE for ease of execution of work.

Provision of feeder wire required for 2X25kV system in station areas, for 3rd & 4th line, under FOB , ROB & at places where clearance from other track is very less (Near DFCCIL track etc.), feeder wire may be provided towards OHE side on supermast. In places where clearance is very low, 25kV feeder cable of suitable size of voltage grade 26kV/45kV (52kV) as per IEC 60840 for 800 amp current carrying capacity as used in Metros may be provided.

However, Presently OHE will have 65 mm^2/107 mm^2 Catenary/contact wire with 1200kgf/1200kgf tension. Feeder wire and AEC conductor shall be 234 mm^2 & 92mm^2 respectively.

Implantation of new feeder line mast should be chosen as per para no 20.1 and 20.2 of Appendix-I of ACTM Vol.-II Part II with latest ACS.

The new Feeder line spans should be chosen from respective Employment Schedule. In case new foundation is infringing with the old OHE mast foundation, the new feeder line span can be reduced to nearest lower value of the permissible span. The two consecutive spans shall not normally differ by more than 18m as per Para 5.5 of ACTM Vol. II Part-II.

Preferably this design of the feeder line should be adopted by the Zonal Railways as this design of feeder line is suitable for 200kmph train operation in future.

1.1.4 Revised Wind Zones: The territorial limits of revised wind zones are available in IS 875-Part 3 (2015) which is attached as Annexure-19.

1.2 Modification in OHE:

1.2.1 Tension in OHE Conductors:

To increase the operational speed of OHE from existing 140 kmph to 160 kmph, the static & dynamic parameters of OHE like tension in conductors,

elasticity, push-up, wave propagation velocity, Doppler coefficient, reflection coefficient & amplification coefficient needs to be improved. For this, tension in contact (107 mm^2) and catenary wire (65 mm^2) is to be increased from 1000 kgf to 1200kgf.
With 1200 kgf tension of contact wire, condemning diameter of contact wire will increase from existing 8.25mm to 8.42mm to achieve minimum factor of safety of 2.3.

1.2.2 Regulating Equipment:

Regulating equipment (Three Pulley Type higher tension) should be provided as per RDSO specification no. TI/SPC/OHE/3PHTATD/0150 with ACS 1) with counter weight eye rod as per drawing no. ETI/OHE/SK/588 Rev. B (Annexure-20).Counter weight assembly should be provided as per RDSO Drawing No. ETI/OHE/SK/587 Rev. B (Annexure-21). X-Y value adjustment chart is attached as Annexure- 22.

1.2.3 Dropper Schedule:

Dropper schedule for 1200/1200 kgf tension with 0.8mm/m pre-sag in OHE issued vide this office letter no. TI/OHE/GA/2018 dated 20.09.2018 (Annexure-23 to 29). Dropper Schedule for 0.9/0.9m Encumbrance is attached at Annexure - 30. For 72m span presag will be 58mm (0.8X72). Dropper Assembly should be provided as per Drg. No. ETI/OHE/P/1190 Rev. B.

1.2.4 Contact wire Gradient:

Reduction of Contact wire Gradient to be done from 3mm/m to 2mm/m & Relative gradient from 1.5mm/m to 1mm/m.

1.2.5 Adjustment at turnouts:

Operation of the Gatimaan express train is being done at 160 kmph, between Palwal - Agra section. Following works have been done in OHE at turnout locations to prevent panto-entanglement as per CEDE/NCR letter no. EL/TRD/NCR/Gatimaan dated 19.11.2018 (Annexure-31)

a. At obligatory mast vertical gap between main line and turn out contact wire is to be maintained between 50 to 60mm.
b. At 5m distance from obligatory mast, gap is to be maintained at 50 mm.
c. At 10m distance from obligatory mast, gap is to be maintained between 40mm to 50mm.
d. Track separation is to be kept between 290mm to 550mm. Mast should be changed if track separation is less than 290mm.
e. Span length of turnout location reduced during increasing track separation.
f. From main line to loop line "take off" may be maintained in between 720 to 750mm.

1.2.6 Drop Bracket Assembly & Steady Arm:

Drop Bracket Assembly as per Drawing No. ETI/OHE/P/2360 shall be provided along with steady arm as per drawing no. ETI/OHE/P/2390 attached as Annexure-32 & 33 respectively.

1.2.7 Current Carrying 'A' Dropper:

Current carrying 'A' dropper as per Specification No.TI/SPC/OHE/CCFD/ 0160(02/2020) or one C jumper (in span jumper) in every span should be provided. The Drawing Nos.TI/DRG/OHE/CCD/RDSO/00001 to 4/20/0 for current carrying dropper assembly, Catenary wire clamp, Contact wire Clamp, Compression sleeve, thimble & cable lug for current carrying droppers is attached as Annexure-34, 35, 36,37.

1.2.8 Droppers:

Rigid droppers shall not be provided, only loop type droppers should be provided.

1.2.9 Double Pole Isolator:

Double pole Isolator type II should be provided at Insulated Overlap of 1250 Amp rating as per Specification No. ETI/PSI/133. Mounting Arrangement should be as per Drawing No.ETI/OHE/G/06005 Sh-2 & ETI/OHE/G/06008 for mast and portals respectively as per Annexure-38 & 39 respectively. Double pole Isolator of 1600 Amp capacity should be provided if 65/107 (Cu-Ag CW) or 125/150 OHE is planned to be provided in future.

1.2.10 Porcelain Section Insulators should not be provided on main line. This should be replaced by Light weight PTFE type Section Insulator (if unavoidable).

1.2.11 Cross type OHE to be converted into Overlap type.

1.2.12 G Jumpers: 105 mm^2 G Jumper may be replaced by 160 mm^2 G Jumper as per specification no. ETI/OHE/3(2/94) with the approval of CEE.

1.2.13 Structure Number Plate:

Retro reflective structure number plate shall be provided as per Railway Board letter No. 2001/Elect (G)/170/1 Pt dated 07.05.2012 (Annexure - 40).Retro Reflective number plate may be provided at additional masts if required, by Zonal Railway, as per Rly Board's letter No. 2001/Elect (G)/170/1 Pt dated 18.10.2012 (Annexure-41).

1.2.14 Contact Wire :

For these two routes contact wire replacement work wherever due should be done with 107 sq. mm silver bearing grooved copper contact wire as per specification no. TI/SPC/OHE/CW(Cu-Ag)/0130 if vendor developed.

The current carrying capacity of OHE with Cu-Ag contact wire (107mm^2) and Cu-Cd catenary wire (65 mm^2) for 80°C maximum allowable temperature with wind velocity 0.6m/s will increase to 696 amp from 600amp current carrying capacity of OHE with Cu contact wire (107mm^2) and Cu-Cd catenary wire (65 mm^2) for 70°C maximum allowable temperature with wind velocity 0.6m/s.

1.2.15 Simulation study/Field trial for OHE and pantograph dynamic interaction should be carried out by Railways to validate OHE design as per EN 50367/EN 50318.

1.3 Earthing & Bonding:

AEC (Arial Earth Conductor) & BEC (Buried Earth Conductor) shall be provided to contain the touch & step potential of the track. AEC of 12.24 mm dia. ACSR Raccoon conductor should be erected on the back side of the OHE masts/Portals. Similarly BEC of 20 mm dia.(cross section 238.64 mm^2), galvanized steel conductor should be laid underground along the UP and DN track separately, 300mm below ground surface and approximately one meter away (or as per site conditions) from the OHE foundation towards opposite direction of track. The BEC will be connected to each OHE mast/Portal and Feeder mast by same conductor having Tee Connector & Lug Connector as per Drawing No. TI/DRG/OHE/TC/RDSO/00001/20/0 & TI/DRG/OHE/SC /RDSO/00001/20/0 attached as Annexure 42 & 43 for BEC end and Lug for connection with mast/portal .The cross bonding of the UP BEC –UP Mast/Portal-UP Traction Rail-DN Traction Rail-DN mast/Portal –DN BEC should be done by 50X6 mm MS/GS flat at every 450 mtr. The details of the AEC/BEC and cross bonding scheme are given in drawing no TI/DRG/OHE/EARTHING/RDSO/00001/20/0 (Annexure–44).
At stations, BEC conductor should be laid underground for Loop lines & platform also. BEC can be run on the side wall of Platform (platform coping) with suitable clamp & bolt grouted in the coping. BEC should be connected to Earth Pit as per Drawing No. ETI/OHE/P/7020 Rev. B at every 450m wherever it is exposed above the ground. At Bridges/Platform coping laying arrangement of BEC should be as given in Annexure-45.
For Three line and four line section separate BEC should be provided for each line.

The above recommendation are as per prevalent practice used in 2X25 KV system with 12 KA fault current adopted by other projects in country. However the adequacy and efficacy of this earthing and bonding system should be verified by the simulation studies/measurements of the touch and

step potential of the rail in normal load and short circuit condition for compliance with EN 50122-1 and IEC 62128-1 (2013).

1.5 LIST OF DRAWINGS:

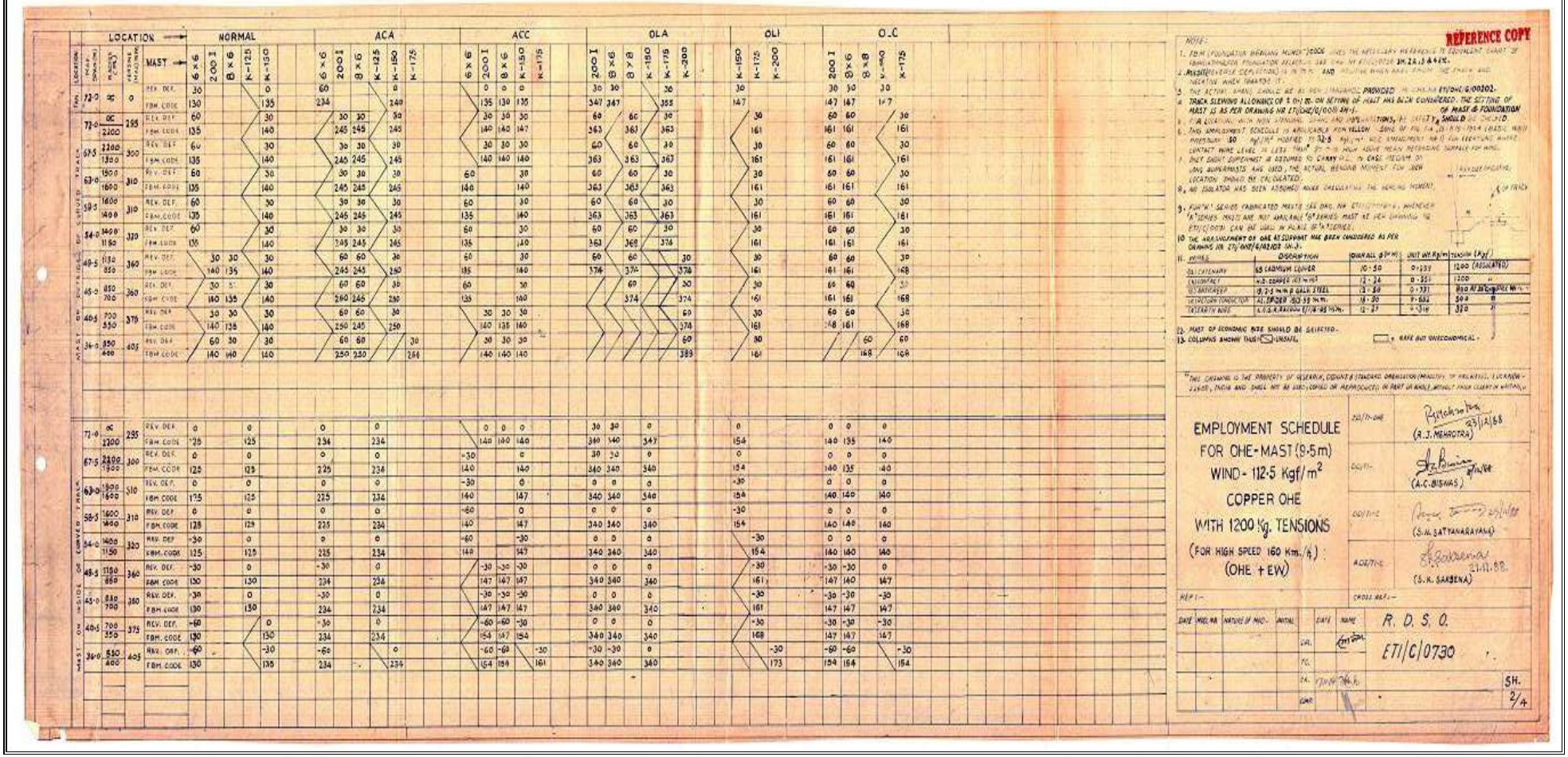
SN	Description	Drawing No	Annexure
1.	Employment Schedule for OHE mast (9.5m) wind pressure 112.5kgf/m^2 Copper OHE with 1200 kgf tension (OHE+EW)	ETI/C/0730 - Sheet-2	1
2.	Instruction for checking Suitability of Mast and Foundation	-	2
3.	25kV Feeder Arrangement on Separate mast	TI/DRG/OHE/FEEDER/RDSO /00001/19/0	3
4.	Employment Schedule for 25kV Feeder Arrangement on Separate mast for 155kgf Wind Pressure	TI/DRG/CIV/FEEDER-ES/RDSO/00001/20/0 (Sheet-I)	3A
5.	Employment Schedule for 25kV Feeder Arrangement on Separate mast for 178 kgf Wind Pressure	TI/DRG/CIV/FEEDER-ES/RDSO/00001/20/0 (Sheet-II)	3B
6.	Feeder Termination Drawing	RE/33/G/05145-1, Rev. A	4
7.	Employment Schedule for OHE Mast (9.5m) wind pressure 155kgf/m^2 & 2.8 m/3.8 m/4.85 m implantation (OHE + Feeder wire + Earth wire) for 1200 kgf tension in 65 mm^2 catenary wire & 1200kfg tension in 107 mm^2 contact wire.	TI/DRG/CIV/ES/RDSO/00004/19/0 (Sheet-I to III)	5,6,7
8.	Employment Schedule for OHE Mast (9.5m) wind pressure 178 kgf/m^2&& 2.8 m/3.8 m/4.85 m implantation (OHE + Feeder wire + Earth wire) for 1200 kgf tension in 65 mm^2 catenary wire &1200kfg tension in 107 mm^2 contact wire.	TI/DRG/CIV/ES/RDSO/00004/19 /0 (Sheet-IV to VI)	8,9,10
9.	General Arrangement of OHE with Feeder, Earth wire & BEC (1200+1200)	TI/DRG/OHE/FEEDER/RDSO /00002/19/0.	11
10.	Employment Schedule for OHE Mast (9.5m) wind pressure 155kgf/m^2& 2.8 m/3.8 m/4.85 m implantation (OHE + Feeder wire + Earth wire) for 1500 kgf tension in 125 mm^2 catenary wire & 1500kfg tension in 150 mm^2 contact wire.	TI/DRG/CIV/ES/RDSO/00004/20/0 (Sheet-I to III)	12,13,14
11.	Employment Schedule for OHE Mast (9.5m) wind pressure 178 kgf/m^2 & 2.8 m/3.8 m/4.85 m implantation (OHE + Feeder wire + Earth wire) for 1500 kgf tension in 125 mm^2 catenary wire & 1500kfg tension in 150 mm^2 contact wire.	TI/DRG/CIV/ES/RDSO/00004/20/0 (Sheet-IV to VI)	15,16,17
12.	General Arrangement of OHE with Feeder, Earth wire & BEC	TI/DRG/OHE/FEEDER/RDSO /00002/20/0.	18

	(1500+1500)		
13.	Territorial limits of revised wind zones	-	19
14.	Counter Weight Eye Rod	ETI/OHE /SK/588 Rev. B.	20
15.	Counter Weight Assembly	ETI/OHE/SK/587 Rev. B	21
16.	X-Y adjustment Chart	TI/DRG/OHE/ATD/RDSO/00003/99/0	22
17.	Dropper Schedule	TI/DRG/OHE/DROP/00001-00007/18/0 & TI/DRG/OHE/DROP/RDSO/00001/20/0	23 to 30
18.	CEDE/NCR letter no. EL/TRD/NCR /Gatimaan dated 19.11.2018	-	31
19.	25mm drop Bracket Assembly	ETI/OHE/P/2360- Rev. N	32
20.	BFB Steady Arm Assembly	ETI/OHE/P/2390-Rev. C	33
21.	Current Carrying Dropper Assembly	TI/DRG/OHE/CCD/RDSO/00001/20/0	34
22.	Catenary wire Clamp for Current Carrying Dropper	TI/DRG/OHE/CCD/RDSO/00002/20/0	35
23.	Contact wire clamp for Current Carrying Dropper	TI/DRG/OHE/CCD/RDSO/00003/20/0	36
24.	Compression sleeve, thimble & cable lug for Current Carrying Dropper	TI/DRG/OHE/CCD/RDSO/00004/20/0	37
25.	Mounting details of Double Pole Isolator on Mast (For 2X25kV)	ETI/OHE/G/06005-Sheet 2	38
26.	Mounting Details of Double Pole Isolator on Portals (For 2X25kV)	ETI/OHE/G/06008	39
27.	Railway Board letter No. 2001/Elect (G)/170/1 Pt dated 07.05.2012	-	40
28.	Railway Board letter No. 2001/Elect (G)/170/1 Pt dated 18.10.2012	-	41
29.	Tee Connector suitable for 20mm dia GS wire to 20mm dia GS wire	TI/DRG/OHE/TC/RDSO/00001/20/0	42
26.	Straight Connector suitable for 20mm dia GS wire to 20mm dia GS wire	TI/DRG/OHE/SC/RDSO/00001/20/0	43
21	Cross Bonding Arrangement	TI/DRG/OHE/EARTHING/RDSO/00001/20/0.	44
22	BEC Arrangement on Bridges and Platform Coping	-	45
23	Railway Board letter No.2001/Elect(G)170/1 Pt-III dated 07.08.2020	-	46
24	Railway Board letter No.2001/Elect(G)170/1 Pt-II dated 16.10.2020	-	47

1.6 LIST OF SPECIFICATIONS & APPROVED VENDORS

SN	Description of item	Specification No.	Annexure	Vendors
1	Three Pulley Higher Tension ATD	TI/SPC/OHE/3PHTA TD/0150 with ACS 1	-	1.M/s Kamgar Engineering Mumbai 2.M/s Shree steel Wire Rope Ltd. Mumbai 3. M/s Economic Electrical Kolkota 4.M/s Khatri Casting, Mumbai
2	107 sq.mm Silver bearing Grooved Copper Contact Wire for Electric traction (Draft)	TI/SPC/OHE/CW(Cu -Ag)/ 0130	-	Draft under approval
3	Current Carrying Dropper (Draft)	TI/SPC/OHE/CCFD/ 0160	-	Draft under approval
4	Double Pole Isolator	ETI/PSI/133	-	Under revision

ANNEXURE 1


REFERENCE COPY
EMPLOYMENT SCHEDULE
FOR OHE-MAST (9·5m)
WIND - 112·5 Kgf/m²
COPPER OHE
WITH 1200 Kg. TENSIONS
(FOR HIGH SPEED 160 Km./h) :
(OHE + EW)
(R.J. MEHROTRA)
(A.C. BISWAS)
(S.M. SATTANARAYANA)
(S.K. SAKSENA)
R. D. S. O.
ETI/C/0730
5H.
2/4

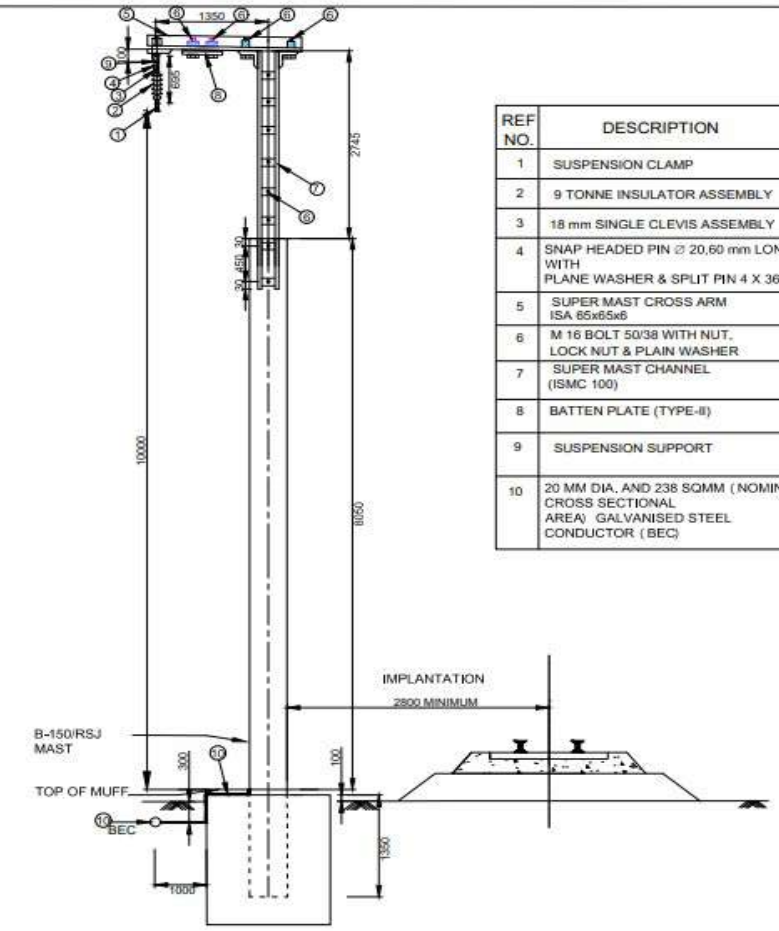
ANNEXURE 2

INSTRUCTION FOR CHECKING SUITABILITY OF

EXISTING MAST AND FOUNDATION

1. Select the Excel Sheet as per mast location.
2. Fill up the following Input design data in Value column.
   (i) OHE span length
   (ii) Tension in conductors =1200 kgf
   (iii) Weight of man = 0 kg
   (iv) Radius of curvature for Curved Track/Tangent Track
   (v) Wind Pressure- 112.5kgf/m^2 for NDLS-HWH & NDLS-BCT section/150kgf/m^2 for Kolkata Region
   (vi) Factor for Conductor -0.67
   (vii) Factor for OHE Mast- 1 for Rolled Mast/1.5 for Fabricated Mast
   (viii) Diameter of Contact wire-12.24mm
   (ix) Diameter of Catenary wire-10.5mm
   (x) Diameter of Earth Wire- 12.27mm
3. Compare total calculated bending moment with the permissible bending moment strength . Mast is suitable if permissible bending moment > Calculated bending moment .
4. For checking suitability of foundation the foundation drawing No. ETI/C/0058 Sheet 1 to 5 should be referred. The FMB code indicated in above drawing for calculated bending moment should be higher or equal to existing foundation at site.
5. There is a correction in Excel sheet circulated on 1.09.2020 for checking Mast and foundation suitability. For ACC outside sheet- Row no. 72-Bending moment due to radial pull on ACC wire up to radius 400m will be negative value (inadvertently it has been mentioned in sheet as positive) and below radius 400m positive value(inadvertently it has been mentioned as negative) will be taken.

ANNEXURE 3



REF NO.	DESCRIPTION	PART NO.	QTY
1	SUSPENSION CLAMP	1580	1
2	9 TONNE INSULATOR ASSEMBLY	6020	1
3	18 mm SINGLE CLEVIS ASSEMBLY	5040	1
4	SNAP HEADED PIN ∅ 20,60 mm LONG WITH PLANE WASHER & SPLIT PIN 4 X 36	262	1
5	SUPER MAST CROSS ARM ISA 65x65x6	8015/8012	2
6	M 16 BOLT 50/38 WITH NUT, LOCK NUT & PLAIN WASHER	16/3 NL	12
7	SUPER MAST CHANNEL (ISMC 100)	8021/8061/8011	2
8	BATTEN PLATE (TYPE-II)	8016	1
9	SUSPENSION SUPPORT	8014 OR 8014-1	1
10	20 MM DIA. AND 238 SQMM (NOMINAL CROSS SECTIONAL AREA) GALVANISED STEEL CONDUCTOR (BEC)	AS PER IS: 2141-2000	

NOTE :-

1. ALL DIMENSIONS ARE IN mm
2. THE 25 KV ALUMINIUM FEEDER WIRE (19.95 MM DIA. AND 233.8 SQMM CROSS SECTIONAL AREA) SHALL BE RUN ON THE REAR SIDE OF THE FEEDER MAST. THE FEEDER MAST WILL HAVE MINIMUM IMPLANTATION OF 2.8M
3. SPAN OF FEEDER LINE WILL BE SAME AS OHE SPAN.
4. TENSION LENGTH OF FEEDER LINE WILL BE 1500M.
5. SUITABLE SUPER MAST AND CROSS ARM SHOULD BE USED AS PER SITE CONDITION TAKING IN TO ACCOUNT THE GROUND CLEARANCE & LATERAL CLEARANCES IN OPEN ROUTE, ACROSS AND ALONG THE STREET/LC GATE.
6. MAST AND FOUNDATION SHOULD BE SELECTED AS PER DRAWING NO.TIDRG/CIV/FEEDER-ES/RDSO/00001/20/0 SHEET 1 & 2.
7. BEC WILL BE CONNECTED TO EACH FEEDER MAST BY BEC CONDUCTOR WITH SUITABLE TEE CONNECTOR AT ONE END & LUG ARRANGEMENT AT MAST END.

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW-11, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING.

25 kV FEEDER ARRANGEMENT ON SEPARATE MAST FOR NDLS-HWH & NDLS-MUMBAI ROUTE

DTI-2

(BHARDWAJ CHAUDHARY)

REF. ETI/C/P/8020

CROSS REF :-

DATE	MOD.	NATURE OF MOD.	INITIALS
	"A"	NOTE 2,3 & 6 MODIFIED AND NOTE 7 & REF. 10 ADDED	

R . D . S . O.

	DATE	NAME
DR		
CK		
CK		

TI/DRG/OHE/FEEDER/RDSO/00001/19/0

ANNEXURE 3A

EMPLOYMENT SCHEDULE: WIND PRESSURE 155 KGF/SQM

MAST ON OUTSIDE OF CURVED TRACK

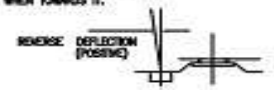
TYPE OF MAST				RSJ	B-150
MAX. SPAN (m)	RADIUS (m)	VERSINE (max.) mm		Normal location	
72	∞	0	REV. DEF.	30	30
			FBM. CODE	147	147
72	∞	295	REV. DEF.	30	30
	2200		FBM. CODE	147	147
67.5	2200	300	REV. DEF.	30	30
	1900		FBM. CODE	147	147
63	1900	310	REV. DEF.	30	30
	1600		FBM. CODE	147	147
58.5	1600	310	REV. DEF.	30	30
	1400		FBM. CODE	147	147
54	1400	320	REV. DEF.	30	30
	1150		FBM. CODE	140	140
49.5	1150	360	REV. DEF.	30	30
	850		FBM. CODE	140	140
45	850	360	REV. DEF.	30	30
	700		FBM. CODE	140	140
40.5	700	375	REV. DEF.	30	30
	550		FBM. CODE	140	140
36	550	405	REV. DEF.	30	30
	400		FBM. CODE	140	140
31.5	400	415	REV. DEF.	30	30
	300		FBM. CODE	140	140
27	300	455	REV. DEF.	30	30
	200		FBM. CODE	140	140

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				RSJ	B-150
MAX. SPAN (m)	RADIUS (m)	VERSINE (max.) mm		Normal location	
72	∞	295	REV. DEF.	0	0
	2200		FBM. CODE	147	147
67.5	2200	300	REV. DEF.	0	0
	1900		FBM. CODE	147	147
63	1900	310	REV. DEF.	0	0
	1600		FBM. CODE	147	147
58.5	1600	310	REV. DEF.	0	0
	1400		FBM. CODE	147	147
54	1400	320	REV. DEF.	0	0
	1150		FBM. CODE	140	140
49.5	1150	360	REV. DEF.	0	0
	850		FBM. CODE	140	140
45	850	360	REV. DEF.	0	0
	700		FBM. CODE	140	140
40.5	700	375	REV. DEF.	0	0
	550		FBM. CODE	140	140
36	550	405	REV. DEF.	0	0
	400		FBM. CODE	140	140
31.5	400	415	REV. DEF.	0	0
	300		FBM. CODE	140	140
27	300	455	REV. DEF.	0	0
	200		FBM. CODE	140	140

NOTES:-

1. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR GREEN REGION OF BASIC WIND SPEED 47 m/s OF FIGURE-1 OF IS: 875 (Part-3)-2015 REVIS (DESIGN WIND PRESSURE 155 Kgf/m²) CALCULATED AS PER CLAUSE 5.4 OF IS: 875 (Part-3)-2015 (Rev.-III).
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR 25 kV FEEDER ARRANGEMENT ON SEPARATE MAST FOR NDLS-HWH & NDLS-MUMBAI ROUTE ONLY.
3. THE 25kV FEEDER SHALL BE RUN ON THE REAR SIDE OF THE FEEDER MAST. THE FEEDER MAST WILL HAVE MINIMUM INFLANDION OF 2.0 M.
4. MAST OF ECONOMIC SIZE SHALL BE SELECTED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVE THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING NO. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION '0' CHART OF (SHEET NO. 1 TO 5).
6. THE CYCLONIC DESIGN AREA FACTOR (K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 4.3.4 OF IS: 875 (Part-3)-2015 (Rev.-III).
7. WHERE ISOLATOR IS CONSIDERED ON FEEDER MAST, RSJ MAST WITH FBM CODE-154 SHALL BE USED.
8. REVERSE DEFLECTIONS ARE IN mm, REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR 25kV FEEDER ARRANGEMENT ON SEPARATE MAST FOR NDLS-HWH & NDLS-MUMBAI ROUTE
BASIC WIND SPEED 47 m/s
WIND PRESSURE 155 kgf/m²
1212 kgf TENSION IN FEEDER WIRE
19.95mm²

DR-2 (BHARDWAJ CHAUDHARY)

REF:- TI/DRG/CIV/FEEDER/RDSO/00001/18/0 "MOD-A" CROSS REF:-

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/FEEDER-ES /RDSO/00001/20/0

NOT TO SCALE SHEET-1

ANNEXURE 3B

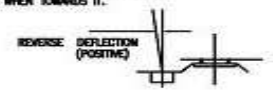
EMPLOYMENT SCHEDULE: WIND PRESSURE 178 KGF/SQM

MAST ON OUTSIDE OF CURVED TRACK					
TYPE OF MAST				RSJ	B-150
MAX. SPAN (m)	RADIUS (m)	VERSINE (max.) mm		NORMAL LOCATION	
67.5	∞	0	REV. DEF.	30	-
			FBM. CODE	154	-
63	∞	200	REV. DEF.	30	-
	2500		FBM. CODE	154	-
63	2500	265	REV. DEF.	30	-
	1900		FBM. CODE	154	-
58.5	1900	265	REV. DEF.	30	30
	1600		FBM. CODE	147	147
54	1600	260	REV. DEF.	30	30
	1400		FBM. CODE	147	147
49.5	1400	265	REV. DEF.	30	30
	1150		FBM. CODE	147	147
49.5	1150	360	REV. DEF.	30	30
	850		FBM. CODE	147	147
45	850	360	REV. DEF.	30	30
	700		FBM. CODE	147	147
40.5	700	375	REV. DEF.	30	30
	550		FBM. CODE	147	147
36	550	405	REV. DEF.	30	30
	400		FBM. CODE	147	147
31.5	400	415	REV. DEF.	30	30
	300		FBM. CODE	140	140
27	300	455	REV. DEF.	30	30
	200		FBM. CODE	140	140

MAST ON INSIDE OF CURVED TRACK					
TYPE OF MAST				RSJ	B-150
MAX. SPAN (m)	RADIUS (m)	VERSINE (max.) mm		NORMAL LOCATION	
63	∞	200	REV. DEF.	0	-
	2500		FBM. CODE	154	-
63	2500	265	REV. DEF.	0	-
	1900		FBM. CODE	154	-
58.5	1900	265	REV. DEF.	0	0
	1600		FBM. CODE	147	147
54	1600	260	REV. DEF.	0	0
	1400		FBM. CODE	147	147
49.5	1400	265	REV. DEF.	0	0
	1150		FBM. CODE	147	147
49.5	1150	360	REV. DEF.	0	0
	850		FBM. CODE	147	147
45	850	360	REV. DEF.	0	0
	700		FBM. CODE	147	147
40.5	700	375	REV. DEF.	0	0
	550		FBM. CODE	147	147
36	550	405	REV. DEF.	0	0
	400		FBM. CODE	147	147
31.5	400	415	REV. DEF.	0	0
	300		FBM. CODE	140	140
27	300	455	REV. DEF.	0	0
	200		FBM. CODE	140	140

NOTES:-

1. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR RED REGION OF BASIC WIND SPEED 50 m/s OF FIGURE-1 OF IS: 875 (Part-3)-2015 REVIII (DESIGN WIND PRESSURE 178 Kgf/m^2 CALCULATED AS PER CLAUSE 5.4 OF IS: 875 (Part-3)-2015 (Rev.-III).
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR 25 kV FEEDER ARRANGEMENT ON SEPARATE MAST FOR NDLS-HWH & NDLS-MUMBAI ROUTE ONLY.
3. THE 25kV FEEDER SHALL BE RUN ON THE REAR SIDE OF THE FEEDER MAST. THE FEEDER MAST WILL HAVE MINIMUM IMPLANTATION OF 2.5 M.
4. MAST OF ECONOMIC SIZE SHALL BE SELECTED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVE THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING NO. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION "B" CHART OF (SHEET NO. 1 TO 5).
6. THE CYCLONIC RESIGN AREA FACTOR (K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 6.3.4 OF IS: 875 (Part-3)-2015 (Rev.-III).
7. WHERE ISOLATOR IS CONSIDERED ON FEEDER MAST, B-200 MAST WITH FBM CODE-161 SHALL BE USED.
8. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR 25kV FEEDER ARRANGEMENT ON SEPARATE MAST FOR NDLS-HWH & NDLS-MUMBAI ROUTE
BASIC WIND SPEED 50 m/s
WIND PRESSURE 178 kgf/m^2
1212 kgf TENSION IN FEEDER WIRE
19.95mm^2

DTI-2 (BHARDWAJ CHAUDHARY)

REF:-TI/DRG/OHE/FEEDER/RDSO/00001/18/0 "MOD-A" CROSS REF:-

DATE	MOD.	NATURE OF MOD.	INITIAL

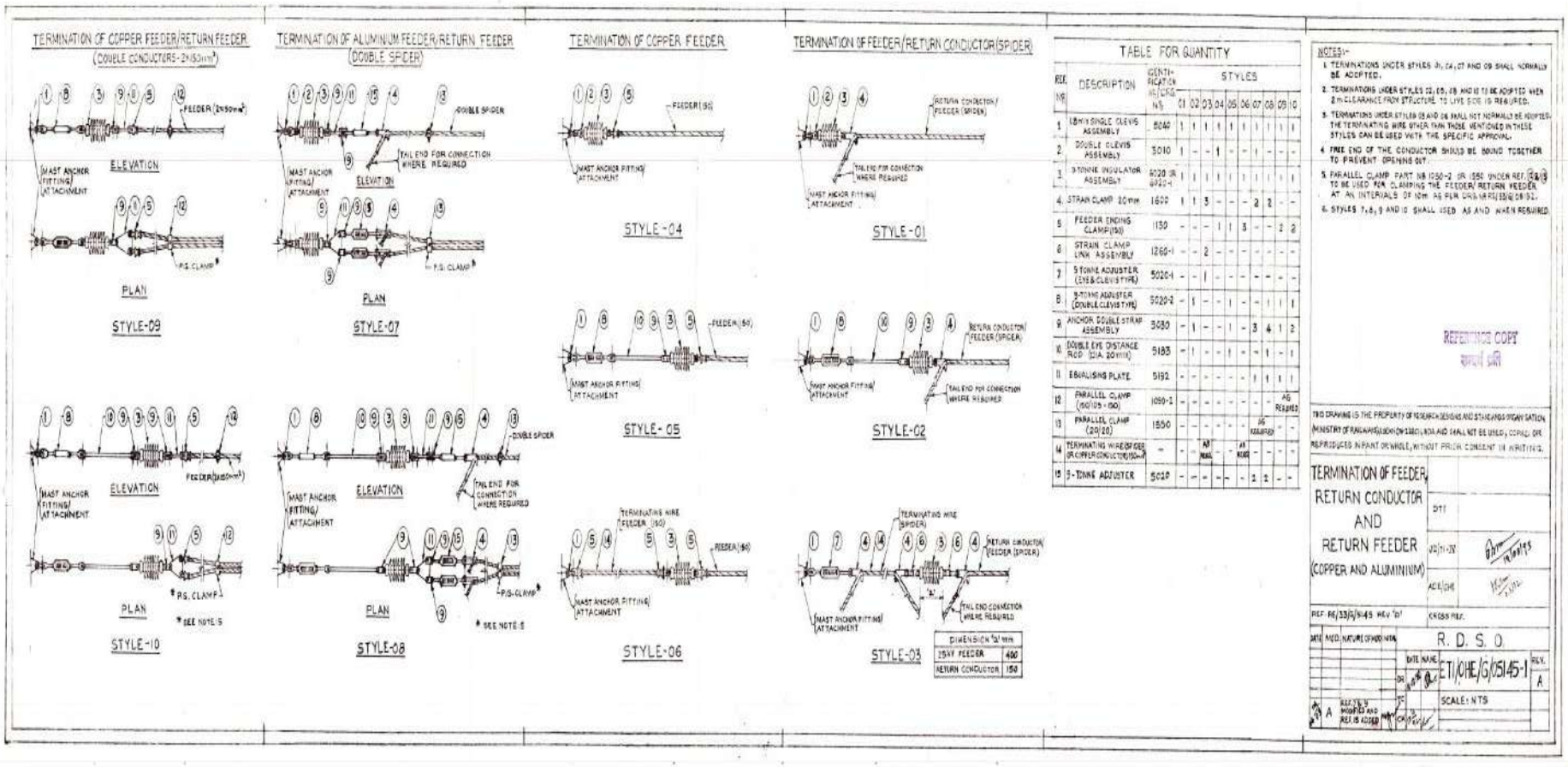
R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/FEEDER-ES/RDSO/00001/20/0

NOT TO SCALE SHEET-2

ANNEXURE 4


TERMINATION OF COPPER FEEDER/RETURN FEEDER
(DOUBLE CONDUCTORS-2×(50 mm²))
TERMINATION OF ALUMINUM FEEDER/RETURN FEEDER
(DOUBLE SPIDER)
TERMINATION OF COPPER FEEDER
TERMINATION OF FEEDER/RETURN CONDUCTOR(SPIDER)
ELEVATION
PLAN
STYLE-09
STYLE-07
STYLE-04
STYLE-01
STYLE-05
STYLE-02
STYLE-10
STYLE-08
STYLE-06
STYLE-03
TABLE FOR QUANTITY
NOTES:-
REFERENCE COPY
TERMINATION OF FEEDER, RETURN CONDUCTOR AND RETURN FEEDER (COPPER AND ALUMINIUM)
R. D. S. O.
ET/OHE/G/05145-1
SCALE: NTS

ANNEXURE 5

EMPLOYMENT SCHEDULE: WIND PRESSURE 155KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

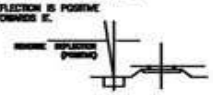
TYPE OF MAST				RSJ (8" x 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
67.5	∞	0	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	161	-	-	-	-	-	-	270	178	-	178	-	389	-
63	∞ / 2500	200	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	161	-	-	-	-	-	-	270	178	-	178	-	389	-
63	2500 / 1900	265	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	161	-	-	-	-	-	-	270	185	-	185	-	395	-
58.5	1900 / 1600	265	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	395	-
54	1600 / 1400	260	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	395	-
49.5	1400 / 1150	265	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	399	-
49.5	1150 / 850	360	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	-	-	-	193	399	193
45	850 / 700	360	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	-	-	-	193	399	193
40.5	700 / 550	375	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	-	-	-	193	399	193
36	550 / 400	405	REV. DEP.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	-	-	-	193	399	193

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				RSJ (8" x 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
63	∞ / 2500	200	REV. DEP.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	161	265	-	-	-	-	-	-	178	363	178	-	-	-
63	2500 / 1900	265	REV. DEP.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	161	265	-	-	-	-	-	-	178	363	178	-	-	-
58.5	1900 / 1600	265	REV. DEP.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	161	265	-	-	-	-	-	-	178	374	178	-	-	-
54	1600 / 1400	260	REV. DEP.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	161	265	-	-	-	-	-	-	178	374	178	-	-	-
49.5	1400 / 1150	265	REV. DEP.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
49.5	1150 / 850	360	REV. DEP.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
45	850 / 700	360	REV. DEP.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
40.5	700 / 550	375	REV. DEP.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-	-30	-	-30	-	-30
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	-	374	-	193	-	193
36	550 / 400	405	REV. DEP.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-	-	-	-	-	-	-	-30	-	-30	-	-30	
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	-	-	-	-	-	-	270	-	374		193	-	193

NOTES:-

1. BEYOND THE WIND SPEED OF 33 m/s THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR GREEN REGION OF BASIC WIND SPEED 47 m/s OF FIGURE-1 OF IS:875 (Part-3)-2015 REV.2 (DESIGN WIND PRESSURE 155 Kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part-3)-2015 REV.2).
3. THE CYCLONIC REGION AREA FACTOR(Ka) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 8.3.4 OF IS: 875(PART-3)-2015(REV.2)
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 2.8 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SWELLING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.ET/OHE/S/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION '0' CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON-STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8. WHERE ISOLATOR IS TO BE PROVIDED ON MAST, NEXT HIGHER SIZE OF MAST AND NEXT HIGHER FBM CODE FOR FOUNDATION SHALL BE SELECTED.
9.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
(b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.8, 5.7, 5.5 OF ACTM VOL.II, PART-2.
10. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ET/OHE/02102, SHEET-3, (REV.B)
11. MAST OF ECONOMIC SIZE SHALL BE SELECTED.
12. THE OHE SPAN AND RADIUS APPROVED BY RAILWAY BOARD FOR MINIMUM MADE CONCEPT.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m) BASIC WIND SPEED 47 m/s WIND PRESSURE 155 kgf/m² (OHE + FEEDER WIRE + EARTH WIRE) 1200 kgf TENSION IN CAT. 65mm² 1200 kgf TENSION IN CONT.107mm² (WITH IMPLANTATION UP TO 2.8M)	EDTI	(BHARDWAJ CHAUDHARY)
REF:-	CROSS REF:-	

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/19/0

NOT TO SCALE (SHEET-1)

ANNEXURE 6

EMPLOYMENT SCHEDULE: WIND PRESSURE 155KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

TYPE OF MAST				RSJ (8" × 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) (mm)		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
67.5	∞	0	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	161	-	-	-	-	-	-	270	178	-	178	-	389	-
63	∞ / 2500	200	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	270	185	-	185	-	395	-
63	2500 / 1900	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	395	-
58.5	1900 / 1600	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	395	-
54	1600 / 1400	260	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	395	-
49.5	1400 / 1150	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	399	-
49.5	1150 / 850	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	-	-	-	193	399	193
45	850 / 700	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	-	-	-	193	399	193
40.5	700 / 550	375	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	168	168	-	-	-	-	-	-	275	-	-	-	193	399	193
36	550 / 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	168	168	-	-	-	-	-	-	275	-	-	-	193	399	193

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				RSJ (8" × 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) (mm)		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
63	∞ / 2500	200	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	161	265	-	-	-	-	-	-	178	363	178	-	-	-
63	2500 / 1900	265	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	161	265	-	-	-	-	-	-	178	374	178	-	-	-
58.5	1900 / 1600	265	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	161	265	-	-	-	-	-	-	178	374	178	-	-	-
54	1600 / 1400	260	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
49.5	1400 / 1150	265	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
49.5	1150 / 850	360	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
45	850 / 700	360	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
40.5	700 / 550	375	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-	-	-	-	-	-	-30	-	-30	-	-30	-	-30
			FBM. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	-	-	-	-	-	-	270	-	374	-	193	-	193
36	550 / 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-	-	-	-	-	-	-30	-	-30	-	-30	-	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	270	-	374		193	-	193

NOTES:–

1. BEYOND THE WIND SPEED OF 33 m/s THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR GREEN REGION OF BASIC WIND SPEED 47 m/s OF FIGURE–1 OF IS:875 (Part–3)–2015 REV.III (DESIGN WIND PRESSURE 155 Kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part–3)–2015 REV.III).
3. THE CYCLONIC REGION AREA FACTOR(K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 8.3.4 OF IS: 875(PART–3)–2015(REV.III)
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 3.8 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SHIELDING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.ET/OHE/0/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION 'B' CHART OF (SHEET No.1 TO 6).
6. FOR LOCATIONS WITH NON–STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8. WHERE ISOLATOR IS TO BE PROVIDED ON MAST, NEXT HIGHER SIZE OF MAST AND NEXT HIGHER FBM CODE FOR FOUNDATION SHALL BE SELECTED.
9.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
   (b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.6, 5.7, 5.5 OF ACTM VOL.II, PART–2.
10. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ET/OHE/02102. SHEET–3. (REV.B)
11. MAST OF ECONOMIC SIZE SHALL BE SELECTED.
12. THE OHE SPAN AND RADIUS APPROVED BY RAILWAY BOARD FOR MIRROR IMAGE CONCEPT.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m) BASIC WIND SPEED 47 m/s WIND PRESSURE 155 kgf/m² (OHE + FEEDER WIRE + EARTH WIRE) 1200 kgf TENSION IN CAT. 65mm² 1200 kgf TENSION IN CONT.107mm² (WITH IMPLANTATION MORE THAN 2.8M AND UP TO 3.8M)	EDTI	(BHARDWAJ CHAUDHARY)

REF:– CROSS REF:–

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/19/0

NOT TO SCALE (SHEET–2)

ANNEXURE 7

EMPLOYMENT SCHEDULE: WIND PRESSURE 155KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

TYPE OF MAST				RSJ (8" × 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
67.5	∞	0	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	270	185	-	185	-	395	-
63	∞ / 2500	200	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	395	-
63	2500 / 1900	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	395	-
58.5	1900 / 1600	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	395	-
54	1600 / 1400	260	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	395	-
49.5	1400 / 1150	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	30	-	30	-	30	-
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	185	-	185	-	399	-
49.5	1150 / 850	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	275	-	-	-	193	399	193
45	850 / 700	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	168	168	-	-	-	-	-	-	275	-	-	-	193	399	193
40.5	700 / 550	375	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	168	168	-	-	-	-	-	-	275	-	-	-	193	399	193
36	550 / 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	30	30	-	-	-	-	-	-	30	-	-	-	30	30	30
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	168	168	-	-	-	-	-	-	275	-	-	-	193	399	193

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				RSJ (8" × 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
63	∞ / 2500	200	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FDN. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	161	265	-	-	-	-	-	-	178	374	178	-	-	-
63	2500 / 1900	265	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FDN. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	161	265	-	-	-	-	-	-	178	374	178	-	-	-
58.5	1900 / 1600	265	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FDN. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
54	1600 / 1400	260	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FDN. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
49.5	1400 / 1150	265	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FDN. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
49.5	1150 / 850	360	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-
			FDN. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	265	-	-	-	-	-	-	185	374	185	-	-	-
45	850 / 700	360	REV. DEF.	0	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-	-	-	-	-	-	-30	-30	-30	-30	-	-	-
			FDN. CODE	154	-	-	-	-	-	-	-	-	-	-	-	154	168	-	-	-	-	-	-	270	185	374	185	-	-	-
40.5	700 / 550	375	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-	-	-	-	-	-	-30	-	-30	-	-30	-	-30
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	270	-	374	-	193	-	193
36	550 / 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-	-	-	-	-	-	-30	-	-30	-	-30	-	-30
			FDN. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	168	-	-	-	-	-	-	270	-	374		193	-	193

NOTES:–

1. BEYOND THE WIND SPEED OF 33 m/s THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR GREEN REGION OF BASIC WIND SPEED 47 m/s OF FIGURE–1 OF IS:875 (Part–3)–2015 REV.III (DESIGN WIND PRESSURE 155 Kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part–3)–2015 REV.III).
3. THE CYCLONIC REGION AREA FACTOR(Kd) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 8.3.4 OF IS. 875(PART–3)–2015(REV.III)
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 4.85 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SHELLING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.ET/OHE/G/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION 'B' CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON–STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8. WHERE ISOLATOR IS TO BE PROVIDED ON MAST, NEXT HIGHER SIZE OF MAST AND NEXT HIGHER FDN CODE FOR FOUNDATION SHALL BE SELECTED.
9.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
(b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 8.1.2.1, 5.8, 5.7, 5.5 OF ACTM VOL.II, PART–2.
10. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ET/OHE/02102, SHEET–3 (REV.B)
11. MAST OF ECONOMIC SIZE SHALL BE SELECTED.
12. THE OHE SPAN AND RADIUS APPROVED BY RAILWAY BOARD FOR MIRROR IMAGE CONCEPT.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m)
BASIC WIND SPEED 47 m/s
WIND PRESSURE 155 kgf/m²
(OHE + FEEDER WIRE + EARTH WIRE)
1200 kgf TENSION IN CAT. 65mm²
1200 kgf TENSION IN CONT.107mm²
(WITH IMPLANTATION MORE THAN 3.8M AND UP TO 4.85M)

EDTI (BHARDWAJ CHAUDHARY)

REF:– CROSS REF:–

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/19/0

NOT TO SCALE (SHEET–3)

ANNEXURE 8

EMPLOYMENT SCHEDULE: WIND PRESSURE 178KGF/SQM

MAST ON OUTSIDE OF CURVED TRACK

MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm	TYPE OF MAST	RSJ (8" x 6") N	RSJ (8" x 6") ACC	RSJ (8" x 6") ACA	RSJ (8" x 6") OLC	RSJ (8" x 6") OLA	RSJ (8" x 6") OLI	B-150 K-150 N	B-150 K-150 ACC	B-150 K-150 ACA	B-150 K-150 OLC	B-150 K-150 OLA	B-150 K-150 OLI	B-175 K-175 N	B-175 K-175 ACC	B-175 K-175 ACA	B-175 K-175 OLC	B-175 K-175 OLA	B-175 K-175 OLI	B-200 K-200 N	B-200 K-200 ACC	B-200 K-200 ACA	B-200 K-200 OLC	B-200 K-200 OLA	B-200 K-200 OLI	B-225 K-225 OLC	B-225 K-225 OLA	B-225 K-225 OLI
63	∞	0	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	30	-	30	-	30	-
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	270	178	-	178	-	389	-
58.5	∞ / 2500	175	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	30	-	30	-	30	-
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	275	185	-	185	-	395	-
58.5	2500 / 1900	225	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	30	-	30	-	30	-
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	275	185	-	185	-	395	-
58.5	1900 / 1600	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	275	-	-	-	193	395	193
54	1600 / 1400	260	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
49.5	1400 / 1150	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
49.5	1150 / 850	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
45	850 / 700	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
40.5	700 / 550	375	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	199	399	199
36	550 / 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	199	399	199

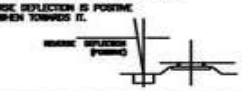
MAST ON INSIDE OF CURVED TRACK

MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm	TYPE OF MAST	RSJ (8" x 6") N	RSJ (8" x 6") ACC	RSJ (8" x 6") ACA	RSJ (8" x 6") OLC	RSJ (8" x 6") OLA	RSJ (8" x 6") OLI	B-150 K-150 N	B-150 K-150 ACC	B-150 K-150 ACA	B-150 K-150 OLC	B-150 K-150 OLA	B-150 K-150 OLI	B-175 K-175 N	B-175 K-175 ACC	B-175 K-175 ACA	B-175 K-175 OLC	B-175 K-175 OLA	B-175 K-175 OLI	B-200 K-200 N	B-200 K-200 ACC	B-200 K-200 ACA	B-200 K-200 OLC	B-200 K-200 OLA	B-200 K-200 OLI	B-225 K-225 OLC	B-225 K-225 OLA	B-225 K-225 OLI
58.5	∞ / 2500	175	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	178	-	178	-	374	-
58.5	2500 / 1900	225	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	178	-	178	-	374	-
58.5	1900 / 1600	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	374	-
54	1600 / 1400	260	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	389	-
49.5	1400 / 1150	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	389	-
49.5	1150 / 850	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	-	-	-	193	389	193
45	850 / 700	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	-	-	-	193	389	193
40.5	700 / 550	375	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	-	-	-	193	389	193
36	550 / 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FEM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	-	-	-	193	389	193

NOTE: 1. FOR OUTSIDE CURVE, ACA LOCATION ONE MAST B/K-200 WITH SPECIAL FOUNDATION DESIGN FOR BENDING MOMENT 8000 KGM TO BE ADOPTED.
2. FOR OUTSIDE CURVE, OLA LOCATION ONE MAST B/K-225 WITH SPECIAL FOUNDATION DESIGN FOR BENDING MOMENT UPTO 11000 KGM TO BE ADOPTED.

NOTES:-

1. BEYOND THE WIND SPEED OF 33 m/s, THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR RED REGION OF BASIC WIND SPEED 50 m/s OF FIGURE-1 OF IS:875 (Part-3)-2015 REV.III (DESIGN WIND PRESSURE 178 Kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part-3)-2015 REV.III).
3. THE CYCLONIC REGION AREA FACTOR(K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 6.3.4 OF IS: 875(PART-3)-2015(REV.III).
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 2.8 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SHELLING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.TI/DRG/CHE/S/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CH/FND/RDSO/00001/04/0 MODIFICATION 'B' CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON-STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8. WHERE BRACKET IS TO BE PROVIDED ON MAST, NEXT HIGHER SIZE OF MAST AND NEXT HIGHER FBM CODE FOR FOUNDATION SHALL BE SELECTED.
9.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
(b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 8.1.2.1, 8.8, 8.7, 8.8 OF ACTM VOL.II, PART-2.
10. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ET/OHE/02102, SHEET-3, (REV.B)
11. MAST OF ECONOMIC SIZE SHALL BE SELECTED.
12. THE OHE SPAN AND RADIUS APPROVED BY RAILWAY BOARD FOR MIRROR IMAGE CONCEPT HAS BEEN ADOPTED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m)
BASIC WIND SPEED 50 m/s
WIND PRESSURE 178 kgf/m²
(OHE + FEEDER WIRE + EARTH WIRE)
1200 kgf TENSION IN CAT. 65mm²
1200 kgf TENSION IN CONT.107mm²
(WITH IMPLANTATION UP TO 2.8M)

EDTI (BHARDWAJ CHAUDHARY)

REF:- CROSS REF:-

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/19/0

NOT TO SCALE (SHEET-4)

ANNEXURE 9

EMPLOYMENT SCHEDULE: WIND PRESSURE 178KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

MAST SPAN (m)	RADIUS (m)	VERTICAL REACH (MAX.) mm		RSJ (8" × 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
				N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
63	∞	0	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	270	185	-	185	-	395	-
58.5	∞ / 2500	175	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	275	185	-	185	-	395	-
58.5	2500 / 1900	225	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	275	185	-	185	-	395	-
58.5	1900 / 1600	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	395	193
54	1600 / 1400	260	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
49.5	1400 / 1150	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
49.5	1150 / 850	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
45	850 / 700	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
40.5	700 / 550	375	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	173	178	SPL	-	-	-	199	399	199
36	550 / 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	173	178	SPL	-	-	-	199	399	199

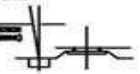
MAST ON INSIDE OF CURVED TRACK

MAST SPAN (m)	RADIUS (m)	VERTICAL REACH (MAX.) mm		RSJ (8" × 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
				N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
58.5	∞ / 2500	175	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	178	-	178	-	374	-
58.5	2500 / 1900	225	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	374	-
58.5	1900 / 1600	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	389	-
54	1600 / 1400	260	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	389	-
49.5	1400 / 1150	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	389	-
49.5	1150 / 850	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	-	-	-	193	389	193
45	850 / 700	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	-	-	-	193	389	193
40.5	700 / 550	375	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	275	-	-	-	193	389	193
36	550 / 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-30	-30	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	178	275	-	-	-	193	389	193

NOTE: 1. FOR OUTSIDE CURVE, ACA LOCATION ONE MAST B/K-200 WITH SPECIAL FOUNDATION DESIGN FOR BENDING MOMENT 8000 KGM TO BE ADOPTED.
2. FOR OUTSIDE CURVE, OLA LOCATION ONE MAST B/K-225 WITH SPECIAL FOUNDATION DESIGN FOR BENDING MOMENT UPTO 11000 KGM TO BE ADOPTED.

NOTES:-

1. BEYOND THE WIND SPEED OF 33 m/s, THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR RED REGION OF BASIC WIND SPEED 50 m/s OF FIGURE-1 OF IS:875 (Part-3)-2015 REV.2 (DESIGN WIND PRESSURE 178 Kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part-3)-2015 REV.2).
3. THE CYCLONIC REGION AREA FACTOR(K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 6.3.4 OF IS: 875(PART-3)-2015(REV.2).
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 3.8 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SHIELDING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.TI/OHE/S/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION 'B' CHART OF (SHEET No.1 TO 6).
6. FOR LOCATIONS WITH NON-STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8. WHERE ISOLATOR IS TO BE PROVIDED ON MAST, NEXT HIGHER SIZE OF MAST AND NEXT HIGHER FBM CODE FOR FOUNDATION SHALL BE SELECTED.
9. (a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
   (b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.8, 5.7, 5.5 OF ACTM VOL.II, PART-2.
10. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ES/OHE/02102, SHEET-3. (REV.B)
11. MAST OF ECONOMIC SIZE SHALL BE SELECTED.
12. THE OHE SPAN AND RADIUS APPROVED BY RAILWAY BOARD FOR MIRROR IMAGE CONCEPT HAS BEEN ADOPTED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m)
BASIC WIND SPEED 50 m/s
WIND PRESSURE 178 kgf/m²
(OHE + FEEDER WIRE + EARTH WIRE)
1200 kgf TENSION IN CAT. 65mm²
1200 kgf TENSION IN CONT.107mm²
(WITH IMPLANTATION MORE THAN 2.8M AND UP TO 3.8M)

EDTI (BHARDWAJ CHAUDHARY)

REF:- CROSS REF:-

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/19/0

NOT TO SCALE (SHEET-5)

ANNEXURE 10

EMPLOYMENT SCHEDULE: WIND PRESSURE 178KGF/SQM

MAST ON OUTSIDE OF CURVED TRACK

TYPE OF MAST				RSJ (8" × 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
MAX. SPAN (m)	RADIUS (m)	VERTICAL X (MAX.) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
63	∞	0	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	275	185	-	185	-	395	-
58.5	∞ 2500	175	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	30	-	30	-	30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	275	185	-	185	-	395	-
58.5	2500 1900	225	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	275	-	-	-	193	395	193
58.5	1900 1600	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
54	1600 1400	260	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
49.5	1400 1150	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	173	SPL	-	-	-	193	399	193
49.5	1150 850	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	173	173	SPL	-	-	-	193	399	193
45	850 700	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	173	178	SPL	-	-	-	193	399	193
40.5	700 550	375	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	173	178	SPL	-	-	-	199	399	199
36	550 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	30	-	-	-	30	30	30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	173	178	SPL	-	-	-	199	399	199

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				RSJ (8" × 6")						B-150 K-150						B-175 K-175						B-200 K-200						B-225 K-225		
MAX. SPAN (m)	RADIUS (m)	VERTICAL X (MAX.) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
58.5	∞ 2500	175	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	178	-	178	-	374	-
58.5	2500 1900	225	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	389	-
58.5	1900 1600	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	389	-
54	1600 1400	260	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-30	-	-30	-	-30	-
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	185	-	185	-	389	-
49.5	1400 1150	265	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	-	-	-	193	389	193
49.5	1150 850	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	270	-	-	-	193	389	193
45	850 700	360	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-30	-	-	-	-	-	-	-30	-30	-	-	-	-30	-30	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	161	-	-	-	-	-	-	173	275	-	-	-	193	389	193
40.5	700 550	375	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-30	-30	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	178	275	-	-	-	193	389	193
36	550 400	405	REV. DEF.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-30	-30	-30	-	-	-	-30	-30	-30
			FBM. CODE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168	178	275	-	-	-	193	389	193

NOTE: 1. FOR OUTSIDE CURVE, ACA LOCATION ONE MAST B/K-300 WITH SPECIAL FOUNDATION DESIGN FOR BENDING MOMENT 8000 KG.M TO BE ADOPTED.
2. FOR OUTSIDE CURVE, OLA LOCATION ONE MAST B/K-225 WITH SPECIAL FOUNDATION DESIGN FOR BENDING MOMENT UPTO 11000 KG.M TO BE ADOPTED.

NOTES:—

1. BEYOND THE WIND SPEED OF 33 m/s, THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR RED REGION OF BASIC WIND SPEED 50 m/s OF FIGURE–1 OF IS:875 (Part–3)–2015 REV.II (DESIGN WIND PRESSURE 178 Kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part–3)–2015 REV.II).
3. THE CYCLONIC REGION AREA FACTOR(K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 5.3.4 OF IS: 875(PART–3)–2015(REV.II).
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 4.85 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SHIELDING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.EI/OHE/S/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION 'O' CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON–STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8. WHERE ISOLATOR IS TO BE PROVIDED ON MAST, NEXT HIGHER SIZE OF MAST AND NEXT HIGHER FBM CODE FOR FOUNDATION SHALL BE SELECTED.
9. (a) UNDER OVERLAP CONTIN. LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
   (b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.6, 5.7, 5.5 OF ACTM VOL.II, PART–2.
10. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. EI/OHE/02102. SHEET–3. (REV.B)
11. MAST OF ECONOMIC SIZE SHALL BE SELECTED.
12. THE OHE SPAN AND RIGIUS APPROVED BY RAILWAY BOARD FOR MIRROR IMAGE CONCEPT HAS BEEN ADOPTED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m)
BASIC WIND SPEED 50 m/s
WIND PRESSURE 178 kgf/m²
(OHE + FEEDER WIRE + EARTH WIRE)
1200 kgf TENSION IN CAT. 65mm²
1200 kgf TENSION IN CONT.107mm²
(WITH IMPLANTATION MORE THAN 3.8M AND UP TO 4.85M)

EDTI (BHARDWAJ CHAUDHARY)

REF:— CROSS REF:—

DATE	MOD.	NATURE OF MOD.	INITIAL

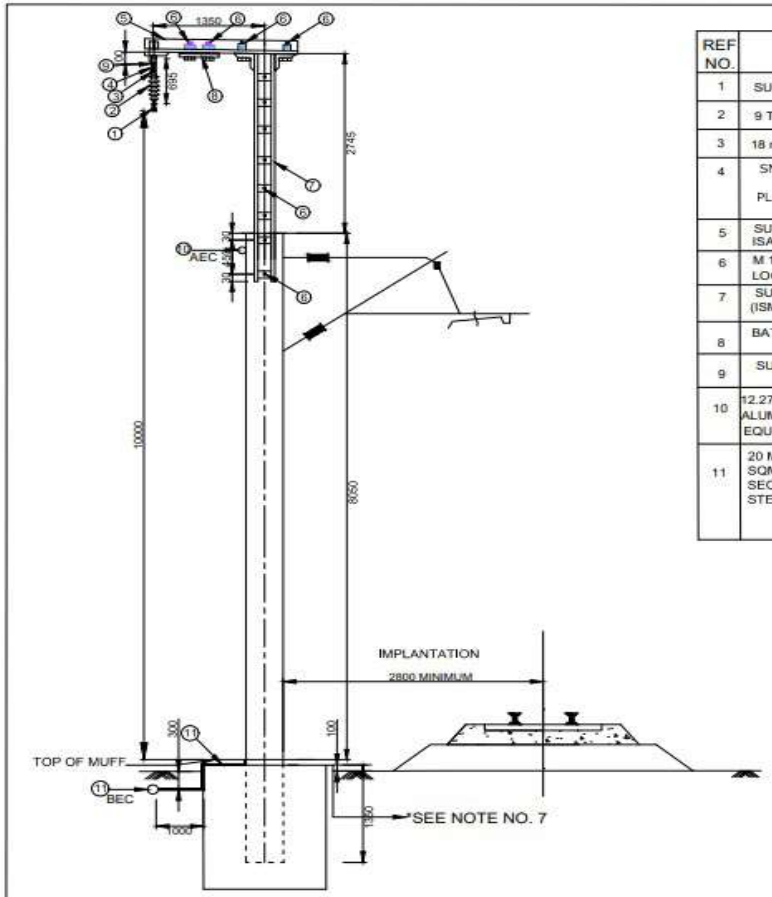
R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/19/0

NOT TO SCALE (SHEET–6)

ANNEXURE 11



REF NO.	DESCRIPTION	PART NO.	QTY
1	SUSPENSION CLAMP	1580	1
2	9 TONNE INSULATOR ASSEMBLY	6020	1
3	18 mm SINGLE CLEVIS ASSEMBLY	5040	1
4	SNAP HEADED PIN ∅ 20,60 mm LONG WITH PLANE WASHER & SPLIT PIN 4 X 36	262	1
5	SUPER MAST CROSS ARM ISA 65x65x6	8015/8012	2
6	M 16 BOLT 50/38 WITH NUT, LOCK NUT & PLAIN WASHER	16/3 NL	12
7	SUPER MAST CHANNEL (ISMC 100)	8021/8061/8011	2
8	BATTEN PLATE (TYPE-II)	8016	1
9	SUSPENSION SUPPORT	8014 OR 8014-1	1
10	12.27 mm DIA. OF STEEL REINFORCED ALUMINIUM RACCOON (50 MM2 Cu EQUIVALENT) (AEC)		
11	20 MM DIA. AND 238 SQMM (NOMINAL CROSS SECTIONAL AREA) GALVANISED STEEL CONDUCTOR (BEC)	AS PER IS: 2141-2000	

NOTE :-

1. ALL DIMENSIONS ARE IN mm
2. THE 25 KV ALUMINIUM FEEDER WIRE (19.95 MM DIA. AND 233.8 SQMM CROSS SECTIONAL AREA) SHALL BE RUN ON THE REAR SIDE OF THE MAST.THE FEEDER MAST WILL HAVE MINIMUM IMPLANTATION OF 2,8M
3. TENSION LENGTH OF FEEDER LINE WILL BE 1500M.
4. SUITABLE SUPER MAST AND CROSS ARM SHOULD BE USED AS PER SITE CONDITION TAKING IN TO ACCOUNT THE GROUND CLEARANCE & LATERAL CLEARANCES IN OPEN ROUTE, ACROSS AND ALONG THE STREET/LC GATE.
5. BEC WILL BE CONNECTED TO EACH MAST BY BEC CONDUCTOR WITH SUITABLE TEE CONNECTOR AT ONE END & LUG ARRANGEMENT AT MAST END
6. SPAN, MAST AND FOUNDATION SHOULD BE SELECTED AS PER DRAWING NO.TI/DRG/ES/RDSO/00004/19/0 (SHEET 1 - 6) .
7. THE CROSS BONDING OF UP BEC-UP MAST/PORTAL- UP TRACTION RAIL-DN-MAST/PORTAL-DN BEC SHOULD BE DONE BY 50X6 MM MS/GS FLAT AT EVERY 450 M.

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW-11, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING.

GENERAL ARRANGEMENT OF OHE WITH FEEDER , EARTH WIRE AND BEC FOR NDLS-HWH & NDLS-MUMBAI ROUTE

DTI-2

(BHARWDAJ CHAUDHARY)

REF. ETI/C/P/8020

CROSS REF :-

DATE	MOD.	NATURE OF MOD.	INITIALS
	"A"	REF. NO. 11 & NOTE 2,6 MODIFIED AND NOTE 7 ADDED	

R . D . S . O.

	DATE	NAME
DR		
CK		
CK		

TI/DRG/OHE/FEEDER/ RDSO/00002/19/0

ANNEXURE 12

EMPLOYMENT SCHEDULE: WIND PRESSURE 155KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

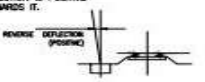
TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL.MAST		
MAX. SPAN (m)	RADIUS (m)	VARIANT (MAX.) mm		N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	CLC	CLA	CLI
63	∞	0	REV. DEF.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
			FBN. CODE	168	173	275	185	-	185	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
63	2200	225	REV. DEF.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
			FBN. CODE	173	173	275	185	-	185	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
63	2200	260	REV. DEF.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
	1900		FBN. CODE	173	173	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
58.5	1900	270	REV. DEF.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
	1600		FBN. CODE	173	173	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
58.5	1600	305	REV. DEF.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
	1400		FBN. CODE	173	173	SPL	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
54	1400	320	REV. DEF.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
	1150		FBN. CODE	173	173	SPL	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
54	1150	430	REV. DEF.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
	850		FBN. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
49.5	850	440	REV. DEF.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
	700		FBN. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
45	700	460	REV. DEF.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
	550		FBN. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
36	550	405	REV. DEF.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
	400		FBN. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
31.5	400	415	REV. DEF.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
	300		FBN. CODE	178	178	SPL	-	-	-	-	-	-	SPL	-	SPL	-	-	-	-	SPL	-	-	-	-
27	300	455	REV. DEF.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	-	-	-	30	-
	200		FBN. CODE	185	185	SPL	-	-	-	-	-	-	SPL	-	SPL	-	-	-	-	-	-	-	SPL	-

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL.MAST		
MAX. SPAN (m)	RADIUS (m)	VARIANT (MAX.) mm		N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	CLC	CLA	CLI
63	∞	225	REV. DEF.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
	200		FBN. CODE	168	168	270	178	-	178	-	-	-	-	389	-	-	-	-	-	-	-	-	-	-
63	2200	260	REV. DEF.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
	1900		FBN. CODE	168	168	270	178	-	178	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
58.5	1900	270	REV. DEF.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
	1600		FBN. CODE	168	168	270	178	-	178	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
58.5	1600	305	REV. DEF.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
	1400		FBN. CODE	168	168	270	178	-	178	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
54	1400	320	REV. DEF.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
	1150		FBN. CODE	168	168	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
54	1150	430	REV. DEF.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
	850		FBN. CODE	173	173	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
49.5	850	440	REV. DEF.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
	700		FBN. CODE	173	173	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
45	700	460	REV. DEF.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
	550		FBN. CODE	173	173	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
36	550	405	REV. DEF.	-30	-30	-30	-	-	-	-	-30	-	-30	-	-30	-	-	-	-	-30	-	-	-	-
	400		FBN. CODE	178	178	SPL	-	-	-	-	-	-	193	-	193	-	-	-	-	SPL	-	-	-	-
27	300	455	REV. DEF.	-30	-30	-30	-	-	-	-	-30	-	-30	-	-30	-	-	-	-	-30	-	-	-	-
	200		FBN. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-

NOTES:–

1. BEYOND THE WIND SPEED OF 33 m/s THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR GREEN REGION OF BASIC WIND SPEED 47 m/s OF FIGURE–1 OF IS:875 (Part–3)–2015 REV.III (DESIGN WIND PRESSURE 155 kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part–3)–2015 REV.III).
3. THE CYCLONIC REGION AREA FACTOR(K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 6.3.4 OF IS: 875(PART–3)–2015(REV.III)
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 2.8 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SWELLING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.ETI/OHE/G/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION '0' CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON–STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
(b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.8, 5.7, 5.5 OF ACTM VOL.II, PART–2.

9. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ETI/OHE/02102. SHEET–3,(REV.–B)
10. MAST OF ECONOMIC SIZE SHALL BE SELECTED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011. INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m)
BASIC WIND SPEED 47 m/s
WIND PRESSURE 155 kgf/m²
(OHE + FEEDER WIRE + EARTH WIRE)
1500 kgf TENSION IN CAT. 125mm²
1500 kgf TENSION IN CONT.150 mm²
(WITH IMPLANTATION UP TO 2.8M)

EDTI (BHARDWAJ CHAUDHARY)

REF:– CROSS REF:–

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/20/0

NOT TO SCALE (SHEET–1)

ANNEXURE 13

EMPLOYMENT SCHEDULE: WIND PRESSURE 155KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL MAST		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm		N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	CLC	CLA	CLI
63	∞	0	REV. DIST.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	168	173	275	185	-	185	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
63	∞ / 2200	225	REV. DIST.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	173	173	275	185	-	185	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
63	2200 / 1900	260	REV. DIST.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	171	173	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
58.5	1900 / 1600	270	REV. DIST.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	173	173	SPL	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
58.5	1600 / 1400	305	REV. DIST.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
			REM. CODE	173	173	SPL	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
54	1400 / 1150	320	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			REM. CODE	173	173	SPL	-	-	-	-	-	-	193	-	193	-	-	-	-	SPL	-	-	-	-
54	1150 / 850	430	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			REM. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
49.5	850 / 700	440	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			REM. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
45	700 / 550	460	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			REM. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
36	550 / 400	405	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			REM. CODE	178	178	SPL	-	-	-	-	-	-	SPL	-	SPL	-	-	-	-	SPL	-	-	-	-
31.5	400 / 300	415	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			REM. CODE	185	185	SPL	-	-	-	-	-	-	SPL	-	SPL	-	-	-	-	SPL	-	-	-	-
27	300 / 200	455	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	-	-	-	30	-
			REM. CODE	185	185	SPL	-	-	-	-	-	-	SPL	-	SPL	-	-	-	-	-	-	-	SPL	-

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL MAST		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm		N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	CLC	CLA	CLI
63	∞ / 200	225	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	168	168	270	178	-	178	-	-	-	-	389	-	-	-	-	-	-	-	-	-	-
63	2200 / 1900	260	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	168	168	270	178	-	178	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
58.5	1900 / 1600	270	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	168	168	270	178	-	178	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
58.5	1600 / 1400	305	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	168	168	270	178	-	178	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
54	1400 / 1150	320	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	168	173	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
54	1150 / 850	430	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	173	173	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
49.5	850 / 700	440	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			REM. CODE	173	178	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
45	700 / 550	460	REV. DIST.	-30	-30	-30	-	-	-	-	-	-	-30	-	-30	-	-	-	-	-30	-	-	-	-
			REM. CODE	178	178	SPL	-	-	-	-	-	-	193	-	193	-	-	-	-	SPL	-	-	-	-
36	550 / 400	405	REV. DIST.	-30	-30	-30	-	-	-	-	-	-	-30	-	-30	-	-	-	-	-30	-	-	-	-
			REM. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
27	300 / 200	455	REV. DIST.	-30	-30	-30	-	-	-	-	-	-	-30	-	-30	-	-	-	-	-30	-	-	-	-
			REM. CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-

NOTES:-

1. BEYOND THE WIND SPEED OF 33 m/s THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR GREEN REGION OF BASIC WIND SPEED 47 m/s OF FIGURE-1 OF IS:875 (Part-3)-2015 REV.III (DESIGN WIND PRESSURE 155 Kgf/m^2 CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part-3)-2015 REV.III).
3. THE CYCLONIC REGION AREA FACTOR(K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 6.3.4 OF IS: 875(PART-3)-2015(REV.III)
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 3.8 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SWELLING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.ETI/OHE/G/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FMD/RDSO/00001/04/0 MODIFICATION "0" CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON-STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 meter SPAN IS CONSIDERED.
(b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.6, 5.7, 5.5 OF ACTM VOL.II, PART-2.

9. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ETI/OHE/02102, SHEET-3,(REV.-B)
10. MAST OF ECONOMIC SIZE SHALL BE SELECTED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m)
BASIC WIND SPEED 47 m/s
WIND PRESSURE 155 kgf/m^2
(OHE + FEEDER WIRE + EARTH WIRE)
1500 kgf TENSION IN CAT. 125mm^2
1500 kgf TENSION IN CONT.150 mm^2
(WITH IMPLANTATION UP TO 3.8M)

IEDTI (BHARDWAJ CHAUDHARY)

REF:- CROSS REF:-

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/20/0

NOT TO SCALE (SHEET-2)

ANNEXURE 14

EMPLOYMENT SCHEDULE: WIND PRESSURE 155KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL MAST		
MAX SPAN (M)	RADIUS (M)	VERSINE (MIDDLE) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
63	∞	0	REV. DIR.	30	30	30	30	–	30	–	–	–	–	30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	173	173	275	185	–	185	–	–	–	–	395	–	–	–	–	–	–	–	–	–	–
63	∞ 2200	225	REV. DIR.	30	30	30	30	–	30	–	–	–	–	30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	173	173	275	185	–	185	–	–	–	–	399	–	–	–	–	–	–	–	–	–	–
63	2200 1900	260	REV. DIR.	30	30	30	30	–	30	–	–	–	–	30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	173	173	SPL	185	–	185	–	–	–	–	399	–	–	–	–	–	–	–	–	–	–
58.5	1900 1600	270	REV. DIR.	30	30	30	30	–	30	–	–	–	–	30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	173	173	SPL	185	–	185	–	–	–	–	399	–	–	–	–	–	–	–	–	–	–
58.5	1600 1400	305	REV. DIR.	30	30	30	–	–	–	–	–	–	30	30	30	–	–	–	–	–	–	–	–	–
			PEN CODE	173	173	SPL	–	–	–	–	–	–	193	399	193	–	–	–	–	–	–	–	–	–
54	1400 1150	320	REV. DIR.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	–	30	–	–	–
			PEN CODE	173	173	SPL	–	–	–	–	–	–	193	–	193	–	–	–	–	–	SPL	–	–	–
54	1150 850	430	REV. DIR.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	–	30	–	–	–
			PEN CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	–	SPL	–	–	–
49.5	850 700	440	REV. DIR.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	–	30	–	–	–
			PEN CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	–	SPL	–	–	–
45	700 550	460	REV. DIR.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	–	30	–	–	–
			PEN CODE	178	178	SPL	–	–	–	–	–	–	SPL	–	SPL	–	–	–	–	–	SPL	–	–	–
36	550 400	485	REV. DIR.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	–	30	–	–	–
			PEN CODE	178	185	SPL	–	–	–	–	–	–	SPL	–	SPL	–	–	–	–	–	SPL	–	–	–
31.5	400 300	415	REV. DIR.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	–	30	–	–	–
			PEN CODE	185	185	SPL	–	–	–	–	–	–	SPL	–	SPL	–	–	–	–	–	SPL	–	–	–
27	300 200	455	REV. DIR.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	–	–	–	30	–
			PEN CODE	185	185	SPL	–	–	–	–	–	–	SPL	–	SPL	–	–	–	–	–	–	–	SPL	–

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL MAST		
MAX SPAN (M)	RADIUS (M)	VERSINE (MIDDLE) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
63	∞ 200	225	REV. DIR.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	168	168	270	178	–	178	–	–	–	–	389	–	–	–	–	–	–	–	–	–	–
63	2200 1900	260	REV. DIR.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	168	168	270	178	–	178	–	–	–	–	395	–	–	–	–	–	–	–	–	–	–
58.5	1900 1600	270	REV. DIR.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	168	168	270	178	–	178	–	–	–	–	395	–	–	–	–	–	–	–	–	–	–
58.5	1600 1400	305	REV. DIR.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	168	168	270	178	–	178	–	–	–	–	395	–	–	–	–	–	–	–	–	–	–
54	1400 1150	320	REV. DIR.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	168	173	275	185	–	185	–	–	–	–	399	–	–	–	–	–	–	–	–	–	–
54	1150 850	430	REV. DIR.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PEN CODE	173	178	275	185	–	185	–	–	–	–	399	–	–	–	–	–	–	–	–	–	–
49.5	850 700	440	REV. DIR.	-30	-30	-30	–	–	–	–	–	–	-30	–	-30	–	–	–	–	–	-30	–	–	–
			PEN CODE	178	178	SPL	–	–	–	–	–	–	193	–	193	–	–	–	–	–	SPL	–	–	–
45	700 550	460	REV. DIR.	-30	-30	-30	–	–	–	–	–	–	-30	–	-30	–	–	–	–	–	-30	–	–	–
			PEN CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	–	SPL	–	–	–
36	550 400	485	REV. DIR.	-30	-30	-30	–	–	–	–	–	–	-30	–	-30	–	–	–	–	–	-30	–	–	–
			PEN CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	–	SPL	–	–	–
27	300 200	455	REV. DIR.	-30	-30	-30	–	–	–	–	–	–	-30	–	-30	–	–	–	–	–	–	–	–	–
			PEN CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	–	SPL	–	–	–

NOTES:–

1. BEYOND THE WIND SPEED OF 33 m/s THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR GREEN REGION OF BASIC WIND SPEED 47 m/s OF FIGURE–1 OF IS:875 (Part–3)–2015 REV.III (DESIGN WIND PRESSURE 155 Kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part–3)–2015 REV.III).
3. THE CYCLONIC REGION AREA FACTOR(K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 6.3.4 OF IS: 875(PART–3)–2015(REV.III)
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 4.85 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SHELLING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.ET/OHE/G/D0111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION '0' CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON–STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
(b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.6, 5.7, 5.5 OF ACTM VOL.II, PART–2.

9. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ETI/OHE/02102. SHEET–3,(REV–B)
10. MAST OF ECONOMIC SIZE SHALL BE SELECTED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m) BASIC WIND SPEED 47 m/s WIND PRESSURE 155 kgf/m² (OHE + FEEDER WIRE + EARTH WIRE) 1500 kgf TENSION IN CAT. 125mm², 1500 kgf TENSION IN CONT.150 mm² (WITH IMPLANTATION UP TO 4.85M)

EDTI (BHARDWAJ CHAUDHARY)

REF:– CROSS REF:–

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/20/0

NOT TO SCALE (SHEET–3)

ANNEXURE 15

EMPLOYMENT SCHEDULE: WIND PRESSURE 178KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

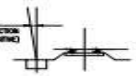
MAX. SPANS (m)	RADIUS (m)	VERSINE (MAX.) mm	TYPE OF MAST	B-200 K-200 N	B-200 K-200 ACC	B-200 K-200 ACA	B-200 K-200 OLC	B-200 K-200 OLA	B-200 K-200 OLI	B-225 K-225 N	B-225 K-225 ACC	B-225 K-225 ACA	B-225 K-225 OLC	B-225 K-225 OLA	B-225 K-225 OLI	B-250 K-250 N	B-250 K-250 ACC	B-250 K-250 ACA	B-250 K-250 OLC	B-250 K-250 OLA	B-250 K-250 OLI	SPL MAST OLC	SPL MAST OLA	SPL MAST OLI
58.5	∞	0	REV. DIST.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
			FBM CODE	173	173	225	185	-	185	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
58.5	∞ 2200	195	REV. DIST.	30	30	30	30	-	30	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
			FBM CODE	173	173	225	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
58.5	2200 1900	225	REV. DIST.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
			FBM CODE	173	173	225	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
58.5	1900 1600	270	REV. DIST.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
			FBM CODE	173	173	SPL	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
54	1600 1400	305	REV. DIST.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
			FBM CODE	178	178	SPL	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
54	1400 1150	320	REV. DIST.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
			FBM CODE	178	178	SPL	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
54	1150 850	430	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			FBM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
49.5	850 700	440	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			FBM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
45	700 550	460	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			FBM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
36	550 400	405	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			FBM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
31.5	400 300	415	REV. DIST.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	-	-	-	30	-
			FBM CODE	178	178	SPL	-	-	-	-	-	-	SPL	-	SPL	-	-	-	-	-	-	-	SPL	-
27	300 200	455	REV. DIST.	30	30		-	-	-	-	-	30	30	-	30	-	-	-	-	-	-	-	30	-
			FBM CODE	185	185		-	-	-	-	-	SPL	SPL	-	SPL	-	-	-	-	-	-	-	SPL	-

MAST ON INSIDE OF CURVED TRACK

MAX. SPANS (m)	RADIUS (m)	VERSINE (MAX.) mm	TYPE OF MAST	B-200 K-200 N	B-200 K-200 ACC	B-200 K-200 ACA	B-200 K-200 OLC	B-200 K-200 OLA	B-200 K-200 OLI	B-225 K-225 N	B-225 K-225 ACC	B-225 K-225 ACA	B-225 K-225 OLC	B-225 K-225 OLA	B-225 K-225 OLI	B-250 K-250 N	B-250 K-250 ACC	B-250 K-250 ACA	B-250 K-250 OLC	B-250 K-250 OLA	B-250 K-250 OLI	SPL MAST OLC	SPL MAST OLA	SPL MAST OLI
58.5	∞	195	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
	2200		FBM CODE	168	168	270	178	-	178	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
58.5	2200 1900	225	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			FBM CODE	168	168	270	178	-	178	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
58.5	1900 1600	270	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			FBM CODE	168	168	225	178	-	178	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
54	1600 1400	305	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			FBM CODE	173	173	225	185	-	185	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
54	1400 1150	320	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			FBM CODE	173	173	225	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
54	1150 850	430	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			FBM CODE	173	173	225	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
49.5	850 700	440	REV. DIST.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			FBM CODE	173	173	225	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
45	700 550	460	REV. DIST.	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-	-	-
			FBM CODE	173	173	225	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
36	550 400	405	REV. DIST.	-30	-30	-30	-	-	-	-	-	-	-30	-	-30	-	-	-	-	-30	-	-	-	-
			FBM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
27	300 200	455	REV. DIST.	-30	-30	-	-	-	-	-	-	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-
			FBM CODE	185	185	-	-	-	-	-	-	SPL	199	-	199	-	-	-	-	SPL	-	-	-	-

NOTES:–

1. BEYOND THE WIND SPEED OF 33 m/s THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR RED REGION OF BASIC WIND SPEED 50 m/s OF FIGURE–1 OF IS:875 (Part–3)–2015 REV.III (DESIGN WIND PRESSURE 178 Kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part–3)–2015 REV.III).
3. THE CYCLONIC REGION AREA FACTOR(K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 6.3.4 OF IS: 875(PART–3)–2015(REV.III)
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 2.8 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SWELLING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.ETI/OHE/G/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION '0' CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON–STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
(b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.6, 5.7, 5.5 OF ACTM VOL.II, PART–2.

9. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ETI/OHE/02102. SHEET–3 (REV–B).
10. MAST OF ECONOMIC SIZE SHALL BE SELECTED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m)
BASIC WIND SPEED 50 m/s
WIND PRESSURE 178 kgf/m²
(OHE + FEEDER WIRE + EARTH WIRE)
1500 kgf TENSION IN CAT. 125mm²
1500 kgf TENSION IN CONT.150 mm²
(WITH IMPLANTATION UP TO 2.8M)

EDTI (BHARDWAJ CHAUDHARY)

REF:– CROSS REF:–

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/20/0

NOT TO SCALE (SHEET–4)

ANNEXURE 16

EMPLOYMENT SCHEDULE: WIND PRESSURE 178KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL MAST		
MAX. SPAN (m)	RADIUS (m)	VERGENCE (MAX.) mm		N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	CLC	CLA	CLI
58.5	∞	0	REV. DIST.	30	30	30	30	–	30	–	–	–	–	30	–	–	–	–	–	–	–	–	–	–
			PRM CODE	173	173	275	185	–	185	–	–	–	–	395	–	–	–	–	–	–	–	–	–	–
58.5	∞ 2200	195	REV. DIST.	30	30	30	–	–	–	–	–	–	30	30	30	–	–	–	–	–	–	–	–	–
			PRM CODE	173	173	275	–	–	–	–	–	–	193	399	193	–	–	–	–	–	–	–	–	–
58.5	2200 1900	225	REV. DIST.	30	30	30	–	–	–	–	–	–	30	30	30	–	–	–	–	–	–	–	–	–
			PRM CODE	173	173	SPL	–	–	–	–	–	–	193	399	193	–	–	–	–	–	–	–	–	–
58.5	1900 1600	270	REV. DIST.	30	30	30	–	–	–	–	–	–	30	30	30	–	–	–	–	–	–	–	–	–
			PRM CODE	178	178	SPL	–	–	–	–	–	–	193	399	193	–	–	–	–	–	–	–	–	–
54	1600 1400	305	REV. DIST.	30	30	30	–	–	–	–	–	–	30	30	30	–	–	–	–	–	–	–	–	–
			PRM CODE	178	178	SPL	–	–	–	–	–	–	193	399	193	–	–	–	–	–	–	–	–	–
54	1400 1150	320	REV. DIST.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	–	–	–	–	–
			PRM CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	SPL	–	–	–	–
54	1150 850	430	REV. DIST.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	30	–	–	–	–
			PRM CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	SPL	–	–	–	–
49.5	850 700	440	REV. DIST.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	30	–	–	–	–
			PRM CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	SPL	–	–	–	–
45	700 550	460	REV. DIST.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	30	–	–	–	–
			PRM CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	SPL	–	–	–	–
36	550 400	485	REV. DIST.	30	30	30	–	–	–	–	–	–	30	–	30	–	–	–	–	30	–	–	–	–
			PRM CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	SPL	–	–	–	–
31.5	400 300	415	REV. DIST.	30	30	–	–	–	–	–	–	30	30	–	30	–	–	–	–	–	–	–	30	–
			PRM CODE	185	185	–	–	–	–	–	–	SPL	SPL	–	SPL	–	–	–	–	–	–	–	SPL	–
27	300 200	455	REV. DIST.	30	30	–	–	–	–	–	–	30	30	–	30	–	–	–	–	–	–	–	30	–
			PRM CODE	185	185	–	–	–	–	–	–	SPL	SPL	–	SPL	–	–	–	–	–	–	–	SPL	–

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL MAST		
MAX. SPAN (m)	RADIUS (m)	VERGENCE (MAX.) mm		N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	N	ACC	ACA	CLC	CLA	CLI	CLC	CLA	CLI
58.5	∞ 2200	195	REV. DIST.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PRM CODE	168	168	270	178	–	178	–	–	–	–	395	–	–	–	–	–	–	–	–	–	–
58.5	2200 1900	225	REV. DIST.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PRM CODE	168	168	275	178	–	178	–	–	–	–	395	–	–	–	–	–	–	–	–	–	–
58.5	1900 1600	270	REV. DIST.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PRM CODE	173	173	275	185	–	185	–	–	–	–	395	–	–	–	–	–	–	–	–	–	–
54	1600 1400	305	REV. DIST.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PRM CODE	173	173	275	185	–	185	–	–	–	–	395	–	–	–	–	–	–	–	–	–	–
54	1400 1150	320	REV. DIST.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PRM CODE	173	173	275	185	–	185	–	–	–	–	399	–	–	–	–	–	–	–	–	–	–
54	1150 850	430	REV. DIST.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PRM CODE	173	173	275	185	–	185	–	–	–	–	399	–	–	–	–	–	–	–	–	–	–
49.5	850 700	440	REV. DIST.	-30	-30	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–	–	–	–	–	–	–
			PRM CODE	173	173	275	185	–	185	–	–	–	–	399	–	–	–	–	–	–	–	–	–	–
45	700 550	460	REV. DIST.	-30	-30	-30	–	–	–	–	–	–	-30	-30	-30	–	–	–	–	–	–	–	–	–
			PRM CODE	173	173	275	–	–	–	–	–	–	193	399	193	–	–	–	–	–	–	–	–	–
36	550 400	485	REV. DIST.	-30	-30	-30	–	–	–	–	–	–	-30	–	-30	–	–	–	–	-30	–	–	–	–
			PRM CODE	178	178	SPL	–	–	–	–	–	–	199	–	199	–	–	–	–	SPL	–	–	–	–
27	300 200	455	REV. DIST.	-30	-30	–	–	–	–	–	–	-30	-30	–	-30	–	–	–	–	-30	–	–	–	–
			PRM CODE	185	185	–	–	–	–	–	–	SPL	199	–	199	–	–	–	–	SPL	–	–	–	–

NOTES:–

1. BEYOND THE WIND SPEED OF 33 m/s THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR RED REGION OF BASIC WIND SPEED 50 m/s OF FIGURE–1 OF IS:875 (Part–3)–2015 REV.III (DESIGN WIND PRESSURE 178 kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS:875 (Part–3)–2015 REV.III).
3. THE CYCLONIC REGION AREA FACTOR(k4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 6.3.4 OF IS: 875(PART–3)–2015(REV.III)
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 3.8 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SHIELDING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.ET/OHE/G/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION '0' CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON–STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
(b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.6, 5.7, 5.5 OF ACTM VOL.II, PART–2.

9. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ET/OHE/02102, SHEET–3 (REV.–B).
10. MAST OF ECONOMIC SIZE SHALL BE SELECTED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m)
BASIC WIND SPEED 50 m/s
WIND PRESSURE 178 kgf/m²
(OHE + FEEDER WIRE + EARTH WIRE)
1500 kgf TENSION IN CAT. 125mm²
1500 kgf TENSION IN CONT.150 mm²
(WITH IMPLANTATION UP TO 3.8M)

EDTI (BHARDWAJ CHAUDHARY)

REF:– CROSS REF:–

DATE	MOD.	NATURE OF MOD.	INITIAL

R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/20/0

NOT TO SCALE (SHEET–5)

ANNEXURE 17

EMPLOYMENT SCHEDULE: WIND PRESSURE 178KG/SQM

MAST ON OUTSIDE OF CURVED TRACK

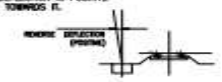
TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL MAST		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
58.5	∞	0	REV. DEPT.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
			PERM CODE	173	173	275	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
58.5	∞ 2200	195	REV. DEPT.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
			PERM CODE	173	173	275	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
58.5	2200 1900	225	REV. DEPT.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
			PERM CODE	178	178	SPL	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
58.5	1900 1600	270	REV. DEPT.	30	30	30	-	-	-	-	-	-	30	30	30	-	-	-	-	-	-	-	-	-
			PERM CODE	178	178	SPL	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
54	1600 1400	305	REV. DEPT.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			PERM CODE	178	178	SPL	-	-	-	-	-	-	193	-	193	-	-	-	-	SPL	-	-	-	-
54	1400 1150	320	REV. DEPT.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			PERM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
54	1150 850	430	REV. DEPT.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			PERM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
49.5	850 700	440	REV. DEPT.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			PERM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
45	700 550	460	REV. DEPT.	30	30	30	-	-	-	-	-	-	30	-	30	-	-	-	-	30	-	-	-	-
			PERM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
36	550 400	405	REV. DEPT.	30	30	-	-	-	-	-	-	30	30	-	30	-	-	-	-	30	-	-	-	-
			PERM CODE	178	178	-	-	-	-	-	-	SPL	199	-	199	-	-	-	-	SPL	-	-	-	-
31.5	400 300	415	REV. DEPT.	30	30	-	-	-	-	-	-	30	30	-	30	-	-	-	-	-	-	-	30	-
			PERM CODE	185	185	-	-	-	-	-	-	SPL	SPL	-	SPL	-	-	-	-	-	-	-	SPL	-
27	300 200	455	REV. DEPT.	-	-	-	-	-	-	30	30	30	30	-	30	-	-	-	-	-	-	-	30	-
			PERM CODE	-	-	-	-	-	-	193	193	SPL	SPL	-	SPL	-	-	-	-	-	-	-	SPL	-

MAST ON INSIDE OF CURVED TRACK

TYPE OF MAST				B-200 K-200						B-225 K-225						B-250 K-250						SPL MAST		
MAX. SPAN (m)	RADIUS (m)	VERSINE (MAX.) mm		N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	N	ACC	ACA	OLC	OLA	OLI	OLC	OLA	OLI
58.5	∞ 2200	195	REV. DEPT.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			PERM CODE	168	168	275	178	-	178	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
58.5	2200 1900	225	REV. DEPT.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			PERM CODE	173	173	275	185	-	185	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
58.5	1900 1600	270	REV. DEPT.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			PERM CODE	173	173	275	185	-	185	-	-	-	-	395	-	-	-	-	-	-	-	-	-	-
54	1600 1400	305	REV. DEPT.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			PERM CODE	173	173	275	185	-	185	-	-	-	-	269	-	-	-	-	-	-	-	-	-	-
54	1400 1150	320	REV. DEPT.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			PERM CODE	173	173	275	185	-	185	-	-	-	-	369	-	-	-	-	-	-	-	-	-	-
54	1150 850	430	REV. DEPT.	-30	-30	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-	-	-	-	-	-	-
			PERM CODE	173	173	275	185	-	185	-	-	-	-	399	-	-	-	-	-	-	-	-	-	-
49.5	850 700	440	REV. DEPT.	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-	-	-
			PERM CODE	173	173	275	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
45	700 550	460	REV. DEPT.	-30	-30	-30	-	-	-	-	-	-	-30	-30	-30	-	-	-	-	-	-	-	-	-
			PERM CODE	173	173	275	-	-	-	-	-	-	193	399	193	-	-	-	-	-	-	-	-	-
36	550 400	405	REV. DEPT.	-30	-30	-30	-	-	-	-	-	-	-30	-	-30	-	-	-	-	-30	-	-	-	-
			PERM CODE	178	178	SPL	-	-	-	-	-	-	199	-	199	-	-	-	-	SPL	-	-	-	-
27	300 200	455	REV. DEPT.	-30	-30	-	-	-	-	-	-	-30	-30	-	-30	-	-	-	-	-30	-	-	-	-
			PERM CODE	185	185	-	-	-	-	-	-	SPL	199	-	199	-	-	-	-	SPL	-	-	-	-

NOTES:-

1. BEYOND THE WIND SPEED OF 33 m/s THE TRAINS WILL HAVE TO BE STOPPED.
2. THIS EMPLOYMENT SCHEDULE IS APPLICABLE FOR RED REGION OF BASIC WIND SPEED 50 m/s OF FIGURE-1 OF IS875 (Part-3)-2015 REV.III (DESIGN WIND PRESSURE 178 kgf/m² CALCULATED AS PER CLAUSE 5.4 OF IS875 (Part-3)-2015 REV.III).
3. THE CYCLONIC REGION AREA FACTOR(K4) HAS NOT BEEN CONSIDERED IN THE DESIGN CALCULATION GIVEN IN CLAUSE 6.3.4 OF IS 875(PART-3)-2015(REV.III)
4. THE EMPLOYMENT SCHEDULE IS SUITABLE FOR IMPLANTATION UP TO 4.85 METER FROM THE CENTRE LINE OF NEAREST TRACK WITH +0.1 m FOR TRACK SHELLING ALLOWANCE ON SETTING OF MAST AND ON INSIDE OF CURVE EXTRA IMPLANTATION AS PER DRG. NO.ET/OHE/G/00111 SH.1 HAS BEEN CONSIDERED.
5. FOUNDATION BENDING MOMENT (FBM) CODE GIVES THE NECESSARY CROSS REFERENCE TO EQUIVALENT FOUNDATIONS, FOR FOUNDATION SELECTION SEE THE DRAWING No. TI/DRG/CIV/FND/RDSO/00001/04/0 MODIFICATION 'B' CHART OF (SHEET No.1 TO 5).
6. FOR LOCATIONS WITH NON-STANDARD SPANS AND IMPLANTATIONS, THE SAFETY OF MAST AND FOUNDATION SHALL BE CHECKED AND SUITABLE MAST AND FOUNDATION SHALL BE PROVIDED.
7. REVERSE DEFLECTIONS ARE IN mm. REVERSE DEFLECTION IS POSITIVE WHEN AWAY FROM TRACK AND NEGATIVE WHEN TOWARDS IT.



8.(a) UNDER OVERLAP CENTRAL LOCATION IN TANGENT TRACK 54 metre SPAN IS CONSIDERED.
(b) THE SPANS ON SPECIFIC LOCATION LIKE, BRIDGES, OVERLAPS, TURNOUTS, NEUTRAL SECTION ETC. SHALL BE AS PER PARA NO. 6.1.2.1, 5.6, 5.7, 5.5 OF ACTM VOL.II, PART-2.

9. THE ARRANGEMENT OF OHE AT SUPPORT HAS BEEN CONSIDERED AS PER DRAWING NO. ET/OHE/02102. SHEET-3(REV.- B).
10. MAST OF ECONOMIC SIZE SHALL BE SELECTED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

EMPLOYMENT SCHEDULE FOR OHE MAST (9.5 m)
BASIC WIND SPEED 50 m/s
WIND PRESSURE 178 kgf/m²
(OHE + FEEDER WIRE + EARTH WIRE)
1500 kgf TENSION IN CAT. 125mm²
1500 kgf TENSION IN CONT.150 mm²
(WITH IMPLANTATION UP TO 4.85M)

EDTI (BHARDWAJ CHAUDHARY)

REF:- CROSS REF:-

DATE	MOD.	NATURE OF MOD.	INITIAL

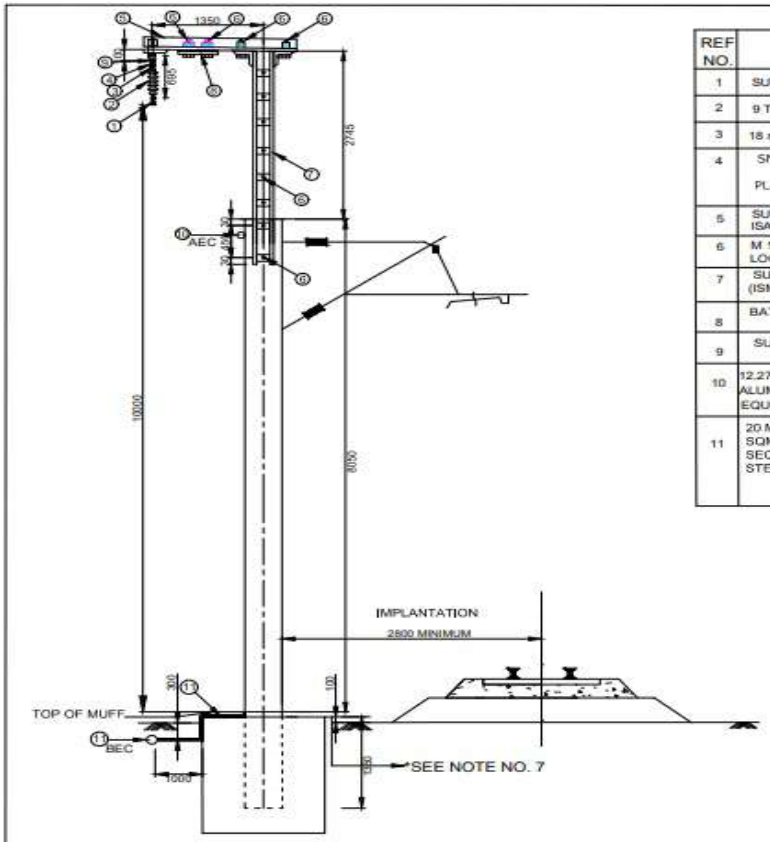
R. D. S. O.

	DATE	NAME
DR.		
CK.		
CK.		

TI/DRG/CIV/ES/RDSO /00004/20/0

NOT TO SCALE (SHEET-6)

ANNEXURE 18



REF NO.	DESCRIPTION	PART NO.	QTY
1	SUSPENSION CLAMP	1580	1
2	9 TONNE INSULATOR ASSEMBLY	6020	1
3	18 mm SINGLE CLEVIS ASSEMBLY	5040	1
4	SNAP HEADED PIN ∅ 20,60 mm LONG WITH PLANE WASHER & SPLIT PIN 4 X 35	262	1
5	SUPER MAST CROSS ARM ISA 65x65x6	8015/8012	2
6	M 16 BOLT 50/38 WITH NUT, LOCK NUT & PLAIN WASHER	16/3 NL	12
7	SUPER MAST CHANNEL (ISMC 100)	8021/8061/8011	2
8	BATTEN PLATE (TYPE-II)	8016	1
9	SUSPENSION SUPPORT	8014 OR 8014-1	1
10	12.27 mm DIA. OF STEEL REINFORCED ALUMINIUM RACCOON (50 MM2 Cu EQUIVALENT) (AEC)		
11	20 MM DIA. AND 238 SQMM (NOMINAL CROSS SECTIONAL AREA) GALVANISED STEEL CONDUCTOR (BEC)	AS PER IS: 2141-2000	

NOTE :-

1. ALL DIMENSIONS ARE IN mm
2. THE 25 KV ALUMINIUM FEEDER WIRE (22 MM DIA. AND 288 SQMM CROSS SECTIONAL AREA) SHALL BE RUN ON THE REAR SIDE OF THE MAST. THE FEEDER MAST WILL HAVE MINIMUM IMPLANTATION OF 2.8M
3. TENSION LENGTH OF FEEDER LINE WILL BE 1500M.
4. SUITABLE SUPER MAST AND CROSS ARM SHOULD BE USED AS PER SITE CONDITION TAKING IN TO ACCOUNT THE GROUND CLEARANCE & LATERAL CLEARANCES IN OPEN ROUTE, ACROSS AND ALONG THE STREET/LC GATE.
5. BEC WILL BE CONNECTED TO EACH MAST BY BEC CONDUCTOR WITH SUITABLE TEE CONNECTOR AT ONE END & LUG ARRANGEMENT AT MAST END
6. SPAN, MAST AND FOUNDATION SHOULD BE SELECTED AS PER DRAWING NO.TI/DRG/ES/RDSO/00004/20/0 (SHEET 1 - 6) .
7. THE CROSS BONDING OF UP BEC-UP MAST/PORTAL- UP TRACTION RAIL-DN-MAST/PORTAL-DN BEC SHOULD BE DONE BY 50X6 MM MS/GS FLAT AT EVERY 450 M.

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW-11, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING.

GENERAL ARRANGEMENT OF FUTURE OHE (125 sqmm CATENARY+150 sqmm CONTACT WIRE) WITH FEEDER (288 sqmm) , EARTH WIRE AND BEC FOR NDLS-HWH & NDLS-MUMBAI ROUTE

ED-TI

(BHARWDAJ CHAUDHARY)

REF. ETI/C/P/8020

CROSS REF :-

DATE	MOD.	NATURE OF MOD.	INITIALS

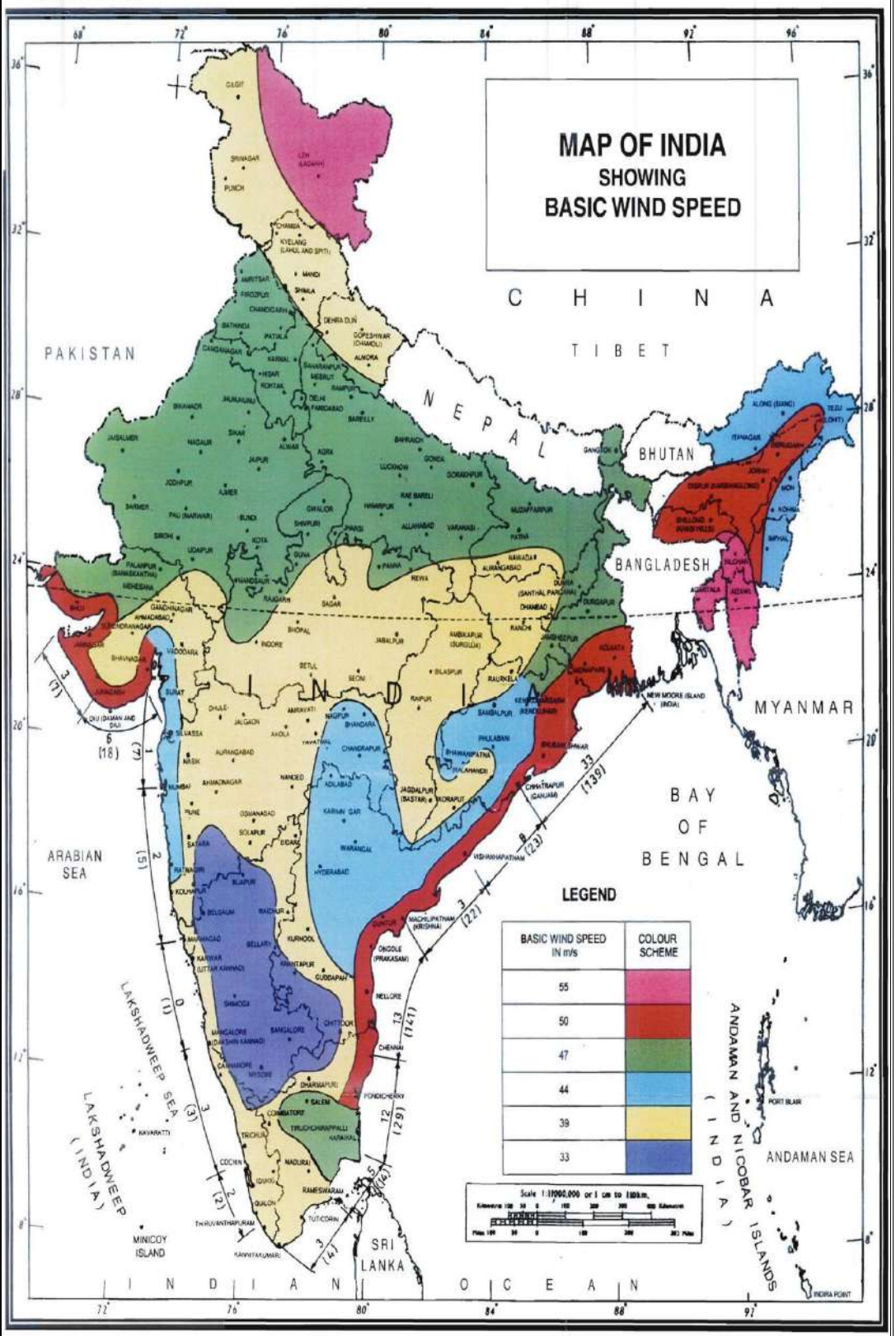
R . D . S . O.

	DATE	NAME
DR		
CK		
CK		

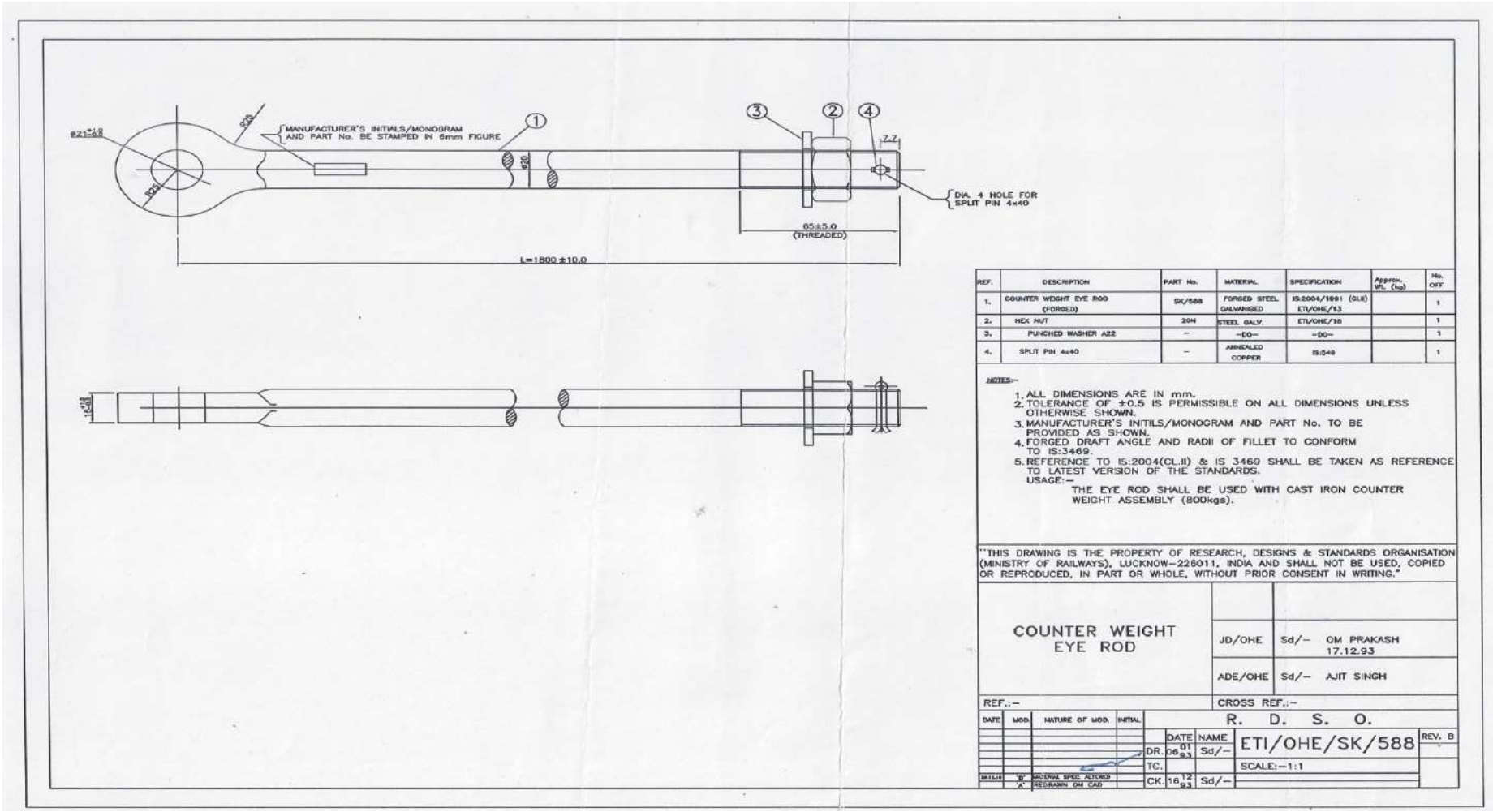
TI/DRG/OHE/FEEDER/ RDSO/00002/20/0

ANNEXURE 19

IS 875 (Part 3) : 2015



ANNEXURE 20



REF.	DESCRIPTION	PART No.	MATERIAL	SPECIFICATION	Approx. Wt. (kg)	No. OFF
1.	COUNTER WEIGHT EYE ROD (FORGED)	SK/588	FORGED STEEL GALVANISED	IS:2004/1991 (CL.II) ETI/OHE/13		1
2.	HEX NUT	20H	STEEL GALV.	ETI/OHE/18		1
3.	PUNCHED WASHER A22	–	–DO–	–DO–		1
4.	SPLIT PIN 4x40	–	ANNEALED COPPER	IS:549		1

NOTES:–

1. ALL DIMENSIONS ARE IN mm.
2. TOLERANCE OF ±0.5 IS PERMISSIBLE ON ALL DIMENSIONS UNLESS OTHERWISE SHOWN.
3. MANUFACTURER'S INITILS/MONOGRAM AND PART No. TO BE PROVIDED AS SHOWN.
4. FORGED DRAFT ANGLE AND RADII OF FILLET TO CONFORM TO IS:3469.
5. REFERENCE TO IS:2004(CL.II) & IS 3469 SHALL BE TAKEN AS REFERENCE TO LATEST VERSION OF THE STANDARDS.

USAGE:–
THE EYE ROD SHALL BE USED WITH CAST IRON COUNTER WEIGHT ASSEMBLY (800kgs).

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

COUNTER WEIGHT EYE ROD

JD/OHE Sd/– OM PRAKASH 17.12.93

ADE/OHE Sd/– AJIT SINGH

REF.:– CROSS REF.:–

DATE	MOD.	NATURE OF MOD.	INITIAL
	'B'	MATERIAL SPEC. ALTERED	
	'A'	RE-DRAWN ON CAD	

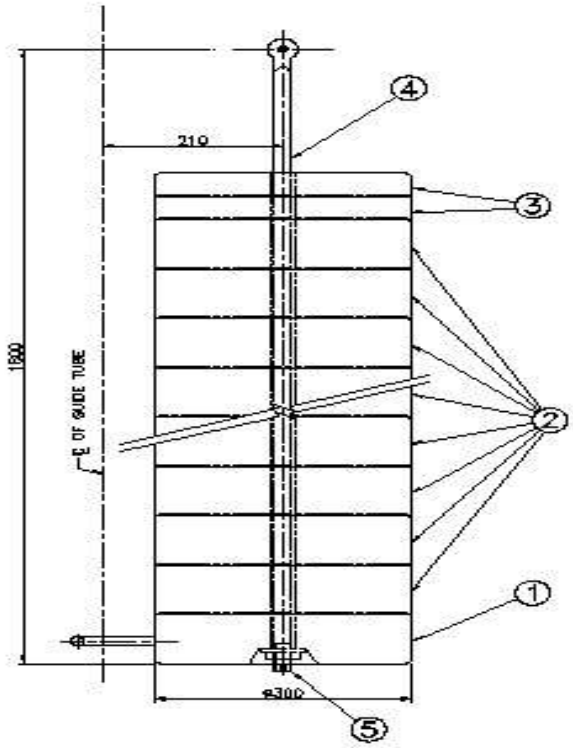
R. D. S. O.

	DATE	NAME
DR.	06.01.93	Sd/–
TC.		
CK.	16.12.93	Sd/–

ETI/OHE/SK/588 REV. B

SCALE:–1:1

ANNEXURE 21



REF.	DESCRIPTION	PART No.	MATERIAL	SPECIFICATION	Approx. WEIGHT(Kg)	NUMBER OFF
1.	CAST IRON BASE WEIGHT	5091	GREY CAST IRON	IS:210 GRADE-15	40	1
2.	40kg COUNTER WEIGHT PIECE	5092	"	"	40	18
3.	20kg COUNTER WEIGHT PIECE	5093	"	"	20	2
4.	COUNTER WEIGHT EYE ROD	SK/587	STEEL GALVANISED	IS:2062 GR-A ETI/OHE/13		1
5.	SPLIT PIN 4x40		ANNEALED COPPER	IS:549		1

NOTES:-

1. ALL DIMENSIONS IN mm.
2. CAST IRON WEIGHTS SHALL BE GIVEN ONE COAT OF PRIMER AND TWO COATS OF ALUMINIUM PAINT FINAL COAT OF ALUMINIUM PAINT TO BE GIVEN AFTER ERECTION.
3. FORGED DRAFT ANGLE AND RADII OF FILLET TO CONFORM IS:3469.
4. MANUFACTURER'S INITIALS/MONOGRAM AND PART No. TO BE PROVIDED AS SHOWN IN PART DRG.
5. THE VARIATION IN WEIGHT OF THE WEIGHT PIECES IS IN THE ORDER OF ±0.5kg FOR PART No.5091/5092 AND ±0.25kg FOR PART No.5093.
6. THE TOTAL Approx. WEIGHT OF THE WHOLE ASSEMBLY IS 800±0.5kg.
7. FOR USE WITH 33.6mm GUIDE TUBE IN TERMINATION WITH REGULATING EQUIPMENT (3:1 RATIO) AND TENSION IN EACH CONDUCTOR BEING 1200kgf.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

COUNTER WEIGHT ASSEMBLY

JD/TI-V	Sd/-	OM PRAKASH 17.12.93
ADE/OHE	Sd/-	AJIT SINGH

REF.:-

CROSS REF.:-

DATE	NOG.	NATURE OF MOD.	INITIAL
	'B'		
	'A'		sd/-

R. D. S. O.

	DATE	NAME
DR.	04 01 93	Sd/-
TC.		
CK.	15 12 93	Sd/-

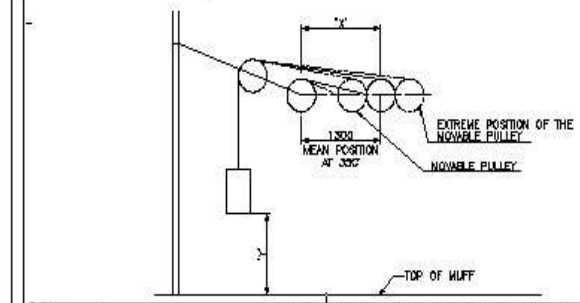
ETI/OHE/SK/587 REV. B

SCALE:-1:5

SUB SCALE:-

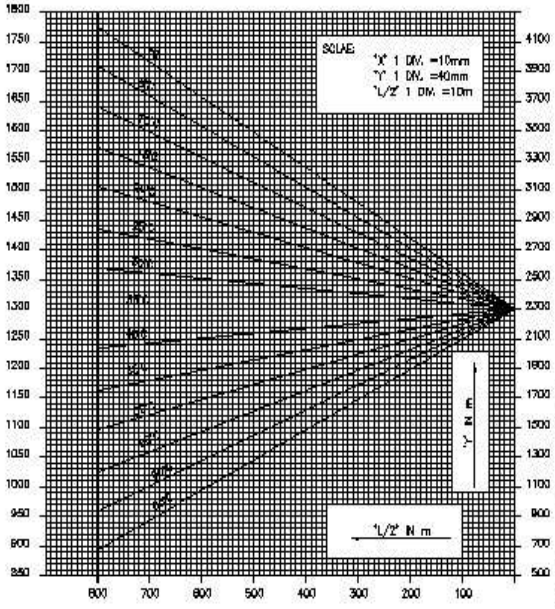
SUB SCALE:-

ANNEXURE 22



TEMP ↓ / 'L/2' IN m →	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
	VALUE OF 'X' IN mm FOR VALUE OF 'L/2' IN m															
0	1330	1360	1389	1418	1448	1479	1508	1538	1568	1598	1627	1657	1687	1717	1746	1776
5	1326	1351	1377	1402	1428	1453	1479	1504	1530	1555	1581	1606	1632	1657	1683	1708
10	1321	1343	1364	1385	1406	1428	1449	1470	1491	1513	1534	1555	1576	1598	1619	1640
15	1317	1334	1351	1368	1385	1402	1419	1438	1453	1470	1487	1504	1521	1538	1555	1572
20	1313	1326	1338	1351	1364	1377	1389	1402	1415	1428	1440	1453	1466	1479	1491	1504
25	1308	1317	1326	1334	1343	1351	1360	1368	1377	1385	1394	1402	1411	1419	1428	1436
30	1304	1309	1313	1317	1321	1326	1330	1334	1338	1343	1347	1351	1355	1360	1364	1368
35	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
40	1296	1292	1287	1283	1279	1275	1270	1265	1262	1258	1253	1249	1245	1241	1236	1232
45	1292	1283	1275	1266	1258	1249	1241	1232	1224	1215	1207	1198	1190	1181	1173	1164
50	1287	1275	1262	1249	1236	1224	1211	1198	1185	1173	1160	1147	1134	1122	1109	1096
55	1283	1268	1249	1232	1215	1198	1181	1164	1147	1130	1113	1096	1079	1062	1045	1028
60	1279	1258	1236	1215	1194	1173	1151	1130	1109	1088	1068	1045	1024	1003	981	960
65	1275	1249	1224	1198	1173	1147	1122	1096	1071	1045	1020	994	969	943	918	892

TEMP ↓ / 'L/2' IN m →	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
	CORRESPONDING VALUES OF 'Y' IN mm															
0	2389	2479	2568	2657	2746	2836	2925	3014	3103	3193	3282	3371	3460	3550	3639	3728
5	2377	2453	2530	2606	2683	2759	2836	2912	2989	3065	3142	3218	3295	3371	3448	3524
10	2364	2428	2491	2555	2619	2683	2746	2810	2874	2938	3001	3065	3129	3193	3257	3320
15	2351	2402	2453	2504	2555	2606	2657	2708	2759	2810	2861	2912	2963	3014	3065	3116
20	2338	2377	2415	2453	2491	2530	2568	2606	2644	2683	2721	2759	2797	2835	2874	2912
25	2326	2351	2377	2402	2428	2453	2479	2504	2530	2555	2581	2606	2632	2657	2683	2708
30	2313	2326	2338	2351	2364	2377	2389	2402	2415	2428	2440	2453	2466	2479	2491	2504
35	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300
40	2287	2275	2262	2249	2236	2224	2211	2198	2185	2173	2160	2147	2134	2122	2109	2096
45	2275	2249	2224	2198	2173	2147	2122	2096	2071	2045	2020	1994	1969	1943	1918	1892
50	2262	2224	2185	2147	2109	2071	2032	1994	1956	1918	1879	1841	1803	1765	1727	1688
55	2249	2198	2147	2096	2045	1994	1943	1892	1841	1790	1739	1688	1637	1588	1535	1484
60	2236	2173	2109	2045	1981	1918	1854	1790	1726	1663	1599	1535	1471	1408	1344	1280
65	2224	2147	2071	1994	1918	1841	1765	1688	1612	1535	1459	1382	1306	1229	1153	1076



NOTES:-

1. 'X' IS THE DISTANCE IN mm BETWEEN CENTRES OF MOVABLE PULLEY AND ADJACENT FIXED PULLEY.
2. 'Y' IS THE DISTANCE IN mm BETWEEN TOP OF MUFF AND BOTTOM OF COUNTERWEIGHT ASSEMBLY.
3. THE TEMPERATURE REFERRED IN THIS DRAWING IS THE TEMPERATURE OF CONDUCTORS WHICH ARE BEING REGULATED FOR TENSION.
4. 'L/2' REFERS TO HALF TENSION LENGTH i.e., THE LENGTH OF OHE BETWEEN ANTICREEP AND REGULATING EQUIPMENT OR BETWEEN FIXED TERMINATION AND REGULATING EQUIPMENT.
5. THE HALF TENSION LENGTH SHALL NORMALLY BE 700m BUT MAY BE INCREASED TO 750m(MAXIMUM) FOR OHE WITH 103mm PRESAG FOR 72m SPAN(PROPORTIONATELY LESS THAN SMALLER SPANS).
6. THE HALF TENSION LENGTH SHALL NORMALLY BE 750m BUT MAY BE INCREASED TO 800m(MAXIMUM) FOR OHE WITH 50mm PRESAG FOR 72m SPAN(PROPORTIONATELY LESS FOR SMALLER SPANS).
7. FOR LIMITATION OF HALF TENSION LENGTHS, RELEVANT PARAS OF PRINCIPLES FOR THE OHE LAYOUT PLANS AND SECTIONING DIAGRAMS No.ETI/OHE/53 MAY BE REFERRED.
8. THIS DRAWING IS APPLICABLE FOR REGULATING EQUIPMENT, THREE PULLEY TYPE(3:1 RATIO) MODIFIED, TO DRG No.TI/DRG/OHE/ATD/RDSO/00001/99/3.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

ADJUSTMENT CHART OF REGULATING EQUIPMENT
THREE PULLY TYPE(3:1 RATIO) (MODIFIED)

DTI-IV Sd/- 16.9.99
ADE/TI-IV Sd/- 15.9.99

REF.:- CROSS REF.:-

DATE	MOD.	NATURE OF MOD.	INITIAL
	'1'	REDRAWN ON CAD	

R. D. S. O.

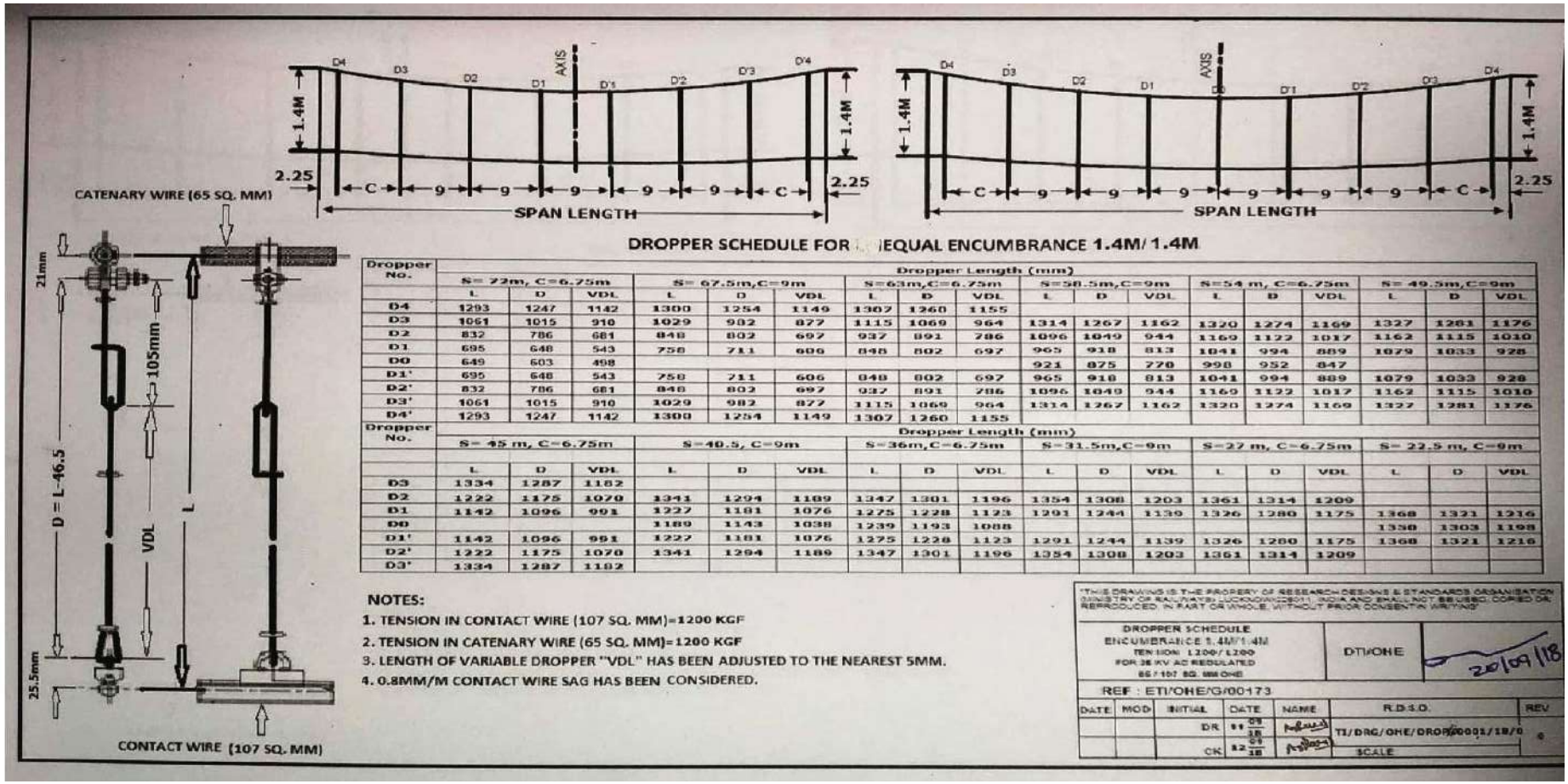
	DATE	NAME
DR.		
TC.		
CK.		

TI/DRG/OHE/ATD/RDSO/00003/99/1

SCALE:-N.T.S.

SUB BOND-
SUB BOND-

ANNEXURE 23



DROPPER SCHEDULE FOR [illegible] EQUAL ENCUMBRANCE 1.4M/ 1.4M

Dropper No.	Dropper Length (mm)																	
	S= 72m, C=6.75m			S= 67.5m,C=9m			S=63m,C=6.75m			S=58.5m,C=9m			S=54 m, C=6.75m			S= 49.5m,C=9m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D4	1293	1247	1142	1300	1254	1149	1307	1260	1155									
D3	1061	1015	910	1029	982	877	1115	1069	964	1314	1267	1162	1320	1274	1169	1327	1281	1176
D2	832	786	681	848	802	697	937	891	786	1096	1049	944	1169	1122	1017	1162	1115	1010
D1	695	648	543	758	711	606	848	802	697	965	918	813	1041	994	889	1079	1033	928
D0	649	603	498							921	875	770	998	952	847			
D1'	695	648	543	758	711	606	848	802	697	965	918	813	1041	994	889	1079	1033	928
D2'	832	786	681	848	802	697	937	891	786	1096	1049	944	1169	1122	1017	1162	1115	1010
D3'	1061	1015	910	1029	982	877	1115	1069	964	1314	1267	1162	1320	1274	1169	1327	1281	1176
D4'	1293	1247	1142	1300	1254	1149	1307	1260	1155									

Dropper No.	Dropper Length (mm)																	
	S= 45 m, C=6.75m			S=40.5, C=9m			S=36m,C=6.75m			S=31.5m,C=9m			S=27 m, C=6.75m			S= 22.5 m, C=9m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D3	1334	1287	1182															
D2	1222	1175	1070	1341	1294	1189	1347	1301	1196	1354	1308	1203	1361	1314	1209			
D1	1142	1096	991	1227	1181	1076	1275	1228	1123	1291	1244	1139	1326	1280	1175	1368	1321	1216
D0				1189	1143	1038	1239	1193	1088							1330	1303	1198
D1'	1142	1096	991	1227	1181	1076	1275	1228	1123	1291	1244	1139	1326	1280	1175	1368	1321	1216
D2'	1222	1175	1070	1341	1294	1189	1347	1301	1196	1354	1308	1203	1361	1314	1209			
D3'	1334	1287	1182															

NOTES:

1. TENSION IN CONTACT WIRE (107 SQ. MM)=1200 KGF
2. TENSION IN CATENARY WIRE (65 SQ. MM)=1200 KGF
3. LENGTH OF VARIABLE DROPPER "VDL" HAS BEEN ADJUSTED TO THE NEAREST 5MM.
4. 0.8MM/M CONTACT WIRE SAG HAS BEEN CONSIDERED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING"

DROPPER SCHEDULE
ENCUMBRANCE 1.4M/1.4M
TENSION 1200/1200
FOR 25 KV AC REGULATED
65 / 107 SQ. MM OHE

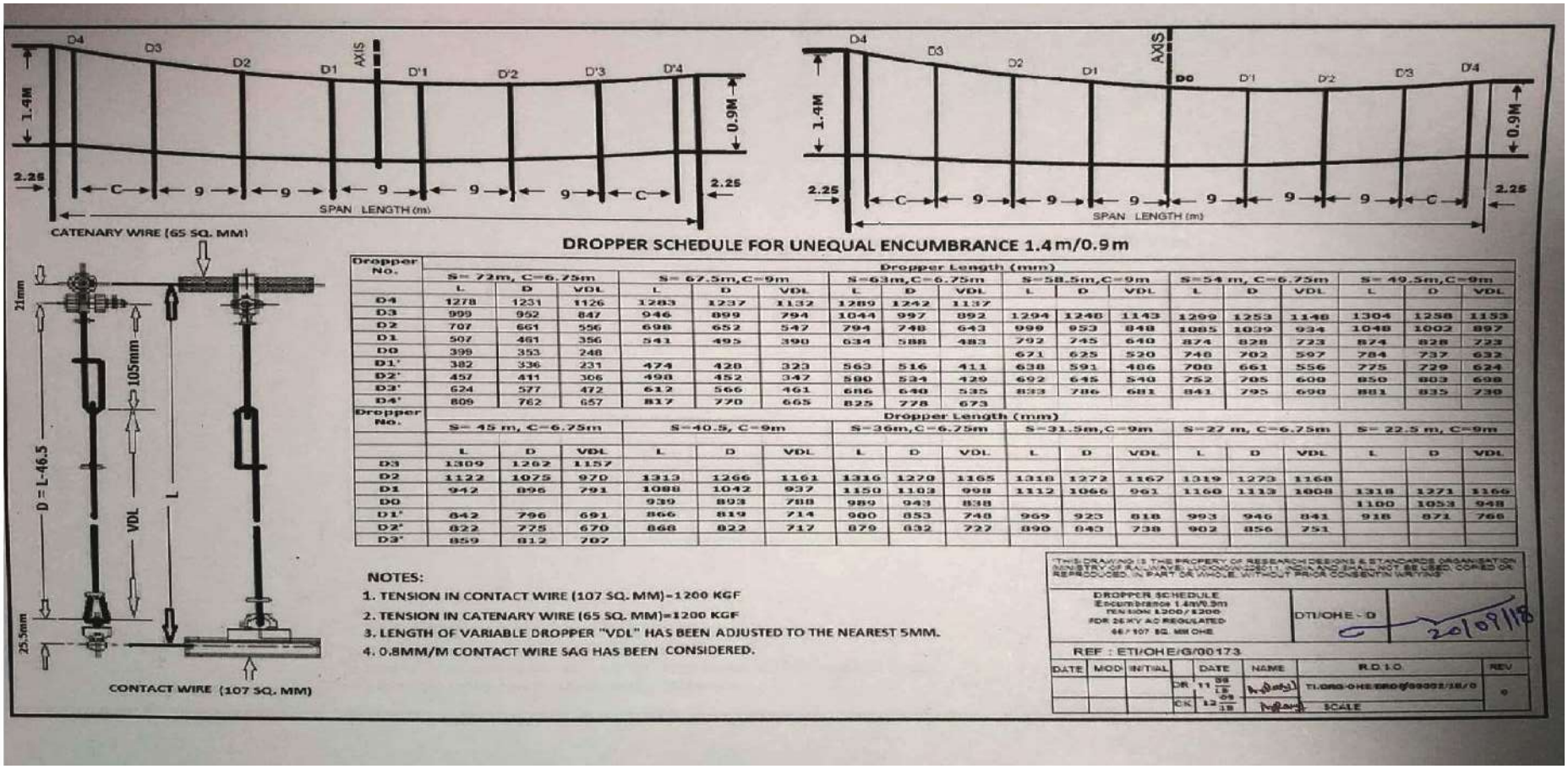
DTI/OHE

20/09/18

REF : ETI/OHE/G/00173

DATE	MOD	INITIAL	DATE	NAME	R.D.S.O.	REV
		DR	11-09-18		TI/DRG/OHE/DROP00001/18/0	0
		CK	12-09-18		SCALE	

ANNEXURE 24



DROPPER SCHEDULE FOR UNEQUAL ENCUMBRANCE 1.4 m/0.9 m

Dropper No.	Dropper Length (mm)																	
	S= 72m, C=6.75m			S= 67.5m,C=9m			S=63m,C=6.75m			S=58.5m,C=9m			S=54 m, C=6.75m			S= 49.5m,C=9m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D4	1278	1231	1126	1283	1237	1132	1289	1242	1137									
D3	999	952	847	946	899	794	1044	997	892	1294	1248	1143	1299	1253	1148	1304	1258	1153
D2	707	661	556	698	652	547	794	748	643	999	953	848	1085	1039	934	1048	1002	897
D1	507	461	356	541	495	390	634	588	483	792	745	640	874	828	723	874	828	723
D0	399	353	248							671	625	520	748	702	597	784	737	632
D1'	382	336	231	474	428	323	563	516	411	638	591	486	708	661	556	775	729	624
D2'	457	411	306	498	452	347	590	534	429	692	645	540	752	705	600	850	803	698
D3'	624	577	472	612	566	461	686	640	535	833	786	681	841	795	690	881	835	730
D4'	809	762	657	817	770	665	825	778	673									

Dropper No.	Dropper Length (mm)																	
	S= 45 m, C=6.75m			S=40.5, C=9m			S=36m,C=6.75m			S=31.5m,C=9m			S=27 m, C=6.75m			S= 22.5 m, C=9m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D3	1309	1262	1157															
D2	1122	1075	970	1313	1266	1161	1316	1270	1165	1318	1272	1167	1319	1273	1168			
D1	942	896	791	1088	1042	937	1150	1103	998	1112	1066	961	1160	1113	1008	1318	1271	1166
D0				939	893	788	989	943	838							1100	1053	948
D1'	842	796	691	866	819	714	900	853	748	969	923	818	993	946	841	918	871	766
D2'	822	775	670	868	822	717	879	832	727	890	843	738	902	856	751			
D3'	859	812	707															

NOTES:

1. TENSION IN CONTACT WIRE (107 SQ. MM)=1200 KGF
2. TENSION IN CATENARY WIRE (65 SQ. MM)=1200 KGF
3. LENGTH OF VARIABLE DROPPER "VDL" HAS BEEN ADJUSTED TO THE NEAREST 5MM.
4. 0.8MM/M CONTACT WIRE SAG HAS BEEN CONSIDERED.

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION MINISTRY OF RAILWAYS, LUCKNOW (INDIA) AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING

DROPPER SCHEDULE
Encumbrance 1.4m/0.9m
TENSION 1200 / 1200
FOR 25 KV AC REGULATED
65 / 107 SQ. MM OHE

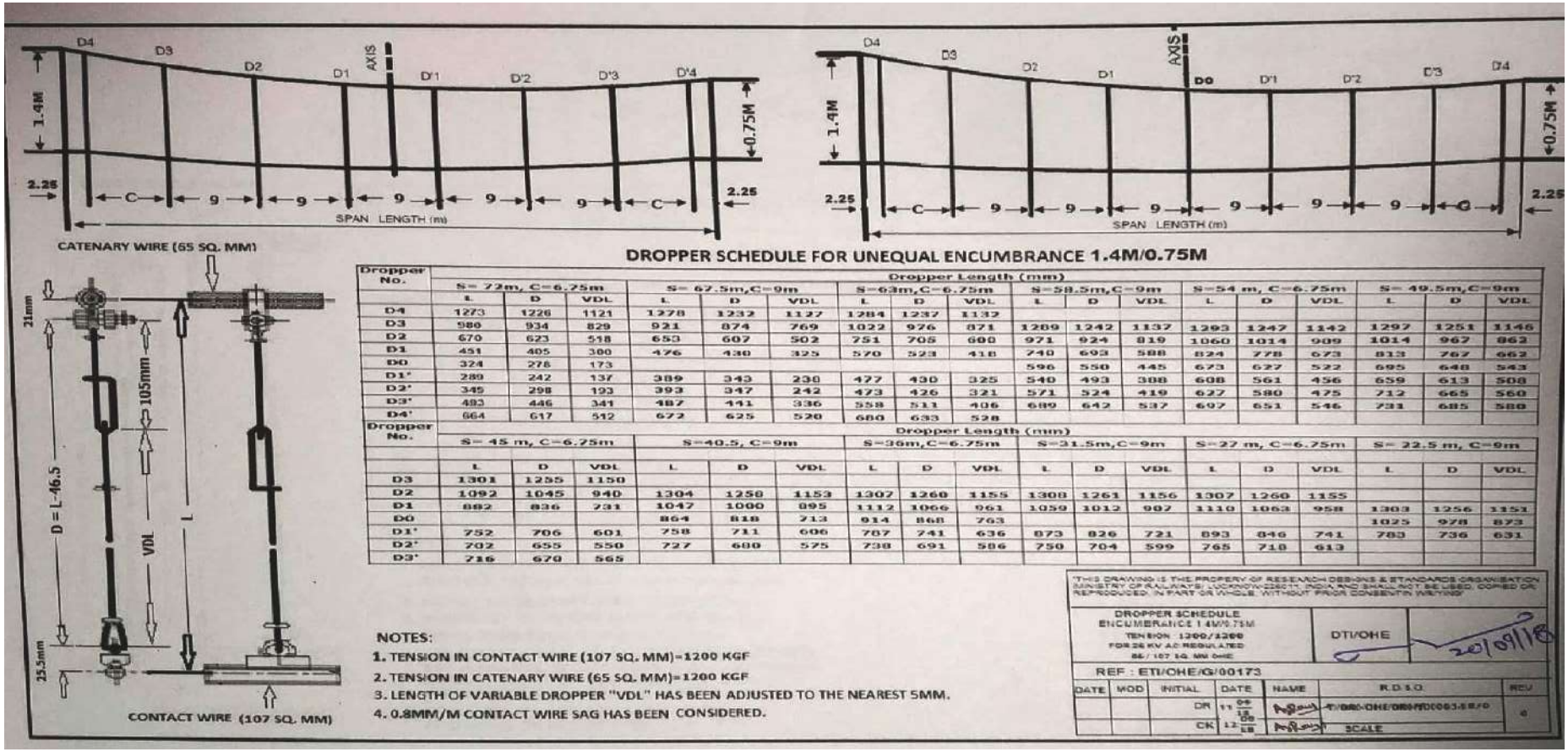
DTI/OHE - D

20/09/18

REF : ETI/OHE/G/00173

DATE	MOD	INITIAL		DATE	NAME	R.D.S.O.	REV
			DR	11 09 18		TI/DRG-OHE/ERG/00302/18/0	0
			CK	12 09 18		SCALE	

ANNEXURE 25



DROPPER SCHEDULE FOR UNEQUAL ENCUMBRANCE 1.4M/0.75M

Dropper No.	Dropper Length (mm)																	
	S= 72m, C=6.75m			S= 67.5m,C=9m			S=63m,C=6.75m			S=58.5m,C=9m			S=54 m, C=6.75m			S= 49.5m,C=9m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D4	1273	1226	1121	1278	1232	1127	1284	1237	1132									
D3	986	934	829	921	874	769	1022	976	871	1289	1242	1137	1293	1247	1142	1297	1251	1146
D2	670	623	518	653	607	502	751	705	600	971	924	819	1060	1014	909	1014	967	862
D1	451	405	300	476	430	325	570	523	418	740	693	588	824	778	673	813	767	662
D0	324	278	173							596	550	445	673	627	522	695	648	543
D1'	289	242	137	389	343	238	477	430	325	540	493	388	608	561	456	659	613	508
D2'	345	298	193	393	347	242	473	426	321	571	524	419	627	580	475	712	665	560
D3'	493	446	341	487	441	336	558	511	406	689	642	537	697	651	546	731	685	580
D4'	664	617	512	672	625	520	680	633	528									

Dropper No.	Dropper Length (mm)																	
	S= 45 m, C=6.75m			S=40.5, C=9m			S=36m,C=6.75m			S=31.5m,C=9m			S=27 m, C=6.75m			S= 22.5 m, C=9m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D3	1301	1255	1150															
D2	1092	1045	940	1304	1258	1153	1307	1260	1155	1308	1261	1156	1307	1260	1155			
D1	882	836	731	1047	1000	895	1112	1066	961	1059	1012	907	1110	1063	958	1303	1256	1151
D0				864	818	713	914	868	763							1025	978	873
D1'	752	706	601	758	711	606	787	741	636	873	826	721	893	846	741	783	736	631
D2'	702	655	550	727	680	575	738	691	586	750	704	599	765	718	613			
D3'	716	670	565															

NOTES:

1. TENSION IN CONTACT WIRE (107 SQ. MM)=1200 KGF
2. TENSION IN CATENARY WIRE (65 SQ. MM)=1200 KGF
3. LENGTH OF VARIABLE DROPPER "VDL" HAS BEEN ADJUSTED TO THE NEAREST 5MM.
4. 0.8MM/M CONTACT WIRE SAG HAS BEEN CONSIDERED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE LISED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING"

DROPPER SCHEDULE
ENCUMBERANCE 1.4M/0.75M
TENSION :1200/1200
FOR 25 KV AC REGULATED
65 / 107 SQ. MM OHE

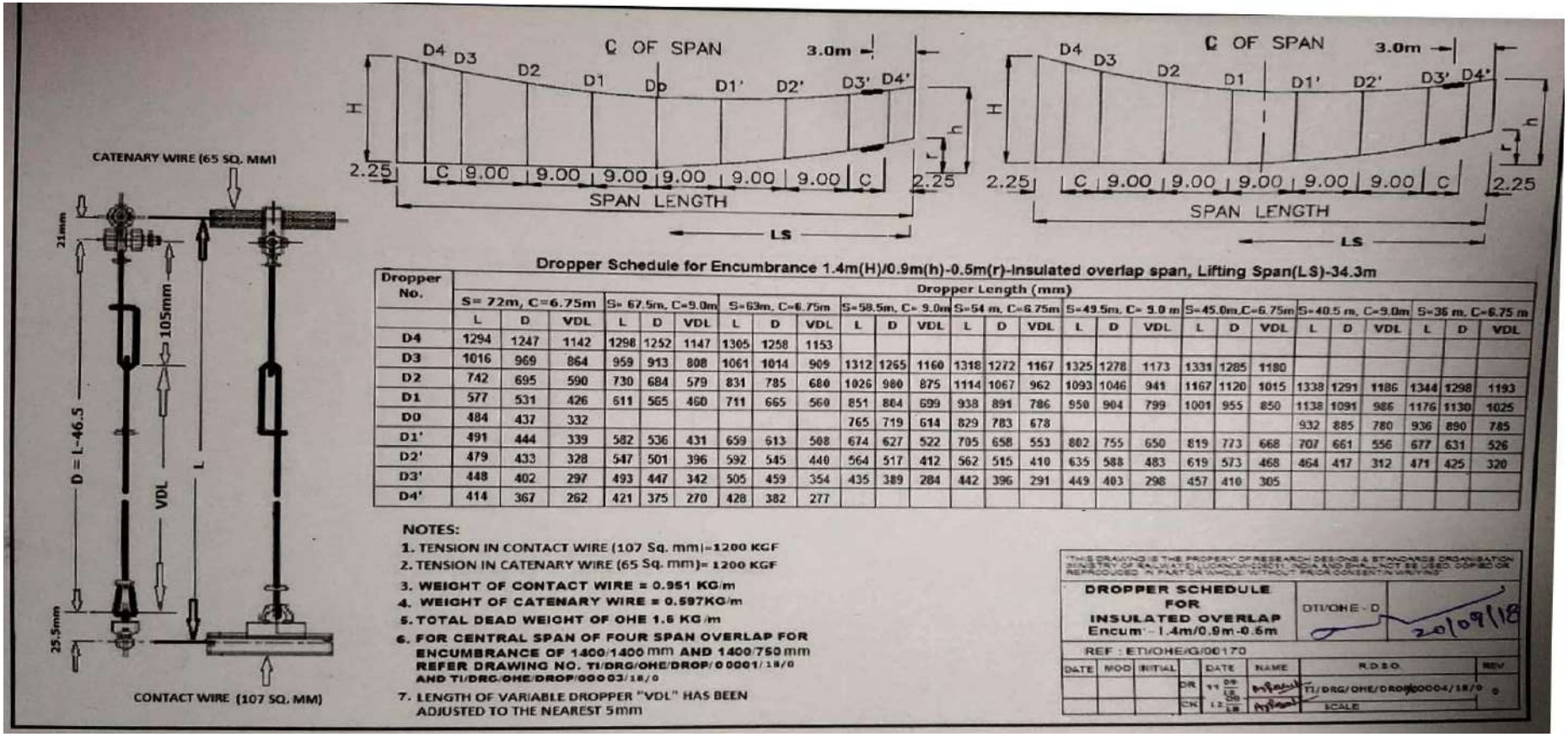
DTI/OHE

20/09/18

REF : ETI/OHE/G/00173

DATE	MOD	INITIAL	DATE	NAME	R.D.S.O.	REV
		DR	11 09 18			
		CK	12 09 18		SCALE	

ANNEXURE 26



Dropper Schedule for Encumbrance 1.4m(H)/0.9m(h)-0.5m(r)-Insulated overlap span, Lifting Span(LS)-34.3m

Dropper No.	Dropper Length (mm)																										
	S= 72m, C=6.75m			S= 67.5m, C=9.0m			S=63m, C=6.75m			S=58.5m, C= 9.0m			S=54 m, C=6.75m			S=49.5m, C= 9.0 m			S=45.0m,C=6.75m			S=40.5 m, C=9.0m			S=36 m, C=6.75 m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D4	1294	1247	1142	1298	1252	1147	1305	1258	1153																		
D3	1016	969	864	959	913	808	1061	1014	909	1312	1265	1160	1318	1272	1167	1325	1278	1173	1331	1285	1180						
D2	742	695	590	730	684	579	831	785	680	1026	980	875	1114	1067	962	1093	1046	941	1167	1120	1015	1338	1291	1186	1344	1298	1193
D1	577	531	426	611	565	460	711	665	560	851	804	699	938	891	786	950	904	799	1001	955	850	1138	1091	986	1176	1130	1025
D0	484	437	332							765	719	614	829	783	678							932	885	780	936	890	785
D1'	491	444	339	582	536	431	659	613	508	674	627	522	705	658	553	802	755	650	819	773	668	707	661	556	677	631	526
D2'	479	433	328	547	501	396	592	545	440	564	517	412	562	515	410	635	588	483	619	573	468	464	417	312	471	425	320
D3'	448	402	297	493	447	342	505	459	354	435	389	284	442	396	291	449	403	298	457	410	305						
D4'	414	367	262	421	375	270	428	382	277																		

NOTES:

1. TENSION IN CONTACT WIRE (107 Sq. mm)=1200 KGF
2. TENSION IN CATENARY WIRE (65 Sq. mm)= 1200 KGF
3. WEIGHT OF CONTACT WIRE = 0.951 KG/m
4. WEIGHT OF CATENARY WIRE = 0.597KG/m
5. TOTAL DEAD WEIGHT OF OHE 1.6 KG/m
6. FOR CENTRAL SPAN OF FOUR SPAN OVERLAP FOR ENCUMBRANCE OF 1400/1400 mm AND 1400/750 mm REFER DRAWING NO. TI/DRG/OHE/DROP/00001/18/0 AND TI/DRG/OHE/DROP/00003/18/0
7. LENGTH OF VARIABLE DROPPER "VDL" HAS BEEN ADJUSTED TO THE NEAREST 5mm

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE WITHOUT PRIOR CONSENT IN WRITING.

DROPPER SCHEDULE FOR INSULATED OVERLAP Encum' - 1.4m/0.9m-0.5m

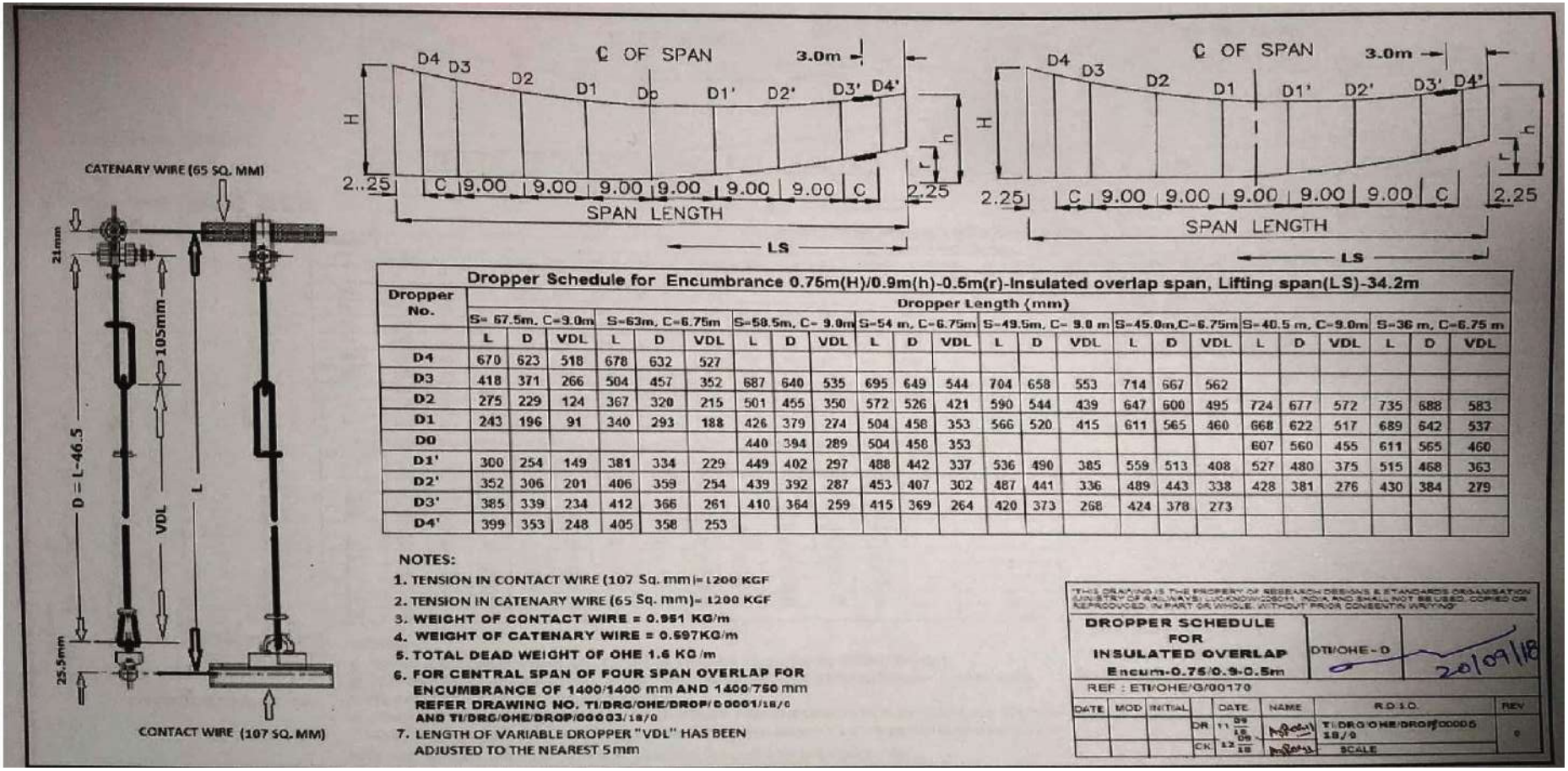
DTI/OHE-D

20/09/18

REF : ETI/OHE/G/00170

DATE	MOD	INITIAL		DATE	NAME	R.D.S.O.	REV
			DR	11 09 18		TI/DRG/OHE/DROP/00004/18/0	0
			CH	12 09 18		SCALE	

ANNEXURE 27



Dropper Schedule for Encumbrance 0.75m(H)/0.9m(h)-0.5m(r)-Insulated overlap span, Lifting span(LS)-34.2m

Dropper No.	Dropper Length (mm)																							
	S= 67.5m, C=9.0m			S=63m, C=6.75m			S=58.5m, C= 9.0m			S=54 m, C=6.75m			S=49.5m, C= 9.0 m			S=45.0m,C=6.75m			S=40.5 m, C=9.0m			S=36 m, C=6.75 m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D4	670	623	518	678	632	527																		
D3	418	371	266	504	457	352	687	640	535	695	649	544	704	658	553	714	667	562						
D2	275	229	124	367	320	215	501	455	350	572	526	421	590	544	439	647	600	495	724	677	572	735	688	583
D1	243	196	91	340	293	188	426	379	274	504	458	353	566	520	415	611	565	460	668	622	517	689	642	537
D0							440	394	289	504	458	353							607	560	455	611	565	460
D1'	300	254	149	381	334	229	449	402	297	488	442	337	536	490	385	559	513	408	527	480	375	515	468	363
D2'	352	306	201	406	359	254	439	392	287	453	407	302	487	441	336	489	443	338	428	381	276	430	384	279
D3'	385	339	234	412	366	261	410	364	259	415	369	264	420	373	268	424	378	273						
D4'	399	353	248	405	358	253																		

NOTES:

1. TENSION IN CONTACT WIRE (107 Sq. mm)= 1200 KGF
2. TENSION IN CATENARY WIRE (65 Sq. mm)= 1200 KGF
3. WEIGHT OF CONTACT WIRE = 0.951 KG/m
4. WEIGHT OF CATENARY WIRE = 0.597KG/m
5. TOTAL DEAD WEIGHT OF OHE 1.6 KG/m
6. FOR CENTRAL SPAN OF FOUR SPAN OVERLAP FOR ENCUMBRANCE OF 1400/1400 mm AND 1400/750 mm REFER DRAWING NO. TI/DRG/OHE/DROP/00001/18/0 AND TI/DRG/OHE/DROP/00003/18/0
7. LENGTH OF VARIABLE DROPPER "VDL" HAS BEEN ADJUSTED TO THE NEAREST 5mm

"THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING"

DROPPER SCHEDULE FOR INSULATED OVERLAP
Encum-0.75/0.9-0.5m

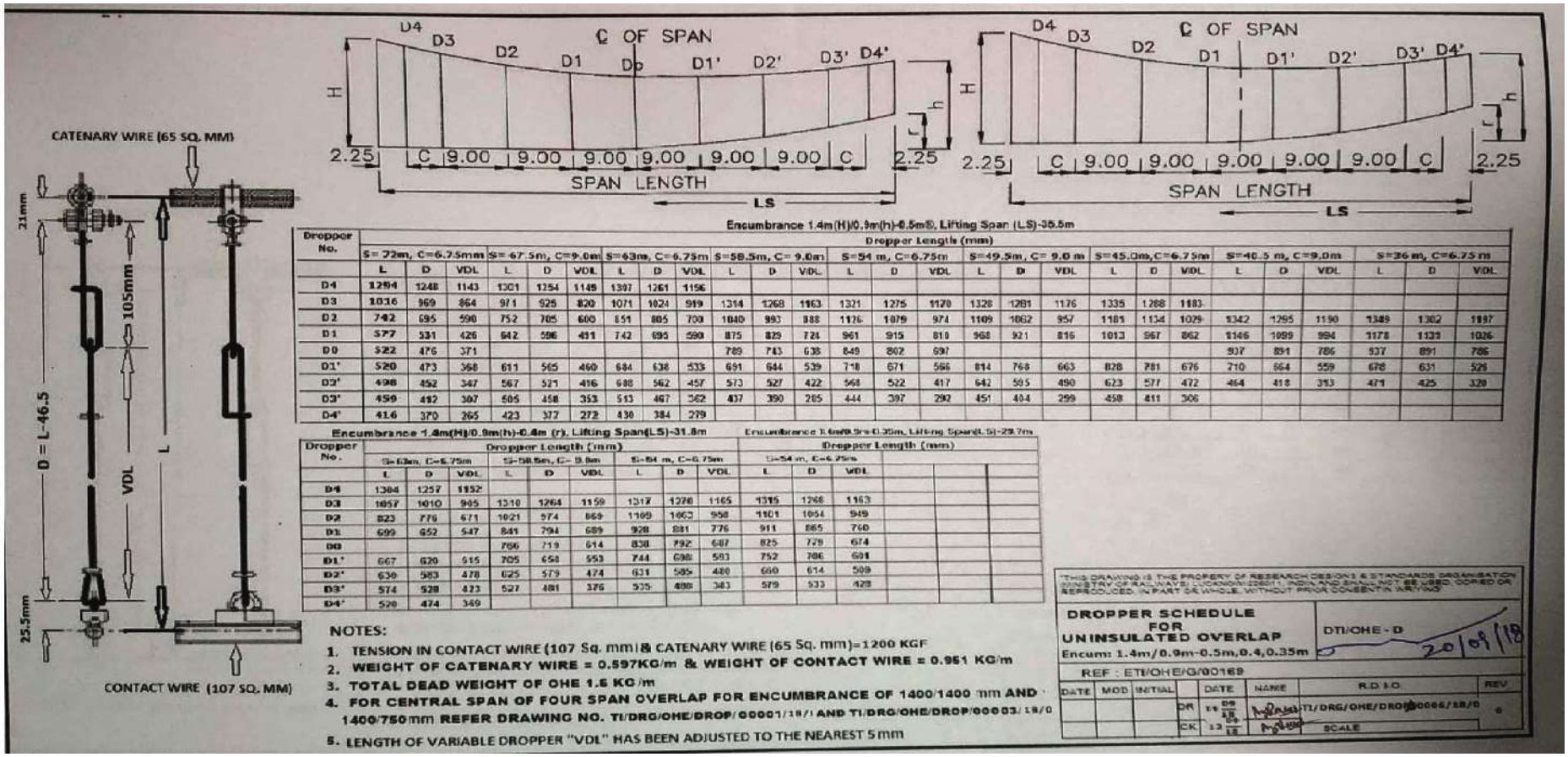
DTI/OHE-D

20/09/18

REF : ETI/OHE/G/00170

DATE	MOD	INITIAL		DATE	NAME	R.D.S.O.	REV
			DR	11.09.18		TI/DRG/OHE/DROP/00005 18/0	0
			CK	12.09.18		SCALE	

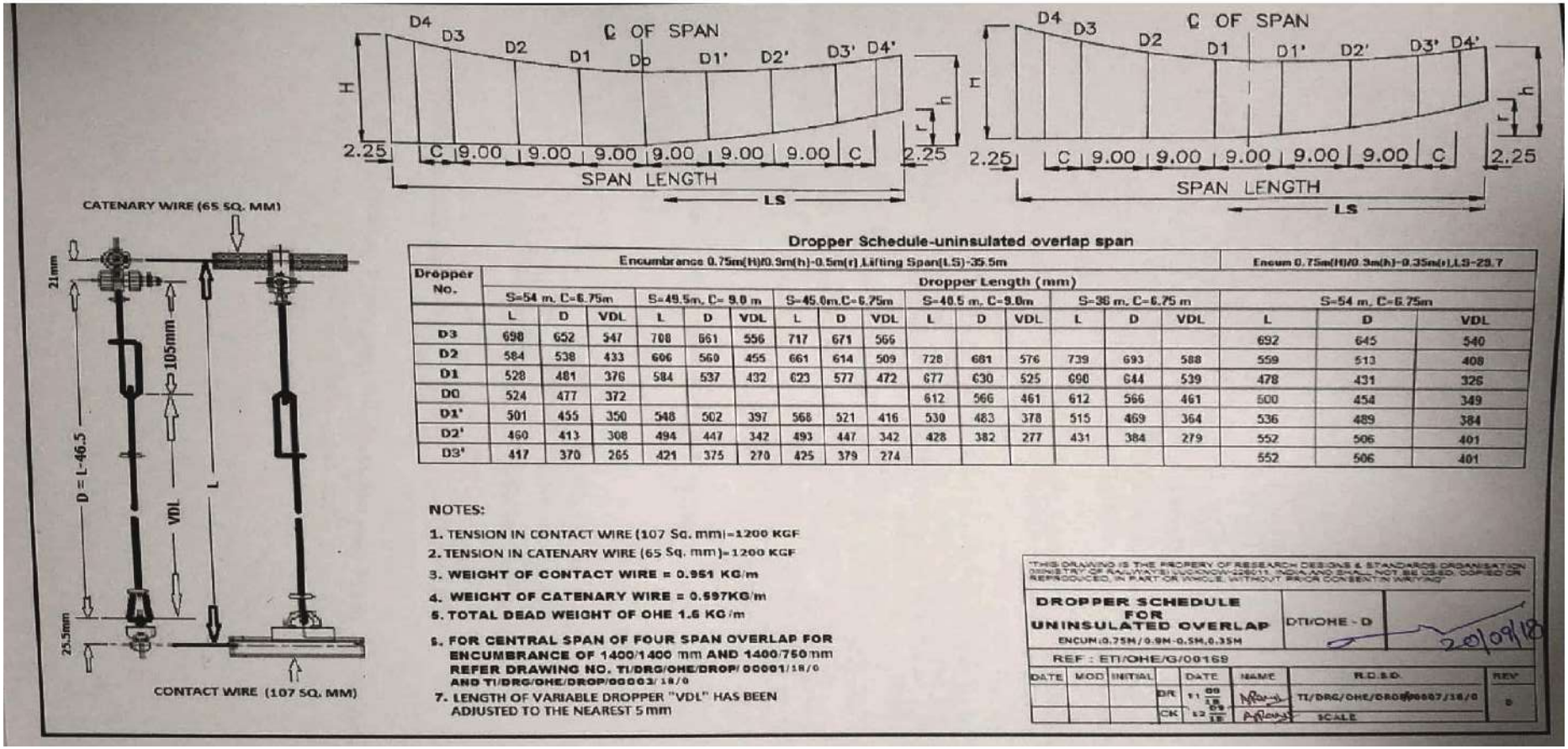
ANNEXURE 28



Dropper No.	S= 72m, C=6.75mm			S= 67.5m, C=9.0m			S=63m, C=6.75m			S=58.5m, C= 9.0m			S=54 m, C=6.75m			S=49.5m, C= 9.0 m			S=45.0m,C=6.75m			S=40.5 m, C=9.0m			S=36 m, C=6.75 m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D4	1294	1248	1143	1301	1254	1149	1307	1261	1156																		
D3	1016	969	864	971	925	820	1071	1024	919	1314	1268	1163	1321	1275	1170	1328	1281	1176	1335	1288	1183						
D2	742	695	590	752	705	600	851	805	700	1040	993	888	1176	1079	974	1109	1062	957	1185	1134	1029	1342	1295	1190	1349	1302	1197
D1	577	531	426	642	596	491	742	695	590	875	829	724	961	915	810	968	921	816	1013	967	862	1146	1099	994	1178	1131	1026
D0	522	476	371							789	743	638	849	802	697							937	891	786	937	891	786
D1'	520	473	368	611	565	460	684	638	533	691	644	539	718	671	566	814	768	663	828	781	676	710	664	559	678	631	526
D2'	498	452	347	567	521	416	688	562	457	573	527	422	568	522	417	642	595	490	623	577	472	464	418	313	471	425	320
D3'	459	412	307	505	458	353	553	467	362	437	390	285	444	397	292	451	404	299	458	411	306						
D4'	416	370	265	423	377	272	430	384	279																		

Dropper No.	S=63m, C=6.75m			S=58.5m, C= 9.0m			S=54 m, C=6.75m			S=54 m, C=6.75m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D4	1304	1257	1152									
D3	1057	1010	905	1310	1264	1159	1317	1270	1165	1315	1268	1163
D2	823	776	671	1021	974	869	1109	1062	958	1101	1054	949
D1	699	652	547	841	794	689	928	881	776	911	865	760
D0				786	719	614	838	792	687	825	779	674
D1'	667	620	515	705	658	553	744	698	593	752	706	601
D2'	630	583	478	625	579	474	631	585	480	660	614	509
D3'	574	528	423	527	481	376	535	488	383	579	533	428
D4'	520	474	369									

ANNEXURE 29



Dropper Schedule-uninsulated overlap span

Dropper No.	Encumbrance 0.75m(H)0.9m(h)-0.5m(r) Lifting Span(LS)-35.5m															Encum 0.75m(H)0.9m(h)-0.35m(r) LS-29.7		
	Dropper Length (mm)																	
	S=54 m, C=6.75m			S=49.5m, C= 9.0 m			S=45.0m,C=6.75m			S=40.5 m, C=9.0m			S=36 m, C=6.75 m			S=54 m, C=6.75m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D3	698	652	547	708	661	556	717	671	566							692	645	540
D2	584	538	433	606	560	455	661	614	509	728	681	576	739	693	588	559	513	408
D1	528	481	376	584	537	432	623	577	472	677	630	525	690	644	539	478	431	326
D0	524	477	372							612	566	461	612	566	461	500	454	349
D1'	501	455	350	548	502	397	568	521	416	530	483	378	515	469	364	536	489	384
D2'	460	413	308	494	447	342	493	447	342	428	382	277	431	384	279	552	506	401
D3'	417	370	265	421	375	270	425	379	274							552	506	401

NOTES:

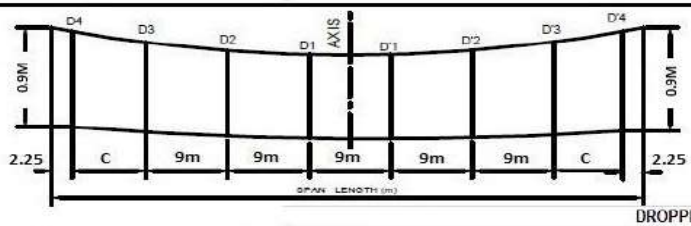
1. TENSION IN CONTACT WIRE (107 Sq. mm)=1200 KGF
2. TENSION IN CATENARY WIRE (65 Sq. mm)=1200 KGF
3. WEIGHT OF CONTACT WIRE = 0.951 KG/m
4. WEIGHT OF CATENARY WIRE = 0.597KG/m
5. TOTAL DEAD WEIGHT OF OHE 1.6 KG/m
6. FOR CENTRAL SPAN OF FOUR SPAN OVERLAP FOR ENCUMBRANCE OF 1400/1400 mm AND 1400/750 mm REFER DRAWING NO. TI/DRG/OHE/DROP/ 00001/18/0 AND TI/DRG/OHE/DROP/00003/ 18/0
7. LENGTH OF VARIABLE DROPPER "VDL" HAS BEEN ADJUSTED TO THE NEAREST 5 mm

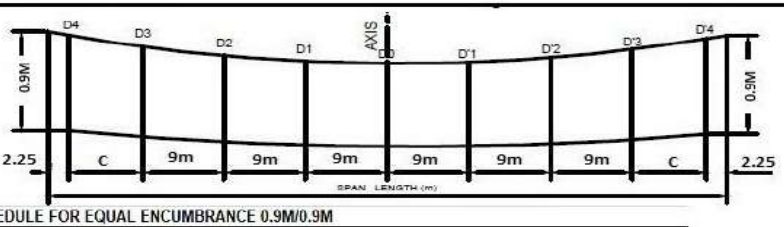
"THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING"

DROPPER SCHEDULE FOR UNINSULATED OVERLAP	DTI/OHE - D
ENCUM:0.75M/0.9M-0.5M,0.35M	20/09/18
REF : ETI/OHE/G/00169	

DATE	MOD	INITIAL		DATE	NAME	R.D.S.O.	REV
			DR	11 09 18		TI/DRG/OHE/DROP/00007/18/0	0
			CK	12 09 18		SCALE	

ANNEXURE 30

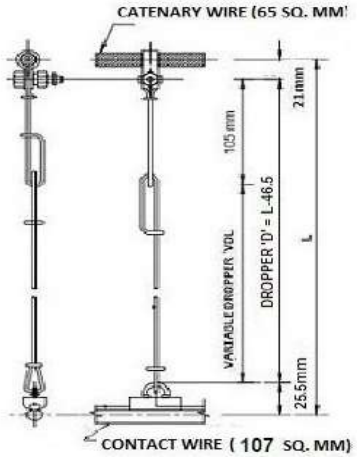




DROPPER SCHEDULE FOR EQUAL ENCUMBRANCE 0.9M/0.9M

Dropper No.	Dropper Length (mm)																	
	S= 67.5m,C=9m			S=63m,C=6.75m			S=58.5m,C=9m			S=54 m, C=6.75m			S= 49.5m,C=9m			S= 45 m, C=6.75m		
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL
D4	800	754	649	807	760	655												
D3	529	482	377	615	569	464	814	767	662	820	774	669	827	781	676	834	787	682
D2	348	302	197	437	391	286	596	549	444	669	622	517	662	615	510	722	675	570
D1	258	211	106	348	302	197	465	418	313	541	494	389	579	533	428	642	596	491
D0							421	375	270	498	452	347						
D1'	258	211	106	348	302	197	465	418	313	541	494	389	579	533	428	642	596	491
D2'	348	302	197	437	391	286	596	549	444	669	622	517	662	615	510	722	675	570
D3'	529	482	377	615	569	464	814	767	662	820	774	669	827	781	676	834	787	682
D4'	800	754	649	807	760	655												

Dropper No.	Dropper Length (mm)																	
	S=40.5, C=9m			S=36m,C=6.75m			S=31.5m,C=9m			S=27 m, C=6.75m			S= 22.5 m, C=9m					
	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL	L	D	VDL			
D2	841	794	689	847	801	696	854	808	703	861	814	709						
D1	727	681	576	775	728	623	791	744	639	826	780	675	868	821	716			
D0	689	643	538	739	693	588							850	803	698			
D1'	727	681	576	775	728	623	791	744	639	826	780	675	868	821	716			
D2'	841	794	689	847	801	696	854	808	703	861	814	709						



NOTES:

1. TENSION IN CONTACT WIRE (107 SQ. MM)= 1200KGF
2. TENSION IN CATENARY WIRE (65 SQ. MM)= 1200KGF
3. LENGTH OF VARIABLE DROPPER "VDL" HAS BEEN ADJUSTED TO THE NEAREST 5MM.
4. 0.8MM/M CONTACT WIRE SAG HAS BEEN CONSIDERED.

"THIS DRAWING IS THE PROPERY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING"

DROPPER SCHEDULE
ENCUMBRANCE 0.9M/0.9M
TENSION 1200/1200KGF
FOR 25 KV AC REGULATED
65 / 107 SQ. MM OHE

EDTI

DATE	MOD	INITIAL		DATE	NAME	R.D.S.O.	REV
			DR			TI/DRG/OHE/DROP/ RDSO/00001/20/0	
			CK			SCALE	

ANNEXURE 31

Duplicate

उत्तर मध्य रेलवे
NORTH CENTRAL RAILWAY
विद्युत विभाग
Electrical Department

प्रधान कार्यालय
Head Quarter's Office
सूबेदारगंज, इलाहाबाद –211015
Subedarganj, Allahabad – 211015
cedencrald@gmail.com

No.EL/TRD/NCR/Gatimaan

Date:19.11.2018

SrED/TI
RDSO/Lucknow

Sub: Work done to run Gatimaan Express at 160 kmph in Agra - Palwal section.

In Palwal-Agra section of Agra Division, Ndls-BPL Shatabdi express was already running at 150 Kmph. When Gatimaan Exp. was introduced in the same section at 160 Kmph, there were several cases of panto entanglement at turn out locations. Hence to prevent the cases of panto entanglement, following works have been done in OHE at turn out locations to run Gatiman Express at 160 Kmph in Agra - Palwal section.

1. At obligatory mast vertical gap between main line and turn out contact wire is maintained between 50 to 60 mm.
2. At 5 mtr distance from obligatory mast, gap is maintained at 50 mm.
3. At 10 mtr distance from obligatory mast, gap is maintained between 40 mm to 50 mm.
4. Track separation is kept between 290mm to 550mm. Mast changed if Track Separation is less than 290 mm.
5. Span length of turn out location reduced during increasing of track separation.
6. From main line to loop line, 'take off' goes in between 720 to 750mm.
7. One Skilled staff is daily going to NZM outpit for checking the Panto of Gatimaan Loco.

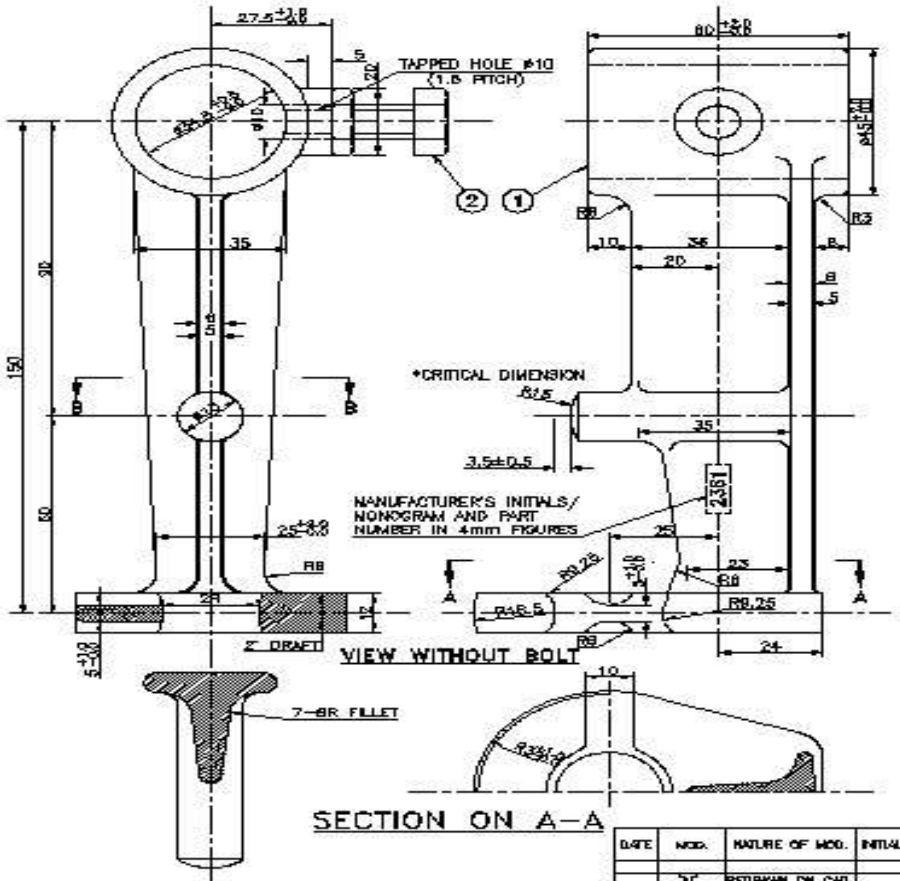
Submitted for kind perusal please.

19/11/18
(V.K.Garg)
CEDE/NCR

Copy to : ED/EEM, Rly. Bd. : for kind inf. Please.

वरि० कार्य० निदेशक/टी० आई०
कार्य० निदेशक/टी० आई०
निदेशक/टी० आई०(लो० एवं टै०-ई०)
निदेशक/टी० आई०(लो० एवं टै०-टी०)
निदेशक/टी० आई०(पी० एवं ट्रा०)
निदेशक/टी० आई०(ब्रा०लिं०)

ANNEXURE 32



REF. No.	DESCRIPTION	PART No.	MATERIAL	SPECIFICATION	Approx. WEIGHT (kg)	NUMBER OFF
1.	25mm DROP BRACKET PART	2361	MALL. IRON CASTING GALVANISED	IS:2108 BM.340 ETI/OHE/13		1
2.	BOLT ø10x25/30 WITH LOCKNUT	10/14LN	STAINLESS STEEL	ETI/OHE/18		1

NOTES:—

ALL DIMENSIONS ARE IN mm.

1. TOLERANCE OF ±0.5mm IS PERMISSIBLE ON ALL DIMENSIONS UNLESS
2. OTHERWISE SHOWN.
3. MANUFACTURER'S INITIALS/MONOGRAM AND PART NUMBER TO BE PROVIDED IN RELIEF.
4. DIMENSIONAL LIMITS APPLICABLE AFTER GALVANISATION.
5. THE SURFACE OF THE MALLEABLE IRON CASTING WHEN EXPOSED BY ROUGH MACHINING OR SECTIONING IN TERMS OF CLAUSE 8.2 OF IS:2108 SHALL PRESENT AN UNIFORM SILKY BLACK APPEARANCE WITHOUT WHITE OR SHINY SPOTS (EXCEPT AT THE EDGES OF THE SURFACE).
6. FOR USE WITH BFB STEADY ARM IDENT NUMBER 2390.
7. UNLESS OTHERWISE SPECIFIED RADII SHALL BE 1.5mm.
8. ALL THE SPECIFICATIONS MENTIONED IN THE DRAWING SHALL BE THE LATEST VERSION.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

25mm DROP BRACKET ASSEMBLY

DOS/CHE Sd/- 29.1.76

ADS/CHE Sd/- 27.1.76

REF.:— CROSS REF.:—

DATE	MOD.	NATURE OF MOD.	INITIAL
	'K'		
	'J'		
	'H'	NUT DELETED IN REF.2	
	'G'	RETRACED	
	'N'	REDRAWN ON CAD	
	'L'		

R. D. S. O.

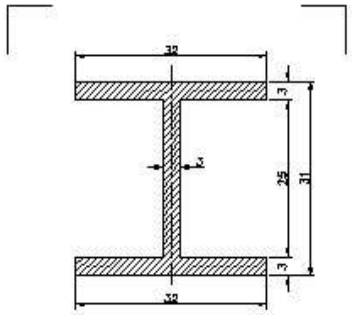
	DATE	NAME	
DR.	21 01 78	VERMA	ETI/OHE/P/2360
TC.			SCALE:—1:1
CK.	24 01 78	Sd/-	

REV. H

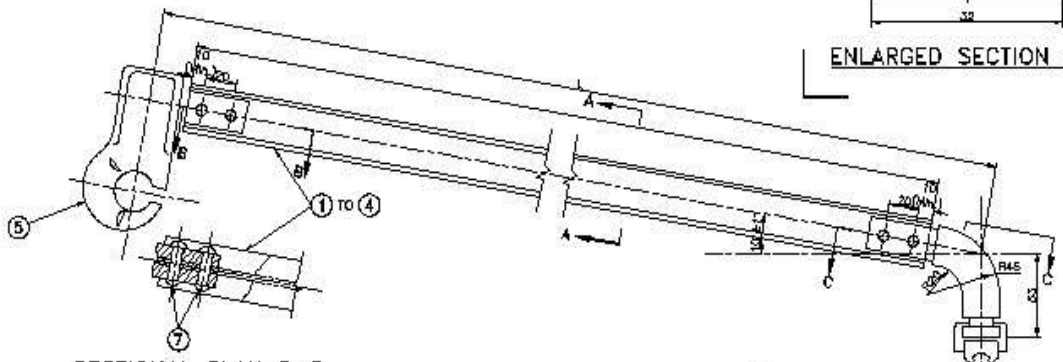
ANNEXURE 33

TABLE

REF. No.	IDENTIFICATION No.	LENGTH 'L' OF STEADY ARM ASSEMBLY (m)	LENGTH 'l' OF STEADY ARM PART (m)	IDENTIFICATION OF STEADY ARM
1	2390/01	0.75	0.69	2544-5
2	2390/02	0.95	0.89	2544-6
3	2390/03	1.15	1.09	2544-7
4	2390/04	1.35	1.29	2544-8



ENLARGED SECTION A-A



SECTIONAL PLAN B-B

SECTIONAL PLAN C-C

REF. No.	DESCRIPTION	PART No.	MATERIAL	SPECIFICATION	Approx. WEIGHT (kg)	NUMBER OFF
1 TO 4	BFB STEADY ARM	SEE TABLE	ALUMINIUM ALLOY	ETI/OHE/21		1
5	STEADY ARM HOOK (BFB)	2391	MALL CAST IRON GALVANISED	IS:2108,GR.BN340 RE/OHE/13		1
6.	BFB STEADY ARM SWIVEL	2392	FORGED STEEL GALVANISED	IS:2004, CL-2 RE/OHE/13		1
7.	RIVET ø6x35		ALUMINIUM ALLOY	IS:240, GRADE HR-E OR HR-B OR HR-30 & IS:2827		4

NOTES:-

1. ALL DIMENSIONS IN mm.
2. DRILLING AND RIVETTING TO BE DONE AFTER ASSEMBLING THE END FITTINGS TO THE STEADY ARM.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

BFB STEADY ARM ASSEMBLY

DDS/OHE

ADS/OHE Sd/- R.P. MITTAL 28.5.76

REF.:-

CROSS REF.:-

DATE	MOD.	NATURE OF MOD.	INITIAL
	'C'	REDRAWN ON CAD	
	'B'	MOD. AS CORRECTED	Sd/-
	'A'	CORRECTED AND TRACED IN ULDHM	

R. D. S. O.

	DATE	NAME
DR.	28-03-76	Sd/-
TC.	29-03-76	Sd/-
CK.	22-03-76	Sd/-

ETI/OHE/P/2390

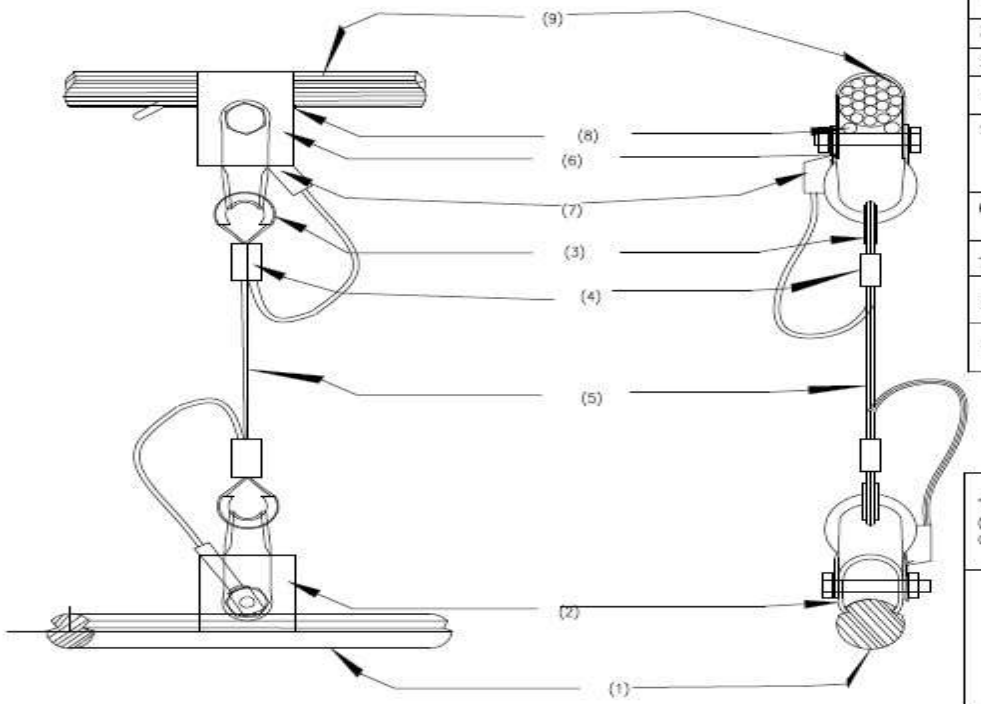
REV. C

SCALE:-1:2

SUB SCALE:-2:1

SUB SCALE:-

ANNEXURE 34



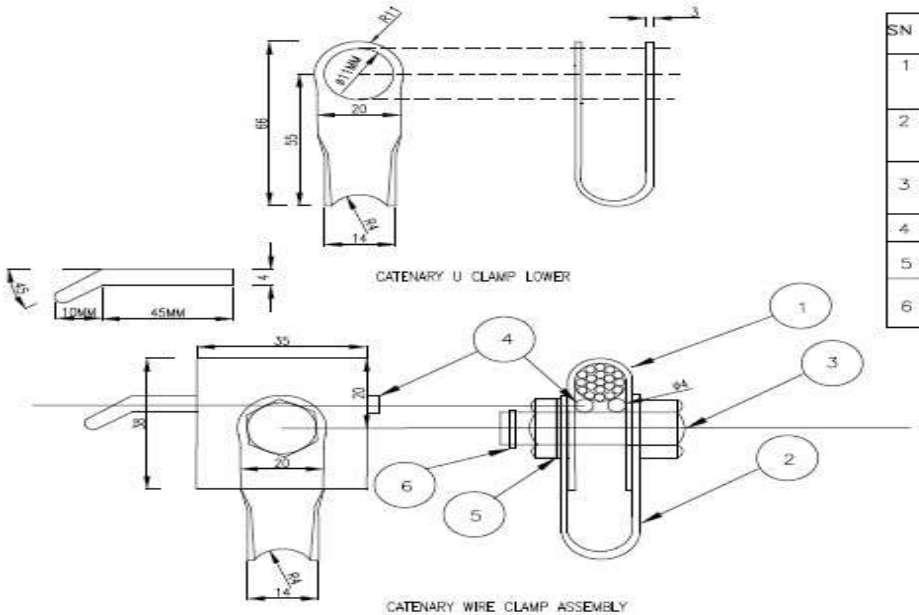
SN	DESCRIPTION	PART No.	MATERIAL	SPECIFICATION
1	CONTACT WIRE		–	ETI/OHE/76(6/97)
2	CONTACT WIRE CLAMP		CuNi2Si	ASTM B411
3	THIMBLE		Cu–ETP	IS:1897–2008
4	COMPRESSION SLEEVE		Cu–ETP	IS:1897–2008
5	CURRENT CARRYING FEXIBLE DROPPER WIRE DIA. 7.5MM, 25 SQMM		Cu–Mg	TI/SPC/OHE/CCFD/0160 (02/2020)
6	CATENARY WIRE CLAMP		CuNI2SI	ASTM B411
7	CABLE LUG		Cu–ETP	IS:1897–2008
8	STOPPER WIRE		ANNEALED COPPER	IS–549
9	CATENARY WIRE		Cd–Cu	ETI/OHE/50 (6/97)

NOTE–
1. ALL DIMENSION ARE IN MM.
2. TOERANCE OF ±0.5MM IS PERMISSIBLE ON ALL DIMENSIONS UNLESS OTHERWISE SHOWN..
3. FOR CONTACT WIRE CLAMP SEE THE DRG. NO.TI/DRG/OHE/CCD/00003/20/0
4. FOR CATENARY WIRE CLAMP SEE THE DRG. NO.TI/DRG/OHE/CCD/00002/20/0
5. FOR CRIMPING SLEEVE, THIMBLE AND CABLE LUG SEE THE DRG. NO. TI/DRG/OHE/CCD/RDSO/00004/0
6. MANUFACTURERS, INITIALS/MONOGRAM TO BE PROVIDED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

CURRENT CARRYING DROPPER ASSEMBLY		DIRECTOR/TI	
REF: ETI/OHE/P/1190		ED/TI	
DATE / MOD NO. / NATURE OF MOD. / INITIALS		TI/DRG/OHE/CCD/RDSO/00001/20/0	

ANNEXURE 35



SN	DESCRIPTION	PART No.	MATERIAL	SPECIFICATION
1	CATENARY U CLAMP UPPER		CuNI2SI	ASTM B 411
2	CATENARY U CLAMP LOWER		CuNI2SI	ASTM B 411
3	BOLT M 10X35/30 WITH NUT		STAINLESS STEEL	TI/SPC/OHE/FASTENER /0120
4	STOPPER PIN		ANNEALED COPPER	IS:549
5	SPRING WASHER		PHOSPHOR BRONZE	TI/SPC/OHE/FASTENER /0120
6	SPLIT PIN 2.5X20		PHOSPHOR BRONZE	IS:549

NOTE–
1. ALL DIMENSION ARE IN MM.
2. TOERANCE OF ±0.5MM IS PERMISSIBLE ON ALL DIMENSIONS UNLESS OTHERWISE SHOWN.
3. MANUFACTURERS, INITIALS/MONOGRAM TO BE PROVIDED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

CATENARY WIRE CLAMP FOR CURRENT CARRYING DROPPER

DIRECTOR/TI

ED/TI

REF:TI/DRG/OHE/CCD/RDSO/00001/20/0

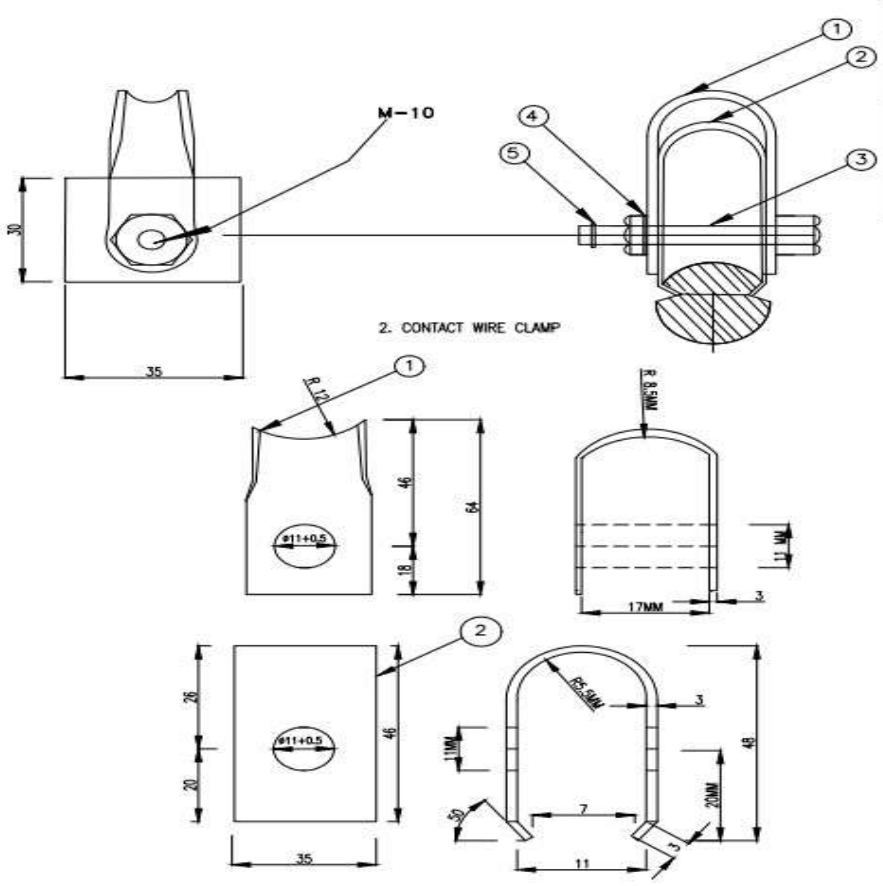
TI/DRG/OHE/CCD/RDSO/ 00002/20/0

REV

IR

DATE	MOD NO.	NATURE OF MOD.	INITIALS

ANNEXURE 36



SN	DESCRIPTION	PART No.	MATERIAL	SPECIFICATION
1	CONTACT U CLAMP LARGE		CuNi2Si	ASTM B411
2	CONTACT U CLAMP SMALL		CuNi2Si	ASTM B411
3	BOLT M10X35/30 WITH NUT		STAINLESS STEEL	TI/SPC/OHE/FASTENER /0120
4	SPRING WASHER		PHOSPHOR BRONZE	TI/SPC/OHE/FASTENERS/0120
5	SPLIT PIN		ANNELEAD COPPER	IS 549

NOTE–
1. ALL DIMENSION ARE IN MM.
2. TOERANCE OF ±0.5MM IS PERMISSIBLE ON ALL DIMENSIONS UNLESS OTHERWISE SHOWN.
3. MANUFACTURERS, INITIALS/MONOGRAM TO BE PROVIDED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

CONTACT U CLAMP (LARGE AND SMALL) FOR CURRENT CARRYING DROPPER

REF: TI/DRG/OHE/CCD/RDSO/00001/20/0

DATE	MOD NO.	NATURE OF MOD.	INITIALS

DIRECTOR/TI

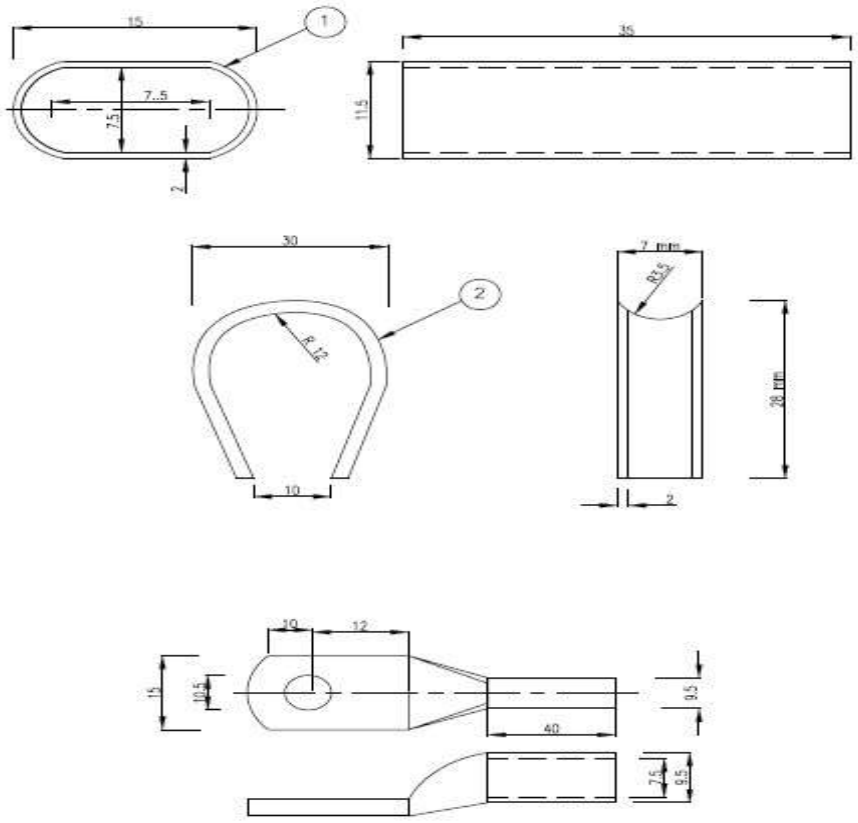
ED/TI

TI/DRG/OHE/CCD/RDSO/ 00003/20/0

REV

IR

ANNEXURE 37



SN	DESCRIPTION	PART No.	MATERIAL	SPECIFICATION
1	COMPRESSION SLEEVE		Cu–ETP	IS:1897–2008
2	THIMBLE		Cu–ETP	IS:1897–2008
3	CABLE LUG		Cu–ETP	IS:1897–2008

NOTE–
1. ALL DIMENSION ARE IN MM.
2. TOLERANCE OF ±0.5MM IS PERMISSIBLE ON ALL DIMENSIONS UNLESS OTHERWISE SHOWN.
3. DOUBLE CRIMPING SHOULD BE DONE ON COMPRESSION SLEEVE.
4. MANUFACTURERS, INITIALS/MONOGRAM TO BE PROVIDED.

"THIS DRAWING IS THE PROPERTY OF RESEARCH, DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW–226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING."

1.COMPRESSION SLEEVE
2. THIMBLE
3. CABLE LUG

FOR CURRENT CARRYING DROPPER

DIRECTOR/TI

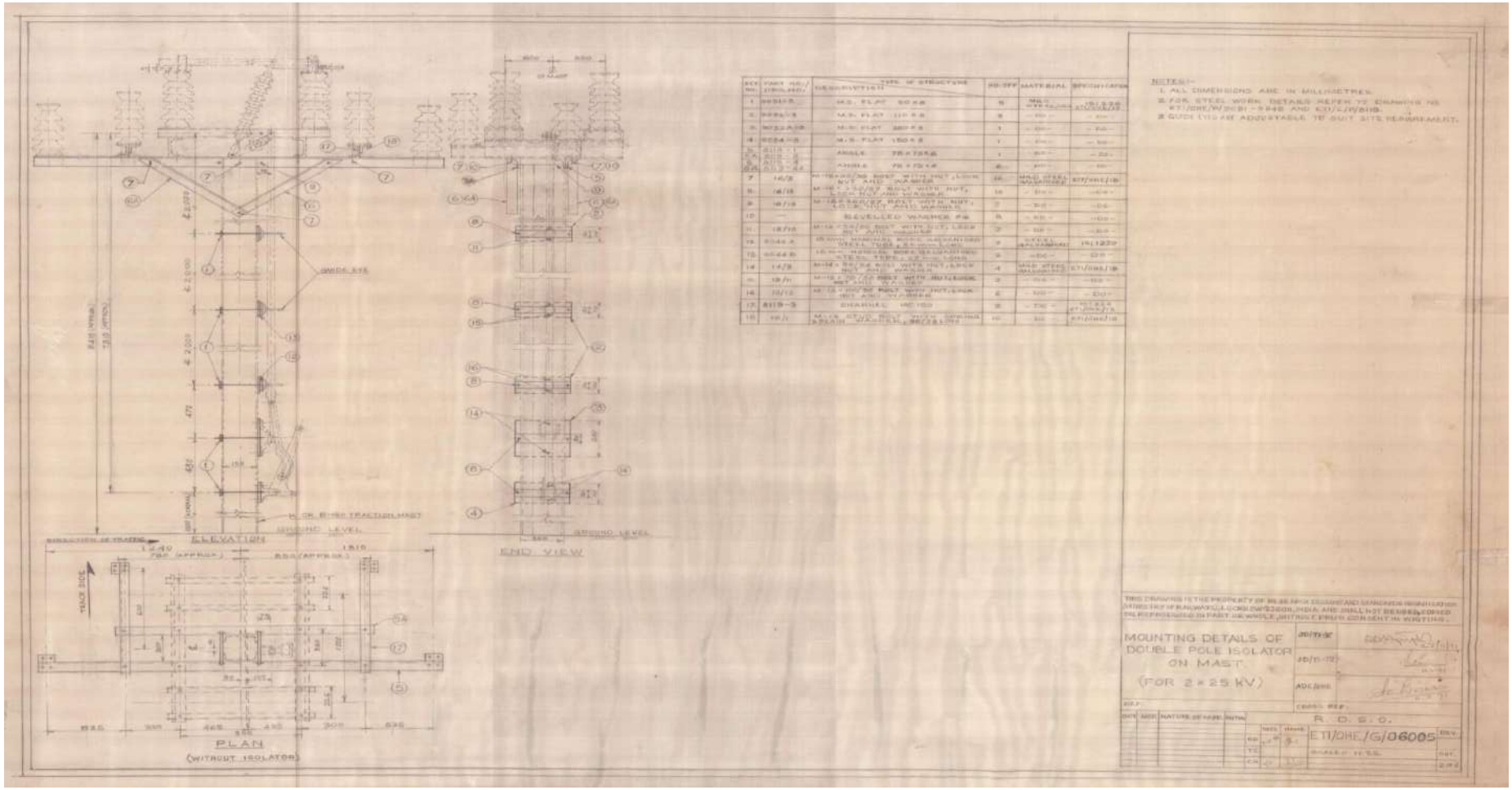
ED/TI

REF: TI/DRG/OHE/CCD/RDSO/00001/20/0

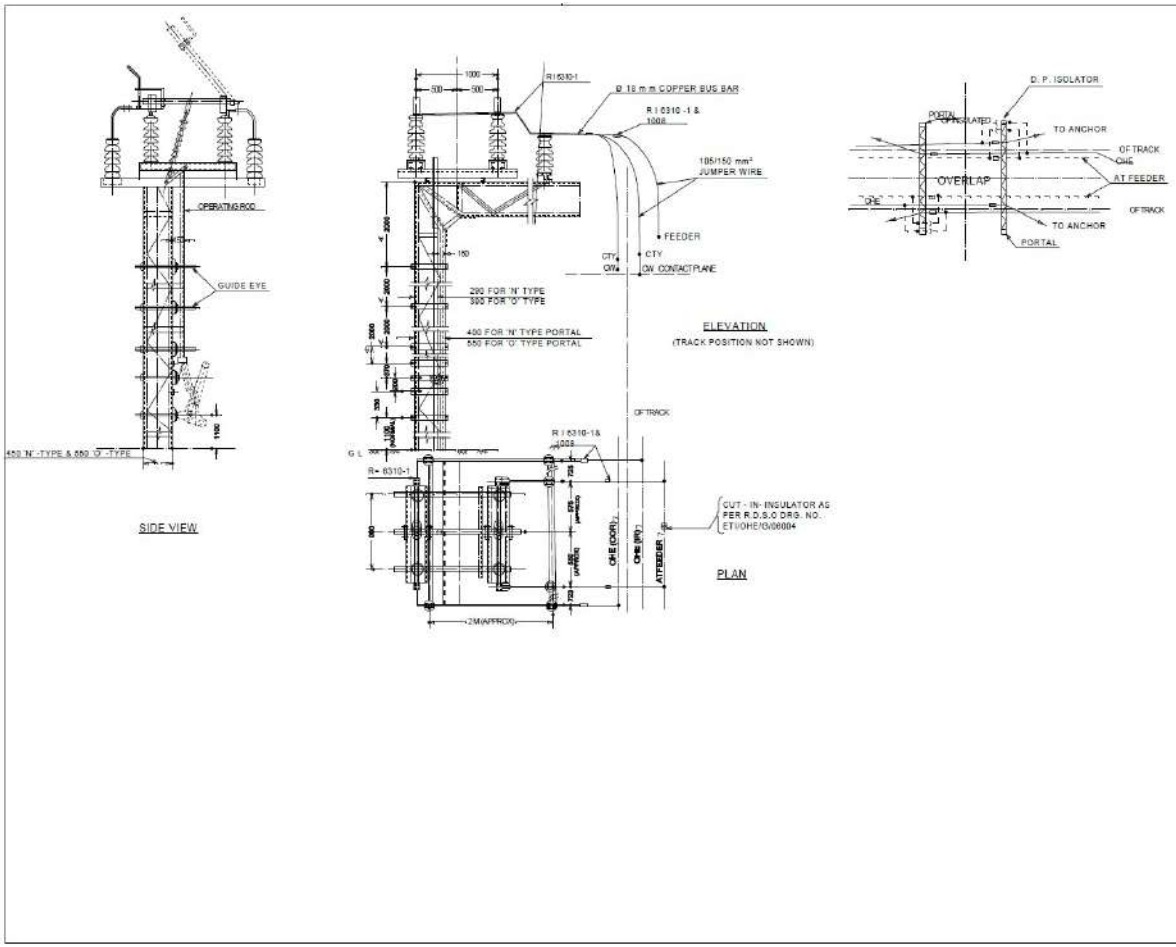
DATE	MOD NO.	NATURE OF MOD.	INITIALS

TI/DRG/OHE/CCD/RDSO/00004/0. REV IR

ANNEXURE 38


ELEVATION
END VIEW
PLAN
(WITHOUT ISOLATOR)
NOTES:-
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. FOR STEEL WORK DETAILS REFER TO DRAWING NO. ETI/DRE/W/3081-9448 AND 9311/9819.
3. GUIDE LUGS ARE ADJUSTABLE TO SUIT SITE REQUIREMENT.
MOUNTING DETAILS OF DOUBLE POLE ISOLATOR ON MAST.
(FOR 2 x 25 KV)
R. D. S. O.
ETI/DRE/G/06005

ANNEXURE 39



NOTES :-

1. ALL DIMENSIONS ARE IN mm.
2. FOR STEEL WORK DETAIL REFER TO DRAWING NO. ETI/OHE/P/9031 - 9045 AND ETI/C/P/ 8118 SHEET 2/2.
3. FOR OTHER SPS AND MOUNTING DETAILS REFER DRAWING NO ETI/OHE/G/05513 SHEET - 1.
4. GUIDE EYES ARE ADJUSTABLE TO SUIT SITE REQUIREMENT.

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS AND STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW - 226011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED, IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING.

MOUNTING DETAILS OF DOUBLE POLE ISOLATOR ON PORTALS (FOR 2 X 25 KV)

DD/TI -V	Sd/- 13.10.1992
ADE/PSI	Sd/- 16.09.1992
ADE/OHE	Sd/- 08.09.1992

REF

DATE	MOD.	NATURE OF MOD.	INITIALS
	0	REPLACED REDRAWN ON C.U.D.	

R. D. S. O.

ETI/OHE/G/06008

	DATE	NAME
DR	15	Sd/-
TC		
CK		Sd/-

SCALE : NTS
SUBSCALE :-
SUBSCALE :-

ANNEXURE 40

GOVERNMENT OF INDIA
MINISTRY OF RAILWAY
RAILWAY BOARD

2001/Elect (G)/170/1 Pt.

Policy Circular No. TRD/2012/2

New Delhi, dated: 07.05.12

Chief Electrical Engineers,
Zonal Railways

Chief Electrical Engineers,
CORE/Allahabad

Executive
Director(Electrical)
RVNL/New Delhi

Sub: Provision of retro-reflective number plate on OHE mast.

Ref: 1. RDSO's letter No TI/OHE/STR/NOP/04 dated 16/20.04.04 & 23.11.2011
2. NR letter No. 230-Elect./TRD/2 dated 11.03.11 & 08.09.2010
3. NCR letter No EL/TRD/NCR/OHE Maintenance dt. 08.11.2010
4. Railway Board letter No. 2001/Elect (G)/170/1 dt. 07.10.2010 & 21.02.12

In supersession of earlier instructions regarding provision of retro-reflective number plates on OHE structures, the following guidelines shall be followed-

(i) One no. of retro-reflective OHE number plates should be provided in each Kilometers at the beginning of kilometer.

(ii) Retro-reflective number plates should be provided at critical locations like before the stop signals and before the permanent speed restrictions.

(iii) All other warning boards as per ACTM like DJ open, DJ close, 500m board, 250m board, coasting, dangers etc. which are used in OHE (not PSI) should be retro-reflective type as it will improve the visibility of running staff.

(iv) Number plate background i.e. traffic blue colour will be non reflective type with no borders.

(v) Only the letters & figures will be retro-reflective type in deep yellow colour.

(vi) The retro-reflective strip in sigma shape for identification of all signals shall be provided two masts prior to all signal locations for easy identification during foggy weather. The detailed design for provision of sigma strip shall be finalized by RDSO. It shall be advised to running staff that this is only an aide to the running staff and it's non-availability/ damaged number plate or poor visibility will not be considered the reason for any signal overshooting.

(vii) Sigma strips wherever provided should be on the lower post of mast for proper retro-reflection.

(viii) Sigma strips may be provided on fog prone area only.

This issues in consultation with Safety Dte. & approval of Board (ML)

(Sushil Kumar)
Director Elect. Engg. (PS)
Railway Board

ANNEXURE 41

5533
22/10/12
महाप्रबंधक (प्रशासन) कार्यालय
पूर्व-मध्य रेल, राजीपुर
रेल बोर्ड का पत्र संख्या सं.
दिनांक 22/X/12

GOVERNMENT OF INDIA
MINISTRY OF RAILWAY
RAILWAY BOARD

(63) (6)

Policy Circular No. RB/Elect./TRD/07-2012

2001/Elect (G)/170/1 Pt.

New Delhi, dated: 18.10.12

ECR
Chief Electrical Engineers,
Zonal Railways, CORE Allahabad,
ED/Elect. RVNL New Delhi.

Sub: Provision of retro-reflective number plate on OHE mast.
Ref: Railway Board Policy Circular No. TRD/2012/2 of even no dated 07.05.12

In continuation to Board's letter under reference regarding provision of retro-reflective number plates for OHE structures, it has been further decided that GMs of the Zonal Railways may permit to provide additional retro-reflective number plates with non-retro reflective background as per the operational/safety requirement on case to case basis such as in fog affected areas.

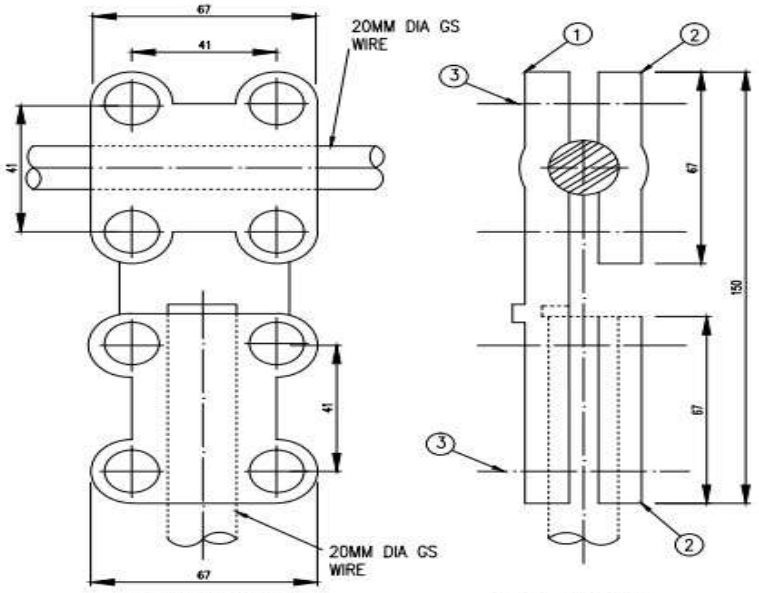
All other conditions stipulated in Board's policy circular under reference (copy enclosed) will remain same.

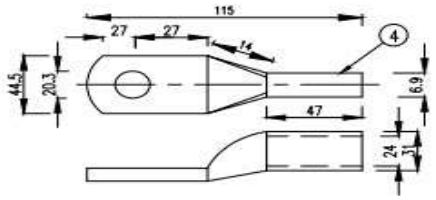
This issue in consultation with Safety Dte. & approval of Board (ML)

(Sushil Kumar)
Director Elect. Engg. (PS)
Railway Board

Copy to: Sr. ED/TI: for information. This is also in reference to RDSO's letter No. TI/OHE/STRNOP/12 dated 22.06.12

ANNEXURE 42





MATERIAL LIST:

REF. NO.	DESCRIPTION	MATERIAL	QTY.
1.	CONNECTOR BODY	MALLEABLE CAST IRON GALVANISED, GR. MB 340, AS PER IS:14329–1995	1
2.	CLAMPING PIECE	–DO–	2
3..	M 12X60 BOLT WITH NUT, PLAIN & SPRING WASHER	HOT DIP GALVANISED AS PER RDSO SPEC. NO.TI/SPC/OHE/ FASTENERS/0120– REV.1	8
3..	SINGLE HOLE ALUMINIUM LUG & M–16, 50/38 BOLT AND NUT	ALUMINIUM & AS PER RDSO SPEC. NO.TI/SPC/OHE/ FASTENERS/0120– REV.1	1

NOTE :–

1. REF. STANDARD : IS : 5561-2018
2. SHORT TIME RATING : 12 KA FOR 3 SEC.
3. ALL SHARP CORNERS SHALL BE SMOOTHLY ROUNDED OFF.
4. MANUFACTURING TOLERANCES :
   UPTO 500 mm ±5% : FROM 51 TO 100 mm: ± 4%:
   FROM 101 TO 300mm : 3%

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW–11, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING.

TEE CONNRCTOR SUITABLE FOR 20mm GS WIRE TO 20 mm DIA GS WIRE

ED–II

(BHARWDAJ CHAUDHARY)

REF.

CROSS REF :–

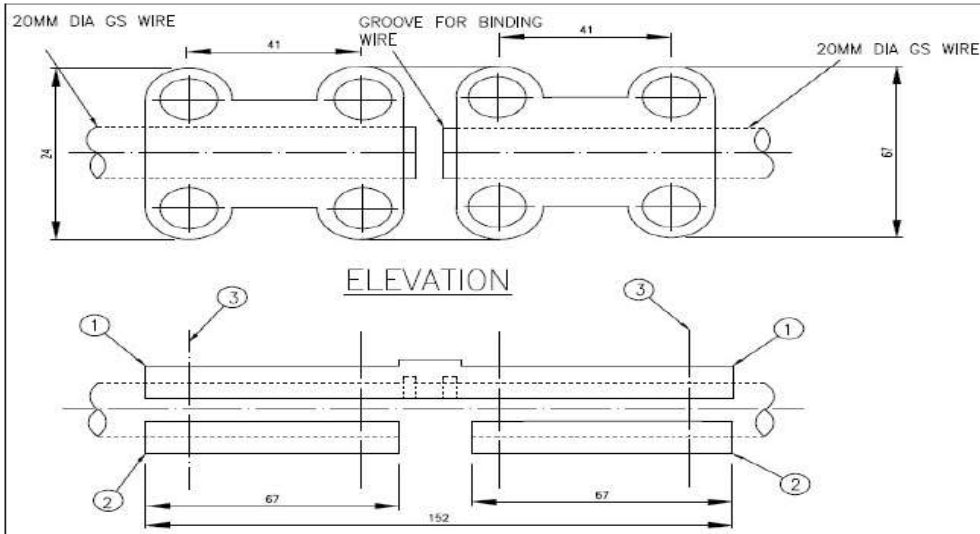
DATE	MOD.	NATURE OF MOD.	INITIALS

	DATE	NAME
DR		
CK		
CK		

R . D . S . O.

TI/DRG/OHE/TC/RDSO/ 00001/20/0

ANNEXURE 43



MATERIAL LIST:

REF. NO.	DESCRIPTION	MATERIAL	QTY.
1.	CONNECTOR BODY	MALLEABLE CAST IRON GALVANISED, GR. MB 340, AS PER IS:14329–1995	1
2.	CLAMPING PIECE	–DO–	2
3..	M 12X60 BOLT WITH NUT, PLAIN & SPRING WASHER	HOT DIP GALVANISED AS PER RDSO SPEC. NO.TI/SPC/OHE/ FASTENERS/0120–REV.1	8

NOTE :–

1. REF. STANDARD : IS : 5561-2018
2. SHORT TIME RATING : 12 KA FOR 3 SEC.
3. ALL SHARP CORNERS SHALL BE SMOOTHLY ROUNDED OFF.
4. MANUFACTURING TOLERANCES :
   UPTO 500 mm ±5% : FROM 51 TO 100 mm: ± 4%:
   FROM 101 TO 300mm : 3%

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW–11, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING.

STRAIGHT CONNECTOR SUITABLE FOR 20MM DIA. GS WIRE TO 20MM DIA GS WIRE

ED–TI

(BHARWDAJ CHAUDHARY)

REF.

CROSS REF :–

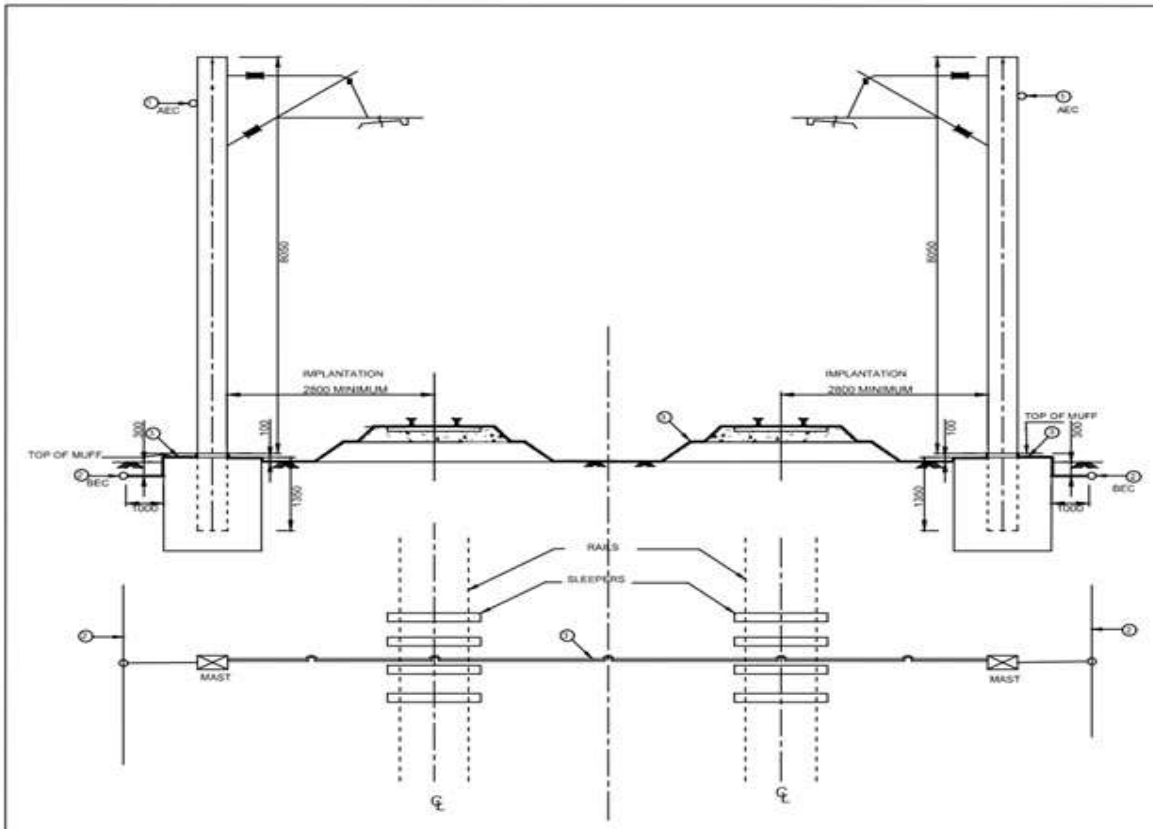
DATE	MOD.	NATURE OF MOD.	INITIALS

R . D . S . O.

	DATE	NAME
DR		
CK		
CK		

TI/DRG/OHE/ST/RDSO/ 00001/20/0

ANNEXURE 44



REF NO.	DESCRIPTION	PART NO.	QTY
1	12.27 mm DIA. STEEL RAINFORCED ALUMINIUN RACCOON (505QMM Cu EQUIVALANT) (AEC)		
2	20 MM DIA. AND 238 SQMM (NOMINAL CROSS SECTIONAL AREA) GALVANISED STEEL CONDUCTOR (BEC)	AS PER IS: 2141-2000	
3	50X6 MS/GS FLAT		

NOTE :-

1. ALL DIMENSIONS ARE IN mm
2. BEC WILL BE LAID 300MM BELOW FORMATION LEVEL ALONG THE TRACK
3. THE CROSS BONDING ARRANGEMENT CONNECTING UP BEC- UP MAST/PORTAL-UP TRACTION RAILS - DN TRACTION RAILS -DN MAST-DN BEC WILL BE PROVIDED AT EVERY 450 M.
4. BEC WILL BE CONNECTED TO EACH MAST BY BEC CONDUCTOR WITH SUITABLE TEE CONNECTOR AT ONE END & LUG ARRANGEMENT AT MAST END.
5. 50X6 MM MS/GS FLAT WILL BE CONNECTED WITH RAIL/MAST BY M-16 BOLT 50X38 MM WITH NUT, LOCK & PLAIN WASHER.

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS & STANDARDS ORGANISATION (MINISTRY OF RAILWAYS) LUCKNOW-11, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING.

CROSS BONDING ARRANGEMENT FOR NDLS-HWH & NDLS-MUMBAI ROUTE

ED-TI

(BHARWDAJ CHAUDHARY)

REF. ETI/C/P/8020

CROSS REF :-

DATE	MOD.	NATURE OF MOD.	INITIALS

R . D . S . O.

	DATE	NAME
DR		
CK		
CK		

TI/DRG/OHE/EARTHING/ RDSO/00001/20/0

ANNEXURE 45



BEC ARRENGMENT ON BRIDGES AND PLATFORM COPING

ANNEXURE 46

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
RAILWAY BOARD

No. 2001/Elect(G)170/1Pt-III

New Delhi, Date: 07.08.2020

Sr. Executive Director (TI)
RDSO, Manak Nagar
Lucknow

Sub: VC held on 02.08.2020 regarding train speed raising upto 160 kmph in Delhi-Howrah and Delhi-Mumbai routes.

A Video Conference was held with Hon'ble MR and zonal railways on 02.08.2020 regarding raising of speed upto 160 kmph in Delhi-Howrah and Delhi-Mumbai routes. It has been instructed that associated electrical works should be completed within 1.5 years.

2. Accordingly, RDSO is advised to finalize all specifications/designs as required so that work could be completed timely. Action plan with timelines to be sent to Railway Board by date 14.08.2020.

This is issued with the approval of Competent Authority.

07/08/2020

(Sumit Garg)
Director Elect. Engg. (PS)

Copy to: DG/RDSO: For kind information please.

ANNEXURE 47

भारत सरकार (GOVERNMENT OF INDIA)
रेल मंत्रालय (MINISTRY OF RAILWAYS)
रेलवे बोर्ड (RAILWAY BOARD)

No. 2001/Elect(G)/170/1 Pt-II New Delhi, Dated: 16.10.2020

Director General
RDSO
Lucknow

Sub: Minutes of Meeting of MTRS (then OSD/Safety), Railway Board with RDSO Officers of TI Dte. at RDSO and Zonal Railway CEEs/CEDEs& ED/DMRC on call on 12.09.2020 regarding 2x25 kV scheme for upgradation of OHE & PSI.

In reference to the above subject, a meeting was chaired by M/TRS (then OSD/Safety) with RDSO Officers of TI Dte. at RDSO on 12.09.2020, in continuation to the meeting held through VC with Zonal Railways and RDSO officers on 29.08.2020 regarding 2x25 kV scheme for upgradation of OHE & PSI.

2. In this regard, minutes of meeting is enclosed herewith for kind information.

Encl: Copy enclosed.

16/10/2020
(Manish Gupta)
Executive Director (EEM)

Copy to:

(i) AM/Traction, Railway Board
(ii) PCEE/ER, ECR, NCR, NR, WCR,WR
(iii) PED/TI, PED/SE, ED/PS & EMU/ RDSO
(iv) CAO/CORE, Prayagraj
(v) ED/RE, Railway Board
(vi) ED/Dev, Railway Board

For kind information please

Minutes of Meeting of M/TRS (then OSD/Safety), Railway Board with RDSO Officers of TI Dte. at RDSO and Zonal Railway CEEs/CEDEs & ED/DMRC on call on 12.09.2020 regarding 2x25kv scheme for upgradation of OHE & PSI

This meeting on 12.09.2020 at RDSO was held in continuation to the meeting held through VC with Zonal Railways and RDSO officers on 29.08.2020.

Following officers were present during the meeting held at RDSO on 12.09.2020:

1.	Shri Rajesh Tiwari	:	M/TRS (then OSD/Safety), Railway Board & Ex-Officio Secretary to Govt. of India.
2.	Shri Sanjiv Swarup	:	PED/SE/RDSO
3.	Shri Sunil Kumar	:	PED/TI/RDSO
4.	Shri Bhardwaj Chaudhary	:	ED/TI/RDSO
5.	Shri Gyan Prakash Katiyar	:	Director/TI/RDSO
6.	Shri Arvind Koomar	:	Joint Director/TI/RDSO

1. Review of the items discussed during VC with Zonal Railways (ER, ECR, NR, WR, & WCR) & RDSO regarding 2x25kv system adoption has been done. Status is as below:

1.1 **OHE Work:**

i) RDSO has finalized draft OHE guidelines for Zonal Railways for increasing the speed to 160 kmph on NDLS-HWH (including CNB-LKO) and NDLS-BCT (incl. Varodara-Ahemdabad) routes and circulated to all Zonal Railways vide instruction No. TI/IN/0042 on 11.09.2020.Final OHE guidelines should be issued by RDSO by this week end after considering comments from Railways.

ii) Detailed guidelines for checking the OHE structure suitability has been given in para 1.1.1 of draft OHE guidelines. Zonal Railways should check the existing mast and foundation as per excel sheet circulated by RDSO and report the status of failed masts and foundation to RDSO for scrutiny. The decision on mast and foundation found not suitable by a small margin should be taken in consultation with RDSO.

Portal structure should also be checked for suitability to take load of feeder wire on super mast, increase in tension in conductors to 1200+1200kgf and aerial earth wire.

iii) Execution strategy of OHE modification work has been discussed and it was concluded that increase in tension in OHE conductor by providing additional counter weight by changing center rod and re-droppering can be done in the field within 2.5 to 3 hrs. for one tension length of 1500 mtrs. This is almost at

xi) Vendor (indigenous) development for Cu-Mg catenary wire should be expedited as in future Cu-Mg catenary may have to be used due to environment and technical considerations.

1.2 **PSI Work:**

i) All the Zonal Railways must send the details of available area for TSS/SP /SSP after site survey. Some of the Zonal Railways have not submitted the details of space availability for TSS/SP/SSP.

ii) Standardized TSS/SP/SSP layout drawings should be finalized by RDSO expeditiously. Minimum 3 types/scheme for layout should be developed. If land availability at site warrants, layouts will have to be developed suiting the site conditions.

a) TSS/SP/SSP having standard dimensions where adequate space is available.

b) TSS/SP/SSP with 25 kV switch yard along the track for lower dimension across the track.

c) Attempt should be made to reduce the dimension of length required across the track upto 50 mtr for Scott/V-connected TSS. This is possible as this exercise has already been done for development of layout drawing of Malwa and Sirathu TSS in NCR.

d) Both type of schematic may be considered for TSS/SP/SSP i.e. with approach Road & without approach Road. However, the TSS if not provided with Road must have cross track.

The acquisition of land is very critical & complicated and wastes a lot of time. Wherever the land is less, the TSS should be tried to be accommodated in the available land. If the connectivity of Road from cross track cum Road is not feasible at present due to less land, the TSS layout should be finalized without approach Road. 25 kV & 132 kV cables instead of overhead wires can be considered at specific locations by Railways where area of land is very less, in order to expedite the work.

iii) SP & SSP should have interrupters in place of circuit breaker for sectioning and paralleling, as the same arrangement has been working satisfactorily in Bina-Katni section.

iv) The requirement of Auto Transformer protection at TSS/SP/SSP should be critically reviewed and removed if not required.

v) Similarly detailed position of transmission line work involved in this up gradation work to meet power supply requirement in the range of 60-80MVA

should also be made by Zonal Railways. The status should contain the following details:

a) Name of the TSS

b) Existing transmission line status (no. of circuit and no. of phase and size of Conductor).

c) Details of Transmission line enhancement work required/proposed.

d) Requirement of separate bay in grid sub-station.

e) Enhancement of transformer capacity etc. in grid sub-station.

Zonal Railways should send letter to the Power Supply Authorities regarding requirement of enhanced demand of energy.

vi) RDSO and Zonal Railways should give time line for completing following items:

a) OHE & PSI guidelines for Raising of sectional speed to 160kmph on New Delhi-Howrah and New Delhi-Mumbai route within a fortnight.

b) All the detailed drawings like structure, foundation, cable lay-out etc and new specifications should be finalized by 31.12.2020.

c) Final report of checking of OHE structure should be submitted by Zonal Railways as per excel sheet circulated by RDSO.

vii) TI Directorate of RDSO should organize Vendor meet to inform the Vendors regarding development of new PSI items required for this work.

2.0 Other Items :

i) The location of pantographs of Vande Bharat rake has been discussed and it has come out that there are four pantographs installed in the Vande Bharat rake, Out of which PT-1 and PT-4 and PT-2 and PT-3 can be raised at a time during operation of the train. The distance between PT-2 and PT-3 is approximately 80 mtr which causes poor current collection from the rear pantograph at high speed. This situation can be improved by relocating the Pantographs. PS&EMU and TI Directorate should further examine the issue.

ii) Zonal Railways should be consulted before deletion of specification of an item from vendor directory. After the feedback of Zonal Railways proposal for deletion of the specification should be sent to Railway Board.

16/X/2020

(Manish Gupta)
Executive Director (EEM)
Railway Board

File No.RDSO-TI0LKO(PSI)/1/2022-O/o PED/TI/RDSO

सत्यमेव जयते

Government of India,
Ministry of Railways
Research Designs & Standards Organisation,
Manak Nagar, Lucknow– 226 011

Telephone: 2465763 (O).
42805(Off.)
Fax : 91-0522-2465763
E-mail:dti.psi.rdso@gmail.com

Date:25.02.2022.

To,

1. The Principal Chief Electrical Engineer,

(i) Central Railway, Station Building, Mumbai CST – 400 001.
(ii) Eastern Railway, Fairlie Place, Kolkata-700 001.
(iii) East Central Railway, Hajipur-844 101.
(iv) East Coast Railway, Bhubaneshwar-751 023.
(v) Northern Railway, Baroda House, New Delhi - 110 001.
(vi) North Central Railway, Allahabad-211 015.
(vii) North Eastern Railway, Gorakhpur-273 012.
(viii) North Frontier Railway, Mailgaon - 781 011.
(ix) North Western Railway, Jaipur – 302 017.
(x) Southern Railway, Park Town, Chennai- 600 003.
(xi) South Central Railway, Railnilayam, Secunderabad-500 371.
(xii) South Eastern Railway, Garden Reach, Kolkata-700 043.
(xiii) South East Central, Railway, Bilaspur-495 004.
(xiv) South West Railway, DRM's Office, Hubli-580 028.
(xv) Western Railway, Churchgate, Mumbai-400 020.
(xvi) West Central Railway, Jabalpur- 482 001.
(xvii) Konkan Railway, Belapur Bhavan, Sector-11, CBD Belapur, Navi Mumbai 400614.

2. Chief Administrative Officer, CORE Allahanbad-211001

Sub: PSI guideline for increasing speed potential to 160kmph on NDLS-HWH & NDLS-BCT routes.

Ref: (i) Railway Board letter no. 2001/Elect(G)/170/1/Pt-II dated 08.09.2020.
(ii) This office letter no. TI/PSI/TSS/POLICY/19 dated 24.11.2020.

Technical Instruction No. TI/IN/0043 Rev.0 for "PSI guideline for increasing speed potential to 160kmph on NDLS-HWH & NDLS-BCT routes" was issued by this office vide letter under reference (ii) above. This instruction has been revised by this office and revised instruction no. TI/IN/0043 Rev.01 is enclosed herewith for information please.

This is issued with approval of the PED/TI.

Gkatiyar 25/02/22

(Gyan Prakash Katiyar)
Director TI-3
For Director General (TI)

Encl: As stated above.

सत्यमेव जयते

भारत सरकार, रेल मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

PSI GUIDELINE FOR

INCREASING SPEED POTENTIAL TO 160KMPH

ON

INDIAN RAILWAYS

INSTRUCTION No. TI/IN/0043 Rev.01

(This supersedes the Instruction No. TI/IN/0043 Rev.00)

Issued by:

Traction Installation Directorate

RESEARCH DESIGNS & STANDARDS ORGANISATION,

MANAK NAGAR,

LUCKNOW – 226 011

(For official use only)

February, 2022

Subject: PSI Guidelines for Increasing Speed Potential to 160kmph on Indian Railways

Technical Instruction No: TI/IN/0043 Rev.01

	Prepared By				
Signature	Ramesh Kr Pal Digitally signed by Ramesh Kr Pal Date: 2022.02.25 10:41:32 +05'30'	RATAN KUMAR SINGH Digitally signed by RATAN KUMAR SINGH Date: 2022.02.25 10:37:45 +05'30'	Praveen Chandra Yadav Digitally signed by Praveen Chandra Yadav Date: 2022.02.25 10:39:55 +05'30'	PRAMOD SAHU Digitally signed by PRAMOD SAHU Date: 2022.02.25 10:36:32 +05'30'	Gautam Kumar Digitally signed by Gautam Kumar Date: 2022.02.25 10:46:21 +05'30'
Date					
Designation	SSE/PQ	SSE/PR	SSE/TR	SSE/SCADA	JE(D)/TI

	Checked By	Reviewed By	Approved By
Signature	GYAN PRAKASH KATIYAR Digitally signed by GYAN PRAKASH KATIYAR Date: 2022.02.25 10:57:43 +05'30'	BHARDWAJ CHAUDHARY Digitally signed by BHARDWAJ CHAUDHARY Date: 2022.02.25 11:18:13 +05'30'	SUNIL KUMAR Digitally signed by SUNIL KUMAR Date: 2022.02.25 15:49:48 +05'30'
Date			
Designation	Director/TI-3	ED/TI	PED/TI

1.0 Up gradation of existing routes of Indian Railways for 160kmph

1.1 This Guideline shall supersede the Guideline no. TI/IN/0043 Rev.00 Issued on 24.11.2020.

1.2 Railway Board vide letter No. 2001/Elect(G)/170/1 dated 11.11.2019 instructed RDSO to issue the suitable guidelines for the up gradation of existing NDLS-HWH and DLI-KOTA-MUMBAI ROUTES for 160kmph in phased manner. Accordingly, RDSO vide letter no. TI/PSI/TSS/Policy/2019 dated 18.11.2019 and 24.12.2019 proposed certain guideline to Railway Board for approval. Draft PSI Guidelines were circulated to Zonal Railways (via CEDE's & 160kmph DLI-HWH, DLI-MUM Whatsapp Group) on 17.10.2020 for comments. The received observations from Railways were addressed and initial guideline was issued on 24.11.2020.

1.3 At the time of issue of initial guideline, number of specifications and drawings were under preparation and now these have been finalized and issued. In addition to this, the layouts of the TSS, SP and SSP have also been revised based on the various technical deliberations within the RDSO and suggestions received form Zonal Railways. Accordingly, the guideline is being revised and issued for implementation.

2.0 Proposal of Power Supply Installation for the 160kmph on the said routes:

In continuation to the different proposal as discussed in letters mentioned in Para 1.2 above, the proposal of 2X25 kV system is recommended as it is preferred solution across the globe to cater the higher power requirement on high density routes. Therefore, 2X25kV System may be used for these sections. The Traction Sub Station (TSS), Sectioning and paralleling Post (SP) and sub-Sectioning and Paralleling Post (SSP) are to be commissioned for 2X25kV System at location identified by Zonal Railways. A boundary SP i.e. interface post of 1x25 & 2x25 kV system may be considered.

3.0 2X25kV system

3.1 BRIEF DESCRIPTION OF THE 2 X 25 KV SYSTEMS.

In 2x25 kV system, power is fed from the TSS at 50 kV and utilization is achieved at 25 kV by providing Auto-transformers of adequate capacity and by providing one additional conductor normally referred as feeder wire (similar to the return conductor in BT/RC system). Centre point of the Auto Transformer is connected to the earth/Rail. This arrangement facilitates +25 kV Voltage between OHE and rail and -25 kV voltage between earth/Rail and the Feeder Wire.

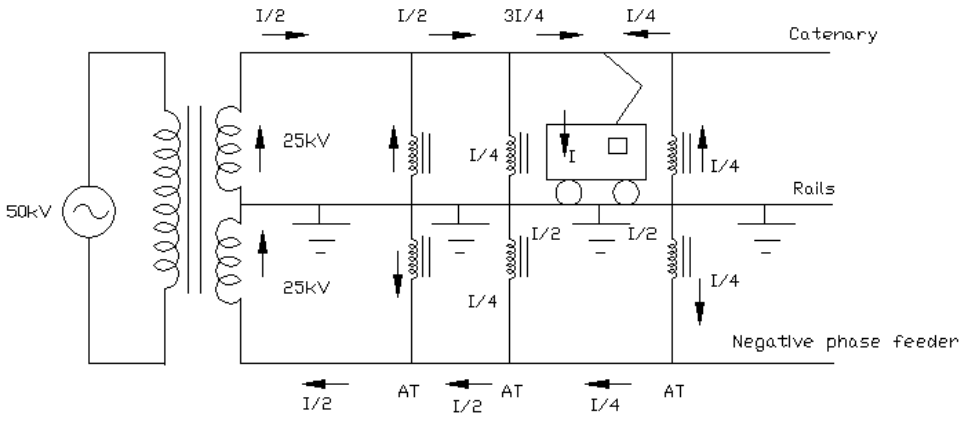


Figure:1

3.2 Advantage of 2X25kV system:-

(a) The 2X25 kV AT feeding system is suitable to meet larger power supply needs with the inherent advantage of less voltage drop in feeder circuit for a given spacing of traction substations. To meet the larger power supply requirements, 2X25kV system is used in various countries including DFCCIL in India.

(b) Power is generally obtained from 220 kV or 132 kV three phase networks from the power utility to reduce voltage unbalance on the transmission network. In the 2X25kV TSS, the three phase supply is utilized at the Traction Sub-station.

(c) The 2X25 kV Auto Transformer (AT) system is having feeding voltage of 50 kV from the substation which is dropped to 25 kV by the AT installed at about 10 to 18 Km spacing along the track for supply to overhead equipment and rolling stocks. A pilot project for this system was provided in Bina-Katni Section. The design of the system was done with the help of Japanese Consultants.

(d) Better voltage regulation even at higher load currents.

(e) Minimized rail currents resulting in reduction in rail potential rise. Return current through ground also reduces considerably.

(f) In 2X25kV system, the return current flows through the feeder wire. Since the direction of current in the feeder wire is opposite to the direction of current in the catenary wire, it minimizes the effect of the electromagnetic Interference in the proximity of the traction line.

(g) Preferred solution across the globe to meet higher power requirement for Traction Purpose.

4.0 Schemes proposed for 2X25kV System along with various Transformers.

4.1 Scott Connected Transformer Scheme:

(a) In this scheme two Scott connected Transformers & four Auto-transformers are to be installed at a TSS along with associated switchgear for Control & protection. The two windings of a Scott transformer i.e. Main and Teaser windings are of equal power rating and feed either side of the TSS independently. The supply of both the windings is at a phase difference of 90 degree and separated by neutral section provided near TSS. Out of two Scott transformers, only one is in operation and the other is on standby.

(b) **Scott Connected Transformer**:

Scott- connected transformer of 60/84/100 MVA (ONAN/ONAF/OFAF) is used to feed power to the traction system. It has a voltage input of 220kV or 132kV, 3 phase, 50 Hz and two independent secondary winding for output at 50 kV. The Transformer has two secondary windings, known as the main winding and teaser winding. The two windings are identical in voltage and current rating but are in phase difference of 90 degree. These two windings of equal power rating i.e. Main & Teaser windings, feed power on either side of the TSS. The feed of different phase is separated by neutral section provided near TSS. The Scott Connected Transformer in ONAN Mode shall feed the 30MVA Power to each side of the TSS.

(c) **Auto Transformers:**

Auto- transformers are used at TSS, SP and SSP. The transformer winding of 50kV with Centre tapped neutral with both the terminals of the Autotransformer winding connected to feeder and contact /Catenary wire. The neutral terminal of the ATs is connected to rail.

Two adjacent ATs feeding on the network share train loads on the section between them and transfer the load current on 25 kV circuit to 50 kV circuit, consisting of contact wire and AT feeder. This reduces the voltage drop on feeding network remarkably. Furthermore, it minimizes the return current on the rail, which results in reducing induced voltage on nearby telecommunication lines.

In the Scott connected arrangement for 2 Line section, 12.3 MVA Auto transformers are to be installed at the TSS and 8MVA Auto transformers to be used at the SP & SSP, as adopted by DFCCIL in Western Corridor. Further, the Scott connected arrangement for 3 Line and 4 line sections have been provided with 12.3 MVA auto transformers at TSS and 16.5 MVA auto transformers at SP/SSP. Moreover, no independent AT post has been proposed in any scheme.

4.2 V Connected Transformer Scheme:

(a) In this scheme, three single phase transformers are connected to different pairs of three phase of incoming supply forming an open delta connection on the primary side. Out of the three single

phase transformers, first transformer feeds the OHE on one side of the TSS, second transformer (mid one) remains as standby and third transformer feeds the OHE on the other side of the TSS. The power supply on either side of TSS is at a phase difference of 120 degree and therefore separated by a neutral section provided near TSS.

(b) **V- Connected Transformer**:

In the above arrangement, three 38/53/63 MVA (ONAN/ONAF/OFAF) Transformers are provided at TSS along with associated switchgear for Control and Protection. Each single phase transformer has a voltage input of 220kV or 132kV, 50 Hz and two independent secondary windings, to be connected externally in such a manner (two inner terminals of these secondary windings are connected with each other and also connected to earth/Rail) so as to give an output voltage of 2X25kV. The outer terminals of the windings are connected to Feeder wire and overhead contact/catenary wire respectively. Two transformers shall be in operation at a time and one shall be on standby. In the V connected Scheme, each transformer in ONAN mode shall feed the 38MVA Power in either side of the TSS.

(c) **Auto Transformers:**

i. Auto- transformers are used at SP and SSP. The transformer winding is 50 kV with Centre tapped neutral with both the terminals of the winding connected to AT feeder and the contact wire. The neutral terminals of the ATs are connected to rail.
ii. Two adjacent ATs feeding on the network share train loads on the section between them and transfer the load current on 25 kV circuit to 50 kV circuit, consisting of contact & catenary wire and AT feeder. This reduces the voltage drop on the feeding network remarkably. Furthermore, it minimizes the return current on the rail, which results in reducing the induced voltage on nearby telecommunication lines.
iii. Auto transformers are not used at the TSS. However, these have been provided at SP/SSP of 16.5 MVA capacities. Moreover, no independent AT post has been proposed.

4.3 Scott connected vs V Connected Scheme

i. Considering the three phase utilization equally in the Scott Connected scheme, it is better in reducing the unbalancing at point of common coupling with the utility as compared to V-Connected scheme. The point of common coupling is already defined in the clause no. 2.2 of RDSO Instruction no. TI/IN/0019 (09/09).
ii. The Voltage Unbalance in Scott Connected Transformer Scheme is least and therefore the Railways should preferably provide Scott Connected Transformer wherever the voltage unbalance problem is seen. The detailed study regarding this is available in clause no. 2.1.13 of Chapter 1, Part-II in Volume-1 of Treatise on Electric Traction Distribution, which can be readily referred (page no. 125 of Volume-1).The problem of unbalancing has been raised by few power utilities and therefore Scott or V connected arrangement should be chosen judiciously after coordinating with the power utilities.
iii. Scott Connected Transformer is more complex and costlier than the V connected Transformer but Scott connected Transformer effectively checks the voltage unbalance.
iv. Initially, in Bina-Katni Section of IR, the Scott Connected Transformers were imported; however, Transformers for V connected scheme were supplied by an Indian Manufacturer.
v. The maintenance/Overhauling of the Scott Connected Transformer is more complex in comparison to Single Phase Transformer. V connected scheme is economical in comparison to Scott Connected scheme.
vi. Since, no AT is to be used at the TSS of V connected scheme; it is simpler than Scott Connected scheme.

4.4 Utilisation of Scheme:

Considering the complexities involved of the unbalancing (as deliberated under Para 4.3 above), space constraints and other site problems, the Scott connected or V connected arrangement may be chosen by the Zonal Railways after coordinating with the power utilities and with the approval of PCEEs.

5.0 Spacing of the TSS & Switching post (SP/SSP):

5.1 Two-line section – Considering the load requirement of 0.5MVA/TKM in ONAN mode on the main line section, the spacing of TSS in Scott connected scheme of 60-70 Km is suggested. In the proposed V connected scheme, the transmission of full power from the transformer is not at 50 kV and therefore the spacing of the TSS in V connected scheme for 2 Line system has been kept same as in Scott connected scheme i.e. 60-70 KM with power requirement of around 0.6MVA/TKM in ONAN mode.

5.2 Three line sections – In the 3 Line section, the loading in MVA/TKM basis will be less than the 2 line system as all the three lines will not be fully loaded at a time. Therefore, the load requirement of around 0.4 MVA/TKM in ONAN Mode for 3 Line section has been considered and accordingly the spacing of TSS in Scott connected scheme is suggested as 50-60 KM. In the proposed V connected scheme for 3 line, the transmission of full power from the transformer is not at 50 kV and therefore the spacing of the TSS in V connected scheme for 3 Line system has been kept same as in Scott connected scheme i.e. 50-60 KM with power requirement of around 0.5 MVA/TKM in ONAN mode.

5.3 Four line section– In the 4 Line section, the loading in MVA/TKM basis will be less than the 3 line system as all the four lines will not be fully loaded at a time. Therefore, the load requirement of less than 0.4 MVA/TKM in ONAN Mode for 4 Line section has been considered and accordingly the spacing of TSS in Scott connected scheme is suggested as 40-50 KM. In the proposed V connected scheme for 4 line, the transmission of full power from the transformer is not at 50 kV and therefore the spacing of the TSS in V connected scheme for 4 Line system has been kept same as in Scott connected scheme i.e. 40-50 KM with a power requirement of around 0.5 MVA/TKM in ONAN mode.

5.4 The sectioning and paralleling post (SP) is to be constructed at approx. midway between consecutive TSS and SSP may be constructed at approx. midway between TSS & SP.

5.5 The transformer is provided with ONAF/OFAF mode to meet the power requirement under feed extension condition and to account for the margin of 10 KM given in the spacing.

5.6 Wherever the Traction Sub Station feeds a mix of 2 line- 3 line sections, 3 line-4 line sections etc., the spacing and location selection of the Traction Sub Station may be decided by considering the above power requirement in ONAN mode on TKM basis as per the scheme adopted. In such cases, the power requirement on each side of Traction Sub Station may be done separately and accordingly the TSS and SP to be located in terms of spacing. The SSP may be provided at approximately mid of TSS and SP.

6.0 Operational Philosophy

6.1 The spacing of the Traction Sub Station has been proposed in the above Para considering the ONAN ratings of the Traction Power transformers and considering the load requirement of normal operation.

6.2 In the case of feed extension from a particular Traction Sub Station due to failure of the adjacent Traction Sub Station, the Transformer of the healthy TSSs may be utilized on the ONAF/OFAF mode and it will be possible to take the full load of the failed Traction Sub Station.

6.3 In Scott connected scheme, there are two double pole feeder circuit breakers for either side of the Traction Sub Station. One Circuit Breaker feeds the OHE with/without interrupters and another is kept redundant for each side of the Traction Sub Station.

6.4 In V connected scheme, the secondary voltages of the traction transformers are out of phase by 120^{O} from each other and therefore it is required to understand the operation. The standby transformer provided in the middle can feed in either direction through the motorized coupling isolator provided on the bus, in case of failure of any of the outer transformer. Also, there are two double pole feeder circuit breakers for either side of the Traction Sub Station. One Circuit Breaker feeds the OHE with/without interrupters and another is kept redundant for each side of the Traction Sub Station.

6.5 SP and SSP for 2 Line systems have been proposed separately for Scott connected arrangement and V connected arrangement. The SP/SSP for 2 Line V connected arrangement is of common Bus type. The SP/SSP for 3 lines and 4 Lines section have been proposed of common bus type and may be used with both kind of feeding arrangement i.e. Scott connected or V connected arrangement.

6.6 In Common Bus type of SP & SSP, the fault on common Bus may hamper the train operation. Therefore, the Bypass Motorised Isolator (for off-load sectioning or off-load feed extension) has been provided to continue the train operation even in fault at common Bus. Further, the common Bus type SP/SSP may be used as a boundary post for interfacing 2Line/3Line/4Line sections of 2X25 kV sections with each other.

6.7 Interlocking

a. Scott Connected TSS

- The Closing of the LVCB on the secondary side of Traction Transformer (i.e. 50kV, SF_6CB) shall be possible only when any one of the Circuit Breaker of associated Autotransformer at TSS is in closed condition.
- The automatic opening of the LVCB on the secondary side of Traction Transformer (i.e. 50kV, SF_6CB) shall happen as soon as all the Circuit Breakers of the associated Autotransformers at the Traction Sub Station are opened.
- The closing of coupling motorised isolator between Main Bus and Teaser Bus should be possible only when all the LVCBs of the Transformer are open. This coupling isolator has been provided for the feed extension in case of failure of TSS.
- To ensure above, necessary interlock shall be provided.

b. V Connected TSS

In this scheme the middle Traction transformer is to be used in either direction in case of failure of any one of the outer transformer. Therefore necessary interlock is to be provided between Motorised Coupling Isolator and LV Circuit Breaker in order to avoid wrong phase coupling as well as to ensure off load operation of the Motorised isolator.

6.8 There is off load circuit tap changer on primary side of the transformer with 6 tap positions (including principal tap) for voltage adjustment. Therefore, the tap changer should be operated only when both the primary and secondary circuit breakers are in open condition.

7.0 Three Phase connectivity to TSS:-

Railways to work out for new 3 phase, transmission line or extending/upgrading the existing transmission line on 3 phase to new location for connecting different TSS on these routes considering

the economics of building this transmission line. In case the new Line is constructed, the line should support the capacity of transformer and adequate redundancy. To meet the power requirement with adequate redundancy, the provision of double circuit Transmission line may be considered. As per the CEA notification, dated 20.08.2010 Chapter IV, Part-A, Para 41 (3), table 7, In case of 66kV Voltage Level, The transformation capacity of any single sub-station for meeting loads shall not normally exceed 75MVA. In view of this limitation, if 66kV incoming supply is there, only ONAN Mode Transformer i.e. 60MVA Scott Connected or 38X2= 76MVA, V connected can be used. To address the huge power requirement for future load, it is suggested to not to take feed from the utility at 66 kV. Therefore, it is suggested to use 220kV or 132kV incoming Voltage only.

8.0 Layout of the TSS, SP & SSP

8.1 Details of the layouts of the Traction Sub Station

8.1.1 Traction Sub Station Layouts with Scott Connected Transformers

SN	Description	Drawing No.	Required area *(Depth x Width)
1.	Typical layout of 132/2X25kV Traction Sub Station with Scott Connected Transformers (For Double Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00009/20/1 Mod C	(46 X 120.5)
2.	Typical layout of 132/2X25kV Traction Sub Station with Scott Connected Transformers (For Double Line section) with perpendicular to track.	TI/DRG/PSI/AT/RDSO/ 00010/20/1 Mod C	(103X48.75)
3.	Typical layout of 132/2X25kV Traction Sub Station with Scott Connected Transformers (For Three Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00030/20/1 Mod B	(50X122)
4.	Typical layout of 132/2X25kV Traction Sub Station with Scott Connected Transformers (For Three Line section) with perpendicular to track.	TI/DRG/PSI/AT/RDSO/ 00031/20/1 Mod B	(105.5X50)
5.	Typical layout of 132/2X25kV Traction Sub Station with Scott Connected Transformers (For Four Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00032/20/1 Mod B	(50X130)
6.	Typical layout of 132/2X25kV Traction Sub Station with Scott Connected Transformers (For Four Line section) with perpendicular to track.	TI/DRG/PSI/AT/RDSO/ 00033/20/1 Mod B	(106.5X50)
7.	Typical layout of 220/2X25kV Traction Sub Station with Scott Connected Transformers (For Double Line section) with parallel to track	TI/DRG/PSI/AT/RDSO/ 00024/20/1Mod C	(46.25X131.5)
8.	Typical layout of 220/2X25kV Traction Sub Station with Scott Connected Transformers (For Double Line section) with perpendicular to track	TI/DRG/PSI/AT/RDSO/ 00025/20/1Mod C	(114X48.75)
9.	Typical layout of 220/2X25kV Traction Sub Station with Scott Connected Transformers (For Three Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00038/20/1Mod B	(47.55 X 134.5)
10.	Typical layout of 220/2X25kV Traction Sub Station with Scott Connected Transformers (For Three Line section) with perpendicular to track	TI/DRG/PSI/AT/RDSO/ 00039/20/1 Mod B	(117.5 X 48.5)
11.	Typical layout of 220/2X25kV Traction Sub Station with Scott Connected Transformers (For Four Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00040/20/1 Mod B	(47.579 X142)

12.	Typical layout of 220/2X25kV Traction Sub Station with Scott Connected Transformers (For Four Line section) with perpendicular to track	TI/DRG/PSI/AT/RDSO/ 00041/20/1 Mod B	(117.5X48.5)

*** (Depth:** Dimension perpendicular to track in meter, **width**: Dimension parallel to track in meter)

8.1.2 Traction Sub Station Layouts with V Connected Transformers

SN	Description	Drawing No.	Required area *(Depth x Width)
1.	Typical layout of 132/2X25kV Traction Sub Station with V-Connected Transformers (For Double Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00034/20/1 Mod B	(50X106)
2.	Typical layout of 132/2X25kV Traction Sub Station with V-Connected Transformers (For Double Line section) with perpendicular to track.	TI/DRG/PSI/AT/RDSO/ 00035/20/1 Mod B	(94X50)
3.	Typical layout of 132/2X25kV Traction Sub Station with V-Connected Transformers (For Three Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00011/20/1 Mod B	(50X114.75)
4.	Typical layout of 132/2X25kV Traction Sub Station with V-Connected Transformers (For Three Line section) with perpendicular to track.	TI/DRG/PSI/AT/RDSO/ 00012/20/1 Mod B	(94.5X50)
5.	Typical layout of 132/2X25kV Traction Sub Station with V-Connected Transformers (For Four Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00013/20/1 Mod B	(50X129)
6.	Typical layout of 132/2X25kV Traction Sub Station with V-Connected Transformers (For Four Line section) with perpendicular to track.	TI/DRG/PSI/AT/RDSO/ 00014/20/1 Mod B	(94.5X52.5)
7.	Typical layout of 220/2X25kV Traction Sub Station with V-Connected Transformers (For Double Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00042/20/1 Mod B	(54.5 x 122) OR (50X122)**
8.	Typical layout of 220/2X25kV Traction Sub Station with V-Connected Transformers (For Double Line section) with perpendicular to track.	TI/DRG/PSI/AT/RDSO/ 00043/20/1 Mod B	(110 x 54.5)
9.	Typical layout of 220/2X25kV Traction Sub Station with V-Connected Transformers (For Three Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00026/20/1 Mod B	(54.5x130.75) OR (50X130.75)**
10.	Typical layout of 220/2X25kV Traction Sub Station with V-Connected Transformers (For Three Line section) with perpendicular to track.	TI/DRG/PSI/AT/RDSO/ 00027/20/1 Mod B	(110 x 54.5)
11.	Typical layout of 220/2X25kV Traction Sub Station with V-Connected Transformers (For Four Line section) with parallel to track.	TI/DRG/PSI/AT/RDSO/ 00028/20/1 Mod B	(54.5 x 145) OR (50X145)**
12.	Typical layout of 220/2X25kV Traction Sub Station with V-Connected Transformers (For Four Line section) with perpendicular to track.	TI/DRG/PSI/AT/RDSO/ 00029/20/1 Mod B	(110X55.5)

*** (Depth:** Dimension perpendicular to track in meter, **width**: Dimension parallel to track in meter)

**Road is not planned initially and Control room to be shifted at the space available towards 25kV Bay.

8.2 Details of the layouts of the SP & SSP

SN	Description	Drawing No.	Required area *(Depth x Width)
1.	General arrangement of Sub Sectioning and Paralleling Post (SSP) in 2X25kV 'AT' System (on double line section) for Scott Connected Transformer TSS	TI/DRG/PSI/AT/RDSO/ 00015/20/01 Mod A	(25X50) or (23.5X50)**
2.	General arrangement of Sectioning and Paralleling Post (SP) in 2X25kV 'AT' System (on double line section) for Scott Connected Transformer TSS	TI/DRG/PSI/AT/RDSO/ 00016/20/01 Mod A	(23.5X50)
3.	General arrangement of Sub Sectioning and Paralleling Post (SSP) in 2X25kV 'AT' System (on double line section) for V- Connected Transformer TSS	TI/DRG/PSI/AT/RDSO/ 00036/20/01 Mod A	(25X50) or (23.5X50)**
4.	General arrangement of Sectioning and Paralleling Post (SP) in 2X25kV 'AT' System (on double line section) for V- Connected Transformer TSS	TI/DRG/PSI/AT/RDSO/ 00037/20/01 Mod A	(25X50) or (23.5X50)**
5.	General arrangement of Sub Sectioning and Paralleling Post (SSP) in 2X25kV 'AT' System (on three line section).	TI/DRG/PSI/AT/RDSO/ 00017/20/01 Mod A	(25X50) or (23.5X50)**
6.	General arrangement of Sectioning and Paralleling Post (SP) in 2X25kV 'AT' System (on three line section).	TI/DRG/PSI/AT/RDSO/ 00018/20/01 Mod A	(25X50) or (23.5X50)**
7.	General arrangement of Sub Sectioning and Paralleling Post (SSP) in 2X25kV 'AT' System (on four line section).	TI/DRG/PSI/AT/RDSO/ 00019/20/01 Mod A	(25X50) or (23.5X50)**
8.	General arrangement of Sectioning and Paralleling Post (SP) in 2X25kV 'AT' System (on four line section).	TI/DRG/PSI/AT/RDSO/ 00020/20/01 Mod A	(25X50) or (23.5X50)**
9.	General arrangement of Boundary Sectioning and Paralleling Post (SP) in 2X25kV 'AT' System for Scott Connected Transformer TSS (on double line section)	TI/DRG/PSI/AT/RDSO/ 00021/20/01 Mod A	(23X50)
10.	General arrangement of Boundary Sectioning & paralleling post (SP) in 2 x 25 kV 'AT' system (on 3 line section)	TI/DRG/PSI/AT/RDSO/ 00022/20/01 Mod A	(25X50) or (23.5X50)**
11.	General arrangement of Boundary Sectioning & paralleling post (SP) in 2 x 25 kV 'AT' system (on 4 line section)	TI/DRG/PSI/AT/RDSO/ 00023/20/01 Mod A	(25X50) or (23.5X50)**
12.	General arrangement of Boundary Sectioning & Paralleling post (SP) in 2 x 25 kV "V-connected" 'AT' system (on Double line section)	TI/DRG/PSI/AT/RDSO/ 00050/21/01 Mod A	(25X50) or (23.5X50)**

***(Depth:** Dimension perpendicular to track in meter, **width**: Dimension parallel to track in meter)
**Reduced size where gantry is on boundary.

Note:

1. The layout of the TSS, SP & SSP detailed in above Para has been prepared by utilizing minimum possible area. Thus, if the required space is not available, use of the underground cables on the HV & LV side may be considered keeping in view the economy of design. The location of the control room, road in TSS etc. can be changed by the Zonal Railways based on their experience and availability of space. Wherever, the acute shortage of land is faced, the Road may not be provided

initially for access but at the same time the process of land acquisition may be started and the layout to be finalized accordingly.

2. The guideline for the provision of ABT based meter has already been issued by this office vide letter no. TI/PSI/TSS/POLICY/17 dated13.10.2017 (Annexure-1) and letter no. TI/PSI/TSS/POLICY/18/02 dated 26.07.2018 (Annexure-2).

8.3 Other Miscellaneous drawings

SN	Description	Drawing No.
1.	Typical schematic diagram of protection for 132/2x25kV Traction sub-station with Scott-connected transformers	TI/DRG/PSI/AT/RDSO/ 00051/21/0 Mod A
2.	Typical schematic diagram of protection for 220/2x25kV Traction sub-station with V-connected transformers	TI/DRG/PSI/AT/RDSO/ 00044/21/0
3.	General scheme of supply for 2x25 kV, 50 Hz Scott connected traction transformer traction system	TI/DRG/PSI/SLD/RDSO/ 00045/21/0
4.	General scheme of supply for 2x25 kV, 50 Hz V- connected traction transformer traction system	TI/DRG/PSI/SLD/RDSO/ 00046/21/0
5.	Typical layout of cable trench, foundation & cable schedule of 132/2x25 kV Traction Sub - Station with Scott connected transformers (for four line section) with parallel to track	TI/DRG/PSI/TRCSFD/RDSO/ 00047/21/0
6.	Typical layout of cable trench, foundation & cable schedule of 132/2x25 kV Traction Sub - Station with V connected transformers (for four line section) with perpendicular to track	TI/DRG/PSI/TRCSFD/RDSO/ 00048/21/0
7.	Typical layout of cable trench, foundation & cable schedule of Switching Station in 2X25kV 'AT' System (for four line section)	TI/DRG/PSI/AT/RDSO/ 00049/21/0
8.	Typical layout of cable trench, foundation & cable schedule of Sectioning and Paralleling Post (SP) in 2x25 kV AT System on Double line for Scott Connected Transformer TSS.	TI/DRG/PSI/AT/RDSO/ 00052/21/0
9.	Typical layout of Control room Building in 2X25kV Traction Sub-Station.	TI/DRG/PSI/CR2X25/RDSO/ 0210
10.	Typical layout of Control room Building in 2X25kV SP/SSP/AT Post.	TI/DRG/PSI/CR2X25/ SPSSPATP/0210
11.	Tee Connector to suit "BERSISMIS" 'AAAC' and "BERSISMIS" 'AAAC' in 2X25 kV system.	TI/DRG/PSI/CONECT/RDSO/ 00053/21/0
12.	Tee Connector to suit BULL 'AAC' conductor and BULL 'AAC' conductor in 2X25 kV system	TI/DRG/PSI/CONECT/RDSO/ 00054/21/0
13.	Rigid connector on S.I. to suit BERSISMIS (36mm Dia.) "AAAC" conductor in 2X25 kV system.	TI/DRG/PSI/CONECT/RDSO/ 00055/21/0
14.	Rigid connector on S.I. to suit BULL (38.25mm Dia.) "AAC" conductor in 2X25 kV system.	TI/DRG/PSI/CONECT/RDSO/ 00056/21/0
15.	Flexible connector to suit 50MM O/D Al. Tube Bus bar for Double Pole circuit breaker and LV side of Traction transformer in 2X25kV system.	TI/DRG/PSI/CONECT/RDSO/ 00057/21/0
16.	Rigid through connector to suit BERSIMIS (36mm Dia) "AAAC" Conductor and SPIDER "AAC" conductor for 25 kV PT type II. (T-Type)	TI/DRG/PSI/CONECT/RDSO/ 00058/21/0
17.	Rigid through connector to suit BULL (38.25mm Dia) "AAC" Conductor and SPIDER "AAC" conductor for 25 kV PT type II (T-	TI/DRG/PSI/CONECT/RDSO/ 00059/21/0

	Type)	
18.	Tee Connector to suit 50 O/D Al. Tube and "BERSISMIS" 'AAAC' conductor in 2X25 kV system.	TI/DRG/PSI/CONECT/RDSO/ 00060/21/0
19.	Tee Connector to suit 50 O/D Al. Tube and BULL 'AAC' conductor in 2X25 kV system.	TI/DRG/PSI/CONECT/RDSO/ 00061/21/0
20.	Typical Termination arrangement for strung bus "BERSISMIS" (AAAC) conductor in 2X25 kV system.	TI/DRG/PSI/CONECT/RDSO/ 00062/21/0
21.	Typical Termination arrangement for strung bus "BULL" (AAC) conductor in 2X25 kV system.	TI/DRG/PSI/CONECT/RDSO/ 00063/21/0
22.	Flexible connector to suit BULL (38.25mm Dia.) "AAC" Conductor for Double Pole circuit breaker and LV Side of traction transformer in 2X25kV System.	TI/DRG/PSI/CONECT/RDSO/ 00064/21/0
23.	Bimetallic terminal Connector to suit ZEBRA (28.58mm Dia.) ACSR conductor & AL/CU Pad of isolator/CT/CB or 50mm O/D Al tube and AL/CU Pad of isolator/CT/CB.	ETI/PSI/P/11030 Mod. D

9.0 Power Factor Improvement

9.1 Railway Board vide letter no. 2008/RE/170/1 dated 12.06.2012 (Annexure-3) has already communicated that "it has been decided that Railways/CORE/MRVC/RVNL etc. should provide only fixed type capacitor bank in all new & existing 25kV & 2X25kV TSSs for the time." Thus, it is proposed to provide only conventional fixed type Capacitor Bank & Reactors in the 2X25kV TSSs.

9.2 There are routes where modern locomotives and train sets having unity power factor are in operation and therefore the extent of compensation of Reactive Power as proposed in the initial guideline and in the initial issued layouts may not be required at certain locations. Further, there may be locations where the compensation at TSS is not being done at all. Therefore, the connection of shunt Capacitor bank in the layouts may be treated as indicative only. Hence, the capacity of the shunt capacitor has to be selected judiciously considering the existing load and Power Factor conditions.

9.3 In Scott Connected Scheme, initially the insulation class of equipment's on Main and Teaser Bus was considered as 72.5kV. After the introduction of interlocking (para 6.7 above) the insulation class of 52kV has been considered. Accordingly, the 52kV Insulation class conventional fixed type Capacitor Bank & Reactors which are provided in 25kV Traction system, are to be provided (if required) in both of the schemes as detailed below:

(a) If there is no requirement of compensation equipment, it is not required to be provided.

(b) If reactive power compensation of 2400kVAR at 25kV is required on both sides of the Traction Sub Station, then capacitor bank along with series reactor and associated equipment will be connected by using Single Pole Circuit Breaker and Isolators in the following manner

- In TSS of V Connected scheme, the capacitor bank along with associated equipment is to be connected on each side of the TSS on Traction Bus.
- In TSS of Scott Connected scheme, one capacitor bank along with associated equipment is to be connected on Traction Bus of Main winding and another is to be connected on Traction Bus of Teaser winding.

(c) If reactive power compensation of 4800kVAR at 25kV is required on both sides of the Traction Sub Station, then in addition to (b) above, another capacitor bank along with series reactor and associated equipment of 2400kVAR at 25kV is to be provided on the Feeder Bus also by using DPCB and isolators as indicated in Layouts.

Remark: For connection arrangements, layouts of the Traction Sub Station to be referred.

10.0 Protection

Technical Specification No. TI/SPC/PSI/PROTCT/7101 or latest for Control and Relay Panel Including Numerical type protection relays for Scott-connected Traction Power Transformers/V-Connected Traction Power Transformers, OHE protection, 55KV AT Protection and Shunt Capacitor Bank Protection for 2X25 kV Traction Sub-Station, Sectioning and Paralleling Post, Sub-Sectioning and Paralleling Post shall be referred.

10.1 Scott Connected TSS (02 Line/03Line/04Line): The details of the required relays for protection in scheme of 2x 60/84/100 MVA for supplying C&R panel for Scott connected transformers of 2x25 kV AT System are as below:

SN	Item	2 Line	3 Line	4 Line
1.	Control & Relay Panel, Incorporating Numerical Type Protective Relays given as under for TSS and Capacitor Bank	As per design of supplier		
2.	Numerical 3OC+EF protection Relay	02	02	02
3.	Numerical Differential Protection Relay	As required for 2 TRFR		
4.	Numerical 2OC+EF Relay	04	04	04
5.	Numerical Feeder Protection Relay	04	04	04
6.	Numerical Delta I Relay + Under Voltage Protection Relay to prevent closing of feeder CB under extended feed condition	04	04	04
7.	Numerical DC& AC Monitoring Relay	As per design of supplier		
8.	Inter-tripping Relay	02	02	02
9.	Master tripping Relay	08	08	08
10.	Voltage operated Auxiliary Tripping Relays	As per design of supplier		
11.	Numerical OC+ Current Unbalance Relay	02	02	02
12.	Numerical Under Voltage & Voltage Unbalance Protection Relay	02	02	02
13.	Master tripping Relay	02	02	02
14.	Numerical AT Differential Protection Relay	04	04	04
15.	Master tripping Relay	04	04	04
16.	Voltage operated Auxiliary Tripping Relays for 4 no. AT	As per design of supplier		

10.2 V-Connected TSS (02 Line/03Line/04Line): The details of the required relays for protection in scheme of 3x 38/53/63 MVA V Connected Transformers 2x25 kV AT System are as below:

SN	Items	2 Line	3 Line	4 Line
1.	Control & Relay Panel, Incorporating Numerical Type Protective Relays given as under for TSS and capacitor Bank	As per design of supplier		
2.	Numerical 3OC+EF protection Relay	03	03	03
3.	Numerical Differential Protection Relay	03	03	03
4.	Numerical 2OC+EF Relay	03	03	03
5.	Numerical Phase Failure Protection Relay	03	03	03
6.	Numerical Feeder Protection Relay	04	04	04
7.	Numerical Delta I Relay+ Under Voltage Protection Relay to prevent closing of feeder CB under extended feed condition	04	04	04
8.	Numerical DC& AC Monitoring Relay	As per design of supplier		
9.	Inter tripping Relay	03	03	03
10.	Master tripping Relay	07	07	07
11.	Voltage operated Auxiliary Tripping Relays	As per design of supplier		
12.	Numerical OC+ Current Unbalance Relay	02	02	02
13.	Numerical Under Voltage & Voltage Unbalance Protection Relay	02	02	02
14.	Master tripping Relay	02	02	02

10.3 The details of the required relays for protection at SP and SSP in scheme of Scott Connected for 02 line:

SN	**Item**	**SP**	**SSP**
1.	Control & Relay Panel, Incorporating Numerical Type Protective Relays for SP & SSP	As per design of supplier	
2.	Numerical AT Differential Protection Relay	04	02
3.	Master tripping Relay	04	02
4.	Voltage operated Auxiliary relay	As per design of supplier	

10.4 The details of the required relays for protection at SP and SSP in scheme of V Connected for 02 line:

SN	Item	SP	SSP
1.	Control & Relay Panel, Incorporating Numerical Type Protective Relays for SP & SSP	As per design of supplier	
2.	Numerical AT Differential Protection Relay	03	02
3.	Master tripping Relay	03	02
4.	Voltage operated Auxiliary relay	As per design of supplier	

10.5 In 3 Line and 4 Line section, same SP and SSP are proposed in both schemes, therefore, the required relays for protection at SP and SSP as detailed under are same in both scheme.

SN	Item	03 Line		04 Line	
		SP	SSP	SP	SSP
1.	Control & Relay Panel, Incorporating Numerical Type Protective Relays for SP & SSP	As per design of supplier			
2.	Numerical AT Differential Protection Relay	03	02	03	02
3.	Master tripping Relay	03	02	03	02
4.	Voltage operated Auxiliary relay	As per design of supplier			

10.6 Boundary (i.e. Interface post of 1X25kV & 2X25kV System) SP for 2 Line/3Line/4Line (for both Scott & V connected scheme)

SN	Item	**Panel**
1.	Control & Relay Panel, Incorporating Numerical Type Protective Relays for SP	01
2.	Numerical AT Differential Protection Relay	02
3.	Master tripping Relay	02
4.	Voltage operated Auxiliary relay	As per design of supplier

(i) Instrument transformer shall be provided as per the relevent specification applicable for the relays.

(ii) The above relays modules are indicative only, some of the above protection function may be clubbed or may be additionally required as per layout.

10.7 Protection for AT to be provided at TSS, SP & SSP

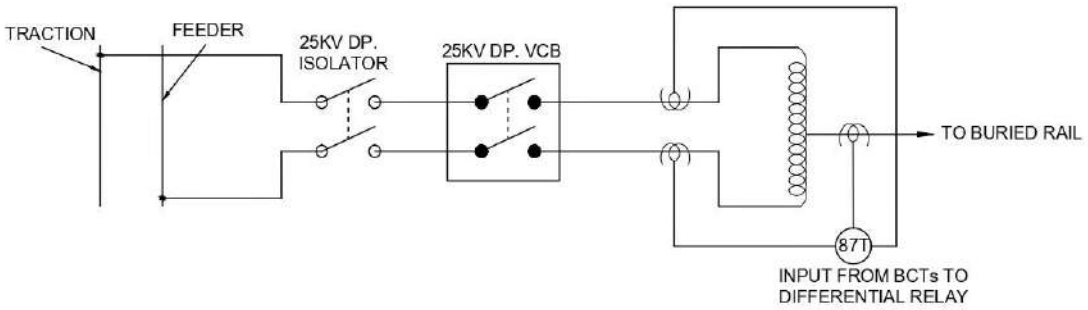


Figure: 2

Protection for Auto Transformer: Auto transformers are to be installed with bushing current transformers, 2X25kV DPCB & isolator as shown in figure 2 above, in order to protect and isolate autotransformer.

(a) Differential Relay (87T): Auto Transformer is protected for its inter-turn short circuits and internal earth faults by means of current differential relay by sensing current from both Line's CTs and comparing it with its neutral CT current.

(b) Other Protective Devices: The Auto transformers as supplied by the purchaser shall be fitted with the following additional protective devices, for which 4 Nos. Voltage operated Aux. Tripping Relays shall also to be provided.

i. Buchholz relay with alarm and trip contacts.
ii. Oil temperature indicator with alarm and trip contacts.
iii. Winding temperature indicator with alarm and trip contacts.
iv. Pressure relief device trip contact.
v. Low oil level alarm contacts.

11.0 SCADA System:

(a) Technical Specification No. TI/SPC/RCC/SCADA/0133 or latest for Supervisory Control and Data Acquisition (SCADA) system may be referred.

(b) As per revised SCADA specification no. TI/SPC/RCC/SCADA/0133, the single set of SCADA server can cater 100 numbers of RTUs. The RTU shall communicate with numerical relays on IEC 61850 protocols. New SCADA system as per RDSO specification no. TI/SPC/RCC/SCADA/0133 shall be provided for 2x25KV traction system. Further, the section where some TSS/SSP/SP are at 2x25 traction and some are on 25KV traction, the existing RTUs of 25KV traction, if feasible, may be interfaced with SCADA server provided for 2x25KV system, to the extent possible.

12.0 Earthing at TSS/SP/SSP:

(a) Earthing as per the RDSO Specification no. TI/SPC/PSI/ERTHNG/0210 is to be provided. The neutral of the Autotransformers at TSS/SP/SSP should also be connected to Buried Rail as mentioned in the specification.

(b) The fault level on the 2X25kV system is to be taken as 12kA for 3 seconds on the lines of DFCCIL as the MVA ratings of the transformers are higher than conventional. Accordingly, Earthing grid at the switching post (SP/SSP) should be prepared by taking fault current of 12kA with 3 second duration in the calculations given in the specification no. TI/SPC/PSI/ERTHNG/0210. The

switching post (SP/SSP) shall have the provision of buried rail for connection of traction return current. The Neutral of the Autotransformer should be connected to Buried rail.

13.0 The main equipment used in various schemes along with their Specification is detailed as under- (Latest specification should be referred)

13.1 Traction Sub Station with Scott Connected Transformer

SN	Equipment Description	Specification no.	Quantity in No.		
			DL	TL	FL
1.	220kV or 132kV , 1250A Triple Pole Isolator (with earth blade)	TI/SPC/PSI/ISOLTR/0210(06/21)	02	02	02
2.	220kV or 132kV , 1250A Triple Pole Isolator (For Bus Coupling)	TI/SPC/PSI/ISOLTR/0210(06/21)	01	01	01
3.	220kV or 132kV Potential Transformer (accuracy class 0.2) for ABT metering (Indication and Metering)	To be procured as per the specification/sources of DISCOMs/Power utilities	06	06	06
4.	220kV or 132kV Current Transformer (accuracy class 0.2s) for ABT metering (Metering)	To be procured as per the specification/sources of DISCOMs/Power utilities	06	06	06
5.	220kV or 132kV , 1250A Triple Pole Isolator (without earth blade)	TI/SPC/PSI/ISOLTR/0210(06/21)	02	02	02
6.	220kV or 132kV Support Insulator	TI/SPC/OHE/POST/0100 (01/10) with A&C slip no.01.	As reqd	As reqd	As reqd
7.	220kV (400-200/5A) or 132kV (800-400/5) Current transformer (For Transformer Protection)	TI/SPC/PSI/CT/0210(06/21)	06	06	06
8.	220kV or 132kV SF6 Circuit Breaker (Triple Pole)	TI/SPC/PSI/HVCB/0121 (05/21) with A&C slip no. 01	02	02	02
9.	198kV or 120kV Lightening arrester (HV Side)	ETI/PSI/137(08/89) with A&C slip no. 01 to 07	06 or 12	06 or 12	06 or 12
10.	60/84/100MVA, 220/2X25kV or 132/2X25kV Single Phase Traction Power Transformer with Bushing CTs	TI/SPC/PSI/TRNPWR/5200 (02/21) with A&C slip no. 01	02	02	02
11.	60kV Lightening arrester	ETI/PSI/137(08/89) with A&C slip no. 01 to 07.	08	08	08
12.	50kV Current Transformer (1500-750/5)	TI/SPC/PSI/CT/0210(06/21)	08	08	08
13.	50kV Double pole SF6 Breaker (2000A)	TI/SPC/PSI/HVCB/0121(05/21)	04	04	04
14.	50kV Double Pole Manual Isolator	TI/SPC/PSI/ISOLTR/0210(06/21)	04	04	04
15.	50kV Support Insulator or 66kV Support Insulator	TI/SPC/OHE/POST/0100 with A&C slip no. 01	As reqd	As reqd	As reqd
16.	27.5kV/110V Potential Transformer (Type-II) (52kV Insulation Class)	TI/SPC/PSI/PT/0210(06/21)	08	08	08
17.	25kV Double Pole Manual Isolator (2000A)	TI/SPC/PSI/ISOLTR/0210(06/21)	12	24	28
18.	27.5kV/110V Potential Transformer (Type-I) (52kV Insulation Class)	TI/SPC/PSI/ PT/0210(06/21)	----	12	16
19.	12.3MVA Autotransformer (55/27.5kV) with Bushing CTs	TI/SPC/PSI/AUTOTR/1200 (02/21)	04	04	04
20.	25kV Double Pole Vacuum Interrupter	TI/SPC/PSI/LVCBIN/0120(12/13)	02	06	08

		with A&C slip no. 01			
21.	50kVA, 25kV/240Volt LT supply transformer	ETI/PSI/15 (08/03)	02	02	02
22.	25kV Drop Out Fuse	ETI/PSI/14(01/86) with A&C slip no. 01	02	02	02
23.	42kV Lightening Arrester	TI/SPC/PSI/MOGTLA/0101 (02/15)	12	16	16
24.	Shunt capacitor 2400kVAR at 25kV	TI/SPC/PSI/FC&SR/0100 (01/10)	04	04	04
25.	Series Reactor for Low loss	TI/SPC/PSI/FC&SR/0100 (01/10)	04	04	04
26.	25kV Single Pole Manual Isolator	TI/SPC/PSI/ISOLTR/0210 (06/21)	04	04	04
27.	25kV Double Pole Vacuum Circuit Breaker (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	10	10	10
28.	25kV Current Transformer (1500-750/5A)	TI/SPC/PSI/CT/0210(06/21)	08	08	08
29.	25kV Current Transformer (200-100/5A) (For compensation equipment)	TI/SPC/PSI/CT/0210(02/21)	04	04	04
30.	Low Tension Distribution Panel	TI/SPC/PSI/LTDPNL/0210 (10/21)	02	02	02
31.	25kV Support Insulator	TI/SPC/OHE/INS/0070 (04/07) with A&C slip no. 01 & 02	As reqd	As reqd	As reqd
32.	25 kV Double Pole Motorised isolator (2000A)	TI/SPC/PSI/ISOLTR/0210(06/21)	01	01	01

13.2 Traction Sub Station with Transformers in V Connection

SN	Equipment Description	Specification no.	Quantity in no.		
			DL	TL	FL
1.	220kV or 132kV , 1250A Triple Pole Isolator (with earth blade)	TI/SPC/PSI/ISOLTR/0210(06/21)	02	02	02
2.	220kV or 132kV , 1250A Triple Pole Isolator (For Bus Coupling)	TI/SPC/PSI/ISOLTR/0210(06/21)	02	02	02
3.	220kV or 132kV Potential Transformer (accuracy class 0.2) for ABT metering (Indication and Metering)	To be procured as per the specification/sources of DISCOMs/Power utilities	06	06	06
4.	220kV or 132kV Current Transformer (accuracy class 0.2s) for ABT metering (Metering)	To be procured as per the specification/sources of DISCOMs/Power utilities	06	06	06
5.	220kV or 132kV , 1250A Double Pole Isolator (without earth blade)	TI/SPC/PSI/ISOLTR/0210(06/21)	03	03	03
6.	220kV or 132kV Support Insulator	TI/SPC/OHE/POST/0100 (01/10) with A&C slip no.01.	As reqd	As reqd	As reqd
7.	220kV (400-200/5A) or 132kV (800-400/5) Current transformer (For Transformer Protection)	TI/SPC/PSI/CT/0210(06/21)	06	06	06
8.	220kV or 132kV SF6 Circuit Breaker (Double Pole)	TI/SPC/PSI/HVCB/0121(05/21)	03	03	03
9.	198kV or 120kV Lightening arrester (HV Side)	ETI/PSI/137(08/89) with A&C slip no. 01 to 07	06 or 12	06 or 12	06 or 12
10.	38/53/63MVA, 220/2X25kV or 132/2X25kV Single Phase Traction Power Transformer	TI/SPC/PSI/TRNPWR/4200 (02/21)	03	03	03
11.	42kV Lightening arrester	TI/SPC/PSI/MOGTLA/0101 (02/15)	18	22	26

12.	25kV Current Transformer (1500-750/5A) (Including 03 as NCT)	TI/SPC/PSI/CT/0210(02/21)	17	17	17
13.	25kV Current Transformer (200-100/5A) (For compensation equipment)	TI/SPC/PSI/CT/0210(02/21)	04	04	04
14.	25kV Double pole Vacuum Circuit Breaker (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	09	09	09
15.	25kV Double Pole manual Isolator (2000A)	TI/SPC/PSI/ISOLTR/0210	17	25	29
16.	25kV Support Insulator	TI/SPC/OHE/INS/0070 (04/07) with A&C slip no. 01 & 02	As reqd	As reqd	As reqd
17.	50kVA, 25kV/240Volt LT supply transformer	ETI/PSI/15 (08/03)	02	02	02
18.	25kV Drop Out Fuse	ETI/PSI/14(01/86) with A&C slip no. 01	02	02	02
19.	27.5kV/110V Potential Transformer (Type-II) (52kV Insulation Class)	TI/SPC/PSI/PT/0210(06/21)	12	08	08
20.	27.5kV/110V Potential Transformer (Type-I)	TI/SPC/PSI/PT/0210(06/21)	----	12	16
21.	25kV Double Pole Vacuum Interrupter (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	02	06	08
22.	Shunt capacitor (2400kVAR at 25kV)	TI/SPC/PSI/FC&SR/0100 (01/10)	04	04	04
23.	Series Reactor for Low loss	TI/SPC/PSI/FC&SR/0100 (01/10)	04	04	04
24.	25kV Double Pole Motorized Isolators (2000A)	TI/SPC/PSI/ ISOLTR/0210	02	02	02
25.	Low Tension Distribution Panel	TI/SPC/PSI/LTDPNL/0210(10/21)	02	02	02

13.3 Sectioning and Paralleling post (SP) for two line

SN	Equipment Description	Specification no.	Quantity in No.	
			Scott Scheme	V Scheme
1.	8MVA Auto Transformer (55/27.5kV) with Bushing CTs	TI/SPC/PSI/AUTOTR/1200 (02/21)	04	--------
	16.5MVA Auto Transformer (55/27.5kV) with Bushing CTs	TI/SPC/PSI/AUTOTR/1200 (02/21)	---------	03
2.	25 kV Double Pole Vacuum Circuit Breaker (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	04	05
3.	50kV Double Pole SF6 Circuit Breaker (2000A)	TI/SPC/PSI/HVCB/0121 (05/21)with A&C slip no. 01	02	02
4.	25 kV Double Pole Vacuum Interrupter (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	02	04
5.	25 kV Double Pole Isolator (Manual) (2000A)	TI/SPC/PSI/ISOLTR/0210 (02/21)	12	13
6.	25 kV Double Pole Isolator (Motorised) (2000A)	TI/SPC/PSI/ISOLTR/0210 (02/21)	-----	02
7.	25kV Potential Transformer (Type-1)	TI/SPC/PSI/PT/0210 (06/21)	04	04
8.	25kV/240V LT Supply Transformer (10kVA)	ETI/PSI/15 (08/03)	02	02
9.	25kV Dropout Fuse Switch	ETI/PSI/14(01/86) with A&C slip no. 01	02	02
10.	42kV Lightning Arrester	TI/SPC/PSI/MOGTLA/0101 (02/15)	08	08
11.	Low Tension Distribution Panel	TI/SPC/PSI/LTDPNL/0210 (10/21)	02	02
12.	25kV Support Insulator	TI/SPC/OHE/INS/0070 (04/07) with A&C slip no. 01 & 02	As reqd	As reqd

13.4 Sub Sectioning and Paralleling Post (SSP) for Two line

SN	Equipment Description	Specification no.	Quantity in No.	
			Scott Scheme	V Scheme
1.	8MVA Auto Transformer (55/27.5kV) with Bushing CTs	TI/SPC/PSI/AUTOTR/1200 (02/21)	02	--------
	16.5MVA Auto Transformer (55/27.5kV) with Bushing CTs	TI/SPC/PSI/AUTOTR/1200 (02/21)	---------	02
2.	25 kV Double Pole Vacuum Circuit Breaker (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	02	02
3.	25 kV Double Pole Vacuum Interrupter (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	05	04
4.	25 kV Double Pole Isolator (Manual) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	12	10
5.	25 kV Double Pole Isolator (Motorised) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	-----	02
6.	25kV Potential Transformer (Type-I)	TI/SPC/PSI/PT/0210 (06/21)	04	04
7.	25kV/240V LT Supply Transformer(10kVA)	ETI/PSI/15 (08/03)	02	02
8.	25kV Dropout Fuse Switch	ETI/PSI/14(01/86) with A&C slip no. 01	02	02
9.	42kV Lightning Arrester	TI/SPC/PSI/MOGTLA/0101 (02/15)	08	08
10.	Low Tension Distribution Panel	TI/SPC/PSI/LTDPNL/0210 (10/21)	02	02
11.	25kV Support Insulator	TI/SPC/OHE/INS/0070 (04/07) with A&C slip no. 01 & 02	As reqd	As reqd

13.5 Sectioning and Paralleling Post (SP) For three line and Four Line (for both Scott Connected and V connected Scheme)

SN	Equipment Description	Specification no.	Quantity in No.	
			TL	FL
1.	16.5MVA Auto Transformer (55/27.5kV) with Bushing CTs	TI/SPC/PSI/AUTOTR/1200 (02/21)	03	03
2.	25 kV Double Pole Vacuum Circuit Breaker (2000A)	TI/SPC/PSI/LVCBIN/0120 (12/13) with A&C slip no. 01	03	03
3.	50kV Double Pole SF6 Circuit Breaker (2000A)	TI/SPC/PSI/HVCB/0121 with A&C slip no. 01	02	02
4.	25 kV Double Pole Vacuum Interrupter (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	06	08
5.	25 kV Double Pole Isolator (Manual) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	17	21
6.	25 kV Double Pole Isolator (Motorised) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	03	04
7.	25kV Potential Transformer (Type-1)	TI/SPC/PSI/PT/0210 (06/21)	06	08
8.	25kV/240V LT Supply Transformer(10kVA)	ETI/PSI/15 (08/03)	02	02
9.	25kV Dropout Fuse Switch (1A)	ETI/PSI/14(01/86) with A&C slip no. 01	02	02

10.	42kV Lightning Arrester	TI/SPC/PSI/MOGTLA/0101 (02/15)	12	16
11.	Low Tension Distribution Panel	TI/SPC/PSI/LTDPNL/0210 (10/21)	02	02
12.	25kV Support Insulator	TI/SPC/OHE/INS/0070 (04/07) with A&C slip no. 01 & 02	As reqd	As reqd

13.6 Sub Sectioning and Paralleling Post (SSP) For three line and Four Line (for both Scott Connected and V connected Scheme)

SN	Equipment Description	Specification no.	Quantity in No.	
			TL	FL
1.	16.5MVA Auto Transformer (55/27.5kV) with Bushing CTs	TI/SPC/PSI/AUTOTR/1200 (02/21)	02	02
2.	25 kV Double Pole Vacuum Circuit Breaker (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	02	02
3.	25 kV Double Pole Vacuum Interrupter (2000A)	TI/SPC/PSI/LVCBIN/0120(12/13) with A&C slip no. 01	06	08
4.	25 kV Double Pole Isolator (Manual) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	14	18
5.	25 kV Double Pole Isolator (Motorised) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	03	04
6.	25kV Potential Transformer (Type-1)	TI/SPC/PSI/PT/0210 (06/21)	06	08
7.	25kV/240V LT Supply Transformer(10kVA)	ETI/PSI/15 (08/03)	02	02
8.	25kV Dropout Fuse Switch (1A)	ETI/PSI/14(01/86) with A&C slip no. 01	02	02
9.	42kV Lightning Arrester	TI/SPC/PSI/MOGTLA/0101 (02/15)	12	16
10.	Low Tension Distribution Panel	TI/SPC/PSI/LTDPNL/0210 (10/21)	02	02
11.	25kV Support Insulator	TI/SPC/OHE/INS/0070 (04/07) with A&C slip no. 01 & 02	As reqd	As reqd

13.7 Boundary Sectioning and Paralleling Post (SP) for Two line, three Line and Four Line

SN	Equipment Description	Specification no.	DL		TL	FL
			Scott Scheme	V Connected Scheme		
1.	12.3MVA Auto Transformer (55/27.5kV) with Bushing CTs	TI/SPC/PSI/AUTOTR/1200 (02/21)	02	----	-----	----
	16.5MVA Auto Transformer (55/27.5kV) with Bushing CTs	TI/SPC/PSI/AUTOTR/1200 (02/21)	-----	02	02	02
2.	50kV Double Pole SF6 Circuit Breaker (2000A)	TI/SPC/PSI/HVCB/0121 (05/21)with A&C slip no. 01	02	02	02	02
3.	25 kV Double Pole Vacuum Circuit Breaker (2000A)	TI/SPC/PSI/LVCBIN/0120(12 /13) with A&C slip no. 01	02	02	02	02
4.	25 kV Double Pole Vacuum Interrupter (2000A)	TI/SPC/PSI/LVCBIN/0120(12 /13) with A&C slip no. 01	01	02	03	04
5.	25 kV Single Pole Vacuum	TI/SPC/PSI/LVCBIN/0120(12	01	02	03	04

	Interrupter (2000A)	/13) with A&C slip no. 01				
6.	25 kV Double Pole Isolator (Manual) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	08	07	09	12
7.	25 kV Double Pole Isolator (Motorised) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	-----	----	03	04
8.	25 kV Single Pole Isolator (Manual) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	02	05	07	08
9.	25 kV Single Pole Isolator (Motorised) (2000A)	TI/SPC/PSI/ISOLTR/0210 (06/21)	—	02	----	----
10.	25kV Potential Transformer (Type-1)	TI/SPC/PSI/PT/0210 (06/21)	04	04	06	08
11.	25kV/240V LT Supply Transformer(10kVA)	ETI/PSI/15 (08/03)	02	02	02	02
12.	25kV Dropout Fuse Switch (1A)	ETI/PSI/14(01/86) with A&C slip no. 01	02	02	02	02
13.	42kV Lightning Arrester	TI/SPC/PSI/MOGTLA/0101 (02/15)	06	06	09	12
14.	Low Tension Distribution Panel	TI/SPC/PSI/LTDPNL/0210 (10/21)	02	02	02	02
15.	25kV Support Insulator	TI/SPC/OHE/INS/0070(04/07) with A&C slip no. 01 & 02	As reqd	As reqd	As reqd	As reqd

14.0 <u>Bus Bar and Conductor to be used in various TSS/SP/SSP are as below:</u>

a) 19/2.5mm Galvanized Steel Stranded Earth Wire to be used as an earth wire. (RDSO Drawing no. ETI/PSI/0225 (Mod B)).

b) Primary Side of the TSS: For 220kV & 132kV, 28.62mmm ACSR “Zebra” conductor to be used. (IS: 398 Part-II).

c) Secondary Side of the TSS:
- For Scott Connected TSS - 50mm DIA Aluminum Bus Bar as per IS-5082 (Aluminium Alloy to Grade in WP condition) & 36mm Dia AAAC ‘Bersismis’ Conductor (IS: 398 Part-4, 767mm^2, 61/4.00 conductors) is to be used. For the specific location of use of Bus bar or Conductor please refer the drawings.
- For V Connected TSS: 50mm DIA Aluminium Bus Bar (IS-5082 (Aluminium Alloy to Grade in WP condition) & 38.25 mm Dia AAC ‘Bull’ Conductor (IS: 398 Part-1, 865.4mm^2, 61/4.25 conductors) is to be used. For the specific location of use of Bus bar or Conductor please refer the drawings.

d) At the SP/SSP Also, 50mm DIA Aluminium Bus Bar (IS-5082 (Aluminium Alloy to Grade in WP condition) & 38.25 mm Dia AAC ‘Bull’ Conductor (IS: 398 Part-1, 865.4mm^2, 61/4.25 conductors) is to be used. For the specific location of use of Bus bar or Conductor please refer the drawings.

e) Accordingly, the connectors of the suitable matching size of the conductor/Bus bar (para 14 above) should be purchased from the CORE approved sources of the connectors. In case, CORE approved sources are not available, the connector shall be procured as per IS: 5561.

f) Required Cables to be procured as per relevant Indian Standard.

15.0 Battery Capacity and battery charger to be used

The stand by battery charger at TSS/SP/SSP should be provided.

SN	Location	Capacity	Specification For	
			Battery	Battery Charger
1.	TSS	Lead Acid Batteries 110V, 250AH	RDSO/PE/SPEC/TL /0040 (Rev. '2')-2021	TI/SPC/PSI/200-250/ CHGR/0210 (07/21)
2.	SP/SSP	Lead Acid Batteries 110V, 150AH	RDSO/PE/SPEC/TL /0040 (Rev. '2')-2021**-**	TI/SPC/PSI/40-150/ CHGR/1210 (07/21)

16.0 Interface of 25kV system with 2X25kV system and extension of feed from 25kV system to 2X25kV System and vice versa:

16.1 The SP may be proposed as an interface between subject two systems as the SP have been provided with adequate AT capacity to cater the feed extension. However, the overloading of the Autotransformer/Autotransformers installed at SP shall determine the extent of feed extension.

16.2 Extension of feed between 2 x25 kV system and 1x 25 kV system

General Principle

Generally speaking, extension of feed from 1x 25 kV section to 2x 25 k V section and vice versa is possible with following remarks concerning capacity of AT at the boundary of both systems.

a) Extension of feed from 1x 25 k V section to 2x 25 kV section.

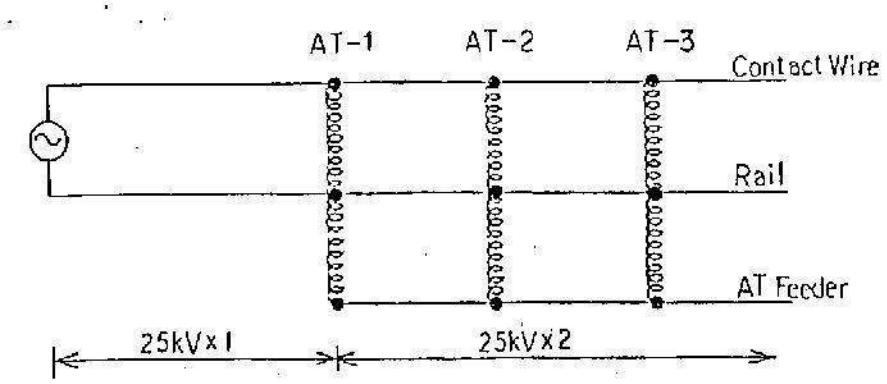


Figure:3

In this case, AT-1 at boundary of both systems is burdened with all the train loads which are located at right side of AT -2 and nearly half of the train loads between AT-1 and AT-2 Therefore, overload of AT-1 shall be observed.

b) Extension of feed from 2 x25 kV section to 1x 25 kV section.

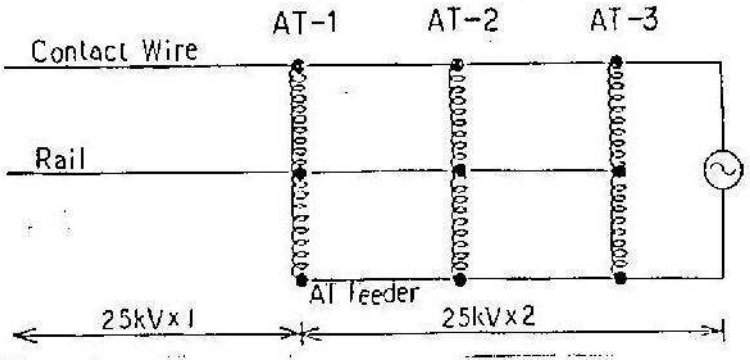


Figure:4

In this case, AT-1 at boundary of both systems is burdened with all the train loads on 1X25 kV section and nearly half of the train loads between AT-1 and AT-2 which shall be remarked on the extension.

End

Annexure-1

Government of India,
Ministry of Railways
Research Designs & Standards Organisation,
Manak Nagar, Lucknow- 226 011

Telephone : 2465763 (O).
42805 (Off.)
Fax : 91-0522-2465763
E-mail:psi.dti@gmail.com

No.TI/PSI/TSS/Policy/17

Dated-13.10.2017

The Chief Electrical Engineer,
South Central Railway,
Railnilayam,
Secunderabad-500 371.

Sub: 132kV Current Transformers for ABT metering.

Ref: Your letter No.E.220/RDSO/PSI/SPEC/Vol.VI dated 03.05.2016.

Reference above, the Traction Sub-station Layout drawings No.TI/DRG/PSI /TSSLO/RDSO/00004/02/1 Rev. 'A' and No. TI/DRG/PSI/TSSLO/RDSO/00005/02/1 Rev. 'A' have been issued vide RDSO letter No. TI/PSI/DRG/TSS-SPC/POLICY/15 dated 15.07.2015 and circulated to zonal Railways with provision of Current Transformers (CTs) & Voltage Transformer (PTs) for ABT metering.

The Current Transformer of 0.2/0.2s accuracy class and potential Transformer of 0.2 accuracy may be used at TSS for ABT metering as stated in the above mention drawings. Since CT and PT required for ABT metering are general purpose commercially available equipment's which are also being used by various DICOMs/Power utilities. Therefore it was decided to use the same spec which is being used by various power utilities and there is no need of having separate RDSO specifications for the same.

(A. K.Sharma)
(Director –PSI)
For Director General(TI)

C/C

Annexure-2

Government of India,
Ministry of Railways
Research Designs & StandardsOrganisation,
Manak Nagar,Lucknow– 226 011

Telephone: 2465763 (O).
42805(Off.)
Fax : 91-0522-2465763
E-mail:psi.dti@gmail.com

No. TI/PSI/TSS/POLICY/18/02 Issued 30/7

Dated, the26rd July, 2018 30

To,

1. The Principal Chief Electrical Engineer,
   - i. Central Railway, Station Building, Mumbai CST – 400 001.
   - ii. Eastern Railway, Fairlie Place, Kolkata-700 001.
   - iii. East Central Railway, Hajipur-844 101.
   - iv. East Coast Railway, Bhubaneshwar-751 023.
   - v. Northern Railway, Baroda House, New Delhi - 110 001.
   - vi. North Central Railway, Allahabad-211 015.
   - vii. North Eastern Railway, Gorakhpur-273 012.
   - viii. North Frontier Railway, Mailgaon - 781 011.
   - ix. North Western Railway, Jaipur – 302 017.
   - x. Southern Railway, Park Town, Chennai- 600 003.
   - xi. South Central Railway, Rail Nilayam, Secunderabad-500 371.
   - xii. South Eastern Railway, Garden Reach, Kolkata-700 043.
   - xiii. South East Central, Railway, Bilaspur-495 004.
   - xiv. South West Railway, DRM's Office, Hubli-580 028.
   - xv. Western Railway, Churchgate, Mumbai-400 020.
   - xvi. West Central Railway, Jabalpur- 482 001.
   - xvii. Belapur Bhavan, Sector-11, CBD Belapur, Navi Mumbai 400614
   - xviii. Central organisation for Railway Electrification, Allahabad-211001
   - xix. Metro Railway, 33/1, Jawahar LAL Nehru Road, Kolkata-700071
2. The Executive Director (Electrical), M/s Rail Vikas Nigam Limited, 1st Floor, August Kranti Bhavan, Bhikaji Cama Place, New Delhi-110066.
3. The General Maneger (Electrical), M/s IRCON, International Limited, C-4 District Center, Saket, New Delhi-110017.
4. Director (Technical), M/s DFCCIL, Pragati Maidan, Metro Station Building, New Delhi-110001.

Sub: General Layout of Traction Sub- Stations.

Ref: (i) Railway Board Letter no. 2006/Elect (G)/170/2 dated 12.07.2018.
(ii) Railway Board Letter no. 2008/Elect(G)/170/1Pt-III(NTPC/RGPPL)Vol-II dated 23.02.2018.

1. In view of the referred Railway Board letter (ii), the General Layout of the Traction Sub-Station for new siteshas been modified by this office for ABT metering. The soft copies of the Drawings has been uploaded on the railsaver website i.e. **www.railsaver.gov.in**& same may be referred. The modified drawing number with revision is tabulated below:

SN	Drawings no.	Description	Rev.	Date.
1.	TI/DRG/PSI/TSSLO/ RDSO/00001/01/0	Typical layout of 132/27 kV traction substation (Type-I).	A	25.07.18
2.	TI/DRG/PSI/TSSLO/ RDSO/00002/02/0	Typical layout of 132/27 kV traction substation (Type – II)	A	25.07.18
3.	TI/DRG/PSI/TSSLO/ RDSO/00003/02/0	Typical layout of 132/27 kV traction substation (Type-III).	A	25.07.18
4.	TI/DRG/PSI/TSSLO/ RDSO/00004/02/1	Typical layout of 132/27 kV traction substation (Type-IV) with outgoing feeders and meteringfacilities.	B	25.07.18
5.	TI/DRG/PSI/TSSLO/ RDSO/00005/02/1	Typical layout of 132/27 kV traction substation (Type-V).	B	25.07.18
6.	TI/DRG/PSI/TSSLO/ RDSO/00006/02/0	Typical layout of 132/27 kV traction substation (Type-VI).	A	25.07.18
7.	TI/DRG/PSI/TSSLO/	Typical layout of 132/27 kV traction	A	25.07.18

0/c

	RDSO/00007/02/0	substation (Type – VII).		
8.	TI/DRG/PSI/TSSLO/ RDSO/00008/02/0	Typical layout of 132/27 kV traction substation (Type-VIII).	A	25.07.18
9.	TI/DRG/PSI/TSSLO/ RDSO/00009/02/0	Typical layout of 132/27 kV traction substation with single transformer (Type IX).	A	25.07.18
10.	TI/DRG/PSI/TSSLO/ RDSO/00010/02/0	Typical layout of 132/25 kV traction substation with 132 kV switching station (Type – X).	A	25.07.18

2. To provide the CT & PT for ABT metering extra space is required in existing TSS. Since the availability of space in existing TSS is site specific, therefore no standard drawing can be issued for existing TSS. However based on space availability and site conditions following solutions are proposed for providing ABT metering system in Existing Traction Sub-Station:

i) Case No.1:In the layout where already there is a provision of metering CT and metering PT.

In such type of TSS existing metering CT & PT may be replaced with ABT metering compatible CT & PT and therefore, no change in layout is required.

ii) Case No.2: Where sufficient space (6 meter or more) is available along the length of existing TSS.

In such type of TSS ABT metering compatible CT & PT may be provided in the incoming side maintaining required 3 meter inter equipment distance on HT side.

iii) Case no. 3:In the layout where only 3-6 meter space is available along the length of existing TSS.

In such type of TSS ABT metering compatible CT may be provided along the length and lateral space available between two bays may be used for metering PT.

iv) Case no. 4:In the layout where space is not available along the length.

In such type of TSS dual core CT and dual core PTs may be used. The additional core of CT & PT will be used for ABT meter.It may be noted that use of dual core CT & PT can be made in TSS provided Railways have examined the acceptability from State Electricity Utilities.

3. Standard Clearances required to be maintained in providing CT & PT on the site for 132kV & 220 kV are as :

		132 kV	220 kV	Reference
1.	Between one phase and earth for rigid connection	1300 mm	2100 mm	As per Para No. 20914 of ACTM Volume II of Part-I
2.	Between any points where man may be required to stand to the nearest			
	(a) Unsecured conductor in air	4000 mm	5000 mm	As per Para No. 20914 of ACTM Volume II of Part-I
3.	Minimum height of Bus bar	4600 mm	5500 mm	As per Para No. 20914 of ACTM Volume II of Part-I
4.	Clearance between equipments	3000 mm	4000 mm	Based on the earlier issued drawings

These issues with approval of the competent authority.

26-07-2018

(A.K. Sharma)
(Director –PSI)
for Director General (TI)

Encl: NIL.

Copy to: The Secretary (Electrical),Railway Board, Rail Bhavan, New Delhi-110001.

Annexure-3

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
RAILWAY BOARD

No. 2008/RE/170/1 **Dated 12.06.12**

Chief Electrical Engineers,
All Indian Railways (Electrified)

Sub: Provision of Dynamic Reactor Power Compensating (DPRC) equipment at 25 kV & 2x25 kV TSSs
Ref: Board Letter No. 2008/Elect(G)/150/10 dt 03.10.08, 04.12.08 & 09.03.11

Board's policy guidelines for provision of Dynamic Reactor Power Compensating (DRPC) equipment for new & existing 25 kV TSS vide above reference has been reviewed based on the performance & progress of implementation, heavy investment involved and recurring auxiliary losses, difficulty in determining the correct rating of DRPC at new TSS due to non-availability of load curves, change in policy by DISCOMs for incentive on power factor improvement beyond a specific value etc.

Accordingly in supersession of all previous policy guidelines on the subject, it has been decided that Railways/CORE /MRVC/RVNL etc. should provided only fixed type capacitor bank in all new & existing 25 kV & 2x25 kV TSSs for the time being.

This issued with the approval of Board (ML).

Sushil Kumar
Director Elect. Engg.(PS)
Railway Board

Copy to : Sr.ED/TI/RDSO: for information. This disposes off RDSO's reference dt. 10.05.10 for provision of DRPC at 2x25 kV TSS.

031746

File No.RDSO-TI0LKO(PSI)/22/2020-O/o PED/TI/RDSO

सत्यमेव जयते

Government of India,
Ministry of Railways
Research Designs & Standards Organisation,
Manak Nagar, Lucknow– 226 011

Telephone: 2465763 (O).
42805(Off.)
Fax : 91-0522-2465763
E-mail:dti.psi.rdso@gmail.com

Date; 21 February, 2022

To,

1. The Principal Chief Electrical Engineer,
   - (i) Eastern Railway, Fairlie Place, Kolkata-700 001.
   - (iii) East Central Railway, Hajipur-844 101.
   - (iv) Northern Railway, Baroda House, New Delhi - 110 001.
   - (v) North Central Railway, Allahabad-211 015.
   - (vi) Western Railway, Churchgate, Mumbai-400 020.
   - (vii) West Central Railway, Jabalpur- 482 001.

2. Chief Administrative Officer, CORE Allahanbad-211001, e mail: ceehq.core@gmail.com

Sub: Cross Acceptance Criteria for new items/design/specification.

Ref: (i) Railway Board letter no. 2021/Elect(Dev)/221/45 dated 18.02.2022.

(ii) Railway Board letter no. 2021/Elect(Dev)/225/44 dated 09.12.2021.

In view of the above references, cross acceptance criteria for evaluation & acceptance of alternative products for which there is no RDSO specification but are already in use with satisfactory performance in one or more major Indian/World Railway(s) system is enclosed herewith for kind information and implementation please.

This is issued with approval of the Competent Authority.

21.2.22

(Arvind Koomar)
Joint Director TI-1
For Director General (TI)

Encl: As stated above.

Copy to:
PED Elect. Engg. (Dev)/Railway Board, New Delhi – For kind information please.



भारत सरकार, रेल मंत्रालय

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

PROCEDURE FOR CROSS ACCEPTANCE CRITERIA FOR NEW ITEM/DESIGN/SPECIFICATION FOR 25KV & 2X25KV AC TRACTION SYSTEM

25 केवी और 2X25KV एसी ट्रैक्शन सिस्टम के लिए नई वस्तु/डिजाइन/विनिर्देश के लिए क्रॉस स्वीकृति मानदंड के लिए प्रक्रिया

INSTRUCTION No. TI/IN/0044 Rev.00

निर्देश संख्या: TI/IN/0044 Rev.00

(Reference: Railway Board letter no. 2021/Elect(Dev)/225/44 dated 09.12.2021 & letter no. 2021/Elect(Dev)/221/45 dated 18.02.2022)

RESEARCH DESIGNS & STANDARDS ORGANISATION
(Ministry of Railways)
Manak Nagar, Lucknow (UP) 226011

1. PREFACE

1.1 The Railway Board vide letter no. 2021/Elect(Dev)/225/44 dated 09.12.2021 (Enclosed as Annexure-2) has directed RDSO to frame the cross acceptance criteria for new items/design/specification used for Traction Installation system for 25kV and 2X25kV AC system for approval by Railway Board.

1.2 Further, PED/TI vide note no. ED/TI/Misc/21 dated 16.12.2021 (Enclosed as Annexure-3) has nominated the committee of DTI/III, DTI/Civil, JDTI/I & JD/TI-II of Traction Installation directorate to prepare the cross acceptance criteria. Also, Railway Board vide letter no. 2021/Elect(Dev)/221/45 dated 18.02.2022 (Annexure – 9) has advised to issue Cross Acceptance Criteria to all concern for implementation on Indian Railways.

1.3 This guideline of cross acceptance is being framed in view of the liberty given to the Contractor in Para 6 of schedule D and Para 2 of Annexure I (Schedule D) in standard EPC document issued by Railway Board vide letter no. 218/CE-I/CT/36-EPC Contract Policy Pt-1 dated 15.11.2021 (Enclosed as Annexure-4) to adopt international practices, alternative specifications, materials and standards to bring in innovation in the design and construction.

1.4 The liberty is given to bring in innovation and therefore an alternative item which is not as per the designs/specifications issued by RDSO, but the same is already in use with satisfactory performance in one or more major Indian/World Railway(s) system.

1.5 The specifications of items are created/revised & issued by RDSO as per the RDSO's ISO procedure no. QO-D-8-1.1 and QO-D-8-1.2 for creation and revision of specifications respectively. During the specification preparation stage the draft specifications are uploaded for the comments of Industry/firms on RDSO's open portal for a period of 30 days and on the basis of comments received, a reason document is prepared for the acceptance/non-acceptance of the comments. Thereafter, Reasoned Document and Final Draft are uploaded again on RDSO's open portal for comments for 15 days. Again the comments received are discussed and reason document is prepared and on the basis of it, Directorate head approves the specification for issue. The process adopted is very transparent as anybody can comment on the specification being framed and the acceptance or rejection of comments is well reasoned and on the basis of this reason document and with the approval of Directorate head the specification is issued. The procedure has been further strengthened w.e.f 19.06.2020 to bring out more transparency and expertise by adopting procedures suggested by Bureau of Indian Standards (BIS) and consequent recognition of RDSO by BIS as Standards Development Organisation (SDO).

1.6 However, the industry always moves with new technologies and the same are not getting updated in the specification as fast as the industry moves. Therefore, there should be some mechanism to introduce the superior/cost effective technology items/design/specification without taking up the task of specification/STR revision and subsequent vendor development.

1.7 It is pertinent to mention here that cross acceptance criteria have been in vogue in METRO/DFCCIL in lump sum/design built contract where the Contractor quotes a lump sum cost for whole work on the basis of functional requirement and is given freedom to adopt new technologies within the ambit of the quoted cost and meeting the functional requirement at the same time.

1.8 Following may please be ensured before proposing an alternate solution;

(i) The proposed new items/design/specification is not specifically refused/ restricted in the RDSO specifications.

(ii) The new items/design/specification should not degrade the performance with respect to the item/design as mentioned in the RDSO specification.

2. OBJECT

The object of this guideline is to outline the procedure for cross acceptance of new items/design/specification in terms of process, responsibility, spare and maintenance etc. in a uniform procedure.

3. APPLICABILITY

i. The cross-acceptance guideline shall be applicable to the items having alternative specifications to RDSO specification which are being used first time in Indian Railways in 25 kV or 2x25 kV systems.

ii. This guideline shall be applied for evaluation & acceptance of alternative products for which there is no RDSO specification but are already in use with satisfactory performance in one or more major Indian/World Railway(s) system.

4. PROCEDURE FOR CROSS ACCEPTANCE

4.1 The alternative specifications of the items/design shall be framed by contractor and shall be supported with authentic specifications and standards specified in paragraph 5, schedule D under chapter 'specifications and standards' of standard EPC document issued by Railway Board vide letter no. 218/CE-I/CT/36-EPC Contract Policy Pt-1 dated 15.11.2021. Such a proposal shall be submitted by the Contractor to the Authority. The specifications of the product offered shall be made by the contractor with clause wise justification vis a vis applicable RDSO specification that offered product is superior/cost effective to the technology stipulated in the applicable RDSO specification. Along with the proposal following minimum details/documents shall also be submitted.

i. Description of item as per the RDSO Specification.

ii. Proposed items/design/specification.

iii. Deviations from RDSO's specification considering the alternate proposal in consultation with OEM.

iv. Advantages of new items/design/specification over as mentioned in RDSO specifications in consultation with OEM.
v. Documents in support of the advantages mentioned.
vi. Schedule of Guaranteed performance.
vii. Reference IS/IEC of the new items/design/specification.
viii. Design/Codal Life of the new item certified by OEM.
ix. Prototype test report issued by designated/notified body/OEM. The details of the testing agencies/lab along with accreditation certificates.
x. Provenness performance certificate from the competent official of end user i.e. from world Railway(s)/ Indian Railways & its PSUs/Metro/DFC/Other Railways (as the case may be). New items/design/specification should be of satisfactory performance as mentioned in Annexure-1. Name, Designation, Phone & Fax Nos. and address of the official and Organisation certifying the performance feedback should be clearly mentioned. It would be responsibility of contractor to ensure that certificate submitted is issued only from competent official of certifying organisation.

4.2 The Cross Acceptance Criteria for the (a) Items not covered by RDSO/CORE Specification OR (b) Items being adopted for the first time in Indian Railways, shall be as under:

a. The item should have already been in-use with satisfactory performance in one or more major world Railway(s)/ Indian Railways & its PSUs/Metro/DFC/Other Railways, for more than 5(five) years from the date of bid opening for the same or higher design speed/rating of equipment offered. The manufacturer should have to meet the criteria of satisfactory performance and has to submit the certificate to this effect as per Annexure-1.
b. The manufacturer should have supplied at least 20% quantity to be used in this contract in last seven years or they can supply, maximum Five times the quantity supplied in last seven years. However, this should not be treated as impediment in timely completion of the project and therefore, the contractor can place the quantity even beyond this with the approval of authority, in order to ensure timelines of Contract.
c. Prototype test Report/Certificate for offered items is to be submitted. Fresh prototype test is to be conducted, if the same has not been carried out:
    i. In last five (5) years from one month prior to date of Bid Opening or later;
    ii. Considering the environmental conditions as specified in the specification or contract.

d. The Manufacturer shall have to support maintenance and repair of the equipment in India and supply spares till the design life of the material such as transformers etc. in India. The Contractor shall submit an undertaking to this effect from the Original Equipment Manufacturer (OEM).

The Original Equipment Manufacturer (OEM) may transfer technology to any Indian Company for manufacture and supply as per Clause 8 (iii) of this document.

4.3 In case, the Authority is of the opinion that the proposal submitted by the Contractor is not in conformity with any of the international standards (IEC, IS, EN, AAR, UIC etc.) or codes or the proposed new items/design/specification is inferior/poor than the RDSO specification, the proposal shall be rejected by the Authority and same shall be communicated to the contractor with reasons of rejection.

4.4 In case, the offered new items/design/specification is accepted by the Authority, the proposal along with documents/details mentioned in Para 4.1 above, in support of justification shall be submitted to RDSO for final approval.

4.5 The decision of RDSO for the acceptance/rejection of the new items/design/specification shall be final and binding.

4.6 After acceptance of the new items/design/specification, following details shall also be submitted by the Contractor,

i. The operation and maintenance manual along with recommended maintenance schedule.
ii. Undertaking regarding the maintenance spare/support till the codal /design life of the product (On stamp/legal paper of appropriate value).
iii. Proposed Training schedule of Indian Railway officials (as required) for the new item.
iv. The design drawings of the new item for the reference of the Indian Railways.

4.7 Type testing for the product as per the new items/design/specification;

i. In case the type test has already been conducted, the repetition of the type test may be waived off in terms of Clause 4.2 of this document. In this case Contractor have to submit a declaration of OEM that submitted prototype test report is of identical equipment (same rating), manufactured with identical component/raw material at the same manufacturing facility & premises and to the identical quality Standard, which have been supplied in world Railway(s)/ Indian Railways & its PSUs/Metro/DFC/Other Railways (as the case may be).

ii. The type test report shall be submitted to RDSO for approval/acceptance.

iii. The non-acceptance of the type test report (completely or partially) shall necessitate the type testing of the new item (completely or partially, as the case may be).

iv. In case the type testing is to be conducted, following shall be followed;

a) The Contractor shall submit the detailed test plan along with the internal test report of the item under consideration to the Authority consisting of the tests to be conducted/verified against test certificates (TC), procedure and acceptance/rejection criteria. The procedure and acceptance /rejection criteria should be supported by the Indian/international standards as applicable.

b) The test plan accepted by RDSO shall be forwarded to nominated testing agency as per Para 5.0 of this guideline for witnessing the type test.

c) Accordingly, the Type test schedule along with internal test reports shall be submitted to the nominated testing agency as per Para 5.0 of this guideline at least 15 days in advance. The schedule shall contain the location and number of days required for testing of each tests.

5. TYPE TESTING AGENCY

RDSO or any other reputed agency approved by RDSO for witnessing the type tests.

6. TYPE TEST RESULTS

i. The final type test certificate of the item shall be issued by the RDSO or nominated testing agency as the case may be.

ii. In case the alternate design/product has failed during the type testing, if the vendor desires for re-testing of same sample or re-testing of improved sample, he may do so by submitting the details of technical explanation and corrective actions taken.

7. CHARGES OF THE TYPE TESTING

Type testing charges shall be borne by the contractor.

8. MAKE IN INDIA POLICY

i. Make in India Policy regarding Public Procurement issued by Department of Promotion and Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry vide order no. P-45021/2/2017-PP(BE-II) dated 16.09.2020 (Enclosed at Annexure-7), Railway Board letter no. 2020/RS(G)/779/2/Pt.1 dated 25.09.2020 (Enclosed at Annexure-6), Railway Board Letter no. 2015/RS(G)/779/5(Vol.III) dated 19.02.2021 (Enclosed as Annexure-5), Public Procurement Policies/Orders issued for business with countries that share land boundaries with India and other relevant policies shall be applicable.

ii. As per Railway Board Letter no. 2015/RS(G)/779/5(Vol.III) dated 19.02.2021 (Enclosed as Annexure-5), Para 3.0 except short neutral section assembly for all items/material used in Railway Electrification, only class I local suppliers shall be eligible to bid and supply, irrespective of the purchase value, shall also be applicable for cross acceptance.

iii. However, in case OEM manufacturing is based outside India, the transfer of technology (TOT) is also permitted as per the following particulates;

   a. The manufacturer (OEM) shall transfer technology to any Indian firm for manufacture and supply of 100% quantity used in the project. However, for Short Neutral section assembly, up to 50% of the required quantity may be supplied by OEM and remaining, i.e. more than 50%, has to be supplied through TOT.
   b. The Provenness criteria of OEM i.e. foreign based firm (item installed in India or abroad) shall be accepted subjected to certification under Annexure-1.
   c. The OEM should have technology tie up with the Indian manufacturer and has signed a Joint Deed of Undertaking (Format enclosed as Annexure-8), by the OEM, the contractor and Indian Equipment Manufacturer/Indian Partner.
   d. Indian Equipment Manufacturer/Indian Partner undergoing with TOT for the supply of offered product by OEM should meet the requirement of "Class–I local supplier" for that item as mentioned in Para 8 (i) above.
   e. In order to ensure satisfactory transfer of technology, the OEM shall provide following:
      (i) Design drawings
      (ii) Manufacturing drawings.
      (iii) Process sheets for Manufacture
      (iv) Inspection and Quality Management procedures
      (v) Complete Material Specifications
      (vi) Jigs and Fixtures

(vii) List of Machinery and Plants along with their functional specifications, which are needed for manufacture

(viii) Manufacturing supervision

(ix) Inspection by OEM's representative

(x) Extended Guarantee for 3 years for items proposed under cross acceptance after expiry of Defect Notification Period.

(xi) Any other assistance, reasonably required.

Annexure-1

CRITERIA FOR THE SATISFACTORY PERFORMANCE

1. The item should have already been in-use with satisfactory performance in one or more major world Railway(s)/ Indian Railways & its PSUs/Metro/DFC/Other Railways, for more than 5(five) years from the date of bid opening for the same or higher design speed/rating of equipment offered.
2. The provenness performance of quantity, 02 numbers or required quantity for 100 Track Kilometres, whichever is higher, shall be provided as per following format by competent official of end user.

Format for the submission of the performance certificate for provenness

Equipment description with design speed/ rating									
Quantity (in figures)									
Governing Specification									
Past application history of the equipment									
SN	Model no.	Batch/ Lot no. (as applicable)	Serial no. of equipment	User Rly/ Authority	Station/ Location/Section	Date of commissioning	Date of start of commercial service	Details of Failures till date	Remarks/ Observation

Note:

i. All the above details shall be provided/certified by the competent official of end user. It would be responsibility of contractor to ensure that certificate submitted is issued only from competent official of certifying organisation.

ii. Name, Designation, Phone & Fax Nos. and address of the Official certifying the performance feedback should be clearly mentioned.

Annexure-2

आज़ादी का अमृत महोत्सव

GOVERNMENT OF INDIA (भारत सरकार)
MINISTRY OF RAILWAYS (रेल मंत्रालय)
RAILWAY BOARD (रेलवे बोर्ड)

Azadi Ka Amrit Mahotsav

No: 2021/Elect(Dev)/225/44

New Delhi, Dated: 09.12.2021

Director General,
RDSO,
Manak Nagar,
Lucknow.

Sub: Cross Acceptance Criteria to new design/specification for AC traction system.

Indian Railways (IR) has adopted 25 kV AC traction system based on SNCF design in 1959. The technological development in traction is a continuous process. The speed of Freight and Passenger trains are increasing day by day. There is need to match the suitable traction system for growing need of traffic requirement on Indian Railways.

2. There is need to upgrade speed to 160 kmph on GQ/GD route as requirement of train speed is increasing day by day so there may be need to allow new design equipment on traction system.

3. 2x25kV system has also been adopted on New Delhi-Hawrah and New Delhi-Mumbai route to upgrade traction system. Recently Dedicated Freight Corridors are commissioned with 2X25 kV AT system where new equipment have been used based on RDSO report TI/REPORT/OHE/0081 (07/2010). RDSO has recommended areas related with alternative design and technology for 2x25 kV DFCC projects and has suggested approved methodology for technology induction on IR (para 11.2 of RDSO report).

4. The new items will be required for 2x25 kV traction system/existing 25 kV traction system which will required to be developed by Railways in short span time in future. There is necessity to fast track process of approval on the basis of cross acceptance criteria for the items used on upgradation of existing 25kV traction system to 2x25 kV traction in Indian Railways.

5. New EPC document have been issued by Railway Board vide letter no. 218/CE-I/CT/36-EPC Contract Policy Pt-1 dated 15.11.221 for New Electrification works and for 2x25 kV upgradation works. The para Clause 6 of Schedule D and Para 2 of Annex I (Schedule D) of EPC document allows alternative specifications and standards/deviations from the Specifications & Standards. The new items shall comply provisions of Cross Approval policy of the Railway Board.

6. Signaling Directorate of RDSO has framed cross acceptance policy for new signaling items which has been approved by Railway Board.

7. RDSO is advised to frame cross acceptance criteria for new items of 25 kV AC and 2x25 kV AC system for new items/new specifications for Railway Board approval.

9. PED/TI, RDSO shall frame Cross Acceptance Criteria for new items used for traction Installation system and submit to Railway Board by 20.12.2021.

(R.K.Jain)
Principal Executive Director Elect.Engg(Dev)
Railway Board

Copy to:

AM/Traction, Railway Board – for kind information please.

Annexure-3

अनुसंधान अभिकल्प और मानक संगठन
(कर्षण संस्थापन निदेशालय)

No.EDTI /Misc/21 Dated, the 16th December, 2021.

Sub : Cross Acceptance Criteria to new design/specification for AC traction system.
Ref : Railway Board's letter No. 2021/Elect(Dev)225/44 dated 09.12.2021.

Railway Board has issued instructions to RDSO for preparation of Cross Acceptance Criteria to new design/specification for AC traction system.

The issue is related with all the four groups of TI Directorate and deals with the policy of vendor approval hence, it is proposed to nominate a committee of the following officers for preparation of the above document.

1. Shri G.P. Katiyar, DTI-3 (Convener)
2. Shri A.K. Yadav, DTI/Civil
3. Shri Arvind Koomar, JDTI-1
4. Shri Girraj Kishore, JDTI-2

Committee should submit the report by 20.12.2021.

16/12/21
(भारद्वाज चौधरी)
कार्यकारी निदेशक / क.सं.

प्रधान कार्यकारी निदेशक / क.सं.
Nomination अनुमोदित।
16/12/21

Annexure-4

आज़ादी का अमृत महोत्सव

भारत सरकार Government of India
रेल मंत्रालय Ministry of Railways
(रेलवे बोर्ड Railway Board)

Azadi Ka Amrit Mahotsav

No.2018/CE-I/CT/36-EPC Contract Policy Pt.–1 New Delhi, Dated: 15.11.2021

As per Mailing List

Sub: Standard EPC Tender Document for Single Stage Two Packet System
Ref: Railway Board's letters No. 2018/CE-I/CT/36-EPC Contract Policy dated 29.10.2019, 15.11.2019, 08.05.2020, 28.05.2020 & 24.08.2021

The documents for Request for Proposal (RFP) and Standard Engineering, Procurement and Construction Contract (EPC) Agreement for Single Stage Two Packet System of Tendering, were uploaded on IR website www.indianrailways.gov.in/railwayboard>>"About Indian Railways">> "Railway Board Directorates" >> "Civil Engineering" >> "EPC Tender document (Single Stage)", vide Railway Board's letter of even number dated 29.10.2019. Later on, the same was amended vide letters dated 15.11.2019, 08.05.2020, 28.05.2020 & 24.08.021.

2. The 'Standard Engineering, Procurement and Construction (EPC) **Agreement** for Railway Projects' has further been amended by the Board (MI, MF, CRB&CEO) duly incorporating all the amendments issued earlier and the same is available on above IR website.

3. This issues with the concurrence of Finance Directorate of Ministry of Railways.

Prem Sagar
15.11.21
(प्रेम सागर गुप्ता)
कार्यपालक निदेशक सिविल इंजीनियरिंग(जी)/रेलवे बोर्ड
[Rly No. 030-44803, MTNL No.-011-23383379]
e-mail address :edceg@rb.railnet.gov.in

Copy forwarded for information to :

1. The Deputy Comptroller & Auditor General of India (Railways), Room No. 224, Rail Bhawan, New Delhi
2. The PFAs, all Indian Railways

For Member Finance

LIST FOR DISTRIBUTION (Letter No. 2018/CE-I/CT/36-EPC Contract Policy dated 15.11.2021)

1. General Managers, All Indian Railways & Production Units
2. General Manager (Con), N.F. Railway, Guwahati
3. General Manager /CORE, Allahabad.
4. Chief Administrative Officers (Con), All Indian Railways (Except N.F. Railway)
5. Principal Chief Engineers, All Indian Railways

(A)

1. CAO, COFMOW, Tilak Bridge, New Delhi
2. Principal CAO, Diesel Loco Modernization Works, Patiala (Punjab)
3. CAO (Workshop Projects), Chamber Bhawan, Judge's Court Road, Anta Ghat, Patna-800001, Bihar

(B)

1. Director General, RDSO, Manak Nagar, Lucknow
2. Director General, NAIR, Vadodara
3. Director, IRICEN, Pune – 411 001 (Maharashtra)
4. Director, IRIEEN, PB No.-233, Nasik Road-422101 (Maharashtra)
5. Director, IRISET, Taa Naka Road, Lalla Guda, Secunderabad-500017
6. Director, IRIMEE, Jamalpur Distt-Jamalpur, PIN-811214 (Bihar).
7. Director, IRITM, Sarswati Residential Estate, IRITM Campus, Manak Nagar, Lucknow

(C)

1. MD, CONCOR, Concor Bhawan, C-3, Mathura Road, Opp. Apollo Hospital, New Delhi- 110076.
2. IRCON International Limited, C-4, District Centre, Saket, New Delhi- 110017
3. MD, RITES Ltd., RITES Bhawan, Plot No.1, Sector-29, Gurgaon.
4. CMD, RVNL, August Kranti Bhawan,Plot No.25, 1st Floor, Bhikaji Cama Place, New Delhi.
5. MD, MRVC Ltd., Churchgate Station Bldg, Mumbai- 400020
6. CMD, KONKAN Railway Corporation Ltd, Rail Bhawan, New Delhi-110001.
7. MD, DFCCIL, 5th Floor, Pragati Maidan Metro Station Building Complex, New Delhi-110001
8. MD, RLDA, Near Safdarjung Railway Station, Moti Bagh, Phase-I, New Delhi- 110021
9. MD, CRIS, Chanakyapur, New Delhi.
10. CMD, RailTel Corporation of India Ltd. Plot No. 143, Institutional Area, Sector-44, Gurgaon – 122003.
11. CME, IROAF, 12th Floor, Core-1, Scope Minar, Distt. Centre, Laxmi Nagar, Delhi- 110092
12. Managing Director, IRFC Limited, UG Floor, EastTower, NBCC Place, Bhisham Pitamah Marg, LodhiRoad, Pragati Vihar, New Delhi.
13. CMD, IRCTC Ltd., B-148, 11th Floor, Statesman House, Barakhamba Road, New Delhi 110001
14. CMD, Braithwaite & Co. limited, 5 Hide Road Kolkata 700043.

Copy to:

(A)

1. General Secretary, IRCA, DRM Office, New Delhi.
2. General Secretary, AIRF, Rail Bhawan, New Delhi
3. General Secretary, NFIR, Rail Bhawan, New Delhi
4. General Secretary, IRPOF, Rail Bhawan, New Delhi
5. General Secretary, FROA, Rail Bhawan, New Delhi
6. General Secretary, AIRPA, Rail Bhawan, New Delhi
7. General Secretary, AISC & STREA, Rail Bhawan, New Delhi
8. The Secretary, RBSS, Group (A) Offices Association, Rail Bhawan
9. The Secretary, RBSS, Group (B) Offices Association, Rail Bhawan
10. General Secretary, RBSSS Association, Rail Bhawan
11. The Secretary, RBMSA, Rail Bhawan
12. The Secretary, Railway, Group (D) Employees Association, Rail Bhawan

(B)

1. Concerned PSO for kind information of Chairman cum CEO, M/Infra, M/T&RS M/O&BD, M/Finance, Railway Board
2. Chief Vigilance Officers, All Indian Railways.
3. DG(RHS), DG(RPF), AM(CE), AM(Works), AM(B), AM(Elec.), AM(RS), AM(ME), AM/Tele, AM/C&IS, AM/Sig., AM(Plg.), PED(B&S), PED(Vigilance), PEDCE(P), EDCE(G), EDTK(M&MC), EDCE(B&S), EDF(X)-I, EDF(X)-II, ED(Works), EDW(Plg.), ED/Project(Mon.), ED(L&A), ED(PSU), EDVE, ED(Safety), ED(SP), ED(Tele), EDRS(G), EDRE, EDEE(G), EDFE, EDE(N), ED(Accounts), ED/T&MPP, EDME(Chg.), EDME(Frt.), ED/Plg., JS(conf), JS(P), JS(G), JS(D), Vigilance-III, Vig(Conf) of Railway Board.

Annexure-5

भारत सरकार **BHARAT SARKAR**
रेल मंत्रालय **MINISTRY OF RAILWAYS**
(रेलवे बोर्ड **RAILWAY BOARD)**

No. 2015/RS(G)/779/5(Vol.III) नई दिल्ली **New Delhi**, Dated: 19.02.2021

The General Managers, All Indian Railways/PUs, NF(C), CORE
The DG/RDSO/Lucknow, NAIR/Vadodara,
PCAO, DMW/Patiala, COFMOW
CAO, WPO/Patna, RWP/Bela.

Sub.: Implementation of Public Procurement (Preference to Make in India) Order, 2017 – Notification of RE items under para-3(a) of PPP-MII Order.

Ref.: (i) DPIIT, Ministry of Commerce and Industry Order No.P-45021/2/2017-PP(BE-II) dated 16/09/2020
(ii) Railway Board's letter no.2020/RS(G)/779/2 Pt.I dated 25-09-2020.

1.0 Para-3(a) of the Public Procurement (Preference to Make in India) Order, 2017 (as amended) issued vide reference above, stipulates as under-

"In procurement of all goods, services or works in respect of which the nodal ministry/department has communicated that there is sufficient local capacity and local competition, only "Class-I local supplier", as defined under the order, shall be eligible to bid irrespective of purchase value."

2.0 Government has desired that Ministries/Departments shall expeditiously issue notification for the items where there is sufficient local capacity and competition and where public procurement shall be done only from 'Class-I local suppliers' under clause 3(a) of PPP-MII, Order, 16/09/2020. Additionally, nodal ministry has been permitted (vide Para 5 of the same order) to increase minimum local content requirement for categorization of vendor into Class-I and Class-II local supplier.

3.0 **Railway Board has reviewed and considered that sufficient local capacity and local competition exist for all the material/items used in Railway Electrification as they are indigenously manufactured and supplied <u>except</u> short neutral section assembly which is an RDSO approved item. It has, therefore, been decided that in respect of these items only Class I local suppliers shall be eligible to bid and supply, irrespective of the purchase value. It has been further decided that the minimum local content for the local supplier, of the above item, to be categorized as 'Class-I local supplier' shall be 50%.**

4.0 Requirement of a vendor to be a Class I local supplier (self-certification by bidder as per PPP-MII order 2017, as amended), to be considered for ordering of item (s) detailed in para - 3.0 above, shall be a mandatory condition in addition to other qualifying criteria, including status of approval with respective vendor approving agencies,

etc., which may be applicable for purchase of the item. Suitable eligibility criteria shall be added in the tenders by procuring agencies. Suitable condition should also be inserted in tenders calling attention of vendors, clearly indicating that in keeping with the Public Procurement (Preference to Make in India) Order, 2017, as amended, it has been found that there is sufficient local capacity and competition in supply of the tendered item of required quality and therefore public procurement of the item is restricted to Class I local suppliers only and the vendors who do not qualify to be Class I local suppliers should not quote in the tender as their offers shall not be considered for any ordering. In case any vendor who does not qualify to be a Class I local supplier for the tendered item participates in the tender it does so at its own risk and cost and Railways shall not be liable for any loss or damage caused to the vendor.

This is issued with the approval of Railway Board (M(TRS)).

19.02.21

(Chandan Kumar)
Director Railway Stores/IC
Railway Board

Copy to:

1. PCMMs, PCEs, PFAs, CMEs, CEEs, CSTEs, All Indian Railways & PUs, RCF/RBL/NDLS, COFMOW, CORE, WPO and RWP/Bela
2. Sr. Prof. (Material Management), NAIR, Vadodara, Executive Director (Stores), RDSO, Lucknow
3. MD, CRIS,Chanakyapuri, New Delhi
4. MD, RITES, RITES Bhavan, Sector-29, Gurugram
5. Director, Iron & Steel, 3, KoilaGhat Street, Kolkata
6. Chief Commissioner, Railway Safety, Lucknow
7. Zonal Railway Training Institute, Sukadia Circle, Udaipur
8. The Genl. Secy., AIRF, Room No. 248, & NFIR Room No. 256-C, Rail Bhavan
9. The Secy. Genl., IRPOF, Room No. 268, FROA, Room No. 256-D & AIRPOA, Room No. 256-D Rail Bhavan.

Copy for information to: Joint Secretary, Department for Promotion of Industry and Internal Trade (DPIIT), Udyog Bhawan, New Delhi.

Copy to:- PSOs/Sr. PPSs / PPSs / PSs to :

1. MR, MoS(R)
2. CRB and CEO, M/TRS, M/Infra, M/OBD, MF, Secretary/Railway Board, DG (RHS), DG (RPF), DG/HR
3. All AMs, PEDs & Executive Directors of Railway Board

Annexure-6

भारतसरकार**GOVERNMENT OF INDIA**
रेलमंत्रालय **MINISTRY OF RAILWAYS**
(रेलवेबोर्ड) **(RAILWAY BOARD)**

No.2020/RS(G)/779/2/Pt.1 New Delhi, dated: 25.09.2020

The General Managers, All Indian Railways/PUs, NF(C), CORE
The DG/RDSO/Lucknow & NAIR/Vadodara
Principal CAOs, DMW/Patiala, WPO/Patna, RWP/Bela, COFMOW/NDLS
CMDs/All Railway PSUs, KRCL, MRVC

Sub: Public Procurement (Preference to Make in India) Order, 2017 – Revision.
Ref: (i) Railway Board's letters No.2015/RS(G)/779/5 dated 03.08.2017, 08-05-2018, 26-06-2018, 07/08/2018, 26/08/2019, 04/05/2020, 26/05/2020 & 03/06/2020.
(ii) Railway Board's letter No. 2020/RS(G)/779/2 dated 12.06.2020.

In reference to the above, the revised 'Public Procurement (Preference to Make in India) Order, 2017' has been issued by the Ministry of Commerce and Industry (Department for Promotion of Industry and Internal Trade) vide their Order No. P-45021/2/2017-PP (BE-II) dated 16.09.2020, which is enclosed for guidance and implementation/compliance. The decisions of the Ministry of Railways on certain matters as required by the Policy and already issued vide Board's letters under reference, unless superseded, will continue to apply.

(Anurag Grover)
Deputy Director Railway Stores(G)
Railway Board

DA: as above.

No. 2020/RS(G)/779/2/Pt.1 New Delhi, dated:25.09.2020

1. PFAs, All Indian Railways & PUs, etc.
2. The PCMMs, PCEs, PCMEs, PCEEs, PCSTEs, All Indian Railways & PUs, RCF/RBL/NDLS, COFMOW, CORE, WPO and RWP/Bela
3. MD, CRIS, Chanakya Puri, New Delhi
4. Sr. Prof. (Materials Management), NAIR, Vadodara
5. Executive Director (Stores), RDSO, Manak Nagar, Lucknow
6. Director, Iron & Steel, 3, Koila Ghat Street, Kolkata
7. Chief Commissioner of Railway Safety, Lucknow
8. Zonal Railway Training Institute, Sukadia Circle, Udaipur
9. CMDs/MDs, RITES, IRCON, IRFC, CONCOR, KRCL, CRIS, IRCTC, RailTel, RVNL, MRVC, RCIL, DFCCIL, Burn Standard, Braithwaite.

Copy to:- PSOs/Sr. PPSs/PPSs/PSs to
1. MR, MoS(R)
2. CRB, MF, M/Infra, M/TRS, M/O&BD, SECY., DG/HR, DG/RHS, DG/RPF.
3. All AMs, PEDs and All Executive Directors of Railway Board.

Annexure-7

No. P-45021/2/2017-PP (BE-II)
Government of India
Ministry of Commerce and Industry
Department for Promotion of Industry and Internal Trade
(Public Procurement Section)

Udyog Bhawan, New Delhi
Dated: 16th September, 2020

To

All Central Ministries/Departments/CPSUs/All concerned

ORDER

Subject: Public Procurement (Preference to Make in India), Order 2017– Revision; regarding.

Department for Promotion of Industry and Internal Trade, in partial modification [Paras 2, 3, 5, 10 & 13] of Order No.P-45021/2/2017-B.E.-II dated 15.6.2017 as amended by Order No.P-45021/2/2017-B.E.-II dated 28.05.2018, Order No.P-45021/2/2017-B.E.-II dated 29.05.2019 and Order No.P-45021/2/2017-B.E.-II dated 04.06.2020, hereby issues the revised 'Public Procurement (Preference to Make in India), Order 2017" dated 16.09.2020 effective with immediate effect.

Whereas it is the policy of the Government of India to encourage 'Make in India' and promote manufacturing and production of goods and services in India with a view to enhancing income and employment, and

Whereas procurement by the Government is substantial in amount and can contribute towards this policy objective, and

Whereas local content can be increased through partnerships, cooperation with local companies, establishing production units in India or Joint Ventures (JV) with Indian suppliers, increasing the participation of local employees in services and training them,

Now therefore the following Order is issued:

1. This Order is issued pursuant to Rule 153 (iii) of the General Financial Rules 2017.

2. **Definitions**: For the purposes of this Order:

   'Local content' means the amount of value added in India which shall, unless otherwise prescribed by the Nodal Ministry, be the total value of the item procured (excluding net domestic indirect taxes) minus the value of imported content in the item (including all customs duties) as a proportion of the total value, in percent.

   'Class-I local supplier' means a supplier or service provider, whose goods, services or works offered for procurement, meets the minimum local content as prescribed for 'Class-I local supplier' under this Order.

.....Contd. p/2

'Class-II local supplier' means a supplier or service provider, whose goods, services or works offered for procurement, meets the minimum local content as prescribed for 'Class-II local supplier' but less than that prescribed for 'Class-I local supplier' under this Order.

'Non - Local supplier' means a supplier or service provider, whose goods, services or works offered for procurement, has local content less than that prescribed for 'Class-II local supplier' under this Order.

'L1' means the lowest tender or lowest bid or the lowest quotation received in a tender, bidding process or other procurement solicitation as adjudged in the evaluation process as per the tender or other procurement solicitation.

'Margin of purchase preference' means the maximum extent to which the price quoted by a "Class-I local supplier" may be above the L1 for the purpose of purchase preference.

'Nodal Ministry' means the Ministry or Department identified pursuant to this order in respect of a particular item of goods or services or works.

'Procuring entity' means a Ministry or department or attached or subordinate office of, or autonomous body controlled by, the Government of India and includes Government companies as defined in the Companies Act.

'Works' means all works as per Rule 130 of GFR- 2017, and will also include *'turnkey works'*.

3. Eligibility of 'Class-I local supplier'/ 'Class-II local supplier'/ 'Non-local suppliers' for different types of procurement

(a) In procurement of all goods, services or works in respect of which the Nodal Ministry / Department has communicated that there is sufficient local capacity and local competition, only 'Class-I local supplier', as defined under the Order, shall be eligible to bid irrespective of purchase value.

(b) Only 'Class-I local supplier' and 'Class-II local supplier', as defined under the Order, shall be eligible to bid in procurements undertaken by procuring entities, except when Global tender enquiry has been issued. In global tender enquiries, 'Non-local suppliers' shall also be eligible to bid along with 'Class-I local suppliers' and 'Class-II local suppliers'. In procurement of all goods, services or works, not covered by sub-para 3(a) above, and with estimated value of purchases less than Rs. 200 Crore, in accordance with Rule 161(iv) of GFR, 2017, Global tender enquiry shall not be issued except with the approval of competent authority as designated by Department of Expenditure.

(c) For the purpose of this Order, works includes Engineering, Procurement and Construction (EPC) contracts and services include System Integrator (SI) contracts.

.....Contd. p/3

3A. Purchase Preference

(a) Subject to the provisions of this Order and to any specific instructions issued by the Nodal Ministry or in pursuance of this Order, purchase preference shall be given to 'Class-I local supplier' in procurements undertaken by procuring entities in the manner specified here under.

(b) In the procurements of goods or works, which are covered by para 3(b) above and which are divisible in nature, the 'Class-I local supplier' shall get purchase preference over 'Class-II local supplier' as well as 'Non-local supplier', as per following procedure:

i. Among all qualified bids, the lowest bid will be termed as L1. If L1 is 'Class-I local supplier', the contract for full quantity will be awarded to L1.

ii. If L1 bid is not a 'Class-I local supplier', 50% of the order quantity shall be awarded to L1. Thereafter, the lowest bidder among the 'Class-I local supplier' will be invited to match the L1 price for the remaining 50% quantity subject to the Class-I local supplier's quoted price falling within the margin of purchase preference, and contract for that quantity shall be awarded to such 'Class-I local supplier' subject to matching the L1 price. In case such lowest eligible 'Class-I local supplier' fails to match the L1 price or accepts less than the offered quantity, the next higher 'Class-I local supplier' within the margin of purchase preference shall be invited to match the L1 price for remaining quantity and so on, and contract shall be awarded accordingly. In case some quantity is still left uncovered on Class-I local suppliers, then such balance quantity may also be ordered on the L1 bidder.

(c) In the procurements of goods or works, which are covered by para 3(b) above and which are not divisible in nature, and in procurement of services where the bid is evaluated on price alone, the 'Class-I local supplier' shall get purchase preference over 'Class-II local supplier' as well as 'Non-local supplier', as per following procedure:

i. Among all qualified bids, the lowest bid will be termed as L1. If L1 is 'Class-I local supplier', the contract will be awarded to L1.

ii. If L1 is not 'Class-I local supplier', the lowest bidder among the 'Class-I local supplier', will be invited to match the L1 price subject to Class-I local supplier's quoted price falling within the margin of purchase preference, and the contract shall be awarded to such 'Class-I local supplier' subject to matching the L1 price.

iii. In case such lowest eligible 'Class-I local supplier' fails to match the L1 price, the 'Class-I local supplier' with the next higher bid within the margin of purchase preference shall be invited to match the L1 price and so on and contract shall be awarded accordingly. In case none of the 'Class-I local supplier' within the margin of purchase preference matches the L1 price, the contract may be awarded to the L1 bidder.

.....Contd. p/4

(d) "Class-II local supplier" will not get purchase preference in any procurement, undertaken by procuring entities.

3B. Applicability in tenders where contract is to be awarded to multiple bidders - In tenders where contract is awarded to multiple bidders subject to matching of L1 rates or otherwise, the 'Class-I local supplier' shall get purchase preference over 'Class-II local supplier' as well as 'Non-local supplier', as per following procedure:

a) In case there is sufficient local capacity and competition for the item to be procured, as notified by the nodal Ministry, only Class I local suppliers shall be eligible to bid. As such, the multiple suppliers, who would be awarded the contract, should be all and only 'Class I Local suppliers'.

b) In other cases, 'Class II local suppliers' and 'Non local suppliers' may also participate in the bidding process along with 'Class I Local suppliers' as per provisions of this Order.

c) If 'Class I Local suppliers' qualify for award of contract for at least 50% of the tendered quantity in any tender, the contract may be awarded to all the qualified bidders as per award criteria stipulated in the bid documents. However, in case 'Class I Local suppliers' do not qualify for award of contract for at least 50% of the tendered quantity, purchase preference should be given to the 'Class I local supplier' over 'Class II local suppliers'/ 'Non local suppliers' provided that their quoted rate falls within 20% margin of purchase preference of the highest quoted bidder considered for award of contract so as to ensure that the 'Class I Local suppliers' taken in totality are considered for award of contract for at least 50% of the tendered quantity.

d) First purchase preference has to be given to the lowest quoting 'Class-I local supplier', whose quoted rates fall within 20% margin of purchase preference, subject to its meeting the prescribed criteria for award of contract as also the constraint of maximum quantity that can be sourced from any single supplier. If the lowest quoting 'Class-I local supplier', does not qualify for purchase preference because of aforesaid constraints or does not accept the offered quantity, an opportunity may be given to next higher 'Class-I local supplier', falling within 20% margin of purchase preference, and so on.

e) To avoid any ambiguity during bid evaluation process, the procuring entities may stipulate its own tender specific criteria for award of contract amongst different bidders including the procedure for purchase preference to 'Class-I local supplier' within the broad policy guidelines stipulated in sub-paras above.

4. **Exemption of small purchases**: Notwithstanding anything contained in paragraph 3, procurements where the estimated value to be procured is less than Rs. 5 lakhs shall be exempt from this Order. However, it shall be ensured by procuring entities that procurement is not split for the purpose of avoiding the provisions of this Order.

5. **Minimum local content**: The 'local content' requirement to categorize a supplier as 'Class-I local supplier' is minimum 50%. For 'Class-II local supplier', the 'local content' requirement is minimum 20%. Nodal Ministry/ Department may prescribe only a higher

.....Contd. p/5

percentage of minimum local content requirement to categorize a supplier as 'Class-I local supplier'/ 'Class-II local supplier'. For the items, for which Nodal Ministry/ Department has not prescribed higher minimum local content notification under the Order, it shall be 50% and 20% for 'Class-I local supplier'/ 'Class-II local supplier' respectively.

6. **Margin of Purchase Preference**: The margin of purchase preference shall be 20%.

7. **Requirement for specification in advance**: The minimum local content, the margin of purchase preference and the procedure for preference to Make in India shall be specified in the notice inviting tenders or other form of procurement solicitation and shall not be varied during a particular procurement transaction.

8. **Government E-marketplace**: In respect of procurement through the Government E-marketplace (GeM) shall, as far as possible, specifically mark the items which meet the minimum local content while registering the item for display, and shall, wherever feasible, make provision for automated comparison with purchase preference and without purchase preference and for obtaining consent of the local supplier in those cases where purchase preference is to be exercised.

9. **Verification of local content**.

   a. The 'Class-I local supplier'/ 'Class-II local supplier' at the time of tender, bidding or solicitation shall be required to indicate percentage of local content and provide self-certification that the item offered meets the local content requirement for 'Class-I local supplier'/ 'Class-II local supplier', as the case may be. They shall also give details of the location(s) at which the local value addition is made.

   b. In cases of procurement for a value in excess of Rs. 10 crores, the 'Class-I local supplier'/ 'Class-II local supplier' shall be required to provide a certificate from the statutory auditor or cost auditor of the company (in the case of companies) or from a practicing cost accountant or practicing chartered accountant (in respect of suppliers other than companies) giving the percentage of local content.

   c. Decisions on complaints relating to implementation of this Order shall be taken by the competent authority which is empowered to look into procurement-related complaints relating to the procuring entity.

   d. Nodal Ministries may constitute committees with internal and external experts for independent verification of self-declarations and auditor's/ accountant's certificates on random basis and in the case of complaints.

   e. Nodal Ministries and procuring entities may prescribe fees for such complaints.

   f. False declarations will be in breach of the Code of Integrity under Rule 175(1)(i)(h) of the General Financial Rules for which a bidder or its successors can be debarred for up to two years as per Rule 151 (iii) of the General Financial Rules along with such other actions as may be permissible under law.

.....Contd. p/6

g. A supplier who has been debarred by any procuring entity for violation of this Order shall not be eligible for preference under this Order for procurement by any other procuring entity for the duration of the debarment. The debarment for such other procuring entities shall take effect prospectively from the date on which it comes to the notice of other procurement entities, in the manner prescribed under paragraph 9h below.

h. The Department of Expenditure shall issue suitable instructions for the effective and smooth operation of this process, so that:

   i. The fact and duration of debarment for violation of this Order by any procuring entity are promptly brought to the notice of the Member-Convenor of the Standing Committee and the Department of Expenditure through the concerned Ministry /Department or in some other manner;

   ii. on a periodical basis such cases are consolidated and a centralized list or decentralized lists of such suppliers with the period of debarment is maintained and displayed on website(s);

   iii. in respect of procuring entities other than the one which has carried out the debarment, the debarment takes effect prospectively from the date of uploading on the website(s) in the such a manner that ongoing procurements are not disrupted.

10. **Specifications in Tenders and other procurement solicitations**:

a. Every procuring entity shall ensure that the eligibility conditions in respect of previous experience fixed in any tender or solicitation do not require proof of supply in other countries or proof of exports.

b. Procuring entities shall endeavour to see that eligibility conditions, including on matters like turnover, production capability and financial strength do not result in unreasonable exclusion of 'Class-I local supplier'/ 'Class-II local supplier' who would otherwise be eligible, beyond what is essential for ensuring quality or creditworthiness of the supplier.

c. Procuring entities shall, within 2 months of the issue of this Order review all existing eligibility norms and conditions with reference to sub-paragraphs 'a' and 'b' above.

d. **Reciprocity Clause**

   i. When a Nodal Ministry/Department identifies that Indian suppliers of an item are not allowed to participate and/ or compete in procurement by any foreign government, due to restrictive tender conditions which have direct or indirect effect of barring Indian companies such as registration in the procuring country, execution of projects of specific value in the procuring country etc., it shall provide such details to all its procuring entities including CMDs/CEOs of PSEs/PSUs, State Governments and other procurement agencies under their administrative control and GeM for appropriate reciprocal action.

.....Contd. p/7

ii. Entities of countries which have been identified by the nodal Ministry/Department as not allowing Indian companies to participate in their Government procurement for any item related to that nodal Ministry shall not be allowed to participate in Government procurement in India for all items related to that nodal Ministry/ Department, except for the list of items published by the Ministry/ Department permitting their participation.

iii. The stipulation in (ii) above shall be part of all tenders invited by the Central Government procuring entities stated in (i) above. All purchases on GeM shall also necessarily have the above provisions for items identified by nodal Ministry/ Department.

iv. State Governments should be encouraged to incorporate similar provisions in their respective tenders.

v. The term 'entity' of a country shall have the same meaning as under the FDI Policy of DPIIT as amended from time to time.

e. Specifying foreign certifications/ unreasonable technical specifications/ brands/ models in the bid document is restrictive and discriminatory practice against local suppliers. If foreign certification is required to be stipulated because of non-availability of Indian Standards and/or for any other reason, the same shall be done only after written approval of Secretary of the Department concerned or any other Authority having been designated such power by the Secretary of the Department concerned.

f. "All administrative Ministries/Departments whose procurement exceeds *Rs.* 1000 Crore per annum shall notify/ update their procurement projections every year, including those of the PSEs/PSUs, for the next 5 years on their respective website."

10A. Action for non-compliance of the Provisions of the Order: In case restrictive or discriminatory conditions against domestic suppliers are included in bid documents, an inquiry shall be conducted by the Administrative Department undertaking the procurement (including procurement by any entity under its administrative control) to fix responsibility for the same. Thereafter, appropriate action, administrative or otherwise, shall be taken against erring officials of procurement entities under relevant provisions. Intimation on all such actions shall be sent to the Standing Committee.

11. **Assessment of supply base by Nodal Ministries**: The Nodal Ministry shall keep in view the domestic manufacturing / supply base and assess the available capacity and the extent of local competition while identifying items and prescribing the higher minimum local content or the manner of its calculation, with a view to avoiding cost increase from the operation of this Order.

12. **Increase in minimum local content**: The Nodal Ministry may annually review the local content requirements with a view to increasing them, subject to availability of sufficient local competition with adequate quality.

.....Contd. p/8

13. **Manufacture under license/ technology collaboration agreements with phased indigenization**: While notifying the minimum local content, Nodal Ministries may make special provisions for exempting suppliers from meeting the stipulated local content if the product is being manufactured in India under a license from a foreign manufacturer who holds intellectual property rights and where there is a technology collaboration agreement / transfer of technology agreement for indigenous manufacture of a product developed abroad with clear phasing of increase in local content.

13A. In procurement of all goods, services or works in respect of which there is substantial quantity of public procurement and for which the nodal ministry has not notified that there is sufficient local capacity and local competition, the concerned nodal ministry shall notify an upper threshold value of procurement beyond which foreign companies shall enter into a joint venture with an Indian company to participate in the tender. Procuring entities, while procuring such items beyond the notified threshold value, shall prescribe in their respective tenders that foreign companies may enter into a joint venture with an Indian company to participate in the tender. The procuring Ministries/Departments shall also make special provisions for exempting such joint ventures from meeting the stipulated minimum local content requirement, which shall be increased in a phased manner.

14. **Powers to grant exemption and to reduce minimum local content**: The administrative Department undertaking the procurement (including procurement by any entity under its administrative control), with the approval of their Minister-in-charge, may by written order, for reasons to be recorded in writing,

    a. reduce the minimum local content below the prescribed level; or
    b. reduce the margin of purchase preference below 20%; or
    c. exempt any particular item or supplying entities from the operation of this Order or any part of the Order.

    A copy of every such order shall be provided to the Standing Committee and concerned Nodal Ministry / Department. The Nodal Ministry / Department concerned will continue to have the power to vary its notification on Minimum Local Content.

15. **Directions to Government companies**: In respect of Government companies and other procuring entities not governed by the General Financial Rules, the administrative Ministry or Department shall issue policy directions requiring compliance with this Order.

16. **Standing Committee**: A standing committee is hereby constituted with the following membership:

    Secretary, Department for Promotion of Industry and Internal Trade—Chairman
    Secretary, Commerce—Member
    Secretary, Ministry of Electronics and Information Technology—Member
    Joint Secretary (Public Procurement), Department of Expenditure—Member
    Joint Secretary (DPIIT)—Member-Convenor

.....Contd. p/9

The Secretary of the Department concerned with a particular item shall be a member in respect of issues relating to such item. The Chairman of the Committee may co-opt technical experts as relevant to any issue or class of issues under its consideration.

17. **Functions of the Standing Committee**: The Standing Committee shall meet as often as necessary, but not less than once in six months. The Committee

a. shall oversee the implementation of this order and issues arising therefrom, and make recommendations to Nodal Ministries and procuring entities.
b. shall annually assess and periodically monitor compliance with this Order
c. shall identify Nodal Ministries and the allocation of items among them for issue of notifications on minimum local content
d. may require furnishing of details or returns regarding compliance with this Order and related matters
e. may, during the annual review or otherwise, assess issues, if any, where it is felt that the manner of implementation of the order results in any restrictive practices, cartelization or increase in public expenditure and suggest remedial measures
f. may examine cases covered by paragraph 13 above relating to manufacture under license/ technology transfer agreements with a view to satisfying itself that adequate mechanisms exist for enforcement of such agreements and for attaining the underlying objective of progressive indigenization
g. may consider any other issue relating to this Order which may arise.

18. **Removal of difficulties**: Ministries /Departments and the Boards of Directors of Government companies may issue such clarifications and instructions as may be necessary for the removal of any difficulties arising in the implementation of this Order.

19. **Ministries having existing policies**: Where any Ministry or Department has its own policy for preference to local content approved by the Cabinet after 1st January 2015, such policies will prevail over the provisions of this Order. All other existing orders on preference to local content shall be reviewed by the Nodal Ministries and revised as needed to conform to this Order, within two months of the issue of this Order.

20. **Transitional provision**: This Order shall not apply to any tender or procurement for which notice inviting tender or other form of procurement solicitation has been issued before the issue of this Order.

(Rajesh Gupta)
Director
Tel: 23063211
rajesh.gupta66@gov.in

Annexure-8

JOINT DEED OF UNDERTAKING BY THE ORIGINAL EQUIPMENT MANUFACTURER ALONGWITH THE CONTRACTOR AND INDIAN EQUIPMENT MANUFACTURER/INDIAN PARTNER

THIS DEED OF UNDERTAKING executed this ……. day of ……. Two Thousand and …… by

M/s. ……, a Company incorporated under the laws of ……. and having its registered Office at …… (hereinafter called the "Original Equipment Manufacturer", which expression shall include its successors, executors and permitted assigns),

And

M/s. ……..……..., a Company incorporated under the Indian Companies Act of 1956 and having its Registered Office at …….. (hereinafter called the "Indian Equipment Manufacturer/Indian Partner", which expression shall include its successors, executors and permitted assigns),

Through

M/s. ……..……..., a Company incorporated under the laws of …… and having its Registered Office at ……. (hereinafter called the "Contractor", which expression shall include its successors, executors and permitted assigns),

In favour of ……. Railway

WHEREAS:

1. The "……. Railway" has invited a bid as per its Tender Specification No…..…… for the execution of …… (Insert name of the package along with project name).

2. The "Contractor" at the time of bidding has submitted its bid to the "……. Railway" vide proposal No. ……dated……..for the said package and accepted by the "……. Railway", resulting into a contract (hereinafter called the "Contract").

3. The "Contractor" has selected "Original Equipment Manufacturer" along with its "Indian Equipment Manufacturer/Indian Partner", for the supply of Equipment in line with the Clause No…....., Section ……, of Volume…… forming part of the contract.

4. Under the provisions of the contract for the supply of the Equipment, the "Original Equipment Manufacturer" will supply _____ Nos. of Equipment "Indian Partner" will supply _____ Nos. of equipment.

NOW THEREFORE THIS UNDERTAKING WITNESSETH as under:

1.0 Without in any way affecting the generality and total responsibility in terms of this Deed of Undertaking, the Contractor, Indian Equipment Manufacturer /Indian Partner and the Original Equipment Manufacturer to ensure:

i. Design of the Equipment manufactured in India shall be identical to the design of equipment to be manufactured and supplied by the Original Equipment Manufacturer.

ii. Adequate up gradation of the facilities including quality systems at Indian works.

iii. Training to staff of Indian Equipment Manufacturer/Indian Partner and certification to its trained personnel to carry out each activity.

iv. Active involvement of Original Equipment Manufacturer expert in various stages of manufacturing of equipment/complete assembly, quality assurance and testing for the first unit of the Equipment at Indian Partner's works.

v. Manufacturing and Quality assurance process of Indian Equipment Manufacturer/ Indian Partner shall be same as that of Original Equipment Manufacturer.

vi. Specification of raw material and specification of major bought out components shall be same as that of Original Equipment Manufacturer.

vii. Timely supply of the said equipment shall be ensured.

viii. If necessary the Original Equipment Manufacturer shall advise the Indian equipment manufacturer/Indian Partner and/or Contractor suitable modifications of designs and implement necessary corrective measures to discharge the obligations under the Contract.

2.0 This Deed of Undertaking shall be construed and interpreted in accordance with the laws of India and the Courts in …… (Place of court to be decided by Zonal Railway) shall have exclusive jurisdiction in all matters arising under the Undertaking.

3.0 We, the Original Equipment Manufacturer/Contractor and/or The Indian Equipment Manufacturer/Indian Partner agree that this Undertaking shall be irrevocable and shall form an integral part of the Contract and further agree that this Undertaking shall continue to be enforceable till the ……. Railway discharges it.

IN WITNESS WHEREOF the Original Equipment Manufacturer, The Indian Equipment Manufacturer/Indian Partner and/or the Contractor have through their Authorised Representatives executed these presents and affixed Common seals of their respective Companies, on the day, month and year first above mentioned.

WITNESS **(For Original Equipment Manufacturer)**
Signature ……. (Signature of the authorized representative)
Name …….. Name ……..
Office Address ……. Common Seal of Company ….……

WITNESS **(For Indian Equipment Manufacturer/Indian Partner)**
Signature ……. (Signature of the authorized representative)
Name …….. Name ……..
Office Address ……. Common Seal of Company ….……

WITNESS **(For Contractor)**
Signature ……. (Signature of the authorized representative)
Name …….. Name ……..
Office Address ……. Common Seal of Company ….……

Note:
1. The non-judicial stamp papers of appropriate value shall be purchased in the name of executants parties and the date of purchase should not be later than six months of date of execution of the Undertaking.
2. The Undertaking shall be signed on all the pages by the authorised representatives of each of the partners and should invariably be witnessed.

Annexure-9

आज़ादी का अमृत महोत्सव

GOVERNMENT OF INDIA (भारत सरकार(
MINISTRY OF RAILWAYS (रेल मंत्रालय(
RAILWAY BOARD (रेलवे बोर्ड(

Azadi Ka Amrit Mahotsav

No. 2021/Elect(Dev)/221/45

New Delhi, Dated: 18.02.2022
Communication No.- S51

Director General(TI),
RDSO,
Manak Nagar,
Lucknow 226011

Sub: Cross Acceptance Criteria for the New Items/Design/Specification.

Ref: Your Office Letter No. NIL dated: 31.01.2022.

*****

Cross Acceptance Criteria for the New Items/Design/Specification received vide letter under reference has been approved by the Board (M/T&RS) with following modifications.

Para No.	As proposed by RDSO	As modified by Railway Board
3 (ii)	This guideline shall be applied for evaluation & acceptance of alternative products which are not as per the specification of RDSO but are already in use with satisfactory performance in one or more major Indian/World Railway(s) system.	This guideline shall be applied for evaluation & acceptance of alternative products for which there is no RDSO specification but are already in use with satisfactory performance in one or more major Indian/World Railway(s) system
4.4	In case the offered new items/design/specification is accepted by the Authority, the proposal along with documents/details mentioned in para 4.1 above, in support of justification shall be submitted to RDSO/Competent Authority (as decided by Railway Board) for final approval.	In case the offered new items/design/specification is accepted by the Authority, the proposal along with documents/details mentioned in para 4.1 above, in support of justification shall be submitted to RDSO for final approval.
4.5	The decision of RDSO/Competent Authority (as decided by Railway Board) for the acceptance/rejection of the new items/design/ specification shall be final and binding.	The decision of RDSO for the acceptance/ rejection of the new items/design/specification shall be final and binding.
4.7 ii.	The type test report shall be submitted to RDSO/Competent Authority (as decided by Railway Board) for	The type test report shall be submitted to RDSO for approval/ acceptance.

18/02/2022

4.7 iv b).	The test plan accepted by RDSO/Competent Authority (as decided by Railway Board) shall be forwarded to nominated testing agency as per para 5.0 of this guideline for witnessing the type test	The test plan accepted by RDSO shall be forwarded to nominated testing agency as per para 5.0 of this guideline for witnessing the type test.
5.	RDSO or any other reputed agency nominated by Authority as his representative for witnessing the type tests.	RDSO or any other reputed agency approved by RDSO for witnessing the type tests

RDSO is advised to issue Cross Acceptance Criteria to all concern for implementation on Indian Railways.

18/02/2022

(Dr. Ram Niwas)
Director Electrical Engineering (Development)
Railway Board

Telegram : 'RAILMANAK', Lucknow
Fax : 91-522-2465765
Telephone : 91-522-2465765
Mob. : 9794863137
E-Mail :dti5rdso@gmail.com
dirti1@rdso.railnet.gov.in

सत्यमेवजयते

भारतसरकार–रेलमंत्रालय
अनुसंधानअभिकल्पऔरमानकसंगठन
लखनऊ–226011
Government of India - Ministry of Railways
Research Designs & Standards Organisation
Manak Nagar, Lucknow - 226011

No. RDSO-TI0LKO(OHE)/42/2020-O/o PED/TI/RDSO Date: 12.01.2023

1. The Principal Chief Electrical Engineer,

i. Central Railway, 2nd Floor, Electrical Branch, Parcel Office Building, Mumbai CST-400001
ii. East Coast Railway, B-Rental Colony, Chandrahekhpur, Bhubaneshwar (Orrisa)-751023
iii. Northern Railway, Baroda House, New Delhi-110001
iv. North East Frontier Railway, Maligaon, Guwahati-781011
v. Southern Railway, Park Town, Chennai-600003
vi. South Central Railway, Rail Nilayam, Secunderabad-500371
vii. South East Central Railway, Bilaspur (Chattisgarh)-495004
viii. South Western Railway, DRM's office, Hubli, Banglore -580028
ix. Eastern Railway, Fairlie Place, Kolkata-700001+
x. East Central Railway, Hajipur (Bihar)-844101
xi. North Central Railway, Block-A, Subedarganj, Allahabad-211033
xii. North Eastern Railway, Gorakhpur (UP)-220055
xiii. North Western Railway, Jaipur-302017
xiv. South Eastern Railway, Garden Reach, Kolkata-700043
xv. Western Railway, Churchgate, Mumbai-400020
xvi. West Central Railway, Jabalpur-482001
xvii. Konkan Railway Corporation Ltd., BelapurBhavan, Sector-11, CBD- Belapur, Navi Mumbai, Maharastra-400614.
xviii. Metro Railway, Kolkata, Metro Bhavan, 33/1, J L Nehru Road, Kolkata-700031.

2. CAO, CORE Central Organisation for Railway Electrification, Nawab Yusuf Road Allahabad -211001
3. Director General, IRIEEN, Post Box 233, Nashik Road-422101
4. Chairman and Managing Director, IRCON, Room No. 505, Palika Bhawan, Sector -13, R. K. Puram, New Delhi-110066
5. Managing Director, DFCCIL, 5th Floor, Pragati Maidan, Metro Station Building Complex, New delhi-110 001
6. Chief Executive Officer, Railway Energy Management Co. Ltd, Ground Floor, Central Wing, Sector 29, Gurgaon-122001
7. Director Technical, MRVC, 2nd Floor, Churchgate, Mumbai-400020.
8. ED (Electrical), RVNL, 1st Floor, August Kranti Bhavan 'B' Block, BhikaJi Cama Place, R K Puram, New Delhi-110066
9. Chairman and Managing Director RITES LTD, Shikhar, Plot No.01, Sector 29, Gurgaon, Haryana, India-122001

Sub: Guideline for hotline cleaning of insulators

Ref: (i) RDSO's letter no. TI/GEN/MSG/TRD dated 31.10.2022
(ii) Item No 6.1 of CRB's Inspection Note No.2022/CRB/TP/13 dated 13.12.2022.
(iii) RDSO's letter no. No. RDSO-TI0LKO(OHE)/2/2020-O/o PED/TI/RDSO dated 06.01.2021
(iv) This office letter no. TI/GEN/MSG/TRD Dated 10.11.2020.
(v) RB letter No.2008/EEM/220/1 dated 27.10.2020.
(vi) Item No.31.6 and 31.12 of 31st MSG/TRD

Vide letter under reference (i)) above, RDSO had circulated draft guidelines for hot line cleaning of insulators to Zonal railways and other stakeholders for comments and suggestion. Comments from SR, CR, SWR and ECoR were only received. Comments were examined and based on the further studies considering safety involved and international standards & practices, Guidelines for Hot Line Cleaning of Insulators, instruction No. TI/IN/0045 Rev.0 has been finalised and approved by the competent authority. Copy of the same is enclosed here with for ready reference and necessary action of Zonal Railways.

This issues with the approval of competent authority.

(अरविंद कुमार Arvind Kumar)
निदेशक/टीआई -1 Director/TI-1
कृते महानिदेशक/ टीआई For Director General/TI

Digitally Signed by Arvind Kumar
Date: 12-01-2023 13:58:18
Reason: Approved

Copy for information please.

1. Executive Director, EEM, Railway Board, Rail Bhavan, New Delhi- 110001
2. Director /Electrical, DMRC, Metro Bhawan,8th Floor,Fire Brigade Lane, Barakhamba Road, New Delhi-110001.

सत्यमेव जयते

भारत सरकार

रेल मंत्रालय

GOVERNMENT OF INDIA

Ministry of Railways

इंसुलेटर की हॉट लाइन सफाई के लिए दिशानिर्देश

Guidelines for hot line cleaning of insulators

निर्देश संख्या टीआई/आईएन/0045 संशोधन 0

INSTRUCTION No. TI/IN/0045 Rev.0

जनवरी January, 2023

जारी कर्ता Issued by:

कर्षण संस्थापन निदेशालय,

Traction Installation Directorate

अनुसंधान अभिकल्प एवं मानक संगठन

RESEARCH DESIGNS & STANDARDS ORGANISATION

मानक नगर MANAK NAGAR

लखनऊ LUCKNOW – 226 011

(केवल आधिकारिक प्रयोग के लिए For official use only)

TITLE: Guidelines for hot line cleaning of insulators.

1. BACKGROUND:

An insulator assembly is used to provide electrical isolation between two elementary sections which are otherwise continuous. Currently conventional solid core porcelain insulators and Silicone based Composite Insulators are being used in Indian railways. Ceramic insulators are made from porcelain, whereas Composite insulators are made of silicone based composite rubber material.

The OHE insulators require regular cleaning to ensure uninterrupted traction power supply. The periodicity of cleaning varies from area to area depending upon pollution level. Where pollution is heavy, the cleaning is to be done more frequently. The cleaning is essential as the insulators are affected by dust/ smoke particles, industry/ chemicals deposits. If these deposits are not removed at regular intervals, they are liable to become hard and difficult to remove in course of time, and by reducing the insulation of the OHE greatly, lead finally to a flashover and puncture.

2. DESCRIPTION OF EXISTING PRACTICE OF CLEANING OF INSULATOR IN IR:

2.1 The existing practice in Indian Railways for cleaning porcelain insulators manually have been given in ACTM Vol- I (20229) with the help of ladder and tower car by taking power blocks. All insulators cleaned with dry cloth and look for any flashover marks, cracks, and chippings. Insulators which are badly chipped are replaced. Minor chippings are rendered impervious to moisture by a light coating of Araldite or similar epoxy.

2.2 For composite insulators, instruction no. TI/IN/0040 Rev.0 (November, 2019) for cleaning of 25 KV composite insulators has been issued by RDSO, which stipulates cleaning of composite insulators with DRY SOFT COTTON CLOTH only to remove the dust/ pollution from the insulator. No water, detergents, any solvents and abrasive materials is to be used for cleaning as use of such material leads to deterioration of electrical properties thus causing failure.

3. Railway Board's Recommendations of 31st MSG (TRD) meeting held on 8th & 9th November, 2019 at Somnath in Western Railway were communicated to Zonal Railways vide RDSO's letter no TI/GEN/MSG/TRD dated 10.11.2020.

3.1 As per the recommendations against item No.31.6 & 31.12 of 31st MSG (TRD) meeting held on 8th & 9th November, 2019 at Somnath, Western Railway; Central Railway (CR) and North Central Railway (NCR), being item proposing Railways were requested vide RDSO's letter no. No. RDSO-TI0LKO(OHE)/2/2020-O/o PED/TI/RDSO dated 06.01.2021 to submit the details regarding Hot line cleaning system for OHE Insulators for further study at RDSO.

3.2 Southern Railway vide letter No. E.134/ET/11/OHE, dated 30.05.2022, had sent recommendations of 31st MSG (TRD) meeting to TI/RDSO. As per the recommendations against item No.31.6 & 31.12, Southern Railway has submitted the details regarding Hot line cleaning system for OHE Insulators

4. Details received from Central Railway and Southern Railway regarding Hot line cleaning system. The same has been examined and following are observed:

4.1 Central Railway and Southern Railway have proposed system for hotline cleaning where high pressure water jet is utilized for cleaning of insulators. Due to presence of triplex piston pump/ high pressure pump, water path is not continuous thus increasing electrical resistivity which minimizes leakage current to a negligible level.

4.2 For operating the system with sufficient electrical resistivity required, the nozzle of water pump is required to be held at a predetermined distance from the live point so that negligible leakage current is encountered. The distance varies with voltage level as given in Para 6.5.2.

4.3 This system requires application of demineralized water with a resistivity greater than 100000 Ω.cm is desirable for insulator cleaning purpose.

4.4 For safety reasons, conductivity of water and leakage current is continuously required to be monitored by suitable conductivity meter & leakage current detector respectively.

4.5 The details of tools/ test instrument of hotline cleaning system sent by Central Railway are for 110 kV system being used at TATA power substation.

4.6 RDSO have done literature survey over internet to see the world wide scenario of hotline cleaning of insulators. As per details available over internet no hot line cleaning of insulator is found in practice for railway system Internationally. However, hotline cleaning is being employed for cleaning of transmission line insulators by various TRANSCOM and DISCOMS.

5. Currently four type of hot line cleaning of insulators suggested worldwide i.e. High-pressure water washing, Compressed air cleaning, CO2 pellets and hot wiping. The details are as under:

5.1 High-pressure water washing:

High-pressure water washing utilizes a narrow stream of water with typical pressures ranging 400 psi to1000 psi at the nozzle. Four types of nozzles are most often used with high-pressure water handheld jet, remote-control jet (pea shooter), fixed spray, and helicopter mounted. The details submitted by Central Railway employs this system.

5.2 Compressed air cleaning:

This method of cleaning insulators involves the use of compressed air and an abrasive cleaning compound. This procedure requires an air compressor capable of supplying a minimum of 0.05 m3/s at 125 psi, an air dryer, a pressure blaster, an applicator wand, adequate supply hoses, and cleaning compound.

5.3 CO2 Pellets (Dry Ice):

CO2 pellets are a commonly used nonabrasive component. In the CO2 process, the pellets of frozen CO2 strike the surface of the insulator, penetrating through the contaminant to the insulator surface. The pellet then sublimates into a gas, which blasts the contaminant from the surface. There is no abrasive action to the insulator. This is normally used to break the ice deposition on insulators.

5.4 Hot Wiping (Using a Live-Line Tool):

A procedure using hot sticks (insulated rods) and a special hammock (usually made from burlap i.e fabric used to make sacks) to clean energized insulators is used on equipment operating at voltages from 4 kV to 69 kV. The need for cleaning energized insulator depends upon the level of contamination and the risk of flashover during washing. This procedure may also be used prior to hot washing of insulators to reduce the possibility of flashover.

Some Railways have tried this process by using discharge rods for wipe cleaning of the insulators but not found very effective.

6. WORLDWIDE PRACTICES OF HOT LINE WASHING OF INSULATORS AS PER IEEE STD 957:2005:

6.1 Water quality for hot line cleaning:

6.1.1 Water of high resistivity or low conductivity is utilized in cleaning energized insulator.

6.1.2 Constant testing of the water being used is important and carried out as resistivity of water can quickly change due to change in temperature.

6.1.3 Water of poor resistivity, in the range of 750-ohm cm to 1000-ohm cm is purified by de-ionizing system or filtering.

6.1.4 Minimum water characteristic is determined based on planed operating practice and expected voltage.

6.1.5 A resistivity greater than 1500 ohm-cm is normally preferred.

6.1.6 Heavy ice accumulation on insulator can be cleaned using hot water jet spray having resistivity in order of more than 50000 ohm-cm. High water resistivity is required due to the fact that resistivity decreases by a factor of two with the increase of temperature from 25^{o}C to 70^{o}C.

6.2 Cleaning Equipment: Cleaning equipment generally consists of high pressure (400 to 1000 psi) generating pump mounted on road/Rail vehicle with electrical/mechanical water control mechanism including piping, hose, nozzle and water spray jets etc. Pump is powered by means of road vehicle engine itself or separate engine mounted on the road/Rail vehicle. Fiber glass coated mild steel tank or stainless steel of adequate capacity to carry the DM water for hot washing of insulator.

6.3 Type of Insulators to be cleaned:

6.3.1 Porcelain insulators are normally cleaned by hot line cleaning systems.

6.3.2 For cleaning of composite polymer insulator, manufacturers recommendations are required as high-pressure washing is not recommended for such insulators.

6.3.3 RDSO have interacted with manufacturers of composite insulators to have broad view on the methodology of cleaning of 25 kV composite insulator on Indian Railways. Based on the feedback received, RDSO have issued instruction no. TI/IN/0040 Rev.0 (November, 2019), instruction for cleaning of 25 KV composite insulators. The same is to be followed for cleaning of 25 KV composite insulators.

6.4 Cleaning of Surge Arrestors, Transformer Bushings etc:

6.4.1 Power Transformer Bushings and external enclosures of the surge arrestors are also made of porcelain. While cleaning bushings much attention and care is given being vital part of power transformers and most of its failure starts from bushing failure. Due consideration is given on the pressure and volume of cleaning water with mechanical support. Normally bushings are cleaned with low pressure water jet with fixed nozzle so as to cover entire bushing in one go.

6.4.2 For surge arrestors, energized washing may impose severe electrical stresses on the surge arresters due to voltage imbalance and is performed under guidance of the arrester manufacturer.

6.5 Other Technical Consideration

6.5.1 Leakage Current:

As per IEEE Std 957:2005, for hotline cleaning system, leakage current is defined as the current that flows through normally nonconducting element such as hose. The parameters that influence the leakage current in the wash water stream are as follows:

(a) Line voltage
(b) Distance from the nozzle tip to the energized parts
(c) Water resistivity or conductivity
(d) Water pressure
(e) Nozzle orifice diameter

Normally, a person feels sensation of leakage current of 1mA. Assuming that washing nozzle is properly grounded, no leakage current should flow. To ensure safety, the hotline cleaning equipment, the structure, and the person handling equipment should be at the same potential. However, in case of accidental ungrounding of the nonconducting path of washing nozzle, the leakage current should be limited to 2mA. Currents exceeding 1 or 2 mA are to be guarded against by the using water that falls within the acceptable range of conductivity or resistivity, replacing worn out nozzles and by carefully maintaining safe working distance.

6.5.2 Safe Working Distance:

Nozzle-to-conductor distance for a given line voltage and nozzle diameter is the most important parameter that influences the leakage current and the washing effectiveness of

the water stream. Washing effectiveness and the magnitude of leakage current decrease with increasing nozzle-to-conductor distance. In cases where the wash distance is limited by the tower/structure dimensions, demineralized water of minimum resistivity of 50000 ohm-cm can be used. IEEE Std 957:2005 defines the minimum nozzle to conductor distance for various line voltages. These parameters for applicable voltage range of Indian Railways are tabulated below:

Line Voltage (kV)	minimum nozzle to conductor distance (m)	Minimum water resistivity (ohm-cm)*	Minimum nozzle pressure (psi)	Maximum orifice diameter (mm)
34.5	2.44	1300	400	4.76 to 6.35
69	2.74 to 3.66	1300	400	4.76 to 6.35
115	3.05 to 3.96	1300	400	4.76 to 6.35
230	3.66 to 4.57	1300	400	4.76 to 6.35

** However, for Indian Railway application, cleaning with demineralised water having resistivity of 100000 ohm-cm or greater is recommended due to safety reasons.*

It may be noted, along with maintaining the minimum distance between nozzle and insulator being cleaned, maintaining the maximum distance is also important to maintain the high-pressure compact stream to effectively and accurately wash the contaminants away from insulators. Failure to establish a maximum distance can place the worker at risk by leading to just wetting the insulator surface thus increasing the chances of insulator flashover during hotline cleaning.

6.5.3 Water Resistivity:

It is also an important factor affecting amount of leakage current. Water should be obtained from clean water source and must not contain any chemical, salt or any type of detergent. Resistivity of water depends on water quality. Water of high resistivity greater than 1500 ohm-cm is widely used in hotline cleaning of insulators. Demineralized water of 100000 ohm-cm or greater resistivity is recommended. Water resistivity decreases with increase of water temperature. India being the country of varying weather cycle, hence it is of utmost important that water resistivity is continuously measured specially in summer seasons. To prevent this, water circulating pumps are given rest and not continuously operated. Further, non-temperature compensation type Portable resistivity meters can be utilized for time-to-time measurement of water resistivity though it is not fail safe in extreme hot weather conditions of Indian sub-continent. It is hence preferable that constant resistivity measurement system (non-temperature compensated) should be in built in the hotline

cleaning system for continuous monitoring of the washing water resistivity while hotline cleaning system is in operation to prevent accidental use of high resistivity water.

6.5.4 Grounding:

Road or Rail Vehicle containing hot line washing system should be properly grounded during hotline cleaning operation to prevent building up of dangerously high voltage charges. Also it should be ensured that no human contact is made with the vehicle to avoid establishing a parallel ground through a person's body.

Adherence of the requirements stated in the preceding subclauses will limit the leakage current to safe limits. Additional protection is provided by placing the washing gun operator in an equipotential zone by bonding and grounding appropriately. Refer to IEEE Std 1048-2003 for additional details related to grounding and IEEE Std 957:2005 for hotline cleaning of the insulators.

7. LIMITATION OF LIVE LINE CLEANING IN INDIAN RAILWAY:

7.1 Normally, hotline washing systems employ washing system with all accessories like DM water tank, pump etc. mounted on Road vehicle. Such system in Indian Railway can only be utilized in the sections which are accessible by Road.

7.2 For sections, where road approach is not possible, dedicated cleaning tower cars equipped with hotline cleaning system with all accessories like DM water tank, pump etc. shall be required this would eliminate the requirement of power block and shall minimize the duration of Traffic block required for cleaning of insulators.

7.3 For hot line washing, the resistivity of water should be greater than 1500 ohm-cm to avoid increased leakage current which is dangerous to human safety. Where de-mineralized water jet at very high pressure (400 to 1000 psi) is used, the resistivity of de-mineralized water should be more than 100000 ohm cm.

8. SAFETY ASPECTS:

Following safety measures need to be ensured during Hot line cleaning:

8.1 In general, live line working condition, there is risk of electrocution of worker due to flow of current from the live equipment through the worker.

8.2 Safety kit materials such as ground mat, rubber shoes, rubber gloves, rain clothes etc. are must for the nozzle operator and should be ensured to avoid getting wet and to prevent electric shock from live voltage.

8.3 Safe working distance shall be maintained in accordance to subclause 6.5.2 of this guideline.

8.4 Water of high resistivity or low conductivity should be utilized in cleaning energized insulator. In general, warm water has a lower resistivity than cold water. The initial stream should be directed away from the energized equipment until the warm water of lower resistivity is cleared from the hose pipes.

8.5 Continuous Measurement of resistivity of water: As resistivity can quickly change due to change in temperature. Resistivity of water and leakage current is continuously required to be monitored by suitable non-temperature compensation type resistivity meter & leakage current detector respectively. Suitable interlock with Audio Alarm to restrict the flow of water in case of water resistivity falling below minimum threshold or leakage current going above threshold level shall also be provided in hotline cleaning system as a safety measure.

8.6 Road or Rail Vehicle containing hot line washing system should be properly grounded during hotline cleaning operation. No person should be allowed to touch the vehicle while hotline cleaning is in process.

8.7 A display board containing Danger sign and symbol should be displayed on Road or Rail Vehicle containing hot line washing system, when in operation.

8.8 The nozzle should be grounded properly with the common earthing system of the metallic structure on which the insulator being cleaned is fixed.

8.9 It should be ensured that washing gun operator is in an equipotential zone by bonding and grounding nozzle appropriately to whatever the operator is standing on.

8.10 Grounding cable used should be as per cable details mentioned in the RDSO specification No. ETI/OHE/51 (9/87) with latest amendments.

8.11 Hotline cleaning of insulators to be preferably done through outsource. Person employed for hotline cleaning should be trained and certified by reputed training institutes like Hot Line Training Centre (HLTC), National Power Training Institute (NPTI), Ministry of Power, Government of India, Bengaluru. Railway officials associated with the work of hotline cleaning of insulators shall also be provided similar training and certification.

8.12 Hot line cleaning is to be done only during bright sunny day and should not be carried out during rainy, cloudy and night conditions.

8.13 Safety Gears and Equipment: the operating personnel should wear prescribed protective gears vis-à-vis safety helmet, tinted UV protected eye glasses, safety shoes and any other safety equipment as prescribed from time to time during Live Line washing.

8.14 The following standards with latest revision should be used for safety items.

(a) Gloves—ASTM D 120 and IEC 60903:2014
(b) Sleeves—ASTM D 1051 and IEC 60984:2014
(c) Protectors for rubber insulating gloves—ASTM F 696

8.15 Water of high resistivity greater than 1500 ohm-cm is widely used in hotline cleaning of insulators. Demineralized water of 100000 ohm-cm or greater resistivity shall be used and can be obtained from demineralizing plants.

For Indian Railway application, cleaning with demineralized water having resistivity of 100000 ohm-cm or greater is recommended due to safety reasons

9. RECOMMENDATIONS:

9.1 RDSO have explored the matter and it is found that on line cleaning of insulators is being carried out by other utility normally through outsource. These sources use demineralized water (DM) for cleaning of insulator. DM is carried on dedicated road vehicle and insulator cleaning is done online with the facilities available on vehicle. The vehicle and accessories are insulated with working voltage.

9.2 In Indian Railway's system, some of the locations are not approachable by road vehicle. Hence this system may not be feasible at all locations over IR. If such cleaning is considered to be done by using Tower Cars, dedicated tower cars equipped with hotline cleaning system with all accessories like DM water tank, pump, hose pipes, spray gun etc. needs to be developed to cover all section of the IR. Alternatively, due to limitation of space available in tower cars, following arrangement can also be considered by Zonal Railways as per feasibility and requirement:

9.2.1 Hot line cleaning system with all accessories like DM water tank, pump, hose pipes, spray gun etc. commissioned on a wagon can be hauled by tower car for undertaking hot line cleaning of insulators.

9.2.2 Road vehicle containing hot line cleaning system can be loaded on Ro-Ro Wagon and be hauled by existing tower wagon to facilitate hotline cleaning in remote areas not approachable by Road. Special precautions to be taken to prevent any miss happening during brake operation and in section with high gradients and sharp curves due to probable offloading of water in onboard DM water tank.

9.3 Hot line cleaning of insulators may be considered for the insulators of transmission lines owned by the Railways, Traction Sub stations, switching station, Main line, Yard lines, sidings where the area is approachable by road vehicle.

9.4 Due care is required for cleaning of Power Transformer Bushings and external enclosures of the surge arrestors due to reasons explained in Clause 6.4 of this guideline.

9.5 Hotline cleaning of insulators to be preferably done through outsource. Person employed for hotline cleaning should be trained and certified by reputed training institutes like Hot Line Training Centre (HLTC), National Power Training Institute (NPTI), Ministry of Power, Government of India, Bengaluru. Railway officials associated with the work of hotline cleaning of insulators shall also be provided similar training and certification.

9.6 It should be ensured that hot line system is equipped with suitable non-temperature compensation type resistivity meter & leakage current detector for online monitoring of cleaning water resistivity and leakage current respectively. Suitable interlock with Audio Alarm to restrict the flow of water in case of water resistivity falling below minimum threshold level or leakage current going above threshold level shall also be ensured in hotline cleaning system as a safety measure.

9.7 For Indian Railway application, cleaning with demineralized water having resistivity of 100000 ohm-cm or greater is recommended due to safety reasons

9.8 An indicative specification for a typical hot line cleaning system is attached as Annexure-I. Zonal Railways are advised to take help of this during procurement/calling tenders as per site requirement.

10. REFERENCES:

- ACTM Vol- I
- RDSO letter No. TI/OHE/INSCOM/GEN, dated 02.11.2019 for Composite insulators, instruction no.TI/IN/0040 Rev.0 (November, 2019) for cleaning of 25 KV composite insulators
- RDSO's letter no TI/GEN/MSG/TRD dated 10.11.2020 for communication of Railway Board's Recommendations of 31st MSG (TRD) meeting held on 8th & 9th November, 2019 at Somnath in Western Railway.
- Southern Railway Letter No. E.134/ET/11/OHE, dated 30.05.2022, for recommendations of 31st MSG (TRD) meeting to TI/RDSO.
- Central Railway Letter No. L.574.TRD.MSG 31ST, dated 21.01.2021
- IEEE 957 -2005 guide for cleaning of insulator.
- RDSO specification No. ETI/OHE/51 (9/87) for Specification for Discharge/ earthing pole assembly for 25kV ac traction.
- SWR letter No. SWR/EL/T-601/RDSO, Date: 03.11.2022.
- SR letter No. /E.220/Policy (e-file 28834), Date: 07.11.2022.
- CR letter No.L.547.TRD.MI.IN, Dated: 10.11.2022
- ECoR letter No. ECoR/EL/TRD/443/56, Date: 09.11.2022

***

Annexure-I

Indicative Technical Specification for a typical Hotline cleaning system for Insulators

SN	Description	Parameter Specification, Capacity, Range	Remarks
1.	Water Pump:	High pressure water pump (Triplex type) Maximum pressure 1800 psi. Suitable pressure measurement device shall be provided with Pump	---
2.	Nozzle to generate water jet pressure of 400 to 1000 psi	Variable Orifice sizes (from 4.76 mm to 6.35 mm) Material: Brass or aluminum bodies with steel, stainless steel, ceramic, or metal compounded tips. The nozzle is to be attached to a handheld wash gun.	---
3.	Water tank	Stainless steel tank with minimum 2000 Ltrs capacity	---
4.	Hose pipe & Reel	High pressure (Minimum 2000 psi) steel reinforced R1/R2 hose pipe with suitable reel with manual rotating arrangement	---
5.	Cleaning Water	Demineralized water with minimum resistivity 100000 ohm-cm	---
6.	Resistivity meter	Non-compensating type, panel mounted resistivity meter to measure resistivity of cleaning water in the range of 0 to 1 megaohm cm.	These items to be integrated on the hot line cleaning system control panel.
7.	Leakage current detector	Rang 0 to 5 mA	
8.	Safety interlock	Suitable safety interlock with Audio Alarm to be provided to restrict flow of water in case of resistivity falling below minimum threshold value.	
9.	Distance/Nozzle pressure	• Minimum nozzle to conductor distance: 2.74 to 3.66 meter • Minimum nozzle pressure: 400 psi • Minimum DM water resistivity: 100000 ohm-cm • Maximum orifice diameter : 4.76 to 6.35 mm	---
10.	Grounding Cable	As per cable details mentioned in the RDSO specification No. ETI/OHE/51 (9/87) with latest amendments.	---
11.	Safety Accessories	SN / Safety Item / Standards (a) Gloves — ASTM D 120 and IEC 60903:2014 (b) Sleeves — ASTM D 1051 and IEC 60984:2014 (c) Protectors for rubber insulating gloves — ASTM F 696	---

Note: *Zonal Railways are advised to take help of this indicative specification for framing of tender specification for procurement/calling tenders for works as per site requirement.*

भारतसरकार - रेलमंत्रालय - अनुसंधानअभिकल्पऔरमानकसंगठन,मानकनगर,लखनऊ-226011
Government of India - Ministry of Railways
Research Designs & Standards Organisation, Manak Nagar, Lucknow – 226011
बीएसएनएल/BSNL:91-522-2465731
रेलवे/Railway: 42804, फैक्स/Fax : 91-522-2465731
ईमेल/E-mail: dtiohed.rdso@gmail.com

No. RDSO/759/2022 Dated, the 12th June, 2023

To,

The Principal Chief Electrical Engineer,

(i) Central Railway, Station Building, Mumbai CST – 400 001
(ii) Eastern Railway, Fairlie Place, Kolkata-700 001.
(iii) East Central Railway, Hajipur-844 101.
(iv) East Coast Railway, Bhubaneshwar -751 023.
(v) Northern Railway, Baroda House, New Delhi - 110 001.
(vi) North Central Railway, Allahabad -211 015.
(vii) North Eastern Railway, Gorakhpur -273 012.
(viii) North Frontier Railway, Mailgaon - 781 011.
(ix) North Western Railway, Jaipur – 302 017.
(x) Southern Railway, Park Town, Chennai- 600 003.
(xi) South Central Railway, Railnilayam, Secunderabad-500371
(xii) South Eastern Railway, Garden Reach, Kolkata- 700 043.
(xiii) South East Central, Railway, Bilaspur -495 004.
(xiv) South West Railway, DRM's Office, Hubli-580 028.
(xv) Western Railway, Churchgate, Mumbai-400 020.
(xvi) West Central Railway, Jabalpur - 482 001.
(xvii) Konkan Railway, Belapur Bhavan, Navi Mumbai – 400614

(b) Chief Administrative Officer, Central Organisation for Railway Electrification, Nawab Yusuf Road, Allahabad-211000.

विषय/Sub: General Guidelines for OHE design in **concourse area** for station development projects.

****

Technical Instruction No. TI/IN/0047 for "General Guidelines to Zonal Railways for OHE design in concourse area for station development projects" has been prepared and enclosed herewith for further n/a at your end."

This is issued with the approval of competent authority.

Digitally Signed by Girraj Kishore
Date: 12.06.2023 17:27:40
Reason: Approved

(Girraj Kishore)
Joint Director/(TI-2)
[*For Director General (TI)*]

Encl: As above

GOVERNMENT OF INDIA
Ministry of Railways

GENERAL GUIDELINES
TO
ZONAL RAILWAYS
FOR
OHE DESIGN
IN
CONCOURSE AREA
IN
STATION DEVELOPMENT PROJECTS

INSTRUCTION No. TI/IN/0047

Issued by:
Traction Installation Directorate
RESEARCH DESIGNS & STANDARDS ORGANISATION
MANAK NAGAR
LUCKNOW – 226 011

(For official use only)

JUNE 2023

TITLE: GUIDELINES FOR DESIGN OF OHE UNDER THE CONCOURSE COMING IN STATION AREAS ON INDIAN RAILWAYS

INSTRUCTION NO.: TI/IN/0047

	PREPARED BY		CHECKED BY	APPROVED BY
Signature			12/6/23	12/6/23
Date	12.06.23	12-06-2023	12/6/23	12/6/23
Name	**GIRRAJ KISHORE**	**A. D. MAURYA**	**BHARDWAJ CHAUDHARY**	**ARUN KUMAR**
Designation	**JDTI-2**	**DIRECTOR/CIVIL**	**EDTI**	**PED/TI**

ASSISTED BY:

i) Smt. Anuradha Srivastava, Senior Section Engineer,

ii) Shri Mukesh Kumar, Senior Section Engineer,

INDEX

SN	DESCRIPTION	PAGE NO.
1.	INTRODUCTION	4
2.	GENERAL GUIDELINES	4-5
3.	OHE SYSTEM REQUIREMENTS	5-6
4.	MINIMUM HEIGHT OF OVERLINE STATION STRUCTURES	6-10
5.	EARTHING AND GROUNDING ARRANGEMENTS	10-12
6.	OHE LOADING FOR STRUCTURE DESIGN	13-16
7.	BIRD MENACE	16-17
8.	SAFETY REGULATIONS	17-18
9.	PHOTOGRAPHS OF OHE ARRANGEMENT AT RAILWAY STATIONS:	19-23

1.0 INTRODUCTION

Many references are being received regarding Technical requirement for finalization of Design for 1X25kV and 2x25 kV OHE under the concourse area in connection with the Redevelopment/Development of Railway Station.

The 25kV OHE will be required to be installed on the ceiling / soffit of the structure built over the track space. OHE Portal upright can also be integrated with steel/RCC structure supporting the platform shelter.

The IRSDCL (Indian Railway Station Development Corporation Limited) report regarding Modification in OHE in connection with Redevelopment of Railway Station accepted by Railway Board (MTR) vide letter no 2003/RE/161/1 Vol-III/Pt. Dated 19/27.09.2017 and the same was circulated to all zonal railways vide TI/OHE/IRSDCL/2017 dated 31.10.2017.

.

Based on the IRSDCL Report and directives issued by Railway Board, Guidelines for design of OHE under the concourse coming in station areas on Indian Railways incorporating latest provisions of IRSOD (BG) Revised-2022, Guidelines has been prepared for guidance that would be applicable while redeveloping the existing stations electrified with 1X25kV AC OHE/2X25kV AC OHE for Electric Traction.

2.0 General Guidelines:

2.1 A study should be carried out covering the following aspects:

(a) Minimum height of the bottom of the beam, which should comply with all the extant regulations.

(b) The concourse structure shall be designed such as to allow the standard OHE equipment to be used. The fixing arrangements (bolts/holes/plates etc.) shall be provided suitably in the concourse structure for OHE arrangement.

(c) Earthing of concourse structure: If the OHE is hung from the concourse structure, proper earthing requirement for steel / concrete structures.

(d) Openings in the concourse on sides: Any special requirements for the design of concourse, which will ensure protection of OHE (so that nothing can be thrown on the OHE / tracks).

(e) Addressing bird menace: The bottom of beams and other arrangements shall be such as not to provide any space for the birds to sit and/or nest as this can create safety issues with OHE. If this cannot be ensured, protection measures required for catenary wires under the concourse.

(f) While designing the concourse structure, it shall be possible to provide OHE even at locations where the main beams of concourse structure are not there. Arrangement shall be there for future tracks.

(g) The concourse structure shall be designed keeping the present and future planned OHE loads in mind. There are several different types of arrangements including single set of wires, double set of wires, anchored wires and ATD arrangement etc. The absolute loads for these arrangements in all three directions need to be considered in design. It is desirable that the maximum spans / maximum wind loads be considered so that flexibility for future modification of OHE is there.

3.0 OHE SYSTEM REQUIREMENTS:

While designing OHE System in Station Area, following OHE parameters should be considered:

(a) Standard Contact wire height at support should be 5.6m/5.55m with 100mm/50mm Presag respectively.

(b) In conventional (1X25kV) 65/107 OHE, tension in Contact and Catenary wire should be 1200/1200 kgf & in 2X25kV System, tension in Contact and Catenary wire should be 1200/1200 kgf in 65/107 OHE or 1500/1500kgf tension in 125/150 OHE.

(c) OHE gradient & Relative gradient outside the station concourse structure (overhead structure) shall be 2mm/m and 1mm/m respectively. Level OHE gradient should be maintained under overhead structure.

(d) Minimum dropper length shall not be less than 200mm.

(e) Rail level shall not be raised (other than 20mm for track maintenance allowance) and permanent bench mark shall be provided to indicate the maximum level of track to be maintained.

(f) OHE spans under concourse area may be selected in line with civil structure design and may not be standard spans.

(g) Minimum height of the bottom most part of the supporting member/structure above the rail level should not be less than 8.03m with 1400mm encumbrance (5.55m contact wire height at support +1.4m encumbrance + 0.2m extended bracket tube + 0.110m distance between catenary to bracket tube + 0.2m short time clearance + 0.05m Oscillation of contact wire + 0.02m track maintenance margin + 500mm additional clearance for civil structure tolerance and conductor diameters). Similarly for other values of encumbrances adopted as per site condition, the height of concourse is given in Para No. 4.0.

(h) For the station being developed / redeveloped, the OHE spans need to be kept in line with the civil structure. For example, if beams are spaced @20m, the OHE span may be selected as 20m or 40m. Dropper schedule for any span can be worked out as per the methodology provided in Chapter 2 (Dropper Schedule), Part IV (Overhead Equipment) of Treatise on Electric Traction Distribution issued by IRIEEN.

(i) Overall proposed vertical clearance of approximately 770 mm between top most portion of Bracket tube and bottom most part of concourse should be maintained (It includes 20mm track maintenance allowance, 250mm minimum Electrical Clearance and 500 mm additional clearance; civil structure tolerance, conductor diameter is included in it).

(j) It should be ensured that minimum clearance of feeder wire at mid span from Rail level should not be less than 5.2m as per clause 58 of CEA guidelines.

(k) Feeder wire should be provided at a distance of minimum 950mm from cantilever assembly as per RDSO Drawing No. ETI/OHE/G/6000 Rev. B. Necessary arrangement for fixing of feeder wire with 9-Tonne Insulator

should be made while casting. 91.97mm^2 ACSR aerial earth conductor should run at the back side on drop arms.

(l) Drop arm over platform should be avoided. If it is unavoidable, vertical clearance of Drop arm from platform should be as per Diagram No. 2 (standard Dimensions in Stations to suit 25kV A.C. Traction Schedule-I chapter II) of IRSOD(BG) revised – 2022. It should also be ensured that no live conductor should be run over platform as per Para 20.4 of Appendix-I of ACTM Volume-II, Part-II.

(m) For 2X 25 OHE system, guidelines regarding OHE parameters, provision of AEC, BEC, Negative feeder etc. given in the RDSO Instruction TI/IN/0042 should be referred.

(n) The design load for each support of OHE cantilevers shall consider two OHEs (65/125 sq. mm catenary wire and 107/150 sq. mm contact wire). The design shall have the following features:

Locations, where foundation bolts are provided for OHE support structure, shall be indicated in the document submitted to the concern division.

(o) Anchor load of 2400/3000 kgf, on beam structure as well as on the face of the station concourse shall be considered in design of concourse. From safety point of view of structures, the broken wire impact on structures due to Anchor load i.e. 2400/3000 Kg should also be considered.

(p) To prevent bird menace, appropriate measures such as closed sections, RSJ/BFB drop arms etc. are recommended so as not to provide any space for birds to make nests. Suitable arrangement for the cantilever support should be done.

(q) To prevent monkey menace, the walls towards the trackside shall have no windows and ledges etc. which can be used by monkey.

(r) Concourse design should not permit any possibilities of physical contact with live parts (in line with EN 50122-1) and which eliminates possibility of throwing any object on live OHE shall be adopted.

(s) All the latest directives of Railway Board & RDSO for installations of OHE shall be ensured.

(t) All the latest stipulation given in IRSOD (BG)-2022, ACTM 2022 and CEA Regulation should be ensured.

4.0 MINIMUM HEIGHT OF OVERLINE STATION STRUCTURE FOR DIFFERENT CASES:

Case-I: Refer to figure 1a, 1b, 1c below for schematic arrangement for (cantilever suspended from concrete beam).

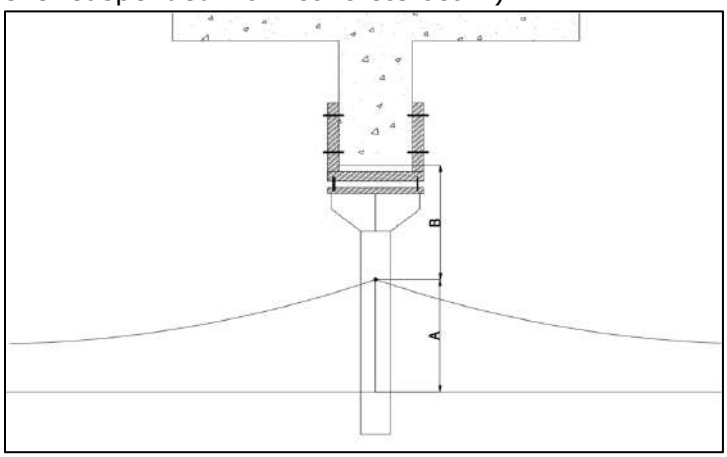


Figure 1a: Cantilever suspended from concrete beam

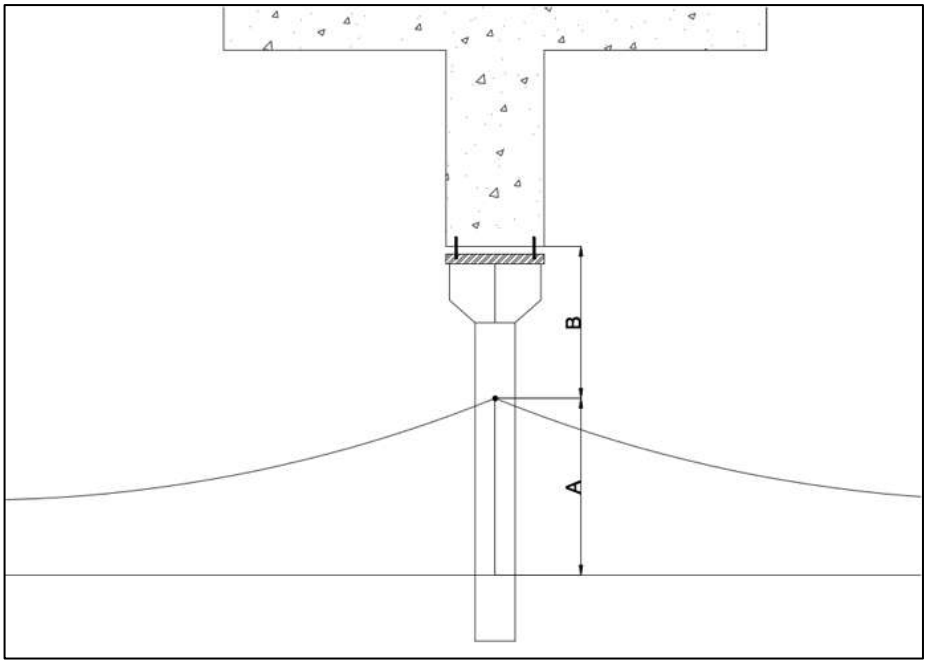


Figure 1b: Cantilever suspended from concrete beam (different fixing arrangement)

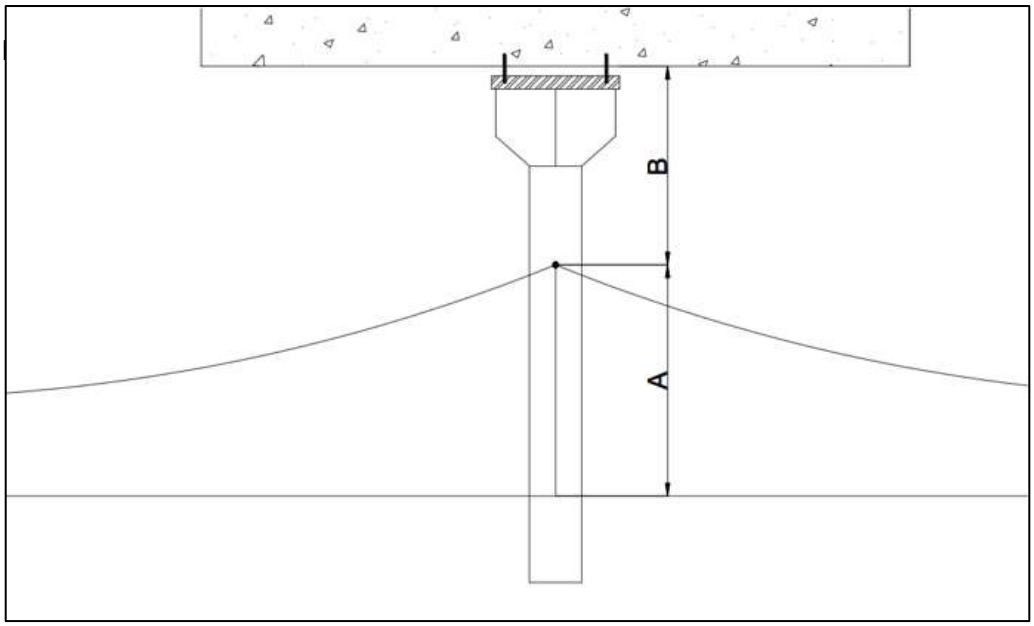


Figure 1c: Cantilever suspended from concrete beam (different fixing arrangement)

'A' is encumbrance in the above figures
'B' is minimum gap between bottom most point of beam and top most point of live parts i.e. top point of bracket tube (refer figure 2 below)

4.1 In figure 2 / 3, case of lower suspension distance (say 1.8m) (distance between mast face and catenary wire) is considered, which will be most onerous in this respect.

Hence B = 770mm (electrical clearance) + 310mm (Vertical distance between Catenary wire and bracket tube top) = 1080mm

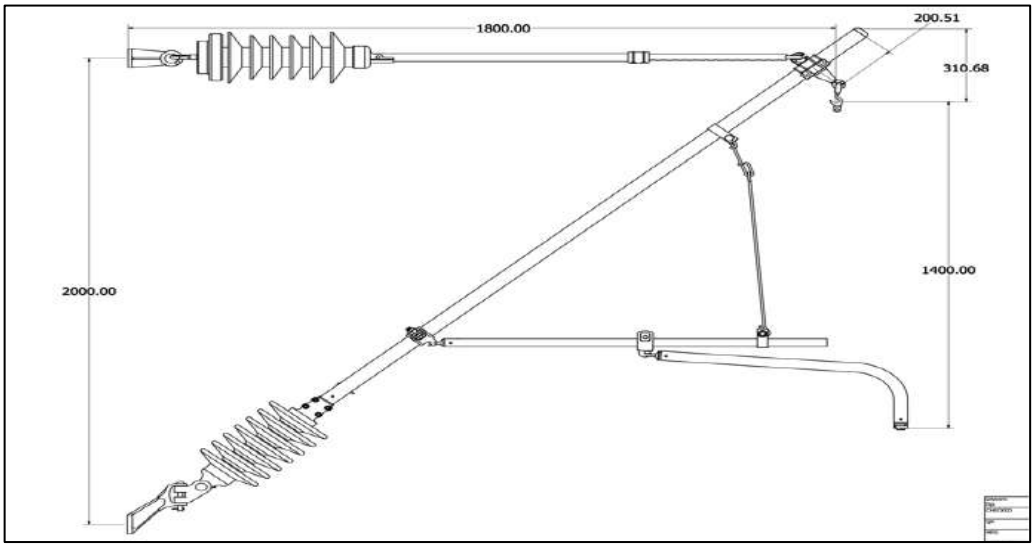


Figure 2: Vertical distance between catenary wire and bracket tube top

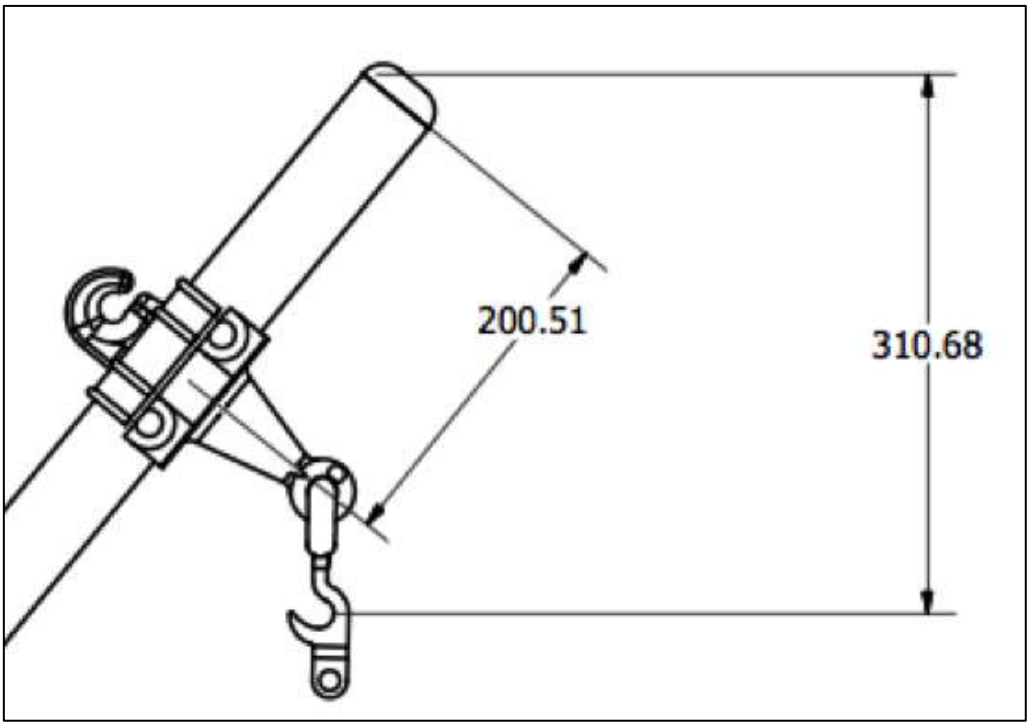


Figure 3: Vertical distance between catenary wire and bracket tube top

The minimum height of concourse should be determined as under:

Contact wire height from rail level at support with 50mm pre sag	5550mm
Vertical distance between catenary wire and top point of bracket tube	310mm
Vertical distance between top point of live part of bracket tube and bottom most part of beam(B)-(250mm Electrical Clearance + 20mm Track	770mm

maintenance margin + 500mm additional clearance including civil structure tolerance & conductor diameter)	
The minimum height of lowest portion of across the track beam from rail level	= 5550mm +310mm+770mm + Encumbrance

Minimum overline structure height determined with different encumbrance for Case-I will be as under:

Minimum overline structure height (in mm) for 5550mm contact wire height at support for different encumbrances				
400	**500**	**600**	**750**	**900**
7030	7130	7230	7380	7530

Case II: In this case, the cantilever support point is kept some distance away from beam. Since the additional vertical space (800-1000mm or so) is available in the non-beam region of the structure, the vertical distance (310mm) between catenary wire and bracket tube top (refer figure 2/3) need not be considered from bottom of the beam. This design will require consideration of additional bending moment on the OHE support structure. Refer to figure below:

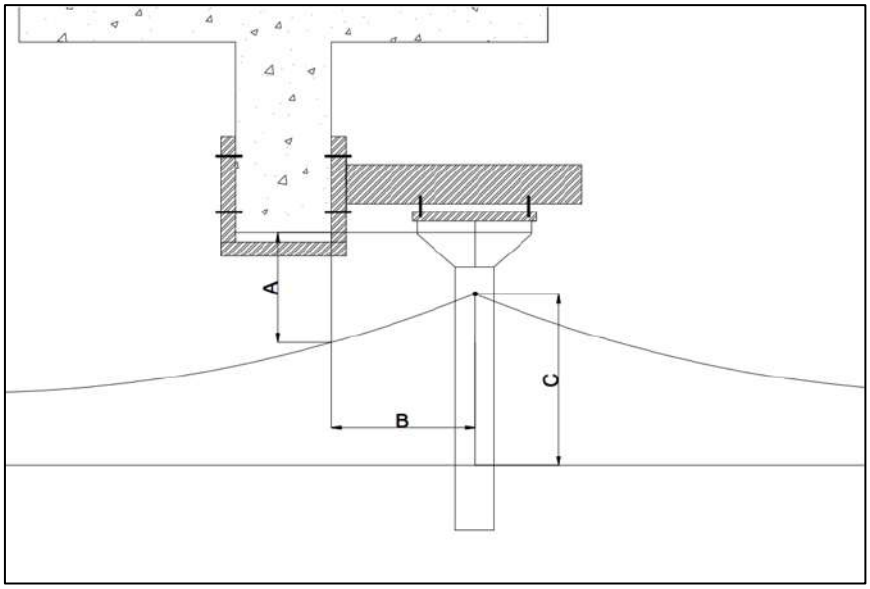


Figure- 4

Further, the catenary will sag a bit away from its support point, and hence the 500mm clearance (between catenary wire and beam bottom – 'A' in above figure) will need to be measured from its actual position rather than suspension point location.
For B = 1000mm, reduction of vertical distance and minimum overline structure height determined with different encumbrance for Case-II will be as under:

Minimum overline structure height for 5550mm high contact wire for different encumbrances (Height of Overline structure -5550mm+Encumbrance+770mm)				
400	**500**	**600**	**750**	**900**
6720	6820	6920	7070	7220

Note: 1. In the above calculations Contact wire height 5550mm at support has been considered.

2. The extra vertical clearance of 275mm for raising of track in future has not be considered for the OHE design purpose.

3. The minimum encumbrance should be kept 600mm for concourse structure height approximately 7000mm.

4. While selecting the encumbrance & OHE span, minimum dropper length should not be less than 200mm.

5. 0 EARTHING / GROUNDING ARRANGEMENTS:

5.1 Structure Earthing

The station structure will need to be earthed as per usual practice of building grounding, irrespective of traction system. The codes to be followed in this respect are IS 3043, IS 2309 etc.

5.2 OHE support earthing : Bonding & Earthing should be as per Earthing & Bonding Code ETI/OHE/71-Rev.1. The adequacy and efficacy of this earthing and bonding system should be verified by the simulation studies/measurements of the touch and step potential of the rail in normal load and short circuit condition for compliance with EN 50122-1 and IEC 62128-1 (2013).

5.2.1 Normally, the OHE masts/structures are bonded to rails (return circuit) and hence any insulator puncture will lead to completion of circuit and tripping of relevant circuit breaker.

5.2.2 In the instant case, the structure bonds between suspended OHE structure (drop arm etc.) is not feasible. Therefore, an earth wire of appropriate section may have to be run connecting masts / portals nearest to the concourse and all the OHE support structure (drop arms) suspended from the concourse. See the schematic below:

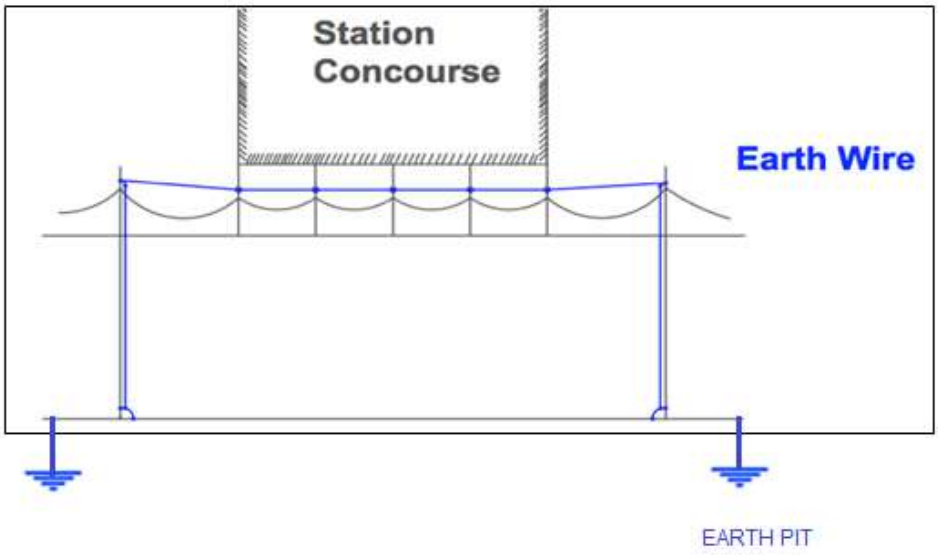


Figure 5: Earth wire for OHE structure below concourse

Notes:

(i) The earth wire shall be connected to an earth as well as to the traction rails at both ends just outside the concourse.

(ii) In case all the rails are track circuited, the earth wire shall be connected to an earth at both ends just outside the concourse.

(iii) If length of the earth wire exceeds 1000m, the stipulation in regard to making it discontinuous as contained in Para 3.4 of Bonding & Earthing code ETI-OHE/71-Rev.1 should be followed.

5.2.3 Further, the earth wires of different tracks can be cross-connected to ensure adequate redundancy of earth connections. See the schematic below:

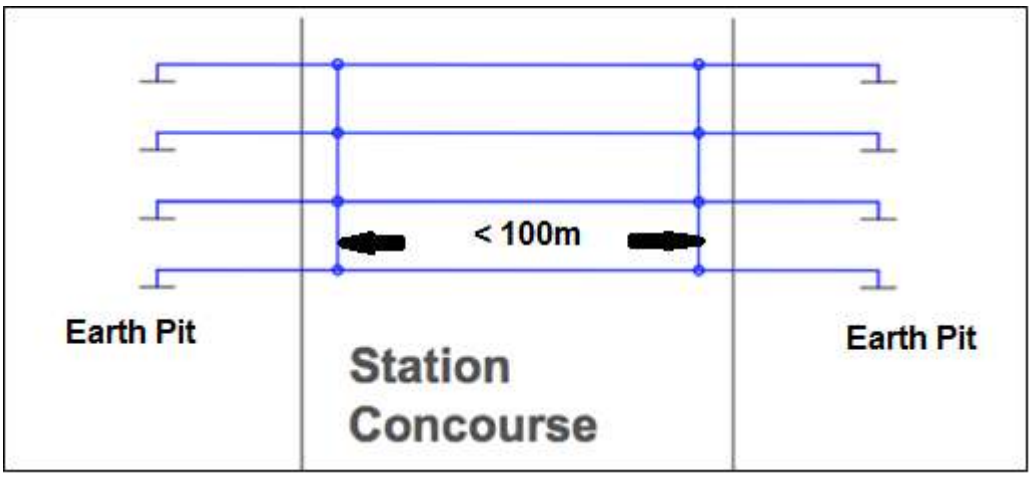


Figure 6: Cross connection of earth wire for redundancy

The cross connection can also be effected with embedded earth strips in the roof slab with earth terminals brought out in either side for construction to structures.

The cross section of an earth wire used for bonding traction masts or structures or supports or the metallic parts supporting the traction overhead equipment in a tunnel or in double rail-track-circuited section shall be not less than 50 mm^2 copper equivalent. Capacity of 93.3 mm^2 AAC (All Aluminium Alloy Conductor) conductor is similar to 50 mm^2 of copper. Hence 93.3 mm^2 AAC as per IS 398 – Part II (or equivalent ACSR) conductor may be used for this purpose.

5.2.4 **Bonding of metallic parts inside a concourse:** The OHE under a 100-200m long concourse structure is a situation similar to tunnel in respect of earthing of OHE support structures. An earth wire connecting all non-current metallic parts, which form parts of the supports for the overhead equipment, shall be run inside the concourse. The earth wire shall be connected to an earth as well as to the traction rails at both ends just outside the concourse. In case, all the rails are track circuited, the earth wire shall be connected to an earth at both ends just outside the concourse. If the length of the earth wire exceeds 1000m, the stipulation in regard to making it electrically discontinuous as contained in Earthing and bonding code should be followed.

5.2.5 The FTA anchor body structure in the concourse area (if used) shall also be earthed by bonding it through the ACSR earthing conductor as above.

5.2.6 **Girder concourse structure supporting OHE:** Bonding & Earthing should be as per Part-II of Earthing & Bonding Code ETI/OHE/71-Rev.1.

As per clause no. 6.3 of BSEN 50122-1 (2011), the reinforcement of the RCC structure in which the OHE support structures & anchor fasteners are installed, shall be earthed and bonded to return rails.

Earthing & Bonding Scheme should be validated by the appropriate agency.

6. OHE loading for structure design

6.1 OHE system weight data

The following are the OHE weight data:

SN	Description	Particular	Remarks
1	Contact wire (107 mm2)	0.952kg/m	If 150 mm^2, then the weight is 1.34 kg/m
2	Catenary wire (65 mm2)	0.5973 kg/m	If 125 mm^2, then the weight is 1.191 kg/m
3	Feeder Wire	-	If 238 mm^2 All aluminium spider conductor, then the weight is 0.654 kg per m/ If 232 mm^2 All aluminium alloy conductor, then the weight is 0.637 kg per meter/If 288 mm^2 All aluminium alloy conductor (AAAC), then the weight is 0.794kg/m
4	Aerial Earth Conductor	-	If 91.97 mm^2 ACSR Conductor, weight is 0.319kg/m
5	OHE weight kg per meter	1.6 kg/m	With some allowance for dropper weights; If higher capacity OHE(150mm^2/125mm^2), then the weight is 2.6 kg/m
6	Earth wire weight	0.437 kg/m	
7	Cantilever assembly weight	60 kg	
8	Weight of maintainer with tools	100 kg	May not be relevant in the instant case, but still conservatively considered
9	Section insulator weight	50 kg	
10	Cut in insulator weight	15 kg	
11	Drop arm bracket assembly weight with SPS	146 kg	DA length of 2375mm with RSJ (8x6”), having unit weight of 53.39kg/m considered
12	Spreader bar weight with SPS (each)	18 kg	1250m length, C channel 150mm x 75mm

6.2 Cases considered

The onerous case could be installing two OHEs on support (one normal and other out-of-run) and running through the length of covered area and one OHE having cut-in insulator.

The situation of OHE termination with ATD inside covered area is not foreseen.

However, OHE termination with FTA arrangement either on face of station structure or at any intermediate concrete beam may be possible and hence considered (though it is not recommended).

6.3 Loads for 72m Span with conductor 65mm^2/107mm^2 for 1200/1200 kg tension.

6.3.1 Vertical Load

OHE weight (2 nos.) = 2 x [72 x (1.6 + 0.437)]	= 294 kg
Cantilever weight (2 nos.) = 2 x 60 kg	= 120 kg
Maintainer weight	= 100 kg
Cut-in insulator weight = 2 x 15	= 30kg
Drop Arm / Spreader arm (2 nos.) / SPS weight	= 182
Total vertical load	= 294 + 120 + 100 + 30 + 182 = 726 kg
Add extra for unforeseen	25 kg

The case with one OHE and section insulator installed in that span will be less onerous than the above one.

6.3.2 Transverse loads

Radial load due to stagger (200mm) of both catenary and contact wire = 1200/72 x (2*0.2 + 2*0.2) = 13.33 Kg. (for each)	= 27 kg (approx.)
Radial load due to stagger of out-of-run OHE is not considered as that OHE can be taken terminated in straight line on concrete beam	= 0
Wind load (considering wind pressure of 216 kg/m^2, high capacity OHE, contact wire diameter 12.24 mm and catenary wire diameter 10.5 mm) = 1.05*0.75*(0.01224 + 0.0105)*216*72=278.5 Kg	= 279 Kg

Note: In Indian Railway OHEs, the catenary wire is not staggered normally, but in many systems (such DFCCIL) the catenary wire is also staggered. For future considerations, the catenary wire is also considered staggered for loading purpose.

6.3.3 FTA load on beam.

FTA load on beam structure (directly installed on concrete beam) = 2400 kgf (in longitudinal direction).The tension used by IR with 107mm^2/65mm^2 combination is 1200 kgf each i.e. 2400 kgf total. Anchor load of 2400 kgf, on beam structure as well as on the face of the station concourse shall be considered in design of concourse. From safety point of view of structures, the broken wire impact on structures due to Anchor load i.e. 2400 Kg should also be considered.

Additionally, the jerk load of OHE breaking shall also be considered.

6.3.4 Other than the OHE loading described above, the station planning shall consider loads for future proposals, alterations, augmentation etc.

6.3.5 The loads shall be considered as follows:

(a) High capacity OHE with 2 OHEs shall be considered for all locations, whether or not the same is currently having 2 OHEs;
(b) For every 5 tracks or part thereof, FTA load for one track shall be considered in design of concourse, which can be in any of the tracks;

6.4 Loads for 72m Span with conductor 125 mm^2/150 mm^2 for 1500/1500 kg tension.

6.4.1 Vertical Load

High capacity OHE OHE weight (2 nos.) = 2 x [72 x (2.6 + 0.437)]	= 438 kg
Cantilever weight (2 nos.) = 2 x 60 kg	= 120 kg
Maintainer weight	= 100 kg
Cut-in insulator weight = 2 x 15	= 30kg
Drop Arm / Spreader arm (2 nos.) / SPS weight	= 182
Total vertical load	= 438 + 120 + 100 + 30 + 182 = 870 kg
Add extra for unforeseen	25 kg

The case with one OHE and section insulator installed in that span will be less onerous than the above one.

6.4.2 Transverse loads

Radial load due to stagger (200mm) of both catenary and contact wire = 1500/72 x (2*0.2 + 2*0.2) = 16.66 Kg. (for each)	= 34 kg (approx.)
Radial load due to stagger of out-of-run OHE is not considered as that OHE can be taken terminated in straight line on concrete beam	= 0
Wind load (considering wind pressure of 216 kg/m2, high capacity OHE, contact wire diameter 14.5 mm and catenary wire diameter 14mm) = 1.05*0.75*(0.0145 + 0.014)*216*72=349 Kg	= 349 Kg

Note: In Indian Railway OHEs, the catenary wire is not staggered normally, but in many systems (such DFCCIL) the Catenary wire is also staggered. For future considerations, the Catenary is also considered staggered for loading purpose.

6.4.3 FTA load on beam.

FTA load on beam structure (directly installed on concrete beam) = 2400 kgf (in longitudinal direction).The tension used by IR with 150 mm^2/125 mm^2 combination is 1500 kgf each i.e. 3000 kgf total. Anchor load of 3000 kgf, on beam structure as well as on the face of the station concourse shall be considered in design of concourse. From safety point of view of

structures, the broken wire impact on structures due to Anchor load i.e. 3000 Kg should also be considered.
Additionally, the jerk load of OHE breaking shall also be considered.

6.4.4 Other than the OHE loading described above, the station planning shall consider loads for future proposals, alterations, augmentation etc.

6.4.5 The loads shall be considered as follows:

(a) High capacity OHE with 2 OHEs shall be considered for all locations, whether or not the same is currently having 2 OHEs;
(b) For every 5 tracks or part thereof, FTA load for one track shall be considered in design of concourse, which can be in any of the tracks;

6.5 The design of support brackets shall be duly proof checked. The design shall have the following features:--

(a) Maintenance instructions shall be given i.e. how the repairs/ replacement work shall be done. This shall be essential feature of design and a maintenance manual shall be prepared and handed over to TRD Department in Division responsible for maintaining the OHE.
(b) Spare foundation bolt for OHE structure to be provided at each concrete beam.

6.6 Fixing Arrangements:-

(a) For safety design of structures, all loads & bending moment should be calculated considering 72m OHE span i.e. maximum from Civil structural point of view. The minimum vertical loads and bending moment arising due to suspension of OHE cantilever along with Drop Arm with Girder/Slab of structures should be approximate 900 Kg (Vertical Load) and 1200 Kg. m (Bending Moment) respectively.
(b) The above mentioned loads and bending moment should be taken while designing of civil structures.
(c) The clamp type fixing arrangement should be preferred from maintenance aspect.
(d) If fixing arrangement is proposed to be erected on Girder/Slab of structures the proper structural design should be done considering all additional loads from safety aspect as per codal provision.
(e) It is suggested that the fixing arrangement should be designed and embedded while casting of structures with the consultation of concerned TRD department as per lay out plan of OHE cantilever assembly at required expected interval from future aspect of RE works.

7.0 Bird menace

All other provisions regarding bird nesting in ACTM are in respect of maintenance / inspection and mitigation measures (e.g. removing the bird nests etc.) should be followed.

The following measures are recommended for avoiding bird menace:

(a) If the structure consists of closed sections which don't permit birds to sit or make nests, such as concrete beams / slab system no special precautions are required
(b) For structures which permit birds to sit or make nests such as in case of steel plate girders / trusses etc. measures given in RDSO SMI No. TI/MI/0050 Rev. 2 should be followed:

(c) Drop arms of RSJ/BFB sections only shall be used and the fabricated / laced drop arms shall not be used.

8.0 Safety regulations

8.1.1 EN 50122-1 (Jan 2011) or IEC 62128-1 (2013) "Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock" elaborates the requirements from the safety perspective.

8.1.2 The basic safety clearances are described in figure 4 of EN 50122-1, which is produced below as figure 7:

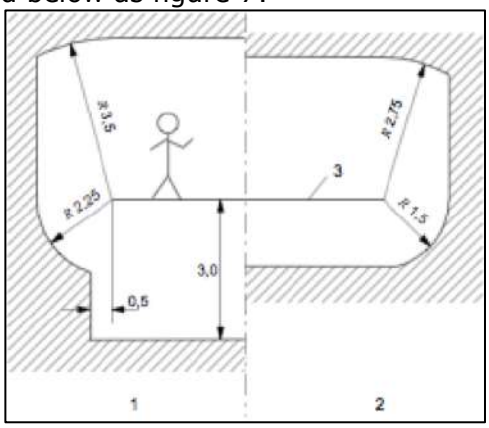


Figure 7: Minimum clearances to accessible live parts on the outside of vehicles as well as to live parts of overhead contact line systems from standing surfaces accessible to persons for high voltages (figure 4 of EN 50122-1)
[1 – public areas; 2 – restricted areas; 3 – standing surface]

The instant case of station development relates to public area (1).

8.1.3 The above-referred EN/IEC further provides for designs of obstacles in case the above clearances are not possible to be achieved (ref Para 5.3.2.2 "Obstacles and standing surfaces above live parts"). Such provisions for 25kV ac traction system are provided in figure A.2 of EN 50122-1, which is produced below as figure 8.

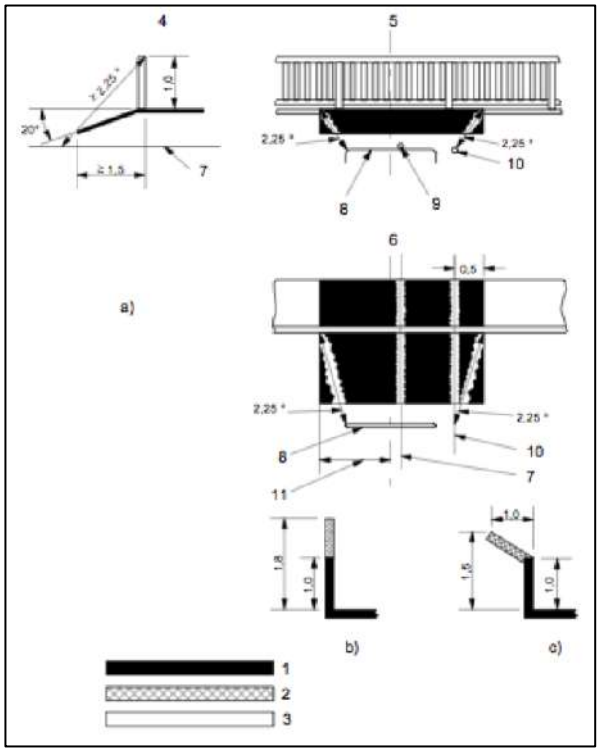


Figure 8: Examples of obstacles along the sides of standing surfaces in public areas for protection against direct contact when live parts on the outside of vehicles or live parts of an overhead contact line system for high voltages (figure A.2 of EN 50122-1)

Key

1 – solid wall design or obstacle confirming to degree of protection IP3X as defined in EN 60529
2 – mesh screen with a maximum 1200 mm2 mesh size (can also be solid wall design)
3 – railing, mesh construction (can also be solid wall design)
4 – side view
5 – front view
6 – plan view
7 – contact wire catenary line feeder
8 – pantograph
9 – contact wire
10 – line feeder
11 – half pantograph zone

8.1.4 IR ACTM basically derives the safety clearance of 2m from live parts and safety screens (on FOBs, ROBs etc.) from the above EN/IEC only. All the regulations basically relates to elimination of possibility of accessing live parts from the standing / working surfaces.

PHOTOGRAPHS OF OHE ARRANGEMENT AT RAILWAY STATIONS:

Examples of DMRC's Pragati Maidan station and UK's Birmingham railway station is shown in below pictures, which does not have openings on the sides above tracks.



Figure 9: Pragati Maidan Metro station



Figure 10a: Birmingham Railway Station



Figure 10b: Birmingham Railway Station



Figure 11: OHE suspension arrangement at DMRC's Tuglakabad station (1)



Figure 12: OHE suspension arrangement at DMRC's Tuglakabad station (2)



Figure 13: OHE suspension arrangement at DMRC's Tuglakabad station (3)



Figure 14: Nerul Station of Central Railway (1)



Figure 15: Nerul Station of Central Railway (2)



Figure 16: Khargar Station of Central Railway

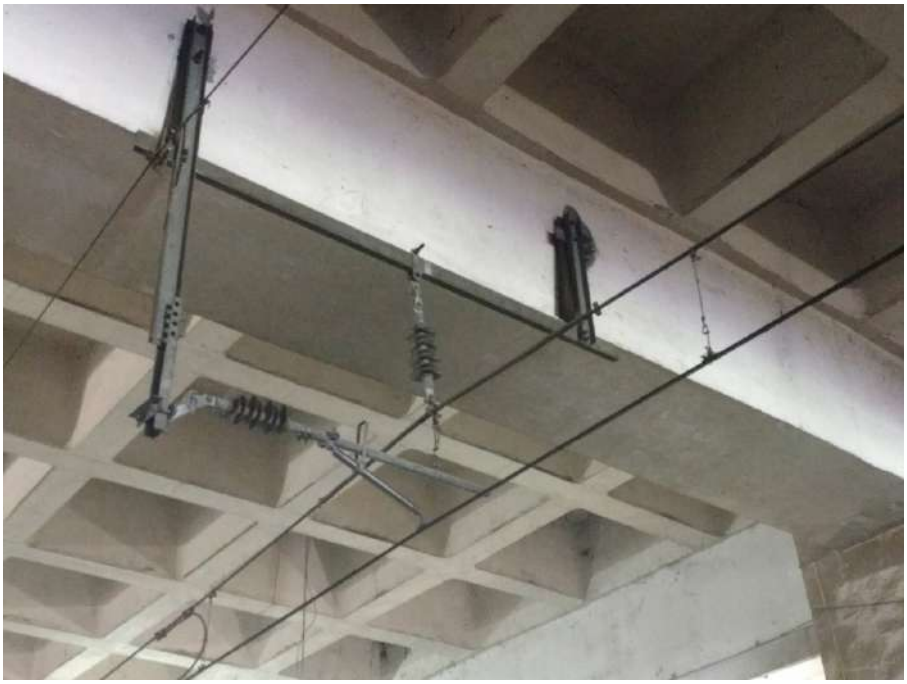


Figure 17: Belapur Station of Central Railway



Figure 18: Churchgate Station of Western Railway

File No.RDSO-TI0LKO(PSI)/11/2021-O/o PED/TI/RDSO

सत्यमेव जयते

Government of India,
Ministry of Railways
Research Designs &
Standards Organisation
Manak Nagar, Lucknow –
226011

Telephone:2465763.
42805(Off.)
Fax: 91-0522-
2465763
E-mail:
psi.ti@rdso.railnet.gov.in

No. RDSO-TI0LKO (PSI)/11/2021-O/o PED/TI/RDSO Dated: As signed

To,
As per the mailing list attached.

Sub: Implementation of Cyber Security Measures in Supervisory Control and Data Acquisition System for 25kV and 2x25 kV Single Phase 50Hz AC Traction Power Supply.

Ref: (i) Technical Instruction No. TI/IN/0048 uploaded on RDSO Public website on 19.04.2024.
(ii) RB letter No. 2022/EEM/148/CII E-3386772 dated 15.03.2024.

****

Regarding the subject mentioned above, it is advised that the upgrade of the existing SCADA Systems, which includes essential Cyber Security features, should adhere to the following conditions:

(i) Before commencing the upgradation work, the concerned vendor should have cleared the type tests as per Specification No. TI/SPC/RCC/SCADA/0134.
(ii) The SCOPE of the upgradation work should be as per Technical Instruction No. TI/IN/0048 (enclosed).

Furthermore, as per Rly. Board's letter dated 15.03.2024 referenced under (ii), Zonal Railways are advised to allocate the appropriate budget provisions within their respective IRPSM works to accommodate the financial implications of implementing the above-stated upgrade work in the existing SCADA systems. To meet future requirements, these enhanced cyber security features have already been incorporated in the revised specification, with a cut-off date of 15.05.2024 for implementation.

This is issued with the approval of the Competent Authority (PED/TI).

Encl: As stated above.

Digitally Signed by
Jitendra Kumar
Date: 19-04-2024 22:14:13
Reason: Approved

(Jitendra Kumar)
Director / TI-III
For Director General (TI)

Copy to:

ED/EEM, Railway Board: For kind information, please.

Mailing List

SN	Railways/ PSUs	E-mail id
1.	Principal Chief Electrical Engineer, Central Railway., 2nd floor, Electrical Branch, Parcel Office Bldg. Mumbai - 400 001.	cee@cr.railnet.gov.in
2.	Principal Chief Electrical Engineer, Eastern Railway, Fairlie Place, Kolkata-700 001	cee@er.railnet.gov.in
3.	Principal Chief Electrical Engineer, East Central Railway, Hajipur (Bihar).844101	cee@ecr.railnet.gov.in
4.	Principal Chief Electrical Engineer, East Coast Railway, B-Rental Colony, Chandrashekharpur, Bhubaneshwar (Orissa)-751 023	cee@ecor.railnet.gov.in
5.	Principal Chief Electrical Engineer, Northern Railway, Baroda House, New Delhi - 110 001	cee@nr.railnet.gov.in
6.	Principal Chief Electrical Engineer, North Central Railway, Block-A, Subedarganj, Prayagraj- 211 033.	cee@ncr.railnet.gov.in
7.	Principal Chief Electrical Engineer, North Eastern Railway, Gorakhpur (UP).220 055	cee@ner.railnet.gov.in
8.	Principal Chief Electrical Engineer, Northeast Frontier Railway, Maligaon, Guwahati - 781011	cee@nfr.railnet.gov.in
9.	Principal Chief Electrical Engineer, North Western Railway, Jaipur (Raj.) – 302017	cee@nwr.railnet.gov.in
10.	Principal Chief Electrical Engineer, Southern Railway, Park Town, Chennai - 600 003 (TN)	cee@sr.railnet.gov.in
11.	Principal Chief Electrical Engineer, South Central Railway, Rail Nilayam, Secunderabad – 500 371	cee@scr.railnet.gov.in
12.	Principal Chief Electrical Engineer, South Eastern Railway, Garden Reach, Kolkata-700 043	cee@ser.railnet.gov.in
13.	Principal Chief Electrical Engineer, South East Central Railway, Bilaspur (Chhattisgarh).4950 04	cee@secr.railnet.gov.in
14.	Principal Chief Electrical Engineer, South Western Railway, DRM's Office, Hubli (Karnataka	cee@swr.railnet.gov.in
15.	Principal Chief Electrical Engineer, Western Railway, Churchgate Stn. Bldg., Mumbai - 400 020	cee@wr.railnet.gov.in
16.	Principal Chief Electrical Engineer, West Central Railway, Jabalpur-482 001 (M.P)	cee@wcr.railnet.gov.in
17.	Director /Electrical, Delhi Metro Rail Corporation Metro Bhawan,8th Floor, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.	eoffice@dmrc.org.
18.	CAO, CORE Central Organisation for Railway Electrification, 1, Nawab Yusuf Road, Civil Lines, Prayagraj -211001	dyceemp@gmail.com, dyceemp1@gmail.com, dyceemp2@gmail.com, ceempcore@gmail.com,
19.	Chairman and Managing Director RITES LTD, Shikhar, Plot No.01, Sector 29, Gurgaon, Haryana, India-122001	info@rites.com
20.	Principal Chief Electrical Engineer, Konkan Railway Corporation Limited, Belapur Bhavan, Plot No 6, Sector 11, CBD Belapur, Navi Mumbai – 400614.	cee@krcl.co.in

2724589/2024/O/o PED/TI/RDSO

सत्यमेव जयते

भारत सरकार GOVERNMENT OF INDIA

रेल मंत्रालय MINISTRY OF RAILWAYS

अनुदेश संख्या: टीआई/आईएन/0048

Instruction No: TI/IN/0048

भारतीय रेल में पुरानी विशिष्टियों के अनुसार प्रयुक्त वर्तमान स्काडा प्रणाली में साइबर सुरक्षा के कार्यान्वयन के लिए तकनीकी अनुदेश

Technical Instruction for implementing Cyber Security in existing Supervisory Control and Data Acquisition System used in Indian Railways as per old Specifications

अप्रैल, 2024 में जारी / Issued in: April, 2024

		हस्ताक्षर/Signature
अनुमोदित Approved by	प्रधान कार्यकारी निदेशक (कर्षण संस्थापन) Principal Executive Director (TI)	19/4/24

जारी कर्ता/ ISSUED BY:

कर्षण संस्थापन निदेशालय

TRACTION INSTALLATION DIRECTORATE,

अनुसंधान अभिकल्प और मानक संगठन

RESEARCH DESIGNS & STANDARDS ORGANISATION,

मानक नगर, लखनऊ- 226011

MANAK NAGAR, LUCKNOW-226011

NOTE: This guideline is the property of RDSO. No reproduction shall be done without the permission of DG (TI) RDSO.

	Prepared By	Checked By	Issued by
Signature	Vikash	RAMESH KUMAR PAL	Kumar 18/4/24
Date	18.04.2024		
Designation	JE/ TI	ADE/ TI-3	DIRECTOR/ TI-3

2724589/2024/O/o PED/TI/RDSO

1 Scope & Objective:

This technical instruction is applicable to different types of existing SCADA Systems provided on Indian Railways. The objective of this technical instruction is to upgrade the existing SCADA System in line with Cyber Security and to identify the migration path for the prevalent systems to a system where Cyber security requirements as per the latest specification TI/SPC/RCC/SCADA/0134 are to be achieved to the maximum extent possible with least amount of replacement/retrofitting.

2 Introduction

Presently the Traction SCADA systems prevalent in Indian Railways are as per the following RDSO specifications –

i. TI/SPC/RCC/SCADA/0990: This is based on the SPORT Protocol and was issued on August 08, 2008.

ii. TI/SPC/RCC/SCADA/0130 (or 0130 Rev1): This is based on the IEC-101 Protocol, supporting the IEC-103 Protocol to integrate protection relays. It was issued on December 12, 2014.

iii. TI/SPC/RCC/SCADA/0130 Rev2: This is based on IEC-104 Protocol using E1 communication channels. It was issued on July 26, 2016.

iv. TI/SPC/RCC/SCADA/0133: This specification adds support for the IEC 61850 protocol for integration with protection relays and basic cyber security requirements. It was issued on July 30, 2021.

v. TI/SPC/RCC/SCADA/0134: This specification incorporates the Cyber Security features to address the Cyber Security vulnerabilities present in the SCADA System. It has been issued on November 09, 2023.

The SCADA System of Indian Railways has been declared as Critical Information Infrastructure (CII) as per directives of National Security Council Secretariat (NSCS), Government of India and Railway Board vide letter No. 2003/Elect (G)/161/1 Vol-III/Pt- Part (4) dated 13.04.2022, had advised RDSO to incorporate the Cyber Security Features in SCADA Specification to address the Cyber Security Vulnerabilities present in the SCADA System. Accordingly, the revised SCADA Specification TI/SPC/RCC/SCADA/0134 incorporating various Cyber Security features has been issued on 09.11.2023 and in view of the same, this technical instruction has been prepared to implement Cyber Security features in the existing SCADA systems as per the specification mentioned above at SN- i. to iv. present in the Indian Railways to the maximum possible extent.

	Prepared By	Checked By	Issued by
Signature	Vikash	RAMESH KUMAR PAL	
Date	18.04.2024		
Designation	JE/ TI	ADE/ TI-3	DIRECTOR/ TI-3

2724589/2024/O/o PED/TI/RDSO

3 Implementation of Cyber Security in 0990 Systems:

3.1 Methodology

Since these are the oldest working versions of the SCADA System, it is not possible to completely implement Cybersecurity requirements. As this specification has been superseded by Specification TI/SPC/RCC/SCADA/0130 Rev.1 dated December 12, 2014, therefore, most of the SCADA systems working in Indian Railways as per this specification are near the end of their codal life. **The SCADA system, which has completed 75% of its codal life (from the date of Commissioning), for such systems, the entire RCC and RTU may be replaced as per the governing specification TI/SPC/RCC/SCADA/0134 or the latest.**

However, for systems where 75% of Codal Life is not yet completed, an intermediate approach as proposed below shall be adopted -

i. Since these systems are based on Windows 7, therefore, RCC (complete hardware and software) shall be replaced, i.e., a system identical to the one specified in the Specification TI/SPC/RCC/SCADA/0134 or latest shall be adopted. For RCCs, where multiple such systems exist, the feasibility of merging those into a single system (up to 100 RTUs) shall also be considered.

ii. Communication links to be upgraded from FSK modem-based channels to E1-based Ethernet channels (This will be provided by the S&T wing of Railway). This will bring all RTUs at par, as currently TSS RTUs are on E1 channels and SP/SSP RTUs are on FSK modem channels.

iii. For RTUs that have completed 75% of Codal Life, these RTUs may be replaced as per the latest specifications.

iv. For RTUs that have not completed 75% of their codal life, the following may be implemented-
   a. Protocol converters shall be installed at each RTU that convert the SPORT protocol of the RTU into secure (encrypted) IEC-104 for compatibility with the new RCC.
   b. When the Codal life of this RTU is completed, it may be replaced with the latest specification RTU with minimal configuration changes at RCC software.

NOTE: In most of the locations, TSS RTUs have already been replaced as per TI/SPC/RCC/SCADA/0130 Rev2, and hence it would not require further replacement. Only the firmware of the RTU needs to be upgraded to achieve the security requirements in line with the Specification TI/SPC/RCC/SCADA/0134 or the latest.

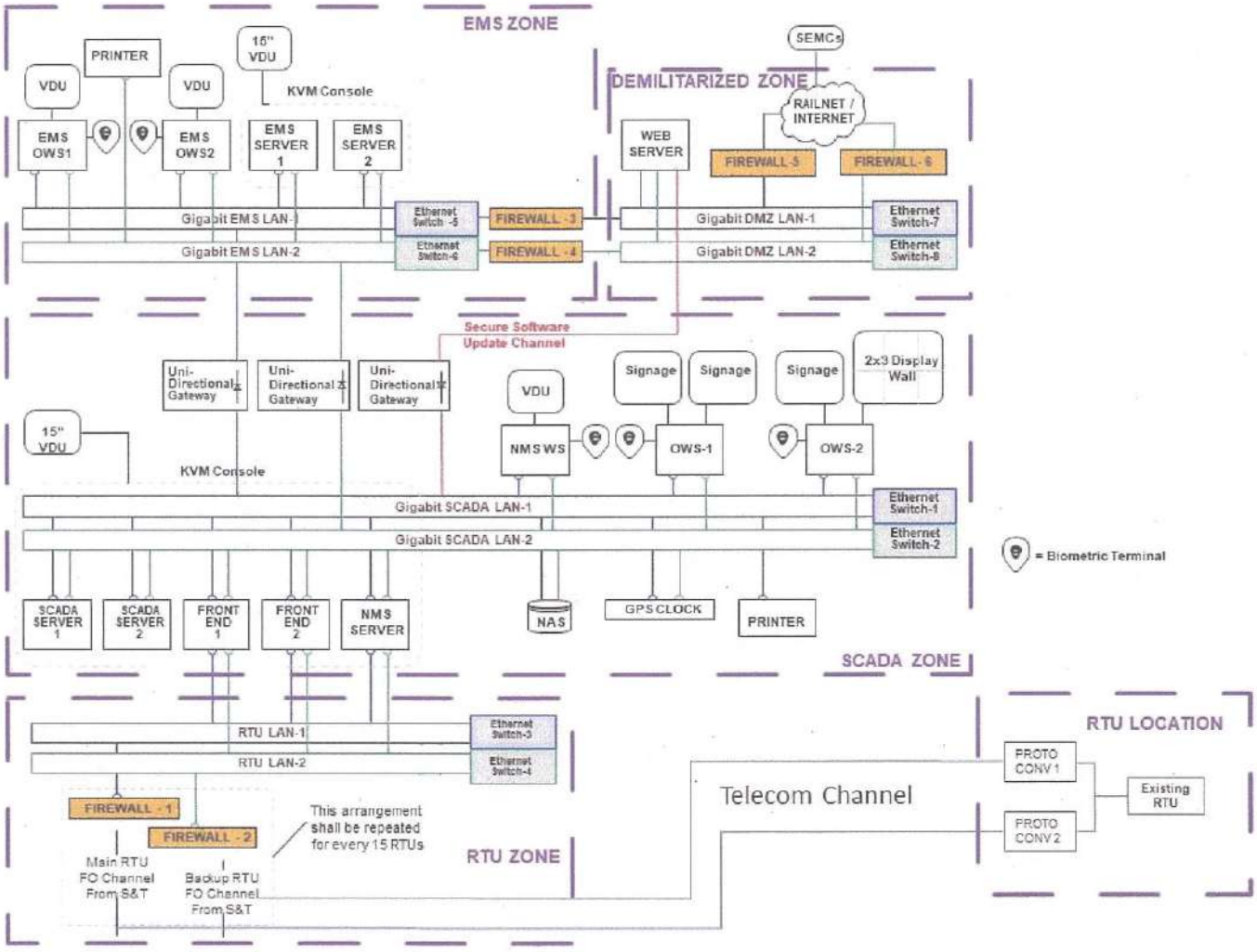
3.2 Protocol Converter Specifications

The Secure (encrypted) IEC-104 protocol converter for existing RTUs shall have the following minimum functions-

- Communicate as SPORT master with existing RTU to perform status, telemetry acquisition, and control functions.
- Convert SPORT protocol data into IEC-104 format and send it to RCC.
- Support Secure IEC-104 protocol as per IEC 62351-3 and IEC 62351-5 towards RCC.
- Receive control commands from RCC on Secure IEC-104 and transfer to RTU on SPORT.
- Two units to be provided to operate in hot-standby mode so that failure of one converter does not lead to loss of RTU functions.

	Prepared By	Checked By	Issued by
Signature	Vikash	RAMESH KUMAR PAL	
Date	18.04.2024		
Designation	JE/ TI	ADE/ TI-3	DIRECTOR/ TI-3

~~2724589/2024/O/o PED/TI/RDSO~~



GENERAL ARRANGEMENT OF MASTER STATION COMPUTER FOR 0990 SYSTEM

	Prepared By	Checked By	Issued by
Signature	Vikash	RAMESH KUMAR PAL	
Date	18.04.2024		
Designation	JE/ TI	ADE/ TI-3	DIRECTOR/ TI-3

2724589/2024/O/o PED/TI/RDSO

4 Implementation of Cyber Security in 0130 Rev1 Systems.

Since the population of SCADA Systems based on this specification is very small in Indian Railways, therefore, for systems on this specification, an approach as proposed below may be adopted-

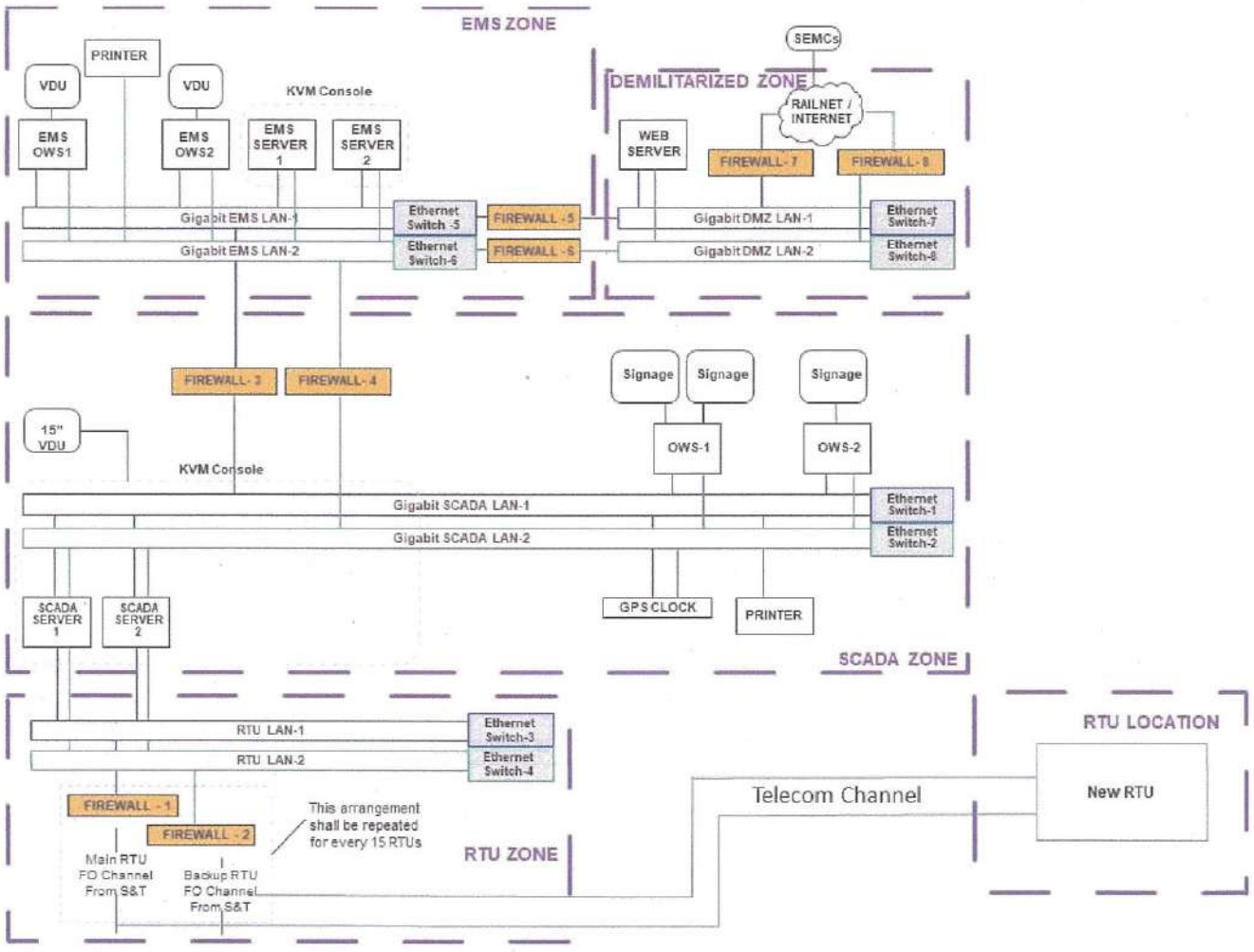
i. Communication links to be upgraded from FSK modem-based channels to E1-based Ethernet channels. This will bring all RTUs at par, as currently TSS RTUs are on E1 channels and SP/SSP RTUs are on FSK modem channels.

ii. Upgradation of RCC hardware is not required, and existing hardware shall be reused.

iii. RCC software shall be upgraded as per specification TI/SPC/RCC/SCADA/0134 or the latest.

iv. Ethernet Switches and firewalls as per specification TI/SPC/RCC/SCADA/0134 or latest shall be installed at respective interconnections.

v. RTU shall be replaced as per specification TI/SPC/RCC/SCADA/0134 or latest.



GENERAL ARRANGEMENT OF MASTER STATION COMPUTER FOR 0130 (Rev.1) SYSTEM

	Prepared By	Checked By	Issued by
Signature	Vikash	RAMESH KUMAR PAL	
Date	18.04.2024		
Designation	JE/ TI	ADE/ TI-3	DIRECTOR/ TI-3

2724589/2024/O/o PED/TI/RDSO

5 Implementation of Cyber Security in 0130 Rev2 Systems

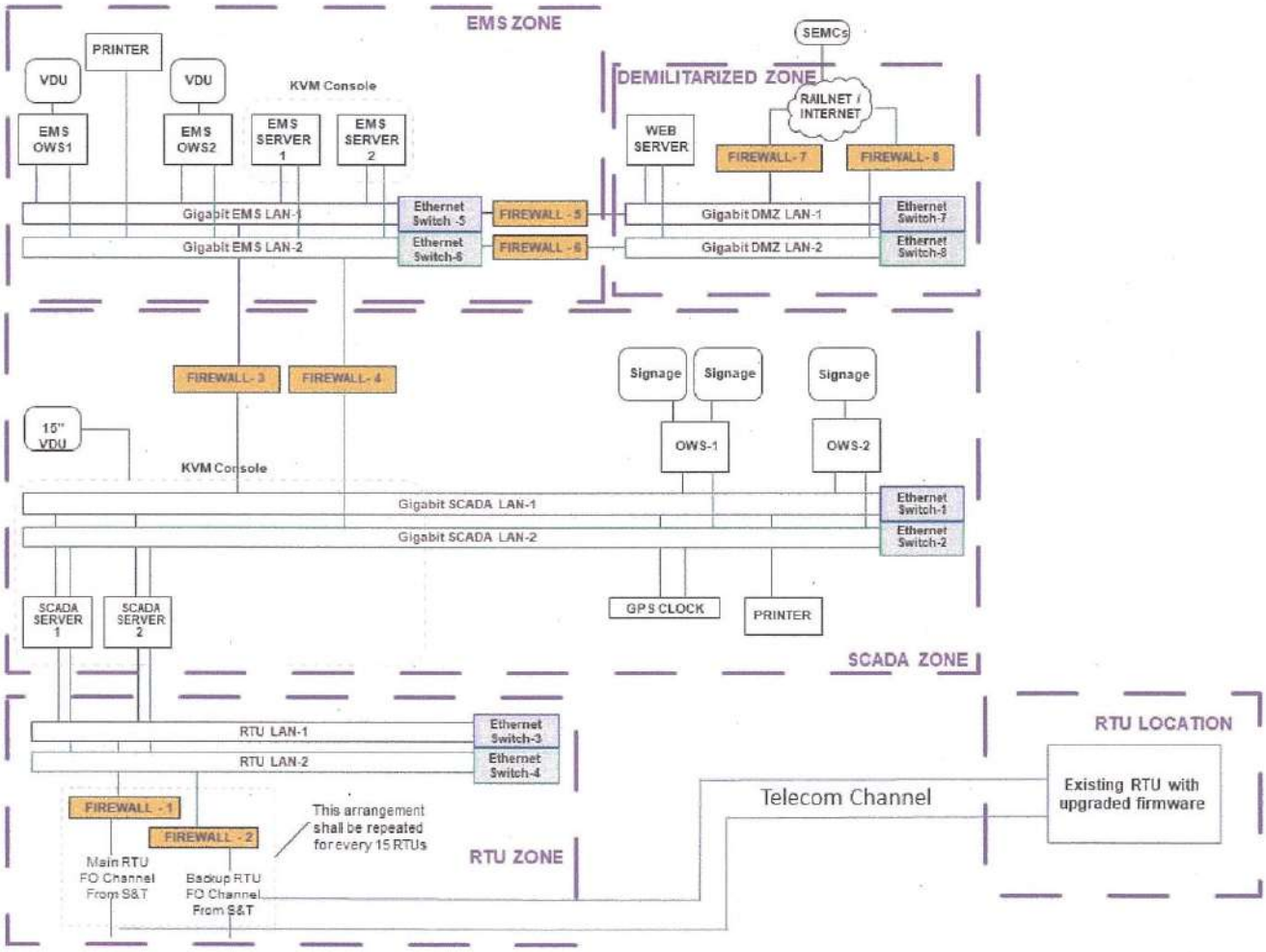
The SCADA system belonging to this specification has major population in Indian Railways. Therefore, for such systems, the approach proposed below shall be adopted:

i. Upgradation of RCC hardware is not required, and existing hardware shall be reused.

ii. RCC software shall be upgraded as per specification TI/SPC/RCC/SCADA/0134 or latest e.g., alphanumeric password protection, Identification and authentication control, patch management, application whitelisting, etc shall be incorporated.

iii. Ethernet Switches and firewalls as per specification TI/SPC/RCC/SCADA/0134 or latest shall be deployed at respective interconnections at RCC.

iv. For RTUs, firmware shall be upgraded to support encryption in IEC-104 protocol to secure the communications between SCADA and RTUs.



GENERAL ARRANGEMENT OF MASTER STATION COMPUTER FOR 0130 (Rev.2) SYSTEM

	Prepared By	Checked By	Issued by
Signature		RAMESH KUMAR PAL	
Date	18.04.2024		
Designation	JE/ TI	ADE/ TI-3	DIRECTOR/ TI-3

2724589/2024/O/o PED/TI/RDSO

6 Implementation of Cyber Security in 0133 Systems:

This specification was issued in July 2021. As this is a recently issued specification, there are very few systems of this type for which the approach as proposed below shall be adopted –

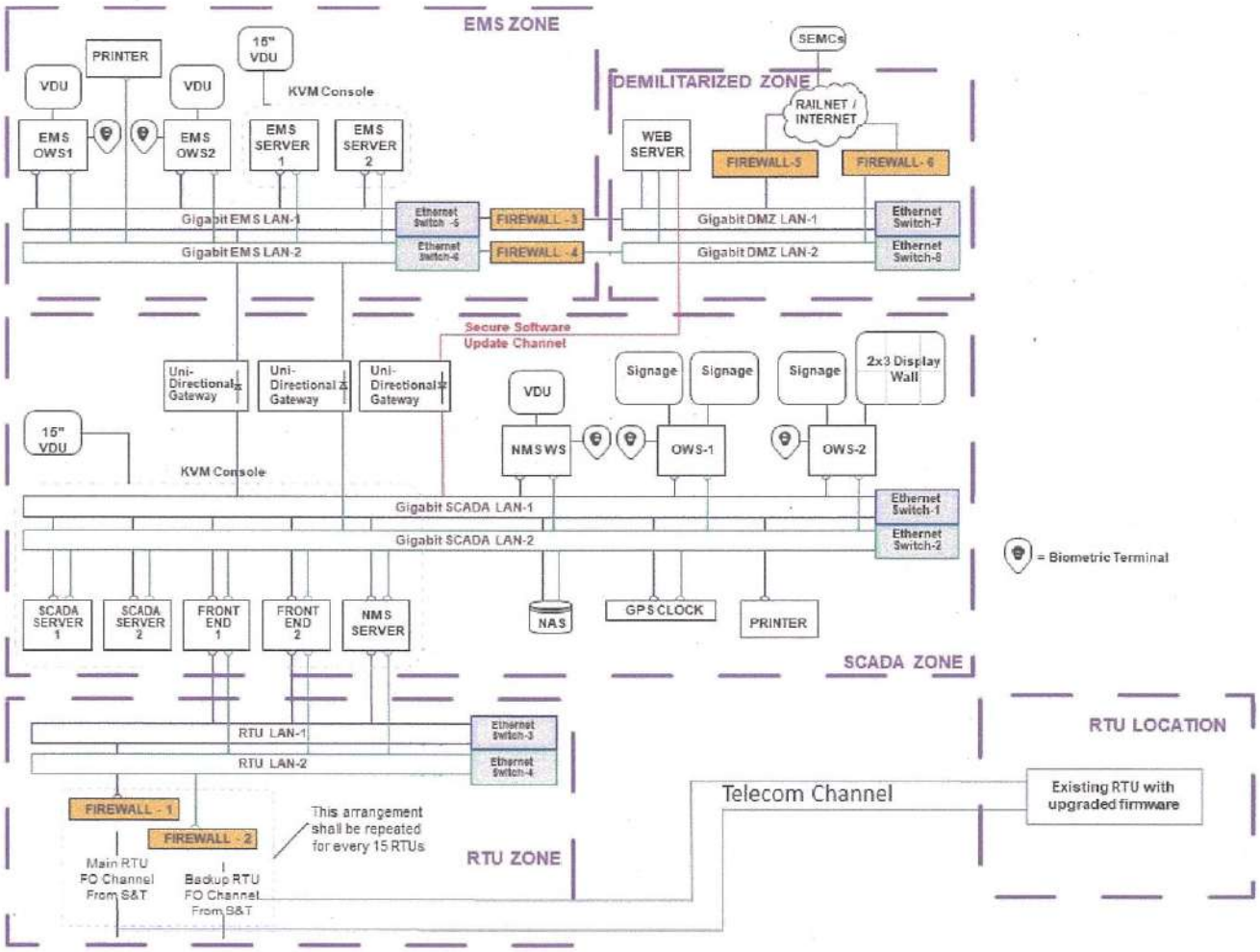
i. Upgradation of RCC hardware is not required, and existing hardware shall be reused.

ii. RCC software shall be upgraded as per specification TI/SPC/RCC/SCADA/0134 or the latest.

iii. Ethernet Switches and firewalls as per specification TI/SPC/RCC/SCADA/0134 or latest shall be deployed at respective interconnections.

iv. Biometric terminals shall be added as per specification TI/SPC/RCC/SCADA/0134 or latest.

v. For RTUs, firmware shall be upgraded to support encryption in IEC-104 protocol to secure the communications between SCADA and RTUs.



GENERAL ARRANGEMENT OF MASTER STATION COMPUTER FOR 0133 SYSTEM

	Prepared By	Checked By	Issued by
Signature	Vikash	RAMESH KUMAR PAL	Kumar
Date	18.04.2024		
Designation	JE/ TI	ADE/ TI-3	DIRECTOR/ TI-3

2724589/2024/O/o PED/TI/RDSO

7. Time Synchronization:

SCADA System, for synchronization of their ICT clocks, shall be time synchronized with Network Time Protocol (NTP) Server of National Informatics Centre (NIC) or National Physical Laboratory(NPL) or with NTP servers traceable to these NTP servers. Entities having ICT infrastructure spanning multiple geographies may also use accurate and standard time source other than NPL and NIC, however, it is to be ensured that their time source shall not deviate from NPL or NIC. CERT-In guideline issued vide No. 20(3)/2022-CERT-In dated 28.04.2022 shall be followed in this regard.

8. Cyber Security Audit of the Upgraded SCADA System:

SCADA vendors shall ensure to conduct Cyber Security Audit after upgradation of the existing SCADA System in terms of Cyber Security requirements, and thereafter annually, by the government agency/government approved third party agency/CERT-In empanelled Information Security Auditing Organization. Any vulnerabilities identified during the audit shall be rectified by the SCADA vendor and get revalidated by the corresponding auditing agency.

Zonal Railways shall specifically include the Cyber Security audit in their tender documents while planning the works related to the implementation of Cyber Security in existing SCADA System.

	Prepared By	Checked By	Issued by
Signature	Vikash	RAMESH KUMAR PAL	
Date	18.04.2024		
Designation	JE/ TI	ADE/ TI-3	DIRECTOR/ TI-3

File No.RDSO-TI0LKO(PSI)/53/2020-O/o PED/TI/RDSO

सत्यमेव जयते

Government of India,
Ministry of Railways Research
Designs & Standards
Organisation Manak Nagar,
Lucknow -226011

Telephone:2465763.
Fax: 91-0522-2465763
E-mail: psi.ti@rdso.railnet.gov.in

No. RDSO-TI0LKO(PSI)/53/2020-O/o PED/TI/RDSO Dated: As signed

To.

As per the mailing list attached.

Sub: Instruction No. TI/IN/0049 for relay setting guideline for Delta-I & Backup DPR relay provided as per RDSO Specification no. TI/SPC/PSI/ PROTCT/1982 with A&C Slip-1 or specification no. TI/SPC/PSI/ PROTCT/6072 at 25 kV AC Traction Sub-station.

Ref: Railway Board letter No. 2022/EEM/220/1 E-3395049 dated 12.12.2023.

Vide letter under reference, the Railway Board communicated recommendations on the various items discussed in 32nd MSG meeting held at Secunderabad in South Central Railway on 12th & 13th October 2023. In respect to Item Nos. 32.8B & 32.13, it was recommended that based on the load, the relay setting table for backup DPR is to be finalized by RDSO.

Accordingly, Instruction No. TI/IN/0049 for relay setting guidelines for Delta-I & Backup DPR relay has been finalized and enclosed herewith for kind information and necessary action, please.

This is issued with the approval of the Competent Authority (PED/TI).

Encl: As above

Digitally Signed by
Jitendra Kumar
Date: 22-04-2024 10:00:16
Reason: Approved

(Jitendra Kumar)
Director/TI- III
For Director General (TI)/RDSO

Copy to:

ED/EMM, Railway Board: For kind information, please

Mailing List

SN	Railways/ PSUs	E-mail id
1.	Principal Chief Electrical Engineer, Central Railway., 2nd floor, Electrical Branch, Parcel Office Bldg. Mumbai - 400 001.	cee@cr.railnet.gov.in
2.	Principal Chief Electrical Engineer, Eastern Railway, Fairlie Place, Kolkata-700 001	cee@er.railnet.gov.in
3.	East Central Railway, Hajipur (Bihar).844101	cee@ecr.railnet.gov.in
4.	Principal Chief Electrical Engineer, East Coast Railway, B-Rental Colony, Chandrashekharpur, Bhubaneshwar (Orissa)-751 023	cee@ecor.railnet.gov.in
5.	Principal Chief Electrical Engineer, Northern Railway, Baroda House, New Delhi - 110 001	cee@nr.railnet.gov.in
6.	Principal Chief Electrical Engineer, North Central Railway, Block-A, Subedarganj, Prayagraj 211 033.	cee@ncr.railnet.gov.in
7.	Principal Chief Electrical Engineer, North Eastern Railway, Gorakhpur (UP).220 055	cee@ner.railnet.gov.in
8.	Principal Chief Electrical Engineer,Northeast Frontier Railway, Maligaon, Guwahati - 781011	cee@nfr.railnet.gov.in
9.	Principal Chief Electrical Engineer, North Western Railway, Jaipur (Raj.) – 302017	cee@nwr.railnet.gov.in
10.	Principal Chief Electrical Engineer, Southern Railway, Park Town, Chennai - 600 003 (TN)	cee@sr.railnet.gov.in
11.	Principal Chief Electrical Engineer, South Central Railway, Rail Nilayam, Secunderabad – 500 371	cee@scr.railnet.gov.in
12.	Principal Chief Electrical Engineer, South Eastern Railway, Garden Reach, Kolkata-700 043	cee@ser.railnet.gov.in
13.	Principal Chief Electrical Engineer, South East Central Railway, Bilaspur (Chhattisgarh).4950 04	cee@secr.railnet.gov.in
14.	Principal Chief Electrical Engineer, South Western Railway, DRM's Office, Hubli (Karnataka	cee@swr.railnet.gov.in
15.	Principal Chief Electrical Engineer, Western Railway, Churchgate Stn. Bldg, Mumbai - 400 020	cee@wr.railnet.gov.in
16.	Principal Chief Electrical Engineer, West Central Railway, Jabalpur-482 001 (M.P)	cee@wcr.railnet.gov.in
17.	Director /Electrical, Delhi Metro Rail Corporation Metro Bhawan,8th Floor,Fire Brigade lane, Barakhamba Road, New Delhi-110001.	eoffice@dmrc.org.
18.	CAO, CORE Central Organisation for Railway Electrification, 1, Nawab Yusuf Road, Civil Lines, Prayagraj -211001	dyceemp@gmail.com, dyceemp1@gmail.com, dyceemp2@gmail.com, ceempcore@gmail.com, chintuies2012@gmail.com
19.	Chairman and Managing Director RITES LTD, Shikhar, Plot No.01, Sector 29, Gurgaon, Haryana, India-122001	info@rites.com
20.	Principal Chief Electrical Engineer, Konkan Railway Corporation Limited, Belapur Bhavan, Plot No 6, Sector 11, CBD Belapur, Navi Mumbai – 400614.	cee@krcl.co.in

TRACTION INSTALLATION DIRECTORATE

सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Instruction No. TI/IN/0049

आरडीएसओ विशिष्टता संख्या टीआई/एसपीसी/पीएसआई/पीआरओटीसीटी/1982 A&C स्लिप-1 या विशिष्टता संख्या TI/SPC/PSI/PROTCT/6072 के अनुसार 25 केवी एसी ट्रैक्शन सब-स्टेशन के लिए डेल्टा-I और बैकअप दूरी सुरक्षा रिले के लिए दिशानिर्देश

Setting guidelines for Delta-I and backup distance protection relay provided as per RDSO Specification No. TI/SPC/PSI/PROTCT/1982 with A&C Slip-1 or Specification No. TI/SPC/PSI/PROTCT/6072 for 25 kV AC Traction Sub-station

Issued on: April, 2024

		Signature
Approved by	Principal Executive Director (TI)	24.4.24

Issued by,

TRACTION INSTALLATION DIRECTORATE
RESEARCH DESIGNS & STANDARDS ORGANISTAION,
MANAK NAGAR, LUCKNOW-226011

Prepared by	Checked by	Recommended by
22.4.2024	22.04.2024	Kumar 22/04/24
SSE/Protection/TI	ADE-III/TI	Director-III/TI

1.0 INTRODUCTION

The Delta-I relay was developed as per old RDSO's Specification No. TI/SPC/PSI/PROTCT/1982 with A&C slip No. 1 or RDSO's Specification No. TI/SPC/PSI/PROTCT/6072 includes Delta-I protection as well as a polygonal characteristic backup distance protection relay. In the 32nd MSG meeting held at Secunderabad, it was decided that RDSO shall issue relay setting guidelines for backup Distance Protection relay in tabular form based on the load at TSS. Accordingly, a relay setting guideline for Delta-I relay and backup Distance Protection relay for 25KV AC Traction Sub-station is issued.

This relay setting guideline gives the method of calculation only. For relay setting procedure and other general parameters setting, refer to the operation & commissioning manual of the relay manufacturer.

2.0 RELAYS SETTING GUIDELINE

2.1 Delta-I relay

Delta-I relay element is to be set in the enable mode.

2.1.1 Delta-I Current Setting

The purpose of the Delta-I relay is to detect high-resistive faults and execute trip commands to the feeder Circuit Breaker. The high resistive reach of the Delta-I relay depends on the set value of the Delta-I current. The higher the Delta-I current setting, the lesser the sensitivity of the relay against high resistive faults. Lowering the setting of the Delta-I current will result in spurious tripping due to a sudden rise in the load current above the set Delta-I current. There is also the probability of spurious tripping when the difference in both feeder CB load currents is high and the electric locomotive bridges the TSS IOL, resulting in a sudden rise in the load current of lightly loaded Feeder CB.

To calculate the Delta-I current setting, it can be assumed that two numbers of electric locomotives simultaneously entered or switched ON in the feeding zone of TSS. The normal load current of an electric locomotive may be assumed as 150 Amp. If the relay malfunctions frequently due to a sudden rise in load current, the Delta-I current setting may be increased further as per site requirements.

The Delta-I current setting on the relay side shall be calculated by the formula given below.

$$\text{Delta} - \text{I current Setting in Amp}$$

$$= \frac{2 * \text{Normal Load Current of an Electric Locomotive}}{\text{CT Ratio}}$$

Setting in % of Delta-I current =

$$\frac{\text{Calculated Delta} - \text{I current setting in Amp}}{5} * 100$$

2.1.2 Harmonic De-sensitivity setting (DS)

A harmonic De-sensitivity setting is provided to minimize spurious tripping of Delta-I relay due to sudden rise in load current. The relay monitors 3rd harmonic components of the current. If 3rd harmonic components are more than the set value, the Delta-I relay executes the trip command as per the given below formula.

Operating value of Delta I Current

$$= \frac{\text{Set Delta I Current} * \text{\% Desensitivity setting}}{100} + \text{Set Delta I Current}$$

De-sensitivity setting is to be set at 100%.

2.1.3 3rd Harmonic Setting

3rd Harmonic is to be set at 12%.

2.1.4 2nd Harmonic Setting

2nd Harmonic setting is provided to avoid spurious tripping of Delta-I relay due to inrush current caused by switching ON multiple electric locomotives simultaneously in the feeding zone of TSS. If 2nd Harmonic component is more than the set percentage, the relay blocks the trip command. 2nd Harmonic is to be set at 15%.

2.1.5 Delta-I Cycle (Delta-T) Setting

Delta-I cycle is the time difference between the base load current sample and the fault current sample. Delta-I cycle (Delta-T) is to be set at 60 ms.

2.1.6 X-Blinder Setting

a) Calculate the single line impedance of the OHE from the feeding post/TSS to the far end SP of the adjoining feeding post/TSS. A factor of 1.25 is to be multiplied by the total impedance to take account of the errors that arise due to CT, PT, and the relays, say this is Z_L.

$$Z_L = 1.25 * \text{calculated impedance of single line OHE}$$

b) Calculate the OHE reactance by using the given below formula. Say this is (X)

$$X = Z_L * \text{Sin of OHE impedance angle}$$

c) Calculate the reactance (X) blinder setting on the relay side by the following formula.

$$X = Z_L \times \text{Sin of impedance angle} \times \frac{\text{CT ratio}}{\text{PT ratio}}$$

d) The OHE reactance shall be calculated for either side of the feeding post/TSS separately. The X-blinder setting of the Delta-I relay provided with both feeder CBs should be set to the higher of the two calculated values.

2.1.7 Additional Time Delay (ATD)

Additional time delay setting is to be calculated as given below.

ATD Setting (ms)

= (DPR Operating Time + MTR Operating Time + CB Operating Time + Tolerance) in ms

The following operating time is to be considered to set additional time delay (ATD)

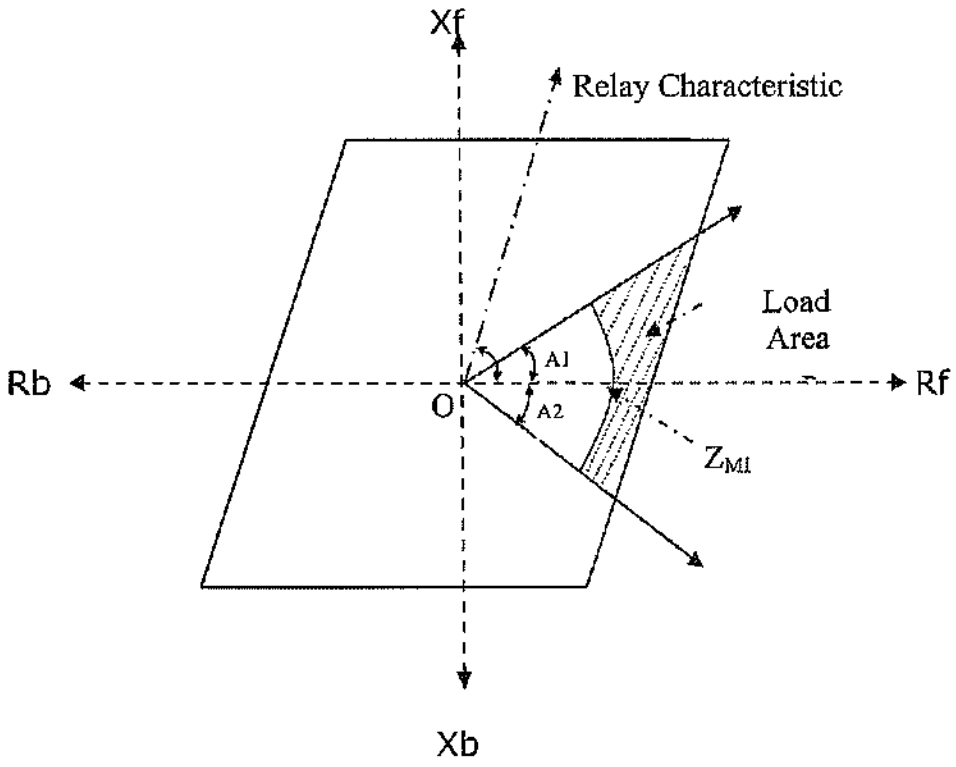
Main Distance Protection Relay (DPR)	=40 ms
Master Trip Relay (MTR)	=10 ms
Circuit Breaker (CB)	=50 ms
Tolerance	=50 ms
ATD	=150 ms

2.1.8 Delta Impedance

This relay may be kept in 'disable' mode.

2.2 Backup Distance Protection Setting (Polygonal Characteristic with Load Blinding)

Backup Distance Protection (Polygonal Characteristic with Load Blinding) relay is to be put in enable mode.



Polygonal Characteristic Distance Protection Relay

2.2.1 Minimum Operating Current

This setting is provided to prevent malfunction of the relay during OHE current and voltage are zero. With both OHE current and voltage are zero; the impedance seen by the relay will zero which may result in a malfunction of the backup DPR element. To avoid malfunction of the relay, the minimum operating current is to be set for 75A OHE current. The minimum operating current setting on the relay side is to be calculated as given below.

Minimum operating current setting on relay side in Amp(Imin)

$$= \frac{75}{\text{CT Ratio}}$$

$$\text{Setting in \%} = \frac{\text{Imin}}{5} * 100$$

2.2.2 Forward reactance setting (Xf)

The procedure given below may be followed to calculate forward reactance settings for single, double, triple lines, etc.

a) To ensure protection under all OHE configurations, calculate the single line impedance of the OHE from the feeding post/TSS to the far end SP of the adjoining feeding post/TSS. In other words, consider the maximum OHE impedance under any possible configuration considering feed extension, long yards, sidings, and feeding lines.

A factor of 1.25 is to be multiplied by the total impedance to take account of the errors that arise due to CT, PT, and the relays, say this is Z_L.

Z_L = 1.25 * calculated impedance of single line OHE

b) Calculate the OHE reactance by using the given below formula. Say this is (X)

X = Z_L * Sin of OHE impedance angle Ω

c) The OHE reactance is to be calculated by following the procedure given at (a) and (b) above for the two sides of the feeding post/TSS separately. However, the backup distance protection relays of both feeders should be set to the higher of the two calculated values. This is to ensure that when one feeder breaker is taken out for maintenance, the relay shall be able to see the faults on either side of the feeding post/TSS.

d) The Forward reactance setting (Xf) on the relay side is to be calculated by the formula given below.

$$\text{Forward Reactance Setting (Xf) in ohm} = \text{Calculated OHE Reactance which is higher as said (c) above} * \frac{\text{CT Ratio}}{\text{PT Ratio}}$$

2.2.3 Backward reactance setting (Xb)

The backward reactance setting on the relay side is to be calculated by the following method

$$\text{Xb} = \text{Forward Reactance Setting (Xf)} * \frac{10}{100} \quad \Omega$$

2.2.4 Forward Resistance Setting (Rf)

This setting is recommended to be set for 30 ohm (OHE side). Forward resistance setting on relay side may be calculated by the formula given below.

$$\text{Forward Resistance Setting (Rf)} = 30 * \frac{\text{CT Ratio}}{\text{PT Ratio}} \quad \Omega$$

2.2.5 Backward Resistance Setting (Rb)

The backward resistance setting is recommended to be set at 10 ohm (OHE side).
The backward Resistance setting on the relay side may be calculated by the formula given below.

$$\text{Backward Resistance Setting (Rb)} = 10 * \frac{\text{CT Ratio}}{\text{PT Ratio}} \quad \Omega$$

2.2.6 Minimum Impedance Setting (Z_{MIN})

This setting is used to permit load on the traction power transformer. A higher setting will increase the sensitivity of the relay against high resistance faults but permit less loading on the traction power transformer. The minimum impedance setting may be calculated based on the peak load impedance of a particular Feeder CB. Zonal Railway may analyze the peak load current of feeder CBs of the TSS recorded by the SCADA system in the last 3 months and calculate Z_{MIN} setting as given below:

$$\text{Peak Load Impedance} = \frac{25000}{\text{Peak load current of Feeder CB}} \Omega$$

To accommodate CT, PT & Relay error, a factor of 0.9 is multiplied in the calculated peak load Impedance.

Minimum impedance setting on the Relay side may be calculated by the formula given below.

$$\text{Minimum Impedance Setting } (Z_{MIN}) =$$

$$0.9 * \text{Peak Load Impedance as calculated above} * \frac{\text{CT Ratio}}{\text{PT Ratio}} \quad \Omega$$

2.2.7 Angle (A1) setting

The load angle (power factor) of traction load widely varies. With higher setting of forward resistance (Rf) for better high resistive reach, the angle (A1) needs accurate setting to prevent malfunction of relay. The angle (A1) is to be set same as maximum load angle of the TSS. Zonal Railway may analyze maximum load angle of a particular TSS recorded by SCADA system in last 3 months and angle (A1) on the relay is to be set accordingly. However, this angle is not to be set beyond 50 deg in any case.

2.2.8 Angle (A2) setting

The angle (A2) is to be set the same as the angle (A1).

2.2.9 2nd Harmonic Setting

2nd Harmonic setting is provided to avoid spurious tripping due to inrush current during switched ON multiple locomotives simultaneously in the feeding zone of TSS. If 2nd harmonic component in the total load current is more than set value, the relay blocks trip command. The 2nd Harmonic is recommended to be set at 15%.

2.2.10 Additional Time Delay (ATD)

Additional time delay setting shall be calculated as given below.

ATD Setting (ms)

= (Main DPR Operating Time + MTR Operating Time + CB Operating Time + Tolerance) in ms

The following operating time is to be considered to set additional time delay (ATD).

Main Distance Protection Relay (DPR)	=40 ms
Master Trip Relay (MTR)	=10 ms
Circuit Breaker (CB)	=50 ms
Tolerance	=50 ms
ATD	=150 ms

2.3 Other Setting

2.3.1 CT (Current Transformer) Primary

CT Primary current on relay is to be set according to the CT used in the field. For example, if CT provided in field is having CT ratio is 750/5, the CT Primary current is to be set at 750

Amp. If CT ratio is 1500/5, the CT primary current is to be set at 1500 Amp.

2.3.2 PT (Potential Transformer) Primary

PT Primary Voltage on relay is to be set according to PT used in the field. For example if PT provided in field is having PT ratio is 27500/110, the PT Primary voltage is to be set at 27500 V.

2.3.3 Local Breaker Backup (LBB) or Breaker Fail or Trip Fail

This feature is used to provide backup protection against feeder Circuit Breaker faults. In other words, in case even after initiation trip command by Delta-I or Backup distance protection, the feeder CB fails to operate within set LBB delay time, an another trip command executes by the same relay to trip the transformer LV CB.

Local Breaker Backup trip delay time may be calculated as given below.

Breaker Fail delay operating time =

MTR operating time + C.B operating time + Tolerance

= 10ms+50ms+140ms
= 200 ms

2.4 After setting of relay as per above calculation, the performance of Delta-I relay shall be monitored by Zonal Railways. Based on the field experience Railways may suggest to RDSO any changes if considered necessary.

3.0 SAMPLE CALCULATION FOR DELTA-I WITH BACK UP DISTANCE PROTECTION RELAY SETTING

The following assumptions are made for sample calculation:

- Traction transformer rating = 21.6 MVA
- No load secondary voltage = 27 kV
- Rated secondary current of transformer $= \frac{21.6\ \text{MVA}}{27\ \text{KV}} =$ 800 Amp
- CT ratio = 750 / 5
- PT ratio = 27500/110
- Single-track OHE without return conductor: $0.41\angle 70^0\ \Omega$/Km

3.1 Delta-I relay

Delta-I relay is to be put in enable mode

3.1.1 Delta-I Current Setting

Assuming normal load current of one loco is 150 Amp and 2 (two) numbers of electric locomotives are entered or switched on simultaneously in the section.

$$\text{Delta} - \text{I current Setting in Amp} = \frac{2 * 150}{750/5}$$
$$= 2 \text{ Amp.}$$

3.1.2 Harmonic De-sensitivity setting (DS)

De-sensitivity setting is recommended to be set at 100%. The 100% de-sensitivity setting means, relay will execute trip command at 2 times of set Delta-I, when 3rd harmonic is more than set value.

3.1.3 2nd Harmonic Setting

2nd Harmonic setting is recommended to be set at 15%.

3.1.4 3rd Harmonic Setting

3rd Harmonic setting is recommended to be set at 12%.

3.1.5 Delta-I Cycle (DeltaT) Setting

Delta-I cycle (Delta-T) is recommended to be set at 60 ms.

3.1.6 X-blinder setting

Let the distance between TSS1 and far end SP of TSS2=95 Km

Single line OHE impedance = $0.41 \angle 70^0\ \Omega$/Km

Total impedance = $95 \times 0.41 \angle 70^0$

= $38.95 \angle 70^0\ \Omega$

Effective impedance (Z_L) considering CT & PT error

$= 1.25 \times 38.95 \angle 70^0$

$= 48.69 \angle 70^0$

$$\therefore \text{Reactance blinder setting } X = 48.69 \times \sin\angle 70^0 \times \frac{750/5}{27500/110}$$

$= 27.45\ \Omega$

3.1.7 Additional Time Delay (ATD)

Main Distance Protection Relay (DPR)	=40 ms
Master Trip Relay (MTR)	=10 ms
Circuit Breaker (CB)	=50 ms
Tolerance	=50 ms

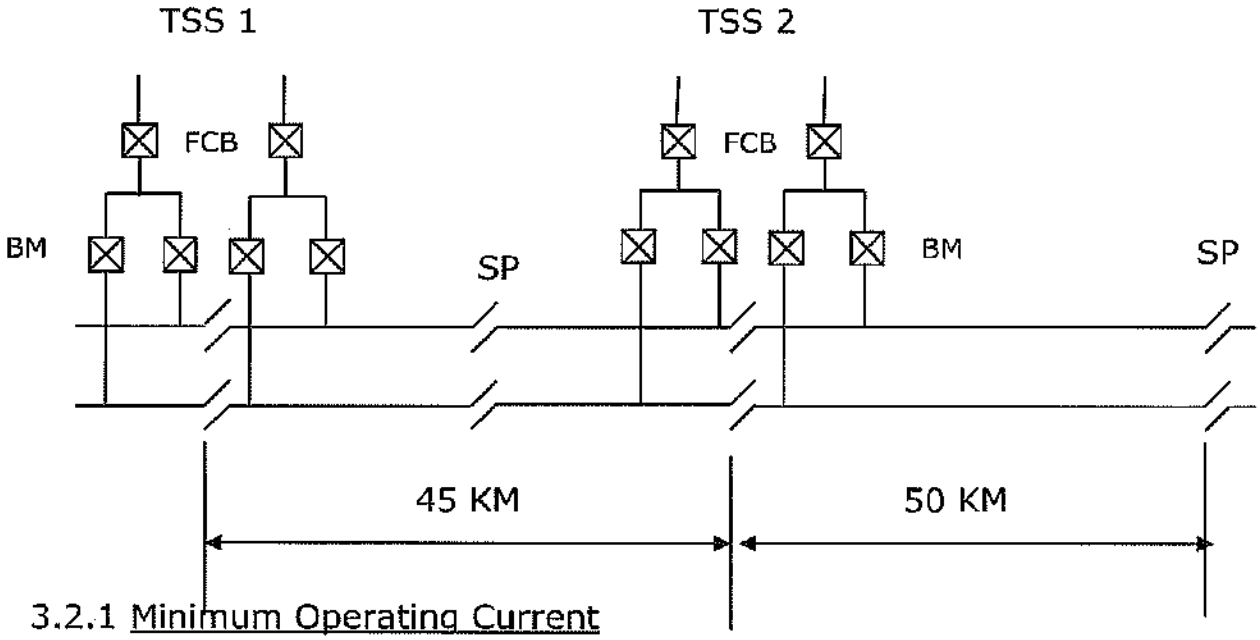
ATD Setting (ms)

= (DPR Operating Time + MTR Operating Time + CB Operating Time + Tolerance)

= 40+10+50+50 ms
= 150 ms

Additional time delay may be set at 150 ms

3.2 Backup Distance Protection Setting (Polygonal Characteristic with Load Blinding)



3.2.1 Minimum Operating Current

Minimum operating current is recommended to be on the relay corresponding to 75A on OHE side.

Minimum operating current setting on relay in Amp.

$$= \frac{75}{750/5}$$
$$= 0.5 \text{ Amp}$$

$$\text{Minimum current setting in \%} = \frac{0.5}{5} * 100$$
$$= 10\% \text{ Amp}$$

If range of setting is not possible on the relay, next lower setting available on the relay may be set.

3.2.2 Forward reactance setting (Xf)

Calculate single line impedance from TSS1 to far end SP of TSS2.

Single line without BT&RC		=	95 Km
Total Line impedance		=	95 x 0.41
		=	38.95 Ω
∴ Z_L	= 1.25 X 38.95	=	48.69 Ω

$X = 48.69 * \text{Sin } 70^0 \ \Omega$

$= 45.75 \ \Omega$

$$\text{Forward Reactance Setting (XF) on relay side} = 45.75 * \frac{750/5}{27500/110} \ \Omega$$

$$= 27.45 \ \Omega$$

3.2.3 Backward reactance setting (Xb)

$$XB = 27.45 * \frac{10}{100}$$
$$= 2.75 \ \Omega$$

3.2.4 Forward Resistance Setting (Rf)

$$\text{Forward Resistance Setting (Rf)} = 30 * \frac{750/5}{27500/110} \ \Omega$$

$$= 18 \ \Omega$$

3.2.5 Backward Resistance Setting (Rb)

$$\text{Backward Resistance Setting (Rb)} = 10 * \frac{750/5}{27500/110} \ \Omega$$

$= 6\ \Omega$

3.2.6 Minimum Impedance Setting (Z_{MIN})

Zonal Railway may analyse peak load current of feeder CBs of particular TSS recorded by SCADA system in last 3 months and calculate Zmin setting. Suppose peak load current on a particular feeder CB is 800 Amp.

$$\text{Peak Load Impedance} = \frac{25000}{800}\ \Omega$$

$$= 31.25\ \Omega$$

Minimum Impedance Setting (Z_{MIN})

$$= 0.9 * 31.25 * \frac{750/5}{27500/110}\ \Omega$$

$$= 16.87\ \Omega$$

Minimum impedance setting on relay with respect to load current on feeder CB

Feeder CB Load current	Calculated minimum impedance setting on relay
200 A	67.5 Ω
400 A	33.75 Ω
500 A	27.00 Ω
750 A	18.00 Ω
800 A	16.87 Ω
1000 A	13.5 Ω
1200 A	11.25 Ω

Note: The above setting is applicable for CT ratio 750/5A. If CT provided in the field of different ratio, the setting may be calculated accordingly.

3.2.7 Angle (A1) & (A2) setting

Zonal Railway may analyze maximum load angle of a particular TSS recorded by SCADA system in last 3 months and angle (A1) & (A2) on the relay is to be set accordingly. However, this angle is not to be set beyond 50° in any case.

Angle A1 & A2 setting on relay

Maximum load angle of a particular TSS recorded by SCADA system in last 3 months	Angle A1 & A2 setting on the relay
10°	10°

30°	30°
37°	37°
43°	43°
50°	50°
60°	50°
70°	50°

3.2.8 2nd Harmonic Setting

2nd Harmonic content is recommended to be set at 15%.

3.2.9 Additional time delay (ATD)

Main Distance Protection Relay (DPR) =40 ms
Master Trip Relay (MTR) =10 ms
Circuit Breaker (CB) =50 ms
Tolerance =50 ms

ATD Setting

= (DPR Operating Time + MTR Operating Time + CB Operating Time + Tolerance)
= 40+10+50+50
= 150 ms

Additional time delay is to be set at 150 ms

3.3 **Other Setting**

3.3.1 CT (Current Transformer) Primary

CT Primary current setting=750 Amp (if CT provided of 750/5 ratio).

3.3.2 PT (Potential Transformer) Primary

PT Primary voltage setting = 27500 V.

3.3.3 Local Breaker Backup (LBB) or Breaker Fail or Trip Fail

Breaker Fail delay operating time =

MTR operating time + C.B operating time + Tolerance)

= 10ms+50ms+140ms
= 200ms

*****

TRACTION INSTALLATION DIRECTORATE

सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Instruction No. TI/IN/0050, Rev.01

आरडीएसओ विनिर्देश संख्या. टीआई/एसपीसी/पीएसआई/प्रोटेक्ट/7101के अनुसार,
2x25 केवी एसी ट्रैक्शन सिस्टम के लिए विकसित कर्षण ट्रांसफार्मर,
फीडर सुरक्षा और शंट कैपेसिटर बैंक सुरक्षा रिले के लिए सेटिंग गाइड लाइन

Relay Setting Guidelines for Traction Transformer, Feeder Protection & Shunt Capacitor Bank Protection Relay developed as per RDSO Specification No. TI/SPC/PSI/PROTCT/7101 for 2x25 KV AC Traction System

Issued on: October, 2025

		Signature
Approved by	Principal Executive Director (TI)	24/10/25
Recommended by	Executive Director (TI)	24/10/25

कर्षण संस्थापन निदेशालय
Traction Installation Directorate
अनुसंधान अभिकल्प और मानक संगठन
Reserch Designs & Standards Organistaion,
मनक नगर,लखनऊ–226011
Manak Nagar, Lucknow- 226011

Prepared by	Checked by	issued by
24.10.2025 SSE (Protection)/TI	24/10/25 ADE/TI-3	24/10/25 Director-3/TI

1.0 INTRODUCTION

The existing RDSO Specification No. TI/SPC/PSI/PROTCT/7100 of control and relay panel including numerical type protection relays for 2x25kV ac traction system has been superseded by revised RDSO Specification No. TI/SPC/PSI/PROTCT/7101 in July 2021.

The 2x25KV AC traction system in the Indian Railway is provided in Bina-Katni-Bishrampur including the Chirimiri section. The design of the system was done with the help of Japanese consultants (JART) in the year 1990.

Now, the traction systems of the Delhi-Mumbai and Delhi-Howrah routes are being converted from 25KV AC traction to 2x25KV AC traction to meet power requirements for the operation of high-speed trains. RDSO has not issued relay setting guidelines for the 2x25KV AC traction system to date. It is therefore, a need to issue a relay setting guideline for a 2x25KV AC traction system for guidance to zonal railways. These relay-setting guidelines shall provide the method of calculations only. For other parameter settings available on the relays, zonal railways may consult the relay manufacturer. The operation, maintenance & commissioning manual of particular make Control and relay panels & relays shall also be followed.

This is the first revision of relay setting guidelines for 2x25KV AC traction. Zonal Railways are advised, to monitor the protection system closely. Based on the field experience, zonal railways may submit their feedback to RDSO for further improvement in the relay setting guideline, if considered necessary.

2.0 Relays setting guidelines for traction power transformer protection

2.1 HV side OCR and REF Protection

2.1.1 IDMT over current relay HV side

To utilize the overload capacity of the traction power transformer, IDMT OCR should be set for 200% of the rated transformer HV current. The setting on the relay side may be calculated by the formula given below:-

$$\text{IDMT OCR Current Setting in Amp } (I_{OCR\ HV}) = \frac{2 * \text{Rated Tx. Primary current (Ipri)}}{\text{CT ratio}}$$

$$\text{IDMT OCR Current Setting in \%} = \frac{I_{OCR\ HV}}{5} * 100$$

2.1.1.1 TMS (Time Multiplier Setting) calculation

TMS should be selected such that the relay executes the trip command in 600 ms for an electrical fault on the LV bus.

Calculate the fault current at the LV bus considering the source impedance and transformer impedance.

$$\text{Fault current at LV bus in Amp } = \frac{\text{No load bus voltage (i. e. 55KV)}}{\text{Source impedance} + \text{Tx impedance}}$$

$$\text{Corressponding fault current on HV side } = \frac{LV\ bus\ fault\ current * KVsec.}{KV\ pri.}$$

Note: For Scott transformer, the calculated value is to be multiplied by a factor $2/\sqrt{3}$

$$\text{Source impedance on Primary side (Zpri)} = \frac{KVpri * KVpri}{\text{Fault MVA on primary side}} \quad \Omega$$

$$\text{Source impedance seen from 55KV bus} = (\text{Zpri}) * \frac{KVsec * KVsec}{KVpri * KVpri} \quad \Omega$$

$$\text{Impedance of Tx. at 55 KV base} = \frac{KVsec * KVsec * percentage \text{ impedance of Tx.}}{\text{Transformer MVA} * 100} \quad \Omega$$

TMS shall be calculated as per the formula given below for operating time 600 ms for fault at LV bus:

$$t = \frac{TMS * a}{[I/Iset] \wedge b - 1}$$

Where a & b are constant a = 0.14, b = 0.02
t = Operating time in second
TMS = Time multiplier setting
I = Fault current seen by the relay in Amp = Fault current in Amp/CT ratio
I_{set} = Set current in amp

2.1.2 Instantaneous over current relay

The current setting of instantaneous OCR shall be corresponding to 1.25 times of fault current on the LV bus to avoid tripping of relay for fault at the LV bus.

$$\text{Over current setting in Amp } (I_{Inst.OCR}) = \frac{1.25 * \text{ fault current at LV bus} * \text{ KVsec}}{\text{KVpri} * \text{CT ratio}}$$

$$\text{Over current setting in \%} = \frac{(I_{Inst.OCR})}{5} * 100$$

2.1.3 Restricted Earth Fault Relay

The REF current setting should correspond to 30 % of the rated current of the traction power transformer.

$$\text{REF setting in Amp } (I_{REF}) = \frac{\text{Tx. rated current} * 30}{100 * \text{CT ratio}}$$

$$\text{REF setting in \%} = \frac{I_{REF}}{5} * 100$$

2.1.4 Definite time over current protection setting

Three stage definite times over current relay is provided for overload protection of traction power transformer. The setting of each stage of HV side definite time OCR is given below:

Current and time setting of definite time overcurrent relay on transformer HV side.

Stage	Current Setting	Operating Time setting
Stage 1 OCR	140% of Full Load	900 Sec.
Stage 2 OCR	160% of Full Load	720 Sec.
Stage 3 OCR	180% of Full Load	300 Sec.

(i) $$\text{Stage1 OCR current setting in Amp} = \frac{140 * \text{Rated Tx. Primary current}}{100 * \text{CT ratio}}$$

$$\text{Stage1 OCR Setting in \%} = \frac{\text{Stage1 OCR current setting in Amp}}{5} * 100$$

(ii) $$\text{Stage2 OCR current setting in Amp} = \frac{160 * \text{Rated Tx. Primary current}}{100 * \text{CT ratio}}$$

$$\text{Stage2 OCR Setting in \%} = \frac{\text{Stage2 OCR current setting in Amp}}{5} * 100$$

(iii) $$\text{Stage3 OCR current setting in Amp} = \frac{180 * \text{Rated Tx. Primary current}}{100 * \text{CT ratio}}$$

$$\text{Stage1 OCR Setting in \%} = \frac{\text{Stage3 OCR current setting in Amp}}{5} * 100$$

(iv) Repeated overload protection

The traction transformer is designed to overload 150% for 15 minutes and 200% for 5 minutes. Two consecutive overloading on the transformer is permitted after an interval of 3 hours. To take care of the defined transformer overloading cycle, a definite time OCR for the post-overload protection is provided.

Post overload OCR Current setting:

$$\text{Post over load setting in Amp} = \frac{110 * \text{Rated Tx Secondary current}}{100 * \text{CT ratio}}$$

$$\text{Post over load Setting in \%} = \frac{\text{Post overload setting in Amp}}{5} * 100$$

Operating time setting:
The operating time of post-overload OCR should be set at 70 sec.

Post overload reset time setting :
The post-over-load reset time should be set to 3 Hours.

2.2 LV side OCR and REF Protection

2.2.1 IDMT relay on transformer LV side.

To utilize the overload capacity of the traction power transformer, IDMT OCR should be set for 190% of the rated transformer LV current. The setting on the relay side may be calculated by the formula given below.

$$\text{IDMT OCR Current Setting in Amp } (I_{OCR\,LV}) = \frac{1.9 * \text{Rated Tx Secondary current (Isec)}}{\text{CT ratio}}$$

$$\text{IDMT OCR Current Setting in \%} = \frac{(I_{OCR\,LV})}{5} * 100$$

2.2.1.1 TMS (Time Multiplier Setting) calculation.

TMS should be selected such that the relay executes the trip command in 300 ms for an electrical fault on the LV bus.

Calculate the fault current at the LV bus considering the source impedance and single transformer impedance

$$\text{Fault current in Amp at LV bus} = \frac{\text{No load bus voltage (i. e. 55KV)}}{\text{Source impedance} + \text{Tx. impedance}}$$

TMS shall be calculated as per the formula given below for operating time 250 to 300 ms for fault at LV bus :

$$t = \frac{TMS * a}{[I/Iset] \wedge b - 1}$$

Where a & b are constant a = 0.14, b = 0.02
t = Operating time in second
TMS = Time multiplier setting
I = Fault current seen by the relay in Amp = Fault current in Amp/CT ratio
I_{set} = Set current in amp

2.2.2 Restricted Earth Fault Relay (For V- Connected Transformer)

The REF current setting should correspond to 50 % of the rated secondary current of the traction power transformer.

$$\text{REF setting in Amp } (I_{REF}) = \frac{\text{Tx rated current} * 50}{100 * \text{CT ratio}}$$

$$\text{REF setting in \%} = \frac{I_{REF}}{5} * 100$$

2.2.3 Restricted Earth fault relay (For Scott- Connected Transformer)

The REF current setting should correspond to 20 % of the rated secondary current of traction power transformer.

$$\text{REF setting in Amp } (I_{REF}) = \frac{\text{Tx rated current} * 20}{100 * \text{CT ratio}}$$

$$\text{REF setting in \%} = \frac{I_{REF}}{5} * 100$$

2.2.4 Definite time over current protection element setting

Three stage definite times over current relay is provided for overload protection of traction power transformer. The setting of each stage of LV side definite time OCR is given below:

Current and time setting of definite time overcurrent relay on transformer LV side.

Stage	Current Setting	Operating Time
Stage 1 OCR	130% of Full Load	840 Sec.
Stage 2 OCR	150% of Full Load	600 Sec.
Stage 3 OCR	170% of Full Load	240 Sec.

(i) $\text{Stage1 OCR current setting in Amp} = \frac{130 * \text{Rated Tx Secondary current}}{100 * \text{CT ratio}}$

$$\text{OL1 Setting in \%} = \frac{\text{Stage1 OCR current setting in Amp}}{5} * 100$$

(ii) $\text{Stage2 OCR current setting in Amp} = \frac{150 * \text{Rated Tx Secondary current}}{100 * \text{CT ratio}}$

$$\text{OL2 Setting in \%} = \frac{\text{Stage2 OCR current setting in Amp}}{5} * 100$$

(iii) $\text{Stage3 OCR current setting in Amp} = \frac{170 * \text{Rated Tx Secondary current}}{100 * \text{CT ratio}}$

$$\text{OL3 Setting in \%} = \frac{\text{Stage3 OCR current setting in Amp}}{5} * 100$$

(iv) Repeated overload protection

The traction transformer is designed to overload 150% for 15 minutes and 200% for 5 minutes. Two consecutive overloading on the transformer is permitted after an interval of 3 hours. To take care of the defined transformer overloading cycle, a definite time OCR for the post overload protection is provided.

Post overload OCR Current setting:

$$\text{Post over load setting in Amp} = \frac{\text{Rated Tx Secondary current}}{100 * \text{CT ratio}}$$

$$\text{Post over load Setting in \%} = \frac{\text{Post overload setting in Amp}}{5} * 100$$

Operating time setting:
The operating time of post-overload OCR should be set at 60 sec.

Post overload reset time setting :
The post-overload reset time should be set to 3 Hours.

2.3 Biased Transformer differential protection

The biasing and operating current setting of the numerical type of differential protection relay should be calculated as follows:

(a) The percentage biased setting should be so chosen that the relay remains inoperative on differential currents resulting from (1) tap changing of traction transformer, (2) mismatch in CT ratios, and (3) difference in CT saturation levels under through fault conditions. Percentage mismatches resulting from factors (1) and (2) may be calculated from actual data and an allowance of 7.5 to 15% may be made for factor (3).

(b) The operating current setting may be taken as 20%. If mal operations of the relay are observed through faults and magnetizing inrush (switching in of power transformer), a higher setting may be considered.

2.3.1 Calculation of ICT multiplication factor setting

This factor is used to neutralize the effect of transformer bushing CTs ratio corresponding to the transformer primary and secondary rated current, as the output current (CT secondary) shall be the same to avoid malfunction during normal operating conditions. The ICT multiplication factor individually for HV & LV shall be calculated by the formula given below:

$$\text{ICT multiplication factor for scott connected Tx. HV (TEASER)} = \frac{5 \text{ x Bushing CT ratio}}{\text{Tx. Primary rated current in Amp}}$$

$$\text{ICT multiplication factor for scott connected Tx. HV (MAIN), V} - \text{connected Tx. HV)} = \frac{5 \text{ x Bushing CT ratio}}{\text{Tx.Primary rated current in Amp}} \text{x1/2}$$

$$\text{ICT multiplication factor for scott connected Tx. LV, V} - \text{connected Tx. LV)} = \frac{5 \text{ x Bushing CT ratio}}{\text{Tx.Secondary rated current in Amp}} \text{ x1/2}$$

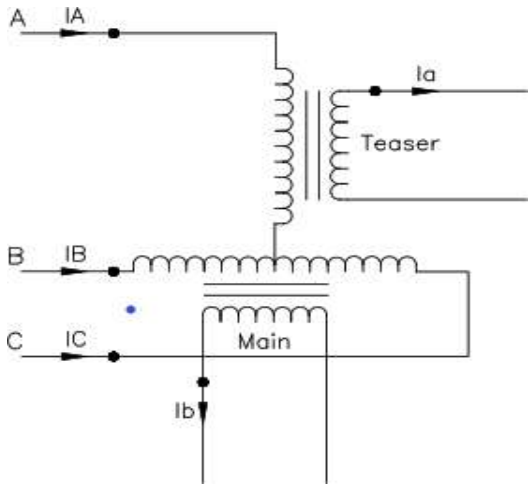
Note:
The calculation of ICT multiplication factor may vary from vendor to vendor. Any different ICT multiplication factor, if suggested by the relay manufacturer, may be accepted by the zonal railway. After applying the ICT multiplication factor, the differential current displayed on the relay should be approximately zero under normal loading conditions.

2.3.2 Bias & Operating Current Setting Calculation (Scott connected Transformer)

Calculate the transformer HV current at the lowest tap position i.e. -15%

$$= \frac{\text{Rated transformer MVA} * 1000}{\sqrt{3} * \text{Rated primary voltage in kV} - 15\% \text{ of rated primary voltage}} \quad \text{Amp}$$

$$\text{Current read by relay} = \frac{\text{vector sum of respective HV current at lowest tap in amp} * \text{ICT multiplication factor}}{\text{HV bushing CT ratio}}$$



Spillover Current in amp = Current read by relay – 5

$$\text{Percentage differential bias current} = \frac{\text{Spill over current in amp} * 100}{(\text{Current read by relay} + 5) / 2}$$

To allow the relay and CT errors, the % differential current further increased by a factor of 1.25.

The differential operating current shall be set at 20% of the transformer-rated current.

2.3.3 Bias & Operating Current Setting Calculation (V- connected Transformer)

Calculate the transformer HV current at the lowest tap position i.e. -15%

$$= \frac{\text{Rated transformer MVA} * 1000}{\text{Rated primary voltage in kV} - 15\% \text{ of rated primary voltage}} \quad \text{Amp}$$

$$\text{Current read by relay} = \frac{\text{2xHV current at lowest tap in amp} * \text{ICT multiplication factor}}{\text{HV bushing CT ratio}}$$

Spillover Current in amp = Current read by relay – 5

$$\text{Percentage differential bias current} = \frac{\text{Spill over current in amp} * 100}{(\text{Current read by relay} + 5)/2}$$

To allow the relay and CT errors, the % differential current further increased by a factor of 1.25.

The operating current shall be set at 20% of the transformer-rated current.

2.4 Phase failure relay (only for V-connected)

If either of the two poles of the circuit breaker does not close or open in its operation, power will be fed to load from half of the secondary winding, this phenomenon is called phase failure. This protection is only provided for the transformer in which secondary winding is earthed (V-connected transformer). The setting of the phase failure relay should be calculated as given below:

$$\text{Phase failure relay setting in Amp } (PI_{PH}) = \frac{50 * \text{ Rated Tx Secondary current}}{100 * \text{CT ratio}}$$

$$\text{Phase failure relay Setting in \%} = \frac{PI_{PH}}{5} * 100$$

Time setting

Time setting is to be kept at 10 sec.

3.0 The summary of transformer protection IDMT & definite time OCR relays setting is as below.

Relay element	**HV side**		**LV side**	
	Current setting in % of transformer rated current	Time setting	% Current setting of transformer rated current	Time setting
REF	30	Not required	50 (For V-connected Xmer) 20 (For Scott connected Xmer)	Not required
IDMT OCR	200	600ms in terms of TMS for fault at LV bus	190	300ms in terms of TMS for fault at LV bus
Stage-1 OCR	140	900 sec	130	840 sec
Stage-2 OCR	160	720 sec	150	600 sec
Stage-3 OCR	180	300 sec	170	240 sec
Post overload	110	70 sec	100	60 sec

4.0 (A) Sample calculation for V-Connected transformer protection relay setting

The following assumptions are made for sample calculation:

(Refer RDSO Spec. No. TI/SPC/PSI/TRNPWR/4200 withA&C Slip No. 1 or latest)

a. Traction power transformer

i) Traction transformer rating = 38 MVA (ONAN)
ii) % impedance = 11
iii) No load primary voltage, V_{PO} = 132 kV

iv) No load secondary voltage, V_{SO} = 55 kV

v) Rated secondary current, I_{Sec}

$$I_{sec} = \frac{38\ MVA}{55\ KV} = 691\ Amp$$

vi) Rated primary current, I_P

$$I_P = 38\ MVA/132 = 287.9 Amp$$

b. CT ratio

i) 55 kV side …… 750 / 5

ii) 132 kV side ……..400 / 5

C. Bushing CT ratio

i) 55 kV side …… 2000 / 5

ii) 132 kV side ……600 / 5

d. **Fault MVA**

10000 MVA at 132kV base voltage.

4.1 (A) HV side OCR and REF Protection

4.1.1 (A) IDMT OCR Current Setting in Amp $(I_{OCR\,HV}) = \frac{2*287.9}{\frac{400}{5}} = 7.2$

$$\text{IDMT OCR Current Setting in \%} = \frac{7.2}{5} * 100 = 144\ \%$$

4.1.1.1 (A) TMS setting

Source impedance, Z_{source} at 132kV base

$$= \frac{(132)^2}{10000} = 1.74\ \Omega$$

Source impedance as seen from the 55 kV bus

$$= 1.74 \times \frac{(55)^2}{(132)^2} = 0.3\ \Omega$$

Impedance of traction transformer at 55 kV base, $Z_{Tx.}$

$$= \frac{(55)^2 \times 11}{38 \times 100} = 8.76\ \Omega$$

Total impedance, Z = 0.3 + 8.76 = 9.06 Ω

$$\text{Fault current at LV bus in Amp } = \frac{55000}{9.06} = 6070A$$

$$\text{Corressponding fault current on HV side } = \frac{6070 * 55}{132} \quad = 2529\ Amp$$

Corresponding fault current to secondary side of CT

= 2529 / (400/5) = 31.61 amp

To achieve the operating time 600 ms for bus fault, the TMS setting =

$$\frac{600}{1000} = \frac{\text{TMS x } 0.14}{[31.61/7.2]^{0.02} - 1}$$

$$\frac{600}{1000} = \frac{\text{TMS x } 0.14}{1.03 - 1}$$

TMS = 0.129

4.1.2 (A) Instantaneous over current relay

$$\text{Over current setting in Amp } (I_{\text{Inst.OCR}}) = \frac{1.25 * 6070 * 55}{132 * \frac{400}{5}} = 39.52$$

$$\text{Over current setting in \%} = \frac{39.52}{5} * 100 = 790\ \%$$

4.1.3 (A) Restricted earth fault relay

REF Current setting in amp

$$= \frac{287.9 \text{ x } 30}{100 \text{ x } 400/5} = 1.08 \text{ Amp}$$

REF current setting in % = 1.08 / 5 * 100

= 21.6 %

4.1.4 (A) Current and time setting of definite time overcurrent relay

(i) Stage1 OCR

Current setting in amp, Stage1 OCR

$$= \frac{287.9 \text{ x } 140}{100 \text{ x } 400/5} = 5.04 \text{ Amp}$$

Setting in % = (5.04 / 5) * 100

= 101 %

(ii) Stage 2 OCR

Current setting in amp, Stage2 OCR

= 287.9 x 160 / 100 x 400/5 = 5.76 Amp

Setting in % = (5.76 / 5) * 100
= 115 %

(iii) Stage 3 OCR

Current setting in amp, Stage3 OCR

= 287.9 x 180 / 100 x 400/5 = 6.48 Amp

Setting in % = (6.48 / 5) * 100
= 130 %

(iv) Post over load

Current setting in amp,

= 287.9 x 110 / 100 x 400/5 = 3.96 Amp

Setting in % = (3.96 / 5) * 100
= 79 %

4.2 (A) LV side OCR and REF Protection

4.2.1 (A) IDMT OCR Current Setting in Amp $(I_{OCR\,LV}) = \frac{1.9*691}{\frac{750}{5}} = 8.75$

IDMT OCR Current Setting in % $= \frac{8.75}{5} *100$ = 175%

4.2.2 (A) TMS setting

Source impedance, Z_{source} at 132kv base

= $\frac{(132)^2}{10000}$ = 1.74 Ω

Source impedance as seen from the 55 kv bus

= 1.74 x $\frac{(55)^2}{(132)^2}$ = 0.3 Ω

Impedance of traction transformer at 55 kv base, $Z_{transformer}$

= $\frac{(55)^2 \times 11}{38 \times 100}$ = 8.76 Ω

Total impedance, Z = 0.3 + 8.76 = 9.06 Ω

Fault current for 55 kV bus fault (between traction and feeder), I_f

$= \frac{55000}{9.06}$ = 6070 amp

Fault current reflected to secondary side of CT

= 6070 /(750/5) = 40.47 amp

To achieved the operating time 300 ms for bus fault, the TMS setting should be

$$\frac{300}{1000} = \frac{TMS \times 0.14}{[40.47/8.75]^{0.02} - 1}$$

$$\frac{300}{1000} = \frac{TMS \times 0.14}{1.031 - 1}$$

TMS = 0.067 i.e.0.07 (nearest setting available on the relay)

4.2.3 (A) Restricted earth fault relay

REF Current setting in amp, I_{REF}

$= \frac{691 \times 50}{100 \times 750/5}$ = 2.30 Amp

REF current Setting in % = (2.30 / 5) * 100
= 46.1 %

4.2.4 (A) Current setting of definite time over current relay

(i) Stage 1 OCR

Current setting in amp, Stage 1 OCR

$= \frac{691 \times 130}{100 \times 750/5}$ = 5.988 Amp

Setting in % = (5.988 / 5) * 100
= 119.77 %

(ii) Stage 2 OCR

Current setting in amp, Stage 2 OCR

$= \frac{691 \times 150}{100 \times 750/5}$ = 6.91 Amp

Setting in % = (6.91 / 5) * 100
= 138.2 %

(iii) Stage 3 OCR

Current setting in amp, Stage 3 OCR

$= \frac{691 \times 170}{100 \times 750/5}$ = 7.83 Amp

Setting in % = (7.83 / 5) * 100
= 156.6 %

(iv) Post over load

Current setting in amp,

$$= \frac{691 \times 100}{100 \times 750/5} = 4.61 \text{ Amp}$$

Setting in % = (4.61 / 5) * 100
= 92.1 %

4.3 (A) Biased differential protection

4.3.1 (A) Calculation of ICT multiplication factor

LV Bushing CT multiplication factor

$$= \frac{5 \times 2000/5 \times 1/2}{691}$$

$$= 1.45$$

HV Bushing CT multiplication factor

$$= \frac{5 \times 600/5 \times 1/2}{287.9}$$

$$= 1.04$$

4.3.2 (A) Bias setting calculation

Calculate the transformer HV current at lowest tap position i.e. -15%

$$= \frac{38 * 1000}{112.2} = 338.7 \text{ Amp}$$

$$\text{Current read by relay} = \frac{2 \times 338.7 * 1.04}{600/5} = 5.87$$

Spill Over Current in amp = 5.87 – 5

$$\% \text{ bias-I setting} = \frac{0.87 * 100}{(5.87 + 5)/2} = 16. \%$$

To allow the relay and CT errors, the % bias-I further increased by a factor of 1.25.

% biased setting (First bias setting) = 1.25 x 16
= 20 %

Second bias to be set at = 80%
Start of second bias = 200%
Second harmonic blocking to be set at = 15%
Fifth harmonic blocking to be set at = 10%

Differential operating current=20%

4.4 (A) Phase failure relay

Phase failure relay setting in Amp $(I_{PH}) = \frac{50 * 691}{\frac{100 * 750}{5}}$ =2.30

Phase failure relay Setting in $\% = \frac{2.30}{5} * 100 = 46\%$

Operating Time setting:

Operating Time setting should be set for 10 sec.

4.0 (B) Sample calculation for Scott Connected transformer protection relay setting

The following assumptions are made for sample calculation:

a. Traction power transformer

(Refer RDSO Spec. No. TI/SPC/PSI/TRNPWR/5200 with A&C Slip No. 1 & 2 or latest**)**

i) Traction transformer rating = 60 MVA (ONAN)
ii) % impedance = 11
iii) No load primary voltage, V_{PO} = 132 kV
iv) No load secondary voltage, V_{SO} = 55 kV
v) Rated secondary current, I_{Sec}

I_{main}= 30 MVA / 55 KV = 545 Amp

I_{teaser}= 30 MVA / 55 KV = 545 Amp

vi) Rated primary current, I_P

I_P = 60 MVA / √3 *132 = 262.5 Amp

b. CT ratio

i) 55 kV side …… 750 / 5
ii) 132 kV side ……..400 / 5

c. Bushing CT ratio

i) 55 kV side …… 1100 / 5
ii) 132 kV side ……550 / 5

d. **Fault MVA**
10000 MVA at 132kV base voltage.

4.1 (B) HV side OCR and REF Protection

4.1.1 (B) IDMT OCR Current Setting in Amp ($I_{OCR\,HV}$) $= \frac{2*262.5}{\frac{400}{5}} = 6.56$

IDMT OCR Current Setting in % $= \frac{6.56}{5} *100$ = 131%

4.1.1.1 (B) TMS setting

Source impedance, Z_{source} at 132kv base

$= \frac{(132)^2}{10000}$ = 1.74 Ω

Source impedance as seen from the 55 kV bus

$= 1.74 \times \frac{(55)^2}{(132)^2}$ = 0.3 Ω

Impedance of traction transformer at 55 kV base, $Z_{Tx.}$

$= \frac{(55)^2 \times 11}{30 \times 100}$ = 11.09 Ω

Total impedance, Z = 0.3 + 11.09 = 11.39 Ω

Fault current at LV bus in Amp $= \frac{55000}{11.39} = 4829$

Corressponding fault current on HV side $= \frac{4829 * 55}{132} x(2/\sqrt{3}) = 2323\ Amp$

Why $x(2/\sqrt{3})$ factor?

As per above calculations, HV rated current, IHV = 262.45A, LV rated current, ILV = 545.45A

As per previous equation “Fault current on HV side” = “LV current x 55/132”

So, rated current at HV side = 545.45x(55/132) = 227.27, but as per transformer spec, HV rated current = 262.45
So, to match the equation multiply with $2/\sqrt{3}$ is required

Corresponding fault current to secondary side of CT

= 2323 / (400/5) = 29.04 amp

To achieve the operating time 600 ms for bus fault, the TMS setting =

$$\frac{600}{1000} = \frac{TMS \times 0.14}{[29.04/6.56]^{0.02} - 1}$$

$$\frac{600}{1000} = \frac{TMS \times 0.14}{1.027 - 1}$$

TMS = 0.13

4.1.2 (B) Instantaneous over current relay

$$\text{Over current setting in Amp } (I_{Inst.OCR}) = \frac{1.25 * 4829 * 55}{132 * \frac{400}{5}} x(2/\sqrt{3}) = 36.3$$

$$\text{Over current setting in \%} = \frac{36.3}{5} * 100 = 726\ \%$$

4.1.3 (B) Restricted earth fault relay

REF Current setting in amp

$$= \frac{262.5 \times 30}{100 \times 400/5} = 0.98 \text{ Amp}$$

REF current setting in % = 0.98 / 5 * 100

= 20 %

4.1.4 (B) Current setting of definite time over current relay

(i) Stage1 OCR

Current setting in amp, Stage1 OCR

$$= \frac{262.5 \times 140}{100 \times 400/5} = 4.59 \text{ Amp}$$

Setting in % = (4.59 / 5) * 100

= 92 %

(ii) Stage 2 OCR

Current setting in amp, Stage2 OCR

$$= \frac{262.5 \times 160}{100 \times 400/5} = 5.25 \text{ Amp}$$

Setting in % = (5.25 / 5) * 100

= 105 %

(iii) Stage 3 OCR

Current setting in amp, Stage3 OCR

$$= \frac{262.5 \times 180}{100 \times 400/5} = 5.9 \text{ Amp}$$

Setting in % = (5.9 / 5) * 100
= 118 %

(iv) Post over load

Current setting in amp,

= $\frac{262.5 \times 110}{100 \times 400/5}$ = 3.61 Amp

Setting in % = (3.61 / 5) * 100
= 72 %

4.2 (B) LV side OCR and REF Protection

4.2.1 (B) IDMT OCR Current Setting in Amp ($I_{OCR\,LV}$) = $\frac{1.9*545}{\frac{750}{5}}$ = 6.9

IDMT OCR Current Setting in % = $\frac{6.9}{5}$ *100 = 138%

4.2.2 (B) TMS setting

Source impedance, Z_{source} at 132kv base

= $\frac{(132)^2}{10000}$ = 1.74 Ω

Source impedance as seen from the 55 kv bus

= 1.74 x $\frac{(55)^2}{(132)^2}$ = 0.3 Ω

Impedance of traction transformer at 55 kv base, $Z_{transformer}$

= $\frac{(55)^2 \times 11}{30 \times 100}$ = 11.09 Ω

Total impedance, Z = 0.3 + 11.09 = 11.39 Ω

Fault current for 55 kV bus fault (between traction and feeder), I_f

= $\frac{55000}{11.39}$ = 4829 amp

Fault current reflected to secondary side of CT

= 4829 /(750/5) = 32.19 amp

To achieved the operating time 300 ms for bus fault, the TMS setting should be

$$\frac{300}{1000} = \frac{TMS \times 0.14}{[32.19/6.9]^{0.02} - 1}$$

$$\frac{300}{1000} = \frac{TMS \times 0.14}{1.031 - 1}$$

TMS = 0.064 i.e. 0.07 (Nearest available setting on the relay)

4.2.3 (B) Restricted earth fault relay

REF Current setting in amp, I_{REF}

$$= \frac{545 \times 20}{100 \times 750/5} = 0.73 \text{ Amp}$$

REF current Setting in % = (0.73 / 5) * 100
= 14.6 %

4.2.4 (B) Current and time setting of definite time over current relay

(i) Stage 1 OCR

Current setting in amp, Stage 1 OCR

$$= \frac{545 \times 130}{100 \times 750/5} = 4.72 \text{ Amp}$$

Setting in % = (4.72 / 5) * 100
= 95 %

(ii) Stage 2 OCR

Current setting in amp, Stage 2 OCR

$$= \frac{545 \times 150}{100 \times 750/5} = 5.45 \text{ Amp}$$

Setting in % = (5.45 / 5) * 100
= 109 %

(iii) Stage 3 OCR

Current setting in amp, Stage 3 OCR

$$= \frac{545 \times 170}{100 \times 750/5} = 6.18 \text{ Amp}$$

Setting in % = (6.18 / 5) * 100
= 124 %

(iv) Post over load

Current setting in amp,

$$= \frac{545 \times 100}{100 \times 750/5} = 3.63 \text{ Amp}$$

Setting in % = (3.63 / 5) * 100
= 73 %

4.3 (B) Biased differential protection

4.3.1 (B) Calculation of ICT multiplication factor

HV Bushing CT multiplication factor (Teaser winding)

$$= \frac{5 \times 550/5}{262.5}$$

$$= 2.09$$

HV Bushing CT multiplication factor (main winding)

$$= \frac{5 \times 550/5 \times (1/2)}{262.5}$$

$$= 1.05$$

LV Bushing CT multiplication factor

$$= \frac{5 \times 1100/5 \times 1/2}{545}$$

$$= 1.01$$

4.3.2 (B) Bias setting calculation

Calculate the transformer HV current at lowest tap position i.e. -15%

$$= \frac{60 * 1000}{\sqrt{3} * 112.2} = 308.75 \text{ Amp}$$

(i) Current read by relay (Teaser winding) $= \frac{308.75 * 2.09}{550/5} = 5.87$

Spill Over Current in amp = 5.87 – 5

$$\% \text{ Bias-1 setting} = \frac{0.87 * 100}{(5.87 + 5) / 2} = 16 \%$$

To allow the relay and CT errors, the % differential current further increased by a factor of 1.25.

% biased setting (First bias setting) = 1.25 x 16
= 20 %

(ii) Current read by relay (main winding) $= \frac{(308.75 \times 2) * 1.05}{550/5} = 5.89$

Spill Over Current in amp = 5.89 – 5

$$\% \text{ Bias-1 setting} = \frac{0.89 * 100}{(5.89 + 5) / 2} = 16.34 \%$$

To allow the relay and CT errors, the % differential current further increased by a factor of 1.25.

% biased setting (First bias setting) = 1.25 x 16.34
= 20.42 %

Second bias to be set at = 80%

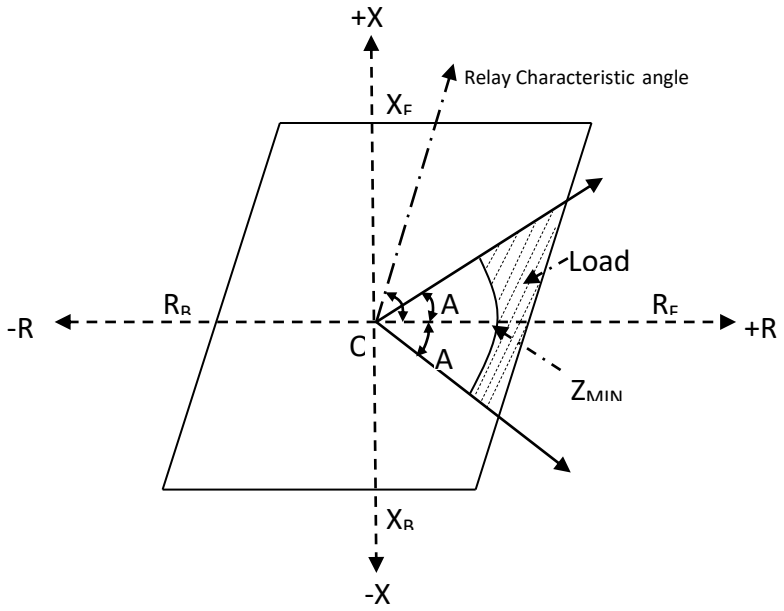
Start of second bias = 200%
Second harmonic blocking to be set at = 15%
Fifth harmonic blocking to be set at = 10%
Differential operating current=20%,

5.0 Relay setting guidelines for Feeder Protection relays

5.1 Integrated feeder protection module (DPR, OCR, PTFF, Auto reclosure etc.)

5.1.1 Distance Protection

Zone-1 setting should be enabled and Zone2 & Zone-3 should be disabled.



Polygonal Characteristic Backup Distance Protection Relay

5.1.1.1 Minimum Operating Current

The minimum operating current 50A shall be set. Relay setting side shall be calculated as given below.

Minimum operating current setting on relay in Amp (I_{min}).

$$= \frac{50}{\text{CT Ratio}}$$

Minimum operating current Setting in % $= \frac{I_{min}}{5} * 100$

5.1.1.2 Zone-1 DPR setting.

(i) Forward reactance setting (XF1)

The procedure given below shall be followed to calculate the forward reactance setting for single, double, or triple lines, etc.

a. In order to ensure protection under all OHE configurations possible (single, double, triple, etc.), calculate the single line impedance of the OHE from the feeding post/TSS to the SP beyond the adjacent feeding post/TSS. In other words, consider maximum OHE impedance under any possible configuration considering feed extension up to adjacent TSS.
A factor of 1.25 is to be multiplied by the calculated impedance to take account of the errors that arise due to CT, PT, and the relays, say this is Z_L.

Z_{L50} = 1.25 * calculated impedance of single line OHE

b. Calculate the OHE reactance (x)

$X_{50} = Z_{L50} * \text{Sin}\ \theta \quad \Omega$

$X_{25} = 0.25 * X_{50}$

Where θ is the OHE impedance angle

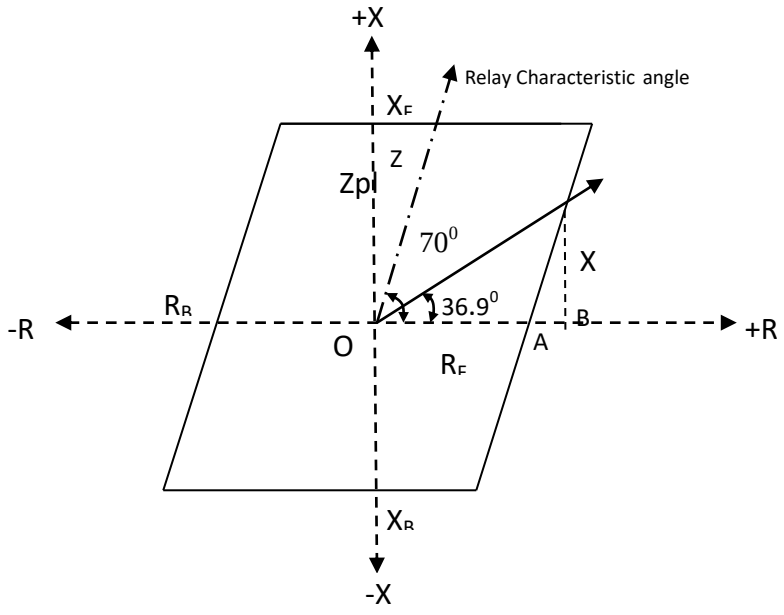
c. The OHE reactance is to be calculated for individual feeder CB as per feeding direction.
d. The Forward reactance setting (XF1) on the relay side is to be calculated by the formula given below.

$$\text{Forward Reactance Setting (XF1)} = \text{Calculated } (X_{25}) * \frac{\text{CT Ratio}}{\text{PT Ratio}} \quad \Omega$$

(ii) Backward reactance setting (XB1)
The backward reactance setting is to be set at a value of 25% of the forward reactance setting.

$$\text{XB1} = \text{Forward Reactance Setting (XF1)} * \frac{25}{100} \quad \Omega$$

(iii) Forward Resistance Setting (RF1)



The forward resistance setting on the relay side may be calculated by the formula given below.

$$\text{Peak Load Impedance (Zpl)} = \frac{25000}{2 * \text{Rated Secondary Current of Tx in Amp}} * \frac{\text{CT Ratio}}{\text{PT Ratio}} \quad \Omega$$

To accommodate CT, PT & Relay error, peak load Impedance should be multiplied by a factor of 0.9

$$Z = 0.9 * \text{Peak Load Impedance}$$

As seen from the above figure

$$X = AB * \tan 70$$

$$\text{Also } X = Z * \sin 36.9$$

$$\text{Hence } AB * \tan 70 = Z * \sin 36.9$$

$$AB = \frac{Z * \sin 36.9}{\tan 70} = 0.2185\, Z$$

$$\text{Also } OB = Z * \cos 36.9 = 0.7997\, Z$$

$$RF = OB - AB = 0.7997\, Z - 0.2185\, Z = 0.5812\, Z$$

$$\text{Forward Resistance Setting (RF1)} = 0.5812 * Z \quad \Omega$$

(iv) Backward Resistance Setting (RB1)
The backward resistance shall be set the same as RF1.
RB1 = RF1

(v) Relay characteristic Angle (RCA)
Relay characteristic angle (RCA) should be set equal to the OHE impedance angle.

(vi) Minimum Impedance Setting (Z_{MIN})
This is to be set the same as RF1.

(vii) Angle (A) setting
This is to be set at zero.

(viii) 2nd Harmonic Setting
2nd Harmonic setting is used to avoid spurious tripping of the backup distance protection relay due to switching on multiple locomotives simultaneously in the feeding zone of TSS. If the 2nd harmonic component in the total load current is more than the set value, the relay will block the trip command. 2nd Harmonic may be set at 15%.

5.1.2 SOTF Setting:

SOTF current is to be set at 3 times of Tx. rated current.

$$\text{SOTF current } (I_{SOTF}) = \frac{3 * \text{Tx. secondary rated current at 27.5KV}}{\text{CT ratio}} \quad Amp$$

$$\text{SOTF current Setting in \%} = \frac{(I_{SOTF})}{5} * 100$$

5.1.3 Over Current Relay:

Stage-1 OCR (Instantaneous):

This protection element provides primary protection to the earth faults and traction to feeder faults in the vicinity of the feeding post. The current setting of the relay should correspond to about 200% of the continuous current rating of the transformer.

$$\text{Stage} - 1 \text{ OCR } (I_{stage1}) = \frac{2 * \text{Tx. secondary rated current at 27.5KV}}{\text{CT ratio}} \quad Amp$$

$$\text{Stage} - 1 \text{ OCR Setting in \%} = \frac{(I_{stage1})}{5} * 100$$

Stage-2 OCR:

The stage-2 OCR is to be set at 180% of the continuous current rating of the transformer. The operating time is to be set at 90 sec.

$$\text{Stage} - 2 \text{ OCR } (I_{stage2}) = \frac{1.8 * \text{Tx. rated secondary current at 27.5KV}}{\text{CT ratio}} \quad Amp$$

$$\text{Stage} - 2 \text{ OCR Setting in \%} = \frac{(I_{stage2})}{5} * 100$$

5.1.4 PTFF setting:

(i) PTFF voltage:

PTFF voltage should be set at 10 % of the rated OHE voltage.

$$\text{PTFF Voltage} = \frac{10 * \text{rated OHE voltage}}{100 * \text{PT ratio}}$$

(ii) PTFF Current setting:

The PTFF low and high currents will be set at 10% and 20% of the transformer-rated secondary current, respectively. The operating time for the PTFF alarm should be set at 5 sec.

$$\text{PTFF low current} = \frac{10 * \text{rated transformer current}}{100 * \text{CT ratio}}$$

$$\text{PTFF low current setting in \%} = \frac{\text{PTFF low current}}{5} * 100$$

.

$$\text{PTFF high current} = \frac{20 * \text{rated transformer current}}{100 * \text{CT ratio}}$$

$$\text{PTFF High current setting in \%} = \frac{\text{PTFF high current}}{5} * 100$$

5.1.5 Auto reclosure relay:

(i) Number of shot =1

(ii) Dead Time = 0.5 sec.

(iii) Reclaim time = 30 sec.

(iv) Auto reclosure bypass current

$$\text{Auto reclosure bypass current (ARB)} = \frac{4000}{\text{CT ratio}}$$

$$\text{Auto reclosure bypass (ARB) current in \%} = \frac{\text{ARB}}{5} * 100$$

5.1.6 Local Breaker Backup (LBB) or Breaker Fail or Trip Fail:

This feature is used to provide backup protection against feeder Circuit Breaker faults. In other words, even after initiating a trip command by Delta-I or Backup distance protection, the feeder CB fails to operate within the set LBB delay time same relay executes another trip command to trip the transformer LV CB.

Local Breaker Backup trip delay time may be calculated as given below.

Breaker Fail delay operating time =

MTR operating time + C.B operating time + Tolerance

= 10ms+50ms+140ms
= 200 ms

5.2 Delta-I relay including backup DPR:

5.2.1 Delta-I Relay

5.2.1.1 Delta-I Current Setting

The Delta-I relay is used to detect high resistive faults. The detection of high resistance depends on the Delta-I current setting. The amount of high resistance fault current that does not allow vectorial delta-I current more than set Delta-I current, those faults cannot be detected by the Delta-I relay. A higher Delta-I current setting reduces the sensitivity of the relay against high resistance faults and less setting may lead to spurious tripping due to a sudden rise in the load current above set Delta-I.

The current setting of the Delta-I relay is based on the assumption of the number of electric locomotives switched on simultaneously in the feeding zone of the TSS. The Delta-I current setting should be more than the sudden rise of load current.

One number of electric locomotives is assumed to enter or switch on at a time in the feeding zone of TSS. The peak load current of 16 coach 'T18' train is 441 Amp. This current may be considered for the setting of Delta-I current.

The Delta-I current setting on the relay shall be calculated as given below.

$$\text{Delta} - \text{I current Setting in Amp} = \frac{\text{Peak Load Current of one number } 'T\ 18' \text{ train}}{\text{CT Ratio}}$$

5.2.1.2 De-sensitivity setting (DS)

A de-sensitivity setting is provided to minimize spurious tripping of the Delta-I relay due to the sudden rise in load currents. The relay continuously monitors the 3rd harmonic component in current, if the third harmonic component is more than the set 3rd value, the Delta-I current required to operate the relay automatically increases according to the below formula.

$$\text{Operating value of Delta} - \text{I Current} = \frac{\text{Set Delta} - \text{I Current} * \%\ \text{De} - \text{sensitivity setting}}{100} + \text{Set Delta} - \text{I Current}$$

The De-sensitivity setting is to be set at 100%.

5.2.1.3 2nd Harmonic setting to block relay operation:

The relay monitors the 2nd Harmonic component in the current. If the 2nd harmonic is more than the set value, the relay restrains the trip command. This feature is provided to avoid spurious tripping of the Delta-I relay during the switching of multiple electric locomotives simultaneously in the feeding zone of feeder CB. The 2nd Harmonic percentage to block Delta-I relay tripping should be set at 15%.

5.2.1.4 3rd Harmonic Setting:

The setting of the 3rd Harmonic is used to minimize spurious tripping of the Delta-I relay due to entering multiple electric locomotives simultaneously at IOL (in front of TSS). If the 3rd harmonic component in the total load current is more than the set value, the relay sensitivity is restrained as per the de-sensitivity setting. The percentage of 3rd Harmonic should be set at 12%.

5.2.1.5 Delta-I Cycle (Delta-T) Setting "Delta-I cycle is the time difference between base load current sample and fault current sample. Delta-I cycle (Delta-T) is to be set at 60 ms.

5.2.1.6 Additional time delay (ATD)

Additional time delay setting is to be calculated by the method given below.

$$\text{ATD Setting (ms)} = (\text{DPR Operating Time} + \text{MTR Operating Time} + \text{CB Operating Time} + \text{Tolerance})\ \text{in ms}$$

The following operating time is to be considered to set additional time delay (ATD)

Main Distance Protection Relay (DPR)	=	40 ms
Master Trip Relay (MTR)	=	10 ms
Circuit Breaker (CB)	=	50 ms
Tolerance	=	50 ms

5.2.1.7 **Reactance (X) blinder setting**:

(a) Calculate the single line impedance of the OHE from feeding post/TSS to the SP beyond the adjacent feeding post/TSS.

A factor of 1.25 is to be multiplied by the total impedance to take account of the errors that arise due to CT, PT, and the relays, say this is Z_L.

Z_L = 1.25 * calculated impedance of single line OHE

(b) Calculate the OHE reactance (x):

$X_{50} = Z_{L50} * \text{Sin}\ \theta \quad \Omega$

$X_{25} = 0.25 * X_{50}$

Where θ is the OHE impedance angle.

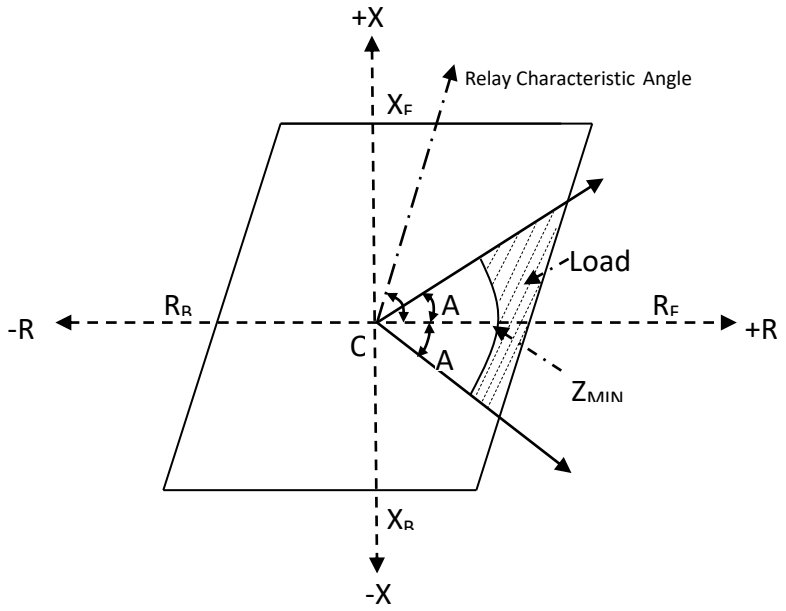
(c) The OHE reactance shall be calculated for individual feeder CB according to their feeding direction.

(d) The X-blinder setting shall be calculated by the formula below.

$$\text{X} - \text{blinder setting} = \text{Calculated OHE Reactance } (X_{25}) * \frac{\text{CT Ratio}}{\text{PT Ratio}}$$

5.2.2Backup Distance Protection Setting (Polygonal Characteristic with Load Blinding)

Backup Distance Protection (Polygonal Characteristic with Load Blinding) relay is to be put in enable mode.



Polygonal Characteristic Backup Distance Protection Relay

5.2.2.1 Minimum Operating Current:

The minimum operating current 50A is to be considered for relay setting. Setting on relay side shall be calculated by the formula given below.

Minimum operating current setting on relay in Amp (I_{min}).

$$= \frac{50}{\text{CT Ratio}}$$

$$\text{Minimum operating current Setting in \%} = \frac{I_{min}}{5} * 100$$

5.2.2.2 Forward reactance setting (XF)

The procedure below shall be followed to calculate the forward reactance setting for single, double, or triple lines, etc.

a) To ensure protection under all OHE configurations possible (single, double, triple, etc.), calculate the single line impedance of the OHE from the feeding post/TSS to the SP beyond the adjacent feeding post/TSS. In other words, consider maximum OHE impedance under any possible configuration considering feed extension up to adjacent TSS.

A factor of 1.25 is to be multiplied by the calculated impedance to take account of the errors that arise due to CT, PT, and the relays, say this is Z_L.

Z_{L50} = 1.25 * calculated impedance of single line OHE

b) Calculate the OHE reactance (x)

$X_{50} = Z_{L50} * \text{Sin}\ \theta \quad \Omega$

$X_{25} = 0.25 * X_{50}$

Where θ is the OHE impedance angle

c) The OHE reactance shall be calculated for individual feeder CB according to the feeding direction.

d) Forward reactance setting (XF) on the relay side shall be calculated by the below formula.

$$\text{Forward Reactance Setting (XF)} = \text{Calculated } (X_{25}) * \frac{\text{CT Ratio}}{\text{PT Ratio}} \quad \Omega$$

5.2.2.3 <u>Backward reactance setting (XB)</u>

The backward reactance setting on the relay side shall be calculated by the following formula.

$$\text{XB} = \text{Forward Reactance Setting (XF)} * \frac{25}{100} \quad \Omega$$

5.2.2.4 <u>Forward Resistance Setting (RF):</u>

To increase the reach of backup DPR against high resistance fault compared to the main distance protection relay (DPR), the RF setting should be set for 30 ohm (OHE side).

$$\text{Forward Resistance Setting (RF)on relay} = 30 * \frac{\text{CT Ratio}}{\text{PT Ratio}} \quad \Omega$$

5.2.2.5 Backward Resistance Setting (RB):

The backward resistance setting should be set at 10 ohm (OHE side).

$$\text{Backward Resistance Setting (RB)on relay} = 10 * \frac{\text{CT Ratio}}{\text{PT Ratio}} \quad \Omega$$

5.2.2.6 Minimum Impedance Setting (Z_{MIN}):

The minimum impedance setting shall be calculated based on peak load impedance, likely occurring in the system.

$$\text{Peak Load Impedance} = \frac{25000}{2 * \text{Rated Secondary Current of Traction Transformer in Amp}} \Omega$$

To accommodate CT, PT & Relay error, a factor of 0.9 is multiplied in the peak load Impedance calculated above.

The minimum impedance setting on the Relay side may be calculated by the formula given below.

Minimum Impedance Setting (Z_{MIN}) =

$$0.9 * \text{Peak Load Impedance as calculated above} * \frac{\text{CT Ratio}}{\text{PT Ratio}} \quad \Omega$$

Note: Peak load impedance can be adjusted by monitoring the peak load of the particular TSS.

5.2.2.7 Angle (A) setting:

With the higher value of the forward resistance setting of the backup distance protection relay, the relay may malfunction due to load current, and the overload capacity of the traction transformer is not utilized. To minimize such tripping, the angle (A) setting shall be set at 50˚ with the assumption that the worst power factor of traction load is 0.64 lagging.

Note: If maximum load angle is less than 50 deg of the particular TSS, it can be set for that value

5.2.2.8 Relay characteristic Angle (RCA):

Relay characteristic angle (RCA) should be set the same as the OHE impedance angle

5.2.2.9 2nd Harmonic Setting:

2nd Harmonic setting is used to avoid spurious tripping of the backup distance protection relay due to switching on multiple locomotives simultaneously in the feeding zone of feeder CB. If the 2nd harmonic component in the total load current is more than the set value, the relay will block the trip command. 2nd Harmonic should be set at 15%.

5.2.2.10 Additional time delay (ATD):

Additional time delay settings shall be calculated as given below.

ATD Setting (ms)

$$= (\text{Main DPR Operating Time} + \text{MTR Operating Time} + \text{CB Operating Time} + \text{Tolerance}) \text{ in ms}$$

The following operating time is to be considered to set additional time delay (ATD)

Main Distance Protection Relay (DPR)	= 40 ms
Master Trip Relay (MTR)	= 10 ms
Circuit Breaker (CB)	= 50 ms
Tolerance	= 50 ms

5.2.3 Local Breaker Backup (LBB) or Breaker Fail or Trip Fail:

This feature is used to provide backup protection against feeder Circuit Breaker faults. If trip command, executed by Delta-I or Backup distance protection, but feeder CB fails to open within the set LBB delay, another trip command is executed by the relay to trip upstream CB i.e. transformer LV CB.

Local Breaker Backup trip delay time may be calculated as given below.

Breaker Fail delay operating time =

MTR operating time + C.B operating time + Tolerance

=10ms+50ms+140ms
=200 ms

5.2.4 Under voltage setting:

To prevent wrong phase coupling during the feed of adjacent TSS extended, an under-voltage relay is provided with each feeder CB. This under-voltage relay will prevent the closing of feeder CB when OHE is already in energized condition (during feed extension of adjacent TSS). The under voltage should be set for 10KV (OHE voltage). The under-voltage setting shall be calculated by the formula given below.

$$\text{Under voltage setting in volt } (V_{Un}) = \frac{10000}{\text{PT Ratio}}$$

$$\text{Under voltage setting in \%} = \frac{V_{Un}}{110} * 100$$

6 Sample calculation for Feeder protection relay setting

The following assumptions are made for sample calculation:

- Scott. connected Traction transformer= 60 MVA (ONAN)
  There are two windings (Teaser & Main) on the secondary side of the transformer. The rating of both windings is equal i.e. 30 MVA
- No load secondary voltage = 55 kV
- Rated secondary current of each winding of Tx. at 55KV

$$= \frac{30 \text{ MVA}}{55 \text{ KV}} = 545 \text{ Amp}$$

- Rated secondary current of each winding of Tx. at 27.5KV

$$= \frac{30 \text{ MVA}}{27.5\text{KV}} = 1090 \text{ Amp}$$

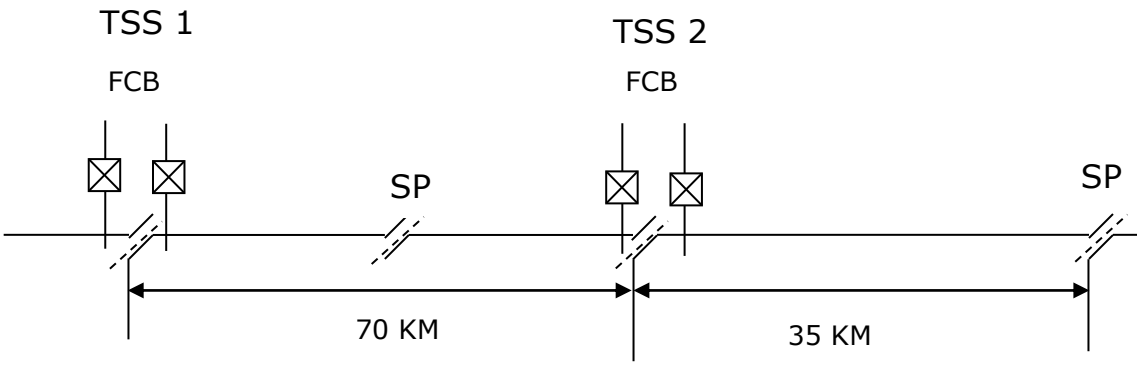
- CT ratio = 750 / 5
- PT ratio = 27500/110
- OHE impedance single line (Cat- 65 mm^2 cd-cu, Contact-107 mm^2, Feeder wire – 234 mm^2 ACSR) assumed: $0.62\angle 70^0$ Ω/Km *

* As per System design report of JARTS to introduce 2x25 kV traction in Bilaspur-Katni-Bina section of Indian Railways.

6.1 Integrated feeder protection module (DPR, OCR, PTFF, Auto reclosure)

6.1.2 Distance Protection:

Zone-1: Enable
Zone-2 & Zone-3: To be kept disabled.



6.1.2.9 Minimum Operating Current:

Min. operating current setting in Amp $(I_{min}) = \frac{50}{750/5}$ = 0.33 A

Minimum operating current Setting in % $= \frac{0.33}{5} * 100$ = 6.6 %

6.1.2.10 Zone-1 DPR setting:

(i) Forward reactance setting (XF1)

Distance between TSS 1 & far end SP of TSS 2 = (70 + 35) Km = 105 Km

Total Line impedance = 105 x 0.62

= 65.1 Ω

Z_L = 1.25 x 65.1 = 81.375 Ω

X_{50} = 81.375 * Sin 70^0 Ω

= 76.47 Ω

X_{25} = 0.25 * 76.47 Ω

= 19.12 Ω

Forward Reactance Setting (XF)on relay side $= 19.12 * \frac{750/5}{27500/110}$ Ω

= 11.472 Ω

(ii) Backward reactance setting (XB1)

$XB1 = 11.472 * \frac{25}{100}$

= 2.87 Ω

(iii) Forward Resistance Setting (RF1)

Peak Load Impedance (Zpl) $= \frac{25000}{2*1090} * \frac{750/5}{27500/110}$ = 6.88 Ω

(Relay measured sum of both CT current i.e. ≈27.5 KV current)

To accommodate CT, PT & Relay error, a factor of 0.9 is multiplied by the peak load Impedance calculated above.

$Z = 0.9 * 6.88 = 6.19$ Ω

Forward Resistance Setting (RF1) $= 0.5812 * 6.19$ Ω

= 3.6 Ω

(iv) Backward Resistance Setting (RB1)

Backward Resistance (RB1) =3.6 Ω

(v) Relay characteristic angle (RCA)

RCA angle is to be set at 70^0

(vi) Angle (A) setting

The angle (A) = 0˚.

(vii) 2nd Harmonic Setting

2nd Harmonic = 15%.

6.1.3 **SOTF Setting:**

$$\text{SOTF current } (I_{SOTF}) = \frac{3 * 1090}{750/5} = 21.8\ Amp$$

$$\text{SOTF current setting in \%} = \frac{21.8}{5} * 100 = 436\%$$

6.1.4 Over current relay:

(a) Stage-1 OCR (Instantaneous):

$$\text{Stage} - 1 \text{ OCR current setting } (I_{stage1}) = \frac{2 * 1090}{\frac{750}{5}} = 14.53\ Amp$$

$$\text{Stage} - 1 \text{ OCR Setting in \%} = \frac{14.53}{5} * 100 = 290\%$$

(b) Stage-2 OCR:

$$\text{Stage} - 2 \text{ OCR current setting } (I_{stage2}) = \frac{1.8 * 1090}{\text{CT ratio}} = 13.08\ Amp$$

$$\text{Stage} - 2 \text{ OCR Setting in \%} = \frac{13.08}{5} * 100 = 261\ \%$$

The operating time of stage-2 OCR = 90 sec.

6.1.5 PTFF setting:

PTFF voltage:

$$\text{PTFF Voltage} = \frac{10 * 27500}{100 * 27500/110} = 11 \text{ Volts}$$

PTFF Current setting

$$\text{PTFF low current} = \frac{10 * 1090}{100 * 750/5} = 0.73 \text{ Amp}$$

$$\text{PTFF low current setting in \%} = \frac{0.73}{5} * 100 = 14.5\%$$

.

$$\text{PTFF high current} = \frac{20*1090}{100*750/5} = 1.45 \text{ Amp}$$

$$\text{PTFF High current setting in \%} = \frac{1.45}{5}*100 = 29\ \%$$

PTFF alarm time = 5 sec.

6.1.6 Auto reclosure relay:

Number of shots =1

Dead Time = 0.5 sec.

Reclaim time = 30 sec.

$$\text{Auto reclosure bypass current (ARB)} = \frac{4000}{750/5} = 26.67 \text{ A}$$

$$\text{Auto reclosure bypass (ARB) current in \%} = \frac{26.67}{5}*100 = 533\ \%$$

6.1.7 Local Breaker Backup (LBB) or Breaker Fail or Trip Fail:

Breaker Fail delay operating time =

MTR operating time + C.B operating time + Tolerance)

= 10ms+50ms+140ms
= 200 ms

6.1.8 Other Setting

(a) CT (Current Transformer) Primary

CT Primary current setting = 750 Amp.

(b) PT (Potential Transformer) Primary

PT Primary voltage setting = 27500 V.

6.2 Delta-I relay including backup DPR

6.2.1 Delta-I relay

6.2.1.9 Delta-I Current Setting

The maximum load current during acceleration of one 'T18' train is 441 Amp is considered to set Delta-I current.

$$\text{Delta} - \text{I current Setting in Amp} = \frac{441}{750/5}$$
$$= 2.94 \text{ Amp.}$$

6.2.1.10Harmonic De-sensitivity setting (DS):

To minimize malfunction of the relay due to sudden changes in load current, the harmonic De-sensitivity should be set at 100%. With the de-sensitivity setting at 100%, the relay will execute

trip command at 2 times of set Delta-I current, when 3rd harmonic content in load current is more than the set percentage.

6.2.1.112nd Harmonic Setting:

2nd Harmonic setting is recommended to be set at 15%.

6.2.1.123rd Harmonic Setting:

3rd Harmonic setting is recommended to be set at 12%.

6.2.1.13Delta-I Cycle Setting

Delta-I cycle is recommended to be set at 60 ms.

6.2.1.14X-blinder setting:

Single line impedance from TSS to the SP beyond the adjacent TSS

Distance between TSS 1 & SP beyond TSS 2 = (70 + 35) Km = 105 Km

Total Line impedance = 105 x 0.62

= 65.1 Ω

Z_L = 1.25 x 65.1 = 81.375 Ω

X_{50} = 81.375 * Sin 70^0 Ω

= 76.47 Ω

X_{25} = 0.25 * 76.47 Ω

= 19.12 Ω

$$\text{Forward Reactance Setting (XF) on relay side} = 19.12 * \frac{750/5}{27500/110} \ \Omega$$

= 11.472 Ω

6.2.1.15Additional time delay (ATD):

Main Distance Protection Relay (DPR)	= 40 ms
Master Trip Relay (MTR)	= 10 ms
Circuit Breaker (CB)	= 50 ms
Tolerance	= 50 ms

ATD Setting (ms)

= (DPR Operating Time + MTR Operating Time + CB Operating Time + Tolerance)

= 40+10+50+50 ms

= 150 ms

Additional time delay may be set at 150 ms

6.2.2 **Backup Distance Protection Setting (Polygonal Characteristic with Load Blinding)**

6.2.2.1 Minimum Operating Current:

$$\text{Min. operating current setting in Amp } (I_{min}) = \frac{50}{750/5} = 0.33 \text{ A}$$

$$\text{Minimum operating current Setting in \%} = \frac{0.33}{5} * 100 = 6.6\%$$

6.2.2.2 Forward reactance setting (XF)

Calculate single line impedance for both side of feeder CB individually provided to feed power on either side of PTFE generally in front of TSS

Distance between TSS 1 & SP beyond TSS 2 = (70 + 35) Km = 105 Km

Total Line impedance = 105 x 0.62

= 65.1 Ω

Z_L = 1.25 x 65.1 = 81.375 Ω

X_{50} = 81.375 * Sin 70^0 Ω

= 76.47 Ω

X_{25} = 0.25 * 76.47 Ω

= 19.12 Ω

Forward Reactance Setting (XF)on relay side $= 19.12 * \frac{750/5}{27500/110}$ Ω = 11.472 Ω

6.2.2.3 Backward reactance setting (XB)

$XB = 11.47 * \frac{25}{100}$

= 2.87 Ω

6.2.2.4 Forward Resistance Setting (RF)

Forward Resistance Setting (RF) $= 30 * \frac{750/5}{27500/110}$ Ω

= 18 Ω

6.2.2.5 Backward Resistance Setting (RB)

Backward Resistance Setting (RB) $= 10 * \frac{750/5}{27500/110}$ = 6 Ω

6.2.2.6 Minimum Impedance Setting (Z_{MIN})

Peak Load Impedance (Zpl) $= \frac{25000}{2*1090} * \frac{750/5}{27500/110}$ =6.88 Ω

(Relay measured sum of both CT current i.e. ≈27.5 KV current)

To accommodate CT, PT & Relay error, a factor of 0.9 is multiplied in the peak load Impedance calculated above.

$$Zmin = 0.9 * 6.88 = 6.19\ \Omega$$

Note: Peak load impedance can be adjusted by monitoring the peak load of the particular TSS.

6.2.2.7 Angle (A) setting:

The angle (A) to be set at 50˚.

Note: If maximum load angle is less than 50 deg of the particular TSS, it can be set for that value

6.2.2.8 2nd Harmonic Setting:

2nd Harmonic is to be set at 15%.

6.2.2.9 Relay Characteristic Angle (RCA)

RCA is to be set at 70^0.

6.2.2.10 Additional time delay (ATD):

Main Distance Protection Relay (DPR)	= 40 ms
Master Trip Relay (MTR)	= 10 ms
Circuit Breaker (CB)	= 50 ms
Tolerance	= 50 ms

ATD Setting

$$= (\text{DPR Operating Time} + \text{MTR Operating Time} + \text{CB Operating Time} + \text{Tolerance})$$

= 40+10+50+50

=150 ms

6.2.3 Other Setting:

(i) CT (Current Transformer) Primary

CT Primary current setting = 750 Amp.

(ii) PT (Potential Transformer) Primary

PT Primary voltage setting = 27500 V.

6.2.4 Local Breaker Backup (LBB) or Breaker Fail or Trip Fail

Breaker Fail delay operating time =

MTR operating time + C.B operating time + Tolerance)

= 10ms+50ms+140ms

= 200 ms

6.2.5 Under voltage setting:

$$\text{Under voltage setting in volt } (V_{Un}) = \frac{10000}{27500/110} = 40 \text{ Volt}$$

$$\text{Under voltage setting in \%} = \frac{40}{110} * 100 = 36\%$$

7 **Differential Protection for Autotransformer (provided at TSS, SSP & SP)**

There are two types of differential protection (Biased differential protection or high impedance type differential protection). In biased differential protection, the relay compares both line CT

currents with the neutral CT current. In high-impedance differential protection, all CTs are connected in parallel, the unbalanced current will be detected by a relay to provide differential protection.

(i) The setting of biased differential protection is to be calculated as given below:

Calculation of ICT multiplication factor setting

This factor is used to neutralize the effect of transformer bushing CTs ratio corresponding to the transformer primary and secondary rated current, as the output current (CT secondary) shall be the same to avoid malfunction during normal operating conditions. The ICT multiplication factor individually for HV & LV shall be calculated by the formula given below:

$$\text{ICT multiplication factor (NCT)} = \frac{5 \text{ x Bushing CT ratio}}{\text{Auto Tx. neutral rated current in Amp}}$$

$$\text{ICT multiplication factor (Line CT)} = \frac{5 \text{ x Bushing CT ratio}}{\text{Auto Tx. (traction + feeder) rated current in Amp}}$$

Bias & operating current setting calculation

The differential current is to be set at 20% of the rated Auto transformer current.

$$\text{Differential current setting in Amp} = \frac{20 * \text{Rated Auto Tx.Current}}{100 * \text{Bushing CT ratio}}$$

$$\text{Differential current setting in \%} = \frac{\text{Differential current setting in Amp}}{5} * 100$$

% biased setting (First bias setting) is to be set at 20 %
The second bias is to be set at = 80%
Start of second bias = 200%
Second harmonic blocking to be set at = 15%
Second harmonic blocking to be set at = 10%

(ii) Setting of high impedance type differential protection

The differential current is to be set 20% of the rated Auto transformer current.

$$\text{Differential current setting in Amp} = \frac{20 * \text{Rated Auto Tx.Current}}{100 * \text{Bushing CT ratio}}$$

$$\text{Differential current setting in \%} = \frac{\text{Differential current setting in Amp}}{5} * 100$$

7.1 Sample calculation for Differential Protection for Autotransformer (provided at TSS, SSP & SP)

The following assumptions are made for sample calculation:

Auto transformer capacity = 8 MVA
BCT ratio = 300/5
NCT ratio = 600/5
I_{LV} = 291 Amp
I_{HV} = 145 Amp

(i) Biased differential protection

(a) ICT multiplication factor (NCT) $= \frac{5 \text{ x } \frac{600}{5}}{291} = 2.06$

(b) ICT multiplication factor (Line CT) $= \frac{5 \text{ x } \frac{300}{5}}{145+145} = 1.03$

(c) Bias & operating current setting

$$\text{Differential current setting in Amp} = \frac{20 * 291}{100 * 600/5} = 0.48$$

$$\text{Differential current setting in \%} = \frac{0.48}{5} * 100 = 9.7\ \%$$

(d) % biased setting is to be set at 20 %
(e) Second bias to be set at = 80%
(f) Start of second bias = 200%
(g) 2nd harmonic blocking to be set at = 15%
(h) 5th harmonic blocking to be set at = 10%

(ii) Setting of high impedance type differential protection

$$\text{Differential current setting in Amp} = \frac{20 * 291}{100 * 600/5} = 0.48$$

$$\text{Differential current setting in \%} = \frac{0.48}{5} * 100 = 9.7\%$$

8 Setting guidelines of DC monitoring/supervision relay

8.1 DC Under Voltage Alarm:

The function of the DC under voltage alarm element is to monitor DC voltage, if the DC voltage falls below the set alarm value for set time delay, then the relay will close the DC under voltage alarm contact for annunciation and telesignalling. The operating value and operating time are to be set on the relay for the DC Under Voltage alarm element as given below.

Operating value = 100 Volt
Operating time (set delay) = 30 Second

8.2 DC Under Voltage Trip:

The function of the DC under voltage trip element is to monitor DC voltage; if DC voltage falls below the set trip value for set time delay, then the relay will close DC under voltage trip contacts for tripping of transformer HV & LV and Feeder circuit breaker along with contact for annunciation and telesignalling. As given below, the operating value and operating time will be set on the relay for the DC Under Voltage trip element.

Operating value = 82 Volt
Operating time (set delay) = 500 ms

8.3 DC Over Voltage Alarm:

The function of the DC over-voltage alarm element is to monitor DC voltage. If the DC voltage rises above the set alarm value for set time delay, the relay will close the DC over-voltage alarm

contact for annunciation and telesignalling. As given below, the operating value and operating time will be set on the relay for the DC over-voltage alarm element.

Operating value = 127Volt
Operating time (set delay) = 30 Second

8.4 AC Under Voltage Alarm:

The function of the AC under voltage alarm element is to monitor AC voltage. If the AC voltage falls below the set alarm value for set time delay, the relay will close the AC under-voltage alarm contact for annunciation and telesignalling. As given below, the operating value and operating time will be set on the relay for the AC under-voltage alarm element.

Operating value = 175 Volt
Operating time (set delay) = 30 Second

8.5 AC Over Voltage Alarm:

The function of the AC Over-voltage alarm element is to monitor AC voltage. If AC voltage rises above the set alarm value for set time delay, the relay will close AC over-voltage alarm contact for annunciation and telesignalling. The operating value and operating time will be set on the relay for the AC over-voltage alarm element as given below.

Operating value = 280 Volt
Operating time (set delay) = 30 Second

9 Setting guidelines for 25 kV shunt capacitor bank protection relay

9.1 IDMT Over current relay

9.1.1 Current setting:

Calculate the capacitive reactance at the rated voltage.

$X_C = kV^2 * 1000 / KVAr \quad \Omega$

Calculate the effective reactance of the complete capacitor & reactor unit.

$X_{C1} = X_C - 0.13\ X_C \quad \Omega$

Calculate the KVA_R capacity of bank at 25 kV

KVAr rating at 25kV system voltage

$KVA_r = (25)^2 * 1000 / X_{C1}$

Calculate the rated current of the capacitor bank at a system voltage of 25 kV

$$\text{Capacitor bank current in amp, } I_{cap} = \frac{\text{KVAr}}{\text{Rated system voltage in kV}}$$

To accommodate the CT and relay errors, the 10% higher value of the above-calculated current is recommended for setting the relay.

$$\text{The current setting of IDMT relay in amp } (I_{relay}) = \frac{1.10 \times I_{cap}}{\text{CT ratio}} \text{ Amp}$$

$$\text{Setting in \%} = \frac{\text{Current seen by Relay } (I_{relay})}{\text{CT secondary}} \times 100$$

9.1.2 TMS setting:

Calculate the fault current after the reactor and select the suitable TMS to achieve the operating time of 500 ms.

$$\text{Fault current} = \frac{27000}{\text{Source Z + transformer Z + Reactance of reactor}} \text{ Amp}$$

$$\text{Plug setting multiplier} = \frac{\text{Reflected fault current to relay side}}{\text{Set current of IDMT relay } (I_{relay})}$$

From the IDMT curve (3 sec at 10 times of setting), choose the suitable TMS for getting the relay operating time of 250 ms. at the above-calculated plug setting multiplier or calculate TMS by the formula given below:

$$t = \frac{TMS \times a}{[I/I_{set}]^b - 1}$$

Where a & b are constant a = 0.14, b = 0.02
t = Operating time in second
TMS = Time multiplier setting
I = Measured current by relay
I_{set} = Set current

9.2 Over voltage relay

9.2.1 Over voltage setting:

The over-voltage relay shall be set at 10% higher than the rated nominal no-load voltage of the traction transformer.

$$\text{Setting in volt } (V_{o/v}) = \frac{1.1 \times \text{Rated nominal no load voltage of traction transformer}}{\text{PT ratio}} \text{ V}$$

$$\text{Setting in \%} = \frac{\text{Setting in volt } (V_{o/v})}{\text{Rated PT secondary voltage}} \times 100$$

9.2.2 Time multiplier setting (TMS):

Calculate the plug setting multiplier by the formula given below:

$$\text{Plug setting multiplier} = \frac{\text{Setting in volt } (V_{o/v})}{\text{Rated PT secondary voltage}}$$

From IDMT curve 7sec at 1.5 times, select the suitable TMS for the above-calculated plug setting multiplier to obtain the operating time of approximately 1 second.

9.3 Under voltage relay

9.3.1 Under voltage setting

The under-voltage relay shall be provided to cut off the shunt capacitor bank from the power supply when the 25 kV supply fails, or low voltage occurs. The bank should not be put back into the system again before it is discharged. To fulfill this requirement a timer is also provided in the closing circuit, it is generally built-in with a numerical relay. The timer setting shall be set at 10 minutes. As the lowest permissible voltage in IR traction is 17.5kV, the under-voltage relay shall be recommended to be set at 17.5kV.

$$\text{Setting in volt } (V_{U/v}) = \frac{17500}{\text{PT ratio}} \text{ V} \qquad \text{V}$$

$$\text{Setting in \%} = \frac{\text{Setting in volt } (V_{u/v})}{\text{Rated PT secondary voltage}} \times 100$$

9.3.2 Time multiplier setting (TMS) setting

Calculate the plug setting multiplier by the formula given below:

$$\text{Plug setting multiplier} = \frac{\text{Setting in volt}}{\text{Rated PT secondary voltage}}$$

From the IDMT curve 5sec at 0 Voltage; select the suitable TMS for the above-calculated plug setting multiplier to obtain the operating time of approximately 1 second.

9.4 Current unbalance relay

9.4.1 Current setting:

This protection element is provided for internal faults in the capacitor units. At present as per RDSO specification No. ETI/PSI/67(11/96) A & C slip No. 7, each capacitor unit of 220 kVAR is rated for 8 kV, and its construction comprises several elements in parallel & individually protected by internal fuses. In case of failure of the element and therefore blowing of the internal fuse the voltage across the remaining healthy elements of affected and other units increases. The neutral unbalanced current protection should be set so that it trips if the ratio of *the voltage across healthy elements in parallel to the failed elements in one unit* and the *rated voltage of healthy element* is above 1.7. The manufacturer of the HT capacitor bank should provide the calculation for the above based on the internal design of the capacitor unit. Generally, the unbalance current generated after the failure of 7-10 elements may cause the voltage, appearing on the remaining healthy elements to be 150-175% of the rated voltage, which may damage the healthy capacitor element. A sample result of unbalance current and voltage rise produced due to failure of several internal elements is placed in Annexure-I for reference.

$$\text{Set current in amp, } I_{UB} = \frac{\text{Recommended unbalance current}}{\text{NCT ratio}}$$

$$\text{Setting in \%} = \frac{I_{UB}}{\text{Rated CT secondary}} \times 100$$

9.4.2 Time setting:

The time setting shall be kept at 200-400 ms.

10 Sample calculation for capacitor bank protection relay setting

10.1 Assumption:

The following assumptions are made for sample calculation:

Shunt capacitor bank rating = 5500 KVAr at 40 kV

NCT ratio = 2/1

PT ratio = 27500/110

Fault MVA = 10000 MVA at 132kV base voltage.

CT ratio = 100/5

10.2 IDMT Over current relay

10.2.1 Current setting

Calculate the capacitive reactance at the rated voltage.

$$X_C = 40^2 * 1000 / 5500$$
$$= 290.91 \ \Omega$$

Calculate the effective reactance of the complete capacitor & reactor unit

$$X_{C1} = 290.91 - 0.13 * 290.91$$
$$= 253.09 \ \Omega$$

Calculate the KVAR capacity of the bank at 25 kV.

$$\text{KVAR} = (25)^2 * 1000 / 253.09$$
$$= 2469.47 \text{ KVAR}$$

Rated current of capacitor bank at system voltage 25 kV.

$$\text{Capacitor bank current in amp, } I_{cap} = \frac{2469.47}{25} = 98.77 \text{ amp}$$

To accommodate the CT and relay errors, the 10% higher value of the above-calculated current is recommended for the setting of the relay.

$$\text{Current setting of IDMT relay in amp } (I_{relay}) = \frac{1.10 \times 98.77}{100/5} = 5.43 \text{ Amp}$$

$$\text{Setting in \%} = \frac{5.43}{5} \times 100$$

= 108.65 i.e. 109 %

10.2.2 TMS setting:

$$\text{Fault current} = \frac{27000}{4.36 + 37.82} = 640 \text{ Amp}$$

(Source and traction transformer impedance 4.36 ohm as calculated above for traction transformer setting)

$$\text{Plug setting multiplier} = \frac{640 * 5 / 100}{5.43} = 5.89$$

To achieve the operating time of 500 ms. for fault after shunt reactor, the TMS

$$\frac{250}{1000} = \frac{\text{TMS} \times 0.14}{[33/5.43]^{0.02} - 1}$$

$$\frac{250}{1000} = \frac{\text{TMS} \times 0.14}{1.0367 - 1}$$

TMS = 0.0656 i.e. 0.07

10.3 Over voltage relay

10.3.1 Over voltage setting:

$$\text{Setting in volt } (V_{o/v}) = \frac{1.1}{27500/110} \times 27500 = 121 \text{ Volt}$$

$$\text{Setting in \%} = \frac{121}{110} \times 100 = 110\%$$

10.3.2 Time setting:

$$\text{Plug setting multiplier} = \frac{121}{110} = 1.1$$

From IDMT curve 7sec at 1.5 times, at 1.2 times of setting the operating time is 17 sec at TMS 1. To achieve the operating time of 1 sec.

$$\text{TMS setting} = \frac{1}{17} = 0.058 \text{ i.e } 0.06$$

10.4 Under Voltage relay

10.4.1 Under voltage setting:

$$\text{Setting in volt } (V_{U/v}) = \frac{17500}{27500/110} = 70 \text{ volt}$$

$$\text{Setting in \%} = \frac{70}{110} \times 100 = 63.64\ \%\ \text{i.e. } 64\%$$

10.4.2 TMS setting:

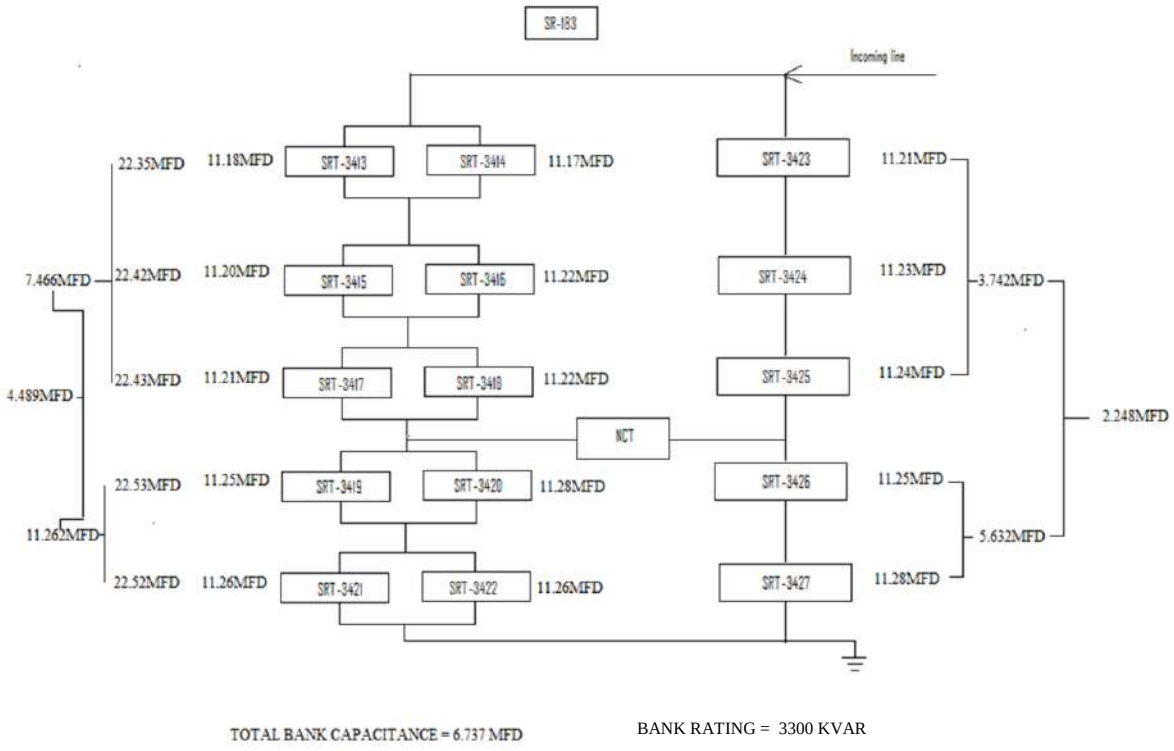
Calculate the plug setting multiplier by the formula given below:

$$\text{Plug setting multiplier} = \frac{70}{110} = 0.64$$

From IDMT curve 5sec at 0 Voltage; at 0.64 times of setting the operating time is nearly 9 sec at TMS 1. To achieve the operating time of 1 sec.

$$\text{TMS setting} = \frac{1}{9} = 0.11$$

10.5 Current unbalance relay



10.5.1 Current setting

A sample result of Unbalance current & voltage rises on healthy elements and units of a capacitor bank are given below:

X	In(A)	Vu/Vuo	Vel/Velo	Iu(A)

0	0.000	1.00	1.00	27.50
1	0.065	1.00	1.06	27.14
2	0.137	1.01	1.12	26.73
3	0.219	1.01	1.19	26.27
4	0.312	1.02	1.28	25.74
5	0.419	1.03	1.37	25.14
6	0.543	1.04	1.48	24.44
7	0.689	1.05	1.61	23.62
8 trip	0.863	1.06	1.76	22.64
9	1.073	1.07	1.95	21.46
10	1.333	1.09	2.18	19.99
11	1.662	1.11	2.47	18.14
12	2.094	1.14	2.86	15.70
13	2.638	1.18	3.38	12.38
14	3.536	1.24	4.13	7.58

X – Number of failed elements.
In(A) – Neutral current in Amps.
Vel – Voltage across a healthy element in parallel to a failed element.
Velo – Rated voltage of healthy element.
Vu – Voltage across the healthy unit in series with a failing unit.
Veo – Rated voltage of healthy unit.
Iu(A) – Unit current in amps.

As per the above sample result, it is seen that with the failure of 8 nos. of elements resulting voltage that appeared across healthy elements parallel to failed elements is 1.76 times the rated voltage, and the Unbalance current above the number of elements failure is 0.863 amps. These are the sample results only; they may vary from manufacturer to manufacturer, therefore approach the capacitor bank manufacturer for actual permitted unbalance current.

$$\text{Set current in amp, } I_{UB} = \frac{0.863}{2/1} = 0.4315 \text{ amp}$$

$$\text{Setting in \%} = \frac{0.4315}{1} \times 100 = 43.15\% \text{ i.e. } 43\%$$

10.5.2 Time setting:

The time setting shall be kept at 200 ms.

*****

Government of India, Ministry of Railways
Research Designs & Standards Organisation,
Manak Nagar, Lucknow– 226 011

सत्यमेव जयते

Telephone : 2465765.42805(Off.)
Fax : 91-0522-2465765
E-mail:dti5rdso@gmail.com

RDSO-TI0LKO(OHE)/36/2020-O/o PED/TI/RDSO Date: As signed

Executive Director/EEM,
Railway Board, Rail Bhawan,
New Delhi-110 001

Sub: RDSO's Instruction for handling of 25 kV Porcelain Insulators.

Ref: Railway Board's letter No. 2022/EEM/161/8/Punct-Part(5) E-3423395 dt. 08.05.2024.

Vide letter under reference above, Railway Board had directed RDSO to issue guidelines/instruction for handling of 25 kV Porcelain insulators and to advise Railway Board.

Accordingly, an instruction for handling of 25 kV Porcelain insulators No. TI/IN/0051, Rev-0 has been prepared and approved by RDSO. The same is hereby submitted for kind perusal please.

यह सक्षम प्राधिकारी के अनुमोदन से जारी किया जाता है।

संलग्नक: Copy of instruction No. TI/IN/0051, Rev-0.

Digitally Signed by
Nishchal Srivastava
Date: 25-06-2024 10:58:06
Reason: Approved

(निश्चल श्रीवास्तव/Nishchal Srivastava)
कार्यकारी निदेशक/कं.सं/Executive Director/TI
कृते महानिदेशक/कं.सं/For Director General/TI

Copy to:

Principal Chief Electrical Engineer: -For Kind information and necessary action please.

1. Central Railway, 2nd floor, Electrical Branch, Parcel Office Bldg. Mumbai - 400001.
2. Eastern Railway, Fairlie Place, Kolkata-700001.
3. East Central Railway, Hajipur (Bihar)-844101.
4. East Coast Railway, B-Rental Colony, Chandrashekharpur, Bhubaneshwar (Orissa)-751023.
5. Northern Railway, Baroda House, New Delhi- 110 001
6. North Central Railway, Block-A, Subedarganj, Prayagraj, (UP)- 211033.
7. North Eastern Railway, Gorakhpur (UP)- 220 055.
8. North East Frontier Railway, Maligaon, Guwahati - 781011.
9. North Western Railway, Jaipur (Raj.) – 302017.
10. Southern Railway, Park Town, Chennai- 600003 (TN).
11. South Central Railway, Rail Nilayam, Secunderabad – 500371
12. South Eastern Railway, Garden Reach, Kolkata-700043.
13. South East Central Railway, Bilaspur (Chhattisgarh)- 495004.
14. South Western Railway, DRM's Office, Hubli (Karnataka), 482001.
15. West Central Railway, Jabalpur (M.P.)- 482001.
16. Western Railway Old Building, 1st Floor, Churchgate, Mumbai- 400020.
17. Central Organization for Railway Electrification, Nawab Yusuf Road, Allahabad- 211 001.
18. Konkan Railway Corporation Ltd., Belapur Bhavan, Sector-11, CBD- Belapur, Navi Mumbai, Maharastra-400614.

सत्यमेव जयते

भारत सरकार GOVERNMENT OF INDIA
रेल मंत्रालय MINISTRY OF RAILWAYS

25 केवी पोर्सिलेन इंसुलेटर के रख-रखाव के लिए अनुदेश
INSTRUCTION FOR HANDLING OF 25 KV PORCELAIN INSULATORS

सं. टी0आई0/आई0एन0/0051(06/2024),संशोधन 0
No. TI/IN/0051 (06/2024), Rev 0

जारीकर्ता/ISSUED BY:

कर्षण संस्थापन निदेशालय
TRACTION INSTALLATION DIRECTORATE,
अनुसन्धान अभिकल्प और मानक संगठन
RESEARCH DESIGNS & STANDARDS ORGANISATION,
मानक नगर लखनऊ-226011
MANAKNAGAR, LUCKNOW-226011

(केवल आधिकारिक प्रयोग के लिए/ For official use only)

	24.06.24		24.06.2024		24.6.24
Prepared By	JE (D)/TI	Checked By	ADE/TI-1	Issued By	DTI-1

1.0 SCOPE :

1.1 This instruction stipulates the action to be taken for handling of 25 kV Porcelain Insulators by all OHE Depot/Construction department/any other agency responsible for maintenance/installation of 25 kV Porcelain insulators.

2.0 OBJECTIVE:

2.1 The performance of Porcelain Insulator not only depends upon the quality of the manufactured product but also on the manner in which the user handles these insulators from the time, it is received in The Railway's premises until the time , it is put into service & as well as, in service (line).

2.2 Since, Porcelain Insulator is prone to mechanical damage and cracks. Porcelain can get damaged during shipping from the manufacturer, transportation to the work site, during installation and even once it is placed in service. Thus special care needs to be taken during their handling.

2.3 Handling of Porcelain Insulator by Depot is important; hence instruction from RDSO is being issued. It is necessary to keep the insulators in suitable stand/rack in covered area and also to be cared during transportation and installation.

2.4 This instruction must be followed by all OHE Depot/Construction department/any other agency responsible for maintenance/installation of 25 kV Porcelain insulators.

3.0 GENERAL INSTRUCTION:

This instruction elaborates the various stages through which the insulator goes through from the production line to the actual service on line. Various stages are as under:-

i. Receiving, unpacking & storage
ii. Transport to construction site.
iii. On-site handling
iv. Installation by TRD staff / Contractors
v. Conductor stringing & Cantilever assembly
vi. Final inspection before energization.
vii. Care during maintenance
viii. Handling in Tower Wagon/Maintenance Vehicle

3.1 RECEIVING, UNPACKING AND STORAGE

3.1.1 Transportation vehicle unloading should be done with care to avoid damage/crack of Porcelain Insulators.

3.1.2 On receipt of Porcelain insulators at the store of user, the packing should be carefully inspected for any sign of damage.

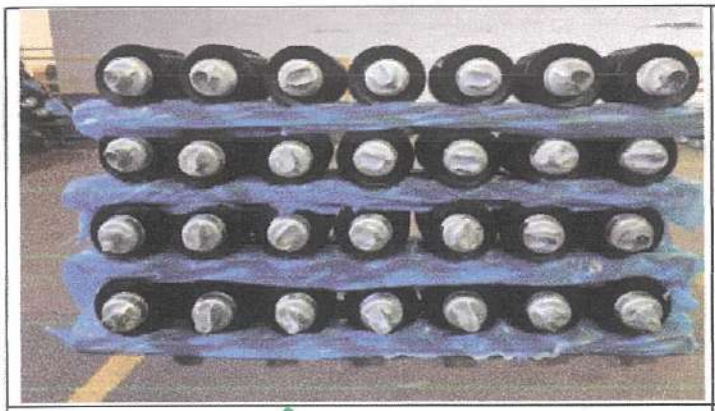
3.1.3 After visual inspection, the insulators should be packed in original packing and preferably be stored in original packing. Alternatively, Insulators can also be or placed on a suitable designed rack/stand.

3.1.4 Packing Boxes should be put one over other in a proper row and in such a way to avoid any damage of Boxes and Porcelain Insulators due to extra weight burdens.

3.1.5 Insulator should not be kept lying on the open ground/dusty grass area. They should be stored in a dry, covered area free from dust and mechanical damage preferably within the packing, raised off the ground on wooden Pallets/racks/stands.








Prepared By	JE (D)/TI	Checked By	ADE/TI-1	Issued By	DTI-1

3.1.6 After pre-installation test as per RDSO's SMI No. TI/MI/0042, Rev-01 or latest on the insulators, the same should be repacked in the Boxes as per Original Packing or may be kept properly to avoid any damage/crack till the final Installation at the site / exact location.

3.2 TRANSPORT TO CONSTRUCTION SITE

Whenever possible, the insulators should be transported to site in their original (closed) packing. However, if this is not possible, they should be transported with care.

3.3 ON SITE HANDLING

Upon arrival at site, the Insulators should be carefully checked for any sign of breakage or crack.

3.4 INSTALLATION

Prior to installation, the insulators should once again be thoroughly examined for any damage or crack. Such Insulators should immediately be discarded from the lot and should not be installed on line.

3.5 CONDUCTOR STRINGING

Care should be during conductor stringing operation, the insulators should not be subjected to any hit or jerk.

3.6 FINAL INSPECTION BEFORE LINE ENERGIZATION

On undertaking a final inspection prior to commissioning of a line, insulators should be examined for any damage/crack. If any damage/crack found should be replaced.

3.7 CARE DURING MAINTENANCE

During Installation and maintenance of the Porcelain Insulator or any other OHE maintenance, only authorized Persons / Skilled Labour should be allowed.

3.8 HANDLING IN TOWER WAGON/MAINTENANCE VEHICLE

Since, Porcelain Insulator is prone to damage and crack. It should be handled with care while keeping/carrying in Tower wagon. Porcelain Insulator shall be kept in Tower wagon in original packing. Any other equipment, loads heavy weight item should not be kept on the Insulator. This may cause damage of shed and development of crack.

***

Prepared By	JE (D)/TI	Checked By	24.06.2024 ADE/TI-1	Issued By	24.6.24 DTI-1