# CHAPTER I

## MANAGEMENT OF AC TRACTION

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CHAPTER I
MANAGEMENT OF AC TRACTION

I. HEADQUARTERS OFFICE
10100 Introduction

Electrification on Indian Railways remained mainly confined to following sections, till early fifties, at 1500 V dc:-

1. Suburban Railways in Bombay
   i) Central Railway
      a) Bombay VT-Kalyan (main line)
      b) Bombay VT-Kurla (Harbour Branch)
   ii) Western Railway
      a) Churchgate-Virar

2. Ghat Sections of Central Railway
   i) Kalyan-Pune
   ii) Kalyan-Igatpuri

3. MG Suburban Sections of Madras
   i) Madras Egmore-Tambaram section of Southern Railway.

Before large scale electrification was thought of on Eastern Railway, the suburban section of Howrah-Burdwan was electrified at 3000 V dc.

In the meantime SNCF (Socieite National Chemin de Fer Francais, i.e., French National Railways) had gone ahead with large scale main line electrification on their system with 25 kV, 50 Hz, ac. SNCF, who worked as Technical Consultants to Indian Railways for adopting a system of electrification on main line, recommended 25 kV, 50 Hz system as technically viable and economical for Indian Railways. Since then the entire electrification on Indian Railways has been carried out on 25 kV, 50 Hz, ac only. The first electrification on 25 kV, 50 Hz ac was taken up on South Eastern Railway between Rajkharaswan and Dongaposi. Even the Howrah-Burdwan section on Eastern Railway and Madras - Tambaram section on Southern Railway were later on converted to 25 kV, 50 Hz ac system. As on 31.3.94, a total of 11793 Route Kilometer have been electrified on 25 kV, 50 Hz ac single phase system.

1500 V dc system is, however, retained on Central and Western Railways, even though further electrification on these two Railways was done on 25 kV, 50 Hz, ac single phase system primarily because of problems of clearances in tunnels and interference with telecommunication lines in the suburban section. The system compatibility was obtained by providing either dual system yard with neutral sections at either end (as in Central Railway) or by using dual voltage locomotives (as in Western Railway).

10101 Chief Electrical Engineer (CEE)-Zonal Railway

CEE is the Administrative Head of the Electrical Department, with overall responsibility for efficient working of the department. He is responsible to the General Manager in all matters pertaining to Electric Traction and Electrical General Services. On behalf of the General Manager, he directs and supervises all electrical works related to Railway, whether executed by Divisional Officer or by independent organisation. He oversees the budget of the Electrical Department and is also responsible for works to be executed by the department.

CEE also functions as Electrical Inspector to the Government as defined in Section 36(1) of Indian Electricity Act- 1910, in respect of all high voltage electrical installations and equipment owned by the Railways. This includes all high voltage electrical installations in the Railway including transmission lines, 25 kV feeder lines, sub-stations, switching stations which although running outside Railway premises, are, nevertheless, owned by the Railway. He is responsible for administration of the Electricity Rules in the Railway.

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In regard to electric traction installations, in his capacity as Electrical Inspector, CEE is chiefly responsible for the following:

1. Scrutiny and approval of the layout and designs for sub-stations, OHE and other installations for compliance with the Indian Electricity Act and Rules;
2. Inspection of the completed installations, either personally or by deputing his officers, for compliance with the safety requirements;
3. Approval for the energization of the Installations;
4. Statutory inspection of the installations periodically under Rule 46 of the Indian Electricity Rules;
5. Investigation of electrical accidents and Issuing directives to prevent their recurrence; and
6. Submission of annual report to Central Electricity Authority.

10102 Control Over Division

In all technical matters, the Senior Divisional Electrical Engineers (Sr. DEEs) in the Division are answerable to CEE.

10103 Duties of Administrative Officers

CEE is assisted by one or more officers of Senior Administrative rank, who will be responsible to CEE for the proper working of the department, the area of responsibility of each will be defined by CEE.

Administrative Officers will:

a) Normally deal with all correspondence except those involving important policy matters and expression of opinion on behalf of the Railway on major matters of policy;

b) On behalf of CEE, exercise administrative and technical control for the efficient planning, design, construction, commissioning, safe and economic operation and effective periodic maintenance of electric traction services, Train Lighting, Air Conditioning on Coaches, General Power Services in Railway premises and equipment owned by the Railway and to achieve this, carry out purposeful periodic inspection of installations;

c) In the event of major breakdowns/accidents, take prompt and energetic action to restore normal services at the earliest possible time and subsequently take follow-up action to investigate the cause of failure and initiate measures to prevent recurrence;

d) Co-ordinate effectively with Administrative Officers of operating and other departments on the Railway and also their counterparts in other Railways in regard to items of common interest;

e) Maintain liaison with the Power-Supply Authorities at Headquarters level in regard to continuity of supply, tariff and policy matters;

f) Keep a close watch over the day-to-day performance of traction services and tighten up preventive maintenance where required;

g) Investigate equipment failures, particularly of recurring nature, initiate appropriate remedial steps to modify the design wherever required in consultation with the Research, Designs and Standards Organisation (RDSO), Locomotive manufacturers; also take follow-up action to ensure prompt completion of modifications ordered on all equipment held by the Railway;

h) Plan and review the organizational set-up required for satisfactory maintenance and operation of the electric traction services;
i) Plan the recruitment and training of staff for maintenance and operation;

j) Exercise effective technical scrutiny over items for inclusion in the M&P, Works and Rolling Stock Programmes and progress items approved in the programmes;

k) Plan in advance the procurement of vital stores required for maintenance and operation of electric traction services and maintain effective liaison with the Stores Department at Headquarters level for prompt procurement and adequate stocking of such stores;

l) Arrange for standardization of stores as required and preparation of drawings and specifications to facilitate procurement;

m) Study and analyze the periodic statistical returns on electric traction and initiate appropriate remedial measures as required to improve efficiency;

n) Monitor energy consumption, power factor and Maximum Demand at various traction sub-stations on the Railway and initiate appropriate measures to ensure efficient utilization of energy and to contain the energy bill;

o) Ensure the prompt submission of periodical returns to the Railway Board and RDSO;

p) Budgeting and control over expenditure, particularly in regard to repair costs, energy bills and maximum demand charges;

q) Carry out studies regarding the feasibility and economics of electrification of additional sections in consultation with the Operating and Accounts Departments and submission of proposals to the Board where found justifiable;

r) Keep in touch with modern technical developments with a view to identify applicability in railway installations to reduce operation and maintenance cost;

s) Maintain liaison with the Railways for quick return of overdue locomotives;

t) Maintain close co-ordination with production units and POH workshops for supply of shop manufactured items, reducing POH time and improving reliability.

10104 Stores Procurement

An important responsibility on the Headquarters and Divisional Offices is to ensure by timely action that sufficient stocks of stores and spares are actually held not only for meeting the day-to-day needs of maintenance and repair, but also for any emergency such as thefts of overhead conductors, uprooting of OHE masts on account of accidents, or to meet urgent operational requirements such as wiring of additional lines in a yard.

Number of component parts involved in rolling stock and OHE maintenance is quite large and each of them should comply with rigid specifications, being of special nature. Reliable sources of supply are also limited. Taking all these factors into account, it is essential to take advance action to make a realistic assessment of the requirements for the whole Railway and take timely procurement action through the Stores Department. Machinery should exist on each Railway to review periodically the supply position jointly with the Stores Department so that prompt corrective action may be taken for items which are likely to be in short supply.

Consolidation and scrutiny of requirements for the whole Railway, follow-up action in regard to the release of foreign exchange for imported items and correspondence with the Railway Board as well as with procurement agencies is the responsibility of the Headquarters Office.
10105 Standard Drawings and Specifications

Indian Railway Standard (IRS) drawings and specifications for electric traction spare parts and stores required will be issued by Chief Electrical Engineer. Drawings and specifications to be issued will keep in view the drawings and standards issued by RDSO and manufacturers and experience of Railways etc.

II. DIVISIONAL ORGANIZATION

10106 Divisional Railway Manager (DRM)

For administrative purposes, the DRM functions under direct control of the General Manager but is responsible to CEE for efficient functioning of electric traction and electrical general services under his direct administrative control.

10107 Duties of Traction Distribution (TrD) Officers

1. Duties of Senior Divisional Electrical Engineer (TrD)

Sr. DEE/DEE(TrD) is the officer in immediate charge of the Traction Distribution section in a Division, responsible for all technical and organizational matters connected with the efficient maintenance and operation of the power supply installations, OHE and RC equipment. He should be intimately acquainted with the technical details, performance rating and operating and maintenance problems of the installations under his charge. His chief duties will be as under:

a) General planning and supervision to ensure efficient and safe maintenance and operation of the installations under his charge in accordance with prescribed schedules and regulations;

b) Study of the day-to-day technical and organizational problems of operation and maintenance and initiation of appropriate measures to deal with these;

c) Man-power planning for effective maintenance at minimum cost;

d) Careful statistical analysis and compilation of details of all defects and failures occurring and initiation of appropriate remedial steps if these are attributable to inadequate or improper operation or maintenance or mismanagement by staff. Where defects are attributable to improper design or manufacture, or where modifications or proposed remedial measures require CEE's approval, prompt submission of detailed analysis together with recommendations, seeking such approval;

e) Watch on the progress and completion of all approved modifications as well as the efficacy of such modifications;

f) Watch on the availability of spare parts and stores required for maintenance and initiation of stores action well in advance for procurement of items involving prolonged delivery and effective follow-up action to ensure timely procurement. Also watch the behaviour of equipment to assess their anticipated life and timely programming of replacements;

g) Overall co-ordination at the divisional level with the operating and other departments to plan power blocks required for maintenance of OHE and careful planning of maintenance work to make the best use of such blocks;

h) Inspection of his jurisdiction as under-

1. Detailed visual inspection of the OHE by push trolley, motor trolley or OHE Inspection Car as often as possible;

2. Detailed inspection of traction sub-stations, switching stations and other power supply and RC installations, in particular protective gear, once in six months,
3. Frequent surprise checks of maintenance gangs at works including gangs working at night. At least one night inspection and one day inspection will be carried out by him;

4. General inspection of all subordinate offices under him once a year, including test check of stores and tools and plant items;

5. At least one current collection test in a year throughout his jurisdiction on main lines;
   i) Liaison with power supply authorities in regard to important matters that cannot be dealt with at lower levels;
   j) Preparation of plans and estimates for works involving the traction distribution system and scrutiny of plans and estimates for works of other departments affecting the traction distribution system. For minor works such as small changes in the layout of lines in yards or alignments, provision of OHE for one or two additional loops, cross-overs etc. designs will be worked out at the divisional level in accordance with approved standards and approval of CEE obtained before the works are executed. Designs for major works will however, be worked out in CEE's office;
   k) Arrange adequate training of staff under him in the correct methods of maintenance and operation;
   l) Careful preparation of the budget for traction distribution section and control over expenditure for operation and maintenance. In addition to scrutiny and passing of power supply bills, study of the energy consumption and maximum demand figures and liaison with the operating department and Rolling Stock section to keep expenditure for these under effective control;
   m) Special watch on the adequacy and alertness of the organization for dealing with failures and break-downs, personal supervision of operations in the event of major failures affecting train services or involving outage of essential equipment, so as to effect quick restoration;
   n) Close association with tests and trials in the area under his jurisdiction and submission of prescribed reports;
   o) Ensuring by periodical and surprise inspections that rules and procedures laid down in the General and Subsidiary Rules, Manual of AC Traction, department codes and orders and circulars issued from time to time are being complied with by all staff under him and that they are Performing their allotted duties efficiently.

2. Duties of Divisional / Assistant Electrical Engineer (TrD)

DEE/AEE(TrD) is the officer in immediate charge of the maintenance, operation and safety of all power supply installations, overhead equipment (OHE) and RC equipment in his jurisdiction and is answerable to Sr. DEE(TrD) in all matters connected therewith. In addition to assisting Sr.DEE(TrD) in his duties, his chief duties will be as under :-

a) Efficient and safe upkeep and operation of the installations under his charge in accordance with the prescribed schedules including detailed planning of all maintenance works;

b) He should ensure that Traction Power Controller (TPC) takes effective and prompt action to restore services in the event of power supply interruptions or other failures of the distribution system affecting train services;

c) Close liaison with power supply authorities to ensure continuity of power supply;

d) Careful and prompt investigation of all recurring or major power supply interruptions and equipment failures and initiation of appropriate remedial measures;
e) Preparation of preliminary plans and estimates called for by Sr.DEE(TrD) for works involving the traction distribution system, and scrutiny as called for by Sr.DEE(TrD) of plans and estimates for works of other departments in the section so far as they affect the system;

f) Personal and periodical checking of the break-down organization to ensure that it is in good fettle to deal with all break-downs;

g) Prompt implementation of instructions received from time to time including those contained in Inspection Notes of superior officers and keeping record of action taken against each item;

h) Careful scrutiny of statistical and other periodical returns before submission to Sr.DEE(TrD) and taking appropriate corrective action;

i) Effective co-ordination with officers and staff of other departments in matters that warrant joint action and similar co-ordination with officers of contiguous sections;

j) Inspection of his jurisdiction as under :-

1. Detailed visual inspection of the OHE in his section from observation dome/roof of OHE Inspection Car once in six months. Similarly inspection from cab of locomotives shall also be carried out:

2. Detailed inspection of traction sub-stations, switching stations and other power supply installations, in particular, protective gear, once in 3 months;

3. Frequent surprise checks of maintenance gangs at work including gangs working at night. The musters for casual staff, if any, should be checked and initialled;

4. Random check of the procedure followed for imposition of power blocks to verify that all prescribed safety rules are being rigidly followed;

5. Periodic inspection of subordinate offices, including stores, at least once in six months;

6. Current Collection Test over his entire jurisdiction at least once in six months.

10108 Duties of Rolling Stock (RS) Officers

1 Duties of Senior Divisional Electrical Engineer (RS)

He is the officer in immediate charge of an Electric Loco or EMU Shed and responsible for all technical and organizational matters connected with the efficient maintenance of the Electric Locos based in the shed. He should be well acquainted with the mechanical and electrical design details, performance data and operating and maintenance problems of locos under his charge. His chief duties will be as under :-

a) Manage the working of the shed to make the best use of manpower and facilities provided. Study the need for additional facilities and manpower to deal with existing and anticipated workload and formulate proposals for such additional requirements;

b) Keep in touch with the day-to-day problems of the shed and take appropriate measures to deal with these;

c) Make a careful statistical analysis of all defects and failures occurring and take appropriate steps if they are attributable to inadequate or improper attention in the shed. In the case of type defects due to improper design or manufacturing defects, furnish full analysis to CEE for taking up the matter with RDSO and the manufacturers;
d) Keep a watch on the progressing of modifications approved and Special Maintenance Instructions (SMIs) as well as the efficacy of such modifications/SMIs;

e) Keep a careful watch on the availability of spare parts and stores required for maintenance of the locos/EMUs and initiate action well in advance for procurement of items involving prolonged delivery and take effective follow-up action to ensure timely procurement also watch the behaviour of equipment to assess their anticipated life and programme procurement of replacements well in time;

f) Through the Planning and Progress Organization (PPO) watch that maintenance is being carried out in accordance with prescribed schedules and carry out frequent test checks to ensure required standard of maintenance;

g) Keep effective liaison with Sr.DEE(OP) in regard to operating problems, particularly shortcomings of the shed affecting optimum utilization of the locos/EMUs. Failures involving special or unusual features should be jointly investigated with Sr.DEE(OP);

h) Careful study of the prescribed statistical returns before submission to CEE, RDSO etc. and initiation of appropriate steps in case of departure from accepted norms;

i) Arrange adequate training of the staff under him in the correct methods of maintenance and operation;

j) Ensure by periodical inspection that rules and procedures laid down in the General and Subsidiary Rules, Manual of ac Traction, departmental codes and orders and circulars issued from time to time are being complied with by all staff under him and that they are performing their allotted duties efficiently;

k) Ensure safety of stock, security of assets and staff in the shed;

l) Prepare the Works Programme, Rolling Stock Programme, M & P Programme and Budget and ensure expenditure control.

2. Duties of Divisional /Assistant Electrical Engineer (RS)
The duties of DEE/AEE(RS) will be similar to those for the Sr.DEE(RS) in respect of all works under his direct charge. He shall work directly under the control of Sr. DEE(RS) and be fully responsible for the proper and efficient functioning of all equipment under his control, and the standard of workmanship of repair and maintenance work carried out. Periodic inspection of subordinate offices including, stores at least once in six months.

10109 Duties of Rolling Stock Operation Officers

1. Duties of Senior Divisional Electrical Engineer (OP)
Sr. DEE(OP) is the officer in immediate charge of the maintenance & operation of electric locomotives and electric multiple unit (EMU) stocks outside the electric loco shed. Sr. DEE(OP) is also responsible for dealing, on behalf of the Electrical Department, with all technical and organizational matters connected with the operation of electric rolling-stock. His chief duties will be as under:

a) Plan the requirements of locos and EMUs to meet traffic requirements and preparation of loco/EMU links to suit traffic requirements;

b) Plan/review of the requirement of crew every six months;

c) Maintain close liaison with the Operating Department officials and keeping himself fully conversant with operating problems and evolving counter measures to get over them so far as electric stock is concerned. Ensure maximum utilization of locos by watching detentions, taking on additional services, improving the engine links etc.
d) Make available locos and EMUs as well as running staff as required for traffic and keeping a watch over train operations and making suggestions for better utilization of available stock.

e) Keep himself fully posted with the technical details of the electrical equipment on rolling-stock so as to give guidance to the Drivers of locos in case of failures of equipment to give first aid attention, and arranging relief when required, so that normal working may be restored with the least possible delay;

f) Ensure by periodical and surprise inspections that rules and procedures laid down in the General and Subsidiary Rules, Manual of AC Traction, departmental codes and orders and circulars issued from time to time are being complied with by all staff under him and that they are performing their allotted duties efficiently;

g) Ensure efficient and safe operation and running maintenance of the rolling-stock under his charge in accordance with the prescribed rules;

h) Prompt and careful investigation of electrical rolling-stock failures and furnishing of necessary details to the maintenance shed for taking remedial action. Failures causing detention of more than 30 minutes or other unusual occurrences shall be investigated jointly with Sr.DEE(RS) in-charge of the loco shed. Appropriate remedial action should be taken by Sr.DEE(OP) himself if the failure is attributable to lapses of running maintenance or defective operation;

i) Organize, in co-operation with the Operating Department, the timely withdrawal of electric rolling-stock for maintenance attention in accordance with prescribed maintenance schedules. Liaison with the PPO of the shed for this purpose;

j) Compile prescribed statistical information on electric rolling-stock, performance and utilization and their timely submission, after proper scrutiny, to CEE and other concerned officers;

k) Maintain watch over the punctual running of electrically hauled trains and report of serious lapses to the Divisional Railway Manager;

l) Study the pattern of energy consumption and maximum demand figures in relation to the traffic handled and initiation of appropriate measures;

m) Give requisite technical guidance to Operating Department officers and staff in regard to the special techniques involved in the operation of electric rolling-stock;

n) Train and examine for competency of electric running staff, watch over their performance and arranging refresher courses for such staff;

o) Arrange the rosters for electric running staff;

p) Issue of trouble-shooting, standing and other instructions required for the guidance and education of running staff. Arrange notification in the Working Time Table of instructions specially applicable to Electric Running Staff;

q) Supervise restoration work personally or through DEE(OP), AEE(OP) when electric rolling-stock is involved in accidents and arranging representation of Electrical Department at joint inquiries;

r) Foot-plate inspection of train working so as to cover the entire division at least once in 3 months, when he should pay special attention to -

i) Punctuality of trains in accordance with the time-table and allotted paths;

(ii) Observance of safety rules by Drivers and other operating staff;
iii) Correct observance of the prescribed rules of driving including, the best use of coasting and gradients for conservation of energy;
iv) Proper functioning of loco/EMU equipment;
v) Observance of speed restriction;
vii) Scrutiny of loco log books and test check of locomotives and EMU stock as often as feasible for compliance with prescribed safety regulations and for efficient upkeep; by frequent surprise checks and questioning of electrical running staff. He will observe their alertness on duty, knowledge of and observance of rules and carrying of prescribed equipment;
(vii) Look for reasons of poor signal visibility, train parting, stalling and other irregularities in the section where such things are reported;
s) Periodic inspection of booking points, running rooms at least once in two months and at least one night inspection in a month.
t) Ensure that speedometer charts are regularly scrutinized through Senior Divisional Inspectors (TELOC) having suitable cell. Duration for which charts are to be preserved, may be fixed by Division.

2. Duties of DEEIAEE((OP)
The duties of DEE (OP) /AEE (OP) will be similar to those for the Sr. DEE (OP) in respect of all works under his direct charge. He shall work directly under the control of Sr. DEE (OP).

10110 Duties of Principal, Training School
He is incharge of Training School of Zonal Railway for training of electric traction, maintenance and operating staff.

The Principal, Training School/Senior DEE(Trg) shall be responsible for :-

1. Estimation of current training needs for maintenance and operating staff of the Railway;
2. Organising and imparting stipulated training for the maintenance and operating staff of the Railway;
3. Planning for future- training needs keeping in view the expansions, increase in traffic, induction of newer technology and to keep the senior personnel of the maintenance shops abreast with the new technology;
4. He will be responsible for equipping the training school with modern aids of teachings and learning and for this he will be assisted by a Vice-Principal and a team of instructors. Training being such an activity, assistance of non-Railway organisations is imperative. He will, therefore, be equipped to draft such assistance as and when required;
5. Up-keep of the training school and its environment in keeping. With the atmosphere required for learning.

10111 Budget Estimates for Electric Traction
The following special points shall be kept in mind when preparing the Budget estimate for electric traction :-

a) Energy consumption and maximum demand for goods and passenger services should be estimated based on an assessment of traffic expected during the next financial year obtained from the Operating Department. This is particularly important for sections where electric traction is likely to be introduced for the first time during the new year. Based on this, necessary provision should be made for energy.
Consumption and other charges. The additional energy consumption may be computed on the basis of the specific energy consumption actually obtained for different services on the Railway during the previous six months. Where maximum demand payment is involved, the additional maximum demand for budgetting purposes may be assumed to be in proportion to the anticipated additional energy consumption if the pattern of train working remains unchanged. If there is material change in the pattern of train working, detailed calculation of maximum demand will have to be made from the proposed Graphic Train Charts for the period of the day when the traffic is heaviest;

b) Anticipated changes in tariff and possibility of application of such changes with retrospective effect;

c) Assessment of additional requirements of operating staff based on the traffic expected;

d) Provision for training of additional staff based on anticipated expansion of services;

e) Careful assessment of the cost of special procurement of stores for normal maintenance and heavy repairs;

f) Provision for clearing backlog of repairs, if any.

**10112 Electrical Department -- Budget Demands**

The demands and the main heads pertaining to the Electrical Department are as under -

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<td>Repairs and Maintenance of Carriages and Wagons Main Head 400 – Electrical Multiple Units Coaches Main Head 500 – TL, Fans &amp; AC on Coaches.</td>
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# GENERAL DESCRIPTION OF FIXED INSTALLATIONS

## I. POWER SUPPLY ARRANGEMENTS AT SUB-STATIONS

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## III. REMOTE CONTROL AND COMMUNICATION ARRANGEMENTS

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## V. SPECIAL WARNING SIGNALS

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INDIAN RAILWAYS — AC TRACTION MANUAL - VOLUME 1
CHAPTER II
GENERAL DESCRIPTION OF FIXED INSTALLATIONS

1. POWER SUPPLY ARRANGEMENTS AT SUB-STATIONS

10200 Power Supply
25 kV, ac, 50 Hz single phase power supply for electric traction is derived from the grid system of State Electricity Boards through traction sub-stations located along the route of the electrified sections at distances of 35 to 50 km apart. The distance between adjacent sub-stations may however be even less depending on intensity of traffic and load of trains.

At present there are broadly four different arrangements in existence as under :-

1. The Supply Authorities supply power at 220/132/110/66 kV Extra High Voltage (EHV) at each traction sub-station which is owned, installed, operated and maintained by the Railway;

2. The Railway receives 3-phase power supply from the Supply Authority at a single point near the grid sub-station, from where the Railway runs its own transmission lines providing its own traction sub-stations;

3. All EHV and 25 kV equipment is owned, installed, operated, and maintained by the Supply Authority, except 25 kV feeder circuit breakers which are owned, installed, operated and maintained by the Railway;

4. All EHV and 25 kV equipment is owned, installed, operated and maintained by the Supply Authority but 25 kV feeder circuit breakers alone are operated on remote control by the Traction Power Controller (TPC).

10201 Duplicate Supply
1. Fig. 2.01 shows schematically the arrangement at a typical traction sub-station.

2. To ensure continuity of supply under all conditions, the high voltage feed to the traction substations is invariably arranged either from two sources of power or by a double circuit transmission line, so that even if one source fails, the other remains in service. Suitable protective equipment is installed at the sub-stations to ensure rapid isolation of any fault in transmission lines and sub-station equipment, so that the power supply for electric traction is maintained under all conditions.

3. At each traction sub-station, normally two single-phase transformers are installed, one of which is in service and the other is 100% stand by. The present standard capacity is 21.6 MVA (ONAN)/30.2 MVA (ONAF). However transformers of capacity 13.5 MVA (ONAN)/10.8 MVA (ONAN) have also been used at many of the sub-stations. These transformers step down the grid voltage to 25 kV for feeding the traction overhead equipment (OHE). 25 kV feeders carry the power from the substations to feeding posts located near the tracks. Each feeder is controlled by a single-pole circuit breaker equipped with protective devices.

10202 Voltage Regulation
The permissible variation of the bus bar voltage on the busbars at the grid sub-station is +10% and –5% i.e., between 27,500 V. and 23,750 V. The tappings on the transformers are on the secondary winding and are set to ensure that the voltage is maintained as high as possible but not exceeding 27.5 kV at the feeding post at any time.

10203 25 kV Supply at Traction Sub-stations
1. On the secondary side, one transformer circuit breaker and one feeder circuit breaker are installed with associated double pole isolator, the busbar connections being such that full flexibility of operation is assured.
FIG. 2.01
(PARA 10201)
2. The traction sub-station is designed for remote operation.

3. The facilities exist to change over from one feeder to the other by means of isolator/bus coupler.

4. One end of the secondary winding of the transformer is solidly earthed at the sub-station and is connected to track/return feeder through buried rail.

10204 Feeding and Sectioning Arrangements

1. The generation and transmission systems of Supply Authorities are 3-phase systems. The single-phase traction load causes unbalance in the supply system. This unbalance has undesirable effects on the generators of the Supply Authorities and equipment of other consumers, if its value becomes excessive.

2. The permissible voltage unbalance at the point of common coupling on the grid supply system should not exceed the following limits:-

<table>
<thead>
<tr>
<th>Voltage Unbalance</th>
<th>(%)</th>
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<tr>
<td>Instantaneous</td>
<td>5</td>
</tr>
<tr>
<td>2 hours</td>
<td>3</td>
</tr>
<tr>
<td>Continuous</td>
<td>2</td>
</tr>
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</table>

3. To keep the unbalance on the 3-phase grid system within the above limits, power for ac single phase traction is tapped off the grid system across the different phases at adjacent sub-stations in cyclic order.

4. Thus it becomes necessary to separate electrically the overhead equipment systems fed by adjacent sub-stations. This is done by providing a ‘Neutral Section’ between two sub-stations on the overhead equipment to ensure that the two phases are not bridged by the pantographs of passing electric locomotives/EMUs.

5. To ensure rapid isolation of faults on the OHE and to facilitate maintenance work, the OHE is sectioned at intervals of 10 to 15 km along the route. At each such point a ‘switching station interruptors’ usually rated at 600A are provided. The shortest section of the OHE, which can be isolated by opening interruptors alone is called a ‘sub-sector’. Each sub-sector is further sub-divided into smaller ‘elementary sections’ by provision of off-load type manually operated isolator switches.

6. At some stations with large yards, alternative feeding arrangements are provided so that the power for feeding and yards may be drawn from alternative routes. Normally the switch is locked in one position, being changed to the other when required after taking necessary precautions.

7. To meet requirements at electric loco running sheds isolators with earthing device in the ‘off’ positions is provided. At watering stations manually operated interrupters and isolator with earthing heels are provided to enable switching off of the power supply locally and earthing the OHE to enable working on roofs of rolling-stock. There are several types of switching stations as detailed in the following paras.

10205 Feeding Post (FP)
Each feeder supplies the OHE on one side of the feeding post through interruptors controlling supply to the individual lines. Thus, for a two track line, there will be four interruptors at each feeding post.

10206 Sectioning and Paralleling Post (SP)
These posts are situated approximately midway between feeding posts marking the demarcating point of two zones fed from different phases from adjacent sub-stations. At these posts, a neutral section is provided to make

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME
it impossible for the pantograph of an electric locomotive or EMU train to bridge the different Phases of 25 kV supply, while passing from the zone fed from one sub-station to the next one. Since the neutral section remains 'dead', warning boards are provided in advance to warn and remind the Driver of an approaching electric locomotive/EMU to open locomotive circuit breaker (DJ) before approaching the 'neutral section', to coast through it and then switch 'on' on the other side. Special care is taken in fixing the location of neutral sections, on level tangent tracks far away from signals, level crossing gates etc. to ensure that the train coasts through the neutral section at a sufficiently high speed, to obviate the possibility of its stopping and getting stuck within the neutral section.

A paralleling interruptor is provided at each 'SP' to parallel the OHE of the up and down tracks of a double track section. 'Bridging interruptors' are also provided to permit one feeding post to feed beyond the sectioning post upto the next FP if its 25 kV supply is interrupted for some reasons. These bridging interruptors are normally kept open and should only be closed after taking special precautions as detailed in these rules.

10207 Sub-Sectioning and Paralleling Post (SSP)

One or more SSPs are provided between each FP and adjacent SP depending upon the distance between them. In a double track section, normally three interruptors are provided at each SSP i.e. two connecting the adjacent sub-sectors of up and down tracks and one for paralleling the up and down tracks.

10208 Sub-Sectioning Post (SS)

These are provided only occasionally. They are similar to SSPs with provision for sectioning of the OHE but not paralleling.

10209 Certain Equipment at Switching Stations

Certain equipments are installed at various points to protect the lines, to monitor the availability of power supply and provide other facilities. These are generally as under :-

1. Lightning arresters are provided to protect every sub-sector against voltage surges.

2. Auxiliary transformers are provided at all the posts and also at certain intermediate points to supply ac at 240 V, 50 Hz required for signalling and operationally essential lighting installations. To ensure a fairly steady voltage, automatic voltage regulators are also provided where required.

3. Potential transformers are provided at the various switching stations for monitoring supply to each sub-sector.

4. A small masonry cubicle is provided to accommodate remote control equipment, control panel, telephone and batteries and battery chargers required for the control of interruptors and other similar equipments.

II. POWER SUPPLY FOR SIGNALLING

10210 Supply Arrangements

1. To ensure reliability of ac 240V, supply through 25 kV/240V auxiliary transformer by tapping 25 kV OHE is made available at following places:

   (a) At each way side station for CLS.
   (b) Level crossings located more than 2 km.away from Railway Station.
   (C) At IBH.
   (d) At all the power supply installations.
2. In the event of power block being given on both the OHE sub-sectors from which the signal supply is derived, electric traffic would necessarily have to be suspended on the line. During such periods, colour light signalling will not also be in operation. Such cases are likely to arise very rarely at any station and the duration of the block is not likely to exceed-one hour at a time. Therefore, no additional power supply arrangement need be made by the Electrical Department at wayside stations. However, to cater for this condition, portable-generating sets should be kept by the S&T Department to be operated until 25 kV supply is restored. At large stations with considerable shunting movements, a stand-by diesel generator set may be installed by the S&T Department to meet emergencies, if considered essential.

10211 Voltage Regulators

The fluctuating nature of traction load causes perceptible fluctuation on the ac 240 V supply affecting operation of signalling equipment. To overcome this, static type voltage regulators are provided by the S&T Department to limit voltage fluctuations to ± 5%. These voltage regulators are installed either in separate kiosks inside the remote control cubicles, inside the ASM's room, or inside the cabins depending upon the position of various load centres.

III. REMOTE CONTROL AND COMMUNICATION ARRANGEMENTS

10212 Remote Control

The interruptors at the various switching stations as well as the feeder circuit breakers (and other switch gear owned and operated by the Railway) at the traction sub-stations are controlled from a Remote Control Centre (RCC) manned throughout the 24 hours of the day. During each shift there is one or more number of Traction Power Controllers (TPC), depending upon the work load. All switching operations on the system are thus under the control of one single person, namely TPC, who is responsible for maintaining continuity of power supply on all sections of the OHE. He also maintains continuous and close liaison with the Section Controllers in regard to train operations on electrified sections.

Further details regarding Remote Control are given in Vol. II of this manual.

10213 Communication Facilities

All aerial telecommunication lines running by the side of the tracks are replaced with under-ground cables/ microwave to overcome the interference caused by 25 kV single phase ac traction. The cables contain adequate number of pairs of conductors for the various types of Railway telecommunication circuits on ac traction. For technical details reference may be made to Indian Railways Telecommunication Manual.

In an electrified section it is essential, in the interest of efficiency, to provide several independent telephone circuits to facilitate quick communication and to achieve necessary co-ordination between different branches of the Railway. In an emergency several alternative telephone channels will be available for communication should any one fail. The various telephone circuits provided in electrified sections are described below briefly :-

1. Train Control/Section Control :

This circuit is operated by the Section Controller and is used mainly for controlling train movements within his jurisdiction. It has connections with Signal Cabins, ASMs Offices, Loco Sheds and Yard Masters' Offices.

2. Dy. Control Telephone

This circuit is operated by the Deputy Controller and is used for directing traffic operations in general. It has connections with the important Station Masters' offices, Yard Masters' Offices, Loco Sheds and Signal Cabins.
3. Stock Control Telephone:
This circuit is operated by the Stock Controller and is mainly used for keeping a continuous watch and to maintain control over the movements of wagons. It has connections with Yard Masters and important Station Masters' offices.

4. Traction Loco Control:
This is a circuit provided for ac traction and is operated by the Traction Loco Controller who is responsible for movements of electric locomotives and Electric Multiple Unit (EMU) stock. It has connections with Electric Loco Sheds, EMU Sheds, important Station Masters, Yard Masters, Divisional Officers such as Sr. DEE/DEE, AEE (RS), Sr DEE/DEE/AEE- (OP), Traffic Control Offices, Traction Foreman and important crew booking points.

5. Traction Power Control:
This is a special circuit on ac traction and is used by TPC for all communications in connection with power supply, switching operations and ‘permit-to-work’. It has connections with Station Masters' offices, cabins, Traction sub-stations, feeding posts, sectioning and sub-sectioning posts, traction maintenance depots, important Signal Cabins, Divisional Officers such as Sr. DEE (TrD), Sr. DEE/OP and Traffic Control Offices.

6. Emergency Control Circuit:
This circuit is provided to facilitate the traction maintenance gangs and electric train crew to get in touch with TPC with the least possible delay in emergencies. It is also used by train crew in times of accidents for communication with the Control Office. This circuit is operated by TPC and is located in the RCC.

Emergency telephone socket boxes are provided along the track at an interval of 0.75 to 1 km and also near the signal cabins, sub-sectioning and sectioning posts, insulated overlaps and feeding posts etc. Portable emergency telephones are given to maintenance gangs, train crew and Station Masters. By plugging the portable telephone into an emergency socket it is possible to communicate with the TPC.

7. Hot Line Communication:
Hot line communication circuit should be provided between the HQ, divisional HQ traction loco controller and electric loco sheds. These would be provided in the HQ with CEE, CEE/Loco, Dy. CEE/RS, Sr. DEE/RS in the sheds and Sr. DEE/OP in the divisions.

8. Walkie Talkie sets
Every maintenance depot of OHE should have adequate numbers of walkie-talkie sets to be available with them during their normal maintenance work as well as break-downs so that not only effective communication is available at site but also to increase the efficiency and productivity of the work during power blocks. These walkie-talkie sets are to be used primarily for the following purposes:

a) To communicate to the maintenance/breakdown gangs/parties that power block has been sanctioned;

b) To direct and supervise work during the period power block is in force;

c) Confirmation regarding cancellation of power block by each individual party and cancellation of power block.

9. Other Communication Facilities:
An independent inter-communication ‘circuit is also provided between the various Section Controllers and the Chief Controller for local communication between themselves. Facilities are also provided for the Chief Controller.
to talk to any station on train control, deputy control, stock control and traction loco control circuits. Similarly, facilities are provided to TPC to talk to any station on the train control and traction loco control in an emergency. However, it will not be possible for the Chief Controller or TPC to ring independently any station on any control circuit as this ringing facility is only provided to the respective Controllers.

IV OVERHEAD EQUIPMENT

10214 Catenary and Contact wire

1. The overhead equipment above the tracks comprises of the following:-

a) A standard cadmium copper wire of about 65 mm² section or standard aluminium alloy wire of about 116 mm² section for catenary.

b) A grooved hard drawn copper contact wire of 107 mm² cross-section (when new) supported from the catenary by means of droppers of 5 mm diameter spaced not more than 9 m apart.

2. The catenary and contact wire together have an equivalent copper section of 157 mm². The current normally permissible on a single track is 600 A approximately, because of equivalent cross-sectional area of OHE. This current limit is based on the temperature limit of 85°C in contact wire. Certain sections in Waltair-Kirandul section have the catenary and contact wires together having an equivalent copper section of 200 mm².

3. For loop lines, sidings, yards and spur lines excluding the main running lines and first loop or lines taking off from main running line, tramway type OHE having only grooved hard drawn copper contact wire of 107 mm² section is provided.

10215 Height of Contact wire

The normal height of contact wire for regulated OHE is 5.60 m (with 10 cm presag for 72 m span) above rail level. For unregulated OHE in areas with a temperature range of 4°C to 65°C, this figure is 5.75 m and in areas with a temperature range of 15°C to 65°C, it is 5.65 m. In certain cases, such as under over-line structures, the height may be as low as 4.65 m on BG and 4.02 m on MG. For passing oversize consignments on such lines, special precautions have to be taken.

10216 Span of Supporting Mast/Structures

The span normally used for supporting the OHE from masts/structures using the cantilever type bracket assembly varies from maximum 72 m on straight track to 27 m on curved track, the spans depending upon the degree of curvature. The catenary system is normally supported on straight tracks at maximum intervals of 72 m (63 m on MG) by cantilever type arms fixed to galvanized broad flange or I section steel masts or fabricated steel structures. On curves the catenary is supported at closer intervals, the spans adopted depending upon the degree of curvature.

10217 Stagger

The contact wire is staggered so that as the pantograph glides along, the contact wire sweeps across the current collecting strips of the pantograph upto a distance of 200 mm on either side of the centre line on straight runs and 300 mm on one side on curves. This ensures a uniform wear of the current collecting strips of the pantographs.

10218 Overlaps

The OHE conductors are terminated at intervals of about 1.5 Km with an overlap generally as shown in Fig. 2.02, the conductor height being so adjusted that the pantograph glides from one conductor to the other smoothly. There are two types of overlap spans as under :-

a) Uninsulated overlap spans where the distance of separation between two contact wires is 200 mm and
the two conductors are permanently connected together electrically by suitable jumpers.

b) Insulated overlaps, where the two OHE systems are kept apart at a distance of 500 mm. Normally the electrical discontinuity at insulated overlaps is bridged by interrupters or isolator except at neutral sections.

10219 Regulated and Unregulated OHE

OHE with automatic tensioning called 'regulated OHE' is generally provided for all main lines, but for large isolated yard and unimportant lines, automatic tensioning is dispensed with in the interest of economy and only unregulated OHE is used.

10220 Section Insulator Assembly

Section insulators are provided to insulate the OHE of one elementary section from the OHE of the adjacent elementary section such as at cross-overs.

When the pantograph of a locomotive passes from one track to another along a cross-over/turnout, current collection changes from one OHE to other and therefore the runners of the section insulators overlap with contact wire so that there is no arcing.

On double line sections with runners trailing, the section insulator assembly using porcelain insulators are fit for speeds upto 120 km/h provided it is installed between the first one-tenth and one-third of the span. In case the runners of the section insulator assembly are in the facing direction or it is not installed within the first one third of the span, the speed should be restricted to 80 km/h.

10221 Mechanical Independence of OHE Track - Structures

By providing independent structures for supporting the OHE of each track, complete mechanical independence of each OHE is secured. Any irregularity or damage or maladjustment of the OHE of one track will not, therefore, affect the performance of the other.
Flexible Head-Span and Rigid Portals.

In large yards, where difficulty is experienced in locating individual supporting structures between the tracks, a cross catenary wire system called flexible head-span is provided to maintain two or more catenaries and their contact wires at the appropriate heights and locations. Where the OHE has to be regulated, rigid portal structures are used.

Maximum Speed

The OHE with maximum span of 72 m and with presag of that span of 10 mm and with tension of 1000 kgf in contact and catenary wire is designed for a speed potential of up to 160 km/h. The existing system is generally fit for 140 km/h with AM-12 pantographs now in use on ac locomotives.

V. SPECIAL WARNING SIGNALS

Signal Marking the end of Catenary

Certain loops and sidings at a station may not be wired. An electric locomotive should not be taken into an unwired track as its pantographs and the OHE may get damaged and it will require a diesel or steam engine to pull the electric locomotive out of the unwired track. Caution boards as per Fig. 2.03 are provided for warning the Drivers of the unwired tracks taking off from wired tracks. In addition special indication boards are provided where the OHE ends on a track. Point levers controlling the movement of trains from the wired track to the unwired track are fitted with warning tablets (Boards) as per Fig. 2.04 painted yellow, to warn the cabinman not to admit electric locomotives on the unwired track.

Warning Signals for Neutral Sections

To indicate to the Driver that he is approaching a neutral section and should be in readiness to open DJ, two warning boards as per Figs. 2.07 & 2.08 are fixed 500 m and 250 m ahead of the neutral section. The point where DJ is to be opened is indicated by a signal shown in Fig. 2.05. Indication that the neutral section has been passed and DJ may be switched on again is given by another signal shown in Fig. 2.06.

Temporary Signals

Occasionally it becomes necessary to lower the pantograph on certain sections when OHE is not properly adjusted so as to avoid damage to the pantographs. In such cases temporary warning boards as shown in Fig. 2.09 are placed ahead of the section, facing the direction from which locomotives normally approach for this purpose. On reaching such a warning board, the Driver shall open DJ and lower pantograph/s of his electric locomotive/s. He may raise the pantographs after passing the section and reaching the signal provided for the purpose as per Fig. 2.10.

After a break-down on OHE normally only temporary repairs permitting electric locomotives to pass with their pantographs lowered are carried out in attending to break-downs, so that the traffic may not be dislocated unduly. Permanent repairs are done as soon as possible thereafter by taking a prearranged block in consultation with the Operating Department.

Special features of Traction Installations in Waltair - Kirandul section of S. E. Railway

Waltair - Kirandul section of South Eastern Railway is about 471 km long, having large number of tunnels and gradients as high as 1 in 60 and sharp curves of 8 degree. The configuration of traction distribution system in the section is as under:

i) OHE- About 329 km of the section has got 19/2.10 mm HDBC catenary and 150 mm² contact wire. The tension in catenary is 800 kgf while contact wire has got 1200 kgf tension.
The balance section of 142 km has got standard OHE. The neutral sections provided in OHE are short neutral sections with section insulators.

ii) Power Supply Arrangement- At present there are 18 traction sub-stations, of these 8 traction sub-stations have two transformers and 10 traction sub-stations have one transformer. There are five zones where traction sub-stations have been connected in parallel to meet requirements of loads and to maintain voltage within the prescribed limits. The protection system for transformers and feeders at the traction sub-stations is the same as used in other traction sub-stations.
CHAPTER III

GENERAL DESCRIPTION OF ELECTRIC ROLLING STOCK

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CHAPTER III
GENERAL DESCRIPTION OF ELECTRIC ROLLING STOCK

10300 Classification of Electric Rolling Stock

Locomotives and Multiple Unit stocks are classified by means of a three/four letter code followed by a number to indicate the individual class and a series of the same.

The code letters used for ac locos and EMUs are given below:

The first letter denotes the Gauge: 'W' for BG and 'Y' for MG.

The second (middle) letters 'A' denotes the system of power supply for which it is suitable - A for ac & C for dc, CA for dc & ac.

The third letter for locos indicates the class of service -
'M' for Mixed traffic locos suitable for both passenger and freight services,
'G' for Freight (Goods) service locos,
'P' for Passenger services locos, and
'S' for Shunting locos.

Multiple Unit Stock is denoted by the letter 'U'

The various classes of ac locos and EMUs at present in service on Indian Railway are as under:-

a) ac Loco- WAG1, WAG2, WAG3, WAG4, WAG5, WAG6, WAG7, WAP1, WAP2, WAP3, WAM1, WAM2, WAM3, WAM4, YAM1.

b) ac/dc Loco- WCAM1.

c) ac EMUs- WAU1, WAU2, WAU3, WAU4, YAU.

In addition two types of BG dc EMUs converted for ac working are in use on the Eastern Railway.

Salient particulars of each type of ac and ac/dc electric locomotive are given in Table No. 3.01 & 3.02.

A set of plates containing coloured photographs of each type of ac/dc Electric Locomotives along with salient features are annexed with this chapter as a pull-out.

Salient particulars of each type of ac EMU are given in Table No. 3.03.

A set of plates containing coloured photographs of each type of ac EMUs along with salient features are attached with this chapter as a pull-out.
10301 Important Equipment of Electric Loco/EMU

1 Pantograph

1.1 For collecting power from 25 kV ac contact wire pantographs are mounted on the roof of the traction vehicles. AM12 pantograph of Faively design has been adopted by Indian Railways for 25 kV ac electric locomotives and EMUs. These pantographs are provided with steel strips for current collection. The raising and lowering of the pantograph is by means of a pneumatically operated servo motor. This pantograph is a single pan design having two o-springs mounted on it. For keeping the pantograph in the lowered condition, main springs have been used. The suspension of pan is on plungers.

This pantograph is suitable for operation up to 140 km/h. For increasing the speed potential, improved pantograph with lower dynamic mass and independent pan heads have been used. Further, in order to improve the life of the contact wire, use of carbon strips has also been tried. Use of carbon strips for current collection has already been adopted in European countries.

1.2 Use of carbon strips necessitates change in the design of the pantograph. The pan head which is more or less rigid in case of steel strip pantograph needs to be made more flexible in the vertical, horizontal and transverse movement for carbon strip pantographs. This is achieved by improved suspension of the pan head. The speed potential of such a pantograph is of the order of 250 km/h.

The pantograph of this design have been imported from M/s Stemman, West Germany for WAG6A, from M/s SMC, Australia and M/s ETK, Austria for WAP1 and WAP3 locomotives.

2. Circuit Breaker

2.1 Since inception of 25 kV ac traction system, Air Blast Circuit Breakers manufactured by M/s Brown Boveri-Corporation were used on electric locomotives as well as on EMUs, and are still in use for about 30 years. These breakers are designed for isolation of power to the traction vehicle in the event of faults. The Air Blast Circuit Breaker needs a great amount of maintenance due to inherent features like large number of parts (735 nos.), complex control block and extinguishing of arc during breaking of current in air. The life of the main contact on this account is also limited. This breaker also requires substantial amount of dry air for each switching operation.

2.2 Vacuum Circuit Breakers were introduced on electric locomotives on Indian Rlys in the year 1985. The VCB is a simplified design with fewer number of parts (260 Nos.), have a simplified control block and self-contained interrupting medium, that is vacuum. Due to these features, the life of the main contact achievable is as high as 1 lakh electrical operations as against 20,000 operations for air blast circuit breakers. As a result, the periodicity of replacement of main contact is second POH for VCB and IOH for Air Blast Circuit Breakers. Besides, these factors, VCB also offers the advantages of reduced size, reduced weight and reduced maintenance cost as compared to these for air blast circuit breakers. The total trip-time for VCB is less than 60 milli-seconds while the same is of the order of 100 milli-seconds for air blast circuit breakers. The air blast circuit breaker is only capable of breaking the fault current with breaking capacity of 250 MVA. The VCB, besides having breaking capacity is also designed for making capacity of the same rating, i.e. 250 MVA and can handle the same level of fault current during closing also.

These circuit breakers (VCBs) were initially imported from M/s. GEC, U.K. and are presently being manufactured indigenously by GEC, Allahabad. The use of these breakers has been extended to EMUs also.

3. Transformer

3.1 Power to the traction vehicles is available at 25 kV ac single phase from the contact wire. In order to step down the voltage as well as to control the same for feeding to the traction motors, the traction power transformers are provided on the traction vehicles.
1.2 These transformers generally have a primary winding, a regulating winding, traction secondary windings and auxiliary windings. The regulating winding is designed for choosing appropriate voltage for the traction motors. The auxiliary winding is required for feeding the auxiliary motors on the locomotive.

3.3 In order to increase the h.p. Of the locomotives, the traction transformers have been uprated from time to time keeping the overall dimensions unchanged on account of space constraint. The upratings have been achieved by using increased copper section of the conductor used, improved insulation scheme and in certain cases adoption of aluminium foil wound construction for minimising the losses.

3.4 The original imported transformer used in WAGI locomotives had a capacity of 3000 kVA which was increased to 3460 kVA for WAG4, 3900 kVA for WAG-5/WAP1 and has been now further increased to 5400kVA for WAG-7 locomotives.

3.5 With the introduction of thyristorised convertors, the design of the traction transformer has undergone simplification with the deletion of regulating winding. The transformer for thyristorised convertor becomes a two limb construction and traction secondary winding split into 4 windings for two step sequence control.

3.6 The traction transformer necessarily has to have forced oil circulation and forced air cooling. For this purpoze oil pump, oil cooler and blower form an integral part of the traction transformer.

4. Tap Changer

4.1 On load tap changer Type No. 32 of M/s. Brown - Boveri Corporation has been used on most of the 25 kV ac electric locomotives. This type of Tap changer is provided on 25 kV (HT) regulating winding of locomotive transformer for controlling the voltage input to main transformer. The Tap Changer operates with the help of elaborate mechanism using an air driven Servo Motor (SMGR) and a bevel gear arrangement. Through precision adjustment and provision of transition resistance (RGR) it is ensured that there is no break of load current in-side the selector (GR) which is oil filled and the load current is broken by load switches known as CGR1, CGR2 and CGR3.

4.2 The on load tap changer presently used on electric locomotives for speed control requires great deal of maintenance on account of its inherent design and construction. Problems of flash over inside the selector and breakage of various components in SMGR and other sub-assemblies are some factors affecting to reliability of the locomotives. The development of thyristor convertors for controlling the voltage input to traction motors was therefore undertaken for replacing the existing tap changer and silicon diode rectifier unit.

4.3 The thyristor convertors for electric locomotives offer the advantage of maintenance reduction, smooth control of speed thereby improving the adhesion and permitting the realisation of higher tractive effort. Thyristorisation of locomotives type WAG1, WAM1, WAM2 and WAM3 is being indigenously done for realising the above benefits.

5. Traction Motor

5.1 In case of traction motor great emphasis is being given on improving power to weight ratio, keeping in view the limited space available on locomotive for mounting the same. There is continuous effort to improve the performance of traction motor by making them lighter/compact, at the same time more reliable. Indian Railways have been adopting the latest technology available for design and manufacture of traction motor. Over a period of years the traction motors have become now 2.5 times lighter specially for EMU application.

5.2 Improvements in the basic design of traction motor has become possible due to availability of new insulating materials with high thermal margins. Over the years not only new and superior materials have been developed but even the basic concepts have undergone radical changes. The method of classi-
5.3 Instead of dealing with individual insulating material, the specification now covers the combination and system as a whole. The new feature is added because of thermal endurance of the system which may not be directly related with thermal capability of individual materials.

5.4 The procedure for functional evaluation of insulation system also has been laid-down as per IEC 505 to evaluate the typical service life under functional test and the influence of thermal, electrical, mechanical and environmental stresses.

6. Arno Convertor

6.1 Arno Convertor is a special duty machine for conversion of single phase in-coming supply into 3 phase output supply. 3 phase supply is essentially required on most of the electrical locomotives for driving certain auxiliary equipment like blowers and compressors. The function of Arno Convertor is to supply 3 phase power required for these auxiliaries.

6.2 Arno Convertor of ACEC make initially imported for WAM-1/WAG-1/ WAG4 were of horizontal construction. Indigenously developed Arno Convertor however is of vertical construction. The machine has mechanical construction suitable to withstand the severe vibrations encountered on locomotives. There was a provision on its top for mounting battery charger generator which has been eliminated in present Arno Convertors.

6.3 The performance of indigenously manufactured Arno was not up to the level of the performance of ACEC make Arno convertor, however, certain improvements like class 'F' insulation scheme, integral epoxy moulded terminal box and revised bearing scheme has led to significant improvements in reliability and performance of these Arno Convertors.

6.4 As the Arno Convertor offers an inherent voltage unbalanced Indian Railways are making an effort to develop suitable static convertor for taking its place. Static convertors are already available in imported WAG6A locomotive.

7. Motor Compressor Set

7.1 There are few locomotives equipped with imported compressor motor set from M/s. Oerlikon. Initially CLW had used motor compressor set developed and manufactured by M/s. Kirloskar Pnuematic Co. however, M/s. Elgi Equipment Ltd. have developed these motor compressors for electric locomotives and the same are being used for the last so many years by CLW. Efforts are being made by CLW vigorously for development of more sources for supply of compressors. The driving motor for the compressors have been developed indigenously by reputed motor manufacturer namely M/s. Siemens, M/s. NGEF, M/s. ABB & M/s. Crompton Greaves Ltd.

7.2. Indigenously manufactured Air Compressor is a vertical cylinder air cooled machine. The compressor is directly driven through an extended crank shaft by an integral direct current motor or alternatively through a flexible coupling by 3 phase induction motor. The compressor is designed to supply compressed air to the associated equipment on 50% duty cycle in normal circumstances. It can be allowed to run continuously without causing any damage or undue wear.

7.3 The driving motor is high torque 3 phase induction motor designed for direct on line starting. The earlier motor manufacture and supply were provided with class 'B' insulation scheme. The flexible complete assembly also incorporate the cooling fan for the compressor. With a view to improve the reliability of 3 phase induction motor certain basic design changes like 'F' insulation, use of double glass cover conductor winding wire Vacuum pressure impregnation, use of solventless varnish were adopted. The reliability of the auxiliary motors have improved considerably due to these steps.
# TABLE NO. 3.01

## Salient Data of Mixed/Passenger Electric Locomotives

<table>
<thead>
<tr>
<th>SN.</th>
<th>Type of Loco</th>
<th>Type of Traction</th>
<th>Guage (MM)</th>
<th>Axle Load (t)</th>
<th>Axle Weight (t)</th>
<th>Brake System</th>
<th>Max. Load (t)</th>
<th>Max. T.E. Speed (KM/H)</th>
<th>Max. Power (HP)</th>
<th>Horse Power as on Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>WAM-1</td>
<td>25 KV ac</td>
<td>1676</td>
<td>18.64</td>
<td>76</td>
<td>Air</td>
<td>25.00</td>
<td>100</td>
<td>2800</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>WAM-2</td>
<td>25 KV ac</td>
<td>1676</td>
<td>19.00</td>
<td>76</td>
<td>Air</td>
<td>25.24</td>
<td>100</td>
<td>2790</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>WAM-3</td>
<td>25 KV ac</td>
<td>1676</td>
<td>19.00</td>
<td>76</td>
<td>Air</td>
<td>25.24</td>
<td>100</td>
<td>3640</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>WAM-4</td>
<td>25 KV ac</td>
<td>1676</td>
<td>18.80</td>
<td>112.8</td>
<td>Air Rheo</td>
<td>33.84</td>
<td>120</td>
<td>3640</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>WAP-1</td>
<td>25 KV ac</td>
<td>1676</td>
<td>18.05</td>
<td>108.3</td>
<td>Air</td>
<td>32.49</td>
<td>130</td>
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<td></td>
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<td>6.</td>
<td>WAP-2</td>
<td>25 KV ac</td>
<td>1676</td>
<td>19.00</td>
<td>76.0</td>
<td>Air</td>
<td>25.24</td>
<td>110</td>
<td>2790</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>WAP-3</td>
<td>25 KV ac</td>
<td>1676</td>
<td>18.05</td>
<td>108.3</td>
<td>Air</td>
<td>32.49</td>
<td>140</td>
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<td>8.</td>
<td>WCAM-1</td>
<td>25 KV ac</td>
<td>1676</td>
<td>18.80</td>
<td>112.8</td>
<td>Air ac dc</td>
<td>33.84</td>
<td>110 ac dc</td>
<td>2930</td>
<td>52</td>
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<td>9.</td>
<td>YAM-2</td>
<td>25 KV ac</td>
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<td>Air</td>
<td>19.50</td>
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### TABLE NO. 3.02

**Salient Data of Goods Electric Locomotives**

<table>
<thead>
<tr>
<th>SN.</th>
<th>Type of Loco</th>
<th>Type of Traction</th>
<th>Guage (MM)</th>
<th>Max. Horse Power (HP)</th>
<th>Axle Load (t)</th>
<th>Total Weight (t)</th>
<th>Brake System</th>
<th>Max. Speed (KM/H)</th>
<th>T.E.</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>WAG-1</td>
<td>25 KV ac</td>
<td>1676</td>
<td>21.30</td>
<td>85.2</td>
<td>Air</td>
<td>Reg</td>
<td>2900</td>
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<td>2.</td>
<td>WAG-2</td>
<td>25 KV ac</td>
<td>1676</td>
<td>21.30</td>
<td>85.2</td>
<td>Air</td>
<td>Rheo</td>
<td>51.5</td>
<td>80</td>
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<td>WAG-3</td>
<td>25 KV ac</td>
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<td>21.83</td>
<td>87.32</td>
<td>Air</td>
<td>Reg</td>
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<td>WAG-4</td>
<td>25 KV ac</td>
<td>1676</td>
<td>21.90</td>
<td>87.6</td>
<td>Air</td>
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<td>WAG-5</td>
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<td>19.80</td>
<td>118.8</td>
<td>Air</td>
<td>Reg</td>
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<td>80</td>
</tr>
<tr>
<td>6.</td>
<td>WAG-6A</td>
<td>25 KV ac</td>
<td>1676</td>
<td>20.50</td>
<td>123.0</td>
<td>Reg</td>
<td>Air</td>
<td>6280</td>
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<td>7.</td>
<td>WAG-6B</td>
<td>25 KV ac</td>
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<td>20.50</td>
<td>123.0</td>
<td>Air</td>
<td>Rheo</td>
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<td>45</td>
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<td>8.</td>
<td>WAG-6C</td>
<td>25 KV ac</td>
<td>1676</td>
<td>20.50</td>
<td>123.0</td>
<td>Air</td>
<td>Rheo</td>
<td>6040</td>
<td>45</td>
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<td>9.</td>
<td>WAG-7</td>
<td>25 KV ac</td>
<td>1676</td>
<td>20.50</td>
<td>123.0</td>
<td>Air</td>
<td>Rheo</td>
<td>5000</td>
<td>18</td>
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1323
TABLE - 3.03

<table>
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<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>WAU1</th>
<th>WAU2</th>
<th>WAU3</th>
<th>WAU4</th>
<th>YAU1</th>
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<tr>
<td>1.</td>
<td>Type of Traction</td>
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<td>25 kV</td>
<td>25 kV</td>
<td>25 kV</td>
<td>25 kV</td>
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<td>ac</td>
<td>ac</td>
<td>ac</td>
<td>ac</td>
<td>ac</td>
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<td>2.</td>
<td>Gauge (mm)</td>
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<td>1676</td>
<td>1676</td>
<td>1676</td>
<td>1000</td>
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<td>4.</td>
<td>Train Formation</td>
<td>3 units</td>
<td>2/3 units</td>
<td>2 Units</td>
<td>3 Units</td>
<td>2 Units</td>
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<tr>
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<td></td>
<td></td>
<td>1 TC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>No. of Driving Cabs per unit.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
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<td>6.</td>
<td>Max. Axle Load (DCL) condition (t)</td>
<td>20.3</td>
<td>17.5</td>
<td>18.92</td>
<td>19.24</td>
<td>13.76</td>
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<td>7.</td>
<td>Train Performance per unit Rating</td>
<td>Cont. 1 Hr</td>
<td>Cont. 1 Hr</td>
<td>Cont. 1 Hr</td>
<td>Cont. 1 Hr</td>
<td>Cont. 1 Hr</td>
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<tr>
<td></td>
<td>Horse Power</td>
<td>840</td>
<td>1032</td>
<td>848</td>
<td>1040</td>
<td>860</td>
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<tr>
<td></td>
<td>Tractive Effort (t)</td>
<td>45.92</td>
<td>62.2</td>
<td>44</td>
<td>59.6</td>
<td>42</td>
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<td></td>
<td>Max. Safe speed of TM km/h</td>
<td>49.75</td>
<td>48.25</td>
<td>50</td>
<td>46.6</td>
<td>55.5</td>
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<td>8.</td>
<td>No. of Pass/Units Normal</td>
<td>288</td>
<td>268</td>
<td>406</td>
<td>400</td>
<td>300</td>
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<td></td>
<td>Crush</td>
<td>567</td>
<td>567</td>
<td>786</td>
<td>774</td>
<td>590</td>
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<td></td>
<td>Dense Crush</td>
<td>844</td>
<td>844</td>
<td>1164</td>
<td>1148</td>
<td>880</td>
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<tr>
<td>9.</td>
<td>Brake system</td>
<td>Air</td>
<td>Air</td>
<td>Air</td>
<td>Air</td>
<td>Vacuum</td>
</tr>
</tbody>
</table>
CHAPTER IV

SAFETY PRECAUTIONS ON ELECTRIFIED SECTIONS

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10400 Induction Effect of 25 kV ac 50 Hz Single Phase Traction

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CHAPTER IV
SAFETY PRECAUTIONS ON ELECTRIFIED SECTIONS
10400 Induction Effects of 25 kV ac 50 Hz Single Phase Traction

1. The attention of all railway staff is drawn to the fact that under 25 kV ac 50 Hz single phase traction, there is heavy induction on all metallic structures and conductors in the vicinity of the track. The induction is two-fold:

a) Electro-static, which results from the high potential of 25 kV on the OHE system.

b) Electro-magnetic, which is proportional to the currents passing from the sub-station to the OHE to the locomotives / EMUs and back partly through the track and partly through the earth.

2. Those who have been used to work on dc traction are liable to overlook taking adequate precautions required to guard themselves against the dangerous inductive effects of 25 kV ac system. Attention is therefore specially drawn to the need for taking adequate precautions.

3. The voltage induced is quite appreciable on overhead conductors running parallel to the tracks depending on the length of parallelism. This explains why most of the overhead telecommunication lines are replaced by underground cables. Special protective measures are required to reduce the adverse effects of induction.

4. In a railway yard, voltage of the order of 200 volts may be induced on yard lighting mains situated 8 m away from the centre of a double-line track, if it runs parallel to the 25 kV lines for a distance of about 270 m., it could be several thousand volts when parallelism is much longer. In such a case, a dangerous voltage due to induction will exist even after power supply to the line has been switched off. No one shall therefore attempt to work on any overhead line running alongside the electrified tracks without taking special precautions of earthing on both sides of the work. Before a section is electrified, the necessary modifications to distribution lines in all stations and yards should be carried out, so as to limit the induced voltage within permissible values, but this by no means obviates the need of earthing the lines on both the sides of the working party. Earthing should be done individually by each working party as close to the work-spot as possible. The distance between the two earths shall not exceed 1 km.

5. Such inductive effects occur on large metallic structures such as fencings, structural steelwork of platforms running parallel to the track. They will therefore have to be earthed suitably to afford safety.

6. Inductive effects also show themselves on any metallic conductor, such as metallic clothes-lines, powerlines and lines belonging to private parties running parallel and close to the electrified tracks. Wide publicity should be given to the effects of induction so that special precautions are taken by the private parties.

I. WORKING OF STEAM AND DIESEL LOCOMOTIVES IN ELECTRIFIED SECTIONS
10401 Prevention of Smoke Pollution

Pollution of OHE insulators due to smoke on account of operation of steam locomotives causes appreciable operating and maintenance difficulties. To reduce pollution to the minimum, the following precautions shall be taken:

1. No steam locomotive should be left standing with the chimney under an OHE insulator. Stabling of steam locomotives with chimneys under traction structure is prohibited.

2. Continuous blowing of safety valves, sudden opening of blower and priming through exhaust steam should be avoided as they cause flashover of insulators resulting in severe consequences. Sudden starting of a steam engine shall also be avoided as it may cause slipping of wheels which would result in priming through exhaust steam, which in turn may cause flashover.

INDIAN RAILWAYS - AC TRACTION MANUAL VOLUME (34)
10402 Standing on Boiler Shell or Tender

Staff are warned of the danger of standing on the boiler shell or tender when stabled under live OHE as it may result in electrocution.

10403 Working the Fire-Spraying, Advancing of Fuel and Handling of Tools

1. Special care must be taken while firing coal or raking fire to ensure that the TOOLS DO NOT GET WITHIN THE DANGER ZONE of the OHE. Spraying of coal with water under electric overhead lines is forbidden.

2. The firing tools must be handled with great care, and special care should be taken to see that THESE TOOLS ARE NEVER LIFTED OR RAISED TOWARDS THE OHE. Tools must always be placed in their respective positions after use.

3. A jet from a hose should never be directed towards the OHE. The jet of water should only be directed horizontally far away from the live OHE and not vertically.

10404 Loading of Fuel

1. The loading of coal or fuelling of the locos shall only be carried out in yards outside the Electrified zones.

2. The height of the coal in the tender must not be more than 4.28 m above the rail level on BG and 3.65 m above rail level on MG.

10405 Watering of Steam Locomotives

Whatever may be the height of the contact wire, NO ONE SHOULD CLIMB ON THE TENDER to open the cover of the water tank or to insert the funnel of the water column. Water columns have been suitably modified for operation from ground level. Only the operating rods provided should be used for this purpose.

10406 Crane Working

No crane shall be worked on or near traction overhead equipment unless an authorised representative of the OHE section is present. When so working, care shall be taken to avoid hitting or damaging OHE structures.

10407 Decorative Fittings

No decorative or extension pieces be attached to the chimney of a steam locomotive that would raise its effective height.

10408 Engines Owned by Outside Parties

The safety precautions mentioned above are equally applicable to locomotives owned by Steel Works or other factories in the neighborhood of electrical sections that are likely to work in electrified sidings for shunting or other purposes. The special safety rules to be observed in electrified sections should be advised by Sr. DEE (TrD) to parties owning such locos and their written assurance obtained that their operating staff have been made familiar with these rules.

II. WATERING OF CARRIAGES IN ELECTRIFIED SECTIONS

10409 Watering Arrangements - Basic Precautions

With electrification, 'side filling' arrangements for coaches have been introduced as a long term measure, in lieu of overhead filling arrangements which necessitate shutting down of power for watering and other precautions. Since all carriages have not yet been provided with side filling arrangement, special arrangements have been made for
Overhead watering of carriages in some electrified stations. The following precautions must be observed in such interim arrangements:

1. If the carriages are standing on lines having overhead traction wires, nobody shall get on to the roofs of the carriages unless the overhead traction wires above are made dead and earthed.

2. Staff getting on to the roofs of the carriages for watering, after the overhead traction wires above such carriages are made dead, should be warned against carrying long poles or any other articles which may come within the danger zone, that is within 2 m of the live traction wires on the adjoining lines. They should also be warned about the risk of extending the water hoses or any part of their body or directing water jets within the danger zone i.e. Within 2 m of live overhead traction wires.

10410 Watering Section

1. For the purpose of isolation and earthing the OHE, wires above the watering arrangements for each platform will form a separate elementary section i.e. different platforms will have different watering sections. This is to ensure that isolation of each platform can be done independently. The limits of each watering section shall be marked by danger limit board (Fig. 4.01) hanging from the catenary at either end. These constitute the limits within which, alone watering of the carriages may be done. In Fig. 4.02 CD is the watering section.

Separate interruptors or isolators shall be provided for controlling supply to each watering section. Keys for such interruptors/isolators shall be provided with metal tags on which the numbers of the interruptors/isolators are punched.

2. A neutral section about 12 m long bounded by section insulators is provided at - , either end of each watering section. The purpose of the neutral section is to afford additional protection to the watering section against approach of any electric locomotive or any other type of "feeding in" from the live sections on either end. In Fig. 4.02, BC and DE are the neutral sections.

10411 Controlling Switches

1. 'L' is the locally operated interruptor/isolator at the end of the platform in a separate enclosure. The Key for the enclosure is with the ASM on duty.

2. S1 and S2 are manually operated isolators - one at each end of the watering section, the purpose being to switch off power from the respective small neutral sections and to earth the two ends of the watering section. For this purpose the two isolators are provided with earthing heels.

3. Elementary sections AB and EF are normally live.

4. A feeder line for maintaining continuity (shown dotted in Fig 4.02) is carried on the OHE structure having supermasts.

10412 Sequence of Interlocking and Operation

The following are the interlocking arrangements and the sequence of operations:-

1. The enclosure to interruptor/isolator 'L' is locked and its key is with the ASM on duty. When required, the ASM issues it to the lineman, only against a receipt on the register kept for the purpose.

2. If an interruptor is provided, on its frame is mounted the opening key which is accessible only after the enclosure to the interruptor is opened. This ensures that no one can open the interruptor, without taking the key of the lock of the enclosure from the ASM. The tripping key is normally back locked in the lock on the interruptor frame. It can be extracted from the lock only after the interruptor is opened to switch off supply to the watering section. Similarly, when an isolator is provided it can be opened only by the linesman on receipt
DANGER BOARD INDICATING LIMIT FOR WATERING

FIG. 4.03

FEEDER LINE FOR CONTINUITY CARRIED ON MASTS OF THE ONE STRUCTURES

REFERENCES:
- AE, EF: ELEMENTARY
- BC, DE: SMALL NEUTRAL SECTION 12 METRES LONG
- CD: WATERING SECTION
- B, C, D, E: SECTION INSULATORS
- S1, S2: MANUALLY OPERATED ISOLATORS WITH EARTHING HEELS
- L1: LOCALLY OPERATED INTERRUPTORS, ISOLATORS

ARRANGEMENT AT WATERING STATION

REV. ISSUE

AUTHORITY BADGE FOR WATERING NO.

NAME OF THE SECTION

NAME OF WATERING SECTION

BRASS BADGES FOR AUTHORISED PERSONS FIG. 4.03
of its key from the ASM on duty. For opening the (main) isolator 'L' the additional precautions detailed in the
Chapter VI of Vol. 11 of this Manual shall be observed.

3. Each of the isolators 'S1' and 'S2' is provided with a double lock. The opening key extracted as above from
interruptor 'L' when inserted in S1 and turned, releases the operating handle of S1. If the isolator S1 is now
opened or closed, a key K1 (normally back-locked in the double lock on S1) is released, simultaneously
locking the operating handle as well as the opening key. This ensures that once the key K1 is in the hands of
the operator, the interruptor 'L' as well as isolator S1 cannot be operated. The key K1 as obtained now is known
as the isolator Interlocked key.

4. Key K1 is taken to the other end of the platform and inserted into the double lock of S2. This releases
the operating handle of S2 and if isolator S2 is now opened another key K2 normally back-locked in lock of S2 is
released. This key is handed over to the TXR in charge by the authorised person as an assurance that the
supply to the watering section is cut-off and made dead and earthed. Key K2 is known as the "permit-to-work"
key.

5. The details given above and in subsequent paras are mainly for watering sections controlled by
interruptors. The same principles however apply for watering sections controlled by manually operated
isolating switches, though the details vary somewhat between installations at different stations.

10413 Persons Authorised to Open Interruptors and Isolator Switches

No staff of rank lower than a linesman working under the Traction Foreman (OHE) is authorised to open or
close the interruptors or isolators controlling power supply to the overhead traction wires in the watering
section.

A list of names of the authorized linesmen duly signed by the Traction Foreman (OHE) shall be exhibited
prominently in the office of the ASM and the TXR of the station concerned. Each such linesman should also
carry an identity card with photograph or specimen signature.

It will be the duty of the linesman concerned to report to the ASM on duty at least half an hour before the
scheduled arrival of a train. No linesman on duty shall leave his place of duty until he has been properly
relieved by his reliever and that too after his reliever has been introduced by him to the ASM on duty at the
time.

10414 Custody of Keys

1. The keys of the interruptor enclosures and isolators shall be inscribed with the distinguishing marks and
locked in glass-fronted Key box and kept in the personal custody of the ASM on duty. The keys should never
be kept in a bunch, but hung on individual pegs provided for each. The description of each key shall be
painted above each peg to avoid confusion.

2. When the watering section of a particular platform is required to be made dead and earthed for watering of
carriages, the ASM on duty shall give the key of the lock of the enclosure of the controlling Interruptor/
isolator of the platform to the linesman on duty and getting his acknowledgment in a "Key Register" to be provided for
the purpose at the station. This key shall be handed over immediately on arrival of the passenger train
concerned, if hauled by an electric loco. If, however, the train, the carriages of which are to be watered, is not
hauled by an electric locomotive, the key may be handed over to the linesman even prior to the arrival of the
train, in question so as to save time, provided the earlier isolation of the watering section does not interfere
with the movement of the other train. (It is to be understood that the handing over of the key of the interruptor
enclosure to the linesman amounts to the requisition for a power block).

3. The ASM shall ensure that no electric locomotive with raised pantograph is allowed to enter a watering
section till the watering linesman returns the key back to the ASM and signs in the Key Register.

10415 Watering of Carriages

On receipt of the "permit-to-work" key of the concerned watering section, the TXR-in-charge of watering shall
personally check that the key received by him bears the correct number and relates to the concerned.
watering section on which the carriages to be watered are standing. The TXR-in-charge shall also ensure that the train is standing within the limit of the watering section bounded by the danger limit boards on the overhead traction wires. He will then arrange to fix yellow flags (or yellow lights by night) on either end of the train high enough to be visible from the carriage roof. He will at the same time hand over to each of his men who are to go up on the roof of the carriages, a number badge of the legend and description shown in Fig. 4.03 as the authority to go on the carriage roof for the watering.

Only the staff holding the badges mentioned above are authorised to go to the roof of the carriages and water the same. The badges when not in use, shall be kept in the personal custody of the TXR-in-charge of watering under lock and key. Any loss of the badge shall be notified immediately and the badge cancelled.

The TXR shall ensure that his staff deputed for watering are conversant with the following precautions:

1. Watering operation shall be confined to the limits specifically marked by "Danger Limit Boards" hanging from the catenary wire of the OHE above the concerned watering section.

2. The hydrants shall not be opened till the other end of the hose pipe has been inserted in the overhead tank of the carriage.

3. The hose pipes shall not be withdrawn from such overhead tank, till the hydrant has been closed.

Precautions 2 and 3 above are necessary to avoid accidental contact of a water jet with the live overhead traction wires of the adjacent tracks.

Each platform adjoining the watering section shall have a small area marked with the legend "Watering Gang". Each of the staff deputed for watering shall be instructed to assemble in this area as soon as watering is completed or they are signalled to stop watering and get down from the roof of the carriages.

On completion of the watering, the TXR-in-charge of watering shall collect the authority badges given to his men and ensure that all the badges have been returned and there are no men on the top of the carriages in the watering section. The TXR shall also ensure that no material has been left on the carriage roof and that all the watering hoses have been brought down and the watering hydrants closed.

10416 Restoration of Supply

On receipt of the permit-to-work key the linemen on duty shall proceed to restore supply as under:-

He shall insert the "permit-to-work key" in the double lock of the isolator switch S2 and turn the same. This will release the isolator switch handle which shall then be operated to close the isolator. After this operation the isolator interlock key shall be extracted from the double lock and taken to isolator S1 and inserted in its double lock and turned. This will release the operating handle of isolator S1 which shall then be closed, thus back-locking the Isolator interlock key. The interruptor opening key may then be taken out and inserted in the key hole of the interruptor lock and turned after which operation the interruptor should be closed. The interruptor enclosure shall then be closed and locked and the key returned to the ASM on duty. The returning of the key to the ASM on duty signifies that the power block has been cancelled. The linesman on duty returning the key shall sign the Key Register entering the time at which the key is returned. The ASM on duty shall also sign the register in acknowledgment of having got the key back.

On receipt of the key the ASM shall arrange to start the train.
10417 Key Register

Each watering station shall have a key register for recording the interchange of keys between the ASM on duty and the linesman. This key register will have the following columns:

1. Date
2. Description of the key
3. Watering Section No.
4. Train No.
5. Time made over
6. Signature of the linesman
7. Time returned
8. Signature of the linesman
10. Signature of ASM on duty.

Safety depends essentially on the proper exchange of the keys and correct record of the same. All exchange of keys shall take place directly between the persons concerned and not through messengers. The custody of any key shall be the responsibility of the person possessing the same at the time.

10418 Loss of Key

In case of loss or damage to any key controlling the switching arrangements to the watering section, the same should be reported at once to the TPC over phone and by XXR message addressed to the Sr. DEE(TrD), Sr. DOM and Chief Controller of the Division. The Sr. DEE(TRD) shall make immediate arrangements for the provision of a new locking system requiring a different set of keys.

During such period the TXR-in-charge of the watering shall personally be responsible for making dead and earthing the overhead traction wires of the watering section concerned. He shall arrange to lock the operating handles of the interruptor'L' and isolator switches S 1 and S2 by his own padlocks, the keys of which shall be in his personal custody till the watering is completed and the brass badges authorizing his staff to go on the top of the carriages for watering are returned to him.

III. LOADING AND UNLOADING OF PETROLEUM PRODUCTS

II. 10419 Precautions to be Observed

In order to avoid any sparking during loading or unloading of petroleum products at the petroleum siding, electrical continuity must be maintained between the earth systems of petroleum installations, the track and electric overhead traction installation. The loading zone should be insulated from the rest of the railway network during loading and unloading operations. The following precautions / arrangements would be necessary.

Arrangements
1. Provision of an equipotential link between the earth system of petroleum siding installations and the track via a switch.
2. Setting up of neutral zones (insulating joints) in the track to avoid any risk of propagating stray current.

3. Setting up neutral zones/sections in the contact and catenary wires similar to loco inspection pits.

4. Provision of longitudinal bonds on both the rails as well as transverse bond (30 m intervals) on the track. All masts and metallic structures in the vicinity of the track/siding should be provided with structure bond.

5. Provision of 10 Ohm earths connected to the petroleum siding on each side at the insulated joint.

Precautions
1. No oil tanker is permitted to stable under live OHE for inspection purpose.

2. Fueling to be done by side filling arrangements only.

3. Pipelines in the vicinity of the track should be properly earthed.

4. Minimum 2 m electrical clearance from live OHE of the adjacent track or any other equipment nearby must be maintained.

5. During service operations, the continuity of track and the contact wire should be set up at the same time the link between the track and petroleum facility should be opened.

6. The isolators at the neutral section of OHE should be kept open, OHE made dead and earthed.

IV RULES APPLICABLE TO PERMANENT WAY STAFF
10420 General

These instructions have already been included in the supplement to Part ‘J’ of Chapter II of the Indian Railways Permanent Way Manual.

These instructions lay down precautionary measures to be observed by railway personnel working in the vicinity of the tracks equipped with 25 Kv ac OHE. These have already been included in the supplement to Para ‘J’ of Chapter II of the Indian Railway Permanent Way Manual which are reproduced below:

10421 Need for Precautions
Precautions are required to be taken on account of the following:

a) Proximity of a live conductor: The risk of direct contact with live OHE is ever present while working in electrified sections such as for painting of steel work of through spans of bridges and platform covered sheds.

b) Build up of potential due to return current in rails: The return current in the rails may cause a potential difference.

g) between rail and the surrounding mass of earth;

ii) between the two ends of a fractured rail;

iii) between the two rails at an insulated joint;

iv) between earth and any other metallic mass.
c) Building up of potential due to induction in metallic bodies situated close the OHE. It is important to note that dangerous voltages may be inducted in metallic masses such as fencing posts in the vicinity of traction conductors. To avoid possibility of shock due to such voltages the metallic structures are bonded together and earthed.

10422 General Precautions.
The precautions laid down below must be followed under all circumstances in sections equipped for 25 Kv ac single phase, 50 Hz. Traction in addition to those referred to in Indian Railway Permanent Way Manual.

1. No work shall be done above or within a distance of 2 m from the live OHE without a ‘permit to work’
2. No part of tree shall be nearer than 4 m from the nearest live conductor. Any tree or branches likely to fall on live conductor should be cut or trimmed periodically to maintain this clearance. Cutting or trimming should be done by engineering staff in the presence of authorized staff of the OHE section.
3. No fallen wire or wires shall be touched unless power is switched off and the wire or wires suitably earthed. In case the wires drop at a level crossing, the Gate-keeper shall immediately make arrangements to stop all road traffic and keep the public away.
4. As far as possible closed wagons shall be used for material trains. In case open or hopper wagons are used, loading and unloading of such wagons in electrified tracks shall be done under the supervision of an Engineering Official not below the rank of a Permanent Way Mistry who shall personally ensure that no tool of any part of the body of the worker comes within the ‘danger zone’ i.e. within 2 m of the OHE.
5. Permanent way staff should keep clear of the tracks and avoid contact with the rails either when approaching or reaching the work-spot when an electrically hauled train is within 250 m.
6. When unloading rails along side the tracks, it should be ensured that rails do not touch each other to form a continuous metallic mass of length greater than 300 m.

10423 Continuity of Track

During maintenance or renewal of track, continuity of the rails serving electrified tracks shall invariably be maintained. For bridging gaps which may be caused during removal of fish plates or rails, temporarily metallic jumpers of approved design shall be provided as under :-

a. In case of a rail fracture, the two ends of the fractured rail shall be first temporarily connected by a temporary metallic jumper of approved design (Fig. 4.04). In all cases of discontinuity of rails, the two parts of the rail shall not be touched with bare hands. Gloves of approved quality shall be used.
b. In the case of track renewals, temporary connections shall be made as shown in Fig. 4.05.
c. In the case of a defective or broken rail bond, a temporary connection shall be made as mentioned in (a) above.
d. Before fish plates are loosened or removed, temporary connections shall be made as in (a) above.

10424 Permanent Way Tools

Permanent Way tools alongwith the gloves shall be used in the manner as approved by the Chief Engineer of the Railway.
TEMPORARY CONNECTIONS DURING TRACK RENEWALS

1. REMOVING OF THE RAIL (BOTH THE RAILS INSULATED FOR TRACK CIRCUITING)

2. REMOVING BOTH THE RAILS SIMULTANEOUSLY OF THE ONE LINE (BOTH THE RAILS INSULATED FOR TRACK CIRCUITING)

3. REMOVING OF THE ONE RAIL (ONE RAIL ONLY INSULATED)

4. REMOVING BOTH THE RAILS SIMULTANEOUSLY OF THE ONE LINE (ALTERNATIVE TO NO.2 ABOVE)

TC=TEMPORARY CONNECTIONS

FIG 4.05

NAKED COPPER WIRE 4 MM

TEMPORARY JUMPERING OF RAILS IN CASE OF RAIL FRACTURE

FIG 4.04
10425 Track-Circuited Rails.

In track-circuited areas where the rail/s has/have insulated joints, such joints shall not be bridged with bare hands or any metallic article. Similarly simultaneous contact with an insulated section of rail/s and non-insulated section of rail/s of the same or other tracks shall be avoided.

10426 Care in Handling Pipes etc.

Use of rails as a foot path, a seat or for such other purposes is strictly prohibited. Particular care shall be taken when carrying or handling long pipes, poles, overhanging on the shoulder or otherwise to avoid all possibility of such objects and work pieces coming inadvertently in contact with or within 2 m of live equipment.

10427 Steel Measuring Tapes not to be used.

In electrified tracks, steel tape or metallic tape or tape with woven metal reinforcement should not be used.

10428 Traction Structure Foundation

1) The top of foundation block of track structures shall be kept clear of all materials and kept tidy.
2) While excavation the foundations not be exposed and there should be no risk of sinking of the foundations.

V. RULES FOR S&T INSTALLATIONS

10429 Effect of 25 KV ac, 50 Hz, Single Phase Traction on S&T Equipment

1. Any circuit in the vicinity of 25kv ac OHE is influenced by electrostatic and electromagnetic induction. The electrostatic induction is practically eliminated by transferring S&T circuits into underground cables protected with metal sheath. The electromagnetic induction causes various currents and voltages to develop in conductors parallel to the track. These include the rails, traction return conductor where provided, cable sheath, any other conductors in the vicinity and S&T circuits. The voltages that occur in the conductors appear a potential gradients. The value of induced voltage depends on various factors such as:

a) Length of parallelism between the cable conductor and electrified track.
b) Soil conductivity.
c) Screening efficiency of cable sheath where existing.
d) Return current through the rails and return conductor where provided.
e) Mutual inductance between catenary and cable conductors.
f) Current in the OHE.

Appropriate precautions to overcome the effects of the induced voltages therefore have to be taken by S&T department.

Other aspects in which S&T equipment is affected are:

i) OHE structures and fittings affect visibility of signals to some extent and may come in the way of a signal;
ii) Restrictions come in the path of traction return currents on section provided with track circuits.

2. Essential precautions to be taken while working on signalling and telecommunication installations as described. Reference may also be made to Chapter XVII of the Indian Railways Telecommunication Manual.

10430 Precautions in the Event of Breakage of Wires.
Should a catenary or contact wire snaps and falls on the running track, it is possible that the fault current may damage signalling equipment. The following precautions shall, therefore, be taken.

1. The Section Controller on receipt of an advice of a break in traction overhead lines shall immediately advise, by the quickest possible means, the signal maintenance and operating staff of the section where the catenary/contact wires have broken.

2. If abnormal working of any equipment is noticed, its working shall be immediately suspended and necessary action under the rules shall be taken.

3. On receipt of the intimation from the Section controller the staff responsible for the maintenance of signaling of the section shall immediately proceed to the site and test all signaling circuits and allied equipment paying particular attention to the outdoor signaling gear to check if any damage has taken place. An authorized representative of the Signal Department shall submit a certificate that everything is working all right and send it to his superiors along with a detailed test report as soon as possible.

10431 Works on Signal Posts and Fittings.

1. No staff shall work on any portion of a signal post or its fittings falling within a distance of 2 m from a 25 Kv live OHE or a metal part electrically connected to this OHE unless such portion is protected with a metallic screen in accordance with approved instructions.

2. If for any reasons the protective metallic screen is not provided, the staff shall not undertaken any work on those portions of the signal or its fittings falling within 2 m of 25 Kv live OHE, unless power to the 25 Kv live OHE has been switched off and a ‘permit to work’ has been obtained. To draw the attention of the staff in such cases a red band 10 cm wide shall be painted all around the signal post at a height of 3 m above the rail level.

3. The inspectors of the Signal Department and the Station Masters shall explain these instructions to the staff working under them and ensure that they are correctly understood.

10432 Precautions against build up of Potential due to Return Current in Rails.

1. The flow of return current in the rails may cause a potential difference to build up between:

   a) two rails at an insulated joint of the track circuit at an ordinary joint in case the fish plates are broken.
   b) two ends of a fractured rail;
   c) an insulated rail and the rail used for the traction return current; and
   d) the rail and the surrounding mass of earth.

2. Whenever staff have to work on installations which are in direct contact with the rails, they shall:

   a) use tools of the type approved for the purpose by the Chief Signal and Telecommunication Engineer of the Railways; and
   b) observe the provisions of Chapter II of the Indian Railways Permanent Way Manual.
10433 Precautions against Induction Potential in Metallic Bodies.

Voltage will be induced in signalling and telecommunication circuits when the length of the parallelism to the track is appreciable, due to normal load currents or short circuit current in the event of a fault on the traction system. Dangerous potentials may also develop in circuits with earth connection if the earth connection gets broken for any reason. Consequently every time staff have to work on signalling and telecommunication circuits along with 25 Kv ac electrified lines, they shall take precautions to protect themselves and the equipment as prescribed by the S&T Department.

Some of the important precautions are however given below:

a) Rubber gloves and tools with insulated handles should be used.

b) When the work to be done is of such a nature that rubber gloves cannot be used, splitting of the circuits into sections to reduce the length of parallelism and earthing them to ‘drain out’ the voltage should be adopted. Both the steps should be taken simultaneously. If these protective measures cannot be applied, staff must get insulated from ground by using rubber mats or other approved form of protection.

c) The line wires of the electric block instruments are likely to get heavy induced voltages and every time the staff handles the line wire terminals of the block instruments, they must observe the provisions of paras (a) and (b) above. Line wire terminals should be painted red to remind the maintenance staff of the danger. The maintenance inspectors shall explain the meaning of this painting to the maintenance staff and ensure that it is correctly understood by them.

d) Before cutting the armour or the lead sheath of a cable or the wires in the cable, an electrical connection of low ohmic resistance should be established between the two parts of the armour or the sheathing and the wires that are to be separated by cutting.

VI OVER-DIMENSIONED CONSIGNMENTS

10434 Definition of Over-Dimensioned Consignments (ODC)

When a consignment whose length, width and height are such that one or more of these infringe Standard Moving Dimensions at any point during the run from start to destination, then the consignment is called an Over-dimensioned consignment (ODC). It is also known as out-of-gauge load.

If any consignment exceeds the following dimensions, it is to be treated as ODC or over dimensioned consignment.

<table>
<thead>
<tr>
<th></th>
<th>BG</th>
<th>MG</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Length</td>
<td>13716 mm</td>
<td>12192 mm</td>
</tr>
<tr>
<td>b) Height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) at centres</td>
<td>2743 mm</td>
<td>2540 mm</td>
</tr>
<tr>
<td>ii) at corners</td>
<td>2134 mm</td>
<td>2134 mm</td>
</tr>
<tr>
<td>c) Width</td>
<td>2997 mm</td>
<td>2540 mm</td>
</tr>
<tr>
<td>d) Top width</td>
<td>610 mm</td>
<td>610 mm</td>
</tr>
</tbody>
</table>
10435 Classification of ODCs

ODCs are classified as under:

‘A’ class ODC having clearance (i.e. clearance measured under stationary conditions) as 228.6 mm and above from the fixed structures but infringes the standard moving dimensions.

‘B’ class ODC having gross clearance of 152.4 mm

‘C’ class ODC having clearance of less than 152.4 mm but more than 76.2 mm.

10436 Precautions for Movement of ODCs in 25 Kv ac Electrified Sections.

The following precautions must be observed for transport of ODCs in the electrified sections:

1. Movement of ODC shall undertaken only after sanction of competent authority has been obtained.

2. In all cases where ODC is to be moved, staff accompanying the ODC shall remember that the OHE is ‘live’ except when a power block has been obtained from the traction officials. Even when a power block has been obtained, all lines other than those for which the power block has been granted are to be treated as ‘live’ at 25 Kv.

3. The following are the prescribed clearances from contact wire for the passage of ODCs through electrified sections and the special restrictions required:

   a) Special speed restriction is not required when the gross clearance is more than 390 mm.

   b) Speed must be restricted to 15 km/h when the clearance is between 390 mm and 340 mm.

   c) Speed must be restricted to 15 km/h and power to OHE must be switched off when the clearance from the contact wire is less than 340 mm.

4. No consignment with less than 100-mm clearance from the overhead contact wire will be permitted in a 25 KV electrified section.

5. A representative of the OHE section should accompany all ODCs having clearance as specified in items 3(b) and 3(c) of item (3) above, to supervise safe movement of the ODC at locations where clearance from the contact wire is critical.

6. A representative of the OHE section should also accompany ODCs having width more than 1981 mm for BG (and 1910 mm for MG) from centre line of track.

7. Section Controller and Traction Power Controller must coordinate while an ODC moves in electrified section in order to ensure that OHE masts are not damaged at locations where the clearance is critical.

8. A list of structures where the clearance are restricted in the electrified section and also the clearance, available under the over-bridges should be with the Section Controller and TPCs.

9. To facilitate checking of clearance from the Contact wire for over-dimensioned consignments, the Operating and Engineering branches at the Divisional and Headquarter level should have with them up-to-date charts showing location of the minimum height of contact wire and clearances of OHE structures in the electrified section. The Operating Department may permit movement of ODCs on the basis of clearance checked with the help of the above mentioned charts subject to the speed restrictions. However, when sanction of CRS is required to be obtained for movement of any particular
ODC, a specific reference should be made to CEE and a certificate obtained from him in the following form.

Certified that the minimum height of contact wire on the section over which the consignment is to move is not less than except at the following locations where restrictions are indicated below should be observed:-

<table>
<thead>
<tr>
<th>Section</th>
<th>Location</th>
<th>Height of Contact wire</th>
<th>Power ‘ON’ or ‘OFF’</th>
<th>Speed Restriction in km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

10437 Power Blocks for Movement of ODC

When an ODC is permitted to be moved in an electrified section with the OHE power off, it will be the responsibility of the Section Controller to arrange with the TPC for power to be cut off before admitting the ODC into the section. An authorised representative of the Traction Distribution Branch will obtain confirmation from TPC by message supported by private number that power has been switched off and then issue a memo to the Guard of other traffic official in charge of the train to the effect that power has been switched off over the specified section. Only on receipt of such memo may the train carrying the ODC be allowed to enter the section.

Note: Since such a memo is not a “permit to work”, earthing of the OHE is not necessary.

VII. OTHER PRECAUTIONS

10438 Movement of Rubber Tyred Vehicles on Railway Wagons.

All metallic parts of rubber tyred vehicles which are transported on railway wagons through 25 KV electrified areas, shall be earthed to avoid the effect of induction.

10439 Hoarding Boards.

Hoarding boards provided in the vicinity of electrified tracks should be located at a safe distance from the track so that the event of their supporting structures being damaged during agitation or storms it should not fall on the OHE or infringe the track. For this purpose, CCS and CPRO will ensure that while granting approval for erection of hoardings boards, it must be ensured that not only these are located at the safe distance from the track but also their structural arrangements are properly secured.

VIII COMPETENCY CERTIFICATE

10440 Competency Certificate and Courses for Assistant Station Masters/Guards of EMUs.

All staff who are required to work in electrified territory must have undergone a course in Electric traction so that they are made familiar with the working rules in the electrified sections. ASMs are also sometimes required to operate isolators at the station premises for which necessary training is to be imparted. Similarly, the guards of the EMUs are also required to undergo an operational course for the working of EMUs and are to undergo a refresher course at regular intervals of 6 months at Electrical Training Schools. Operating department will ensure that only that staffs who have undergone the course in Electric traction are posted in electrified areas.
CHAPTER V

ELECTRICAL ACCIDENTS

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<th>Para No.</th>
<th>Subject</th>
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<td>Electrical Accident</td>
</tr>
<tr>
<td>10501</td>
<td>Electrical Accidents – Action to be taken</td>
</tr>
<tr>
<td>10502</td>
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<td>10503</td>
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<td>10507</td>
<td>First Aid</td>
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RESUSCITATION FROM ELECTRICAL SHOCK

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<tr>
<th>Para No.</th>
<th>Subject</th>
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<tr>
<td>10508</td>
<td>Instructions to be Displayed</td>
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<tr>
<td>10509</td>
<td>Removal from Contact</td>
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<tr>
<td>10510</td>
<td>Artificial Respiration</td>
</tr>
<tr>
<td>10511</td>
<td>Typical Electrical Accidents.</td>
</tr>
</tbody>
</table>
CHAPTER V
ELECTRICAL ACCIDENTS

10500 Electrical Accident

An electrical accident is caused directly or indirectly due to electrical causes, that is, it includes any electric shock or electric burn, whether minor, major or fatal and whether suffered by railway servants or others.

A person may suffer electric shock by coming in contact with:

1. Live mains. LT or HT.
2. Overhead lines, which although made dead by isolation at both ends still develop high potentials on account of electro-static or electro-magnetic induction due to parallelism with other high voltage live lines, or due to lightning discharges during thunderstorms:
3. Parts which have become live due to leakage either because of low insulation resistance of the electrical windings, high earth resistance of discontinuity of the earthing lead to the body:
4. Areas which develop a high potential gradient such as near an earth electrode through which a fault current is flowing, and is insufficient to blow the fuse or cause the circuit breaker to trip.

In any well-maintained installation, no electrical accidents should occur. Every accident can, in the final analysis, be traced to one or more of the following causes, if properly probed into:

1. Disregard or non-observance of the prescribed rules laid down:
2. Ignorance of rules and insufficient training of staff:
3. Carelessness, casual and indifferent methods of working, including improper earthing indicating inadequate supervision:
4. Faulty protective equipment and poor maintenance:
5. Over-confidence or sheer laziness:
6. Old habits of working on non-electrified lines:
7. Misunderstanding of instructions:
8. Inadvertence.

Every rule prescribed is the result of experience gathered over the years by several persons, and owes its origin to some electrical accident or damage to equipment observed in the past. Rules and procedures prescribed should therefore, be taken seriously, and never allowed to fall into disuse.

To enable a better appreciation of the need for meticulous observance of the safety rules prescribed, brief particulars of several case histories have been presented in para 10511.

10501 Electrical Accidents – Action to be taken

1. In the event of an electrical accident or the possibility of an accident, the senior most official present at the site of the accident shall take the following preliminary precautions immediately:
a) If there is a breakdown of the overhead lines, he should arrange to cordon off the area, so that no one else may get injured. He shall also warn Drivers of trains.

b) Arrange to cut off supply to the installation concerned by telephoning to the Traction Power Controller or the nearest Electrical Department official, and simultaneously arrange for an Authorised person to the spot. No one may attempt to rescue an electrocuted person until power supply has been cut off.

b) Send for medical assistance. In the meanwhile, after the injured person, if any, has been separated from the electrified lines, he shall arrange to render first aid; artificial respiration should be started immediately if the patient is not breathing.

2. Immediately on arrival at site, the Authorised Electrical Department Official (Foreman/Chargeman), shall first check and made sure that the steps mentioned have been correctly taken. After attending to the injured and clearing the lines, he shall make a detailed note of all factors relating to the accident, preserve evidence and record the statements of those who were near the accident spot. He shall also carry out a preliminary investigation as to the possible cause of accident and get full particulars of the injury or damage suffered and advise the Sr. Divisional Electrical Engineer of the details in writing.

The treatment laid down for resuscitation after electric shock shall be carried out immediately if applicable. The treatment should be continued for at least two hours or more as there have been cases where patients, although apparently dead, have regained consciousness.

3. All electrical accidents occurring within Railway premises shall be reported to the Electrical Foreman/Chargeman in charge of the area and by him to the Sr. Divisional Electrical Engineer without delay, however slight the injury may be and even though the injured man is capable of performing his duties.

10502 Observance of Rules
All accidents arising out of the use of electricity within the railway premises are required not only to be dealt with under the provisions of the ‘Rules for Reporting Accidents’ of the Zonal Railway but also according to the procedures under the Indian Electricity Act, 1910, section 33 and Rule 44 A of I.E. Rules, 1967.

Section 33 of I.E. Act 1910 reads as under:

1. If any accident occurs in connection with the generation, transmission, supply or use of energy in or in connection with any part of the electric supply lines or other works of any person and the accident results or is likely to have resulted in loss of human or animal life or in any injury to a human being or an animal, such person shall give notice of the occurrence and of any such loss or injury actually caused by the accident, in such form and within such time as may be prescribed, to the Electrical Inspector and to such other authorities as the appropriate Government may be general or special order, direct.

2. The appropriate Government may, if it things fit, require, any Electrical Inspector, or any other competent person appointed by it on his behalf, to inquire and report:

a) as to the cause of any accident affecting the safety of the Public, which may have been occasioned by or in connection with, the generation, transmission, supply or use of energy, or

b) as to the manner in, and extent to, which the provisions of this Act or any license or rules thereunder, so far as those provisions affect the safety or any person, have been complied with.

3. Every Electrical Inspector or other person holding any inquiry under sub-section (2) shall have all the powers of a Civil Court under the Code of Civil Procedure 1908, for the purpose of enforcing the attendance of witnesses and compelling the production of documents and material objects; and every person required by an Electrical Inspector or such other person as aforesaid to furnish any information shall be deemed to be legally bound to do so within the meaning of Section 176 of the Indian Penal Code.
10503 Electrical Inspector to Railway

The Chief Electrical Engineer of each Railway is appointed to function as Electrical Inspector to the Central Government for the Railway vide Railway Board's Notification No. 60/Elec/112/6 dt. 10th June 1961. All matters in regard to the functions of Electrical Inspector shall be referred to him.

10504 Reporting of Accidents

The Electrical Foreman/Chargeman shall send in respect of every electrical accident a notice of the accident in writing to the Electrical Inspector viz., Chief Electrical Engineer, through the Sr.DEE/DEE.

In case where the accident results in or is likely to have resulted in loss of human being or animal, intimation shall be given within 24 hours of the knowledge of the occurrence of the accident by express telegram to be confirmed by a post copy.

The written report of the accident shall be sent in the form set out at Annexure ‘XIII’ of I.E Rules.

All fatal and grievous hurt accidents shall also be immediately reported to the nearest Police Station. District Magistrate or Sub-Divisional Officer in charge of the Civil Jurisdiction and the body (in case of fatal accidents) shall not be moved until the Police Inquiry is completed.

In the case of electrical accident occurring within workshop premises, the Factory Rules and Act will apply. In this instance the “Manager” of the workshop will send the detailed report on the forms prescribed in the Factory Rules to the Factory Inspector, in addition to CEE, CWE, DRM etc.

10505 Accident Inquiries

Every electrical accident shall be inquired into by an officer and a report submitted to the Chief Electrical Engineer (functioning as the Electrical Inspector for the Railways) giving complete information within one week of the accident. The report should in particular cover the following points:-

1. A clear description of the locality and a sketch showing all the relevant details;
2. An analysis of the evidence recorded;
3. Findings as to the exact cause of the accident;
4. Fixing up of responsibility of staff negligence, if any, indicating whether the “Rules for Safe Working on Electrical Equipment” have been followed or not:
5. Recommendations for preventing such accidents in future : and
6. Any special features peculiar to the case.

Until the official inquiry is conducted all material evidence should be preserved by the official in-charge of facilitate the inquiry. Where restoration of supply is likely to obliterate marks on the premises or in any other way destroy evidence which may be of use in an inquiry, the Senior Electrical Official who first arrives at the site should carefully make notes and sketches and preserve the evidence as far as possible, for production at the inquiry.

10506 Accident Registers and Annual Returns.

Every Electrical Official in-charge shall maintain a register showing the particulars in regard to all electrical accidents taking place under his jurisdiction in the proforma below:-

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Brief description of the accident</th>
<th>Date &amp; Time of issue of accident</th>
<th>Date accident report submitted</th>
</tr>
</thead>
</table>

INDIAN RAILWAYS-AC TRACTION MANUAL-VOLUME I [52]
He will also submit by 15th April of each year a statement of accidents during the previous financial year to Sr. DEE, who in turn will submit the statement for the entire division to the CEE for incorporation in the Electrical Inspectors Annual Report to CEA.

10507 First Aid

A box containing first aid equipment shall be kept in each generating station or each sub-station and electrical work depot (except where adequate medical facilities exist for all the 24 hours of the day) close at hand for use when required. A periodical check shall be made of the contents and any deficiencies shall be reported to the Medical Department for replenishment.

RESUSCITATION FROM ELECTRICAL SHOCK

10508 Instructions to be Displayed

Instructions in English and the Regional language regarding the treatment of persons suffering from electric shock shall be exhibited in all inspection sheds, stabling depots, repair shops, stations, sub-stations etc. and it is the duty of every authorised official to make himself thoroughly familiar with such instructions, and to be able to render artificial respiration when necessary. Instructions regarding the methods of rendering artificial respiration have been given in paras 10509 and 10510. Electrical shocks are easily received but are as easily avoided if proper precautions are taken in maintaining and handling electrical equipment.

10509 Removal from Contact

If the person is still in contact with the apparatus that has given him the shock, the rescuer should, if possible, stand on a dry wooden chair while removing the victim. Otherwise pull him free by using a dry coat, dry rope, coconut matting or stick, preferably standing on a rubber mat or any other dry mat handy. Never touch the man's body with bare hands.

Extinguish any sparks if the patient's clothes are smouldering; ascertain if he is breathing and send for a Doctor. If apparently not breathing, proceed as described in para below.

10510 Artificial Respiration

If there are any burns, avoid, if possible, so placing the patient as to bring pressure on the burns. It is preferable to operate as in the Diagrams A & B, Fig. 5.01, with the face downward. If badly burnt in front, turn to the second method shown later.

First Method
First Motion : Observe Diagram A – “Expiration”. Kneel over the patient, rest the hands flat in the small of his back, let your thumbs nearly touch, spread your fingers on each side over his lower ribs as in the first diagram.

Now lean firmly but gently forward over the patient, exerting a steady pressure downwards, still following the first diagram.

Second Motion : Observe Diagram B – “Inspiration”. Rock yourself gently backwards but do not remove your hands.

Merely keep then in position for the next expiration pressure.

Continue these two movements.
The double movement should be gone through about fifteen times per minute. The object is to keep expanding
and contracting the patient's lungs so as to imitate slow breathing. If the operator himself breathes slowly, letting the air out as he presses forward, and drawing it in as he rocks backward, he will naturally arrive at the proper rate, and will understand the reason for the movements.

Do not cease operations until natural breathing is re-established. It may take half an hour or even longer, to produce a desired effect.

Second Method

Should it be expedient to place the patient on his back, first loosen the clothes around the chest and stomach. Then place a rolled-up coat, or other improvised pillow, beneath the shoulders so that the head falls backwards. The tongue should then be drawn forward.

First Motion: The operator must kneel in the position shown by Diagram C. Grasp the patient just below the elbows and draw his arms over his head until horizontal, retaining them there for about two seconds.

Second Motion: Next bring the patient's arms down on each side of its chest and pressing inwards upon his arms so as to compress his chest as in Diagram D. Remain thus for two seconds, and then keep repeating the two motions at the same rate.
The lung-inflating effect in Diagram C is much assisted if the arms be swung outwards as they are lifted.

If more than one person is present, the patient’s tongue should also be drawn out during each outward or lung-inflating stroke (Diagram C) and released during each inward or lung deflating stroke (Diagram D).

In both case, be careful to avoid violent operations, as injury of the internal organs may result from excessive and sudden pressures. After recovery, burns if serious, should be treated with a proper oil dressing. Avoid exposing patient to cold. Administer no restoratives until the Doctor comes. Cold water may be given and smelling salts applied in moderation.

Two methods of treatment for electric shock have been described above. It is the duty of every railway servant to be familiar with these methods of rendering artificial respiration.

10511 Typical Electrical Accidents

Brief particulars of a few electrical accidents which have actually occurred are given below. A study of these particulars will help officers and staff in appreciating the importance of the various safety rules prescribed.

1. A khalasi of the Engineering Department, engaged in construction work, sustained severe burns when handling a long boiler tube under live OHE. The boiler tube accidentally touched the contact wire. This accident could have been prevented if proper supervision had been exercised and the Supervisor in-charge of the work had warned all his staff of the danger of electrocution if the OHE is accidentally contacted by poles, ladders, pipes or tools. Whenever there is even a remote possibility of any person coming within the danger zone of live 25 kV installations at sub-station, Switching stations or if any work has to be done within 2 m of live OHE, the supervisory official in-charge should invariably obtain permit to work after the lines are made dead and earthed before allowing staff to start work.

2. An electric fitter working on a locomotive stabled in a loco shed climbed on to the roof to examine the pantograph which was in the lowered position. The height of the contact wire on the stabling line was 5.5 m and the height from rail level of the pantograph in the lowered position was 3.66 m. The fitter was apparently under the impression that he could conveniently examine the lowered pantograph taking advantage of the clearance of nearly 2m. Unfortunately, while he was examining the lowered pantograph, the other pantograph of the locomotive was inadvertently raised by another employee thus energising the lowered pantograph also. There was also danger of the employee getting a shock if he had inadvertently stood up on the roof in the course of his work. This emphasizes that no one should ever get up on the locomotive roof when the locomotive is under a live OHE. A shut down should invariably be effected before climbing on to the roof of stabled locomotives.

3. Two work parties were required to work at an insulated overlap connected together by an interruptor. Shutdown was effected on both the elementary sections and the interruptor was also opened. One party earthed the OHE on one side of the insulated overlap and the supervisor of this party permitted his men to commence work on the insulated overlap without earthing the other portion of the OHE presuming that the other portion had been earthed by the other work party. This resulted in some of the workmen getting electric shock due to contact with the unearthed wires. This accident emphasizes the importance of the rules that (a) each party should protect itself by independent earths and (b) when work is to be done at an insulated overlap either both portions of OHE should be independently earthed or the electrical continuity between the two portions should be ensured by keeping isolators/interruptors closed.

4. A supervisor took power block for two elementary sections supported on a portal and overlooked the fact that the same portal supported the wires of a siding. Consequently a worker sent to work on the portal structure came into contact with the live OHE of the siding and sustained shock which resulted in his death. This serious accident could have been prevented if the supervisor had made himself thoroughly familiar with the details of OHE supported on the portal and had ensured that all the wires on the portal structure were made dead and earthed before permitting his men to commence work on the portal.
5. An Electrical Chargeman (OHE Maintenance) received a fatal shock when he came into contact with OHE, which had been isolated but not earthed. On completion of work, he removed the earth and went down into the OHE Inspection Car to check up the time. Subsequently, he went up the OHE Inspection Car again and came into contact with OHE, which was not earthed though isolated. A slight drizzle earlier contributed to the severity of the shock as the Chargeman’s feet and the tower wagon platform were wet. Due to parallelism with the live OHE of an adjacent line, there was an appreciable induced voltage in the line, though it was isolated. This emphasizes the need for ensuring that the OHE is earthed in accordance with the rules prescribed before commencing work and during the whole time the work is in progress.

6. An Assistant Driver of a diesel locomotive of a Steel Works doing shunting work in an electrified yard close to the Steel Works received a severe shock when he went up on the roof of the locomotive. The warning notice regarding live OHE was not painted on the locomotive nor was the Assistant Driver properly instructed on the hazards of working in close proximity to live OHE. This emphasizes the need for painting the warning notice not only on the locomotives belonging to the Railway but also of private parties likely to work in electrified railway yards. Operating staff of private parties also should be educated in the safety rules prescribed.

7. A Linesman received a severe shock when working on an isolator. Before commencing the work one earth has been placed on each side of the isolator. However, during the course of the work, the isolator was opened when the Linesman received a shock. The possible cause is that one of the discharge rods was not making proper contact with the result that effect of induced voltage on that portion of the OHE caused the shock. This emphasizes the need for ensuring that when working on an isolator, either the isolator is kept jumpered or not opened at all during the course of the work, in addition to the precaution that an earth should be placed on each side of the isolator.

8) Supply from an auxiliary transformer has failed. An unskilled khalasi was sent by the fitter to check up and renew the high voltage fuses. The khalasi attempted to do this without getting a permit to work, accidentally came into contact with live 25kv wires and was electrocuted. This accident was a direct result of an unauthorized person not holding a certificate of competence being deputed to work on live equipment.

9) An electrical fitter was electrocuted while carrying out repairs to a jumper connection to a transformer. He had isolated the transformer and climbed up the pole to repair the jumper. He had posted a helper near the circuit breaker with instructions that on receiving a signal from him, the helper should close the circuit breaker. The helper saw a person at a distance waving his hands and presuming that the signal is from the fitter, closed the circuit breaker. The accident was the result of adopting short circuit methods rather than the prescribed procedure for effecting shut down and issue of permit to work. Such short circuit methods are not permissible even if the intention is to speed up the work.

The above cases would illustrate that a heavy responsibility rests with officers and senior supervisory officials to prevent possibilities of electrical accidents not only by insisting on strict compliance with rules and procedures laid down for safe working on electrical equipment, but also by giving wide publicity to the need for utmost precautions on the part of everyone when working in electrified sections.
### CHAPTER VI

**FIRE PRECAUTIONS.**

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CHAPTER VI
FIRE PRECAUTIONS

10600 Duties of Electrical Department Staff

1. It is the duty of every railway officer and supervisor to ensure by periodical inspections that installations, offices, shops and rolling-stock under his control are:

a) well protected against risk of fire;

b) well equipped with fire-fighting equipment, and

c) that staff are well trained and fire-fighting appliances are properly maintained to fight the fires, should they develop.

2. The majority of fires are preventable if only those in charge are security minded and make it a point to check the installations under their control from the point of view of fire risk and take necessary precautions. Accumulation of debris and rubbish near offices, workshops and installations should never be permitted even from the point of view of cleanliness -- much more so because it is such accumulations that are responsible for most fires.

3. Points which should be checked during periodical inspections are:

a) Whether the fire fighting appliances are maintained in working condition, and if each installation has the full complement of fire buckets, extinguishers etc.

b) How well staff are trained to fight a fire.

b) Whether close liaison is maintained by the local official with the Fire Fighting Organization and telephone numbers of Fire Station are properly displayed.

c) When the last fire drill was conducted, a fire drill register should be maintained at each installation by subordinate incharge.

10601 Classification of Fires

For all practical purposes the basic types of fires can be grouped into following four classes;

Class A Fires:
Fires involving combustible materials of organic nature, such as wood, paper, rubber and many plastics, etc., where the cooling effect of water is essential for extinction of fires.

Class B Fires:
Fires involving flammable liquids, petroleum products, or the like, where a blanketing effect is essential.

Class C Fires:
Fires involving flammable gases under pressure including liquefied gases, where it is necessary to inhibit the burning
gas at fast rate with an inert gas, powder or vaporizing liquid for extinguishment.

Class D Fires:
Fires involving combustible metals, such as magnesium, aluminium, zinc, sodium, potassium, when the burning metals are reactive to water containing agents, and in certain cases carbon dioxide, halogenated hydrocarbons and ordinary dry powders. These fires require special media and techniques to extinguish.

**10602 Precautions to be Observed**

1. **Class A Fires:**

   Fires of this type can be readily extinguished by water or a solution containing large amount of water due to the cooling and quenching effect of water.

   The following precautions should be taken to prevent Class A Fires:

   a) Glowing cigarette butts and matches shall not be thrown into waste baskets, oil rag bins, or other places of fire hazard.

   b) Smoking and use of open flames shall be prohibited in oil storage rooms, battery rooms and places where combustible material is kept.

   c) High standard of cleanliness shall be maintained. Waste material, oily waste or rags etc. shall be removed from the premises daily and suitably disposed of.

   d) Trees and rank vegetation shall not be permitted to grow in the neighbourhood of sub-stations, switching stations or other buildings. Roofs of buildings and the whole area of the sub-stations and offices shall be kept clear of dry leaves, packing cases or other dry combustible material.

   e) Before starting welding and cutting operations, it shall be ensured that sparks arising therefrom do not lodge in wood-work or ignite other combustible material in the area.

   f) While installing heating device, hot water pipes, etc. suitable clearances from the combustible material shall be maintained.

2. **Class B Fires:**

   For extinguishing these fires some blanketing agent is required such as foam which deprives the fire of its oxygen requirement. If water is used, there is greater danger of the fire spreading.

   The following precautions are required against Class B fires:

   a) Cable trenches inside stations containing cables shall be filled with sand or pebbles or covered with non-inflammable slabs.

   b) Oil-filled containers and equipment in receiving stations, sub-stations, buildings, store rooms, etc. be so located that fire and smoke from oil is not likely to do any damage.

   c) Concrete dykes or floor drains and loose rock-filled pits shall be provided near oil storage rooms and oil filled equipment to prevent spread of spilled oil [(I.E. Rule 64 (2) (e) )].

   d) Empty oil drums, boxes or other combustible material shall never be piled near storage oil tanks and oil-filled equipment.

   e) Petroleum containers shall be labelled and kept securely stoppered.
f) When a vehicle is re-fuelled or petrol transferred from one container to another, no smoking or open flames shall be permitted in the vicinity.

g) Places where paints, varnishes, lacquers, thinners, etc. are stored or used shall be kept scrupulously clean.

3. Fires in Electrical Equipment:

Fires that occur in electrical equipment or in equipment close to electric circuits preclude the use of water spray or foam type extinguishers. Such fires are extinguished by employing some insulating agent like sand, carbon tetra-chloride or carbon dioxide or halon type fire extinguishers.

The following precautions are required against such fires:

a) Electrical equipment shall be installed, operated and maintained properly and in such a manner as to eliminate arcs due to poor contacts in switches and fittings, damaged insulation, crossed wires, opening of switches carrying large currents, etc.

b) Leakage on and/or overloading of circuits with consequent heating up of wiring must be guarded against.

c) Motors shall be equipped with over-current and under-voltage protection to prevent excessive heating.

d) Insulation strength of the equipment and cable shall be checked periodically.

e) Temperature and loading conditions of the equipment shall be recorded and studied.

f) Electric lamps shall not be surrounded by or laid on combustible material.

g) The vicinity of cables should be kept clear of oily dirt or other combustible material.

h) Battery rooms shall have no loose connections and there shall be no sparking devices e.g., bells, buzzers, relays, fuses or switches in the room. Smoking shall be prohibited and rubbish and other combustibles shall not be permitted to accumulate in the battery room.

i) Metal parts of oil tanks, electrical equipment and buildings shall be adequately bonded and earthed to prevent fires by lightning and static electricity. The earth resistance shall be checked periodically.

j) Flammable gases and materials shall not be stored near electrical equipment.

In designing, electrical installations in buildings, Indian Standard 1646 (Code of Practice for Fire Safety of Buildings (General): Electrical Installations and IS 3034: Code of Practice for Fire Safety of Industrial Buildings: Electrical Generating and Distributing Stations) should be followed.

10603 Fire Extinguishers

1. The types of extinguishers mentioned below against each class of fire are generally most suited. Details of suitability as a guide of each type of extinguisher is shown in Table 1. It may, however, be noted that this is only for guidance and does not cover special cases.

a) Class A Fires - Water expelling type extinguishers.

b) Class B Fires - Foam, dry powder, vaporizing liquid, carbon dioxide extinguishers.

c) Class C Fires - Dry powder and carbon dioxide extinguishers.

d) Class D Fire - Extinguishers designed for expelling special dry chemical powder.
Table 1

Suitability of Different Types of Fire Extinguishers for Different Class of Fires

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Types of Extinguishers</th>
<th>Types of Fires</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>1.</td>
<td>Fire extinguisher, soda acid (see IS..934)</td>
<td>S</td>
</tr>
<tr>
<td>2.</td>
<td>Fire extinguisher water type, gas cartridge (see IS:940)</td>
<td>S</td>
</tr>
<tr>
<td>3.</td>
<td>Water type bucket pump (see IS:6234)</td>
<td>S</td>
</tr>
<tr>
<td>4.</td>
<td>Water type stored pressure (see IS:6234)</td>
<td>S</td>
</tr>
<tr>
<td>5.</td>
<td>Fire extinguisher chemical foam (see IS:933)</td>
<td>S</td>
</tr>
<tr>
<td>6.</td>
<td>Fire extinguisher dry powder (see IS: 2171)</td>
<td>NS</td>
</tr>
<tr>
<td>7.</td>
<td>Fire extinguisher carbon dioxide type (see IS:2878)</td>
<td>NS</td>
</tr>
<tr>
<td>8.</td>
<td>Fire extinguisher using Halon gas (see IS: 11108)</td>
<td>S</td>
</tr>
</tbody>
</table>

S - suitable. NS - not suitable. @ - suitable if special dry powder for burning metal is used.

2. Where the energized electrical equipment is involved in a fire, the non-conductivity of the extinguishing media is of utmost importance and only extinguisher expelling dry powder or carbon dioxide (without metal horn) or halon should be used. Once the electrical equipment is de-energized and extinguisher suitable for Class A, B and C Fires may also be used safely.

    Where cleanliness is of importance and contamination of sensitive electrical equipment should not be caused, only carbon dioxide or Halon type fire extinguishers should be used in case of fire in such equipment.

3. At times it may become necessary to use water from a fire hydrant to control a major fire involving electrical equipment or in the vicinity of electrical equipment. In such cases, it must be ensured that the electrical equipment is made dead before using the fire hydrant.

10604 Training of Staff

1. Sr. DEEs concerned should ensure that categories of staff listed below are adequately trained in fire precautions:

   i) Drivers, Motormen, Asst. Drivers, Engine Turners:- They should be fully familiar with the physical location of fire fighting equipment in locos/EMUs and the correct method of operation of the equipment including the precautions to be followed. Guards of trains hauled by electric locos and of EMU trains should be similarly trained by the Operating Department.
ii) All supervisors and skilled artisans of Loco and EMU sheds, OHE depots, PSI & RC sections:- They should be familiar with the physical location of all fire fighting equipment including fire hydrants in their place of work, the correct method of operating the equipment and precautions to be observed, as well as location of and means of summoning of Railway and Municipal Fire Brigades. Immediately after coming on duty the supervisor must daily check the fire fighting equipments.

2. The Security Department of the Division will train the staff in operation of fire fighting equipment on requisition from the Electrical Department. A register should be maintained in each Loco/EMU shed, OHE depot, TF(R)'s office etc. indicating the name of staff who have been so trained. Divisional Fire Inspector be contacted for advice and training in fire fighting.

10605 Technical Investigations of Fires

1. Constant study and investigation of causes of fires are very essential. Every case of fire minor or major, irrespective of the location, whether in power, auxiliary or control circuits, should he investigated very carefully, even though an enquiry in accordance with the Accident Rules may not be called for. The causes as established by the investigation should be analysed by the SR.DEE periodically to identify areas requiring further investigation and to tighten up preventive measures. The Divisional Fire Inspector should always be associated in any fire enquiry.

2. A report on each case of fire should also be furnished to CEE as well as the Divisional Fire Inspector concerned.

10606 Fire Accidents

1. Fires in trains, whether carrying passengers or not, resulting in loss of human life or injury to any person or loss of or damage to railway property to the extent of Rs.500 or over are required to be treated as "accidents" and have to be inquired into in accordance with the "Rules for Reporting and Inquiring into Accidents". Fires in other railway premises resulting in damage to railway property of Rs.500 or over are also to be treated as "accidents". Fire accidents involving loss of human life or injury to persons or damage to railway property estimated to cost Rs. 300,000 or over have also to be reported as soon as possible on telephone to the Railway Board by the Operating (safety) Branch.

2. When electrical installations or electric rolling-stock are involved or when there is possibility that the fire was caused by electrical short circuit or due to defect or malfunctioning of electrical equipment, a representative of the Electrical Department should invariably be a member of the inquiry committee. Rules also require that a representative of the Security Department should be associated with all inquiries into fire accidents.

3. The composition of the inquiry committee and the method of disposal of the report of the inquiry committee will be as laid down in the "Rules for Reporting and Inquiring into Accidents" issued by the Zonal Railway, with which the officers and supervisor should be fully conversant.

10607 Organisation for Fire Fighting

1. On each railway a fire-fighting organisation exists primarily to look after major fires and to render help to the Department in imbibing good fire fighting practices and achievement of high fire fighting efficiency.

2. The administration and control of the Fire Service organisation in the Zonal Railways is under the control of the Chief Security Commissioner of the Railway with an Assistant Security Commissioner (Fire) in direct overall charge of the work in the Headquarters office. ASC (F) is a specialist officer responsible not only for exercising technical supervision over the fire service organisation on the entire railway but also for advising other Departments in regard to fire precautions.

3. The day-to-day control over all Fire Fighting units in the divisions is exercised by the Divisional Security Commissioner of the Division/Security Officer of the Division.
4. The responsibility for providing adequate fire fighting equipment, initially as well as on replacement account, rests with the Departments concerned. The type and scale of fire fighting equipment to be provided in each installation as also on rolling-stock should be decided on the advice of ASC (F).

5. All fire fighting equipment in traction installations, loco sheds etc. excluding the mobile fire engines and trailer pumps, if any, should be borne on the books of the Electrical Department. The mobile fire engines and trailer pumps will be on the books of the Security Department.

6. Repairs and maintenance of the fire fighting equipment will be undertaken by Fire Service Section of Security Department. Detailed local instructions should be issued jointly by the Sr. Divisional Electrical Engineer concerned and the Divisional Security Commissioner fixing the periodicity of inspection of the fire fighting equipment by the Security Department, the procedure for requisitioning the services of the Fire Service personnel for repairs and maintenance of the equipment and similar connected matters.

7. Officers and supervisors in charge of traction installations and rolling-stock will render all necessary assistance to the Security Department in inspection, maintenance and operation of the fire fighting equipment. Although ultimate responsibility for efficient working of fire service organisation is that of the Security Department, the officials of Electrical Department may also organise surprise fire drills in loco and EMU sheds, OHE depots etc. and record the same in Fire drill register.

10608 Maintenance and Inspection of Fire Extinguishers

1. Inspection and testing:

Routine maintenance of all fire extinguishers in respect of mechanical parts, extinguishing media and expelling means should be carried out by properly trained personnel at frequent intervals but at least once in a month to make sure that these are in their proper condition and have not been accidentally discharged or lost pressure or suffered damage. Following procedure should be followed for monthly maintenance, inspection and testing. Divisional Fire Inspector should be approached for this purpose.

a) Clean the exterior of the extinguisher: polish the painted portion with wax polish, the brass parts with metal polish, chromium plated parts with silver polish.

b) Check the nozzle outlet vent holes and the threaded portion of the cap for clogging and check that plunger is in fully extended position and is clean.

c) Check the cap washer, grease the threads of cap plunger rod and wipe clean.

d) Make sure that the extinguisher is in proper condition and is not accidentally discharged. In case of stored pressure extinguisher, pressure gauge is to be checked for correct pressure.

e) Check all mechanical parts thoroughly.

f) All fire buckets should be refilled, some with clean water and others with dry sand and checked daily by the supervisor incharge of the maintenance.

2. Annual Inspection

At least once in a year, inspection and maintenance of extinguisher, including chemical charge inside and expellent should be carried out by trained personnel. Any extinguisher showing corrosion or damage to the body internally or externally should be replaced. Faulty, damaged and corroded parts shall be replaced by correct component. Illegible labels should be replaced.

10609 Code of Practice for Prevention of Fires of EMU Stock

Guide lines for prevention of fires on EMU stock have been laid down in Code of Practice for Preventon of Fires of EMU stock (first revision) issued by RDSO in October 1991.

The Code lays down detailed instructions regarding prevention of fires on the EMU stock which is newly built and also instructions regarding prevention of fires on EMU stock already in service.
## CHAPTER VII

**ENERGY CONSERVATION**

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II. ENERGY CONSERVATION

10700 Monitoring of Energy Conservation

1. The Staff connected with electric traction shall make every effort to avoid wastage in use of electricity through constant vigil.

2. One Senior Administrative Grade Officer of Electrical Department shall be nominated by Chief Electrical Engineer to be incharge of matters pertaining to Energy Conservation. The officer shall:

   - Monitor pattern of consumption of electrical energy on electrified divisions based on the reports from Divisions;
   - Plan for Energy Conservation measures and monitor their implementation;
   - Provide guidance to Divisional Officers;
   - Arrange for training of officers and supervisors;
   - Discharge other related functions.

3. Sr. DEE (TrD) and Sr. DEE (OP) shall hold monthly meetings to analyze energy consumption and maximum demand for the preceding month vis-a-vis earlier months. The figures should have a relation to the traffic moved. In the event of maximum demand and energy consumption being found disproportionately high, a detailed investigation should be made and corrective action, if any, should be advised to concerned departments.

10701 Energy Conservation Measures

While development of better designs and use of energy efficient equipment will bring about reduction in energy consumption, yet on the existing systems the following measures listed below will contribute to conservation of electrical energy in traction. While working to these recommended measures no compromise shall be made with the safe and reliable operation of equipment and train services.

10702 Energy Conservation Measures for Traction Installations

1. Shunt capacitor banks shall be provided at traction sub-stations, where not done, to reduce maximum demand and line losses. Priority should be given to the sub-stations feeding large marshalling yards.

2. Standby traction transformers should be kept de-energized to save on no load losses.

3. Demand monitoring equipment, wherever provided, shall be maintained in the working order.

4. Traction Power Controller should co-ordinate with the Section Controller to avoid simultaneous starts of trains, as far as practicable. Bunching of the train in the event of breakdown has to be avoided to the extent feasible.

5. Wherever standby emergency power supply is also derived from OHE, the associated auxiliary trans-
former should be kept isolated from 25 kV side to avoid no load loss. This, however, shall not be applicable for power supply to signals where changeover has to be immediate.

6. Ensuring of good electrical contact to attain low resistance at conductor joints (splices) and parallel groove (PG) clamps through periodical inspection and maintenance.

7. Connections to buried rail opposite sub-stations for return current are prone to corrosion leading to increased resistance and loss of energy. These connections should be inspected periodically and maintained to obtain good electrical connection.

10703 Energy Conservation Measures for Rolling Stock

1. Drivers/Motormen are expected to be well-conversant with the road to make the best use of down gradients to effect maximum possible saving in energy consumption.

2. In level sections and particularly in suburban sections, coasting should be resorted to as much as possible and brake applied only when essential to control the speed or stop the train. To help Drivers and Motormen "Coasting Boards" are fixed at appropriate points on suburban sections. In some Railways, time totalizers have been provided in EMUs.

3. In the undulating terrain, speed may be allowed to drop down when going up a short up-gradient. After passing over the crest, the train will automatically pickup the speed with power off when going down-hill, so that it attains maximum permissible speed on the section when it arrives at the foot of the next up-gradient. This feature should receive special emphasis during learning the road period.

4. Re-scheduling of booked speed of EMU to help conservation of energy.

10704 Energy Conservation Measures for Maintenance Installations

1. Switch off lights, fans and air conditioners when not required.

2. Keep standby transformers deenergized from HV side.

3. Check idle running of machines.

4. Check leakage and misuse of compressed air.

5. Check leakage and wastage of water.

6. Maximise use of natural day light in service building to reduce need for electric light.

10705 New Developments

1. The traction staff should keep themselves fully abreast of technological developments like 3 phase drive Electric locos being made elsewhere, within the country and abroad, in respect of efficient utilization of electric power in traction applications and try to derive benefits from such developments.

2. Electric locomotives simulator: Training of Drivers on simulator can help drivers in running of trains with optimum consumption of energy.

## CHAPTER VIII

### TRACTION STORES AND THEIR ACCOUNTAL

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CHAPTER VIII

TRACTION STORES AND THEIR ACCOUNTAL

10800 Introduction

The Indian Railway Code for the Stores Department (hereinafter referred to as the Code) contains instructions for the purchase, receipt, custody, issue, accountal and disposal of stores of all kinds. Officers and staff of the Electrical Department should make themselves familiar with the relevant portions of the Code, which have a direct bearing on their day-to-day work. Instructions in this Chapter are supplementary to the provision of the Code.

10801 Standardization of Stores

1. All items for which the demand is recurring and in sizable quantities should be standardized and arranged to be stocked in the concerned Stores Depots.

2. The work of standardization and issue of stocking advice to the Stores Branch should be dealt with by a separate section in CEE's Office. When a new item is required to be standardized, the Sr.DEE concerned should send a preliminary proposal to CEE giving the description of the item, available details of specifications and drawings, where item is proposed to be used, estimated annual consumption, basis of the estimated consumption, likely sources of supply and other relevant details. The proposal will be carefully scrutinized in CEE's office and if standardization is considered justified, a complete proposal, as prescribed by the Stores Department will be forwarded to COS, who will arrange to include the item in the 'Standard Nomenclature List of Stores under advice to the Stocking Depots and the Sr.DEEs concerned.

3. Standard drawings and specifications for some items to be used by more than one Zonal Railway are also issued by RDSO. Items required exclusively by a Railway will be covered by drawings and specifications issued by CEE. Sr.DEEs may issue local specifications and drawings for items required to be purchased once or only occasionally.

10802 Stock Items and Special Requisitions

1. Items having a recurring consumption should as a rule be only obtained through the Store Depots. Procurement of stores against requisition for direct delivery by the trade to the consuming units should be avoided except in the following cases:-

   a) Items which have a very low annual consumption and hence cannot be included as stock items and at the same time do not fall within the definition of 'Emergency' stores e.g., bearings of particular sizes only a small number of which may be required per annum.

   b) Stores required for special works, modifications or programmed replacement of parts,

   c) Items, although stocked by the depot, which have a non-recurring demand for a specified purpose and cannot be met from the stocks held for normal consumption e.g., cables required for special rewiring of locos and EMUs.

   d) 'Break-down Stores' such as OHE conductors and other stores to be held by OHE depots to meet unforeseen contingencies such as thefts and accident.
Non-standard items and other items required regularly but not stocked by stores Depots, pending standardization.

2. Quantities to be obtained against requisitions for (b) and (c) above should be on the basis of approved estimates for each item for the specified purpose. Quantities against (a), (d) and (e) should be generally equal to the anticipated consumption for one year or for such longer period as convenient for procurement, fixed in consultation with the Stores Department, taking into account the normal delivery period for the anticipated consumption during the period required for receipt of fresh stocks according to normal delivery anticipated for each item plus a buffer stock to cover 6 months requirements. On the basis of experience it should be possible to fix this minimum level quantitatively for each item.

3. Requisitions for non-stock stores and special requisitions for stock items as above are required to be scrutinized personally in regard to specification and quantity and signed by Technical Officers of appropriate rank. Officers/Supervisors initiating such requisitions should enclose a brief note for the information of the officer empowered to sign the requisition, bringing out the need for the procurement and explaining how the quantity has been arrived at.

**10803 Emergency Stores**

1. 'Emergency Stores' comprise items of stores which do not ordinarily wear out or require renewal, which have, however, to be kept in stock to meet emergencies, such as that due to breakage or unanticipated deterioration, and which are not readily obtainable. The stock cards relating to such stores should be marked with the letter 'E'.

2. When an item is to be stocked as 'Emergency Stores', the Sr. DEE concerned should, in consultation with DCOS/ACOS in-charge of the depot, obtain CEEs personal sanction giving adequate justification.

3. The list of 'Emergency' items should be reviewed annually by the Sr. DEE and the Depot Officers concerned. It may be possible to transfer some of the items to ordinary stock and to dispose off items no longer required on account of obsolescence.

**10804 Imprest Stores**

Stores with a regular recurring consumption required by OHE depots, PSI depots, etc. and for outstation maintenance of rolling-stock should be arranged against 'charged off' imprests. The procedure as detailed in the Stores Code should be followed in regard to sanction, recoupment and accountal of such stores.

**10805 Proprietary Articles**

1. Proprietary articles are required to be purchased from the specified firm on single tender basis. Only when acceptable alternatives cannot be used a 'Proprietary Article Certificate' be issued. The officer signing a Proprietary article certificate should satisfy himself on this point.

2. A proprietary Article Certificate in the prescribed form should be issued only by technical officers of appropriate rank. The name and designation of the officer signing the certificate should be clearly indicated in the certificate.

3. While the greatest care should be exercised before issuing a Proprietary Article Certificate, when the Department officer is personally satisfied that the item of the required quality can only be obtained from the original manufacturer, there should be no hesitancy in issuing the Proprietary Article Certificate.

**10806 Estimates for Stock Items**

1. The procedure to be followed by stores depots in compiling annual estimates for stock items is given in Chapter VI of the Stores Code. In regard to traction items, the quantity should be vetted and countersigned by Sr.DEEs concerned before submission of the estimate sheets by the Depots to COS.
since the Stores Department has to follow a rigid time table for preparation and submission of the estimate sheets, Sr.DEEs should have suitable machinery for expeditious scrutiny and return of the estimate sheets when received.

2. In scrutinizing the estimate sheets Sr.DEEs may, if necessary, suggest modification of the quantities arrived at by the depot giving specific reasons. These suggestions should be considered by the Stores Department before finalizing the Estimate Sheets.

3. Another important check to be made by Sr.DEEs when scrutinizing the Estimate Sheets is to see whether all the items included will actually be used. If there are many items which have become obsolete, they should be discontinued.

**10807 Items with Protracted Delivery**

1. The minimum limit should be a quantity of stock representing an average weekly issue multiplied by the number of weeks, which from past experience, it is known will lapse from the date of placing an order before fresh stocks can arrive at the depot.

2. In fixing the minimum stock for traction items, the protracted delivery periods for imported items and items for which the approved sources are limited, should be invariably taken into account and an adequate buffer stock also fixed to ensure that the items do not go out of stock due to delayed supply or other reasons.

**10808 Local Purchase by DRM**

1. The power of local purchase delegated to DRM should be made use of by Sr. DEEs to the minimum extent necessary to meet urgent requirements of stores only. Detailed local instructions should also be laid down to regulate the scrutiny of demands for local purchases as well as accountal of stores purchased in this manner.

2. Stores Code lays down the powers of DRM for local purchase of stores. DRMs are also empowered to re-delegate these powers to lower authorities.

**10809 Specifications**

Procurement of stores should be arranged against standard specifications wherever possible. Local specifications when framed should be clear and precise in regard to requirements, tests etc. It must be remembered that a vague specification may result in incorrect supply. It may also attract offers which do not meet the Railway's requirements, but at the same time are difficult to be ignored, necessitating cancellation of tenders and re-tendering, which result in infructuous expenditure, apart from delay in procurement.

**1 0810 Preparation of Indents**

When indents are prepared, the essential points to be borne in mind are listed below

a) The description should be complete and written out clearly. Figures in the description (e.g., kW rating) should be spelt out also in words. If the space in the standard form is not sufficient to write out the description in full, it should be given in a separate attached sheet, preferably typed.

b) When mention is made of a local drawing or specification, requisite number of copies should be attached, taking care that these are with the latest amendments.

c) The quantity should be invariably given in words and figures in the respective columns.

d) The designation and full postal address of the consignee and the controlling officer should be given to facilitate correct dispatch of Railway Receipt and other documents.

e) When a non-standard item is asked for, particulars of the last supply, if any, should be given to enable the Store Department to locate likely suppliers.

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f) When the requisition is for a proprietary article, the ordering reference as given by the Manufacturer should be quoted and carefully tallied and a Proprietary Article Certificate in the prescribed form should be attached, duly signed and countersigned by the Competent Authority.

g) The rate should be either on the basis of last purchase rate suitably adjusted for price variations or on the basis of actual market quotations or a reasonable estimate. It will be helpful if the basis on which the rate is quoted is mentioned on the indent itself or in the covering letter.

h) The chargeable head of account should be correctly indicated.

i) Any corrections should be initialed by the officer signing the requisition.

10811 Imported Stores.

1. All demand for stores involving imports should be meticulously scrutinized by the indenting officer to ensure that the requirement is for minimum quantity possible.

The procedure involved in import is summarized below: -

i) On receipt of tenders, if import is found necessary, the stores Department will prepare a 'Foreign Exchange Proposal' in the prescribed form. The possibility of obtaining an alternative available from indigenous sources, if any, will be carefully considered by a Committee of officers before import is considered. A higher price, up to certain limits is also admissible for indigenous stores.

The foreign exchange proposal will be personally countersigned by the Head of the user Department, after satisfying himself that import is inescapable and also that the quantity asked for cannot be reduced. The proposal accompanied by its justification is then vetted by the Accounts Department and then forwarded to the Railway Board.

ii) In every case the requisite foreign exchange requires sanction by the Railway Board, either against allotment made periodically by the Ministry of Finance or after getting special clearance from that Ministry, where large amounts of foreign exchange is released, clearance is also required from the Directorate General of Technical Development.

iii) On receipt of sanction for the foreign exchange, the Stores Department will issue a Purchase Order to the firm concerned, the delivery period stipulated counting from the date of issue of import license.

(An import license where the quantity imported is meant solely for use of the organisation sponsoring the issue of license is called an 'Actual User's license'. Sometimes, firms offer stores imported against block licenses in their own possession in which case the Railway does not have to assist them in obtaining an Actual User License).

iv) On receipt of the Purchase order, the firm will submit an application for import license in the prescribed form quoting reference to the Purchase Order, which will be scrutinized and forwarded by the Stores Department to the Chief Controller of imports, New Delhi, through the Railway Liaison Office, New Delhi. When an import license is issued, the purchasing authority is also advised.

Import License is valid for a stipulated period. If the item is not imported within that period, the license requires re-validation by the issuing authority.

2. Because of the involved procedures as above, all requirements for imported stores should be foreseen well in advance and indents placed in time. A time lag of two years or more is not unusual between the placing of indent and actual receipt of the stores.

3. A register should be maintained in the CEE's office listing out every approved case for imported equipment. This register should be scrutinized every month by a nominated officer, to keep track of the progress and to take prompt steps if there is any hold-up.
4. Defective Imported Equipment: Sometimes imported equipment are found on receipt to be defective, having suffered damage during transit before the equipment are cleared from the port. Such defects/damages should be noted and a certificate obtained from the port authorities. Such defects/damages are usually covered by Insurance and replacements will have to be obtained.

Occasionally some imported equipment are found to have inherent manufacturing or other defects, after they are put into service. If they are covered by guarantee, the railways are entitled to obtain free replacements. The Contractor of firm concerned will then have to obtain another import license duly supported by a certificate issued by the Railway to import the replacement. Where the defective part has to be returned, an export/import license will have to be obtained by the firm.

5. With changes in Govt. policy regarding import, certain changes in procedure are being progressively introduced. Indenting officials should make themselves familiar with such changes.

10812 Follow UP

1. When issuing reminders to the Stores Department regarding supplies due against requisitions placed, care should be taken to give complete references such as description and quantity of item, indent number and date, forwarding letter number and date etc. Each reminder should be self-contained in regard to these details.

2. In the case of stores to be received directly against purchase orders, consignees should arrange to notify the Controlling Officer, COS/DCOS/DGS & D who has placed the purchase order and the firm on whom the order has been placed, if supply or dispatch advice is not received by the due date. Prompt advice of failure of supply to materialize by the stipulated date will enable the Purchasing officer to take up the matter with the supplier and arrange alternative procurement, if required.

10813 Check on Bills

Detailed instructions issued by the Stores Department are available in regard to the procedure to be followed for checking and passing of supplier's bill. The 'original' bill is sent to the consignee and the 'duplicate' to the controlling officer. The original bill checked and signed by the consignee is sent to the controlling officer for countersignature and onward transmission to the supplier under advice to the bill passing Accounts Office. A few illustrative points in regard to technical and other checks to be exercised by consignees and controlling officers are explained below for guidance. These are supplementary to the procedural instructions of the Stores Department referred to above: -

1. Sometimes Purchase Order are placed FOR destination station. Freight then is required to be borne by the suppliers and the accepted rate is inclusive of this. In some other cases Purchase Orders specify dispatch of the stores FOR dispatching station, when freight is to be borne by the consignee. Only in the latter case should the consignee ordinarily give a credit note to cover the freight charges. In the case of the first type of Purchase Order i.e., FOR destination, if erroneously the stores are booked by the supplier 'freight to-pay', the freight, for which a credit note is given by the consignee, is recoverable from the bill and the controlling officer should be advised accordingly.

To avoid errors of this type, it is advisable for consignees to maintain separate registers, preferably in different colors, to register purchase orders of the two types. It should also be remembered that loss suffered by the railway due to such errors is recoverable from the supervisor responsible.

2. Inspection of the equipments supplied should be carried out carefully in accordance with the specifications and drawing mentioned in the Purchase Order. Metallurgical tests should invariably be arranged through the Chemist and Metallurgist of the Railway when required, particularly for OH E fittings, alloy steel components for rolling-stock etc., where strict adherence to the specified material is very important. Test certificates produced by the suppliers are of doubtful reliability, unless they are from recognized laboratories.

2. Quantity check should be carried out carefully, number, weights and lengths stated by the suppliers on packages should be checked at random and based on these checks, if required, 100 per cent checks should be carried out. Where Railway samples have been made available to the manufacturer these should be taken back and accounted for.
4. The quantities accepted are required to be entered forthwith in ledgers and the details of entries shown on the bills before they are certified. Controlling Officers should test-check these entries frequently.

5. Where the supply has been received after, the due date stipulated in the order, sanction of the Competent Authority should be obtained before the supply is accepted.

3. In the event of rejection, a letter should be addressed to the firm forthwith detailing the reasons and duly countersigned by the controlling officers. Rejected supplies when dispatched by rail to the supplier, should be invariably sent ‘freight to pay’. Rejected supplies not removed by local suppliers from the consignees premises within the stipulated time are liable to levy of storage charges as laid down by local instructions.

7. Occasionally suppliers allow a small rebate if their bills are passed within a specified period. This condition is incorporated in the order itself at the time of analyzing the order or it may be indicated by the Supplier when submitting his bill. Such bills specially watched and passed in time, both by the consignee and the controlling officer, to take advantage of the rebate admissible. It should, however, be noted that tests required to prove the quality of the supply should not be waived merely to pass the bill by the stipulated date.

8. Occasionally, orders are placed on ‘time preference’ basis i.e., a lower quotation is passed over and higher quotation accepted to take advantage of the earlier delivery offered by the latter. In such cases delivery of supplies after the stipulated date will automatically involve certain penalties on the supplier. Acceptance of delayed supplies against time preference orders should be in accordance with instructions on the subject issued by the Stores Department.

10814 Break-Down Stores

1. The breakdown stores should be kept earmarked for use in breakdowns and should not ordinarily be diverted for normal maintenance work or against sanctioned works. Such diversion may be resorted to only in exceptional circumstances and with the prior written approval of competent authority.

2. As soon as the authorized minimum limit for any particular item has been reached, stock should be recouped by placing requisitions and by effectively chasing supplies.

3. The maximum and minimum limits should be reviewed periodically by Sr. DEE and revised as required based on experience.

108 15 Stores for Works

Officers and Supervisor in-charge of maintenance have to often execute sanctioned minor works such as electrification of additional sidings new cross-overs etc. The basic rules to be followed in regard to procurement and accountal of stores for such works are as under-

1. For each work a detailed estimate is required to be sanctioned by the competent authority before any procurement of stores for the execution of the work is initiated. The stores indented for the works should only be in accordance with the sanctioned detailed estimates. Even though detailed estimates for certain new minor works are not required a rough estimate should be prepared and got approved by Sr. DEE, incorporating therein a list of stores required for the purpose. When placing indents, availability of funds against the sanctioned budget should be invariably certified by the works accountant for receipt and issue of stores.

2. A tally book should be maintained separately for each sanctioned work to account for receipt and issue of stores.

3. Maintenance stores should not ordinarily be drawn for use against works. Transfer of stores to and from a sanctioned work should invariably be authorized by competent authority and covered by adjustment memo.
5. On physical completion of a work surplus stores received against the work and stores released, if any, on execution of the work, should be disposed off in the manner authorized by SR.DEE.

10816 Liaison with Stores Department

1. Officers and nominated supervisors at the Divisional and Shed/Workshop level should be in touch with the stores depots in regard to the supply position of stores required by them. By scrutiny of the depots in cards it should be possible to anticipate if any critical situation is likely to develop due to non-availability of any particular item and to initiate timely measures for Purchasing up supplies.

2. A meeting should be held periodically at agreed intervals between stores officers and traction officers at the Divisional/Workshop level. Apart from general review of the stores position, a detailed review of vital items should be carried out so as to foresee in time difficulties likely due to short-supply of any item and to decide on measures to be taken to forestall such difficulties. Matters requiring decision of Executive officers such as review of annual requirements of particular items, clarifications regarding specification etc. are best discussed and settled, at such meetings rather than by correspondence.

Minutes of such meetings should clearly bring out items on which action is required to be taken by the Divisional/Workshop electrical officers, Stores Depot Officers and headquarters officers. Meetings should also be held at agreed intervals at headquarters level between officers of the stores and Electrical Departments, to review the position and to settle matters requiring decisions at headquarters level. The minutes of meeting held at Divisional/Workshop level should generally be the basis of discussions at the meetings in the Headquarters office.

3. During their visits to Stores Depots, electrical officers should particularly check the manner in which electrical stores are stored/stacked and guide the Depot officials for safe storage. Particular attention should be paid to shelf stacked items such as varnishes, resins and other explosive/inflammable materials.

10817 Custody and Accountal of Charged-Off Stores

1. In loco and EMU sheds the receipt, custody and issue of charged-off stores mentioned should be under the supervision of the DCOS/ACOS attached to the shed. An experienced supervisor of the Electrical Department may be posted to work under the day-to-day control of the DCOS/ACOS to look after this work and to assist him in technical matters as required.

2. In OHE depots, PSI depots and outstation rolling-stock maintenance depots, such custody and accountal will be the responsibility of the supervisors in charge of the depots. Delivery of such stores from the trade to the depots should be routed through the nearest stores depot, except in special circumstances.

10818 Inspection of Stores

1. The responsibility for inspection of stores and the procedure for inspection have been defined in paras 757 and 761 of the stores code reproduced below:-

'757. Inspection: All stores purchased direct by the Controller of Stores should ordinarily be inspected by an Inspecting Officer of the Railway. When however, the Controller of Stores, places an order for stores with instructions to dispatch the materials directly to an Indenter, the Indenter is responsible for the inspection and for arranging for suitable tests to be carried out where he considers these necessary.

'761. Procedure of Inspection: Stores should be checked with the standard specification or drawing on which the order is based. In the rare cases where orders have been made to a sample, a standard sealed sample shall be held by the Inspecting Officer and Stores accepted only if they are up to the standard sample'.

2. Sr. DEE should assist Stores Depots in regard to technical inspection of stores received by the depots. Such inspections should not be merely left to subordinates. Sr.DEE/DEE should carry out surprise checks as often as possible to make sure that accepted items do comply with the specifications and items rejected are for sufficiently valid reasons. All inspection reports should be sent to the Stores Depots countersigned by an officer.
10819 Inventories of Dead Stock
Inventories of Dead Stock (i.e., Tools and plant Registers) should be maintained in accordance with the rules contained in the Stores Code.

10820 Safe Custody of Stores
During periodical inspection, officers and supervisors should critically review the adequacy of security precautions against possibility of pilferage, loss; damage or misuse of stores held by themselves or their subordinates and take preventive action as necessary.

For each establishment, clear standing instructions should be available defining the procedure to be followed and fixing the responsibility for-

a) Locking and sealing of stores,

b) Custody of keys and

c) Opening the stores in the event of any emergency arising during non-working hours and on holidays.

Officers should, during their inspections, make it a point to check that the prescribed procedure is in fact being followed.

10821 Accountal and Disposal of Scrap, Emptys etc.
Care should be exercised in the accountal and disposal of scrap, unserviceable stores and empties. This applies particularly to non-ferrous scrap such as copper conductors and non-ferrous fittings, which being costly are liable to be pilfered. In view of this the Sr,DEE/DEE should as soon as possible after renewals make regular checks to ascertain whether the quantities brought on the books are commensurate with quantities expected to be released. Such scrap should be disposed on in the manner laid down in the Stores Code. Similarly empties such as oil drums, cable drums, packing cases etc. should be accounted for and disposed of in the manner laid down in the Code.

10822 Condemnation Certificates
The general rule governing the condemnation of assets is contained in para 716 of the General Code, Volmel which is reproduced below:

‘Scrapping, condemning and abandoning assets: An asset may be scrapped, condemned or abandoned without replacement, when the service rendered by it is no longer required. If the service rendered by it is still necessary and if it is proposed to make other arrangements for such service, it should be definitely established that it is more economical to scrap condemn or abandon the existing asset and obtain the required service from the new arrangement than to continue to obtain the required service from the existing asset. Here also the relative economy of the two proposals should be assessed on the basis of the average annual cost of service or the cost per unit of service as the case may be’.

When important components used in traction installations or rolling-stock such as traction motors, rectifier assemblies, auxiliary machines, circuit breakers, control panels, section insulators, machinery, testing instruments etc., are to be condemned, the SR,DEE should personally inspect the item and satisfy himself that it is beyond economic repairs. A Condemnation Certificate detailing the reasons for condemnation should be issued to the subordinate supervisor authorizing him to return the item to the Store Department as unserviceable. In the ‘Advice of Return Stores’ the reference to the condemnation certificate issued should invariably be quoted.

2. In the case of electric locomotives and EMU coaches which have completed their normal life, condemnation has to be sanctioned by CEE and CME following the procedure prescribed for the purpose and obtaining FA
CAO's concurrence. Similarly CEE and CME can sanction with Finance concurrence the condemnation of over-aged electric locomotives and EMU coaches which have not completed their normal life. It requires sanction of the Railway Board based on the joint recommendation of CEE and CME and concurrence of FA & CAO.

10823 New for Old
In accordance with para 1839- certain items can be obtained from the Stores Department only in exchange for corresponding old items. A list of items which should be obtained only by exchange in this manner is also given in the Stores Code. It is important that in regard to such items the procedure laid down is strictly followed.

10824 Verification of Stock
Instructions for verification of stock by stock verifiers of the Accounts Department are contained in the Code.

2. Each stockholder should verify his stocks once in six months. He may do so by verifying certain items every month provided the whole stock is verified in the course of six months prior to April and October every year. The date of verification should be entered in the relevant page of the tally book/tally card along with the signature and designation of the official. Excesses and shortages discovered during the verification should be dealt with as laid down in the Code.

3. Officers should carry out test verification of stock with Stock Holder under them to cover important items the charged-off and surplus stocks and items in which deterioration is liable to occur, such as insulating varnishes and lubricants with limited shelf-life. The test verification should not be confined to new items only, but should also include second-hand stores and scrap returned to stock and released from works.

During the test verification the officer should initial tally books and ensure that -

A) The materials and tools are borne against proper classifications;
b) Surplus stores for which no immediate use can be found are referred to SR.DEE for orders regarding disposal;
c) Unserviceable items that have scrap value are returned to the Stores Department;
d) Unserviceable items that have no scrap value are written off with Sr.DEEs approval and a certificate recorded to this effect;
e) Repairable or reconditionable items are sent to workshops with work orders;
f) Contents of tools and materials in Break-down Train, Wiring Train, Tower Wagon, OHE Depot etc. are in ready-for-use condition and to the approved scales;
g) The issues shown are commensurate with requirements. Heavy issues soon after receipts should be particularly scrutinized carefully.

4. DEE/AEEs should carry out such test verification of stores of all their subordinates atleast once in 6 months and Sr. DEEs once per annum.

5. Verification of balances are made periodically by stock verifiers of the Accounts Department to whom every assistance should be afforded. The stock verification sheets should be signed jointly by the Stock Holder and the Stock Verifier.

Discrepancies should be explained, but no adjustments should be made until orders have been received from SR.DEE. The necessary receipts and issues should then be shown in the ledgers and returns with remarks and references to the order of SR.DEE.

10825 Computerized Stores Accounting

With computerization of stores accountal, certain changes in procedures are being progressively introduced with which indenting officials should make themselves familiar.
CHAPTER IX

QUALITY ASSURANCE & RELIABILITY ENGINEERING

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**Annexure 9.1 - Note on Quality Management**

**Annexure 9.2 - Note on Reliability Engineering.**
CHAPTER IX

QUALITY ASSURANCE & RELIABILITY ENGINEERING

10900 General

It shall be endeavour of every official to take steps towards quality in their set-up to improve productivity. Quality Assurance involves effects towards quality improvement, quality development and quality maintenance to meet service requirements at economical levels. This would require enhancing quality of products, services and activities.

10901 Definition of Quality

Use of quality spares for maintaining traction assets plays a vital role in their reliable operation. Quality of a product/equipment is defined as compliance with the following:

a) The specifications as established by the purchaser and accepted by the supplier;

b) The design details as declared by the supplier and accepted by the purchaser; and

c) Sound engineering practice though not specifically defined either in the specifications or in the designs.

A note on scope of quality assurance, quality aspects in manufacturing, system of acceptance sampling, quality, indices for acceptance is given in the Annexure - 9.1 for reference.

10902 Purchase of Spares

The following guide-lines have been laid down for purchase of quality spares: (ref. Board's letters nos. 73/RS(G)/30/RLL dt. 30.3.87 & 17.2.89).

The various components, sub-assemblies and spare parts shall be purchased from original/approved suppliers. Railways will however make out a compendium of RDSO approved manufacturer's list. Any variation from the same shall only be permitted personally by the Chief Electrical Engineer.

10903 Application of Reliability Engineering

To improve quality of service and improve availability of equipment for operations, application of concept of reliability engineering is also being considered as one of the scientific approaches in use. A note on Reliability Engineering is enclosed as Annexure-9.2 for reference.

10904 Employees Participation

Participation of employees in Quality Circles and quality improvement is essential for Quality Management of services. It is to be remembered that Quality involves every one in the organisation, management, workers towards improving performance at every level to build an organisational culture where the quality improvement are embedded into the work and the activities.
NOTE ON QUALITY MANAGEMENT

1. Scope of Quality Assurance

1) Quality Assurance consists of the measures taken to ensure that three conditions listed below are fulfilled.

a) The specifications as established by the purchaser and accepted by the supplier;

b) The design details as declared by the supplier and accepted by the purchaser; and

c) Sound engineering practice though not specifically defined either in the specifications or in the designs.

2. The main aim or objective of Quality Assurance is to prevent any defect from appearing or developing in the work done and not merely to detect and reject defective work.

3. While occasional rejection requiring rework or replacement is not ruled out, the objective is to take every possible step to eliminate the basic or root causes of defects.

4. It is also the purpose of Quality Assurance to maintain records in such detail and manner as to facilitate investigations into problems or failures that may arise during the life time of the work done.

2. Quality Aspects in Manufacturing

The specific quality aspect in manufacturing includes:

1. Choice of machines, processes and tools capable of maintaining the tolerances.

2. Choice of instrument of an accuracy adequate to control the processes.

3. Planning the flow of manufacturing information and criteria.

4. Planning of process quality controls.

5. Selection and training of production personnel.

6. Planning the quality aspects of purchasing and shipping.

3. Planning Through Trial Lots

The trial lot is used to "clear the track" for full scale production by:

1. Proving that the tools and processes can indeed turn the product out successfully.

2. Proving, on test, that the product will process the essential functional features.

3. Proving, on use, that the product will achieve the desired field performance.

4. Remedying the deficiencies in manufacturing process of product before embarking on full scale production.

These proofs and remedies cannot be provided from the record of samples made in the pilot plant. In the pilot plant the basic purpose is to prove engineering feasibility, in the production shop the purpose is to meet standard of quality, cost and delivery. The pilot plant machinery, tools, personnel, supervisions, motivation, etc. are all different from the corresponding situation in the production shop.
4. Acceptance Sampling

1. Introduction

1.1 Acceptance Sampling is the process by which decisions are taken either to accept or to reject an entire ‘Lot’ of products offered for inspection, on the basis of detailed 100 percent inspection of one or more samples drawn at random from the lot.

1.2 The number of items to be drawn from each sample, the number of samples to be drawn from the lot and the number of permissible detectives in each sample, constitute what is known as the Sampling Plan.

1.3 Acceptance Sampling is based on the mathematics of Probability and Statistics. Sampling plans are generally selected from published tables to suit the expected quality levels.

1.4 The following Indian Standards must be studied by all Engineers concerned with Inspection and Quality Control.
   a) IS 397 - Methods of Statistical Quality Control During Production
   b) IS 1548 - Manual on Basic Principles of Lot Sampling
   c) IS 2500 - Sampling Inspection tables
      Part I - Inspection by Attributes and by Count of Defects.
      Part II - Inspection by Variables for Percent Defective.
   d) IS 5002 - Methods for Determination of Sample Size to Estimate the Average Quality of a Lot or Process.

2. Quality Indices for Acceptance Sampling

2.1 Acceptable Quality Level (AQL):

This is usually defined as the worst quality level that is still considered satisfactory. The units of quality level can be selected to meet the particular needs of a product. Thus, "MIL-STD-105 D" defines AQL as "the maximum percent defective (or the maximum number of defects per hundred units) that, for purposes of sampling inspection, can be considered satisfactory as a process average." If a unit of product can have a number of different defects of varying seriousness, then demerits can be assigned to each type of defect and product quality measured in terms of demerits. As an AQL is an acceptable level, the probability of acceptance for an AQL lot should be high (see Figure 9.01)

2.2 Rejectable Quality Level (RQL):

This is a definition of unsatisfactory quality. Different titles are sometimes used to denote an RQL for example, in the Dodge-Romig plans, the term "Lot tolerance percent defective (LTPD)" is used. As an RQL is an unacceptable level, the probability of acceptance for an RQL lot should below (see Figure 9.01). In some tables, this probability is known as the consumer's risk designated as P_c and has been standardized at 0.1 .

The consumer's risk is not the probability that the consumer will actually receive product at the RQL. The consumer will in fact not receive 1 lot in 10 at RQL fraction defective. What the consumer actually gets depends on actual quality in the lots before inspection, and on the probability of acceptance.
2.3 *Indifference Quality Level (SQL):*

This is a quality level somewhere between the AQL and RQL. It is frequently defined as the quality level having a probability of acceptance of 0.50 for a given sampling plan (see Figure 9.01).

![Quality Indices for Sampling Plans](image)

2.4 *Average Outgoing Quality Limit*

A relationship exists between the fraction of defectives in the material before inspection (incoming quality \( p \)) and the fraction of defectives remaining after inspection (outgoing quality AOQ) : \( \text{AOQ} = p \cdot p \). Obviously, when incoming quality is perfect, outgoing quality must likewise be perfect. However when incoming quality is very bad, outgoing quality will still be perfect because the sampling plan will cause all lots to be rejected and detailed inspected. Thus at either extreme incoming quality very good or very bad the outgoing quality will tend to be very good. Between these extremes is the point at which the percent of defectives in the outgoing material will reach its maximum. This point is known as the average outgoing quality limit (AOQL).

3. **Sampling Plans**

3.1 Normally, Sampling Plans have to be specified clearly by the purchaser because it is essential to have agreement on this issue between the Purchaser and the Supplier. When so specified, the sampling plans should be followed scrupulously by the Inspector.

3.2 When the specification does not include Acceptance by Sampling and if the Inspector considers that 100 percent inspection is neither practicable nor necessary, a reference should be made to the purchaser.

3.3 Different Sampling plans may be adopted for different properties or parameters of the items to be inspected. More important properties may be checked on sample of larger size.
3.4 Where the items being inspected are being produced by fully automatic machines the sample size specified may be smaller than in the case of manually produced items. It is desirable in such cases and also in general when lots of identical items are inspected repeatedly, to carry out the inspection in the same sequence as manufacture. Control charts should also be maintained to enable timely detection of dimensions going beyond permissible limits. Whenever the machine is reset or retooled, 100 percent inspection should be carried out by the manufacturer's Inspection organisation until consistently good results are obtained.

4. Random Sampling

The conclusions drawn, relating to the quality of a whole lot on the basis of a 100 percent check on a sample, can be relied upon only if the sample is sufficiently large and the sample is selected in a totally unbiased or random manner. Above all, the selection should not be influenced in any manner by the Supplier's suggestions or actions. The quality of acceptability of an item should not determine the choice of items for the sample. Even the inspector himself should try to avoid any inadvertent or unintended bias in the selection of the sample. This can be ensured by using a table of random numbers.

5. Sample Size

5.1 One item drawn from a lot of any size cannot be relied upon to give any idea of the quality of the lot except in the case of fluids or fluid-like fine powders which have been thoroughly mixed together. In these exceptional cases a small quantity-apparently a single sample-will give a reliable measure of the whole lot.

5.2 The Sample size, i.e. the number of items included in the sample, is very important. It increases with increasing lot size but not in the same proportion. For example, for an AQL of 0.65 :-

<table>
<thead>
<tr>
<th>Lot Size</th>
<th>Sample Size</th>
<th>Sample Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>1000</td>
<td>125</td>
<td>12.5</td>
</tr>
<tr>
<td>3000</td>
<td>200</td>
<td>6.7</td>
</tr>
</tbody>
</table>

6. Limitations of Acceptance Sampling

6.1 The limitations of Acceptance Sampling are as follows:

a) Acceptance Sampling involves some uncertainty or risk. For instance, it is not possible to say with certainty whether any individual item taken from a lot which has been accepted by Sampling, is good or bad. Therefore, Acceptance Sampling should not be adopted where defects are not acceptable in even one item as, for example, in Safety Items.

b) It is possible to estimate the percentage of good or bad items in a lot accepted by sampling with adequate accuracy and confidence, only if all the rules of sampling are followed strictly.

c) If an incorrect sampling plan is adopted or if sample selection is not properly randomized there is danger of very bad lots getting accepted.

6.2 Where large quantities or numbers of identical items have to be inspected, the advantage of acceptance Sampling outweigh its limitations. Moreover, destructive tests have necessarily to be based on 'Sampling' basis.
1. **Introduction**

Reliability Engineering is not totally new to engineers. They have always been practicing the essentials of reliability engineering without giving it this name or using its terminology.

1.1. Reliability engineering is the discipline concerned with the prevention of defect, failures, fires, accidents etc., in all types of hardware from the smallest items like hand tools to the largest units like locomotives, boilers, turbines etc. This discipline has been successfully applied in a number of complicated and baffling cases to reduce the breakdown rate of equipments, improve the availability of plants for operation and thus to help in reduction of costs and improvement of efficiency and productivity.

1.2. Even though the overall or general design of the multitudes of types of hardware are widely different, the detailed design of components as also the mechanisms of failures are generally similar. The basic principles of reliability engineering can be applied to identify the root causes of failures such as weak links in the systems, starting points of material failures, causes of workmanship defects, degradation processes, and many other such factors which usually lie hidden under the obvious causes of failures.

1.3. Reliability engineering is most appropriate for repetitive types of failures which continue to occur again and again despite various measures being taken to avoid these failures. In such intractable cases, the user has either to suffer the failures continuously or to take the burden of replacing the entire equipment in question. Such intractable cases have been solved economically by the application of the principles and methods of reliability engineering.

While the basic principles of design, manufacture and maintenance differ widely between the fields of civil, electrical, mechanical or signal & telecommunication engineering, across all these specialist branches cuts the new disciplines of reliability engineering. The modes and mechanisms of failures of all types of hardware are the same and the statistical/mathematical methods for understanding and studying them all, are identical.

2. **Basic Principles**

2.1 **Definition of Reliability**

Formally, reliability is the probability that an item will perform as required, under stated condition, for a stated period of time. Thus if we have a large number items on test, we can write:\n
\[
\text{Reliability at time } t = \frac{\text{Number surviving at present}}{\text{Number at start}}
\]

2.2 **Failures**

When an item no longer works as intended we say it has failed. Therefore, "Failure is the termination of the ability of an item to perform its required function."

2.3 **Classification of failures.**

Failures can be classified as follows:

a) As to Cause:

'Misuse failure' is a 'failure attributable' to the application of stress beyond the stated capability of the item. Thus it has been ill treated. An 'inherent weakness failure' is a failure inherent in the item itself.
when subjected to stresses within the stated capabilities of the item. Thus the item has not been ill treated, and its failure is probably due to a design and manufacturing fault.

b) As to Suddenness:

A 'sudden failure' is one which could not be anticipated by prior examination. A gradual failure is one which could be anticipated by prior examination. Thus because it takes place gradually it is possible to predict that it will occur.

c) As to Degree:

A 'partial failure' is one resulting from deviations in characteristics, beyond specified limit, but not such as to cause complete lack of the required function. Thus the item does not work as well as it should, but it has not completely failed.

A 'complete failure' is one resulting from deviations in characteristics(s) beyond specified limits, such as to cause complete lack of the required function. The limits referred to in this category are special limits for this purpose.

d) By combination of the above terms

A 'Catastrophic failure' is one which is both sudden and complete. A 'degradation failure' is one which is both gradual and partial.

2.4. Failure patterns

The failure rate is not necessarily constant. Suppose we put a large number of particular part on life test, and we are able to run the test until every part has failed. We note when each time failure occurs and plot a graph of observed failure rate against time we might curve typically as in Figure 9.02. This curve is called bathtub curve because of its shape. It divides into three periods as follows:

a) Early failure period:

At start of the test the failure rate may be relatively high but this usually falls progressively until at A where the failure rate is approximately constant and at its lowest level. The most important causes of early failures are:

i) manufacturing fault
ii) design faults
iii) misuse

The period is also referred to as infant mortality period.

---

THE BATHTUB CURVE

FIG. 9.02

INDIAN RAILWAYS — AC TRACTION MANUAL - VOLUME 1
b) Constant failure period:

Once the early failures have been removed, the parts usually settle down to what may be a relatively long period, when the failure rate is approximately constant.

During the constant failure period, it is usual for failures from a wide variety of causes occur at random with no obvious pattern, except that the failure rate is roughly constant. Such failures are also commonly called random or chance failure. Where failures do form a well defined pattern the reliability engineer calls them 'systematic failures' and such patterns usually provide valuable information about the cause of a failure.

c) Wear out failure period:

The incidence of failure in this period is high since most of the component will have exceeded their service life and consequently would have deteriorated.

2.5. Failure Mechanism:

A few of the common failure mechanisms are

<table>
<thead>
<tr>
<th>Mechanism</th>
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<th>Mechanism</th>
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<tbody>
<tr>
<td>Adherence</td>
<td>Deterioration</td>
<td>Piezo electric defect</td>
</tr>
<tr>
<td>Arcing</td>
<td>Diffusion</td>
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<tr>
<td>Backlash</td>
<td>Drift and shift</td>
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<tr>
<td>Bleeding</td>
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<td>Seizure</td>
</tr>
<tr>
<td>Carbonisation</td>
<td>Electric Breakdown</td>
<td>Silver migration</td>
</tr>
<tr>
<td>Composite behaviour</td>
<td>Erosion</td>
<td>Slip</td>
</tr>
<tr>
<td>Contact bounce</td>
<td>Fatigue</td>
<td>Smearing</td>
</tr>
<tr>
<td>Contamination</td>
<td>Frettng or galling</td>
<td>Sublimation</td>
</tr>
<tr>
<td>Corona</td>
<td>Frequency effect</td>
<td>Voltage Breakdown</td>
</tr>
<tr>
<td>Creep</td>
<td>Leakage</td>
<td>Voltage overload</td>
</tr>
<tr>
<td>Creep rupture</td>
<td>Magnetic hysteresis</td>
<td>Wear</td>
</tr>
<tr>
<td>Cross talk</td>
<td>Mass unbalance</td>
<td>-</td>
</tr>
<tr>
<td>Current Overload</td>
<td>Noise</td>
<td></td>
</tr>
<tr>
<td>Decarbonisation</td>
<td>Opens</td>
<td></td>
</tr>
</tbody>
</table>

2.6. Mean Time Between Failures (MTBF):

Where the failure rate is approximately constant, it is convenient to use the Mean Time between Failures (MTBF). The mean time between failures is the reciprocal of the failure rate. It should be as long as possible.

2.7. Mean Time To Failure (MTTF):

The term mean time to failure is analogous in every way with mean time between failure and is used where a failure can not be repaired.
2.8. Mean Time To Repair (MTTR):

It is the mean time taken to put the equipment right after it has failed. It should be as short as possible.

2.9. Availability:

It is the probability that an equipment will be available for use and is given by the following relationship:

\[
\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}
\]

3. Failure mode effect and criticality analysis (F-MECA)

a) F-MECA method is used very widely at the design stage for estimating the reliability of any new system or product and, more importantly, for evolving more reliable designs through the identification of vulnerable or failure prone components.

b) The method is described in United States MIL - STD-1629 (Procedures for Performing a Failure Mode, Effects and Criticality Analysis). The basic principle of this method consists of listing all the components of an equipment or system and to evaluate, the effects of each possible failure mode of each component on the equipment or system as a whole. The results of failures are classified according to the severity of the effects.

c) This method was originally developed mainly for electronic equipment but it can be applied equally well to heavy electrical equipment or even mechanical equipment or systems.

d) Formal application of F - MECA methods is certainly useful for evaluating or designing complex systems but there is another advantage of learning this system. It gives an insight to the engineer which is useful for not only designing but also for investigating failures of small equipment or components. Therefore, it is useful to study this system for even those who will not be called upon to apply it for designing, evaluating or improving complex systems.

e) Although F-MECA methods as defined in MIL-STD-1629 were originally developed for the purpose of evaluation of reliability of electronic equipment at the design stage, it is possible to devise a variation which is suitable for a complex operational system such as the Railways, not so much for designing the system as for evaluating the effects of various failure modes on performance. Such an analysis will help to place in the proper perspective different types of failures which occur everyday. The overall picture -so produced will help the top management firstly to determine the most effective application of available resources and secondly to asses the effectiveness of measures taken to prevent any type failure.

4. Failure Reporting and Corrective Action Systems (FRACAS)

a) FRACAS system was originally designed for reporting and investigating systematically all failures which occur during the development of any new product. However, it can equally well be applied to an organization such as the Indian Railways to systematize the action that needs to be taken to improve the reliability of the hardware. It is as important for old designs of equipment which have been in service for many years as for new equipments introduced into service recently. If the very first failure of each type on any new equipment is treated as a problem to be investigated and corrected much time and money can be saved.

b) The starting point for the establishment of a FRACAS is the constitution of a failure review group (FRG) comprising:
Divisional officer in-charge of maintenance.

HQ officer in-charge of design/development

Any other officers who could contribute to the solution of the problem.

c) The FRG should work as a team to solve the problem and not as a forum for fixing responsibility, preparing a report or commenting on failure reports. Its recommendations should aim at practical and economical solutions. Where action is within their own powers or capacity the FRG should implement their decisions, if not, they should consider it their responsibility to obtain the required approvals from higher levels. They should always keep in mind that the effort must always be to determine the technical solution in detail. Merely reporting the problems to manufacturers for necessary action is not the function of an FRG.

d) The FRG should meet at least once a week to review the failure reports on the equipment under consideration and to determine the corrective actions.

e) Whenever any new equipment is commissioned an FRG should be set up. Similarly an FRG may be established for a few specific problems of old standing which may be causing concern. The FRG should remain in force until the reliability of the equipment attains the desired level.

f) The starting points for an FRG are the source reports on defects, failures, observations on operating irregularities etc. United States MIL-STD-781 provides a description of failure reporting methods. The common elements of all such failure reports are:

- description of failure symptoms
- effect of failure
- immediate action taken
- elapsed time after commissioning, after various maintenance schedules.
- operating conditions
- date, time, place of failure
- make, type, serial number of equipment and of component(s)
- opinion of person writing the report regarding possible cause of failure
- design modifications, if any.

g) Failure report forms should be designed to cover all the above details as also any other relevant data specific to the equipment in question.

h) Corrective action proposed by the FRG and approved for implementation should be clearly defined and its implementation on the entire population of the equipments in question should be watched. Then performance after the corrective action should be monitored. The FRG for any particular equipment may be wound up only when the desired reliability level is attained.

5. Potential of Reliability Engineering

5. 1 Design Stage

i) If the specification is drawn up carefully, it takes care of what we may call the 'Gross' design requirements. If the equipment complies with the specification and passes the tests stipulated therein, it will meet all the performance requirements and is unlikely to have any major defects which could render it unserviceable in a short time. However, this is not enough. The number of ways in which things can go wrong is so large that careful scrutiny of design details in every component is essential. Such scrutiny is inescapable in the case of equipments being manufactured by new firms for the first time. Even in the case of products made by reputed firms, if it is a new product, it is desirable to carry out such detailed scrutiny of designs. Very often, apparently minor deviations or discrepancies.
can lead to avoidable failures in service. It is in the interest of not only the user but also the supplier that the
detailed working drawings are scrutinized by reliability engineers familiar with the performance of the
equipments under actual service conditions. The only time such designs scrutiny can be waived is when an
identical design has been in successful service for many years under identical conditions. Even in such cases
it is necessary to check that there has been no change in the detailed design of any component. Further, the
opportunity should be taken to review the reliability and failure statistics to see whether any improvements in
the design of the concerned components can be introduced.

5. 2 Manufacturing Stage

i) It is always not possible to visualize everything at the drawing board stage. When the manufacture of the
high prototype is undertaken, various problems may be exposed, particularly in the case of complex systems.
The problems may relate to manufacture or to maintainability and reliability. Studies relating to
maintainability/reliability must continue concurrently during the manufacture of prototypes.

ii) As far as the actual method is concerned the best way in the long run to ensure reliability is to insist on a
fanatic or rigid adherence to drawings, process sheets and such other production documents. Relaxations/deviations and even so called 'improvements' in process should be reviewed carefully by both
basic design engineers and reliability engineers before permitting them on the production line. If such scrutiny
reveals an unnecessary or superfluous feature in the drawing, the drawings or processes should be modified
but as regards the production staff are concerned, production documents mentioned above viz. working
drawings, process sheets, etc. should be treated as sacrosanct.

5.3 Inspection and Testing

i) While the function of inspection and testing organization is to carry out the actual inspection and testing, it is
the function of reliability engineering service to define what these inspections and tests should be, when they
should be carried out and what criteria should be followed and so on.

ii) Organization of stage inspection from raw material stage through components and sub-assemblies upto the
final inspection and testing of the finished product is of the utmost importance. There are many types of
defects in regard to tolerances, material specification and process parameters which will have little or no effect
on the performance of the equipment as may be judged during acceptance tests or even limited actual service
but such defects can cause even catastrophic failures in actual service. These failures may occur at any time.
Some may occur within days after commissioning whereas some others may develop after several years
service. It is the function of the reliability engineer to investigate all such failures to determine the real or
probable causes and to alert the stage inspection organization to watch for and eliminate these types of
defects.

iii) In this connection, special mention must be made of screening or burning-in procedures. Many
components, particularly those which require sophisticated technology in production or those in which
contamination and invisible dimensional inaccuracies can cause failures, exhibit a high rate of failure, initially.
This is termed as 'Infant mortality'. Examples of components which exhibit this pattern of failures are semi-
conductors, fuses, incandescent lamps, coils with very fine wire etc. Reliability of such components in service
can be improved by operating them at a stress level which is significantly higher than that in service. Weak
components which would otherwise have failed in service will fail or at least show some deterioration of
properties during the screening procedures. By eliminating such components the reliability of the remaining
components which survive the screening process will be much higher in actual service. It must be noted that
'screening or burning - in' does not improve the quality of the components. It merely accelerates the failures of
those which would have failed any way in service.

5.4 Operation and Maintenance

i) The most important contribution that can be made by operating staff and maintenance staff towards the
improvement of reliability is in regard to investigation of failures. It is necessary to determine and
analyze as accurately as possible the actual conditions of service under which the failures occur and to re-construct from the observed data and study of failed components the exact mechanism of failures. On the success of these studies depends the evolution of the quickest and most cost-effective solutions to the problems. Experience in failure investigations is invaluable for this purpose but a systematic study and application of the principles of reliability engineering can greatly speed up the investigation. A through insight into the design of the equipment with regard to the calculation of various types of stresses is of-course desirable and often essential but it is also possible to evolve elegant solutions without going into the full design details.

6. Reliability and Cost

a) It is not always necessary that improvement in reliability must cost more. Better designs, different materials, better quality control during production etc. may achieve improved reliability at little or no extra cost. If scrap is reduced at the same time, the overall cost may actually come down. Predicting the cost of achieving any given reliability is nearly always difficult, so that in general we only know the cost accurately afterwards.

b) Maintenance costs are also difficult to estimate. If we know precisely what repair work has to be done each time an equipment fails, then we can predict its cost.

However we are unlikely to be able to foresee associated costs such as:-

i) The value of production/service lost through breakdowns.

ii) The cost of having the equipment of action.

7 Suggested Books for Further Reading

1. Practical Reliability Engineering by Patric O’Connor (Published by John Wiley)


*3. MIL-HDBK-217C: Reliability Prediction for Electronic Systems

*4. MIL-STD-1629: Failure Mode, Effects and Criticality Analysis

*5 MIL- HDBK-189: Reliability Growth Management.


7- Selection and use of Engineering Materials by FAA Crane and J.A. Charles (Published by Butterworths).

* United States Military Standards obtainable from National Technical Information Service, Springfield Virginia, USA.
CHAPTER X

SURVEYS, ESTIMATES & PROGRAMMES

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I. SURVEYS

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II. ESTIMATES

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CHAPTER X
SURVEYS, ESTIMATES & PROGRAMMES

11000 General

Engineering Code covers various aspects of Project development process. The following relevant Chapters of the Code should also be referred:

Chapter II Modes of Investigation of Railway Project

Chapter III Traffic Survey

Chapter IV Engineering Survey - Reconnaissance, Preliminary and Final Location Surveys

Chapter V Engineering Survey - Project Reports, Techno- Economic Survey Report and Feasibility Report

Chapter VI Estimates

I. SURVEYS

11001 Railway Electrification Surveys

1. Only a brief introduction to Railway Electrification surveys is given in this Chapter.

2. Railway Electrification surveys may be classified broadly in two categories;-

a) Cost-cum-feasibility-survey as a pre-investment investigation to assist decision making: and

b) Foot by foot survey to assist in preparation of working designs and drawings for actual construction work.

In case of urgency it may be necessary to include portions of (b) along with (a), but normally the two surveys are taken up separately.

11002 Cost-cum-Feasibility Survey

It is quick survey of the route proposed for electrification to examine major engineering installations which may have a bearing on the cost of electrification.

1) Civil Works:

This will include study of heavy overline structures like flyovers, road over bridges, through girder bridges and long deck type girder bridges and tunnels to examine whether these will require major or minor modification to permit erection of overhead equipment. An examination of the proposedremodelling plans, rack renewals, reballasting including changes in the level of track, realignment of curves, all having a bearing on track geometry and the dates when these are proposed to be completed, will be necessary. In yards, a survey of track proposed to be wired will have to be examined for track centres to prepare slewing plans and assess their cost, for location of OHE structures.

- Feasibility of running 12 wide stock on suburban routes in vicinity of cities.
- Availability of suitable land for location of locomotive shed, remote control centre, maintenance depots.
- Quick survey of soil to assess cost involved in foundation.

2. Signalling & Telecommunication works.
- Modification needed to existing installations General Power Supply.

3. Modification to track crossings
- Modification to HT and LT lines.

**11003 Foot by Foot Survey**

On acceptance of a project report, foot by foot detailed surveys are required for the preparation of working drawings for the electrification.

The scope broadly is as under: -

- Checking of configuration of layout of the track, chainage of turnout, cross overs, diamond crossing etc., Inter - track distances, curvature of tracks, versine, super elevation, cross section of track formation at an interval of 200m, detail of embankment/cutting etc.
- Checking of setting distance of existing signals, signalling rocks, wires junction boxes, cranes blocks etc.
- Checking of position of cabins, cable huts, station buildings, goods shed etc.
- Checking of position of overline structures.
- Determination of type of soil along the route at intervals not more than 5 Km.
- Collection of site details regarding bridges, tunnels etc. including study of clearances.

The data so collected is utilized to correct and update survey plans. These are then used for of preparation of pegging plans showing tentative location of OHE structures following 'Principles for OHE Layout Plans and Sectioning Diagrams for 25 kV ac Tactions', Appendix I, Vol. II of this manual. Site confirmation of prepegging plans is then carried to ascertain feasibility of structural locations.

**II. ESTIMATES**

**11004 Estimates**

All proposals for-

a) The construction or purchase of material for new works or assets,
b) The renewal and replacement of existing works or assets,
c) The scrapping, dismantlement or abandonment of existing works or assets,
d) The repairing or reconditioning;
e) Temporary and experimental works;
Should be scrutinized by the authority Competent to sanction them before any expenditure or liability is incurred thereon.

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME 1 [92]
Broadly estimates are of two types: -

a) Abstract Estimates  
b) Detailed Estimates  

11005 Abstract Estimates

An abstract estimate is prepared in order to enable to the authority competent to give administrative approval to the expenditure of the nature and magnitude contemplated to form a reasonably accurate idea to enable that authority to gauge adequately the financial prospects of the proposal. Abstract estimates avoid the expense and delay of preparing estimates for works in detail at a stage when the necessity or the general desirability of the works proposed has not been decided upon by competent authority. An abstract estimate should contain a brief report and justification for the work, specifications, and should mention whether funds are required in the current year and to what extent. It should also show the cost subdivided under main heads and subhead or specific items, the purpose being to present a correct idea of the work and to indicate the nature of the expenditure involved. The allocation of each item as between Capital, Development Fund, Open Line Works - Revenue, Depreciation Reserve Fund and Revenue should be indicated.

11006 Detailed Estimates

On receipt of administrative approval to a project or scheme conveyed through the sanction to the abstract estimate relating there to detailed estimate for various works should be prepared and submitted for technical sanction of the competent authority. It should be prepared in sufficient detail to enable the competent authority to make sure that the abstract estimate sanctioned by the higher authority is not likely to be exceeded. No work included in an abstract estimate should be commenced till a detailed estimate for the same is prepared and sanctioned and adequate funds are allotted by the competent authority allots adequate funds. The detailed estimate will comprise (i) statements showing details of estimated cost and (ii) an outer sheet giving the abstract of cost of work, the report, the financial justification and the allocation.

11007 General Rules Applicable to All Estimates

1. Responsibility for Preparation of Estimates

For proposals initiated in the Division estimates shall be prepared in the Division. Estimates of works, which the Senior Divisional Electrical Engineer or the Divisional Railway Manager is not empowered sanction, shall be submitted to the Chief Electrical Engineer duly verified by the Accounts Officer for Administrative approval and Technical sanction.

2. Design and Execution

The designs and execution of all new works and designs of equipment should conform to IRS/RDSO Standards, Drawings, Codes, Rules, Principles, Guidelines wherever available. No work which infringes “Schedules of Dimensions” shall be executed unless prior sanction of the CRS has been obtained.

3. Alternative Proposals

When alternative proposals are made, separate estimate should be prepared for each, together with a general abstract showing in tabular form the comparative cost of the various alternatives.

4. Grouping of Items

As far as possible items of estimates chargeable to the same head or sub-head of account should be grouped together so that the number of items under expenditure posted in the Register of Work may be reduced to a minimum.
5. Grouping of Works

a) When two or more works are so connected either by their situation, or by the purpose or purposes which they are designed to serve, that the construction of one necessarily involves that of the other or others, the works should be considered to comprise one scheme and the aggregate estimated cost of the works so connected shall determine the authority competent to sanction expenditure on the scheme.

When the works constituting a connected scheme are situated in more than one executive division separate detailed estimates should be prepared of the cost of the work in each division so that the Engineer entrusted with the actual construction may be in a position to watch expenditure against sanctioned estimate of the cost of the work in his charge.

6. Establishment and Other Charges

a) It should be ensured that due provision for establishment charges is made in major schemes under the heading 'Establishment'. If any such charges are not foreseen and additional establishment is required, sanction of the competent authority should be obtained and the expenditure shown against 'Establishment' and not against 'Contingencies', the excess being subsequently provided for in a revised estimate, if necessary, or explained in the completion report.

b) The engagement of work-charged establishment is subject to the following conditions-

i) The cost of establishment should be shown in detail under separate sub-heads of the estimate.

ii) If an Engineer, Supervisor, or other staff is actually employed on the supervision of two or more works his pay and allowance should be charged proportionately to those works.

Provisions made in Indian Railway Financial Code should be kept in view in respect of various charges to be included.

7. Currency of Sanction

The sanction to estimate shall ordinarily remain current for 5 years from the date it has been accorded, unless it has been renewed for a further term by the acceptance of a revised estimate. Acceptance by competent authority, however, of a budget estimate which includes specific provision for expenditure on a work which is in progress, may be regarded as reviving for the year in which provision is made, the sanction to the estimate regardless of the five years limit. But if no work has been commenced within 2 years of the date of sanction, the sanction shall be considered as having lapsed and fresh sanction shall be obtained from the competent authority by submitting an up-to-date estimate.

8. Register of Estimates

All estimates should, before they are submitted for accounts verification for sanction of the competent authorities, be registered in the office of origin. For this purpose register in the following form should be kept-
9. Competency of Sanction

Subject to the provisions of the rules in paragraph 748 of the Engineering Code, the General Managers of Indian Railways have full powers to delegate their powers on any portion of them, to authorities subordinate to them, with powers to redelegate to lower authorities. A schedule of the powers delegated from time to time to various departmental officers on each railway is maintained by each Railway administration so as to enable the Accounts Officer to determine in each case the authority competent to sanction the expenditure.

11008 Works Programme, Machinery & Plant Programme and Rolling Stock Programme

1. Proposal for sanction of new works under works programme for setting up new/additional facilities are initiated 18 months in advance.

2. Proposals for provision of major items of locomotives either for addition or replacement are processed under rolling stock programme and are initiated 18 to 24 months in advance of the programme of the year.

3. Proposals relating to machinery and plant for maintenance of asset are processed under M&P programme and are initiated 18 to 24 months in advance.
## DOCUMENTS FOR REFERENCE

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<tr>
<td>11102</td>
<td>Drawings and Specifications</td>
</tr>
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</table>
CHAPTER XI
DOCUMENTS FOR REFERENCE

11100 Books of Reference

A list of books of reference to be held at various Electrical Department offices is appended. CEE may authorize additions to this list as required.

The Chief Electrical Engineers and Sr. Divisional Electrical Engineers offices should be equipped with adequate number of copies of each publication. The publication should be accounted in the Dead Stock Register. Officials for whose personal use publications are supplied shall be responsible for their custody and handing them over prior to retirement from service.

11101 Standing Instructions

Instructions of a standing nature issued by the Railway Board, RDSO, CEE, Sr.DEE / DEE etc. should be filed subject-wise to be readily available for reference. An index sheet should be opened on the file containing a complete and up-to-date list of the standing instructions received. This file should be gone through from time to time to make certain that all of them are being complied with. When taking over charge of a post, the officer/supervisor should study these standing instructions carefully.

11102 Drawings and Specifications

1. In CEE's Drawing Office original tracings of drawings and copies of documents listed below should be carefully stored and preserved for reference when required:

a) Specification and relevant tender and contract documents pertaining to OHE, PSI, RC and Rolling-Stock for the entire Railway.

b) Tracings or reproducible prints of design drawings and 'as erected' drawings for all Traction Installations and Rolling-Stock.

c) Drawings and specifications for all modifications approved for Traction Installations and Rolling-Stock on the Railway.

d) One set with up-to-date corrections of all Maker's Manuals and Maintenance Instructions issued by RDSO etc. for Traction Installations, Rolling-Stock and important machines installed in Loco and EMU sheds, OHE depots etc.

2. Officers and supervisors who have independent offices should similarly maintain drawings, specifications, Maintenance Manuals and other documents pertaining to installations and equipment under their charge. Each supervisor will be responsible for safe custody and keeping up-to-date the documents in his charge. Sr. DEEs may nominate a supervisor attached to their offices for the purpose.
## APPENDIX – I

### DOCUMENTS FOR REFERENCE

List of Books for Reference
Offices which should be equipped with copy of the publication.

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<th>TLC</th>
<th>Electrical OHE</th>
<th>PSI</th>
<th>RC</th>
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CHAPTER XII
MISCELLANEOUS INSTRUCTIONS

11200 General

These instructions are for general guidance of officers and supervisory officials. Every railway servant connected with ac traction shall be responsible for compliance with the instructions.

I. GENERAL INSTRUCTIONS

11201 Knowledge of Rules

He shall observe the rules and procedures laid down in the General and Subsidiary Rules, Manual of ac Traction, the departmental codes, orders and circulars issued from time to time and shall ensure by frequent inspections and questioning of staff, relevant rules and working methods and are observing them in practice and performing their allotted duties efficiently.

11202 Co-operation with Other Staff

He shall co-operate fully with officers and staff of the Electrical and other departments in all matters that warrant joint action.

11203 Periodical Inspections

He shall, by periodic and surprise inspections, ensure safety of installations and equipment under his charge and in particular the safety of men under his control in carrying out works on high voltage equipment and rolling-stock.

11204 Responsibility For Work Done-By Staff Below

He is answerable to his superiors not only for his own work but also for the work done by staff below him and hence should consider it as part of his supervisory duty to guide the men below in the proper discharge of their duties.

11205 Personal Contact with Staff Below

He shall maintain cordial relations with men below and pay particular attention to their problems and difficulties met within their daily work. Where he is unable to find a satisfactory solution, he shall seek the guidance of his superiors. A sympathetic and human approach should be brought to bear especially when dealing with the personal problems of staff under him.

11206 Courtesy

All staff, particularly those whose duties bring them into frequent contact with the Public, should always be courteous towards the public in all their dealings.

11207 Review of Security Measures

A constant review should be made of the adequacy of security measures for traction installations, offices, stores depots, maintenance sheds and workshops including efficacy of fire-fighting arrangements.
11208 Economy
All possible economy should be exercised in the operation and maintenance of traction installations and rolling-stock, so as to achieve maximum benefits from electric operations.

11209 Records, Registers etc.
Prescribed records, registers, plans, specifications, technical data etc. relating to his work shall be maintained up-to-date and stored properly to be readily available when required. Superseded documents, drawings and specifications shall be cancelled and taken out of circulation.

11210 Statistical Returns
Prompt submission of periodic statistical returns is of the utmost importance. Compilation of primary records should be accurate and returns should be carefully scrutinized before submission to higher authorities. Failure reports shall be carefully and objectively analyzed to establish the root cause of failures and corrective steps taken to prevent recurrence.

11211 Daily Diary
A daily diary shall be maintained in which all important work done, instructions given, movements, inspections, meetings etc. are recorded.

11212 Office Work
All offices shall be maintained neat and tidy and correspondence dealt with promptly. Where replies are due, reminders should be issued periodically. References should be given clearly on letters to facilitate quick disposal.

11213 Major Emergencies, Break-Downs and Accidents
The organization should always be maintained in a state of readiness to meet any emergency. Emergency equipment should be maintained in proper condition and emergency staff kept fully aware of their respective duties. While possible action should be taken to initiate and progress restoration work, an important duty is to keep superiors fully informed of what is being done, so that they in turn can give further guidance or render additional assistance, if required.

11214 Training of Staff
It is a part of one's duty to be acquainted with latest developments and to instruct, educate and train men below and make them proficient in their allotted work. The performance of each person should be reviewed periodically. Deficiencies, if any, should be pointed out and opportunities given to improve. Where, however, a person continues to be negligent, indifferent or inattentive to his duties, appropriate disciplinary action should be taken. It is equally important on the other hand to notice the good work done and express appreciation.

Personal interest should be taken to see that staff posted for training receive the necessary assistance and facilities to learn the work.

Periodic tests should be conducted in accordance with prescribed procedure and an objective and informative assessment report submitted to superiors.

11215 Relinquishment of Charge
The officials handing over and taking over should carry out joint inspection of all important installations to the extent possible. The 'Transfer of Charge' statement should include a detailed list of maintenance works in progress and in arrears, if any; list of items requiring special attention, details of plant out of commission for repairs or overhaul, progress of works, particulars of important works, proposed and staff position. This statement should be submitted in duplicate to the higher authorities. One copy of this statement of transfer of charge between officers shall be submitted to CEE.
After taking over charge, the official concerned shall pay particular attention to the prompt clearance of pending items and submit a progress report at the end of three months to his superior.

11216 Duties Defined Not Exhaustive

The duties prescribed in the Manual are meant for general guidance and pertain mainly to technical aspects of the work. In common with other railwaymen, duties and responsibilities prescribed in the Establishment, Accident and other Manuals are equally applicable to staff connected with electric traction.

II THEFTS AND LOSSES

11217 Responsibility for Losses

Para 1801 of the General Code is reproduced below:

"Every public officer should exercise the same vigilance in respect of public expenditure and public funds generally as a person of ordinary prudence would exercise in respect of the expenditure and the custody of his own money. Means should be devised to ensure that every railway servant realizes fully and clearly that he will be held personally responsible for any loss sustained by Government through fraud or negligence on his part and also for any loss arising from fraud or negligence on the part of any other railway servant to the extent it may be shown that he contributed to the loss by his own action or negligence".

11218 Thefts

Thefts of stores or equipment pertaining to electric traction can be of the following types:

1. Thefts of OHE conductors or fittings or equipment from sub-stations, switching stations or RCC.
2. Thefts from electric locos or EMU stock, when stabled or otherwise.
3. Thefts of stores and equipment in the custody of traction officials or from loco/EMU sheds, depots or PSI depots and offices.

11219 Anti-Theft Measures

Officers and supervisors should constantly review the security arrangements which are in force in the various offices, stores and depots under their control and endeavour to develop ways and means of combating thefts of OHE conductors, fittings and other equipment. Surprise checks should be made to make sure that locking and sealing of doors of offices, stores etc. are being done properly and they are handed over to the custody of Security staff.

Staff below should also be encouraged to come forward with their ideas regarding anti-theft measures and should be adequately rewarded for helpful suggestions resulting in development of such anti-theft measures. Other Divisions and Railway should also be informed of details of any device or modification found successful in combating thefts.

Particular care should be taken in regard to the accountal and disposal of valuable components such as copper scrap.

11220 Watch on Criminal Elements

Officers and Supervisors of the Electrical Department should keep themselves informed of bad characters amongst their staff and pass on the information in their possession confidentially to the Security Officer concerned. Similarly, any other information which may assist the Security Branch in apprehending criminals should also be given to the Security Officer. DRM and CEE should also be kept informed of all important cases reported to the Security Department.

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11221 Procedure to be Followed

If a theft has occurred or is suspected as having taken place, the procedure to be followed is as under:-

1. The official holding charge of the installation should make a thorough check of the stores/installation and carry out an investigation:

   a) To check whether the procedure laid down for locking up and sealing of premises is being complied with.

   b) To assess the extent of loss suffered, if any.

   c) To take possession of relevant registers, account books and other evidence which may be of assistance to the RPF and Police authorities in their investigations.

   d) To record all the facts of the case such as the time when the theft occurred, statements of the concerned staff etc.

2. All cases should without delay be reported to the Railway Police Authorities, the Security Department and SR.DEE concerned. Complete details such as description and quantity of materials lost, estimated cost, place of occurrence, time of occurrence and any other relevant particulars helpful to the investigations should be given. When the amount of loss is estimated to be over Rs 500, a copy of the report must invariably be sent to the Accounts Officer concerned also.

3. Every important case should be reported by the Sr. DEE promptly to GM(Elect) who in turn will report the matter to the Railway Board and to the Chief Auditor through FA&CAO, if the loss exceeds Rs. 5,000.

4. The SR.DEE should arrange for a departmental inquiry into every important case with the association of the Accounts Officer concerned. The inquiry amongst other things should fix responsibility for the theft to the extent possible and submit recommendations to set over the lacunae which may come to light during the investigation.

   Such departmental inquiries should not be delayed pending police investigation or decision of criminal cases.

5. Cases reported to the Railway Police should be followed up vigorously with the Police authorities by Sr. DEE/AEE, with the assistance of the Security Officer.

6. All irrecoverable losses are required to be written off with Accounts concurrence and sanction of the competent authority, in accordance with local delegation of powers.

   The following procedure should be followed for periodic reconciliation of losses:

   a) All losses, on their detection, should be entered in a register by the officer incharge. A similar register is also required to be maintained by the Accounts and Security Officers.

   b) At the end of each quarter, the figures in their respective registers should be totaled up by the official in-charge, the Security Officer and the Accounts Officer.

   c) The reconciled figures, duly signed by the Sr. DEE, Accounts Officer, and Security Officer will be forwarded to CSO and FA&CAO for compiling a consolidated figure for the railway as a whole for submission to the Railway Board. (Board's letter No. 64/Sec.(CR)147/13/Pol dated 2nd August, 1968).
III. CARE AND CUSTODY OF INSTRUMENTS

11222 General
The maintenance of electrical equipment necessitates the use of variety of specialized and often costly instruments. Proper use of these instruments, their care and custody should receive special attention.

11223 Distribution of Instruments
1. Instruments for day-to-day use e.g. megger, cell-testing voltmeter, ordinary types of volt-meter, ammeter, ohm meter etc. may be issued to each section supervisor requiring such instruments, for custody. It may even be necessary to issue a few instruments for every day use to selected individual workmen.

2. Specialised instruments such as multi-metres, sub-standard metres, precision gauges, Ductor set etc. should be kept in the custody of senior supervisors only to be issued as and when required to individual sections.

3. Some types of special instruments such as high voltage insulation tester, sub-standard energy metres, oscilloscopes, instruments for localization of cable faults etc. should generally be kept in a central place in each Division to be used for special tests as authorised by Sr. DEE/DEE/AEE.

4. Certain types of special and expensive instruments such as HV pressure testing sets may be maintained in a common pool for a Railway as a whole.

5. All instruments should be borne on the "Inventory of dead stock" and should bear the T&P number, either painted or punched on a metallic label securely fixed to the instruments. Periodic verification of stores should be carried out as explained in Chapter X. A separate register should be maintained to record issues and receipts.

11224 Use of Instruments
1. Testing and measuring instruments are delicate equipment and should be handled with great care otherwise they will get damaged and their accuracy badly impaired. These remarks apply particularly when instruments are being transported from one place to another; they should be taken properly packed in a wooden case with enough cushioning material.

Certain types of instruments e.g. CRO, Selective level meter, sub-standard and standard instruments etc. are meant only for stationary use and should not be moved outside the testing laboratory. Such instruments should be carefully stored in a cup-board and care should be taken that they are not taken out for field use.

Oil testing sets should be permanently installed at suitable locations e.g. Central/PSI Depot, a nominated room in the loco / EMU shed etc. Test samples should be taken to the depot/ shed for testing, by a trained supervisor.

2. Operating instructions received with special types of instruments should be carefully preserved. When only one copy is received, additional copies as required should be made out. One set of instructions should be kept with the instrument for day to day use and at least one more set should be kept in a central place e.g. Foreman's or Sr. DEE's Office. The T&P register for each item should show the distribution of copies of its operating instructions.

At least two supervisors should make a detailed study of each instruction book and be fully familiar with their use. Experience has shown that quite often a number of instruments are held which are never used in practice either because it has been handled or used by someone who is ignorant or not qualified to use it. Every supervisory official shall inspect the equipment under his control at least once in 3 months and certify that it is in good working order.
Only persons who are fully familiar with all the details should be permitted to handle and use the instruments, especially the expensive specialized instruments. Amateurish handling of instruments, even comparatively simple instruments such as Avo-meters, can result in serious damage to them.

4. Instruments meant for field use should invariably have suitable carrying cases. Even if such carrying cases are not received with the instruments, they should be got manufactured to ensure that the instruments do not get damaged due to careless transporting.

11225 Periodic Calibration and Repair of Instruments

1. Each Zonal Railway should have a qualified supervisor and a few specially skilled and trained men, attached to the Central PSI Depot or other convenient place, for carrying out simple repairs of common instruments such as ammeters, volt-meters, ohm-meters, pressure gauges etc. The repair section should be equipped with special tools like watchmaker's hand tools, watchmaker's lathe, winding machine for small coils, testing instruments of sub-standard accuracy, test bench with variable voltage and current supply etc.

2. Special instruments should as far as possible be got repaired by the makers or their authorized representatives. When these are not available, care should be taken to entrust such repairs only to reliable firms specializing in such jobs and having adequate facilities for repair and testing.

3. Standard and sub-standard meters, gauges etc. should be got tested once in two years by recognized laboratories and test certificates obtained. A copy of the test certificate should be placed in a plastic envelope and kept along with the instrument, while the original should be carefully filed.
## CHAPTER I

### POWER SUPPLY FOR TRACTION

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CHAPTER I
POWER SUPPLY FOR TRACTION

20100 Supply System
1. The single phase 50 Hz. Power for the electric traction is obtained from 220/132/110/66 KV Extra High Voltage 3-phase grid system through step down single-phase transformers. For this purpose duplicate feeders comprising of only 2 phases are run from the nearest grid substation of the Supply Authority to the traction substation. The brief description of the system is given in Chapter 2 of Volume I. The 25 KV single phase conventional system as adopted on Indian Railways has been described in that chapter. A schematic diagram of the traction sub station and feeding post indicating the general feeding arrangement is indicated at Fig. 1.01.

Salient technical features of the 2x25KV AutoTransformer (AT) feed system are indicated in Chapter XI.

20101 Liaison with Power Supply Authorities.

For ensuring continuity and reliability of power supply for traction it is important that effective liaison is maintained between the officials of Railway and Supply Authorities. Broadly action on the following lines be taken:

a) A system of periodic meetings at different levels at mutually agreed intervals needs to be evolved.

b) Reliability of supply involves also the maintenance of traction voltage between 25 KV and 27.5 KV at the feeding posts and frequency between 48.5Hz. and 51.5 Hz. The serious repercussions on Railway traffic if the above limits are not adhered to should be constantly impressed upon the Supply Authorities.

c) The traction load should be treated as essential load and should not be disconnected or reduced to meet supply system exigencies. This principle has been accepted by most Supply Authorities and where this has not been done, constant efforts should be made at the high level periodic meetings to get this principle accepted.

d) Since the cumulative effect of frequent power supply interruptions, even though of short duration at a time, can be very serious to Railway working, a periodical review of all such interruptions should be made at the Divisional level and the cause of each interruption ascertained as far as possible. The results of the review should be furnished to CEE to keep him fully informed of the power supply position. This subject should also form an important item for discussion at the periodic meetings with the Supply Authorities.

e) Power supply for electric traction should be governed by a specific Agreement entered into by the Railway with the concerned Supply Authority before the supply is actually taken. Where this has not been done already, urgent action should be taken to have it finalized without delay.

f) When grid supply to any traction sub-station fails and consequently emergency working has to be resorted to by extending the feed from adjacent sub-stations, the maximum demand at these sub-stations may go up. Most Supply Authorities have agreed to ignore such temporary increase in maximum demand for billing purposes. Where this has not yet been agreed to, efforts should be continued to persuade the Supply Authorities to accept this principle.

g) The present methodology of measuring maximum demand at each individual sub-stations for the purpose of billing has been reviewed by the Central Electricity Authority. It has been agreed that Railways should be charged for traction power on the basis of simultaneous maximum demand recorded in contiguous sub-stations of the SEB serviced by the same grid transformers. Modalities to implement the decision would have to be mutually settled between SEBs and Railways, with cost of the equipment borne by Railways.

INDIAN RAILWAYS – AC TRACTION MANUAL – VOLUME II PART I
20102 Tariff for Traction

a) In Electric Traction the energy cost forms a substantial portion of the total operating and maintenance cost. The tariffs charged by various state Electricity Boards vary from a simple flat rate for the energy (charged by some states like MSEB & GEB) to a very complex tariff structure covering a variety of parameters (as indicated in the tariff charged by MPEB). The implications of the various parameters should be studied carefully to keep the energy cost to the minimum possible level.

b) Contract demand for each sub-station should be stipulated in relation to the expected actual Maximum Demand in such a manner that in fructuous payments by way of minimum guarantee on the one hand and penal charges for exceeding the contract demand on the other, are avoided. Notice period for altering Contract Demand should also be kept as low as possible in the agreement, preferably 4 to 6 weeks.

c) In the tariff charged for electric traction, following are some of the parameters that should be given careful consideration with a view to keeping down the energy bill to the minimum.

i) Maximum demand charge Rs/KVA/month : Normally one feeder is “ON” for feeding the traction load. If two sets of trivector meters are provided, the higher of the two should be the MD to be charged. Caution may be exercised to ensure that addition of both is not taken as MD in billing.

ii) Energy charge Paise/Kwh

iii) Fuel Adjustment Charge (FAC) accounting for the variations in cost of fuel and calorific value compared to stipulated basis figures. This charge should be realistic and should be periodically verified with the Supply Authorities.

iv) Penalty for low power factor : The penal charge is prescribed as an extra amount livable in Rs/KVA of Maximum Demand if power factor falls below a specified value. SEBs usually insist on consumer providing PF correcting equipment and do not permit power factor lower than a prescribed value.

v) Billing Demand is usually a certain percentage of contract demand or the actual MD whichever is higher.

vi) Excess over Contract Demand and corresponding units of energy are usually charged at higher tariff (excluding FAC). Even if the excess MD is for a short period of just 15 min. proportionate units for the entire month are charged at penal rate. One of the SEBs does computation of excess energy as under:

\[
\text{Excess Energy} = \text{TU} \times (1 - \text{CD/MD})
\]

Where \( \text{TU} \) = Total Energy

\( \text{MD} \) = Maximum Demand

\( \text{CD} \) = Contract Demand

The Contract demand therefore, has to be carefully determined, and reviewed periodically and if necessary modified to avoid penal charges.

vii) Minimum Guarantee

Usually, the agreement with SEB stipulate a percentage of 15 to 20% on the capital cost invested by the SEB for giving the connection, as minimum guarantee. This is generally met by the pattern of energy consumption in traction. However, minimum guarantee in some cases is specified in terms of guaranteed average load factor (say 30%). This ties up the Contract Demand with the units consumed.
If a few heavy trains operate in a section raising the Maximum Demand high, the average load factor may not reach 30% unless adequate frequency of passenger trains also forms part of the traffic pattern. Here, if contract demand is too high, 30% load factor is difficult to achieve while if contract demand is too low, exceeding it and attracting penal changes becomes a possibility. Careful balance between the two conflicting requirements has, therefore, to be struck.

viii) Harmonic Voltage Distortion

The consumer is required to carry out Harmonic Analysis under full load conditions. It is stipulated that the individual harmonic voltage distortion (Vn) at the point of supply shall not exceed 1% and 3% respectively.

\[ Vt = \left( \frac{V_2^2 + V_3^2 + V_4^2 + \cdots + V_{13}^2}{V} \right)^{1/2} \times 100 \]

\( V \) - RMS value of fundamental voltage.

\( Vn \) – RMS value of harmonic voltage of order “n”, expressed as percentage of RMS value of the fundamental and shall be calculated using the following expression:

\[ Vt = \left( \frac{V_2^2 + V_3^2 + V_4^2 + \cdots + V_{13}^2}{V} \right)^{1/2} \times 100 \]

d) The tariff charged for traction should be reviewed periodically with the SEB, it should be ensured that the rates do not exceed those charged in EHV tariff of the SEB applicable to other consumers.

20103 Monthly Meter Readings

a) In earlier Railway Electrification installations, only one set of meters owned by the Supply Authorities has been installed to meter the traction load. In later installations, a second set of meters is being provided on the sub-station switchboard at Railways cost. Where only one set of meters belonging to the supply authority is installed yearly testing of the meter should be carried out. If its accuracy is in doubt at any point of time, the Railway is entitled to ask for testing and certification of the meter. Where a second set of meters has been provided at Railways cost, the figures for billing purposes should ordinarily be based on the average readings of the two sets of meters, unless specifically provided for otherwise in the Agreement. The exact procedure covering these aspects should be embodied in the Agreement with the Supply Authorities.

b) The monthly meter readings should be taken on an agreed date each month jointly by representatives of the Supply Authority and the Railway. The meter card as well as the printomaxigraph chart reading showing the maximum demand for the month should be initialed by representatives of both parties. Only readings jointly recorded as above should be accepted for billing purposes.

c) When visiting the grid sub-stations for taking meter readings, the supervisory official concerned will also obtain additional information such as daily maximum demand for traction, power factor, load factor, variation of voltage, changes in the system of interconnection, which have a bearing on power supply for traction. Suggestions for suitable changes in the Supply Authority’s network may be made at appropriate level and if necessary concrete proposals initiated for making power supply 100% reliable.

20104 Scrutiny of Bills

a) The Supply Authorities bills should be carefully scrutinized in the Divisional Office with reference to the Agreement and the tariff. A time schedule should be laid down jointly with the Accounts Department for scrutiny and passing of the bill so as to take advantage of the rebate admissible, if any, for prompt payment. Panel charges levied, if any, should be carefully scrutinized and appropriate remedial measures
taken to prevent recurrence. If the minimum charge payable is in excess of the amount warranted by the actual energy consumption, this fact should be promptly brought to the notice of CEE as well as the operating Department to take special steps to arrange for movement of additional traffic, to the extent possible, in the affected section, including diversion from other routes.

b) Detailed instructions should be issued locally, jointly with the Accounts Department, listing the items to be checked prior to passing the bills from the Supply Authorities. An illustrative list is given below:

i) Arithmetical accuracy
ii) Meter readings shown on the bill tally with those received earlier from the subordinates.
iii) The tariff applied is in terms of the agreement.
iv) The method of computation of the maximum demand for billing purpose is in accordance with the agreement and that temporary increase in maximum demand on account of emergency feeding has not been taken into account where this principle has been accepted.
v) The time allowed for payment is in accordance with the agreement.
vi) There is no duplication in billing.
vii) The payee as provided for in the agreement is clearly indicated. The full particulars of the payee should be advised to the Accounts branch to enable that Branch to issue cheques accordingly.
viii) Each new bill should be analyzed and compared with earlier bill and the reasons for any significant departures investigated.

In case of any dispute/discrepancy, the payment be made “under protest”

20105  Power Factor Improvement

a) Provision of power factor improvement capacitors at 25 KV bus of traction substations should be planned giving priority to substations (i) which feed large marshalling yards and (ii) where penalty for low power factor and / or exceeding maximum demand has been stipulated in the tariff.

b) The average monthly power factor is calculated as ratio of KWh and KVAh over a month. Care should be taken to make sure that it does not go ‘leading’ while P.F. correcting equipment is used and is kept near unity. Switched capacitor be used where load violations are wide.

c) The Guidelines issued by RDSO in respect of selection of the KVAr rating should be kept in view at the time of planning.

20106  Shut-Downs of Traction Supply to be Pre-planned

a) At all grid sub-stations and traction sub-stations owned by the railways, duplicate EHV feeders are available. Most of the sub-stations also have two sets of traction power transformers and associated switchgear. Maintenance of equipment and transmission lines should not, therefore, necessitate total shut-down of EHV and 25 Kv supply at a sub-station. It should be arranged with the Supply Authorities that on the rare occasions when such shut-down becomes inescapable, notice should be given well in advance to Sr. DEE/DEE(TRD) stating the reasons for the shut-down and the anticipated duration. Such shut-downs should be arranged by Sr. DEE/DEE (TRD) in consultation with the Operating Department which may have to re-schedule trains and take a other measures as necessary.

b) A double circuit set of transmission lines from the Grid sub-station are run to give supply to traction sub-station. Therefore, maintenance of the transmission line does not necessitates total shut-down of
the systems. However, all such shut-downs should be planned well in advance giving the reasons for the shut-down and anticipated duration.

20107 Operating instructions for Grid Sub-stations
Detailed operating instructions mutually agreed to between the Supply Authorities and the Railway should be made out for each grid sub-station as well as traction sub-station owned by the Railway and should be issued to TPC as well as operators at grid stations. These instructions should contain the following details.

a) Procedure for carrying out switching operations at the sub-station.

b) Procedure for interchange of message of pre-planned or emergency shut downs.

c) Procedure to be followed in case of failure of supply and information to be conveyed by grid sub-station operator regarding duration of failure and anticipated time of restoration to enable emergency working to be introduced.

d) Records to be maintained by grid sub-station operator and TPC regarding emergency feed arrangements.

e) List of office and residential telephone numbers of important grid and railway officials to be contact in an emergency.

f) Mutual assistance to be rendered for transmission of important messages in the event of telephone failures at the grid sub-stations or RCC.

20108 Statistical Data Regarding Energy Consumption

In the divisional office, all register should be maintained to record month wise the following particulars in regard to energy consumption at each supply point:

a) Energy consumption (Kwh)
b) Maximum demand (Kva)
c) Average power factor (KWH/KVAH)
d) Monthly average load factor per cent
e) Payment for energy
f) Payment for maximum demand
g) Payment towards meter rent
h) Payment of fuel surcharges, if any
i) Payment for P.F. surcharge/penal charge
j) Payment of covering the minimum guarantee load, if any
k) Other payments, if any
l) Total amount of bill under all heads

m) Average total cost per Kwh.

A consolidated statement giving the above details for all supply points should be furnished by Sr. DEE/TRD to CEE each month by a stipulated date. CEE will in turn furnish a monthly statement in the prescribed Performa to the Railway Board and Research Design and Standards Organization (RDSO).
### CHAPTER II

**SUB-STATIONS AND SWITCHING STATIONS**

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CHAPTER II
20200 Introduction

1. This chapter is divided into 4 sections as under –

**Section I**  Organisation: A broad set up of the organisation and duties of Chief Traction Foreman (Power Supply Installations) are covered.

**Section II**  Operation of Sub-Stations: The important points relating to operation of transformers and protective devices are covered.

**Section III**  Guiding Notes on Maintenance: The important points to be borne in mind in the maintenance of chief power supply equipments are covered.

**Section IV**  A recommended schedule of maintenance for power supply equipments is given.

2. The following documents have been incorporated as Appendices to this Volume.

2.1 “Code of Practice for Earthing of Power Supply Installations for 25 KV ac, 50 Hz. Single Phase Traction System issued by RDSO (Appendix III)

2.2 Guidelines for Relay setting at Traction Sub-stations and Switching Posts issued by RDSO (Appendix V)

2.3 Guidelines for Provision of Maintenance Depots, Tools and Plants and Transport Facilities (Appendix VI)

2.4 List of Specifications and for Equipments and Materials for Railway Electric Traction issued by RDSO Appendix IX)

1. ORGANISATION

20201 Organizational Set up

The Divisional set up of senior subordinates working under Sr. DEE/TRD has been arranged on two types of patterns.

a) Territorial basis

b) Functional basis

In the territorial set up one Sr. Subordinate is responsible for all the activities of maintenance and operation over a predetermined section of electrified territory or a sub-division. The functional set up envisages separate Sr./ Subordinate to be in charge of each activity viz.. sub-station, OHE, workshop, PSI etc. in a division or sub-division. Duties, however, have been specified here in relation to particular function. For territorial set up, the CTFO in charge will perform his duties keeping all functions in view, the next in command viz. TFO being the functional in charge of the specific activity.
Remote Control system or protective relay testing being a specialized activity, CTFO (RC) and CTFO/Test Room usually have a functional jurisdiction over the entire division, with Head Quarters at the Remote Control Centre and Divisional Repair Shop respectively. The CTFOs in territorial charge, should keep a constant liaison between themselves since these aspects will have an element of dual control.

20202 Duties of Chief Traction Foreman, Power Supply Installation
He is the senior supervisor working under the control of DEE/AEE/TRD and directly responsible for the safe and efficient operation and maintenance of traction power supply installations including sub-stations (when owned by the railway), switching stations, booster transformers and auxiliary transformers in his jurisdiction. He shall be thoroughly conversant with all technical details of the equipment under his charge including their rating, trend of power demand as also correct methods of their operation and maintenance, in particular, he shall

1. supervise the maintenance of installations under his charge in accordance with the prescribed schedules to keep them fully serviceable at all times and in a state of good repair:

2. maintain proper co-ordination with the Traction Power Controller, Chief Traction Foreman (OHE), Supply Authorities and render assistance when required to ensure reliability of power supply:

3. keep his organisation in constant readiness to deal promptly with any breakdowns and failures of equipment;

4. ensure that the programme of testing and maintenance of protective relays is adhered to and ensure that other safety equipment including bonding and earthing are functioning effectively;

5. instruct, train and supervise staff under his control and ensure that they do operate and maintain the equipment properly and in particular do actually observe all rules and regulations and safety precautions laid down;

6. depute staff for refresher courses as prescribed, particularly for such staff as are found deficient in their working;

7. ensure that special instruments and tools provided for maintenance operation and testing of all installations are properly cared for;

8. keep a close watch on availability of spare parts and other stores required for maintenance and operation of the installations and initiate timely action to recoup stocks;

9. ensure proper accountal and periodical verification of stores and tools in his charge.

10. Depute staff when required to man sub-stations and switching stations in the event of failure of remote control equipment.

11. Inspect all installations under his charge at least once a month, with particular attention to safety aspects;

12. Submit prescribed periodical returns after careful scrutiny to AEE/TRD and Sr. DEE/DEE(TRD);

13. Keep his superior officers fully informed of all important development and seek their guidance when required;

14. Carry out such other duties as may be allotted by superior officers from time to time.

15. Carry out inspections as indicated at Annexure 2.01.
II  OPERATION OF SUB-STATIONS

20203  Introduction

Since the electric traction system depends upon continuous availability of power supply, sub-stations and switching stations have to be kept in proper working condition at all the time. To ensure this, the transmission lines, the 25 KV feeder lines and traction transformers with associated switch gear and control and relay panels are duplicated so that if one unit fails, the standby unit can be brought into service to continue power supply. All switching operations are also centralized and controlled by remote operation by a single authority, namely Traction Power Controller.

20204  Inspection Book and Log Book at Sub-Stations

An “inspection Book” shall be maintained at every sub-station in which observations made by supervisory officials visiting the sub-station for periodical inspections shall be recorded. In addition a log book should also be maintained to keep a record of the traction transformer oil temperature, ambient temperature as well as currents and voltages as indicated on the control panel at a fixed time every morning. If there is anything abnormal unusual, CTFO/PSI will investigate the cause thoroughly and take necessary remedial action.

20205  Overload Capacity of Traction Transformers

Traction transformers usually have the following overload capacity:

1. Overload rating : (a) 50% overload for 15 min. and (b) 100% overload for a period of 5 min.: after the transformer has attained steady temperature on continuous operation at full load.

2. Over an ambient temperature of 45 degree C the maximum permissible temperature rise shall be as under:

(a) Winding  =  50degree C (by resistance method)
(b) Oil  =  40 degree C (by thermometer)
(c) Current carrying parts  =  35 degree C (BY THERMOMETER)

3. The hot-spot temperature after 50 % overload for 15 min, or 100% overload for 5 min. shall not exceed 100 degree C for an ambient temperature of 45 degree C.

4. Interval of time permissible between two successive overloads (after continuous working at maximum ambient temperature of 45 degree C is 3 hours for both 50% overload for 15 min. and 100% overload for 5 min.

20206  Tap Setting on Traction Transformers

Traction Transformers are usually provided with off-load tap changers (operated locally or by remote control) with taps from + 10% to (-) 15% in steps of 5%. To decide the correct tap setting a recording voltmeter should be connected at the traction sub-station to the secondary side of a potential transformer to ascertain the pattern of voltage variation throughout the 24 hours for at least 3 typical days. Based on the readings from the recording the tap position should be fixed so that the daily OHE voltage peaks at the traction sub-station lie just below 27.5 KV but does not touch 27.5 KV. This will ensure that the OHE voltage is well above the minimum of 19 KV at the farthest point on the system even when heavily loaded. Once a year a 24 hours record of voltages available on the two sides of every neutral section should be taken to make sure that the voltage does not fall below 19 KV at any time.

Since any change in the inter-connections of the grid system would have repercussions on the voltage at the traction sub-station, the CTFO/PSI should keep in touch with the supply authorities in regard to system changes
so that he may arrange to take another set of 24 hour voltage readings if any change has taken place and to change the tap setting if required.

20207 Tests on Transformer Oil
In order to improve the performance and to prolong the life of the transformers, EHV grade oil is used. The following two specifications the first one for new oil and the second for oil in service, are adopted.

(a) IS- 335 Specification for New Insulating Oils.
(b) IS- 1866 Code of practice for maintenance and supervision of insulating oil in service.

A summary of tests for various characteristics, the requirements to be complied with and methods of tests as contained in the two specifications is at Annexure 2.03 (A&B). The tests are wide ranging and should be done once a year. However, some of the tests like Breakdown voltage (BDV) test, acidity tests, crackle test for moisture, may be carried out in PSI depots or sub-stations once in six months when samples are drawn for condition monitoring as per para 20216. Procedures for these test are indicated in IS 1866.

20208 Purification of Transformer Oil
The object of oil purification is to remove all contaminants such as water, carbon deposits, dirt, sludge, dissolved moisture and gases. The most important quality to be preserved is the di-electric strength, which is affected by the presence of moisture.

The insulating materials used in the winding are hydroscopic by nature and therefore moisture is absorbed through defective breathers, gaskets and addition of untreated make up oil. It is essential to remove these impurities by purifying the oil when the di-electric strength goes below the permissible limits.

20209 Oil Purification Plant
For purifying the transformer oil, machines conforming to RDSO’s Specification No. ETI/PSI/103 may be used. These are normally operated from 240 V single phase supply taken from the 100 KVA Station transformer provided at the sub-station. Supervisory officials in charge of maintenance of transformers should make themselves familiar with the supplier’s instructions in regard to the operation and maintenance of the oil purifying equipment.

20210 Insulation Resistance During Drying Out
Readings of temperature and insulation resistance should be recorded every two hours, from commencement until the full operation is completed. If the readings are plotted on a graph, the appearance will be as shown in Fig. 2.01.

It will be observed that there are four distinct stages:

A. Initially the insulation resistance drops down to a low value because of rise in temperature of the oil upto about 75 degree C.

B. Insulation resistance will continue to remain at a low level despite temperature being maintained at a high level until most of the moisture from the windings and oil has been driven out.

C. The insulation resistance will thereafter rise gradually and level off, indicating that all moisture has been driven out and the drying out operation has been completed. At this point oil circulation should be discontinued.

D. As the oil cools off, the insulation resistance will rise much above the leveling off point at the end of stage ©. This is because the insulation resistance value doubles for a fall in temperature of about 10 degree C to 15 degree C.
20211 Protective Devices

A number of protective devices are provided to ensure safe operation of traction transformers and other equipment (under normal and extended feed condition with appropriate adjustment of settings). Alarm and trip circuit operations are tele-signalled and indicated at the RCC. The TPC shall in every such case advise CTFO, so that he could arrange for the inspection of the sub-station to investigate the cause and take necessary corrective action and submit a detailed report to Sr. DEE/DEE(TrD).

20212 Operation of Temperature Alarm or Trip

Alarm and trip contacts are provided to operate should the temperature of transformer windings or transformer oil exceed pre-set limits. If alarm or the trip contacts have operated, both of which are indicated at the RCC, CTFO should personally inspect the installation. If the dial settings are correct, the reason for excessive temperature rise should be investigated. Normally instantaneous overloads of over 150% of full load are taken care of by overload relays, while sustained overload below 150% are cleared by thermal protection. It is advisable to connect a recording ammeter and get a 24 hour chart showing the current loading of the transformer in services. The shape of the load curve would give valuable clues as to corrective action to be taken.

If the alarm and trip circuits operate frequently during peak periods, attempt should be made with Operating Department to space out the trains more uniformly throughout the day so as to reduce the peak load. If, on the other hand, it is a suburban section and the peak load cannot obviously be brought down, the second standby
transformer may have to be pressed into service for the duration of the peak load. Such parallel operation of traction transformers may sometimes also incidentally result in reduction of the total losses thereby effecting economy. Secondly, it will also result in higher OHE voltage, since traction transformer impedance is now halved as the transformers are identical.

If a sub-station is persistently overloaded and an adjacent sub-station is appreciably underloaded, the possibility of shifting the neutral section may be considered.

20213 Operation of Differential Protection

Apart from operation on account of internal faults in the transformer, the differential relay could also operate either because of current in-rush on account of magnetization of the core at the time of switching on or because of spill current caused by lack of perfect balance between secondaries of EHV and 25 KV current transformers. The causes for such mal-operation may be defective harmonic restraint filters or wrong CT ratios and should be eliminated.

20214 Buchholz Relay

The Buchholz relay assembly is provided on transformers to detect evolution of gas caused due to internal faults. After first commissioning, the upper assembly of the relay may sometimes be found to operate causing the relay to trip. Analysis of the composition of gas collected will indicate the nature of fault. If it is mere air bubbles the transformer is sound. For details of tests manufacturers write up may be referred to. It is always a wise policy to get the de-electric strength of the oil tests, measure the insulation resistance and carry out ratio test.

III Guiding Notes On Maintenance

20215 Introduction

1. For better utilization of traction assets, outage of any traction equipment from service should be minimum without compromising on safety of the equipment and personnel. Monitoring of condition of the equipment by reliable means is essential for following system of need based maintenance i.e. directed maintenance. However, till such time reliable condition monitoring techniques are introduced, the present system of preventive maintenance has to continue.
2. Recommendations of Original Equipment Manufacturer (OEM) and guidelines issued by RDSO, time to time, shall be kept in view while defining the scope and periodicity of the schedules.
3. The tightening torque for fasteners of various sizes is given in Annexure 2.08.

20216 Transformers

1. Condition Monitoring
In oil filled equipment like transformers, normal deterioration or ageing of insulation is caused by thermo-chemical reaction with participation of heat, moisture and oxygen. This results in formation of soluble and insoluble products which accumulate and deteriorate the properties of oil and cellulosic insulation. Whereas the oil can be reconditioned to restore functional properties, no such treatment is possible for the cellulosic insulation, which suffers from reduction of mechanical and di-electric strength. The condition of the insulation, therefore, needs to be checked by suitable methods.

The thermal and electrical stresses caused during short circuits, overloads and over voltages in the system result is gas formation in appreciable amount and deterioration of di-electric properties and lowering of flash point of oil from 145 degree C to somewhere between 50 degree to 80 degree C in extreme cases. In the case of incipient faults, the gases being soluble, are absorbed in oil. The Buchholz relay cannot respond during early stages of trouble and by the time these devices operate the damage is done. Dissolved gas analysis (DGA, provides an important means in the art of condition monitoring of power transformers and other oil filled equipment. Of the various methods of gas
analysis Gas Chromatography (GS) is one of the most sensitive, efficient and rapid method, eminently suited for detection of incipient faults and for monitoring of growing faults which are not always revealed by established routine tests etc. In order to timely detect the deterioration of insulation, oil sample shall be drawn annually and subjected to gas chromatography.

Guidelines for condition monitoring of traction transformers by Dissolved Gas Analysis technique are appended at Annexure 2.04.

2. Overhaul Of Transformers.
   a) Overhaul of a transformer is normally undertaken either if it is faulty or at the end of 7-10 years by way of periodic maintenance. This can be done in the Central Repair Shop which is a covered shop having full facilities including a core lifting bay with a crane. Before commencing the work ensure that spare gaskets of proper quality are available. Drain out the oil, disconnect at leads, remove manhole covers where required. The EHV and 25 KV bushings are then carefully removed out and stored well protected in a safe place. Then remove the core by means of the lifting hooks and place on shop floor over a trestle in a large receptacle into which oil can drain out.

   b) If the transformer has been opened up because of any internal fault, make a careful note of colour of transformer oil, arc-marks, carbon deposits, charring of insulation, condition of the windings, unusual odour and other abnormalities which would all help in ascertaining the cause of the failure. If a coil has been burnt out, the whole transformer will have to be completely dismantled and then the damaged coil replaced with a new coil. In the case of the traction transformer, the replacement of the damaged coil is best done in the manufacturer’s works where necessary facilities and staff with the requisite skill are available.

   c) Arrange for the interior of the transformer tank to be thoroughly cleaned of all accumulated debris, sludge, etc. and wash with fresh oil. Remove the drain plug, lightly polish the valve seat and renew the oil-tight gasket round the spindle so that when assembled the plug is fully oil tight: the same remarks apply to the oil sampling valve, if provided. Opportunity should also be taken to plug or weld up any small blow holes through which oil seepage was observed earlier. Finally paint the exterior of the tank if necessary after thoroughly cleaning it up of all paint work, rust and traces of oil and dirt.

   d) If the coil assembly is lifted up after 5, 10 or more years of service, considerable amount of sludge formation would have occurred on all parts of the transformer i.e. at the bottom of the tanks, metal work of the transformers, windings and inter-spaces between windings. All these should be scrapped off carefully with a wooden or fiber wedge without causing any damage to the windings. Traces of the sludge left over in inaccessible places are best removed by directing a thin jet of transformer oil under pressure using small oil purifier. At the same time the old surface contamination should be brushed and washed down, until the clear surface of the winding is exposed.

   e) Care should be taken to protect the windings against ingress of moisture particularly during inclement weather. Care should also be taken by wiping off body sweat with a towel. The windings should also be kept warm by surrounding the open windings by a number of infra-red lamps or by other means.

   f) Fully push home the wedges between the coils and take up the slackness of end-plates by tightening up the bolts and locking them. These are provided on traction transformers to hold the windings tightly together to withstand the high mechanical forces generated at the time of short circuits. Shrinkage and settlement usually take place within the first six months of the commissioning of a transformer. The coils are also liable to suffer displacement due to short circuit forces. If the coils are not held tightly in position, it will lead to repeated movement of the coils as well as layers and turns which will in turn cause abrasion and wear of insulation and ultimately failure. It is, therefore, sometimes recommended that the first available opportunity should be taken to have the wedges fully home and tighten up the pressure screws where they are provided.
Finally put back the core assembly inside the tank, assembly the bushing check tightness of all internal connections, fit the top, provide new gaskets, fill pure oil and dry out as detailed in para 20208 to 20210. Experience has shown that tools like spanners and foreign objects like washers, pieces of cloth, etc. are sometimes inadvertently left behind in the transformers, which present hazard of short circuits. It is, therefore, important that all tools, etc. used in the overhaul work should be listed out at the beginning and accounted for at the end of the work.

When overhauled transformers are to commissioned the same procedure as detailed in Chapter IX for new transformers should be followed;

Each railway should plan, taking into consideration the resources available with them to carry out the POH and repairs of the transformer and decide the agency to execute the work.

2. Investigation into causes of Failures of Transformers.

In most cases the causes of the fault can be surmised by careful observation of the condition the windings, e.g. displacement of the turns or coils, coil insulation (brittle or healthy), evidence of overheating carbon deposit or flash marks on the core, supports, the inner surface of the tank or cover. The following notes may be of help in identifying the cause.

a) Failure due to lightning discharge or overvoltages - This is characterized by breakdown of the end turns close to the line terminal. There may be a break in the turns or end lead, and also flash marks on the end coil and earthed parts close to it, but the rest of the coils will be found to be healthy.

b) Sustained overloads – The windings in one or all phases would show signs of overheating and charring; the insulation would be very brittle and would have lost all its elasticity.

c) Inter-turn short, inter-layer short, or inter-coils short - The same signs as for indicated for sustained over load would be noticed, but only on affected coils, the rest of the coils being intact. This is likely if the differential relay or the Buchholz relay has operated.

d) Dead short circuit – This can be identified by the unmistakable, lateral or axial displacement of the coils. The coils may be loose on the core, some turns on the outermost layer may have burst outwards and broken as if under tension. If, in addition to these signs, the windings are also completely charred, it is conclusive evidence that the short circuit has continued for an appreciable period, not having been cleared quickly by the protective relays.

e) If the upper chamber of the Buchholz relay alone has tripped, check the insulation of core bolts, by applying a voltage of 230 V to 1000 V between the core and each bolt. If it fails, renew the insulating bush. Observe also all the joints, and tap-changer contacts, for over heating and arcing.

f) If the oil shows a low BDV, it does not necessarily mean that it has caused the breakdown. At high voltage ratings, excessive moisture content in the oil may result an internal flashover between the live parts and earths, which will leave corresponding tell-tale marks.

20217 Circuit Breakers and Interruptors.

The following types of circuit breakers and interruptors are now in use.

Circuit Breakers:

a) 220/132/110/66 KV Double pole
   - Minimum oil type
   - SF6 type
b) 25 KV single pole  
- Minimum oil type  
- SF 6 type  
- Vacuum type  
c) Interruptors  
- Bulk oil type  
- Minimum oil type  
- SF6  
- Vacuum type

Oil type circuit breakers/interruptors require considerable attention for maintaining satisfactory condition of the oil. In case of minimum oil type equipments frequent replacement of oil is necessary on account of service conditions. To overcome these limitations, SF-6 type and vacuum type circuit breakers and interruptors are now standardized.

Manufacturer's detailed instructions may be referred to for installation, commissioning, operation and maintenance for all types of breakers/interruptors. RDSO's additional instructions on maintenance and modifications to the circuit breakers/interruptors should also be followed. Some tips for the maintenance of circuit breakers and interruptors, in general, are given in the succeeding paragraphs.

20218 Guidelines for Maintenance of Circuit Breakers and Interruptors.

A. Minimum Oil Circuit Breakers.

1. Oil

When a circuit breaker trips the arc is extinguished by the oil and, therefore, the oil gets carbonized and contaminated. Although 25 KV traction circuit breakers are designed for 100 successive trippings or for short circuit currents upto 4000 A, without requiring replacement of oil, experience has shown that because of heavy contamination of oil, insulation level comes down rapidly even with 40 or 50 trippings. A record should, therefore, be maintained by the ATFO, based on TPC’s register/computer print out of the number of trippings of each circuit breaker since last attention. The CTFO/PSI should keep a watch over these figures and arrange to measure the BDV of oil samples at intervals to be decided in the light of experience. Oil shall be purified or replaced if the di-electric strength falls below the prescribed value.

2. Gaskets

During inspections, look for evidence of oil leaking out of bushings, tank body, etc. Slight oil leakage could occur due to (a) the mating surfaces are not perfectly flat (b) the gasket is not being quite free from dirt or extraneous matter (c) the gasket is not being properly compressed (d) gasket has lost its elasticity.

Leaky gaskets shall be attended to or replaced without delay, as they may allow moisture to get in and contaminate the oil.

3. Bushings

The porcelain exterior surfaces should be maintained in a perfectly clean and bright condition. Deposits of salt and industrial dust should be removed periodically so that there may be no possibility of flash-over. Where the
deposits are heavy a wet cloth may be used for wiping it off, falling which carbon tetra-chloride may be used. After removing the contamination the surfaces should be wiped out with a dry cloth so that the gloss on the surface is restored.

During inspection the insulator surface shall be very carefully examined all round for any fine surface cracks so that the damaged insulators may be replaced. If the chipping on bushing sheds is only very slight, replacement may not be necessary.

4. Internal Insulating Parts

Every time an oil circuit breaker is opened and oil has been drained out, all the interior parts including the bushing in the minimum oil type units or tank in the bulk of units should be thoroughly cleaned to remove all traces of carbon or sludge that may have adhered thereto. Thereafter, the parts should be first cleaned with dry non-fluffy cloth (never with cotton waste), then thoroughly flushed out with good oil and are assembled.

5. Contacts

It is essential for the contact surfaces to be properly aligned with sufficient area of contact and pressure between the contacts to ensure that when carrying full-load currents, the contacts remain quite cool. Badly pitted or burnt-out contacts should be replaced before they cause damage to other parts. If they are only rough, the surface irregularities should be smoothed out by touching up lightly with a clean line file taking care not to overdo it. Where the contact mechanism consists of main and secondary contacts, the main contacts do not normally require any maintenance, because the current is made or broken only at the secondary contacts. The main contacts should, however, be inspected for good condition and kept smooth and clean. The adjustment of contacts should be made in accordance with Maker’s instructions.

6. Operating Mechanism

Check whether the elastic mounting pads are in good condition and capable of absorbing the mechanical shocks during operation. The length of the breaker stroke should be measured and adjusted if necessary in accordance with the Maker’s instructions book. Ensure that the operating mechanism functions smoothly and freely through the entire stroke and without binding. Lubricate all pins and bearing surfaces with light oil and wipe off the excess. Ensure that all cotter pins are open and locking plate and nuts are in place and properly tightened.

The operating springs are quite powerful and when they are in the charged condition considerable energy is stored. Serious damage and injury to personnel may be caused if they are released inadvertently.

Parts which are scored or which show excessive wear should be replaced and adjustment should be made within the tolerances as indicated in the Maker’s instruction book.

The circuit breaker or interruptor is guaranteed to work satisfactorily between the specified voltage limits. During annual inspection check performance of interruptors and circuit breakers to ensure that they function properly at the lowest specified voltage for the operating coil. Measure and record the opening and closing times both at normal and minimum voltage.

7. Interlocks

Pay attention to the proper functioning of interlocks, both mechanical and electric, and particularly to auxiliary contacts, spring tension and screws, bolts, pins, etc. securing the contacts. Check that the wiring connections at terminal boards are properly secured.
B. SF 6 Circuit Breakers:

1. Gas System

The SF-6 gas in a pure state is inert, exhibits exceptional thermal stability and has excellent arc quenching properties as well as exceptional high insulating properties. Physical properties of SF-6 gas are indicated in the Annexure 2.05. There is very little decomposition of the gas after long periods of arcing. Such decomposition has virtually no effect upon dielectric strength and interrupting capability. The solid arc product formed by arcing is metallic fluoride which appears in the form of a fine gray powder which has high dielectric strength under dry conditions as existing in the breaker. A good quality absorbent is used in the apparatus to remove decomposed gaseous by-product. During the maintenance record gas pressure and temperature. Supply the gas if pressure is less than the prescribed value. Check setting of gas pressure switches.

2. Interrupting Unit

Clean the surface of the porcelain and other parts. Contacts should be inspected and replaced if necessary.
Renew the absorbent taking care that exposure of the absorbent to the atmosphere is minimal. The breaker should be evacuated as soon as possible.

3. Operating Mechanism

Check stroke from closed position to completely opened position and over stroke from completely opened position to stopped position. Check prescribed clearances. Relubricate moving parts. Check that pressure gauge is working correctly. Check pneumatic system for tightness.

The housing should be checked for water penetration and rust. Ensure that fasteners are not loosened. Check connections of control circuit wires for tightness.

C. Vacuum Circuit Breakers

Guidelines as indicated above in case of the other two types of circuit breakers in respect of operating mechanism and its housing and other components are generally applicable in case of vacuum circuit breakers also except the interrupting chamber and pneumatic circuit. As regards interrupting chamber (vacuum bottle) no maintenance as such is required to be carried out.

20219 Lead Acid Batteries

A battery is considered to be very vital equipment in the power supply installations and therefore, its proper maintenance is imperative.

On electrified sections batteries and battery chargers are installed at the following locations:-

1. Traction Sub-stations –
110 V 200 Ah. Lead acid cells for control, protection and indication circuits.

2. Switching Stations –
110 V or 72 V, 40 Ah. Lead acid batteries for operation of circuit breakers and interruptors and motor operated isolators.

3. Remote Control Equipment

Batteries of suitable voltage and capacity at remote control centre, traction sub-station and switching stations.
To reduce number of batteries at TSS/SS the remote control equipment is now being connected to the battery of TSS/SS

In all cases, mains operated battery chargers are provided with facilities for either trickle charge or boost charging. The rating of the battery charger should be related to the capacity of the battery.

**20220 Guidelines for Maintenance of Batteries.**

1. As the entire system of protection at a sub-station depends upon a sound battery it should always be in proper condition. It should under no circumstances be disconnected when the sub-station is in operation.

Batteries should be maintained keeping in view instructions of the manufacturer by a trained staff. The points to be observed during the inspections are summarized below –

   a. General condition of the battery room and cells
   b. Specific gravity of electrolyte in the cells
   c. Charging current
   d. Cell voltage
   e. Condition of the plates and extent of deposits
   f. Inter-cell connectors and main battery terminals

A detailed history of every battery should be separately maintained in which all relevant information is periodically entered. Fortnightly specific gravity readings should be taken and recorded in appropriate forms.

Smoking or the use of open flames or tools which may generate sparks is strictly forbidden in the battery room. The battery room should be well ventilated and dust free and should have acid proofing done on the walls and flooring. It should be kept isolated from other electrical equipment. Appropriate fuse protection for short circuit in the wiring between the battery and distribution switch board should be provided.

2. Specific Gravity

The specific gravity of the electrolyte should be maintained at about 1.210 at 27 degree C and when it drops to 1.150 the cell may be considered discharged. These values vary with the type of battery, temperature, age and working conditions.

Specific gravity is related to electrolyte temperature. For the purpose of test requirements, the fully charged specific gravity shall be 1.20 + 0.005 corrected to 27 degree C. Temperature correction hydrometer readings of specific gravity shall be made as follows (Ref. IS 1652)

   a) For each 1 degree C above 27 degree C add 0.0007 to the observed reading and
   b) For 1 degree C below 27 degree C deduct 0.0007 from the observed reading.

When the battery is first commissioned the specific gravity of the all cells would be almost equal. Subsequently during periodical inspections, variations in specific gravity may be observed due to unequal rate of evaporation. This should be corrected by adding distilled water. In no circumstances should concentrated or diluted sulphuric acid be added to any cell except when acid is known to have spilled out. Distilled water alone should be used for topping up the level.

**Hydrometer readings taken when a cell is gassing freely gives the specific gravity of a mixture of gas bubbles and**
electrolyte and not the true specific gravity of the electrolyte. The readings should therefore be taken after allowing all bubbles to subside. Hydrometer of reputed make should only be used. Hydrometers of 300 mm length are necessary to give required accuracy. Two hydrometer should always be maintained in a station and they should be periodically checked to see that they read alike.

3. Pilot Cells
One of the cells in each row of the battery set should be selected and kept as the pilot cell. Readings should be taken on these cells with sufficient frequency to indicate its state of discharge and charge and serve as a guide to the condition of the other cells. The pilot cell when once selected should not be changed unless the cell has to undergo special treatment or repairs in which case a note should be made immediately on record sheets. The height of the electrolyte in the pilot cell should invariably be kept at a fixed point (say 12mm) above the top of plats by adding distilled water every fortnight, if necessary.

4. Trickle Charging
Lead acid batteries are very sensitive to overcharging as well as under discharging. If over charged, the positive plates will shed their active material quickly. If kept in discharged condition for long, the plates will suffer ‘sulphation’ evidenced by appearance of whitish deposits on the plates. Prolonged charging at a very low rate after emptying the electrolyte and filling the cell with distilled water is sometimes useful if the sulphation is very light. However, there should be no occasion at all for any battery set used in stationery traction installations to be sulphated, as they are continuously on trickle charge. A long life for the battery is achievable if the battery is kept floating on a battery charger so that the terminal voltage of each cell is maintained close to 2.15 V.

This can be achieved if the battery is kept on a very low rate of charge, say, 1 milli-ampere per Ah capacity of the battery. The exact rate of charge should be fixed having regard to the normal and intermittent rates of discharge over a period of 24 hours, so that the battery is always kept in fully charged condition and never overcharged or over-discharged.

When a battery is being properly float-charged very small gas bubbles (about the size of a pin head) rise slowly from the plate to the surface of the electrolyte in batteries, that are being overcharged the bubbles are much larger and reach the surface at a higher rate.

5. Cell Voltage
The voltage of cell at the end of charger is not a fixed value but will vary depending on the age of the battery. The temperature, specific gravity of the electrolyte and charging rate. The voltage of new cells at the end of a full charge will be about 2.5 to 2.75 V when it is receiving charge at the 10 hour rate. This gradually decreases as the age of the battery increases until it comes down to 2.4 V with normal temperature and charging rate.

No cell should ever be discharged below the point where the cell voltage reaches 1.85 V as measured when the cell is discharging at the normal 10 hour rate.

It should be noted that the voltage of a cell gives an approximate indication of its state of charge (or discharge) only when it is being discharged, say at the 10 hour rate, and not when the cell is an open circuit.

Sulphated plates, lug corrosion, partial short circuit due to cracked separators and other defects of a lead-acid cell cause a noticeable drop in the terminal voltage with current flowing in the cell. This drop varies with the amount of current flowing and in order to get voltages that can be compared from month to month, the voltages should be taken with the same current flowing in the cell. The cell testing voltimeters in use should be periodically checked and recalibrated, if necessary. When not in use they should be kept in a safe place.

6. Condition of Plates and Deposits
The active material in the positive plates in healthy cells in use for more than 12 months (when fully charged) should
be chocolate in color and negative plates light or bluish grey according to age. The chief indications of weak cells are badly coloured plates, irregularity in gassing or entire failure to gas and a fall in voltage and specific gravity below that of other cells.

In new batteries, flakes of brown scale will be seen getting detached from edge of positive plates. This formation of scale is normal. Until all this scale is dispersed, the plate cannot be considered as stabilized. Sometimes pieces of this scale may lodge across adjacent negative plates and cause a partial short circuit. Such flaked pieces should be gently dislodged with a thin piece of wool and allowed to fall to the bottom of the cell. This scaling occurs only on the edges of the plates. The removal of the scales should be done very carefully so that the plates are not damaged.

Examine carefully the physical condition of the plates such as cracks, distortions, accumulation of whitish deposits, etc.

The color of the deposits gives a good indication of the state of health of the cells. Whitish deposit indicates undercharging leading to discharged condition. In healthy cells, the deposit is brown in colour but excessive shedding of active material for the positive plates indicates overcharging of the battery. If this is noticed, reduce the rate of charge immediately. If all the cells in a battery show whitish deposits immediate action should be taken to give a boost charge at an appropriate rate and then to increase the trickle charging rate sufficiently to keep the battery in a healthy condition all the time. Weak cells should be immediately examined for any possible short circuit or metallic contact between positive and negative plates. The short circuit should be removed and the cell should then be given special additional charging by cutting it out and putting it back again when a healthy condition is regained, after it is attended to.

7. Inter-Cell Connectors

The inter-cell connectors of the battery should be examined to ensure that they are clean and tight, making perfect contact with cell lugs and that no corrosion is taking place. Light viseline should be applied to prevent corrosion.

Inspection of copper inter-row connectors should also be made for any signs of copper sulphate corrosion which should be cleaned up. Acid-proof paint or enamel should be applied to all exposed copper work in the battery room and any flaking of paint work given prompt attention.

20221 Protective Relays

1. Each electrified division shall have specialist staff attached to the Central Repair Shop trained in the maintenance overhauling, testing adjustment and calibration of protective relays as well as indicating, integrating and recording instruments. Such specialist staff shall hold competency certificate No. TR-7 as explained in Chapter XII.

2. The Central Repair Shop should be fully equipped with necessary apparatus, instruments, tools and equipment for overhauling, testing and calibration of relays.

3. Each Supervisor responsible for maintenance and testing of protective relays should maintain a register in which full details regarding each relay should be entered. The details to be recorded are the type and serial number, PT & CT ratios, range of settings available, characteristic curves (where applicable), location where installed, schematic diagram of connections, normal settings and details of calculations for fixing the normal setting. Details of tests as well as repairs carried out should be entered in this register from time to time. These particulars should also be maintained in the office of Sr. DEE/TRD.

4. No alterations in the settings of protective relays should be carried out without the written authorization of Sr. DEE/TRD, who will submit proposals including detailed calculations for changes required, if any, for prior approval of CEE. Guidelines for setting of relays are given in the Appendix V.

5. The procedure for commissioning of protective relays has been given in Chapter IX.
6. The normal maintenance attention required for relays in service is generally as under –

a) It is essential to ensure that the cover gaskets are in good condition and the fixing screw quite tight, so that the instrument is dust-tight.

b) Manual operation to confirm that the relays do operate the trip circuits in the manner prescribed. These tests should be carried out by atleast at the level of AEE once in a year for all relays. Simultaneously visual checks on relay connections, condition of the trip battery, trip and alarm circuits, and also the dust-tightness of protective covers should be made. The relay cover should then be sealed. A record should be maintained showing the date and time this is done.

On each occasion when the seal is broken subsequently the reasons should be recorded in the log book.

c) Distance protection relay may be tested for calibration once in a year with primary injection set.

d) Secondary injection test - These should be done annually preferably before onset of busy season, making use of portable testing equipment and at the settings approved by the competent authority. Apart from testing the operation at the normal setting tests should also be carried out at other settings to make sure that the relay has the required characteristic.

e) Overhaul bench tests and calibration : These are necessary once in ten years of when a relay is not found functioning correctly. This work should invariably be carried out only in the Central Repair Shop by highly skilled technicians fully conversant with all details of construction and adjustment.

The bench tests and final calibration should be carried out after overhaul of the moving parts and measurement of coil resistance and other data. Transport of the relays to and from the Central Repair Shop also requires utmost care including locking of the moving parts and careful packing and handling. When laboratory tests are fully satisfactory, the relays should be sealed and date of overhaul painted on the outer cover of the relay.

20222 Guidelines for Maintenance of Switching Stations

The maintenance required for equipment in switching stations is more or less similar to that for traction sub-station equipment, except that traction transformers, circuit breakers and current transformers are not present and area is much smaller. However, the only additional but important item which requires attention is condition of the return feeder connection to all the rails (at the feeding posts). These return feeder connections are liable to be damaged by Permanent Way gangs in their normal work of packing and maintaining the permanent way. Supervisory officials, therefore, should stress the importance of these from the electrical point of view to the PWIs so that they in turn may warn their maintenance gangs not to damage the connections. In addition, the supervisory officials shall, during their periodical inspection, make it a point to inspect the return feeder rail connections and ensure that they are in excellent condition.

IV MAINTENANCE SCHEDULES

20223 Schedules of Inspection

1. In order to achieve high reliability and ZERO DEFECT, and to ensure effective checks on the maintenance work minimum schedules of inspections to be carried out each month by the TRD officers and Sr. Subordinates in charge of operation and maintenance of PSI equipments, are indicated at Annexure 2.01.

The schedule of inspections as indicated is the minimum quota to each official per month and should be independent of other tasks. They will not be of routine nature but shall be carried out in depth to identify:

i) Deficiencies and short comings.  
ii) Lack of skill amongst staff.
iii) Inadequacies in maintenance facilities.
iv) Constraints experienced
v) Conditions of environment, which lead to poor quality of work if any.

2. The inspecting officials should adjust their inspections in such a manner as to cover all of the installations in their jurisdiction within the stipulated periods and stagger the inspections among themselves to avoid over inspections of the some installations repeatedly in a very short time and neglect of other installations. A check list in brief for various inspections is given in the Annexure 2.02.

3. The items of attention listed hereunder at any particular periodicity are over and above those mentioned in the previous schedule. This should be kept in view while carrying out maintenance work.

4. The periodicity of the items of attention listed in the following paragraphs may be modified to suit local requirements with the approval of CEE.

5. As regards new equipments, if schedules have not been drawn up, tentative schedules may be evolved, based on the Original Equipment Manufacturer’s guidelines and RDSO’s recommendations, keeping in view the local conditions also and followed with the approval of CEE.

6. Schedules for maintenance of SF-6 type circuit breakers as recommended by one of the manufacturers are indicated in the Annexure 2.06. Schedules for maintenance of vacuum circuit breaker as recommended by one of the manufacturers are indicated in the Annexure 2.07. Schedules as indicated in the following paragraphs are for minimum oil circuit breakers.

20224 General
1. No work of any kind shall be commenced on or in the vicinity of live equipment unless power supply to the particular part has been switched off and all other prescribed safety measures taken.

2. To guard against the possibility of unauthorised interference and pilferage from unattended sub-stations and switching station, all electrical department staff shall be vigilant and watch for any such activity when they are in the vicinity. Surprise checks coupled with periodical inspections will also act as deterrents.

3. The TPC shall once a day check up communication to each of the grid sub-stations and obtain the maximum demand and energy consumption for the previous 24 hours and enter the figures in a register. Whenever inspecting staff visit the sub-station or switching stations, they shall contact the TPC on the telephone.

FORTNIGHTLY MAINTENANCE

20225 General Inspection by a PSI Supervisor

1. Go round the whole area of the sub-station; inspect for general cleanliness, proper drainage, road and rail access. The surface of the roadway and pathways in the sub-station should be firm and sufficiently elevated to prevent water logging. Remove any undergrowth of vegetation around the outer periphery; cut any tree branches likely to come in the vicinity of live lines.

2. If lubricating or transformer oil is stored, inspect for security and fire risk and see that no combustible material is in the vicinity.

3. Examine all “Caution”, “Danger”, “Shock Treatment” and other boards, whether they are clean and well secured. Inspect fire extinguishers, fire buckets and First Aid Boxes, if they are intact and serviceable.

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4. Inspect structure and plant foundations for any sinking or cracking. Go round the structural work for checking tightness of various bolts and nuts.
5. Inspect all indication lamps on control panels for correct working.
6. Carry out inspections as indicated at Annexure 2.01.

20226 Battery

1. Check all cells generally in accordance with para 20220.
2. Take specific gravity and cell voltage of pilot cell and record in register. If any significant change is noticed specific gravity and voltage for all cells should be taken to identify any weak cells. Then top up with distilled water exactly to the correct level for every cell.
3. Check operation of battery charger and note charging rate in register.

MONTHLY MAINTENANCE

20227 Bonding And Earthing

Visually inspect all earth connections and see that they are in order and that every equipment has duplicate earth’s. Tighten connecting bolts and nuts as necessary. Where the sub-station and feeding post are close by ensure that sub-station structures are properly bonded with the feeding post and the track by two independent connections.

20228 Oil Level in Transformers, Circuit Breakers, CTS etc.

Check oil level in sigh gauge glass and examine all joints, valves, plugs etc for oil leakage in each equipment; rectify leaky parts if found and restore the oil level.

20229 Insulators

Clean all insulators with dry cloth and look for any flashover marks, cracks, chippings. Insulators which are badly chipped should be replaced. Minor chippings can be rendered impervious to moisture by a light coating of Araldite or similar epoxy resin.

20230 Traction Transformers

1. Clean externally the tank, conservator, radiator, bushings, oil level indicator, gauges, etc with dry cloth.
2. Make a note in the Register of the maximum temperature of transformer oil on dial indicator; reset indicator.
3. Check explosion vent diaphragm for any damage and presence of oil
4. Check silica-gel breather. If turning pink in appearance, replace it with dry gel (blue color) and recondition the old silica-gel. If the silica-gel is too wet, check di-electric strength of transformer oil.
5. Check for gas collection, if any, in Buchholz relay.
6. Check for oil leakage on transformer body, conservator tank, oil drain valve and foundations. If leaking, take corrective action by tightening the bolts; replace gaskets, if necessary.
7. Check if heater in the marshalling box is functioning properly, and if all terminal connections are in order.
20231 Operating Mechanism of Circuit Breakers and Interruptors.

1. Open the cover of control box. Examine the interior and remove the accumulated dust, if any part of the interior is badly rusted indicating entry of moisture, find out the cause, plug the holes and repaint the rusted parts. Check in particular if the weather-proof gaskets are in good condition; if not, replace them to make the control box water-tight and dust-tight. Examine if the leading in pipe connections are properly bushed, sealed and water-tight. Check if all pins and checknuts are in place. Check also tie-rod nuts for tightness.

2. Operate the mechanism at least twice manually. Have it operated on remote control from RCC; keeping the control door open, observe whether the mechanism functions smoothly without any rubbing or obstruction, and also if the shock absorber functions properly when circuit breaker is tripped.

3. Examine the commutator of the motor and clean with muslin cloth. Examine carbon brushes and replace if necessary.

4. Check breather and breather holes for clogging.

5. Check gear-oil level in the mechanism and replenish it, if required

6. Check if heater is functioning properly

7. Check interlocks of the equipment and associated isolators.

8. Check local position indicator and remote semaphore indicator for operation. Observe for the correct operation of recording counter.

After complete checking, close the cover and test the breaker for operation under remote, local and manual control.

20232 Isolators

1. Manually operate isolator several times and observe if it operates smoothly and correctly. Check interlocks and integral lock, lubricate moving parts as necessary with appropriate lubricant.

2. If isolator is motor-operated, check commutator of motor and clean with dry mull cloth, and check carbon brushes for proper bedding and wear. Check if motor is working smoothly, clean limit-switch and auxiliary switch contacts and check tightness of wiring connections. Examine contactor box and signal box; clean thoroughly and lubricate all gears, shafts, bearings contact etc.

20233 Busbars, Clamps and Connectors

Immediately after switching off the power supply and earthing the lines, feel by hand all connectors and clamps on busbars and equipment terminals which carry heavy currents to see if they are too hot. If any connection is too hot, it indicates poor contact. Open up the connector; carefully clean the contact surfaces, touch up the high spots on the contact surfaces so that the mating surfaces bed well together; apply a very light coat of viseline, refit and tighten up. Wherever applicable, replace bimetallic strip.

20234 Control and Relay Panels.

1. Make a note of flag indications, if any, then reset.

2. Check if all indicating and recording instruments are working normally and the pointers are not sticky.

3. Note and record in the Register the ranges of voltage and current variations during a 15 minute period at the time of the day when inspection was carried out. Abnormal voltage or current should be noted for corrective action.

4. Clean the panels externally.
QUARTERLY MAINTENANCE

20235 Batteries and Battery Chargers

1. Take specific gravity and cell voltage of every individual cell and enter in the register.

2. If the battery is not in a fully charged condition, boost charger should be given as required and trickle charging rate increased to the extent required. This should only be done by a supervisory official after investigating the causes for excessive discharge.

3. Make a general examination of battery charger. Check earth connection to the body.

20236 PTs and CTs

These should be maintained generally on lines similar to that of traction transformers except for items which do not obviously apply. In addition, for PT check the fuse holders on the LV side to see if they are in order.

20237 Booster Transformers

a) Replace or recondition silica-gel breather, if necessary.
b) Check earthing connections from bottom of structure to the earth electrodes or to the rails, Check the availability of duplicate earth strip and its proper connection.
c) Check all caution boards, name plates and anti-climbing devices for proper condition
d) Check foundation for any sinking or cracking : Check all structure bolts and nuts for proper condition.

Annual maintenance and periodical overhaul are to be carried out, generally as indicated for the traction transformer.

20238 Auxiliary Transformers

1. Measure insulation resistance of transformer winding and record values alongwith temperature.

2. Test a sample of oil for BDV

3. Check that the 25 KV fuse-holder out freely on raising the spring latch. Check rod gap setting. Measure earth resistance of neutral conductor.

Annual maintenance and periodical overhaul are to be carried out, generally as indicated for the traction transformers.

HALF YEARLY MAINTENANCE

20239 General

CTFO/PSI should visit the grid sub-station and ascertain whether any significant change in the EHV grid network has occurred during the past six months or are expected shortly.

20240 Traction Transformers

1. Test oil sample from tank bottom for crackle test, acidity and BDV,. If BDV is below the prescribed value, oil should be dried out.

2. Check whether the rod gap settings on bushings of transformers are in order, as per Maker’s drawing.
3. Measure and record insulation resistance of all windings to earth and other windings with a
2500 V megger, along with temperature of windings and ambient temperature.

4. Check all alarm and trip devices for proper functioning.

20241 Isolators

1. Observe for any signs of overheating and check the wipe of contact blades. Clean blade tips
and fixed-contact fingers and lightly wiseline the contact making surfaces.

2. Clean all articulated joints, sliding and bearing surfaces thoroughly.

3. Check all split pins, lock nuts and check nuts for proper condition.

4. Check for correct setting and alignment of arcing horns.

5. Operate the isolator slowly, check for simultaneous operation of the blades on the poles and
correct alignment of blade tips in the fixed contact jaws of the ples. Adjust if required to ensure that
the blades are fully horn between the contacts when handle is in closed position.

6. Check locking arrangements.

20242 Control and Relay Panels.

1. Check tightness of all connections, remove cobwebs and wipe off accumulated dust with dry
cloth.

2. Check if tap and time settings of the relays are in order.

3. Examine fuses for signs of overheating or aging, springiness and cleanliness of contact
making parts. Clean up and lightly wiseline to ensure proper contact.

YEARLY MAINTENANCE

20243 General.

1. Inspect the fence all-round the sub-station and bonding between metal fencing panels and to
earth. Put a drop of oil in the hinges of all doors. Repaint any of the structural parts as necessary.

2. Open all the trench cover and clean them completely. Clean all culverts and remove
cobwebs; check possibility of lizards or other inspect gaining entry into enclosed control equipment,
and make them insect-proof.

3. Arrange for painting of walls and metal-works as necessary.

4. Check all explosion vent disphragms for any damage.

5. Check rod gap setting.

20244 Lightning Arrestors

1. Check earthing terminals and earth strips for proper condition. Check connection to the line.

2. Where lightning arrestors are provided with discharge counters, record the counter reading.
20245 Bonding and Earthing

1. Check physically the soundness of bonding and earthing connection to every electrical equipment, structural steel, lightning arrestor etc. and inter-panel connections.

2. Record earth resistance to body of electrical equipment as well as to all parts of the fencing and structural steel work.

3. Check if the terminations of the overhead shield wire covering the whole sub-station are in good physical condition and properly bonded electrically to the structures.

4. Check and record resistance of each group of earth electrodes, after disconnecting it from common earth system. Improve, if necessary.

5. Check condition of connections to the buried rails.

20246 Traction Transformers.

1. Send samples to approved laboratory for all tests listed at Annex. 2.03B (IS 1866) including dissolved gas analysis.

2. Check oil level in bushing

3. Inspect bushing gaskets for leaks and tighten bolts.

4. Move the tap-setting switch up and down the full range a few times so that by self-wiping action good contact is assured. Set the tap finally at the correct position making sure that tap-indication corresponds to position of main contacts.

5. Paint transformer tank on such parts as required.

20247 Isolators

1. Smoothen burrs, if any on the blade tips and fixed contact fingers with fine emery paper and smear wiseline.

2. Measure clearance of blade in open position and record and adjust crank mechanism, if found necessary.

3. Check the adjustable stop set-screws for proper condition and correct positioning.

4. If the isolator is motor-operated, measure and record insulation resistance of motor windings and contactor coils using a 500 V megger.

20248 Bus Bars and Connectors

Measure with a ‘Ductor’ or other low resistance measuring instrument the contact resistances of all connections which are carrying heavy current.

20249 Control and Relay Panels

1. Carry out maintenance on relays as detailed in para 20221.

2. Check and clean up control switches and push-button contacts for burnt or corroded marks; polish the surfaces. Check also if the contact springs have the correct springiness.
20250 Batteries and Battery Chargers

IF the battery is not in a healthy condition or if there is excessive accumulation of sediment, the whole battery should be replaced with a new set.

Battery Charger

Open out the covers of the battery charger and blow out all dust. Check tightness of all connections, bolts, Nuts and screws. Measure and record the insulation resistance of the transformer windings of the battery charger with 500 V megger.

20251 PTs and CTs

1. Test oil samples if possible.
2. Check rod gap setting, if provided
3. Measure insulator resistance.
4. Check conditions of fuses of PTs and terminal connections for CTs.

20252 Special Maintenance Schedules for Minimum Oil Circuit Breakers and Interruptors.

This schedule will apply to minimum oil circuit breakers and interruptors with the following proviso:

132 KV CBs - 6 trippings on fault
25 KV CBs - 30 trippings on fault
25 KV Interruptors - 250 openings on normal current for minimum oil type and 500 openings on rated current for bulk oil type.

a) Open the extinction chamber, examine the contact-rod arcing-tie, upper and lower contact fingers and fixed arcing-contacts for burring or putting. Check contact springs for loss of temper, breaks or other deterioration; replace wherever necessary. Remove any beads of fused metal from arcing-tips and clean pitted surfaces. Change the contacts when the wear reaches the limits prescribed by the manufacturer. Tighten up all bolts and current carrying parts. Check contact rod for correct alignment and setting.

b) Test oil samples for BDV. If it falls below the prescribed value the oil should be purified or replaced.

c) Clean the explosion chamber with dry and clean cloth. Remove the carbon deposits if any; wash out all traces of moisture from all parts with fresh oil having high dielectric strength and refill with good oil.

d) In addition, the operating mechanism of circuit breakers and interruptors should be attended to annually as under:

1. Lubricate bearing surfaces of rollers, bearings and sliding surfaces with good quality machine oil. Since oil tends to collect dust and dirt, if should be used sparingly and any surplus should be wiped off with a clean cloth.

2. See that all links and levers move freely. Operate the mechanism slowly by hand to see that all parts move freely and no undue friction is noticeable. Observe the mechanism to see that everything is in working order.
3. Check all pins, latches, etc. for binding and misalignment. Check latch carefully to see that is not getting worn so as to cause unlatching from vibration or sticking and failure to trip.

4. Check that the mechanism operates with 80% of the nominal operating voltage. Check and record the insulation resistance.

5. Observe operation of trip coil during electrical trippings and the plunger for fast action and freedom from any stickiness. The plunger should have sufficient travel to ensure an adequate impact that will positively release the breaker latch. Check insulation resistance of the coil.

6. Check if the breaker mechanism operates smoothly and freely without binding. Check that the contact rod is not binding against its guide.

7. Wash out bearings, pivots, etc. with carbon tetra-chloride if they are dirty, and lubricate very lightly.

8. Examine the accelerating spring and see that adjusting nuts are locked tight.

9. Measure the length of the breaker stroke and check and adjust in accordance with Manufacturer’s instructions.

10. Check opening and closing position of the auxiliary contacts with respect to the main contacts. Adjust where necessary. Check the condition of the contacts and refinish with fine file if burnt or corroded. Ensure that good contact is made without excessive friction. Check operating rods and levers to ensure that they are secure and move freely. Smear auxiliary contact surfaces lightly with wiseline or petroleum jelly. Drain oil from gear box of the spring charging motor and refill to correct level with the right grade of oil. Measure the duration for which the motor runs to charge the spring and compare with Maker’s instructions.

20253 Pre-Monsoon Check

Before onset of monsoon season, it should be ensured that for every equipment no scheduled maintenance work is overdue. In the scheduled inspection just preceding the monsoon, special attention should be paid to the vulnerable points likely to permit ingress of moisture resulting in reduction in dielectric strength of the equipments and rusting of parts.

20254 Overhaul Schedule for Equipment

1. Transformers in case of an internal fault or once in 7-10 years.

2. Operating mechanism of circuit breaker and interruptors. Once in 10 years or as and when any major part like springs have To be replaced or the mechanism is sluggish, and needs shop attention and overhaul.
Annexure 2.01
(Para 20202, 20223)

SCHEDULE OF MONTHLY INSPECTIONS.

<table>
<thead>
<tr>
<th>SN.</th>
<th>Nature of Inspection</th>
<th>Sr. DEE</th>
<th>DEE</th>
<th>AEE</th>
<th>CTFO*</th>
<th>TFO*</th>
<th>ATFO*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Traction sub-station</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>Switching stations</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>PSI Depots</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4.</td>
<td>Grid Sub-station</td>
<td>2 in a Yr.</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Office Insp.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes:

1. These inspections are the minimum quantum per month
2. * In respect of Supervisory staff, the inspections pertain to their respective jurisdiction
3. Check lists of items to be broadly covered are indicated at Annexure 2.02. The maintenance schedules prescribed should also be kept in view.
4. Quota of inspections by HQ officers may be laid down by CEE.
CHECK LIST FOR INSPECTIONS

1.0 PSI depots including Subordinate Offices

a) OHE/PSI Depots

Check

1. Staff grievance register
2. Quarter Register.
3. Attendance register
4. Cleanliness of depot
5. Upkeep of stores.
6. Stock position in Stores
7. Compliance of audit & account inspection notes.
8. Test & Trial report
9. Availability of latest and specifications
10. Planning and Progress of Section works.

b) Subordinate Office:

Check

1. Attendance register.
2. Compliance of audit & account inspection notes.
3. Compliance of officer’s inspection notes.
4. Test & Trial report
5. Availability of Drgs. And specifications.
6. Progress & Planning of section works.

2.0 Inspection of Grid Sub-station.

1. Be on look out for any modifications made/being made in the power supply arrangement.
2. Check up if there is any equipment under breakdown which is likely to increase risk of interruption. In power supply to traction.
3. Note down meter readings and scrutinize and record important data regarding power supply parameters including daily. MD, variation in voltage, frequency and power factor.

3.0 Inspection of Traction Sub-Station.

a) Switch Yard:

Check

1. For vegetation growth and spreading of pebbles.
2. Painting of fencing and equipments.
3. Condition of cable trenches & trench covers.
4. Condition of approach road.
b) Power Transformer:
Check
1. OTI and WTI temperature – present and maximum readings.
2. Oil level in conservation tank
3. Tap changer position of standby & service transformer.
4. For abnormal humming.
5. Colour of silica gel.
6. For leakage of oil on transformer body, conservator tank, oil drain valve and radiator.

c) Circuit Breaker and Interruptors
Check
1. Control box gaskets for water and dust tightness.
2. Operation by local & remote control.
3. Operating mechanism for smooth operation
4. Oil level and leakage.
5. Closing time of interruptor.
6. Number of trippings since last replacement of oil in case of circuit breaker and counter reading of interruptor.

d) PT, CT, AT.
Check
1. Leakage of oil

e) Isolator.
Check
1. Locking arrangements.
2. For correct alignment of blade tip in the fixed contact jaws.
3. For correct matching & alignment of arcing horns,

f) Control Panel
Check
1. Fuses for the correct size, overheating or aging sings.
2. For loose connections at terminal boards.
3. Functioning of Alarms and visual indication on control panel.
4. Functioning of auxiliary relays.

g) Battery charger & Batteries.
Check
1. Acid level
2. Presence of sedimentation
3. Specific gravity & voltage of pilot cell
4. Presence of sulphation and tightness of inter cell connectors.
5. Size of fuses of battery charger.
6. Voltmeter and ammeter readings.

h) Energy meter
Check
1. Recorded maximum demand.
2. Condition of the seal.

i) Earthing
Check
1. Soundness of earth connection to each electrical equipment and structure.
2. Last recorded earth resistance readings.

j) Remote Control Equipment
Check
1. General function of relays and selectors.
2. Wiring for loose connection if any.
3. For presence of dust & condition of cubicle gaskets.

k) General
Check
1. Availability of fire buckets, Respiration chart, First Aid Box, Tools & Plants.
2. Working of TPC Phones and emergency sockets.
3. Inspection register and remarks made therein
4. History sheets of various equipments.

4.0 Switching Stations

a) Switch yard.
Check
1. For vegetation and spreading of Pebbles.
2. Painting of fencing and equipments
3. Condition of cables trenches & trench cabins.

b) Interruptors
Check
1. Control box gaskets for water and dust tightness.
2. Operation by local & remote control.
3. Operating mechanism for smooth operation.
4. Oil level & leakage.
5. Interlocking of interruptors and under voltage relay operation at SP.

c) PT & AT
Check 1. Leakage of oil

d) Isolator
Check 1. Locking arrangements
2 For correct alignment of blade tips, in the fixed contact jaws & alignment of arcing horns.

e) Battery charger & Batteries.
Check 1. Acid level.
2. Presence of sedimentation
3. Specific gravity & voltage of pilot cells.
5. Size of fuses of battery charger.

f) Earthing
Check 1 Soundness of earth connection to each electrical equipment & structures.
2 Last recorded earth resistance readings.

g) General
Check 1 Availability of fire buckets, respiration chart, First Aid Box, Tools & Plants.
2 Inspection register and remarks made therein
3 History sheets of various equipments.
### SOME IMPORTANT CHARACTERISTICS OF NEW OIL WHEN TESTED AT THE MANUFACTURER’S WORKS

*Ref. : IS 335*

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Characteristics</th>
<th>Test Method</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Appearance</td>
<td>A representative sample in 100 mm thick layer</td>
<td>The oil shall be clear and transparent, free from suspended matter or sediments</td>
</tr>
<tr>
<td>2.</td>
<td>Electric strength (break down voltage)</td>
<td>IS:6792-1972</td>
<td>Min. 30 kV (rms)</td>
</tr>
<tr>
<td></td>
<td>a) New Unfiltered Oil</td>
<td>IS:6103-1971</td>
<td>35 x 10&lt;sup&gt;12&lt;/sup&gt; Ohm-cm</td>
</tr>
<tr>
<td></td>
<td>b) After filtration</td>
<td>IS:6262-1971</td>
<td>1500 x 10&lt;sup&gt;12&lt;/sup&gt; Ohm-cm</td>
</tr>
<tr>
<td>3.</td>
<td>Resistivity at</td>
<td>Min.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) 90 °C</td>
<td>IS:6103-1971</td>
<td>35 x 10&lt;sup&gt;12&lt;/sup&gt; Ohm-cm</td>
</tr>
<tr>
<td></td>
<td>b) 27 °C</td>
<td>IS:6103-1971</td>
<td>1500 x 10&lt;sup&gt;12&lt;/sup&gt; Ohm-cm</td>
</tr>
<tr>
<td>4.</td>
<td>Dielectric dissipation factor (tan delta) at 90 °C</td>
<td>IS:6262-1971</td>
<td>Max. 0.002</td>
</tr>
<tr>
<td>5.</td>
<td>Water content</td>
<td>Appendix E of IS:335-1983</td>
<td>Max. 50 ppm</td>
</tr>
<tr>
<td>6.</td>
<td>Interfacial tension at 27 °C</td>
<td>IS:6104-1971</td>
<td>Min. 0.04 N/m</td>
</tr>
<tr>
<td>7.</td>
<td>Flash point</td>
<td>IS:1448</td>
<td>Min. 140 °C</td>
</tr>
<tr>
<td>8.</td>
<td>Dissolved gas content</td>
<td></td>
<td>4-8%</td>
</tr>
<tr>
<td>9.</td>
<td>Neutralization value</td>
<td>IS:1448</td>
<td>Max. 0.03 mg KOH/g</td>
</tr>
<tr>
<td></td>
<td>a) Total acidity</td>
<td>-do-</td>
<td>Nil</td>
</tr>
<tr>
<td></td>
<td>b) Inorganic acidity/alkalinity</td>
<td>-do-</td>
<td>Nil</td>
</tr>
</tbody>
</table>
### APPLICATION AND INTERPRETATION OF TESTS ON TRANSFORMER OIL IN SERVICE

(Ref. : IS 1866)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Tests</th>
<th>Value as per IS:1866</th>
<th>Permissible limits</th>
<th>To be re-conditioned</th>
<th>To be replaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Electric Strength (Breakdown voltage)</td>
<td>Min</td>
<td>Less than the value specified in Column 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Below 72.5 kV</td>
<td>30 kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>72.5 kV and less than 145 kV</td>
<td>40 kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>145 kV and above</td>
<td>50 kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Specific resistance (Resistivity) Ohm/cm at 27 °C</td>
<td>above 10 x 10^12</td>
<td>Between 1 x 10^12 to 10 x 10^12</td>
<td>Below 1 x 10^12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Below 145 kV</td>
<td>25 ppm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Above 145 kV</td>
<td>35 ppm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Water content</td>
<td>Max</td>
<td>Greater than the value specified in Column 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Below 145 kV</td>
<td>25 ppm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Above 145 kV</td>
<td>35 ppm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Dielectric dissipation factor, Tan delta at 90° C</td>
<td>0.01 or less</td>
<td>Above 0.01 to 0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>less</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Neutralization value mg KOH/g of oil</td>
<td>0.5 or less</td>
<td>Above 0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>less</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Interfacial tension N/m at 27° C.</td>
<td>0.02 or more</td>
<td>0.015 and above but below 0.02</td>
<td>Below 0.015</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>or more</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Flash point in °C</td>
<td>140 or more</td>
<td>125 and above but below 140</td>
<td>Below 125</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>more</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Sludge</td>
<td>Non-detectable</td>
<td>Sediment</td>
<td>Perceptible Sludge</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Dissolved Gas Analysis (DGA)</td>
<td>Refer Annex. 2.04</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
GUIDELINES FOR CONDITION MONITORING OF TRACTION POWER TRANSFORMER BY DISSOLVED GAS ANALYSIS (DGA) TECHNIQUE

(Reference RDSO’s circular No. ETI/PSI/M/4 dated 5.2.91)

1.0 Introduction

1.1 Dissolved gas analysis (DGA) is a powerful diagnostic technique for monitoring the internal condition of transformer as it is capable of detecting faults in the incipient stage, before they develop into major faults and results in the outage of the transformer. The conventional Buchholz Relay is universally used in transformers to protect against severe damages. However, its limitation is that enough gas must be generated first to saturate the oil fully and then to come out or there should be a gas surge to operate this relay. Moreover, Buchholz Relay is never meant to be a diagnostic device for preventive maintenance of transformers.

1.2 The DGA technique is very sensitive as it detects gas in parts per million (ppm) of the oil by use of the GAS Chromatograph, it is possible to check whether a transformer under service is being subjected to a normal aging and heating or whether there are incipient defects such as Hot Spots, Arcing, Overheating or Partial discharges. Such incipient faults otherwise remain undetected until they develop into a major failure.

2.0 Formation of Gases in Oil Filled Transformers.

2.1 It is well known that insulating oil in high voltage equipments can break down under the influence of the thermal and electrical stresses to produce hydro-carbon gases, hydrogen and carbon oxides. Gases may be formed in transformers and other high voltage oil filled equipment due to aging and to a greater extent as a result of faults. The accumulation of gases in transformer oil may be sudden due to a severe arcing fault or more gradual as in the case of slow deterioration of insulation. The principle mechanism of gas formation in a transformer tank can be classified as under:

A. Oxidation b) Vapourisation, c) Insulation decomposition d) Oil breakdown e) Electrolytic action

2.2 Oxidation
Carbon dioxide is the gas predominantly liberated during the process of oxidation. The process begins when small quantities of oil combine chemically with the dissolved oxygen in the oil resulting in formation of traces of organic acids. These acids react with the metal of the transformer, forming metal based soaps which dissolve in the oil and act as a catalyst to accelerate the process of oxidation.

2.3 Vapourisation
The vapourisation of oil occurs at about 280 degree C while that for water occurs at about 100 degree C. The false alarm of a Buchholz relay may be attributed to the fact that the condensation of water vapour takes place when the excess moisture in the tank is vapourized by a heat source. False alarm can also occur, when hydro-carbons, the constituents of the insulating oil, vapourize.

2.4 Insulation Decomposition
The solid insulants in power transformers are mainly of cellulose or resinous type, viz. Paper, press board, cotton, resins and varnishes. These substances contain in their molecular structure substantial amounts of oxygen, cabin and hydrogen. In the temperature range of 150 degree C to 400 degree C the insulation breakdown results in liberation of hydrogen, carbon dioxide and carbon monoxide. Above 400 degree C the gases formed are relatively less.

2.5 Oil Break Down
The direct break down of oil by arcing results in cracking of the oil. The aromatic contents breakdown into simple
hydro carbon gases and hydrogen. Acetylene and methane are the major constituents. Other hydrocarbon gases may also be liberated due to cracking. If the necessary temperature is maintained for their stable formation.

2.6 Electrolytic action

Hydrogen and oxygen are liberated during electrolytic action. Presence of minute and small particles of fibres within the oil leads to electrolytic action. Light hydrocarbon gases may also be present. If solid insulation is involved.

3.0 Types of Fault Conditions

There are three main types of fault viz. Overheating of windings, core and joints, partial discharges, and arcing.

3.1 Overheating

Overheating metallic parts heat up the surrounding regions such as paper insulating tapes and oil. This leads to thermal deterioration of these materials. Thermal degradation of paper produces carbon dioxide. Carbon monoxide and water. The ratio of carbon dioxide to carbon monoxide is typically five, but if the ratio falls below three, there is indication of severe overheating of the paper. Oil degradation produces a number of hydrocarbon gases such as methane, ethane, ethylene, and acetylene. Methane and ethane are decomposition products that appear above 120 degree C ethylene appears above 150 degree C while acetylene is a high temperature product, appearing at several hundred degrees centigrade. Some hydrogen is also produced along with the hydrocarbons gases. The proportion of the various hydrocarbons varies with temperature. This is the basis of the well known Ratio code introduced several years ago by Dorenberg and R.R. Rogers.

3.2 Partial Discharge

The second type of fault condition is partial discharge which occurs due to ionization of oil in highly stressed areas where gas/vapour filled voids are present or the insulation is continuing moisture. The main product during particle discharge is hydrogen, though small amounts of methane and other gases would also be present depending upon thermal digression. The disintegration of oil and cellulose due to particle discharge is characterized by the removal of the outer hydrogen atoms to form hydrogen gas. The remaining molecular framework polymerizes and long chain products such as waxes are formed. Thermal degradation is a more predictable phenomenon which involves the break up of chemical bonds. Cellulose decomposes ultimately to CO, CO2 and water; oil break up into lower molecular hydro carbons.

3.3 Arcing

The third type of fault condition is arcing. Arcing can occur between leads, between lead and coil and between other highly stressed regions weakened by fault conditions. The high temperature caused by arcing results in the production of acetylene and hydrogen.

3.4 Pattern of generation of gases in transformer is summarized below:

<table>
<thead>
<tr>
<th>FAULT/PATTERN</th>
<th>KEY GAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor Overheating</td>
<td>CO/CO2 (carbon oxides)</td>
</tr>
<tr>
<td>Oil overheating</td>
<td>C2H2 (Ethylene)</td>
</tr>
<tr>
<td>Particle discharge</td>
<td>H2 (Hydrogen)</td>
</tr>
<tr>
<td>Arcing</td>
<td>C2H2 (Acetylene)</td>
</tr>
</tbody>
</table>

4.0 Solubility of Gases.

4.1 The solubility of gases in oil varies with temperature and pressure. While solubility of H2, N2, CO, O2 in
oil increases with temperature and that of CO2, C2, H2, C2 H4 and C2 H6 decreases with temperature, solubility of CH4 remains essentially constant.

All the gases become more soluble in oil with increase in pressure. Solubility of gas is one of the factors contributing to the complexities in formulating permissible levels of gases on the basis of service life of a transformer. Table I show solubility of different gases 25 degree C and at 1 atm. The homogeneity or the gases in the oil is dependent on the rate of gas generation, access of the fault area to flowing oil, rate of oil mixing and presence of gas blanket.

5. Dissolved Gas Analysis (DGA)

5.1 Dissolved gas analysis (DGA) of the oil of a transformer in operation is a specialized technique to assess the internal condition of the transformer. DGA is performed by Gas Chromatography. The gases extracted from the oil by a suitable apparatus are transferred to the Gas Chromatograph system for analysis.

5.2 The knowledge of solubility of Hydro-carbon and fixed gases at different temperatures, in insulating oils helps in interpretation of gas analysis. The permissible concentration of dissolved gases in the oil of healthy transformer is shown in table II. The combinations of Gas levels for different types of faults are shown in Table III while table IV shows the gas composition by volume under arcing fault with participation of various components of solid dielectrics in a transformer.

5.3 While the absolute concentration of fault gases gives an indication of status of insulation of transformer, whereas the relative concentration of these gases provides a clue to the type of fault. For fault diagnosis the method based on Rogers ‘Analysis is adopted.

5.4 Ropger’s method:

This method hold good for hydro carbon gasses. By evaluating the gas ratios, the type of fault is detected. Four ratios are used viz. Methane/Hydrogen, Ethane/Methane, Ethylene/Ethane and Acetylene/Ethylene. The value of ratios can be greater or smaller than unity. The ratio and type of fault represented by that ratio are given in Table V.

6.0 Data Collection and Analysis.

6.1 It is recommended that DGA be performed irregularly once a year on every transformer upto 4 years of service and thereafter twice a year upto 10 years and the frequency thereafter may be increased to thrice a year.

Note: Wherever the Buchholz relay operates, the dissolved gas analysis be carried out immediately after operation of the relay to ascertain the cause of fault.

6.2 The results of the DGA for each transformer should be built into a data and based on the trend of the gas levels over a period of time as well as the faults, if any, that the transformer had suffered, an analysis may be done to establish the exact nature of the incipient fault that may be developing in the transformer.
**TABLE I**

SOLUBILITY OF DIFFERENT GASES IN TRANSFORMER OIL AT 25 DEGREE C 1 atm

<table>
<thead>
<tr>
<th>Gas</th>
<th>Volume %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>7</td>
</tr>
<tr>
<td>Oxygen</td>
<td>16</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>8.6</td>
</tr>
<tr>
<td>Argon</td>
<td>15</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>9</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>120</td>
</tr>
<tr>
<td>Methane</td>
<td>30</td>
</tr>
<tr>
<td>Ethane</td>
<td>280</td>
</tr>
<tr>
<td>Ethylene</td>
<td>280</td>
</tr>
<tr>
<td>Acetylene</td>
<td>400</td>
</tr>
<tr>
<td>Propylene</td>
<td>400</td>
</tr>
<tr>
<td>Propane</td>
<td>1900</td>
</tr>
<tr>
<td>Butane</td>
<td>4000</td>
</tr>
</tbody>
</table>

**TABLE II**

RANGE OF GAS LEVELS
(All concentrations are in PPM)

<table>
<thead>
<tr>
<th>Gas</th>
<th>0-4 years</th>
<th>4-10 years</th>
<th>10 years.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>10-30</td>
<td>30-80</td>
<td>30-130</td>
</tr>
<tr>
<td>Ethane</td>
<td>10-30</td>
<td>30-50</td>
<td>30-110</td>
</tr>
<tr>
<td>Ethylene</td>
<td>10-30</td>
<td>30-50</td>
<td>50-150</td>
</tr>
<tr>
<td>Acetylene</td>
<td>10-16</td>
<td>10-30</td>
<td>10-40</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>20-150</td>
<td>150-300</td>
<td>200-500</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>200-300</td>
<td>300-500</td>
<td>500-700</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>3000-4000</td>
<td>4000-5000</td>
<td>4000-10,000</td>
</tr>
</tbody>
</table>
### TABLE III

**GAS LEVELS FOR DIFFERENT FAULT CONDITIONS**

<table>
<thead>
<tr>
<th>Fault Conditions</th>
<th>Hydrogen $H_2$</th>
<th>Methane $CH_4$</th>
<th>Ethane $C_2H_6$</th>
<th>Ethylene $C_2H_4$</th>
<th>Acetylene $C_2H_2$</th>
<th>Carbon dioxide $CO$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arcing</td>
<td>500-1000</td>
<td>20-130</td>
<td>10-30</td>
<td>10-30</td>
<td>40-100</td>
<td>3000-4000</td>
</tr>
<tr>
<td>Partial Discharge</td>
<td>500-1000</td>
<td>20-130</td>
<td>10-30</td>
<td>10-30</td>
<td>10-15</td>
<td>3000-4000</td>
</tr>
<tr>
<td>Hot Spot</td>
<td>20-150</td>
<td>10-30</td>
<td>10-30</td>
<td>150-200</td>
<td>10-15</td>
<td>3000-4000</td>
</tr>
<tr>
<td>Gradual Overheating</td>
<td>20-150</td>
<td>10-30</td>
<td>150-200</td>
<td>10-30</td>
<td>10-30</td>
<td>3000-4000</td>
</tr>
</tbody>
</table>

### TABLE - IV

**GAS COMPOSITION BY VOLUME (%) WITH REFERENCE TO VOLUME OF OIL DUE TO ARCING FAULTS**

<table>
<thead>
<tr>
<th>Insulation</th>
<th>$H_2$</th>
<th>CO</th>
<th>CO$_2$</th>
<th>CH$_4$</th>
<th>C$_2$H$_6$</th>
<th>C$_2$H$_4$</th>
<th>C$_2$H$_2$</th>
<th>O$_2$</th>
<th>$H_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil only</td>
<td>60</td>
<td>0.1</td>
<td>0.1</td>
<td>3.3</td>
<td>0.05</td>
<td>2.1</td>
<td>2.1</td>
<td>2.4</td>
<td>6.3</td>
</tr>
<tr>
<td>Oil/Kraft paper</td>
<td>52</td>
<td>14</td>
<td>0.2</td>
<td>3.8</td>
<td>0.05</td>
<td>8</td>
<td>12</td>
<td>3</td>
<td>6.7</td>
</tr>
<tr>
<td>Oil/Press board laminate</td>
<td>48</td>
<td>27</td>
<td>0.4</td>
<td>5</td>
<td>-</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>6.2</td>
</tr>
<tr>
<td>Oil, Alkyl paint</td>
<td>55</td>
<td>20</td>
<td>0.2</td>
<td>4</td>
<td>-</td>
<td>5</td>
<td>8</td>
<td>2.4</td>
<td>7</td>
</tr>
<tr>
<td>Oil/Polyurethane enamel</td>
<td>60</td>
<td>1</td>
<td>0.1</td>
<td>9</td>
<td>-</td>
<td>11</td>
<td>10</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Oil/P.V.A enamel</td>
<td>61</td>
<td>5</td>
<td>0.1</td>
<td>6.0</td>
<td>-</td>
<td>14</td>
<td>5</td>
<td>2.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Oil/Epoxy glass clothes</td>
<td>57</td>
<td>2</td>
<td>0.1</td>
<td>14</td>
<td>-</td>
<td>10</td>
<td>8</td>
<td>2.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Oil/Isophthalate Cotton tape</td>
<td>55</td>
<td>11</td>
<td>4</td>
<td>8</td>
<td>-</td>
<td>8</td>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
TABLE V  
ROGER's METHOD OF DIAGNOSIS BY HYDRO-CARBON GAS RATIOS

<table>
<thead>
<tr>
<th>Methane</th>
<th>Ethane</th>
<th>Ethylene</th>
<th>Acetylene</th>
<th>Diagnosis</th>
<th>% of transformers Sampled</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>If Methane/Hydrogen less than 0.1- partial discharge.</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Normal deterioration</td>
<td>34.2</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Slight overheating below 150 °C</td>
<td>11.8</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Slight overheating 150° - 200 °C</td>
<td>9.0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Slight overheating: 200° - 300 °C</td>
<td>7.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Normal conductor overheating</td>
<td>11.1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Circulating currents and/or overheated joints.</td>
<td>9.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Flashover without power follow through.</td>
<td>2.1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>Tap changer selector breaking current.</td>
<td>1.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Arc with power follow through or persistent arcing.</td>
<td>9.7</td>
</tr>
</tbody>
</table>

\[CH_4\] - Methane  
\[C_2H_6\] - Ethane  
\[C_2H_4\] - Ethylene  
\[C_2H_2\] - Acetylene  
\[H_2\] - Hydrogen
PHYSICAL PROPERTIES OF SF 6 GAS

1. Molecular Weight 146.07
2. Melting point -50.7 degree C
3. Sublimation Temperature -60.8 degree C
4. Critical Temperature 45.547 + 0.0003 degree
5. Critical Pressure 38.55 Kgf/Cm²
6. Critical Density 0.730 g/Cm²
7. Dielectric constant at 25 degree C 1 atm 1.002
8. Thermal conductivity at 30 degree C 3.36 x 10
9. Density at 20 degree C:
   Kgf/Cm²     Gm/lit.
   At 0         : 6.25
   At 1         : 12.3
   At 5         : 38.2
   At 10        : 75.6
   At 15        : 119.0
MAINTENANCE OF SF 6 CIRCUIT BREAKERS

1.1 Schedules

The maintenance and check execution standard depends upon the working conditions of the CB. The checks to be carried out, their frequency and scope are broadly as under:

<table>
<thead>
<tr>
<th>Type of check</th>
<th>Frequency</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patrol Inspection</td>
<td>Every Week</td>
<td>The patrol inspection is an external check of the Circuit breaker in live condition for irregularities.</td>
</tr>
<tr>
<td>Ordinary Inspection</td>
<td>After every 1000 operation</td>
<td>The ordinary inspection is inspection performed by turning off the circuit breaker for a relatively short time for simple inspection and servicing with emphasis on functional checks e.g. visual check of irregularities and cleaning of dust and dirt.</td>
</tr>
<tr>
<td>Detailed Inspection</td>
<td>After every 3000 operation</td>
<td>The detailed inspection is an inspection performed by turning off the circuit breaker for a relatively long time to dismantle and inspect the mechanism for irregularities for the purpose of continuously maintaining the performance</td>
</tr>
<tr>
<td>Incidental Inspection</td>
<td>-</td>
<td>The incidental inspection is performed when inspection And repair are necessary due to the detection of an irregularity during patrol inspection or during operation.</td>
</tr>
</tbody>
</table>

1.2 General

Attention should be paid to the following points during ordinary and detailed inspection.

a) Switch off control/compressor motor supply. Discharge all the air in the air receiver through the drain valve.

b) The circuit breaker is to be inspected in the open position unless otherwise specified in these instructions. At the open position of the breaker the safety pins for preventing closing and opening must be inserted. On completion of the inspection, the safety pins must be removed.

c) Good quality grease should be used adequately.

d) Circlips and split pins which are removed must be replaced with new ones.

e) Remove "O" rings must be replaced with new ones. While handling and placing "O" rings in their grooves care should be taken to avoid dust falling on them.
### 1.3 Inspection and Servicing Procedure

<table>
<thead>
<tr>
<th>Point / Location</th>
<th>Item or Part / Procedure</th>
<th>Patrol Inspection</th>
<th>Ordinary Inspection</th>
<th>Detailed Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>1) Check the porcelain</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>for damage.</td>
<td>2) Check the main terminal for discoloration</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>3) Check the foundation bolts for looseness</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>4) Check the grounding pad for looseness</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>5) Check the position indicator</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>6) Drain water from air reservoir</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>7) Record the number of circuit breaker operations</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Interruption</td>
<td>8) Inspection of contacts &amp; renewal if necessary</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Unit</td>
<td>9) Renewal of absorbent</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>10) Measurement of resistance of interrupting units.</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Gas System</td>
<td>11) Record of gas pressure &amp; temperature</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>12) Check the valve B is open and valve A is closed.</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>13) Supply the gas, if the pressure is less than</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>prescribed value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14) Check setting of gas pressure switch</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Operating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mechanism</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>housing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pressure Gauge:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Ensure that needle indicates rated operating pressure</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>2) Ensure that needle indicates within tolerance (1.5% of full scale) when air is released thoroughly from air tank.</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Point / Location</td>
<td>Item or Part/Procedure</td>
<td>Patrol Inspection</td>
<td>Ordinary Inspection</td>
<td>Detailed Inspection</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------</td>
<td>-------------------</td>
<td>---------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Air Leakage:</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>1) Check pneumatic system such as valves and piping for air leak sound</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Heater:</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>1) Check for disconnection.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Counter:</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>1) Check number of operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Ensure that counter counts with operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draining:</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Drain water from air tank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water penetration &amp; rust:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Check penetration of rain water and rust.</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fastened Joints:</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>1) Ensure that bolts nuts, etc. are not loosened.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Circuits:</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>1) Check connections of control circuit wiring for fastening.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tripping mechanism

Check the dimensions of tripping solenoid magnet:

1) Check the clearance “ST” (solenoid magnet stroke) between armature and core | x | x |
2) Check the clearance “G,” between plunger and trigger | x | x |
3) Check $S_t - G_t$ | x | x |

Part replacement and relubrication (Grease):
<table>
<thead>
<tr>
<th>Point / Location</th>
<th>Item or Part/ Procedure</th>
<th>Patrol Inspection</th>
<th>Ordinary Inspection</th>
<th>Detailed Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripping Mechanism</td>
<td>Roller Lever of Control Valve Assy.</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Close the breaker and fully drain out the air from air reservoir. Operate Control valve by pushing down trip coil plunger with soft mallet. Rotate rollers (C) and (D) to check that they rotate freely. Open the breaker by using Manual Jack Assembly.</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Closing Mechanism</td>
<td>Check the dimensions of closing solenoid magnet:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Check the clearance “SC” (solenoid magnet stroke) (between armature (27) and core (28))</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check of pumping prevention pin to latch distance:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Check the clearance “P” between anti-pumping pin and latch.</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Main Piston Rod</td>
<td>Relubrication (Grease):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Wipe contaminated grease off piston rod and apply new grease, in closed position.</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Mechanism</td>
<td>Operating Mechanism Stroke:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Check stroke “S” from closed position to completely opened position.</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2) Check over-stroke “So” from completely opened position to stopped position.</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Testing</td>
<td>Manual Operation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Remove closing and opening lock pins, and charge air up to 15 kg/cm². Operate closing solenoid magnet and opening solenoid magnet to check operation.</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
Check of minimum operating pressure:

1) Make sure that circuit breaker is opened at air pressure of 11kg/cm²

Air Pressure Switch:

1) Make sure that air pressure switch is properly set.

---

**MAINTENANCE OF VACUUM CIRCUIT BREAKERS**

1.0 General

The maintenance and check execution standard depends upon the working conditions of VCB, such as the environmental condition, current switching frequency and others. The checks to be carried out, their frequency and scope are broadly as under:

<table>
<thead>
<tr>
<th>Type of check</th>
<th>Frequency</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patrol Check</td>
<td>Daily</td>
<td>Check VCB under daily operating condition.</td>
</tr>
<tr>
<td>Ordinary check</td>
<td>Once every 3 years or once every 1000 switching times</td>
<td>Check VCB after disconnection main supply and local Remote switch in LOCAL position.</td>
</tr>
<tr>
<td>Detailed check</td>
<td>Every 6 years</td>
<td>“</td>
</tr>
<tr>
<td>Provisional check</td>
<td>When a trouble occurs.</td>
<td>“</td>
</tr>
</tbody>
</table>

For the minimum number of operation without replacement of vacuum bottle para 1.5 below may be referred.

1.1 Patrol Check

Patrol check shall be done visually. If any abnormality is found, stop the operation forthwith and examine.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Check items</th>
<th>Checking parts &amp; key points.</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>General parts</td>
<td>a) Dust and moisture condensation and evidence of ingress of rain water in operating box.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Unusual sound, small and decolouration.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Condition of open-close indication</td>
<td>“On in red, closed condition; “off” in green, open condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Working condition of charge indicator</td>
<td></td>
</tr>
</tbody>
</table>

---
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Check items</th>
<th>Checking parts &amp; key points.</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Temperature</td>
<td>Main circuit terminals and electrode pole assembly</td>
<td>Check carefully if the terminal section is discoloured and also, the air is waving with heat.</td>
</tr>
<tr>
<td>3.</td>
<td>Control voltage</td>
<td>Check if the operating voltage and control voltage are kept at the respective specified values.</td>
<td></td>
</tr>
</tbody>
</table>

### 1.3 Ordinary check

The standard checking items and servicing intervals (given by years or number of operation) are generally suggested in Table below. However, it is recommended that the checking intervals shall be determined according to the actual working conditions including the installed atmosphere and operating frequency of the circuit breakers.

| Item Classification | Checking & Servicing | Recommended Checking & Servicing procedure | Remarks
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. General parts</td>
<td>Cleaning each part</td>
<td>Remove dust sticking to circuit breakers, especially the insulators</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td>Tightened parts</td>
<td>Looseness in bolts and nuts, and also break &amp; drop off of washers, snap rings, snap retainer etc.</td>
<td>3 years</td>
</tr>
<tr>
<td>2. Operating units</td>
<td>Operating mechanism &amp; link mechanism</td>
<td>Check the movement Check the deformation &amp; rust. Check limit switches for proper function</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td>Control circuit</td>
<td>Condition of links and collars and damage in them</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td>Counter</td>
<td>Leakage of oil in the speed regenerator.</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td>Open close indicator</td>
<td>Looseness of the terminations of wires.</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td>Charge indicator</td>
<td>Number of operations</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operating condition</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operating condition</td>
<td>3 years</td>
</tr>
<tr>
<td>Item Classification</td>
<td>Checking &amp; Servicing</td>
<td>Recommended Checking &amp; Servicing procedure</td>
<td>Remarks Standard checking intervals</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------</td>
<td>--------------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>3. Check of operation</td>
<td>Open-close operation</td>
<td>Close and open several times each in manual and electrical operations. Spring charging operation</td>
<td>3 years</td>
</tr>
<tr>
<td>4. Measurement of insulation</td>
<td>Across main conductive parts and ground and across poles.</td>
<td>More than 500 M. ohms the general standard (by 1000 megger)</td>
<td>3 years</td>
</tr>
</tbody>
</table>

### 1.5 Detailed Check

Checking shall be performed as per items listed in ordinary check and as per items listed below:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Classification</th>
<th>Checking &amp; servicing parts</th>
<th>Suggested Checking &amp; servicing procedures</th>
<th>Remarks standard checking intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VI</td>
<td></td>
<td>Vacuum check</td>
<td>Contact manufacture</td>
<td>6 years 3000 operations.</td>
</tr>
<tr>
<td>2. Operating units</td>
<td>Operating mechanism</td>
<td>Lubrication to rotary part, sliding parts and pin engaging part (use low viscosity machine oil or equivalent)</td>
<td></td>
<td>6 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check of adjusting dimensions of each part</td>
<td>Gap between trip hook and roller followers and other adjusting dimensions Refer to clause 5-6</td>
<td>6 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>Rust, damage and deformation</td>
<td>6 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coils</td>
<td>Breaking of wires and others.</td>
<td>6 years</td>
</tr>
<tr>
<td>3. Check of operating condition</td>
<td>Min. operating voltage</td>
<td>Tripping Voltage: under 70% rated voltage Closing Voltage: under 85% rated voltage</td>
<td></td>
<td>6 years</td>
</tr>
</tbody>
</table>
1.6 25 KV Vacuum interruptor

The minimum numbers of operations of interrupter without replacement of vacuum bottle is as follows:

1. At a rated breaking current of 4 kA - 4600 nos.
2. At a breaking current of 2 kA - 8000 nos.
3. At a breaking current of 1.2 kA - 10,000 nos.
4. At a breaking current of 0.4 kA - 10,000 nos.
5. At a breaking current of 600 A - 10,000 nos.

Annexure 2.08
(Para 22015 and 20304)

TORQUE FOR VARIOUS SIZES OF BOLTS IN kg.m

<table>
<thead>
<tr>
<th>Bolt Size</th>
<th>Nominal Stress</th>
<th>Steel</th>
<th>Stainless Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>58</td>
<td>4.73</td>
<td>5.91</td>
</tr>
<tr>
<td>12</td>
<td>84.3</td>
<td>8.25</td>
<td>10.31</td>
</tr>
<tr>
<td>14</td>
<td>115</td>
<td>13.14</td>
<td>16.42</td>
</tr>
<tr>
<td>16</td>
<td>157</td>
<td>20.61</td>
<td>25.61</td>
</tr>
<tr>
<td>18</td>
<td>192</td>
<td>28.18</td>
<td>35.23</td>
</tr>
<tr>
<td>20</td>
<td>245</td>
<td>39.96</td>
<td>49.95</td>
</tr>
</tbody>
</table>
CHAPTER III
OVERHEAD EQUIPMENT

Para No. Subject
20300 Introduction

I. ORGANIZATION

20301 Duties of Chief Traction Foreman-CTFO (OHE)
20302 Duties of Field Supervisors
20303 Linesman

II. GUIDING NOTES ON MAINTENANCE

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20305 Out of Plumb Masts
20306 Rail level and Setting Distance
20307 Contact Wire Hard Spots and Wear
20308 Sparking During Current Collection
20309 Contact Wire Wear
20310 Splice Fittings
20311 Section Insulator Assembly
20312 Short Neutral Section Assembly
20313 Jumper Connections
20314 Environmental Effect on OHE
20315 Clearances in Tunnels and Other Overline Structures
20316 Regulating Equipment
20317 OHE Inspection Car (Tower Wagon)
20318 Salient Features of OHE Inspection Cars
20319 Rules for Operation of OHE Inspection Car

III. MAINTENANCE SCHEDULES FOR OHE

20320 Schedule of Inspections
20321 General
20322 Foot Patrolling of OHE
20323 Trolley Inspection of OHE
20324 Current Collection Tests
20325 Special Checks
20326 Annual Maintenance and Checks by OHE Inspection Car
20327 Integrated Blocks
20328 Re-tensioning of Unregulated OHE
20329 Periodical Overhaul
20330 Rehabilitation of OHE
20331 Transmission Lines
IV. SAFETY RULES

20332 General
20333 Documents to be kept with OHE Supervisors for Work on OHE.
20334 Permit to Work
20335 Protection of Staff Against Traffic Movement and Protection of Trains.
20336 Earthing Before Commencement of Work
20337 Procedure for Providing Temporary Earth.
20338 Precautions in Regard to Discharge/Earthing Pole Assembly
20339 Work on OHE or any Conductor Having Sectioning Point.
20340 Protective Helmets
20341 Safety Belt
20342 Rules for use of Ladders
20343 Other Important Precautions to be Taken While Carrying out Works on OHE.
20344 Procedures for Effecting Shut-down for Work on Auxiliary Transformers.
20345 Work on Overhead Lines running parallel to Electrified Tracks.
20346 Isolation of Booster Transformers
20347 Isolators
20348 Petroleum Sidings.

V. FORMS AND REGISTERS

20349 Records to be maintained
IV. SAFETY RULES

20332 General
20333 Documents to be kept with OHE Supervisors for Work on OHE.
20334 Permit to Work
20335 Protection of Staff Against Traffic Movement and Protection of Trains.
20336 Earthing Before Commencement of Work
20337 Procedure for Providing Temporary Earth.
20338 Precautions in Regard to Discharge/Earthing Pole Assembly
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20342 Rules for use of Ladders
20343 Other Important Precautions to be Taken While Carrying out Works on OHE.
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20345 Work on Overhead Lines running parallel to Electrified Tracks.
20346 Isolation of Booster Transformers
20347 Isolators
20348 Petroleum Sidings.

V. FORMS AND REGISTERS

20349 Records to be maintained
Chapter III
OVERHEAD EQUIPMENT

20300 Introduction

1. This chapter is divided into five Sections as under:

Section I - Organization: A broad description of the duties of 3 important categories of staff in OHE Section is given. Here also, in territorial distribution of work, the CTFO in charge have all activities under his control, and TFOs next in command will be in charge of functional activity.

Section II – Guiding Notes on Maintenance: The important points to be borne in mind in the maintenance of the main items of OHE are enumerated.

Section III – Maintenance Schedules for OHE: A recommended schedule of maintenance for OHE is given.

Section IV – Safety Rules for OHE: The essential safety rules applicable to OHE staff are given.

Section V - Forms and Registers: The records to be maintained in regard to OHE maintenance and recommended performance for these are given.

2. The following relevant documents have been incorporated as Appendices to this Volume.

2.1 “Principles for Layout Plans and Sectioning Diagram for 25 kV ac Traction” issued by RDSO (Appendix I).
2.2 “Code for Bonding and Earthing for 25 KV ac 50 Hz. Single Phase Traction System” issued by RDSO (Appendix II).
2.3 “Regulations for Power Line Crossing of Railway Tracks “ issued by Railway Board (Appendix IV)
2.4 “Guidelines for Provision of Maintenance Depots, Tools and Plants and Transport Facilities (Appendix VI)
2.5 Model Circulars” (Appendix VII)
2.6 “List of Specifications and for Equipments and Materials for Railway Electric Traction” issued by RDSO (Appendix IX)
2.7 “Diagrams of General Arrangement and Fittings” a reference booklet issued by RDSO (Appendix X).

1. ORGANISATION

20301 Duties of Chief Traction Foreman – CTFO (OHE)

He is the senior supervisor working under the control of Sr. DEE/DEE (TRD) and directly responsible for the proper maintenance of OHE including the 25 KV feeders and return feeders from the traction sub-stations to the feeding posts. He should be fully conversant with the layout and sectioning of OHE in his jurisdiction as also the rules and procedures laid down for efficient maintenance of OHE and safe working on OHE.

In particular he shall:

1. supervise the maintenance of installations under his charge in accordance with the prescribed schedules, to keep them fully serviceable and in a state of good repair.
2. Plan in advance the requirement of power blocks for OHE maintenance based on the work to be done in consultation with his section supervisors and ensure the completion of the work within the time allotted.

INDIAN RAILWAYSAC TRACTION MANUAL VOLUMEII PART1[58]
3. Carry out detailed inspections of OHE under his control by push trolley or motor trolley to cover the entire section once in 3 months.

4. Scrutinize daily the reports on foot patrol and other defects on OHE, as well as reports from section supervisors and inspection reports of officers and arrange prompt rectification of defects pointed out and report compliance to Sr. DEE/DEE/AEE (TRD).

5. Check the work by sectional gangs under him to ensure that quality work is done and that compliance with prescribed schedules is adhered to.

6. Keep the organization for attending to breakdowns in constant readiness to act promptly and expedite restoration whenever there is a breakdown.

7. Instruct and train staff under him in the correct methods of maintenance with special reference to safety precautions.

8. Arrange to send his staff for training courses as required.

9. Ensure that special testing instruments, tools and equipment including the OHE inspection cars and breakdown vehicles, provided for maintenance of OHE are properly cared for and maintained in proper condition.

10. Keep a watch on availability of spare parts and stores required for maintenance of OHE and initiate timely action to recoup stocks.

11. Ensure proper accounting and periodical verification of the stores and tools under his charge.

12. Submit the prescribed periodical returns to DEE/AEE(TRD) and carry out their instructions issued, if any, on the basis of such returns.

13. Keep his superior officers fully informed of each and every important development and seek their guidance when required.

14. Carry out such other duties as may be allotted to him by his superior officers; and

15. Carry out inspections as indicated at Annex. 3.01.

20302 Duties of Field Supervisors.

The field supervisors in charge of OHE (ATFO, chargeman, inspector etc.) will be under the CTFO(OHE) and each supervisor will be responsible for the following.

1. Maintenance of the OHE and allied installations in his jurisdiction in accordance with the prescribed schedules.

2. Submission of the requirements of power blocks for OHE maintenance, in co-ordination with permanent way maintenance as far as possible, so as to take maximum advantage of traffic blocks.

3. Detailed inspection of OHE under his charge by push trolley or on foot as indicated in para 20322 and 20323.

4. Scrutiny of daily foot patrol and other reports of defects and take prompt action to remedy the defects brought out.

5. Close supervision of the maintenance gang under his control to ensure a high standard of work and compliance with prescribed schedules.

6. Keeping the organisation under his control in readiness to deal with breakdowns.

7. Guidance to the maintenance staff for the proper execution of work in accordance with standing instructions.

8. Ensuring that tools and equipment under his charge are properly cared for and maintained in proper condition.

9. Keeping watch and taking necessary action to recoup stores and spares required for his jurisdiction.

10. Preparation and submission of periodical reports and returns to superior officials as laid down:

11. Keeping CTFO(OHE), AEE(TRD), DEE(TRD) and Sr. DEE(TRD) informed of all important developments and seeking their guidance when required.

12. Carrying out any other duties allotted by superior officials.

13. Carrying out inspection indicated at Annex. 3.01.
1. All linesmen should have requisite educational qualifications to enable their working independently – to take power blocks from TPC, deal with messages in connection with power blocks and also to submit written reports to their supervisor in regard to patrol and inspection work assigned to them. However, until it is possible to have all Linesmen with the requisite educational qualifications, it will be necessary to authorize only selected linesmen to deal independently with taking of power block and issue of messages. Literate Linesman to be authorized to take power blocks independently should be trained and certified.

2. Every linesman should be conversant with the safety rules pertaining to his work and be capable of independently attending to minor repair and adjustment work on OHE. For this purpose he would be required to carry his tool box, telephone etc. with him wherever needed.

3. A linesman should be able to carry out operation at switching stations on local control in an emergency under instructions from the TPC.

4. Linesman shall look for the common types of defects on OHE when they are deputed for patrol work and to report on defects noticed during such patrols to the Section Supervisor (Para 20322)

5. Every linesman should develop the ability to carry out temporary repair in the event of breakdowns so as to restore traffic as quickly as possible and to deal with repairs necessary for all types of breakdowns of OHE.

II GUIDING NOTES ON MAINTENANCE

20304 Introduction

1. For better utilization of traction assets, outage of any traction equipment from service should be minimum without compromising on safety of the equipment and personnel. Monitoring of condition of the equipment by reliable means is essential for following the system of need based maintenance i.e. directed maintenance. However, till such time reliable condition monitoring techniques are introduced, the present system of preventive maintenance has to continue.

2. Recommendations of Original Equipment Manufacturer (OEM) and Guidelines issued by RDSO, from time to time, shall be kept in view while defining the scope and periodicity of the schedules.

3. The tightening torque for fasteners of various sizes is given in the Annexure 2.08.

20305 Out of Plumb Masts

Inspite of the care taken in design and erection, OHE masts do sometimes get out of plumb. This occurs largely on embankments, due to erosion of earthwork on the outer side of the mast on account of poor drainage or excavations in the vicinity or due to sinking of foundations on new embankments. The extent of earthwork initially provided at the back of foundations on embankments is shown in Structure Erection (SEDs). OHE maintenance staff should, during patrolling and inspections, make a particular check of the condition of earthwork has been or is likely to be eroded away, the Engineering Department should be approached to strengthen the embankment, and the matter pursued until it is satisfactorily completed.

Masts which appears to be out of plumb should be checked with a plumb bob. Since the normal height of the contact wire is 5.60 m above rail level, the extent of deflection of the masts at this height can be conveniently found by measuring the deflection at a height of 1.85 m above rail level and multiplying this figure by 3. If the mast is out of plumb, by more than 3 cm upto 5 cm, it should be kept under watch after making sure that there is enough earthwork all round. To identify such masts requiring watching, a yellow bend of width 5 cm should be painted at a height of 1.85 m from rail level.

Masts which are out of plumb in excess of 5 cm can be set right by releasing the OHE and pulling the mast by a “Tirfor”. To facilitate this, the foundation must first be exposed on the side to which the mast is to be pulled by the Tirfor., and the rear under side of the foundation should be packed and rammed with pieces of stone until the foundation is fully supported. If necessary the newly packed part may be strengthened by pouring in cement.

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concrete. A temporary strut or guy as convenient may be provided for a few days. The work must be so done that when the Tirfor is released the mast remains reasonably vertical, i.e. with the allowance for reverse deflection as required. The earth may be refilled all-round the foundation to a sufficient depth and distance beyond it to stabilize the mast. Finally it is checked up with plumb bob and it is made sure that the setting distance is with reference to the centre line of the track is right.

Fig. 3.01 indicates the nature of work to be carried out in straightening of out-of-plumb masts.

(i) PREPARATION FOR JACK OPERATION

CUT STONE OR PLANE SIDED RUBBLE PACKING ALONG TRACK

(ii) SECURING THE FOUNDATION AFTER STRAIGHTENING

CONCRETE FILLED IN

(iii) CONCRETING AND EARTH FILLING
Any other method considered appropriate as per site conditions may be adopted.

RDSO’s report No. ETI/OHE/55 on Tilting of OHE masts, Causes and Remedies may also be referred to.

20306 Rail Level and Setting Distance

Structure Erection (SEDs) show setting distance or implantation of the OHE masts i.e. distance of the nearest part of mast from the centre line of the nearest track as well as the height of the contact wire from rail level at each location. These are with reference to alignment and level of the track at the time of erection of OHE. Before electrification work is taken up, it should be ensured that the track alignment and level are finalized. This is particularly so in the case of yards under remodeling.

Any change in alignment due to slewing of tracks will affect the setting distance and consequently the stagger of the contact wire. At locations where the setting is critical i.e. close to the minimum permissible value, slewing of track may result in infringement of the moving dimensions with consequent danger of accidents. Change in rail level due to variation in ballast cushion or packing up or packing down of the track will also result in change in contact wire height. Though provision exists in the cantilever assembly for adjustments of the stagger and height, such adjustment are not to be made unless absolutely necessary. It is best to maintain the position of OHE and tracks as in the SEDs.

General Rule (1976) 17.06 stipulates as under:

Alteration to track

“How before any alteration to alignment or level of electrified track is commenced, due notice shall be given to those responsible for the overhead equipment so that the overhead equipment may be adjusted to conform to the new conditions:”

If follows, therefore, that any alterations of the alignment of the track on electrified sections shall only be made with the prior knowledge and concurrence of the Sr. DEE(TRD) so that he may arrange to correct the SEDs to the extent required. No alterations to the track affecting OHE parameters may be carried out without obtaining specific approval from Sr. DEE(TRD). Whenever any permanent changes are effected, the SEDs should be revised and a note made of the circumstances and the authority under which the revision has been made.

To facilitate periodical checking, rail level and setting distance should be painted at the base of each OHE mast face soon after commissioning, preferably in black letters. A horizontal line would indicate the rail level. The setting should be marked in correct to the second decimal place. Repainting of the these markings will ordinarily be required once in two years. Where pollution due to brake shoe dust etc. is severe, repainting may be required more often.

During yearly maintenance of OHE, rail level and setting distance should be checked and compared with the original figures. Any variations above 30 mm in setting distance and 20 mm in rail level should be advised to the PWI for correction. No change in setting distance and rail level should be allowed if such change results in infringement of moving dimensions.

It is essential to have a joint annual check of rail level and setting distance by the Chargeman/OHE and APWI.

In addition to the marking on the masts, a register should be maintained by CTFO(OHE) to record the annual measurements of implantation at critical locations over his jurisdiction. A similar register should be maintained by each Chargeman for his own section (see proforma 03-8 in Section –V).

Limits for mast setting distances are indicated in Appendix I.
20307 Contact Wire Hard Spots and Wear

Hard spots are points on the OHE where contact wire wear is likely to be higher than at normal locations, due to less flexibility in the OHE. Smoke pollution aggravates wear at hard spots. The usual spots where the contact wire is likely to show more wear are –

1. Support points at curves.
2. Section insulators.
3. Splices
4. Turn outs
5. Central mast of 2 span uninsulated overlaps of unregulated OHE
6. At approaches to tunnels and over line structures.
7. Locations where smoke pollution is pronounced, namely, tunnels with steam traction and at the ends of platforms where steam locos halt for a long time under OHE.
8. Pull offs

At such hard spots, it is important to keep a watch on wear of contact wire by measuring and keeping a record of contact wire thickness periodically. It is essential to concentrate on these spots during annual measurement of contact wire wear.

20308 Sparking During Current Collection

Sparking occurs when there is loss of contact (or improper contact) between the pantograph and the contact wire. The common causes attributable to the OHE are:

1. Incorrect tension in regulated OHE due to maladjustment or sluggish operation of regulating equipment;
2. Inadequate tension of contact wire in the case of unregulated OHE;
3. Deposit of soot on contact wire due to steam and diesel traction and the resulting roughness of contact face during current collection;
4. Kinks in contact wire.

If OHE on the main line is unregulated the tension in the contact wire should be checked and adjusted if need be once in 2 years. The speed being low in yards and sidings, the adverse effect of incorrect tensioning will be less pronounced and re-tensioning at longer intervals of 3-4 years will be adequate (para 20330)

Deposits of soot on account of steam and diesel traction may cause trouble due to sparking at points where steam engines halt for long periods. Particular note should be made of such locations and cleaning done at shorter intervals. The importance of cleaning of contact wire before introduction of electric traction is dealt with in Chapter IX.

Kinks detected during patrolling and inspection should be straightened or removed without delay. After re-tensioning it is particularly necessary to inspect the section for kinks.

The periodic current collection tests (para 20324) would reveal points where sparking takes place. Apart from investigating and rectifying the cause of such sparking, it is also important that the roughened surface of the contact
wire be attended to, failing which, there will be further deterioration, with successive passage of pantographs resulting in reduced life of contact wire.

**20309 Contact Wire Wear**

Hard drawn grooved copper contact wire of 107 mm² cross sectional area when new is used in the 25 kV electric traction system. With a proper maintenance of the OHE the contact wire is expected to have a life of about 30 years, with average traffic density and conditions of pollution.

The thickness of new contact wire is 12.24 mm. It will be necessary to replace the contact wire when it has worn to a thickness of 8.25 mm corresponding to a cross sectional area of approximately 74 mm². At this point 2 mm clearance shall be available between the bottom most point of the dropper clip, parallel groove clamp as well as contact wire splice and the pan of pantograph. Any further reduction in cross sectional area will result in the current density in the contact wire splice and the pan of pantograph. Any further reduction in cross sectional area will result in the contact wire under certain conditions exceeding the permissible limit of 4.7 A/mm² apart from reduced factor of safety under tension. In siding and lines with a low traffic density, a lower thickness limits of 8 mm may be adopted.

It is important to measure and record the wear of contact wire at the known hard spots (para 20307) and at a few selected locations where heavy wear may be expected, so as to keep a watch on the rate of wear. Observations have indicated the wear of contact wire between starter and advance starter is high where the train picks speed, specially in suburban sections. In addition to the known hard spots, the wire thickness may be measured at one or two points between each pair of stations where speed is maximum. These measurements should be taken at the time of yearly maintenance and recorded in a register. When the average wire thickness has reached approximately 10 mm, the number of points where measurement is taken may be increased and one location in each tension length may be covered in addition to the known hard spots.

Measurements of contact wire thickness in the vertical direction should be made with a micrometer, preferably one fitted with a ratchet screw adjustment to ensure that the pressure between the jaws when taking measurement does not exceed a particular value. Considerable care is required in using the micrometer.

The measurement will be meaningful only if in successive years the thickness is measured at the same point at each location. It is only then that the values recorded can be directly compared. A 75 mm wide band may be painted on the mast fact with black paint. If the location is identified in this manner and a convention followed that measurement should be taken say 20 mm before the swivel clip in the direction of motion. It can be ensured that in successive years, measurement will be taken at identical points. The measurements must be taken personally by a supervisor well acquainted with the use of micrometer. Registers should be maintained in the office of the ATFO(OHE) for his jurisdiction and CTFO(OHE) for the entire division in proforma 03-4 given in Section V.

If any isolated point the contact wire reaches the condemning limit of thickness, a splice should be introduced at the point.

**20310 Splice Fittings**

The splice in OHE becomes necessary when a small length requires replacement as a result of excessive wear or restoration after breakdown.

The splice fittings commonly in use are –
1. splice for single contact wire to identification No. 1080 or 1080-1
2. splice for double contact wire to identification No. 1280
3. splice for Catenary to identification No. 1090
4. splice for feeder wire to identification No. 1100

The main components are made of aluminum bronze and the studs of contact wire splice are of stainless steel. Samples of splices from each batch of supply are required to be subjected to special tensile tests in addition to the normal tests for quality of material, in view of the need for ensuring reliability of these important fittings.
A splice should, as far as possible, be located at a distance of not less than 5 m from the support in the direction of traffic to avoid a hard spot on the OHE. Not more than 15 splices shall be used in one tension length. The distance between adjacent splices should, as far as possible, be more than 100 m.

In new construction normally no splice shall be provided. Under exceptional circumstances a maximum of two splices may be permitted.

The main points requiring attention during inspection of splice fittings are –

1. Careful examination for cracks or other casting defects or abnormalities.
2. In case of Catenary splice fitting tightness of the right hand and left-hand joint sockets.
3. Check to see if any slipping of the ends of two contact wires has taken place. When viewed through the top window, there should be no gap between the two contact wire ends.
4. Tightness of the stainless steel studs.

Contact wire splices should not ordinarily be re-used. If they are re-used at all, new brass ferrules for contact wire splice to Id No. 1080 should invariably be used to ensure that worn serrations of the ferrules do not result in insufficient grip on the contact wire.

Over-tightening of the stainless steel studs of contact wire splice fittings is harmful. Tightening should only be done to the extent possible with a standard spanner. No extra leverage by means of a pipe etc. should be used.

Registers should be maintained in the Offices of Sr. DEE(TRD), AEE(TRD), CTFO(OHE), TFO/ATFO(OHE) and OHE Section Chargeman showing the location and date of installation of all splice fittings under their jurisdiction. These registers should be brought up-to-date by taking an inventory of splice fittings during yearly maintenance and POH.

**203011 Section Insulator Assembly**

1. Section Insulators assembly is used to provide electrical isolation between two elementary sections which are otherwise continuous. They are used mainly on cross overs, diamond crossings and turnouts for loops and sidings to isolate section from main line. They may be used on main lines to form neutral sections in heavily graded sections, suburban sections and at inspection pits on secondary lines as well as lines for sheds for maintenance and inspection. Rules regarding the location of section insulators are contained in Appendix I; the speed permissible at these locations is also indicated therein.

2. The section insulator assembly is shown Fig. 3.02. The assembly comprises of a strain insulator with two runners connected to one of contact wires. The bottom of the runners is at the same height as the contact wire on the other side, and so shaped as to allow a smooth passage of the pantograph underneath it. The two runners overlap with the contact wire on the other side for a short length to ensure that there is no interruption in the current drawn by the locomotives as it passes underneath the section insulator. The flexibility of the OHE is reduced where a section insulator assembly is provided.

3. The essential points to be checked during periodical maintenance are as under-
   a) The weight of the section insulator should be fully taken up by the droppers so that the runners are at the same height as the adjacent contact wires both longitudinally and transversely. Fasteners are provided, at both the contact wire ending clamps, at the ends of the contact wire and link assembly and section insulator cross beam assembly, for effecting the adjustment accurately. When correctly adjusted, there should be no sparking when a pantograph negotiates it. The runners if bent or damaged should be either replaced or straightened out. The runners as well as the contact wire should be smoothened by filling off globules of copper which might have formed due to arcing. The distance between the contact wire and the runner on either side should be not less than 220 mm.
The termination of the contact wire anchoring at both ends should be checked and the stainless steel studs of the contact wire ending clamps tightened properly.

As the section insulator is located in the centre line of the track it is particularly subject to heavy smoke pollution. The deposition of smoke on the insulator, if allowed to accumulate, can easily cause enough leakage to render an adjacent section live even after it has been isolated. The periodicity of cleaning...
Conventional Section Insulator Assembly (Porcelain Insulator)
परमार्गांत खड्ड विद्युतरोधक समुच्चय (पोर्सलीन विद्युतरोधक)

Short Neutral Section with Synthetic Resin Bonded Glass Fibre
Contact wire Insulator (Composite insulator)
शार्ट न्युटरल सेक्शन ग्लास फाइबर सम्पर्क तार रीसिन बाउंड विद्युतरोधक
(मिश्र विद्युतरोधक)
Two Cantilever Arrangement for an Overlap
एक अतिव्यापन के लिए दो केंटीलीवर व्यवस्था
and application of silicone grease should be decided based on the extend of smoke pollution in the area (para 20314)

b) The PG clamps holding the stiffeners at both ends should be checked to ensure that the stiffeners do not work loose.

20312 Short Neutral Sections Assembly.

1. Short neutral sections assembly incorporating light weight contact wire insulator of composite type (resin bonded glass fibres core protected with wear resistant ceramic beads) has now been adopted as standard. Ease of installation even on flat curves and difficult locations, substantially reduced maintenance and other advantages are gained by introducing short neutral section. Conversion of existing overlap type neutral sections to short neutral sections may be done where it is not yet done. Short neutral sections should also be introduced in lieu of insulated overlaps opposite to the feeding posts at sub-stations. (Board’s Ref. 86/RE/501/1N/S dt. 16/22.7.1987.)

2. The general construction, design and other requirements of short neutral sections shall conform to RDSO’s Drg. Nos. (i) ETI/OHE/SK/551-Arrangement of Neutral Sections for Conversion with Short N.S. (ii) ETI/OHE/SK/552-Arrangement of short N.S. at Existing Feeding Post.

3. The essential points to be checked during periodical maintenance are as under:
   a) cracked beads.
   b) Electrical erosion of coating
   c) State of cleanliness of insulators.
   d) Burning of arcing horns and arc traps
   e) Pantograph hit marks on the under side of compression ferrules and end sleeves of the contact wire insulators to ascertain need for adjustment to be runners.
   g) Elastomeric bellows for cracks
   h) Insulation resistance.

20313 Jumper Connections.

The following types of jumper connections, using standard copper conductors and PG clamps, are in common use in 25 KV OHE.

1. In-span jumpers of approximately 50 mm² cross section for electrical continuity between contact and Catenary wires, at intervals not exceeding 400m.

2. Potential equalizer jumpers of approximately 50 mm² cross section at insulated overlaps and neutral sections to keep the portion of OHE between the cut in insulators and the nearer anchorage at the same potential as the adjacent run of OHE.

3. Continuity jumpers of cross section 105 mm² to provide electrical continuity between the two portions of OHE at uninsulated overlaps and between the main line OHE and turn out/cross over OHE at turn outs/cross over.
4. Jumpers of cross section 105 mm² or 150 mm² between feeders and OHE at feeding points.
5. Jumpers of cross section 50 mm² provided between out of run. OHE and anticreep wire as an anti theft measure.

Jumper connections play a vital part in maintaining continuity of supply. On account of the up and down movements of the contact wires, the jumper connections are bent to some extent every time a pantograph passes through. With repeated bendings the strands of the flexible jumper connections are liable to get broken in course of time on account of fatigue. To guard against this possibility, special attention should be devoted to the jumpers during periodical maintenance.

The essential requirements for reliability of jumpers are –

1. Sufficient length and adequate looping to provide flexibility so as to prevent failure on account of repeated up and down movements and movements on account of elongation and contraction of OHE due to temperature variations.
2. Adequate cross section to carry the normal currents and possible overloads due to shut downs on adjacent lines, as well as faults.
3. Proper bonding and in soldering of the ends.
4. Proper seating and tightness of connections at PG clamps.

Failure of continuity jumpers will result in discontinuity of the OHE and consequent serious interruption of traffic. Though failures of potential equalizer jumpers may go unnoticed, such failures can result in electrical accidents. Also, unscheduled attention to such jumpers will necessitate power-block on both the adjacent elementary sections, which may be quite difficult to arrange without repercussion to traffic. Proper attention to jumpers during scheduled maintenance is, therefore, very important. Jumpers, particularly continuity jumpers, with broken strands should be invariably replaced, failing which the reduced cross-section may cause overheating and eventual failure. Broken strands are most likely at the point of entry into PG clamps, possibly due to sharp edges in the clamp. PG clamps should have properly rounded off edges to prevent the cutting of strands. The clamps should be checked for signs of overheating and proper tightness.

It should, however, be remembered that a PG clamp should not be interfered with unless there are signs of overheating or damage.

**20314 Environmental Effect on OHE**

**Atmospheric Pollution**

The atmospheric pollution has caused a large number of insulators flash over in certain areas such as Howrah and Assansol in Eastern Railway. Ahmedabad, Vadodara, Surat and Valsad sections of Western Railway and Madras-Gudur section of Southern Railway. The flash over mainly occur in the early morning in winter before sun rise and in the pre monsoon period, specially when monsoon are delayed. The pollutants provide a creepage path resulting into flash over of insulators and consequent tripping of the 25 Kv and EHV circuit breakers. Pollution can be classified, broadly into the following categories.

i) Saline Pollution : caused by salt deposits in coastal areas. The adverse effect get magnified in foggy, humid and light rain conditions, resulting in series of flashovers.

ii) Chemical and Industrial Pollution : Waste gases from industries – hydrochloric acid, sulphuric acid, hydrofluoric acid fumes etc. and minute particles of urea, cement etc. affect insulators of the electrified tracks in the vicinity of these industries. These conditions not only effect the insulators, but also affect the steel parts including mast, which corrode rapidly and need frequent attention. Special steps are required to be taken throughout the year, suitably modifying the insulator cleaning schedules to ensure trouble free service.
1. Insulators

Although insulators supporting OHE are by the side of supporting masts, they are subject to settlement of carbon deposits, smoke pollution due to steam trains, oily deposits on account of diesel engine and cement or other industrial dust as mentioned earlier. 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. Further, a dirty insulator of a section insulator can result in a dangerous potential in a section made dead.

The remedy lies in cleaning the insulators at regular intervals. Where there is no pollution, cleaning need be done only once a year or even at longer intervals. Where pollution is not appreciably high, the interval may be three months or longer depending upon the degree of pollution in the area. Generally in heavy industry areas more frequent cleaning of insulators may have to be done.

Cleaning is done by wiping the surface with a piece of dry cloth. A wet cloth may be necessary if the coating is hard. If the deposits are oily, petrol may be used for cleaning. If this too in ineffective where encrustation has become hard due to continued neglect, the coating may have to be removed by rubbing with a wet coir rope using a suitable detergent. After removing the deposits, the surface of the insulator should be washed well with water, wiped with dry cloth and polished until the normal glaze is restored.

The periodicity of cleaning of insulators in polluted locations should be laid down by local instructions. The affected section should be divided into various zones based on the degree and nature of pollution. And periodicity of insulator cleaning fixed suitably. The cleaning will be required more frequently in foggy weather compared to dry or rainy season. The periodicity may be reviewed based on effect of special measure.

Other steps for reducing flashovers due to pollution ...

i) Application of High Voltage Insulating Silicone Compound
The frequency of manual cleaning can be substantially reduced by application of silicone grease or similar anti tracking compounds. Application of high dielectric strength anti acidic varnish has also been found to be useful under certain conditions. The surface of the insulator is cleaned and then a light coat of the material is applied so that a dust and water repellent surface is produced.

ii) Use of longer creepage path insulators
Use of Insulators of longer creepage path will reduce frequency of cleaning.

The problem can be tackled in many ways mainly to reduce the frequency of cleaning, which can be established by constant endeavor in trying out what is best for a specific section over a period of 2 to 3 years.

2. OHE Structure and Fittings.

Due to effluents discharged by the factories which are close to the railway tracks, the atmosphere gets surcharged due to presence of corrosive fumes in the effluents. Such cause corrosion of steel structures and OHE parts. In order to safeguard against this problem, remedial action as under should be taken.

a) Matter should be taken up with the factories and the Board of Control of Pollution of that area, they should ensure that the discharge of the factories is well within the limits laid down by the Board.

b) A special check at regular intervals should be conducted to see that the corrosion does not affect the performance of the components.

c) Chlorinated paints may be tried on the steel structures to off set the effect of pollution on the steel structures.
20315 Clearances in Tunnels and Other Overline Structures.

If the OHE construction as well as the tunnels and over line structures are not modified subsequent to the electrification, the clearances provided at the time of erection will remain unaltered. It is, however, important to check the clearances during the annual maintenance, compare the values given in as erected and take corrective action as required.

20316 Regulating Equipment

1. There are three types of regulating equipment in use at present viz. The winch type, pulley block type and 3 pulley type. With all the three types of equipment the chief task of maintenance is to ensure that the counter weight is free to move up and down in the guides without any chafing or obstruction. If the movement of the counterweight is obstructed, the tension of the OHE will not be correctly regulated resulting in poor current collection. The counterweight should not come down so low so as to touch the muffing in summer, nor should if strike the guide fixture at the top during winter.

During yearly maintenance of the pulley block type of equipment dimension ‘X’ (i.e. the distance between the centres of the movable and fixed pulleys) and ‘Y’ (i.e. the distance between the bottom of the counterweight and the top of the muffing) should be checked against prescribed values and adjusted as required according to the tension length of the OHE and prevailing temperature. Small adjustment can be effected by using the adjusters provided. In the event of appreciable stretching of the contact and catenary wires, particularly a few months after installation, it will be necessary to cut small lengths of contact and catenary wires at the terminations to get correct alignment and adjustment.

In the winch type equipment, corresponding to dimension ‘X’ in the pulley block type dimension ‘Z’ i.e. the distance between the centres of the movable pulley and the winch drum is required to be measured.

To facilitate checking, the position of the bottom of the counterweight corresponding to the lowest and highest temperature should be marked on the masts by means of black bands of width 20mm. The position of the counterweight at ambient temperature of 35 degree C may be marked by a red band which can be seen during trolley inspection readily. The bottom of counter weight should coincide with the band mark.

2. The usual defects to be looked for in the pulley block type of equipment are –

a) damage to pulley grooves by the stainless steel rope due to misalignment of the equipment and the catenary wire being not vertically above the contact wire at the termination;
b) seizing of the needle bearings due to drying up of lubricant and consequent jamming of the pulleys;
c) jamming of guide pulley due to lack of lubrication and consequent grooving of the pulley. This can be checked by pushing up the counter weight and allowing it to descent due to its own weight;
d) damage to neoprene washers provided between pulleys resulting in ingress of dirt and water into the needle bearings;
e) bent sliding rods obstructing the movement of the movable pulley;
f) blocking of grease nipples.

These defects except for replacement of the guide pulley and attention to blocked grease nipples are not capable of being attended to in-situ. The complete equipment should be replaced with a spare one and the removed equipment taken to the workshop for attention.

The main pulley and guide pulley bearings of the pulley block type equipment should be lubricated using approved type of grease which will be able to withstand 60 degree C without drying.
Another important check required for the pulley block type equipment is to see that that the stop nuts provided at the end of the guide rods are intact. These are provided to prevent the movable pulley coming off the guide rods in the event of breakage of the stainless steel rope.

3. The common defects to be looked for in the winch type equipment are:

a) Over riding of stainless steel rope and grazing of grooves.
b) Breakage of strands of stainless steel wire rope.
c) Seizure of pulley bearing.
d) Tilting of anti falling device.

Stainless steel ropes should be examined periodically with a magnifying glass for putting and other signs of corrosion.

Regulating equipments should be checked periodically for free movement with the help of a spring balance. If pull required for a visible movement of counter weight exceeds 10 kgf. The regulating equipment should be overhauled.

Whenever a panto/OHE entanglement takes place the regulating equipments of all the concerned OHEs should be checked thoroughly, particularly if any of them was overhauled more than two years earlier.

Until such time a grease capable of retaining the properties for 4 years becomes available, all regulating equipments should be overhauled every two years. Priority should be given to those which cover the more vulnerable locations.

During overhaul of regulating equipment special attention should be paid to the shape and dimensions of the winch frame arms (right and left) as they have a direct influence on the angle of incidence of the stainless steel wire rope on the winch drum.

Whenever a regulating equipment is dismantled, the condition of the bearing grease should be checked. If it is found to have lost its oil content and exhibits the consistency of hard soap, the source and type of grease used initially should be investigated.

The condition of rubber or felt seals provided to prevent the ingress of water into bearings should be checked and if they have deteriorated, the quality and source should be investigated and remedial steps taken. All seals should invariably be replaced during periodical overhaul unless their condition is found to be good enough to work satisfactorily for another four years.

4. Most of the points mentioned above are also applicable to pulley type regulating equipment which is now standard.

20317 OHE Inspection Car (Tower Wagon)

1. OHE inspection car has a key role in the maintenance of OHE and for attending to break downs. The satisfactory upkeep of the car is, therefore, or utmost importance. ATFO (OHE) should ensure that the car under his control is maintained satisfactorily and is available at all times for attending to OHE and for use in the event of break downs.

Each car should carry necessary tools for maintenance of OHE and attending to breakdowns, such as tackles, straining screws, clamps, ropes a minimum of two ladders as well as an adequate stock of insulators, lengths of contact and catenary wires and other OHE fittings. An approved list of tools and equipments to be carried in each care should be issued by DEE(TRD). ATFO(OHE) should ensure that tools and equipment as per the approved list are always available in the car.
Winch Type Regulating Equipment

विंच टाइप नियामक उपकर
2. A monthly mechanical inspection of the bogies and running gear of each car shall be done by a nominated TXR of the Mechanical Department, headquartered close to the OHE depot where the car is normally stabled. For each car on a Zonal Railway, the TXR responsible for monthly mechanical inspection will be nominated and a joint circular to this effect issued by CME and CEE laying down his duties.

The ATFO(OHE) in charge of the car will advise the TXR concerned the date on which it is required to be inspected and running repairs carried out. Such advise shall be given at least 48 h. in advance. ATFO(OHE) should ensure that this monthly advise is issued regularly and the car is offered for inspection and attended to every month. The TXR will arrange for examination of bogies, running gear, underframe, under gear fittings and axle boxes only, in accordance with IRCA rules, Part-III. He will also arrange for stenciling the date of monthly examination on the sole bar of the car. The POH of the car shall be done at an interval of 3 years in an EMU shop/electric loco shed/Electric workshop, as decided by CEE. (Ref. Board's letter No. 84/Elec/140/4 Vol. I dt. 1.3.90)

3. The day to day maintenance of the diesel engines and driving gear of the car will be the responsibility of the ATFO(OHE) concerned. The OHE inspection car drivers should carry out the daily maintenance. Specialist staff conversant with the maintenance and overhaul of diesel engines and driving gear should be available on each division for attending to monthly and six monthly maintenance of the diesel engines and driving gear. If it is more convenient and depending upon the work load, two or three divisions may be grouped together for the purpose of posting such specialist staff.

4. Taking into account the total number of OHE inspection cars and the need for relief of such cars for purpose of POH etc. in each Zonal Railway, one or more spare OHE inspection cars may be provided as necessary.

20318 Salient Features of OHE Inspection Cars.

The salient features of the OHE inspection cars presently in use of on Indian railways are as under –

1. Mark II 4 wheeler manufactured by Kanchrapara Workshop/E. Rly.
   i) Diesel engine 83 HP (Simpson make)
   ii) Axle load 6.8 tonnes
   iii) Pay load 3 tonnes
   iv) Speed potential 40Km/h
   v) Transmission Gear box system
   vi) Brake system Vacuum

   i) Diesel Engine 185 HP
   ii) Axle load 16 tonnes
   iii) Speed potential 75 Km/h
   iv) Transmission Hydraulic/Hydro mechanical
   v) Brake system Compressed Air Brakes.
3. OHE Inspection Car – 8 wheeler

i) Diesel engine    Single 530 HP or twin 285 HP
ii) Transmission    Volt’s Hydraulic Transmission
iii) Axle load      16 tonnes
iv) Pay load        10 tonnes
v) Speed potential  110 Km/h on level tangent track
                   30-40 km/h on 1 in 60 t rising gradient while hauling
                   a loaded bogie flat wagon of 60t
vi) Brake system    Compressed air brakes
vii) Paying out facility on one drum each of contact and catenary wires
viii) Small workshop fitted with drilling machine etc.

ii) Two staff cabins with toilet
iii) A small kitchen, storable space for tools, spares, and traction mast etc.
iv) Adjustable lifting and swivelling platform
v) Observation dome  To watch pantograph and contact wire interaction
during motion.

20319 Rules for Operation of OHE Inspection Car.

General

i) Authorization:

No OHE inspection car may be operated by any person unless he is specifically authorised to do so
after he has been trained and examined for his knowledge of the rules prescribed ( chapter XII)

ii) Scope

The following rules shall govern the working of an OHE inspection car fitted with a pantograph for
the purpose of inspection of OHE either during commissioning of completed sections of OHE or
during periodical inspections carried out by the OHE inspection car maintenance staff. All staff in
charge of operation of OHE inspection are shall make themselves fully conversant with and act
according to the special instructions given below:

iii) Movement

The movement of OHE Inspection Cars on tracks will be governed by all the rules governing
movement of trains.

Driving

j) OHE Inspection Car shall be driven only by an authorized person, and no person shall be so
authorized unless he has knowledge of the section (Road and Signals) on which the car is to
operate and is conversant with the operation and maintenance of car. He should also be in
possession of competency certificate for the purpose.
ii) The OHE Inspection car shall be driven at a speed not exceeding 10 km/h when checking contact wire level and stagger. This shall be done by running on the first gear. Riding on the clutch for this purpose is prohibited.

iii) If the OHE inspection Car is driven for other than recording operations, the speed should not exceed the designed speed subject to the speed restrictions imposed in the section.

iv) In every depot, at least two OHE staff shall be trained and issued with competency certificate to drive an OHE Inspection Car in the event of an emergency.

Pantograph Operation.

i) The pantograph mounted on the roof of the OHE Inspection Car is electrically bonded to the underframe by means of a cable connection. This cable connection should be checked before starting any operation for checking and adjustment of OHE.

ii) The pantograph should normally be kept in the fully lowered position and clamped securely by means of the special clamp provided for the purpose. No string, cord, etc. shall be used for the purpose.

iii) Before any person goes up to the roof of the OHE Inspection Car for commencing inspection and adjustment, the section of the OHE concerned shall be made dead and earthed on either sides. Additional earths shall be provided where necessary. After earthing the OHE, an additional earth shall be provided near the OHE Inspection Car on the OHE of the track on which it is standing. An authorized person not lower in rank than a linesman shall then go up on the roof and remove the clamps to release the pantograph.

iv) Under no circumstances should the OHE inspection car be worked with the pantograph raised without an earth on either side of it on the section of the OHE in which it is to be worked.

v) In order to ensure that the pantograph does not enter a section where the OHE is live the OHE inspection car shall be protected on both the sides with banner flags and other signal flags.

The Driver shall always stop the OHE Inspection Car ahead of all turnouts, cross overs, insulated overlaps and section insulators first and then proceed only after ensuring that the section ahead is dead and earthed. Banner flags shall then be removed for the purpose of admitting the OHE inspection car into the section ahead.

vi) At the end of the Inspection and checking, the pantograph, shall be lowered and clamped by an authorized person not lower in rank than a linesman working on the roof after earthing the OHE of the track on which the OHE inspection car operating. The earths on the OHE near the OHE Inspection Car shall then be removed after all persons working on the roof have come down.

Operation of Lifting and Swivelling Platform

a) The lifting and swivelling platform shall ordinarily lie in the fully lowered position along the length of the OHE Inspection Car.

ii) The swivelling platform shall be raised or lowered only when the OHE Inspection Car is stationary.

iii) The platform shall be moved out of the normal position only when the OHE Inspection Car is stationary.

iv) The OHE Inspection Car shall be moved only after the platform has been put back in the normal position.

v) If the OHE Inspection Car is to be moved with the platform raised, it may be done at a speed not exceeding 5 km/h.
III MAINTENANCE SCHEDULES FOR OHE

20320 Schedule of Inspections

1. In order to achieve high reliability and ZERO DEFECT OHE, and to ensure effective checks on the maintenance work a minimum schedule of inspections to be carried out each month by the officers and Senior Subordinate in charge of operation and maintenance of OHE and associated system, is indicated at Annexure 3.01.

2. The schedule of inspections is the minimum quota for each official and should be independent of other tasks. They will not be of routine nature but shall be carried out in depth to identify:

b) Deficiencies and short comings.

ii) Lack of skill amongst staff.

iii) Inadequacies in maintenance facilities

iv) Constraints experienced

v) Conditions of environment leading to poor quality of work.

3. The inspecting officials should programme their inspections in such a manner as to cover the widest areas in their jurisdiction over the year and so stagger the inspections as to avoid over inspections of the same section repeatedly, in a very short time while neglecting other areas. A check in brief for various inspections is indicated at Annexure. 3.02

20321 General

The OHE is subject to dynamic oscillations due to the constant contact and movement of the fast moving pantograph coupled with wind pressure. It is necessary to maintain the OHE in perfect condition through proper checks on its geometry and all parameters adopted in the design.

The following schedules of maintenance for the OHE are required to be followed to ensure good current collection as well as safety of installations and personnel –

i) Foot Patrolling

ii) Trolley inspection

iii) Current collection Tests

iv) Special checks

v) Annual Maintenance and OHE Inspection Car Checks.

vi) Periodical Overhaul

vii) Re-tensioning of Unregulated OHE.

2. The importance of OHE arises from the fact that it is extensive, with a very large number of insulators, fittings and other parts; failure of any one of which may result in dislocation of train services for appreciable periods until the defect/breakdown is rectified. The adjustment work is particularly important at cross overs and at overlaps spans since any departures from the standards laid down could cause entanglement of the pantograph with the OHE, with serious repercussions. The need for a thorough detailed inspection of every part of the installation, mast by mast need not therefore be over-stressed.
3. The periodicity of schedules laid down below apply to the majority of installations. The periodicity may however, be modified by CEE, where local conditions warrant.

4. As regards new equipments, if schedules, have not been drawn up, tentative schedules may be evolved based on the Original Equipment Manufacturer’s guidelines and RDSO’s recommendations, keeping in view the local conditions also and followed with the approval of CEE.

20322 Foot-Patrolling of OHE

The object of foot-patrolling is to make visual inspection of every part of OHE (including feeder line) so that any defect and abnormalities noticed are recorded and reported to the maintenance gangs for attention.

2. An experienced OHE linesman (accompanied by a Khalasi if deemed necessary by local conditions) should be deputed to patrol the section on foot by day, so as to cover every part of the section including years once a fortnight and suburban sections once a week. If this patrolling is done thoroughly, many of the defects will be noticed at the incipient stage, before they develop into major defects. ATFO or Chargeman should foot patrol the section once in six months.

3. The Linesman on foot patrol should be equipped with signal flags, an emergency telephone instrument and essential tools required for attending to defects on the spot e.g. spanners for tightening bond connections.

4. The Linesman on patrol duty should particularly look for the following –

a) Chipped or damaged insulators.
b) Displaced fittings and droppers
c) Excessive sagging or hogging of contact wire
d) Whether equalizing plate is tilted
e) Free movement of auto tensioning device and position of counterweight with reference to upper and lower limits of movement marked on the mast.
f) Presence of protective screens, caution and warning boards and Anticlimbing devices.
g) Structural soundness of height gauges at level crossings.
h) Bird nests and pieces of stray wire likely to cause short circuits and branches of trees likely to infringe the OHE.
i) Defective bonds and earth connections.
j) Defects in return conductor connecting booster transformers and its connection to rails. Oil leakage if any from BT and AT.
k) Any obstructions including tree branches in the way of free movement of pantograph and trains.
l) Signs of heavy sparking when trains pass.
m) Isolators blades being fully in and for signs of sparking or overheating of isolators as also condition of locks.
n) General condition of switching stations en-route.
(o) Tilting of masts especially on high banks and masts with sand core foundations.
(p) Number plates
(q) Any other abnormal/unusual situation

5. Major defects noticed by the Linesman which endanger safety shall be reported forthwith to TPC through the nearest telephone. Full details should be given to enable the TPC to decide on the course of action to be taken and if required to regulate train movements in the affected section.

6. The Linesman should himself attend to and rectify such of the minor defects (e.g. loose bond connections) which can be rectified by him on the spot without special assistance. To facilitate this, he shall carry with him a few essential tools. Other minor defects should be noted by him in his diary and entered by him in a Register (see para 20351) maintained for the purpose in the depot/sub depot. The roster of patrolling Linesmen should be so arranged that they will be able to return to the depot sub-depot for submission of report as above before going off duty for the day. Where this is not convenient, the Linesman must report the defects on telephone to the depot/sub-depot followed by a written report in the register on the next day. The supervisor in charge of the depot/sub-depot will carefully scrutinize the Register and take prompt action to rectify defects reported, making suitable entries in the Register.

7. Testing of Emergency Telephone Sockets: During patrol duty, the Linesman will speak to TPC from every emergency telephone socket in route. Such calls from patrolling Linesmen should be recorded in a Register by the TPC indicating the date, time and serial number/location of the socket tested. Defective sockets should be reported promptly to the S&T Department for rectification.

A proforma for Linemen’s Foot Patrol Report is given at Annexure 3.03

20323 Trolley Inspection of OHE

Inspection of OHE by push trolley is essential except in sections where use of trolley is prohibited. The object of such inspection is to enable supervisors and officers in charge of OHE maintenance to observe closely the OHE under their charge and should be carried out during day time. The depot in charge (TFO or ATFO) should inspect his entire section once a month. CTFO/AEE(TRD) should inspect their respective sections once in 3/6 months respectively by push trolley or motor trolley as convenient. Sr. DEE/DEE(TRD) also should cover his entire section at least once a year by push trolley or motor trolley.

2. Apart from trolley inspection as above, officers and senior subordinates shall travel by the cabs of locomotives and EMU trains as often as possible but at least once a month to observe the general condition of OHE and to get a first hand knowledge of operating conditions.

20324 Current Collection Tests
It is necessary to carry out periodic tests to detect points at which contact between the contact;Are and pantograph is unsatisfactory resulting in sparking. Such current collection tests are performed at night.

A mirror can be fixed in front of the look-out glass of the rear cab of a locomotive and adjusted so as to get a reflection of the rear pantograph which is normally in service. A person travelling in the cab can then observe through the mirror any sparking which may take place. The location where the sparking is observed and the severity of the sparking should be immediately noted down and the OHE at the location got checked up as soon as possible to find out and eliminate the cause of sparking.

The current collection tests as above should be carried out by the depot-in-charge (TFO or ATFO) once in 3 months over his entire section. The CTFO/AEE (Trd) should accompany the depot-in-charge during such tests alternately so as to cover their sections once in 3/6 months respectively. DEE (trod) should accompany the depot-in-charge so as to cover his jurisdiction once a year.
The form in which a record is to be maintained is indicated in para 20349.

**20325 Special Checks**

While the majority of items require attention only during Annual Maintenance and Periodical Overhaul, items listed below will require more frequent attention as indicated against each -

1. **Insulators:** Generally insulators need cleaning once a year along with the annual maintenance schedule. At locations subject to smoke pollution on account of steam loco or pollution due to industrial dust, the frequency of cleaning will have to be fixed based on the extent of such pollution. Where pollution is heavy, cleaning may have to be done more frequently. With the application of silicone grease, the interval for cleaning at such locations can be extended significantly.

2. **Section Insulators:** Section insulators on the main lines such as at neutral sections and passenger yards should be attended to as under once in three months -
   (a) Clean insulators and replace badly chipped or even slightly cracked insulators.
   (b) Check runners for flash-marks.
   (c) Check level of the assembly and adjust as required.
   (d) Check for excessive contact wire wear near anchor clamps.
   (e) Tighten properly the PG clamps of droppers and stiffeners.
   (f) Check that pantograph passes underneath the section insulator smoothly.

3. Isolating switches at Yards/Loading sidings: The continuity and soundness of earth connections should be checked once a month.

4. **Bi-metallic clamps:** These should be checked for tightness and signs of overheating once in 3 months.

5. **Earth Connections:** Apart from general inspection of bond and earthing connections during foot-patrolling, all such connections should be specially checked for continuity and soundness of connections once in six months. Particulars of all earthing connections (other than structure bonds) should be entered in a Register station-wise for each section and the dates of six-monthly inspection entered therein (see para 20351).

6. **Feeders:** Foot-patrolling of 25 kV feeders should be carried out every month. During this check, the Linesman shall also check that safety guards provided under the feeders properly earthed, if the clearances are adequate and caution notice boards are in position.

7. **OHE supported on steel girder bridges** should be examined as frequently as possible depending upon traffic conditions.

8. **Bird nests:** Vigil should be exercised especially during the nesting season and the nests removed as soon as possible.

9. **Pre-monsoon checks:** Some of the items to be attended are -
   (i) Checking condition of insulators specially that of section - Insulators at major yards having mixed type of traction;
   (ii) Over-line structures for any water leakage on the OHE and PVC insulators at major yards having mixed type of traction;
   (iii) Trimming of trees branches;
   (iv) Condition of embankments with respect to stability of masts; Rod gaps.
   (v) Rod gaps
20326 Annual Maintenance and Checks by OHE Inspection Car

1. This schedule must be carried out by Inspection Car. During the schedule, fittings are not generally dismantled, but all fittings which are found defective must be replaced. In addition clearances, heights, staggers etc. should be checked and corrected.

2. The details of work to be carried out during this schedule are as under-

(a) Masts, portals and cantilever supports:

(i) Check rail level and setting distance against markings on the masts and entries in the Register. Variation above 30mm in setting distance and 20mm in rail level should be notified to the PWI for correction. Variations, even within the above limits, should not be permitted if the Schedule of Dimensions are infringed.

(ii) Check all steel parts and remove rust, if any, from painted steel work. Rusted portions, after cleaning, must be given two coats of zinc chromate primer followed by aluminum paint.

(iii) Check all anchors for tightness of bolts, nuts and checknuts and pins, Lubricate all turn buckles/adjusters and pulleys.

(iv) Examine the base of each structure to ensure that muffs permit drainage of water. Clean the muffs removing any muck or dirt. Cracked or damaged muffs must be recast.

(v) Check all bonds thoroughly. Defective bonds must be rectified and missing bonds provided,

(vi) Check and tighten all G.I. bolts and nuts.

(vii) Check all galvanized pipes and fittings. Where galvanization is found to be chipped off, the fitting of pipe should be replaced. Minor chippings may be repaired using 'cold galvanizing paint'.

(viii) Examine register arm and all hooks and fittings for cracks. Check for cracks on steady arm tube also.

(ix) Clean all insulators and carefully check for cracks and broken sheds. If more than 2 sheds are broken or there is any crack on the core the insulator should be replaced.

(X) Check and adjust heights and staggers on the basis of setting distance and rail level marked. Close co-ordination with Permanent Way Inspectors is required for keeping the permanent way at the correct location.

(Xi) Check presence and condition of caution notice boards, number plates, coasting boards, etc. Paint the boards as required. Ensure that they are all well secured.

(xii) Ensure that the drain holes in the tubes are free and not clogged.

(b) Contact and Catenary Wires:

(i) Check carefully condition of contact and catenary wires, particularly for kinks and twists in contact wire and broken strands of catenary wire. Any stranded conductor (catenary wire etc.) should be spliced if more than 20 per cent of the strands are broken.

(ii) Check condition of PG clamps and jumpers after opening the clamps and tighten properly.
(c) Droppers:
   (i) Check droppers and tighten bolts wherever required.
   (ii) Make droppers vertical.

(d) Turn outs
   (i) With OHE Inspection Car running on main line check up if pantograph glides smoothly under the loop line OHE.
   (ii) With OHE Inspection Car running on loop line check up if pantograph glides smoothly under the main line OHE.
   (iii) Check stagger of both the OHEs at turn cuts. (It shall not normally exceed 300 mm).
   (iv) Check that the main line OHE of overlap type turn out is about 50 mm below that of the turnout OHE.
   (v) Check up cross contact bar, if any, for displacement and distortion. Check up for hit marks, if any.
   (vi) Check for hit marks, if any.
   (vii) Check up rail level and setting of the obligatory mast.
   (viii) Check up for hard spots near rigid droppers, if any.

(e) Section Insulators Assemblies:
   (i) Clean insulators and replace chipped or cracked insulators.
   (ii) Check runners for flash-marks, hit marks and proper adjustment.
   (iii) Check for excessive contact wire wear near anchor clamps.
   (iv) Check the level of the assembly and adjust if necessary.
   (v) Tighten PG clamps of droppers and stiffeners.

(e) Isolators:
   (i) Check number plates for cleanliness and security.
   (ii) Check number plates for cleanliness and security.
   (iii) Check correctness of operation, alignment of contacts and arcing horns. Check earth continuity where applicable.
   (iv) Lubricate moving parts and locks.
   (v) Check interlocks where provided.
   (vi) Check that the distance between male and female contacts in open position is 380mm to 500mm depending upon the type of isolator.
(g) Short Neutral Section Assemblies

Carry out all checks as indicated in para 20312.

(h) Overlaps:

(i) Check height and stagger of OHE in the overlap section.

(ii) Check whether the normal minimum clearance of 500mm is available between the two OHEs in an insulated overlap and 200mm in an uninsulated overlap.

(iii) Check whether the lifting of out-of-run OHE is correct.

(iv) Check that parallel running of contact wires in the overlap for a minimum 2m in the pantograph sweep region.

(i) Contact Wire thickness:

Measure and record thickness of contact wire as detailed in para 20309.

(k) Neutral Sections:

Carry out all checks as for an insulated overlap in case of overlap type neutral sections and as for section insulators in the case of section insulator type neutral section.

(l) Overline, Structures/Tunnels

(i) Check and record horizontal and vertical clearances and adjust OHE as required.

(ii) Check for any flash-marks on the underside of the bridge structures.

(iii) Check that the prescribed height of contact wire is available.

(iv) Check that the gradient of contact wire on either side does not exceed 3mm/m.

(v) Check that smoke screens are properly secured and have adequate clearance from OHE. If not, get these attended to by Engineering Department.

(vi) In tunnels get necessary repairs done by Engineering Department.

(vii) Check rail level mark on sides of tunnels.

(m) Level Crossings

(i) Check height and gradient of contact wire.

(ii) Check condition of road surface and clearance of height gauge (a black band may be marked on the uprights at a distance of 4m from bottom face of the boom to facilitate measurement of clearance.)

Regulating Equipment:

(i) Check ‘X’ and ‘Y’ dimensions in the case of pulley block type equipment and ‘Z’ and ‘Y’ dimensions in the case of winch type equipment against prescribed values for the temperature at the time of checking. Make use of turn-buckles to adjust as required.

(ii) Check that the compensating plate is vertical. If not, adjust as required.
(iii) Lubricate pulleys and other moving parts.

(iv) Check if 20mm wide bands in black colour are painted on the mast to indicate upper and lower limits of movement of counter weight.

(v) Check condition of stainless steel wire rope for any signs of corrosion and breakage of strands.

(vi) Check condition of grooves on the drum of winch type regulating equipment.

(o) Bonds & Earthing Connection.

(i) Check all bonds and replace defective or missing bonds. Paint all bonds.

(ii) Inspect earths and record earth resistance. Earths having resistance of over 10 ohm should be attended to.

(P) Masts:

Check verticality of all masts with plumb-bob and take remedial action as required (see para 20305).

(q) Sites affected by accidents:

Such sites should be specially checked and attended to.

(r) Feeder Lines:

(i) Check guard wires at road crossings, if any.

(ii) Check earthing of towers.

(iii) Measure and record earthing resistance of towers.

(iv) Clean insulators and replace those which are cracked or chipped.

(v) Check the jumper connections, strain clamps, PG clamps and bi-metallic strip.

PG clamps:

(i) Check and clean oxide from surface.

(ii) Apply corrosion inhibiting compound.

(iii) Tighten to the prescribed torque.

30327 Integrated Blocks

The annual maintenance schedules can best be organized by adopting the system of Integrated Blocks. In this scheme, a 3 to 6 km block (Jumbo Block) is taken by introducing single line working in the off peak traffic hours between any two stations. Simultaneous work is carried out by permanent way, signal OHE/PSI staff during day light hours. This saves considerable time for taking and returning blocks, which forms a sizeable proportion of a short duration block. Effective use of available man-power can also be made by using extra gangs depending upon the nature of work. Such work may be organized for 2 or 3 days a week in selected sections and instructions issued in advance by appropriate planning.

20328 Re-tensioning of Unregulated OHE

The re-tensioning of unregulated OHE in accordance with the tension-temperature chart should be done ordinarily at the end of 6 months from the date of erection and again at the end of 12 months. Thereafter the tension should be checked up once in 2 years and retensioning done as required.
20329 Periodical Overhaul

1. The aim of POH is to recondition and restore the installation in the condition it was when it was first commissioned, whereas preventive maintenance has for its objective to take care of the wear and tear during normal service and forestalling possible failures by regular inspection and prompt attention. The POH should be thorough and cover every part of the installation.

The tests to be done at the time of commissioning of new OHE have been detailed in Chapter IX. The work involved during 4-year POH is somewhat greater in scope than the pre-commissioning tests, since after years of service many parts would have suffered wear and tear, of which necessary adjustments will have to be made or repairs done to make good the wear, or the irreparable items replaced.

The POH of OHE should be planned on a programmed basis so that every part of the installation receives detailed attention, repair and overhaul at an interval of 4 years. For programming POH, the entire section in each Division should be divided into smaller sections. POH gangs may be provided with camps at convenient locations so that heavy materials do not have to be carried from depot or sub-depot every day. Gangs can move to the site of work in convenient trains or by other means of transport.

As far as possible, gangs for the work should be earmarked so that a uniform standard of is achieved. All POH work should be done under the direct supervision of a supervisor not lower in rank than an ATFO/TFO.

To summarize, the object of POH is to make a thorough inspection of the OHE and to replace such of the worn-out or damaged parts by those, which have been reconditioned earlier in the maintenance depots and kept ready. The parts removed are sent to the maintenance depots for dismantling, thorough examination, re-conditioning if possible and re-assembly for use again as required.

Maintenance charts, prepared in different colours may be made indicating the type of schedule each section has to undergo. The same chart can be used to indicate the progress of work and special works to be done to exercise check over the tasks and targets.

2. In addition to the items detailed under annual maintenance, the following items should be attended to during POH:

(a) Masts, portals and cantilever supports:
   (i) least one complete cantilever assembly per 10 track-km (this may be modified by CEE if considered necessary) should be removed and taken to the workshop for dismantling and detailed examination of various components after thorough cleaning. This test check would reveal the extent to which other cantilever assemblies have to be examined.
   (ii) All regulating equipment should be replaced by previously overhauled ones and the removed equipment should be sent to the workshop for overhaul.
   (iii) As the bracket is articulated, check the position with reference to the axis of the mast. The position will vary with temperature and distance from anti-creep. The register arm and steady arm should as far as possible be in the same plane as the bracket.
   (iv) Check adjustments of cantilever assemblies, their slope and displacements at every structure for compliance with the 'as erected' SEDs.

(b) Catenary and Contact Wires:
   (i) Dismantle all jumper connections, clean the conductors, (with emery paper in case of copper or bronze conductors and metallic brush in case of aluminium conductors) clips etc. If the pieces show signs of overheating, this may be because either they are not tightened properly or the clips are deformed and
contact surface is insufficient. In the latter case they should be replaced. In case of the contact wire, it is the groove that has to be cleaned with either a fine metallic brush or emery paper. The use of scraper or file is forbidden. Replace frayed or damaged jumpers.

(i) Remove kinks if noticed.

(c) Insulated and Uninsulated Overlaps:

(i) Check the position of contact wire respect to tracks to comply with SEDS.

(ii) Ensure that insulators of anchoring wires are crossing the plane of OHE in correct position as per plan.

(d) Overline Structures: Check the height and gradient of the contact wire and tally the same with 'as erected'.

(e) Tunnels:

(1) Check the height and gradient of the contact wire and adjust as per SED.

(ii) 100 per cent OHE fittings in tunnels should be replaced with new or previously over-hauled fittings and the removed fittings taken to the Workshop for detailed examination.

(f) Turn outs:

Check the position of the contact wires with respect to the track for compliance with SED.

(g) Overhead Cross-feeders, Return Conductors and 25 kV Feeders:

(1) Examine wires for frayed strands, overheating, pinching or corrosion, especially at suspension clamps and PG clamps. Tighten junction sleeves.

(ii) While tightening PG clamps ensure that all joints are properly coated with veseline.

(iii) Check tension in wires and adjust if necessary.

(iv) Other overhead wires such as bypass feeders and earth-wires should be inspected. The insulator attachments should be dismantled, overhauled and put back in position. The insulators should be cleaned at the same time.

(h) General:

(i) During POH, fittings, which do not provide prescribed margin of adjustment and proper fitting should be replaced.

(ii) All fittings on masts should be checked against "as erected" drawings and any variation should be recorded and reported to Sr. DEE for changing the drawings.

(iii) The position of splice should be recorded in the relevant lay out plans.

(i) Work to be done in Workshops:

(i) Aluminium bronze fittings, bolts and nuts should be cleaned and carefully examined if necessary with a magnifying glass. Particular care should be taken to see that the threads are in good condition. Fittings which have developed cracks should invariably discarded.
(ii) All G. I. fittings and pipes should be examined for deterioration of galvanization. Minor chippings may be repaired by using cold galvanizing paint. (Sand or emery paper should never be used for cleaning).

(iii) In case of a major OHE break down, it is advisable to remove the bracket assemblies in about 8 to 10 spans on either side and examine them critically for cracks, twists, bends or other defects which may cause failures later on.

(iv) The regulating equipment should be dismantled and every part should be cleaned. Bearings should be fitted back after lubricating. Rubber washers/rings should be replaced where necessary. Any grazing or rubbing on pulleys should either be repaired if possible or the damaged equipment should be replaced. All lubricating holes should be free for passage of grease. The stainless steel rope should be closely examined for damage to the strands. Particular attention should be given to the end fittings on the stainless steel rope. Only approved type of lubricant should be used for regulating equipment components.

20330 Rehabilitation of OHE

Depending upon the condition of the fittings, rehabilitation of the OHE may be undertaken after a period of 20 year. CEE may decide the assemblies to be replaced after a special drive for condition monitoring.

20331 Transmission Lines

1. General

The overhead lines should be inspected periodically to detect any faults and necessary repairs should be done immediately.

2. Patrolling of Overhead Lines from the Ground

Patrolling of all overhead lines should be done before and after the monsoon. The frequency of patrolling of the overhead lines for the rest of the period will depend on local conditions. The patrollers should write the inspection notes and pass them on to the maintenance gang for carrying out repairs. The patrollers, should be equipped with Inspection books, tape and binoculars. The main points to be noted while patrolling are as follows:

a) Structures: Leaning structures; deformed members; buckled structures; missing fasteners and members; accessories removed; protective coatings like galvanizing or paints disappeared; suspension and strain insulator attachments damaged.

b) Foundations - Signs of external damage; settled and washed out soil below normal ground level over foundations within uplift frustum perimeters; tilted stubs; cracks or breaks in chimney top; slippage oil stubs from encasing chimney concrete; uneven settlement of footings; disappearance of gravel blanket protection; backfill embankment and its covers (rip-rap or revetment); damage to retaining walls, abutments and breast walls and disappearance of external earth backing retaining walls below designed lines.

c) Insulators and Fittings:- Damage to insulators, heavy surface pollution, missing locking devices like nuts, washers and pin, burnt out fittings, deflected strings, damage to protective coatings. The cracked insulators, bird droppings, dense spider webs, kites with threads hanging on the insulators string.

d) Conductors and Jumpers: - strands cut and opened up; loose jumpers out of shape and causing infringement of clearance of live wire to earthed metal parts, dead birds, fallen branches or fallen trees on conductors.

e) Earthing Equipment: - Damaged, broken or missing earthing strips.

f) Right of Way and Clearance: - Shrubs and trees within right-of-way causing obstruction and infringe.
ment of clearance of bottom conductor to ground; objects within line clearance excavation. In no circumstances, however, clearance measurements should be taken from live line.

3. Foreign Objects: - Construction works near lines causing infringement in line safety or electrical clearance; birds' nests on structures; use of structure for applying permanent support or pull to other objects; huts newly constructed underneath lines, and embankments/fencing.

3. Inspection of Overhead Lines from Tower Tops

Many breakdowns including slipping of conductor due to loose clamps, cracks in insulator porcelain, defects in insulator fittings, conductor, earthwire and accessories and their attachment points on structures can only be dispensed or seen by going on top of every structure. This inspection should be carried out by taking a shutdown of the line at least once in six years. Along with such inspection, repairs should also be carried out. Any replacement as required should also be made.

4. Special and Emergency Inspection

A special inspection of the overhead lines should be carried out after severe wind/hail storms, quakes, snowfalls, forest fires, floods or heavy rains. Such inspection should be done after sabotage too. The purpose of such inspection is to detect any damage or breakage on line and to effect necessary repairs.

When an overhead line is subject to fault often, it should be inspected to ascertain the nature of fault, such as too much sag, tree branches touching the line, etc. and to find out remedial measures required with a view to avoiding their recurrence.

5. Maintenance Tests and Measurements

Insulation resistance of line should be measured at convenient interval particularly at the time when the line is shutdown for repairs or maintenance. In regard to measurements of earth resistance of metal structures, it should normally be carried out annually, however, local circumstances and experience may dictate increase or decrease in this interval but it should not be less than once in two years.

The clearance and shape of the jumpers should be checked at an interval not exceeding 3 years.

6. Line Repairs Tools

The following special tools, apart from tools required for maintenance of civil works of the lines, should be kept handy and in working order:

a) Conductor jointing tools,

c) Bolted come-along clamps,

c) Winches,

d) Aerial trolleys

e) Aerial rollers,

f) Thermometers,

g) Dynamometers,

h) Level and theodolite,
i) Measuring tapes

k) Linesman's ratchet,
IV. SAFETY RULES FOR OHE

20332 General

1. The following rules are supplementary to the General and Subsidiary Rules and the instructions contained in Volume 1.

2. Printed boards containing instructions regarding treatment of persons suffering from electric shock should be exhibited in every OHE maintenance depot, equipment room, switching station, cabin, OHE Inspection Car shed, loco shed, OHE Inspection Car and wiring train and also in offices of SM, ASM, CYM, AYM and HTXR.

3. First Aid Boxes should be kept at every switching station, maintenance depot, in OHE Inspection Car, breakdown vehicle and wiring train.

4. Ropes, come-along clamps, tirfor etc. should be tested once in six months at least, in the presence of an ATFO, and record of such tests maintained in each depot.

20333 Documents to be kept with OHE Supervisors for Work on OHE

1. The ATFO (OHE) or other official supervising OHE work shall have with him a complete set of structure erection drawings, lay out plans, sectioning diagram and general supply diagram etc. pertaining to the overhead equipment under his charge. He shall also have with him Station Working Rules for the stations between which he is working. He shall, in addition, keep with him all useful information regarding the running of trains over his section.

2. It shall be the responsibility of the TFO/ ATFO (OHE) or in his absence the senior-most official in-charge of the work to ensure that all safety rules prescribed are actually observed by the staff when carrying out work on traction installations. It shall be the duty of the supervisor to remind the staff periodically of the various safety rules to be observed at work site.

20334 Permit to Work

Before commencing work on any part of the dead OHE or within 2m of live OHE, a permit-to-work shall be obtained from TPC or other authorized person as detailed in Chapter VI.

20335 protection of Staff against Traffic Movements and Protection of Trains

1. The supervisory official in-charge of work on OHE shall observe relevant provisions of GR and SR for protection of trains before work on OHE is commenced and for the whole time the work is in progress.

2. Measures laid down in the Chapter VI shall be observed by all concerned to prevent accidental energization of the section under power block on account of electric train movements.

20336 Earthing before Commencement of Work

1. All metallic parts within reach (either directly or through tools etc.) shall be earthed, after they are made dead.

2. Each working party shall be protected by at least two independent earths, one on each side of a working party.
3. If the distance between the working parties exceeds 100m intermediate earths shall be provided in such a manner as to ensure that the distance between earths does not exceed 100m.

4. Even when earthing is provided by isolator switches with earthing heels, additional temporary earths as above shall also be provided.

20337 Procedure for Providing Temporary Earths

The following sequence of operations shall be carried out while providing temporary earths on OHE:

1. Men shall be posted on both sides of the site of work to warn the working party of any approaching train on the same track and adjacent track(s).
2. The permit-to-work shall be obtained prior to commencing work to make sure that power supply has been switched off.
3. For providing temporary earth on the OHE or other equipment after it has been made dead, only discharge/earthing pole assembly specially designed for this purpose alone should be used. The cable shall be flexible and should have adequate cross-section (40 mm²) to be able to withstand short circuit currents.
4. Fix the earthing-clamp securely to a mast at least one span away on one side of the work site after making sure that the mast-to-earth rail bond of this mast is intact. Alternatively, the clamp may be fixed to the bottom flange of one of the traction rails, taking the cable under the rails.

In single-rail track-circuited sections, the earthing clamp should be fixed to the traction rail i.e. non-track-circuit rail; on double-rail track-circuited sections the earthing clamp should be fixed to the mast.

The mast-end or rail-end clamp of the discharge/earthing pole assembly should be checked for tightness just before connecting the top clamp on to the OHE as the earthing clamp fixed to the rail or mast in advance could have worked loose.

5. Hook securely with a snap action the top clamp of discharge/earthing pole assembly to the OHE conductor close to the mast/structure and tie the earthing pole to the mast/structure. Never hook on the top hook of the earthing cable to the OHE, till the other end has been first connected to earth.
6. The earthing clamps should always be fixed to the traction rail or mast/structure first and then the top clamp should be hooked to the OHE to be earthed.
7. Repeat operations 4 and 5 for the second temporary earth on the other side of the working party.
8. After temporary earths have been fixed on the OHE on both sides of the work site, staff may proceed with the maintenance work.
9. After work is completed and men, materials and tools have been removed and the OHE is clear, the above earthing rods may be removed in the reverse order i.e., first remove the hook on the OHE and then the clamp fixed to the rail or mast/structure. After warning all staff that supply will be restored and that they should keep away from live equipment, the permit-to-work may be returned and supply restored.

20338 Precautions in Regard to Discharge/Earthing Pole Assembly

1. The continuity of the cable connection between the top clamp and the earthing clamp should be checked once a fortnight.

Cable should be renewed if more then 20% strands are broken. During use, cable should be continually examined for fraying and breakage of strands.
Discharge/Earthing pole assembly should be inspected by TFO/ATFO once a month.

2. During accidents when slewing the OHE and in similar circumstances, the discharge/earthing pole assembly should be provided at a location where it is not likely to be interfered with during crane working or due to work on the permanent way.

20339 Work on OHE or any Conductor having a Sectioning Point

When work is to be carried out on OHE or conductors, which are not electrically bonded, following additional precautions are required.

i) The two sections of conductors or ends of conductor which may have snapped may be at different potentials. Each end should, therefore, be separately earthed at two points after switching off supply to both parts, of the OHE or conductor.

1) This precaution should also be observed when working on or in the vicinity of a sectioning point and cut-in insulators.

3. Neutral Sections should be treated as live equipment and earthed separately at two points on either side of the work party before commencing work.

4. When work is to be carried out on an isolator, both sides of the isolator should be earthed at two points or more conveniently, isolator jumpered temporarily.

20340 Protective Helmets

At the work-site, staff are advised to wear helmets to protect their heads against any tools or equipment which may drop down accidentally, as well as to minimize head injury in case of accidental fall from a height.

20341 Safety Belt

Staff working on structures or a ladder are advised to protect themselves against an inadvertent fall by wearing a safety belt for supporting themselves by a rope sling.

20342 Rules for use of Ladders

1. It shall be the responsibility of the supervisor to ensure that ladders are stored in a protected enclosure, properly maintained and reconditioned as often as required.

A ladder should never be in such a position so as to likely to fall on a live part.

2. Ropes used with ladders should be of cotton or jute. Use of metallic ropes is prohibited. A ladder should be held by one person on the ground to prevent slipping, while the top end should be tied to the supporting structure or conductor to keep it in position and prevent it sliding away.

3. Ladders should never be allowed to fall on or rest against the contact wire.

4. If the nature of the work involves risk of the conductor breaking into two parts (due to opening out of sleeves or splices) the ladder shall not be rested against the conductor. Trolley ladders shall be used in such cases.

5. More than one person shall not normally be allowed on a ladder as far as possible.

6. Climbing on a ladder with wet or slippery foot-wear is forbidden.

7. Ladders should not be used for transporting materials.

8. A rope should be used to pass tools or any equipment to the men working on a ladder.
9. No one should stand directly below a work spot under a ladder.

**20343 Other Important Precautions to be taken while Carrying out Works on OHE**

1. The useful cross section of a conductor shall not be reduced while making joints.

2. Any contact with conductors, which are not specifically earthed, is forbidden.

3. The strength of the anchoring rope should be not less than that of the cable to be anchored.

4. Temporary anchoring of conductors should only be done by using stranded flexible steel cable at least of the same tensile strength as the cable to be anchored. Use of two cables of different strengths joined together is prohibited. Use of cotton, jute or other non-metallic ropes for anchoring is forbidden.

5. Structure bonds and cable connections of the structure to earth shall be maintained in proper condition. No heavy materials should be stacked on the rail bonds; transverse bonds between two rails of the same track as well as rails of different tracks shall also be maintained in proper condition.

6. Where rails to which structures are connected are replaced, the structure shall be connected to the new rail immediately after it has been laid.

**20344 Procedure for Effecting Shut-Down for Work on Auxiliary Transformers**

Power supply to auxiliary transformers is effected through fuse-switches on the 25 kV side and the LT Side is controlled through fuses or double-pole iron-clad switch-fuses. Isolating fuse switches should be opened out and fuses removed both on the HT and LT sides and the transformer earthed before starting work.

**20345 Work on Overhead lines Running Parallel to Electrified Tracks**

No work on any span of any overhead line (LT power line or other line) running parallel to an electrified track where the minimum distance between the nearest conductor of the overhead line and the centre-line of the nearest electrified track is less than 8m, should be done without switching off power from the 25 kV traction line (in addition to making dead and earthing the overhead line on which work is to be carried out, in the normal manner) excepting for the following specific items for work:

1. Replacement of lamps, if below line.

2. Painting of structures / poles up to a distance of 2m from the live wires of the power line.

3. Reinforcement of foundations where such reinforcement does not involve any prior weakening of the foundation at any time during the work.

4. Replacement of aerial fuses.

**20346 Isolation of Booster Transformers**

To isolate a booster transformer for maintenance or other work, the following sequence of operations should be carried out:

1. Where no isolator is provided a permit-to-work should be obtained for both the elementary sections, the BT should be disconnected from the OHE and the OHE made through by jumpering.

2. When an isolator is provided to disconnect the BT primary winding from 25 kV lines, power must be switched off from both the elementary sections to which the BT is connected after which the isolator should be opened to disconnect the BT from the OHE and to make the OHE through.

3. The secondary winding of the BT should be disconnected from the return conductor and the return conductor made through by jumpering.

4. The return conductor should be earthed at the location where the BT has been disconnected; and the mid-
point rail links on both sides of the BT should be opened so that booster cells on either side will extend over a longer section temporarily.

5. With the OHE and return conductors made through, 25 kV power supply may be restored

It should be noted that during the period when a BT has been disconnected from service, the interference on adjacent communication circuits will be enhanced. In view of this the defective BT should be replaced with a good BT with the least possible delay.

20347 Isolators

Isolating Switches on the 25 kV system shall not be opened or closed when current is passing through them. Normally, isolators should only be opened or closed, after power supply to the section has been switched off by opening the appropriate interruptor (see para 20600 & 20601).

20348 Petroleum Sidings

The following arrangements/precautions would be necessary:

**Arrangements**

i) An equipotential link between the petroleum sidings installation earth and the track via a switch

ii) Setting up of neutral zones (insulating joints) in the track to avoid any risk of propagating stray current.

iii) Setting up of neutral zones/sections in the contact wire similar to loco inspection pits.

iv) The tracks must be provided with longitudinal bonds on both the rails as well as transverse bond (30 m intervals). All masts and metallic structures in the vicinity of the track/ sidings should be provided with structure bonds. Copper rivets should be used for bonding.

v) 10 ohm earths must be connected to the petroleum siding on each side at the insulated joint.

**Precautions**

c) No oil tanker Is. permitted to stable under live OHE for inspection purpose.

ii) Fuelling to be done by side filling arrangement only.

iii) Pipe lines in the vicinity of the track should be properly earthed.

iv) Minimum 2 m electrical clearance from live OHE of the adjacent track or only other structure nearby must be maintained.

v) During filling/loading and unloading of petroleum products the isolators at the neutral section of OHE should be kept open to ensure that the OHE is dead and earthed.

V. FORMS AND REGISTERS

20349 Records to be Maintained

In Chapter VI the recommended proforma for Power Block and Permit-to-Work messages have been given.

Particulars of other essential records to be maintained in regard to OHE maintenance are given below

1. Daily Report of OHE Maintenance to be submitted by the Supervisor in-charge of field work to ATFO. This should be in proforma No. 03-1 appended.

The form in which reports are to be submitted by the ATFO/CTFO to AEE (TrD) and SR.DEE / DEE (TrD) may be laid down locally by each Division.
2. Register for Foot-Patrol Reports: The reports regarding foot-patrolling (para 20322) should be entered by the Linesman in a Register to be maintained for the purpose by each Section Supervisor. The Register shall be generally as shown in proforma No. 03-2 appended.

3. Cantilever Assembly Maintenance Register as per proforma No. 03-3. This should be maintained by each depot/sub-depot.

4. Register of Contact Wire Thickness Measurements: This Register shall be maintained in proforma No. 03-4.

8. Register of Clearance under over line Structures as per proforma No. 03-5.

9. Register of Earth Resistance Measurement as per proforma No. 03-6.

7. Register of Current Collection Tests shall be maintained in proforma No. 03-7.

8. Register of Regulating Equipment shall be maintained by each depot/sub-depot for its jurisdiction. This Register should have a page allotted for each Regulating Equipment. Particulars of adjustments carried out, amount of catenary and contact wire cut etc. shall be recorded in this Register, indicating the dates on which these items of work have been done, as per Proforma No. 03-10.

9. Register for Isolator Switches shall be maintained by each depot/sub-depot indicating dates on which the isolators have been inspected and the details of work carried out, as per Proforma No. 03-11.

10. Register for Turn cuts and Cross-overs shall be maintained by each depot/sub-depot. This should indicate the dates on which each turn out/cross-over has been checked for adjustment and particulars of work done, as per Proforma No. 03-12.

11. Register of Vulnerable Foundations: This should contain details of checks carried out on foundations at vulnerable locations, such as on over bridges, embankments susceptible to erosion etc., as per Proforma No. 03-13.

12. Register for Feeder Lines shall be maintained by concerned depots/sub-depots to indicate particulars of patrolling of 25 kV feeder lines and maintenance carried out on such feeder lines.

13. Register of Critical Implantation: The annual check of Implantation at critical locations (para-20306) shall be recorded in this Register as per Proform'a No. 03-8.

14. Register of Level Crossings: This should contain dates on which height of contact wire at Level Crossings as well as that of the height gauges at Level Crossings have been checked. See Proforma No. 03-14.

15. Register of Splices as referred to in para 20310 as per Proforma No. 03-15.

16. Register of OHE Break-downs: Each depot/sub-depot should maintain particulars of OHE break-downs occurring in its jurisdiction in Proform'a No. 03-9. For each break-down a page should be allotted. Reference to detailed reports submitted should also be given to facilitate investigations subsequently.

Registers may also be maintained for any other additional items in the proformae prescribed by CEE.

The registers should be of A-4 size. As they are required for permanent record they should be cloth-bound. The nomenclature of the register should be shown on the cover in 6 mm block letters.

The Supervisor of the depot/sub-depot will be held responsible for ensuring that these registers are maintained up-to-date. Officers and Senior Supervisors during their inspections should scrutinize these registers and initial a few important entries.
### SCHEDULE OF MONTHLY INSPECTIONS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Nature of Inspection</th>
<th>SR.DEE</th>
<th>DEE</th>
<th>AEE</th>
<th>CTFO*</th>
<th>TFO*</th>
<th>ATFO*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Locomotive Cab</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>2.</td>
<td>OHE Inspection Car</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
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<tr>
<td>3.</td>
<td>Push Trolley</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>4.</td>
<td>OHE Depot</td>
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<td>4</td>
<td>4</td>
<td>-</td>
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<tr>
<td>5.</td>
<td>Station</td>
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<td>2</td>
<td>4</td>
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<tr>
<td>6.</td>
<td>Night Inspection</td>
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<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>7.</td>
<td>Office Inspection</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Notes:**

1. These Inspections are the minimum quantum per month.
2. In respect of Supervisory Staff, the inspections pertain to their respective jurisdiction.
3. Brief checklists of items to be broadly covered are indicated at Annexure 3.02. Detailed maintenance schedules prescribed should also be kept in view.
4. Quota of Inspections by HQ officers may be laid down by CEE.
CHECK LIST FOR INSPECTIONS

1.0 OHE Depots & Subordinate Offices

(a) OHE Depots
1. Staff grievance register.
2. Quarter register.
3. Attendance registers.
4. Availability of all drawing (latest), SWRs with latest correction slips.
5. Cleanliness of depot.
6. Upkeep of Stores.
7. Stock position of stores.
8. Upkeep of wiring train, OHE Inspection car, ladders, tools etc.

b) Subordinate office:
1. Attendance registers.
2. Compliance of audit & account Inspection notes.
3. Compliance of Officer's inspection 'notes.
4. Test & Trial report.
5. Latest drawings & specifications.
6. Planning & progress of section

1.0 Station
a) SWR
1. SWRs with latest correction slips.
2. Display of traction working diagram and its correctness at SM room & cabins.
3. Traction KeyBoard and key register for its proper maintenance.
4. Knowledge of traction working of SM/ASM on duty.
5. Validity of the competency certificate of SM/ASM.

b), CLS Board in SM room/cabin
1. AT standby supply.

c) Isolator.
1. Locking arrangements.
2. Correct alignment of blade tip in the fixed pole contact jaws.
3. Correct matching & alignment of arcing horns.

d) General
1. Fire extinguishers, sand/water buckets, Respiration chart, First Aid Box, Tools & Plants.
2. Working of TPC phones & emergency telephone sockets.
3. History sheets of various equipments.

### 3.0 Cab Inspection

**a) Condition of OHE**
1. Flashed/damaged insulators
2. Displaced fittings & droppers
4. Number plates, warning board for rusting & tightness.
5. BT : Oil leakage and deposits of pollutants on insulators
6. AT : 011 leakage and deposits of pollutants on insulators

**b) Obstruction to OHE:**
1. Birds' nests
2. Tree branches near OHE.

**c) Cab equipments**
1. Emergency telephone.
2. Focussing of head lights & flasher light.
3. Voltage on loco voltmeter at FP & SP locations.

**d) Driving technique of Driver**
1. Exchange of signals with station staff.
2. DJ opening & closing at neutral section.
3. Observation of caution orders.

**e) Night Inspection**
1. Incidence of sparking from the rear cab of locomotive.
2. Other items as above.

### 3.0 Push Trolley Inspection

**a) Mast:**
1. Implantation at selective locations.
2. Deflection of mast, on leading mast.
3. Areas affected by accident.
4. RC, to rail connection for any loose connection.
5. Connection bonds and earthing connection.
6. Number plate.
7. Muffing.

**b) OHE fittings:**
1. The isolator blade is fully in and also for signs of sparking or overheating.
2. Insulators for any chipping/flash marks/damages.
3. Displaced fittings & droppers.
5. Birds' nests, stray wire pieces and tree branches likely to infringe the OHE.
6. Free movement and position of counter weight with reference to upper and lower limits marked on the mast.

c) L. C Gate & over line structures.

1. Protective screens at FOB/ROB.
2. Height gauges at level crossings and height.

(f) Booster Transformer & Auxiliary, Transformer

1. Oil level and leakage of oil.
2. Anticlimbing devices.
4. Earthing.
5. Fuses on ATs.

e) General

1. Signs of heavy sparking on OHE when train passes.
2. General condition of switching stations enroute.
3. Emergency telephone sockets at important locations.

Inspection with OHE Inspection Car

a) Mast, portals and cantilever supports.

1. Structures and galvanized tubes for rust & chipping off galvanization.
2. Cracks on steady arm & register arm.

b) Contact & Catenary wires

1. Kinks & twists on contact wire.
2. Broken strands on catenary wire.
3. PG clamps, Jumpers.
4. Contact wire wear at selected locations.
5. Height and stagger at selected locations.

c) Section insulators

1. Flash or hit marks on and adjustment of runners.
2. Level of assembly & alignment.
3. Chipped/cracked insulator.

d) Turn-out

1. Stagger of both the OHES.
2. With Inspection Car running on loop line, check up if the-main line OHE passes smoothly under the pantograph.
3. With Inspection car running on main line, check up if the loop OHE passes smoothly under the pantograph.
Overlaps:

1. Height and stagger of OHE in the overlap section.
2. Whether normal minimum clearance of 500mm is available between the two OHEs in an insulated overlap and 200mm in the case of uninsulated overlap.
3. Check up whether lifting of out-of-run contact wire is correct.

(f) Overline structures

1. Horizontal & vertical clearances.
2. Flash marks underside of the structures.
3. Gradient of contact wire on either side.
4. Insulation on catenary wire under the structure.

(g) Level Crossing.

1. Height & gradient of contact wire.

(h) Regulating Equipment:

1. X-Y and Z-Y values with temperature.
2. Free movement of drum.
3. Lubrication of pulley and other moving parts.
4. Stainless Steel wire rope for opening of strands, broken or rusted strands.
PROFORMA 03-1

......................... RAILWAY
......................... DIVISION
TRACTION DISTRIBUTION SECTION
Daily OHE Maintenance Report

Date .......... 
................. Depot

Note : - To be submitted to ATFO by the field supervisor on the same day after completion of work.

1. Power Block in sub-sector/Elementary. Section :
(a) Time asked ...........................................................................................................................
(b) Time received ........................................Time returned.............................................

Remarks, if any ................................................................................................................................

2. Staff utilized –Skilled ....................................................Semi skilled ......................................

Unskilled ..............................................

3. Details of work carried out:

(a) Stay/Bracket/Anchor insulators cleaned from Mast No . --------------------------

-------------------------------------------------------------To Mast No. ........................

(b) Section Insulator cleaned and checked Nos....

(c) OHE checked and adjusted between Mast No

............... .................................................To Mast No .................

(d) Height and stagger of contact wire to be measured and recorded


<table>
<thead>
<tr>
<th>Mast No, SED</th>
<th>Height of contact wire</th>
<th>Stagger</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>As per SED</td>
</tr>
<tr>
<td>Mast No,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SED</td>
<td></td>
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<tr>
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<td></td>
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<tr>
<td>SED</td>
<td></td>
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</tbody>
</table>

(e) Checked and adjusted X and Y at Mast Nos.


<table>
<thead>
<tr>
<th>Mast No cut</th>
<th>How adjusted</th>
<th>By turn buckle</th>
<th>By cutting</th>
<th>Length of wire</th>
</tr>
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<tbody>
<tr>
<td>Mast No</td>
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<tr>
<td>Mast No</td>
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</table>

INDIAN RAILWAYS - AC TRACTION MANUAL VOLUME 11 PART 1
(f) Dia. of contact wire checked at location Nos ............. .... ................................................................. Dia
...............................................................................................................................................................

(g) Clearance checked at location ................................................................. Measurements
...............................................................................................................................................................

(h) Insulated overlap at location No ................................................................. clearance between OHE ............................................... (500mm min.)

(i) General condition of contact and catenary wires ................................................ Report if any catenary strands are damaged.

4. Work done without Power Block

(a) Muffs cleaned from Mast No ........................................... to Mast No..............................

(b) Bonds checked and tightened from Mast No ........................ ..............

To mast no. ........................................................................

  1. Discrepancies ...............................................................
  2. Repairs done .............................................................

(c) Rail level and implantation checked from Mast No ..... ........ to Mast No

Rail level mark missing .............................................
Repainted .................................................................

Discrepancies .................................................................

-------------------------------------------------------------------------------------------------------------------------------
Rail level Implantation
-------------------------------------------------------------------------------------------------------------------------------
Mast No. Low by cm. High by cm. As checked As per SED
-------------------------------------------------------------------------------------------------------------------------------

-------------------------------------------------------------------------------------------------------------------------------
Station............................... Signature of Supervisor
Dated. ............................. Designation

-------------------------------------------------------------------------------------------------------------------------------
**PROFORMA 03-2**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Date</th>
<th>Location No.</th>
<th>Nature of Defect</th>
<th>BY whom noticed</th>
<th>Date of rectification</th>
<th>Initials of Supervisors</th>
</tr>
</thead>
</table>

Note - One Page to be allotted for each km.

**PROFORMA 03-3**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Location No.</th>
<th>Type of Location</th>
<th>Date on which attended</th>
</tr>
</thead>
</table>

Note - 1. Each km should start with a fresh page.
2. Type of location should indicate BWA (Balance weight), FTA (Fixed termination), IR (In-run wire), OOR (Out-of-run wire) etc.
3. When POH is carried out on individual cantilevers, the date should be recorded in red.

**PROFORMA 03-4**

<table>
<thead>
<tr>
<th>Location Line Remarks</th>
<th>Date</th>
<th>Thickness of Wear since last</th>
</tr>
</thead>
</table>

---

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## PROFORMA 03-5

**Register of Clearances under Over line Structures**

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Contact</th>
<th>Remarks</th>
<th>Clearances of</th>
<th>Contact wire</th>
<th>Clearances</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Height</td>
<td>Catenary wire height</td>
<td>as adjusted height if any,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Above Rail level</td>
<td>adjusted to</td>
<td>as per</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I End</td>
<td>II End</td>
<td>I End SED</td>
<td>(m)</td>
<td>(cm)</td>
<td>(cm)</td>
</tr>
</tbody>
</table>

---

**Span**

**Push up**

**Clearance**

**As per profile**

*Note:* Each line under FOB/ROB to be allotted a separate page.

## PROFORMA 03-6

**Register of Earth Resistance Measurements**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Date of Test</th>
<th>Resistance in Ohms</th>
<th>Remarks</th>
<th>Over all Resistance</th>
<th>Initials of Supervisors</th>
</tr>
</thead>
</table>

---

*Note:*

1. Half page to be allotted for Each pit.
2. Earth test should be carried out on a dry day preferably in March/April once a year.

## PROFORMA 03-7

**Register of Current collection tests**

<table>
<thead>
<tr>
<th>Date</th>
<th>By whom Done</th>
<th>Loco No.</th>
<th>Train No.</th>
<th>Approx. Action</th>
<th>Loca Obser</th>
<th>Action Date</th>
</tr>
</thead>
</table>

---

*Note:* One page to be given to each block section (up and down lines separately).
PROFORMA 03-8

Record of Locations with critical implantation

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Block No.</th>
<th>Location No.</th>
<th>Line No.</th>
<th>Implantation (m)</th>
<th>Date As checked</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Section</td>
<td>Line No.</td>
<td>Actual</td>
<td>Per SED</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: - One page in the Register to be allotted for each location

PROFORMA 03-9

Register of Break-downs/ Accidents involving OHE

1. Date of accident/break-down .................................................................
2. Station ........................................................................
3. OHE Locations affected ......... ...........
4. Details of damages ......................
5. Probable cause ..........................................................
6. Brief description and remedial action taken .................................
7. Reference to detailed reports sent ..............................................

8 Remarks, if any ................. ................................

Note:- One page in the register to be allotted for each case.
### Traction Distribution Section

**Regulating Equipment**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Date of checking</th>
<th>Tension length m</th>
<th>Temp. °C</th>
<th>Noted Value X/Z mm</th>
<th>Adj. required X/Z mm</th>
<th>Date of adjust.</th>
<th>By turn buckle</th>
<th>Wire Co. Calenary Contact</th>
<th>Final Values X/Z mm</th>
<th>Adj. done</th>
<th>Whether greased</th>
<th>Signature of ATC/ELC</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
</tbody>
</table>

(N.B.: One page to be allotted for each ATD location)

### Traction Distribution Section

**Isolator Switches**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Location</th>
<th>Particulars of Isolator Switch connected</th>
<th>Elementary section checked</th>
<th>Date Checked</th>
<th>Condition</th>
<th>Particulars of work done, if any.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

(N.B.: Half page to be allotted for each switch)
### Profonna 03-12

**RAILWAY DIVISION**

**TRACTION DISTRIBUTION SECTION**

**Turnout and Cross Overs**

**TURNOUT/CROSS OVER NOUMBERS**

**SECTION**

**STATION**

---

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Date checked</th>
<th>Whether cross type or overlap</th>
<th>Height of Mainline contact wire,m.</th>
<th>Stagger of Turnout/OHEmm</th>
<th>Mainline X-over Contact wire,m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
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<td>3</td>
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<td>9</td>
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<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

(N.B. Half Page to be allotted for each turnout/crossover)

---

### Profoma 03-13

**RAILWAY DIVISION**

**TRACTION DISTRIBUTION SECTION**

**Vulnerable Foundations**

---

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Action checked</th>
<th>Height of HRL mark</th>
<th>Amount of leaning in mm at cont. wire level taken at 1.85mm from HRL taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
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<td>4</td>
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<td></td>
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<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Location:

Type of Mast:

Type of Foundation:

Type of Soil:

Whether the foundation situated on embankment/cutting, bridge, flyover, tunnel etc.

Implantation as per SED:

(N.B. One Page for each masts/location)
## Level Crossing Gauges

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Location</th>
<th>Line</th>
<th>Date of Checking</th>
<th>Height of Contact</th>
<th>Condition of Height gauge</th>
<th>Level of Road or Rail level</th>
<th>Whether manned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Half page for each level crossing)

## Record of Splices

### BLOCK SECTION

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Date when Provided</th>
<th>Location in between</th>
<th>Date of Checking</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME 11 PART [1 07]
## CHAPTER IV

REMOTE CONTROL EQUIPMENT

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</tr>
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</tr>
</tbody>
</table>
CHAPTER IV

REMOTE CONTROL EQUIPMENT

I. GENERAL

20400 Introduction

A Remote Control Centre (RCC) is set up near the Traffic Control Office on each Division having electric traction, to work in close liaison with the traffic control. The RCC includes the main control room, equipment room, Uninterrupted Power Supply (UPS) room, Remote Control laboratory and Battery Room and is the nerve centre of the Traction Power Control.

Types Of Equipment:

The following types of Remote Control Equipment are mainly in use on Indian Railways at present:

(i) Frequency Modulated Voice Frequency Telegraph (FMVFT), Strowger type equipment for supervisory control.

(ii) Supervisory Control And Data Acquisition (SCADA) systems with Microprocessor based equipment and/or Computer based equipment.

The FMVFT equipment was in use for all electrification schemes prior to 1980. Being mainly all relay system, the equipment has become outdated although some Remote Control Centres still continue to operate on this system. Salient features of the system are indicated at paras 20401 to 20406.

The SCADA equipment based on State of the art technology has come into use after 1980. Considering the fast growth and development of computer based equipment, newer types with enhanced capabilities and new makes are being introduced. Additional facilities at each new RCC is also natural as new features get incorporated.

11. FMVFT EQUIPMENT

20401 Transmission Path

For transmitting control signals from the Remote Control Centre (RCC) to the various controlled posts underground cable circuits suitable for voice frequency (VF) operation are employed. These consist of star quads with an attenuation of about 0.3 dB/km. Isolating transformers are provided on the cable circuits at intervals of 10 to 15 km to limit the build up of longitudinal induced voltage on account of induction effect of single 25kV ac traction. Line losses are made good by VF repeaters provided by the S&T Department at interval of 30 to 50 km. The maximum gain in the repeater is 20 dB. Depending upon the distance of the RCC or controlled post (TSS/SP/SSP), repeater gain is so set that signal level at any point is within prescribed limit. Impedance matching transformers of ratio 1120 : 1120 are provided at points where communication cable is tapped for taking connection to the R.C. Centre or to the controlled posts. Suitable surge arresters are also provided inside the equipment room at the termination point of communication cable to protect the circuits.

Normally three pairs of conductors are earmarked for Remote Control System, one pair reserved for telecommand signals from RC Centre to the posts and one pair from the posts to RC centre for telesignals. The third pair is spare for use in emergency, when any one of the other two pairs become unhealthy.
20402 Remote Control Switching Equipment

The RCC switching equipment consists of the following five major units

1. Pulse Generator
2. Send Selector Circuit
3. Receive Selector Circuit
4. Check Circuit and
5. Indication Circuit.

All the units are of the plug-in-type and are housed inside the steel cabinet, which is provided with dust proof front and back doors. A number of such cabinets are provided in the remote control centre depending upon the number of controlled posts in a section.

20403 Mimic Diagram Board at RCC

The mimic diagram board at the RCC comprises several control panels on which the mimic diagram is shown. Every apparatus to be remote controlled is represented on this mimic diagram board by a control discrepancy switch. Hand operated dummy switches similar to but clearly distinguishable from the control discrepancy switches are provided to represent certain non-remote controlled apparatus like sub-station isolators. The electrified tracks are represented on the mimic diagram by white perspex strips or metallic strips. Whenever the 2SKV voltage on any portion of the OHE between two controlled posts fails, or is not available, the corresponding portion of the mimic diagram lights up. The mimic diagram, however, remains dark under normal working conditions.

Each control discrepancy switch includes a built-in-jamp in a central indicator bar. If the controlled equipment is in closed position, the central indicator bar shows continuity of the diagram. If it is open, the central indicator bar will be at right angles, breaking the continuity of diagram.

Besides above, fault annunciation windows on the mimic diagram board are provided for each controlled post, with suitable inscription to annunciate the following kinds of fault:

1. Station Blocked
2. R.C. Equipment Defective
3. Contact Failure
4. Low volt d. c.
5. 240 V a.c. Failure
6. Transformer Alarms
7. Transformer faults

Item 6, 7, 8 are provided only for traction sub-stations. Item 6 & 7 are provided separately for each individual transformer.
20404 FMVFT Equipment
The control signals from the RCC as well as indication signals from the various controlled posts are transmitted on separate channels within the voice frequency range of 420 to 2460 Hz, at a transmission speed of 50 baud, with a 120 Hz separation between the channels. Only 18 channels are thus available for use. Frequency modulation is employed. The oscillator unit on the transmitter modulates the frequency +30 Hz (for ‘mark’) -30 Hz (for ‘space’) of the channel frequency.

The transmitting level of each channel is -22 dB across 1120 Ohm. The normal receiving level can be, between -22 dB and a minimum level of -30 dB.

Due to availability of only 18 channels within the voice frequency range of 420 to 2460 Hz, with channel separation of 120 Hz each pair of conductor can control up to 18 independent of grouped stations, where the number of such stations exceeds 18, one more pair would be required for purposes of telesignals only.

20405 Frequency Allocation
In view of their operational importance, all the feeding and sectioning posts are controlled independently by using a separate frequency channel for transmission of telecommands and telesignals to/from each post. For purposes of telecommand only SSPs are grouped (not more than 3) in order to economize in the number of channels. Telecommunication for all the posts in the same group are transmitted on the same frequency channels. However, the individual controlled post in a group is identified by inserting a code in the shape of a long pulse or a long pause in the impulse train generated by the pulse generator in the switching equipment. When posts are grouped as explained above, only one operation at a time can be carried out in the grouped posts from the RCC.

20406 Controlled Post Equipment
The switching and FMVFT equipment at each controlled post are housed in one steel cabinet with dust proof doors. The switching equipment is similar to that provided at the RCC.

The FMVFT equipment has one send channel panel and one receive channel panel. The equipment works on 24V dc battery power supply. All the panels except the termination panel are of plug-in-type. An amplifier is provided with attenuation pads for level adjustment. The channel panels are of the same type as those in the RCC.

III. SCADA EQUIPMENT
20407 General
The SCADA equipment at the RCC is called master Station while that of the controlled station is referred to as Remote Terminal Unit (RTU).

20408 Transmission Path
Underground telecommunication trunk cable is provided for transmitting the signals from and to the RCC and the controlled Remote Terminal Units (RTU). Three pairs of conductors (One pair for "Send", one pair for “receive” and the third as spare) from this cable are made available for remote control operation.

20409 Isolating Transformers
To limit the build up of longitudinal induced voltage on account of induction effects of 25 kV traction, isolating transformers are provided on the cable circuit at intervals of 10 to 15 km. The cable is tapped at the RCC and each controlled station and 3 pairs of conductors are terminated on a terminal board. Isolating transformer of impedance ratio 1120:1120 is provided at the point of tapping.
20410 Repeater Stations.

Voice frequency repeaters are provided at intervals of 40-50 km to boost the signal and to make good the line attenuation. The amplifier gain at the repeater station is about 20 dB, with an equalizer incorporated to compensate upto 0.02 dB/kHz/km. Depending upon the distance, the repeater gain is set so that the signal level at any point en-route is within certain prescribed limits.

If the lead is long suitable surge arresters are provided inside the equipment room to protect the circuits. The metallic sheath of the lead in cable shall also be kept insulated from the earth system of the switching station to prevent induction effect, the insulated conductor alone being led into control panels. For the same reason, switching station earthing, LT 240 V auxiliary transformer neutral earthing and earth of R. C. equipment are all kept separate and distinct and are NOT interconnected. In addition, the switching station structure should be solidly bonded to the track rails by two independent connections.

20411 Microwave Communication

In some of the sections on Indian Railways dedicated Microwave channel at carrier frequency of 18 GHz has been provided for the purpose of communication.

20412 Optical Fiber Cable

Optical fibre cable has also been introduced for communication in some sections of Indian Railways, which is also used for RC equipment.

Details of the interface between the latest communication systems and the RCC/RTU equipment may be seen in the relevant technical documents.

20413 Master Station Equipment

Hardware Configuration: Dual main micro-computer/mini-computer system, one main and the other hot stand-by, is provided at the master-station, each system interfaces with its front end processors, if any, and modem for communication with RTUs and with the man-machine interface equipment to provide up-to-date network data and to accept commands. Each system has its own system console and hard and floppy disks along with their drives. Watch dogs are provided for monitoring the health of the computer system. In case of failure of one computer system, the standby system takes over automatically.

Two data-logging printers, one on-line and other as standby, are provided, both being connected to the same on-line computer system. In case of failure of one printer, the other printer automatically takes over.

Man-Machine-Interface : Work Stations

Two work-stations, one for each of the two operators, each consisting of two semi-graphic colour Visual Display Units (VDUS) and a key-board are provided at the RCC. The key board contains both functional keys for operations that are repeated frequently and alpha-numeric key for input of numerical data and text.

Both workstations are connected to the same on-line computer and meet the following requirements..

(i) Normally control pre-defined and physically demarcated sections.
(ii) In case of complete outage of one workstation, all of its functions can be transferred to the healthy workstation, so that normal operations can continue.
(iii) Normally one VDU is on-line and the other acts as standby at each work station. However, if so needed, it is possible to have both VDUs of each work station on lines simultaneously, either of the two VDUs being used for viewing diagram for telecontrol purposes and the other for viewing alarm, on-demand trend curves, histograms or any other data.
20414 Mimic Diagram Board (MDB)

A mimic diagram board and its associated mimic driver is provided at the RCC. The MDB depicts the traction power supply diagram, indicating the energize/de-energize condition of the sub-sectors of the catenary, status of the interruptors and CBs at TSS & FP, SSP and SP.

Unlike in the conventional Mimic Diagram Board used in RCCs prior to introduction of SCADA system (see para 20403) all control operations are carried out from the key board(s) provided at the workstations. The Mimic Diagram Boards sole purpose is, therefore, to give an overall view of the traction power supply system to the operator. Size of the MDB is, therefore, very much smaller. It is the intention to do away with the MDB altogether since the system can be viewed in the VDUS.

20415 Annunciations

Controlled Station

"Remote Station Defective" is annunciated by a LED.

Master Station

The following annunciations by LEDs are provided on the MDB.

(i) Main System "ON"
(ii) Standby System "ON"
(iii) Main System Defective
(iv) Standby System Defective
(v) Main UPS Failed
(vi) Standby UPS Failed
(vii) UPS battery low (below 90% of nominal voltage)
(viii) 415 V, ac, 3 Ph, supply to UPS failed

20416 SCADA Software

The operating system used is suitable for multi-user, multi-tasking, net working and real time applications.

20417 VDU Display

The, application software supports a large number of versatile semi-graphic coloured displays for issuing telecommands, blocking/deblocking the controlled points, viewing alarm listing, event listing or for carrying out special functions. For details of these displays, manufacturers Operating Manual may be referred to. Calling any of the VDU displays is by simple keyboard operation by the operator, with pre-defined options available for the order and manner in which displays are called.

20418 Transmission and Coding System

The master station equipment normally scans continuously all the RTUs in a pre-defined cyclic sequence, to update the equipment status, alarms, events and measurands. Exchange of information between Master Station and RTUs takes place on interrogation by master followed by reply from RTU. The communication technique is based on Digital Address Time Division Multiplexing. Every data exchange is based on well defined transmission protocol. Each transmitted Information contains sufficient parity check bits to detect transmission errors.

20419 Historical Data Storage

The SCADA system is designed to cater for historical data storage of traction power supply system data for a period of one year. This includes:
(i) All alarms/events / measurands of controlled stations and all system alarms.

(ii) Day wise storage of average feeder current and voltage during the day, maximum demand, maximum and minimum feeder voltage in the 25 kV side, total number of operations of feeder protective relays viz. OCR, DPR and WPC relays, CB trappings and maximum and minimum OHE voltage on both sides of the neutral section. A memory capacity of 40 MB is provided for this purpose in the hard disk, with provision for further expansion of the memory as required.

**20420 UPS and Batteries at RCC**

Dual Stand-alone UPS System of adequate capacity to supply 240 V a. c. 50 Hz single phase supply to the SCADA system at Master Station is provided.

Both the UPS work in parallel sharing the load. In case of failure of one, the entire load is automatically taken over by the healthy UPS without affecting the working of the system.

In case of outage of both the UPS at the same time, the load of SCADA equipment is directly connected to input mains through a static switch without any break.

A single battery is provided with both the UPS with adequate Ah capacity to provide 2 h supply to various equipments in case of failure of input 415 V ac. 50 Hz supply.

**20421 Remote Terminal Unit (RTU)**

The RTU is microprocessor based and includes its associated digital Input/output modules, alarm input modules, analog input modules, watchdog transducers, memory modules, interposing relays, summation CTs, power supply unit(s), surge arresters and other items necessary for its proper working.

**20422 Storage of Events and Alarms**

All changes (one or more) in the status of the CBS/interruptors / motor-operated isolators and alarms that may occur between consecutive polling are stored by RTU until they are reported to the master station. This is to eliminate any loss in reporting to the master station due to intermittent failures of channel or any other reason. In other words, no event is lost without its being reported to master station.

**20423 SCADA Equipment Capacity**

The SCADA equipment is generally designed for the following tele commands, telesignals and telemetered parameters for a typical TSS, SP & SSP of a double line section:

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>CONTROLLED STATION</th>
<th>TELECOMMAND</th>
<th>TELESIGNAL</th>
<th>MEASURANDS</th>
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<td>1.</td>
<td>TSS</td>
<td>24</td>
<td>64</td>
<td>8</td>
</tr>
<tr>
<td>2.</td>
<td>SP</td>
<td>8</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>SSP</td>
<td>8</td>
<td>12</td>
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</tbody>
</table>

Number of controlled stations (TSS, SP, SSPS) to be controlled from an RCC mall be as per the requirements of the section.

**Speed of Transmission and Update Time**

The communication between the master station and the RTUs is at a suitable transmission speed not exceeding 600 baud. Normal polling time for updating status, alarm and measurands for the designed capacity is not more than 4 sec for 20 controlled stations and not more then 6 sec for 30 controlled stations. The actual timings may slightly vary depending on communication protocol adopted and the system design.
The RCC should be in the middle of the electrified section if the number of controlled stations exceeds 30 so that scanning on either side is possible and update time kept to the minimum.

20424 Modems

(i) The modems (modulator/ demodulators) provided for communication between the master station and the RTUs utilize frequency shift keying (FSK) modulation and include send, receive and timing functions. The send and receive functions are independently programmed as required. The modem works satisfactorily up to an input signal level of -45 dBm.

(ii) The modem also incorporates necessary amplifier having a minimum gain of 30 dB to compensate for any signal variation at different points in the system. Suitable attenuation is provided within the amplifiers to adjust the level through trim pot/rotary switch. It has an output signal level adjustable between 0 and -30 dBm in steps of 1 dBm.

20425 Special Features in SCADA Equipment

The following additional features are incorporated in the SCADA equipment:

(I) Tripping of bridging interrupters on under voltage at SP in extended feed condition.

(II) Interlock release request facility for circuit breakers/interruptors control at boundary post (for guidelines for these interlocks see RDSO's letter No. ETI/PSI/RC/SPEC.19 dated 10.3.1989).

(iii) Control of shunt capacitor bank and monitoring of power factor.

(iv) Automatic localization of fault on OHE and isolation of faulty sub-sector.

SCADA systems on Indian Railways are being supplied by various manufacturers. Although the systems are different, the basic features of the systems are similar. For details of operating instructions and maintenance, the operating technical manuals of the makers should be referred to.

IV. OPERATION AND MAINTENANCE OF RC EQUIPMENT

20426 Duties of CTFO (RC)

He is the senior supervisor working under the control of DEE/AEE (TRD) and directly responsible for the proper operation and upkeep of the RC equipment, which are vital for the efficient operation of the electric traction system. He shall be thoroughly conversant with all the technical details of the equipment under his control. In particular, he shall perform the following duties.

1. Maintain the RC equipment at the RCC and the controlled stations in accordance with the prescribed schedules.

2. Keep close liaison with the S&T department as to the sound condition of the cable pairs allotted for RC operation.

3. Measures periodically the levels of voice frequency signals at controlled stations and arrange with the S&T department for correction, when required, at their repeater stations.

4. Keep in constant touch with the TPC on shift duty and ensure prompt rectification of defects reported in the RC system.

5. Ensure proper maintenance of UPS/battery sets for uninterrupted operation of the RC equipment and the stand by generating set in the RCC.

6. Inspect the RC equipment at every controlled post once in two months.
Impart necessary training to the staff under him in the special techniques of maintenance of RC equipment as well as trouble shooting.

8. Ensure that the special instruments and tools provided for maintenance of the RC equipment are properly cared for.
9. Keep a watch on stocking of spare parts and other stores required for the RC equipment and initiate timely action to recoup stocks.
10. Co-ordinate with CTFO (PSI) and CTFO (OHE) or territorial CTFOs for manning the controlled posts in the event of persisting faults in the RC equipments.
11. Submit prescribed periodical returns on RC equipment to AEE (TrD) and Sr. DEE (TrD).
12. Keep his superior officer fully informed of all important developments and seek their guidance when required.
13. Carry out such other duties as may be allotted by his superior officers.
14. Carry out minimum monthly inspections as per manufacturers recommendations.

20427 Operation of RC Equipment

The RCC is the nerve center of the traction system, from which full control over every switching operation on the entire electrified route is exercised. It should, therefore, be kept in perfect operating condition at all times. No one, other than an authorized official, shall at any time operate the equipment. The TPC shall, at every change of shift, carry out a lamp test and, once a day give a general check for all stations and thereby ensure that the indications on the mimic panel are in order. Any defects observed in operation shall immediately be reported to the CTFO(RC) and the entry made in the log book of the time defect was reported and the time it was rectified. Any excessive delay in rectification which militates against operation shall be brought to the notice of AEE(TRD). Depending upon the nature of the defect TPC shall take adequate precautions against mal-operation until the defect noticed is rectified.

Should RC equipment of a switching station fall completely, the failure shall be reported to AEE(TRD) and Sr. DEE (TrD) and arrangements made to man the switching station with trained personnel to carry out the switching operations, observing the precautions prescribed in the Chapter VIII 'Breakdowns'.

TPC shall once a day contact on telephone the Operators of each Grid sub-station from which traction power supply is obtained and ensure that the communication facilities are intact.

20428 Investigation of Failures by CTFO

As with any other equipment, every failure of RC equipment should be separately registered, investigated and rectified, making a brief note in the failure report of the action taken as well as classifying and finally pin-pointing the exact cause of the failure. The failures should be analyzed every month and any special steps required taken to overcome the trouble and prevent recurrence should be taken. A 'history sheet' showing the faults that have occurred on different items of equipment will assist in carrying out detailed investigation of recurring troubles in consultation with the Manufacturers of the equipment.

20429 Maintenance Schedule

The specific maintenance instructions issued by the respective suppliers of SRC/SCADA systems should be observed and changes to be made therein may be decided in consultation with the manufacturers. For the batteries used in the remote control centre and the remote terminal units (RTUs), the instructions in Chapter 11 for fortnightly maintenance and quarterly maintenance shall be applicable.
## CHAPTER V

**OPERATION OF TRACTION POWER CONTROL**

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CHAPTER V
OPERATION OF TRACTION POWER CONTROL

20500 Remote Control Centre

The Remote Control Centre (RCC) constitutes the 'heart' of the control system from where the switching operations over the electrified system are controlled by one single authority i.e., the Traction Power Controller.

20501 Manning of RCC

The RCC shall be manned throughout the 24 hours. There shall be shifts in each of which there will be at least one Traction Power Controller (TPC) who shall be in charge and, depending upon the workload, an Assistant Traction Power Controller (ATPC) to assist him. The CTPC will be directly responsible for the correctness of all-switching operations and entries in the LogBook. No person is permitted to operate the control switches except with the specific permission and knowledge of CTPC. No person shall be permitted to work as a TPC or ATPC, unless so authorized in writing by SR.DEE (TrD).

20502 Knowledge of Rules

TPC (and ATPC where provided) shall be fully conversant at all times with the rules and regulations laid down by the Administration as well as with the details of the electrical distribution system. He shall keep all instructions issued from time to time as well as copies of documents like General and Subsidiary Rules, Station Working Rules etc. ready at hand. He shall keep all books and records up-to-date, posting all correction slips on the day of receipt in the appropriate document.

20503 Entry into RCC

No person is permitted to enter the TPC unless he has an authority for the purpose. The TPC and ATPC who are on duty shall not be disturbed or distracted.

20504 Shift Duty

No interchange of shift duty or variation of hours shall be permitted without the specific sanction of DEE/AEE (TrD). In case of unavoidable circumstances the staff may make the necessary arrangement with other shift duty staff before approaching AEE (TrD) for permission. No one shall leave his post of duty until he is relieved by an authorised person.

20505 Shift Duty Register,

A shift Duty Register shall be maintained in which shall be noted every change of shift duty. Before handing over charge, the outgoing TPC shall, record in the Shift Duty Register all points (shut downs, power blocks, defects in plant, any special instructions received, pending message, if any etc.) requiring the attention of the TPC who takes over. Before taking over of a shift duty, the TPC shall scrutinize all the entries recorded during the previous shift in the Shift Duty Register a..jJ in the log book, study the entire mimic diagram in the presence of the previous shift TPC and clear all points of doubt, if any. He should then sign with time in the Shift Duty Register, thereby admitting having taken over correctly and assuming full responsibility from then onwards.
20506 Repair and Adjustment of RC Equipment
1. TPC shall not repair, adjust or any way interfere with any of the RC equipment at the RCC except for carrying out switching operations. Every defect shall be reported at once to the Chief Traction Foreman (Remote Control) or the Assistant Traction Foreman (Remote Control), who are responsible for the maintenance work.

2. No work may be commenced by any person on remote control or power supply equipment at the RCC or any controlled post without prior intimation to and approval of the TPC on duty, who shall record the event in the Log Book. At the end of the work, the TPC should test the equipment on remote control and satisfy himself that everything is in order.

20507 Switching Operations to be Deliberate

Since all circuit breakers and interruptors are operated through remote control, the TPC will have control over the switching operations over a wide area. The time required for each operation is of the order of only a few seconds. Every switching operation should, therefore, be carried out only after due thought and deliberation. Operation of several switches simultaneously should be avoided as far as possible as it may lead to wrong operations.

20508 Liaison with Section Controller

While the Section Controller is directly in charge of all movements of trains, TPC is directly responsible for maintaining the power supply for all electrified tracks. For operation of the train services, it is necessary that the close liaison be maintained between the Section Controller and the TPC at all times. The particulars of communication facilities provided for this purpose have been described in Chapter 11 of Vol 1.

The TPC should also be in touch with the operators at the various Grid Substations.

20509 Prompt Attention to Telephone Calls

Either TPC or the ATPC shall attend promptly to all calls received on any of the telephones at the RCC, priority however being given to emergency telephone and TPC telephone.

20510 Log Book

The Log Book is a primary minute-to-minute record of every switching operation carried out at the RCC, every interruptions to power supply, unusual or abnormal occurrences, messages received over the telephones, special instructions received from superior officers, defects reported in equipment and action taken to have them rectified as and when they occur, in chronological order.

20511 Movements of Maintenance Staff

It is also the duty of the TPC to keep a track of the movements of all maintenance staff of the Traction Distribution Branch so that in an emergency he is in a position to summon the nearest gang/person, as required. It is primarily the duty of the maintenance staff to keep the TPC informed of their movements - which shall be recorded in a “Register of staff movements.”

20512 Checking of Time

The TPC shall check the correctness of the time on the clock at 1600 h of each day when time signal is received from the Traffic Control Office.

20513 Alarm Circuits

At every change of shift, the TPC taking over shall check all the alarm circuits and carry out a lamp test of the mimic diagram panel wherever this facility exists.
20514 Emergency Generator Set
A 415/240V, ac, 50 Hz, 3 phase Diesel Engine Driven Generator Set is provided at each RCC for feeding of the essential loads in the event of failure of the mains supply. Each TPC and ATPC shall be fully conversant with the starting of the Generator Set. It shall be started and worked for an hour at least once a week if it has not been operated due to failure of mains supply.

20515 Duties of Chief Traction Power Controller

The Chief Traction Power Controller (CTPC) shall perform the following duties:-
1. Study of all failure reports of OHE, switching stations etc. daily specially In so far as they affect the operation of trains and submit connected periodical reports to AEE (TrD). He shall maintain complete statistical data relating to operation of RC equipment and ensure that the schedules of maintenance are carried out regularly;

2. Scrutiny of traffic delays shown against the Traction Distribution Branch and liaison with the Chief Controller, as necessary, for ensuring the correctness of the records;

3. Maintenance of close contact with the Chief, Deputy and Section Controllers, TPC and ATPC, TLC, Sr DEE (TrD) and AEE (TrD) and study of all problems relating to train operations, as far as the Traction Distribution Branch Is concerned, to seek solutions;

4. Scrutinize the Log Book and the Shift DutV Register once a day and ensure that they are properly maintained and actionas necessary is taken,

5. In an emergency or disorganization be in direct touch with the Traffic Control Office and help in every way to restore and maintain the train services and take over operation of power control himself, if required;

6. Ensure that TPCs and ATPCs are adhering to the rules and instructions in force. Study all the rules in force and suggest amendments, modifications, corrections as may be found necessary in practice;

7. Co-ordinate the Weekly Power Block Programme of all traction staff and other departments and finalize It in consultation with the Traffic Department. Take steps to adhere. to the agreed programme as far as practicable.

8. Compile periodical statistics from the data collected on SCADA system and as per instruction of SR.DEE TrD including the analysis of failures on the SRC system, and submit thorn to Sr. DEE(TrD).

9. Report daily to the CEE’s office all matters as laid down by the CEE.

20516 Duties of Traction Power Controller
He is the official in direct charge of the control of 25 kV power supply for electric traction and shall be fully acquainted with all the traction power supply Installations, and sectionalizing arrangements. There will be a TPC in each shift in the RCC and, depending upon the workload, he may be assisted by an ATPC. The essential duties of the TPC/ATPC are as under:

1. When taking over shift duty, he should acquaint himself with the prevailing position of the entire section including working of the RC equipment, condition of all transformers, circuit breakers, Interruptors and isolators, sections under power block, any special Instructions to be carriedout,-movements of important officials connected with the traction distribution system, position of the OHE Inspection Cars and break- down vehicles etc.;
2. Maintain continuous contact with the Power Supply Authorities;
3. Maintain continuous contact with the Traffic Section Controllers in regard to power supply affecting train movements, imposition of power blocks etc.;

4. In the event of power supply interruptions or other failures, take prompt action in accordance with prescribed rules and local instructions for restoration of supply;

5. Imposition of and removal of power blocks as required, following the prescribed procedure and safety rules.

6. In the event of power supply failures, OHE break-downs, accidents etc. in the electrified section, advise promptly the concerned Foreman, AEE, DEE/5r. DEE (and other officials in accordance with local Instructions), and keep them posted with all important developments;

7. Record in the Log Book, on prescribed proforma, full details of all switching operations carried out, power blocks imposed or refused (or delayed) and other occurrences in the distribution system;

8. Maintain the following registers and records in the proforma prescribed:
   (i) Shift Duty Register indicating points of importance including messages, movements of ODC involving power blocks and other details to be noted by following 'shifts.
   (ii) Record of standing instructions.
   (iii) Register of temporary instructions.
   (iv) Register of Staff Movements;
   (v) Emergency Telephone Testing Register.
   (v) Register of train delays due to failures of signal supply.
   (vill) Weather forecast register.

9) By 10 h each day submit the following reports to Sr. DEE/ DEE (TrD) and other officials as laid down in local instructions:
   (i) List of power blocks availed.
   (ii) Particulars of telecommunication failures.
   (iii) Particulars of RC failures
   (iv) Power Supply failures.
   (v) Maximum demand and energy consumption at each traction sub-station.
   (vi) Condition of traction sub-station equipment
   (vii) All unusual occurrences, if any.

**20517 Failure of Traction Power Supply**

Failure of 25 kV ac, 50 Hz Signal phase power supply can be due to

(a) failure of equipment of Supply Authorities or

(b) failure of railway equipment.

When the indications at the RCC are that failure of power supply is over the entire area fed by one sub-station, the cause and likely duration of failure should be ascertained immediately from the Operator of the Grid sub-station.
20518 Failures of Grid Supply

In the event of failure of Grid power supply at a sub-station, if the Operator at the Grid sub-station advises that he anticipates that the power supply may not be restored in less than 3 min, the TPC should immediately initiate emergency working extending the feed from the adjacent substation up to the failed sub-station, as a first step. He should inform the Sr DEE /DEE (TrD), AEE (TrD) and Section Controller of this situation. He should also keep in continuous communication with the Grid sub-station, pursue and restore supply to OHE as quickly as possible.

20519 Prolonged Power Supply Failures

1. If the power supply is anticipated to be restored after 10 minutes, as ascertained from the Operator at the Grid sub-station, or if he is unable to state when power supply is likely to be restored, TPC shall immediately proceed as follows:

(a) Advise the Deputy/Section Controller that emergency feeding arrangements are being introduced in the area fed by the particular sub-station. The Section Controller shall then inform the stations on either side of the concerned feeding post to issue caution orders to every electric loco and EMU driver entering the affected area to lower pantographs while passing the feeding post, specifying the structure number at which the Driver shall lower pantograph and the structure number on reaching which, he may raise it. The Section Controller shall also repeat the information to all loco sheds, both major and minor, and to all train ordering stations. After this has been done the Section Controller shall confirm to the TPC that instructions for issue of caution orders for lowering of pantographs have been issued and emergency feeding arrangements may be made. These instructions do not apply for locations where short neutral section assemblies have been provided opposite the feeding post.

(b) On receipt of the above information, TPC will open the two 25 kV feeder circuit breakers at the sub-station where supply is interrupted and put “Red Warning Caps”/"Device inhibited tags“ on the corresponding control switches in the RCC.

(c) TPC will then close the bridging interruptors at the neutral Sections on either side.

(d) On restoration of supply from the grid sub-station, “Red Warning Caps”/"Device inhibited tags" shall not be removed and the feeder circuit breakers shall not be closed until the bridging interruptors have been opened first.

2. If emergency feeding is to be continued for long periods, temporary signals for lowering and raising of pantographs shall be provided.

20520 Faults on Railway Equipment and Lines

Any faults on OHE and 25 kV feeders lines will cause the corresponding feeder circuit breaker to trip, thus interrupting supply to the corresponding sector. When this happens TPC shall reclose it once immediately. If it trips again he shall keep the circuit breaker open and proceed to isolate the fault. Where auto reclosing feature is provided, the TPC should take action to isolate the fault after the auto-reclosure scheme locks out. After isolation of faulty section TPC shall release the auto reclosure lock-out.

20521 Lowering Pantographs of Defective Locos

Before concluding that the fault is on the OHE and directing the OHE staff to proceed to the faulty section to rectify the fault, the TPC should first make sure that there is no defective locomotive or EMU in the faulty section, which could cause tripping of the feeder circuit breaker. If there is a locomotive in the faulty section he should arrange to have its pantograph lowered to ascertain if the fault is on the OHE or on the locomotive.
Drivers and motormen should lower the pantographs of their units if they have reason to believe that a fault has developed causing tripping of 25 kV feeder circuit breaker at the sub-station as for example when 25 kV supply gets interrupted simultaneously with the tripping of the air blast circuit breaker on the rolling-stock. If this happens more than once, it is most probable that the 25 kV power supply interruption is due to fault on the loco. In such a case, the Driver should lower the pantograph and inform the TPC through emergency or other telephone of his observations and action taken by him so that TPC may take appropriate action. Whenever pantograph on the loco is defective, the TPC should ensure from the driver that the pantograph is properly tied down and secured, and does not come into contact with the OHE.

20522 Isolation of Faulty Section

1. Expeditious isolation of a faulty section is of the greatest importance. This can only be achieved if the TPCs are fully drilled in the correct method of fault localization. The method of fault localization which takes the least possible average time is the best. It is best to standardize the procedure with a "Control Card" for every circuit breaker and keep the card in a serial order so that, when a circuit breaker trips, the particular card can be picked out and the sequence of switching operations, as given in the card, carried out in the card till the faulty section is isolated and power restored to the other sections. Such control cards ensure correct sequence of operations irrespective of who is the TPC on shift duty.

2. Fig 5.01 is a typical control card for a double line section. The basic idea is to divide the section into sub-sections and find out whether the circuit breaker trips or not after reclosure. The full-line arrow shows the action to be taken if the circuit breaker holds and the dotted line arrow, if it does not. Following the arrows action has to be taken to open or close the interruptors and the feeder circuit breaker till the faulty section is identified.

3. Sr. DEE (TrD) should ensure that control cards similar to the above are carefully prepared and kept with TPC for every feeder circuit breaker. He should also ensure that all TPCs and ATPCs are fully familiar with the method of using the control cards. In the case of some SCADA systems, the fault localization and isolation sequence is automatic. TPC should carefully note the sequence and the section that is isolated. He should ensure that power supply is available on the rest of the OHE after a fault-tripping is noticed and try to minimize the length of the faulty section by directly opening of isolators manually.

4. While control card is generally drawn up after careful thought, yet, there could be reduction in average time taken to localize a fault by a change in the switching operations. This may be brought out by any official to the notice of Sr. DEE/TrD.

20523 Faulty Section to be kept Isolated

(A) On Single Line Sections

After the fault has been located, the faulty section shall be kept isolated by keeping open the concerned isolators. Feed to other elementary sections shall be restored by closing the concerned interruptors/isolators.

(B) On other than Single Line Sections

After the faulty section has been located in accordance with para 20522, the faulty section as also the healthy sections on the adjacent lines over the same route as the faulty section, shall be kept isolated by keeping open the concerned interruptors. Feed to all other sections shall be restored by closing of other interruptors/isolators.

Further, the Section Controller shall be immediately informed by the TPC of the faulty and healthy sections. Feed to the healthy sections isolated shall be restored only on receipt of advice from the Section Controller of his having taken special precautions as per para, 20524.
TYPICAL CONTROL CARD FOR LOCALIZATION
OF FAULTS IN OHE

EXPLANATION OF SYSTEM:

AV.

FAULTY

TIME

SECTION

F 6 5 4 1 2 3 AVERAGE

136

TOTAL 0 2 7 8 7 8 7 6 6 4

SEC

OPERATIONS C 1 8 8 6 7 7 5 6

FEEDER F

OPEN (7 Sec) O

CLOSE (15 Sec) C

CB. HOLDING

CB. TRIPPED

FAULT LOCATED

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME II PART I
20524 Advice to Section Controller

(A) Faulty Section
The Section Controller shall immediately be informed by the TPC to take all precautions as per Station Working Rules, as though the particular faulty section is under emergency power block and the Assistant Traction Foreman or other traction official in the neighbourhood shall be advised to check the faulty section. AEE (ffrd) and DEE (TrD) shall also be informed.

Only when the OHE staff are able to inspect and find out the nature of the fault, it will be possible for them to say how long it will take to rectify the fault and restore the power supply. The Section Controller shall decide whether single line working is to be introduced or not taking into account the following factors:

(a) The traffic he has on hand,

(b) The anticipated time by which the OHE maintenance staff can reach the site as ascertained from TPC.

(B) Healthy section kept isolated (Para 20523)

On receipt of advice from TPC of temporary isolation of healthy section on line adjacent to a faulty section, the Section Controller shall immediately take necessary action for having caution orders issued to drivers of all trains due to enter any of the concerned block sections (with OHE temporarily isolated, though healthy) to watch out for possible obstruction arising due to an unusual occurrence on a track with faulty OHE and be prepared to stop.

In respect of the trains stranded in any of such concerned block sections, it will be possible to issue caution orders to their drivers only after they reach the next station. Separate Instructions for drivers of such trains to proceed cautiously up to next station, in case of being detained in block section for no tension in OHE for more than 5 min, are contained in G & SR etc.

20525 Information to Traction Staff
All information regarding any unusual occurrence received from Station Masters etc. shall be given by the Section Controller to the TPC to assist him to quickly locate faults.

20526 Action to Rectify OHE Fault

1. The Section Controller shall give top priority for the movement of the maintenance staff (by train, OHE insection Car or motor trolley) to reach the faulty section, it is the duty of all concerned to reach the breakdown site either by rail or by road in the quickest possible time. They should carry with them a portable emergency telephone and keep in touch with TPC.

2. The TPC after locating the fault shall reduce the section under power block to the elementary section concerned by arranging either by trained station staff or TrD staff the opening of isolator Switches. They shall, after inspecting the fault, inform TPC the time expected to be taken for rectifying the same. TPC shall pass on this information to the Section Controller.

3. The OHE staff shall then take a permit-to-work and proceed to rectify the fault duly observing the rules for the purpose.

20527 Emergency Telephone Working
If an Operator at a Grid sub-station is not able to speak to the adjacent Grid sub-station due to some fault or failure on their telecommunication system, the TPC shall arrange for the messages to be transmitted over the railway or other telephone, where practicable. Similarly, in case of fault or failure of telecommunication system on the railway, the Operator of the Grid sub-station shall arrange to transmit messages, if any from the TPC to any other.
sub-station through the Grid telecommunication system, on a reciprocal basis. Such messages should be passed only if they are very urgent and related to maintaining continuity or restoration of power supply.

20528 Breakdowns and Emergencies

The TPC shall always be in a state of readiness to take quick and prompt action to tackle any breakdown or emergencies. He will keep liaison with not only the field officials at site who are engaged in restoration of affected section, but also the Head Quarter officials, giving details of the breakdown to the extent, they are known apart from, help from the neighbouring divisions or Head Quarters as the circumstances warrant.

20529 Obstruction of Track - Protective Steps to be taken by TPC

On being informed by the Section Controller/Station Master of any accident/incident likely to obstruct one or more tracks or OHE in a multitrack section, necessitating immediate suspension of movement of trains and being told by Section Controller to switch off power, the TPC shall immediately switch off power supply to the OHE of the affected track as also that of the adjacent tracks over the length of the track affected. The power supply shall be restored only after it is confirmed to the TPC that the track and OHE are clear of any obstruction and movement of electric trains is safe.
TYPICAL CONTROL CARD FOR LOCALIZATION

OF FAULTS IN OHE

EXPLANATION OF SYSTEM:

FEEDER
OPEN (7 SEC) P
CLOSE (15 SEC) C
CB. HOLDING
CB. TRIPPED
FAULT LOCATED

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CHAPTER VI

POWER BLOCKS AND PERMITS-TO-WORK

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CHAPTER VI
POWER BLOCKS AND PERMITS-TO-WORK

20600 Operation of Isolator Switches

1. Before considering the procedure for obtaining power blocks, attention is drawn to the precautions to be taken in opening an isolator switch...Manually operated isolator switches are provided at different points on the main line to sectionalize the OHE into elementary sections and at large yards to isolate different elementary sections for maintenance of the OHE.

2. The operating handle of every isolator switch shall always be kept locked either in the open or closed position. Any loss or damage of a padlock or key shall be reported immediately to the OHE Section Chargeman, Chief Traction Foreman (OHE) and TPC.

3. An isolator switch is not meant for breaking a current, but only to break a circuit when no current is passing through it. If an attempt is made to open a switch when it is actually carrying current, severe arcing will occur at the switch contacts and may result in serious consequences including danger to the operator. AN ISOLATOR SWITCH SHALL NOT BE OPENED WHEN CURRENT IS PASSING THROUGH IT.

4. Isolator switches on the main line may only be opened provided the corresponding sub-sector is first made dead by TPC. The person operating the isolator switch shall not open it, unless specifically asked to do so by TPC by a clear message supported by a private number or after receipt of a separate permit-to-work for the section which includes the elementary sections on either the isolator switch. TPC shall ensure that the sub-sector is dead before he orders opening of an isolator switch in it.

5. Isolator switches, however, can be closed by a duly authorised person even if the adjacent Interruptors are closed (i.e. on load) provided the closure is made swiftly in one motion. It is imperative that once the fixed and moving contacts have met, the contacts are not separated.

20601 Isolators in Yards and Sheds

(a) Isolator switches provided for isolating sidings and yards and also to feed OHE inside running sheds, may be opened provided the official concerned makes it certain that -

(a) the entire section is visible; and

(b) There is no locomotive with raised pantograph in the section.

If is not possible to get an assurance of these conditions, the principles of para 20600-4 shall be followed.

20602 Maintenance Blocks

There are generally two types of blocks required for maintenance work on electric traction Installations:

(a) Traffic Block: Where a line is blocked against movement of vehicles whether steam, electric or diesel locomotive hauled. This will be required whenever heavy repair have to be carried out. A traffic block will be granted by the Section Controller in consultation with the TPC.

(b) Power Block: Where a section of line is blocked against movement of electric locomotive hauled vehicles or EMUs only i.e., a section where 25 kV electric supply to the OHE is switched off and the section made dead. Power block will be required whenever light repairs to or maintenance of the OHE
has to be carried out and the nature of the work is such that traffic block is not necessary. Power blocks are granted by TPC in consultation with the Section Controller. Whenever a power block is granted by TPC, movement of vehicles hauled by other than electric power, i.e., steam or diesel may be permitted, provided a caution order is issued as per General and Subsidiary Rules drawing the attention of the Driver to the fact that the OHE staff are working at the kilometrage specified and he should exercise caution when passing over the section and obey signals displayed at the place of work.

20603 Power Blocks
1. Power blocks are of three different types:
   (a) Emergency power block,
   (b) Pre-arranged power block,
   (c) Locally arranged power block.

Power blocks on the OHE of “Secondary lines”, i.e., siding, yards, sheds, etc. arranged by the Station Master, Yard Master, Shed Foreman or Engine Examiner concerned locally come under category (c).

2. In all cases of power block TPC shall put red warning caps on control switches corresponding to interruptors which are kept open for isolating the section. Similarly, warning boards shall be fixed on all manually operated switches opened locally for isolating the section. This shall be done by the operator who opens the switches. These red warning caps and warning boards can be removed only when cancelling the power block. In case SCADA system is in operation instructions issued for the operation of the system shall be followed.

20604 Emergency Power Block
An “Emergency Power Block” shall be arranged by the TPC and 25 kv supply to the OHE affected shall be switched off by him immediately on receipt of an advice of any break-down of the OHE or Injury to persons or damage to property particularly in the following cases:

(a) The whole or part of the OHE or a feeder or a cable falling down and or persons or animals or falling trees or vehicles coming in contact with or likely to come in contact with live equipment;

(b) A damaged catenary or contact wire fouling the vehicle gauge;

(c) A damaged electric locomotive getting damaged to rectify which the Driver requires the permit-to-work;

(d) Derailment or any other traffic accident on the electrified lines, where cutting off of 25 kV power supply is considered necessary by TPC or the Section Controller, in the Interest of safety. ,

20605 Reporting Abnormalities in OHE
It is the duty of every railway official to report immediately any abnormalities on the OHE such as are mentioned in para 20604 or of tracks, masts/structures or pantographs of locomotives As may adversely affect safety of trains movements, to the TPC either directly or through any Station Master, Section Controller or through the nearest available telephone. If the damage is heavy or the moving dimensions are infringed he should take steps to protect the lines in accordance with General and Subsidiary Rules.

20606 Request for Emergency Power Block
1. The person who gives the first Information of break-down on the OHE shall invariably give all essential information, such as his name, designation, kilometrage where the abnormality has been noticed, its nature and
place from where he is reporting. He should leave the place only with the permission of the TPC.

2. The reason for asking for an emergency power block should be brief and to the point, but explicit. Much time and trouble can be saved if the first information given is clear and unambiguous, to enable the TPC to decide upon the course of action to be taken.

**20607 Action to be taken TPC**

On receiving the information the TPC shall immediately arrange to switch off power supply to the section affected (the details of defects being obtained after the supply is switched off). He shall at the same time advise the Section Controller on duty the section made dead by him. The Section Controller in turn should arrange with the Station Masters concerned to take protective measures in accordance with "Station Working Rules".

**20608 Precautions after Emergency Power Block is Imposed**

Once an emergency power block is imposed, no work on the affected lines shall be commenced until an authorized OHE official arrives at site and earths the OHE at two points or more as per rules. Power supply to the section concerned shall not be restored by TPC until the authorized official at the site issue a message supported by private number.

**20609 Identification of Sectors, Sub-Sectors and Elementary Sections**

1. It is vitally important for every Railway official who has occasion to ask for Power block to know the correct method of Identifying and describing any section of the OHE where shutdown is required. He should have with him the upto-date Station Working Rule Diagram for the section, showing all relevant particulars such as station names, position of all isolators, interruptors, circuit breakers, "up" and "down" tracks, cross-over section insulators, sectors, sub-sectors and elementary section numbers.

   **Sectors:** These are described by referring to a section of OHE of a track which can be energized by closing a feeder circuit breaker at the substation/feeding post. It covers the section between substation/feeding post and adjacent neutral sections.

   **Sub-sectors:** These are described by the names of two limiting switching stations in the order in which the train moves and adding the name of the track, e.g., Sub-sector Kendposi-Tabu Dn.

   **Elementary Sections:** are referred to by four/five digit numbers. The sections are numbered serially in the direction of power supply i.e., from the feeding post/substation towards the neutral section or the terminal point. At each feeding post/substation a new series of numbers starts. The first two/three digits represent the interrupter controlling feed to the section and the last two digits the serial number of the elementary section. Up line elementary sections have progressively odd numbers and Down line elementary sections have progressively even numbers. e.g., elementary section 0202 means the first elementary section from the feeding post/sub-station on the down line, fed by interrupter 02.

Whenever there is a doubt in the description, the person asking for power block shall state clearly the track and OHE structure numbers between which work is to be done.

**20610 Telephone Messages**

All messages relating to shut-down and restoration of power supply, permits-to-work, etc. issued over the telephone shall invariably be supported by exchange of Private Numbers. The procedure to be followed is as detailed below -

(a) Every official who has to exchange such messages shall maintain a Private Number book. As each message is sent, the Private Number used should be scored out in the Private Number sheet, initialled and dated. The message number should also be recorded. Every Private Number book and permit-to-

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work form is an important document and should be carefully preserved for a period of one year unless required for a longer period in connection with an inquiry or investigation.

(b) Every message shall start with the Private Number of the sender and end with the Private Number of the person who has received it.

(c) Messages should be brief and to the point. They shall be written out in full before they are sent. The description of the section on which power block is required should be unambiguous as detailed in para 20609. All messages regarding permits-to-work shall be in the standard form.

(d) The same person who asks for and obtains a power block should also cancel it before power supply is restored. The persons exchanging the private numbers should identify themselves by name over the telephone.

(e) The correctness of every massage shall be confirmed by the person who has received it by repeating it. Each message shall be recorded by the sender as well as by the receiver in message books maintained for the purpose.

(f) To avoid confusion, use words "Open" and "Close" shall be used instead of phonetically similar words such as "Switch Off", "Switch On". Whenever necessary words may have to be spelt out (e.g., 1 (one) 4 (four) and not fourteen), B for Bombay, C for Calcutta and so on.

20611 Procedure for Obtaining Traffic or Power Blocks and Permits-to-work

Officials in the electrified area who require prearranged traffic blocks, power blocks or permits-to-work in the danger zone of traction equipment, or who require OHE and or bonding staff to be present at site for scheduled maintenance works, shall deliver at the office of Sr DEE (TrD) not later than 10 hours on the first working day of the week statements in the prescribed form showing:

(I) the nature of the work and the date on which it is to be performed;
(ii) by whom the work is to be carried out
(iii)location of the work and the section of the lines to be blocked;
(iv)The trains between which the block is required; and
(v)Whether the track will be available for steam or diesel traffic.

2. The requirements of all departments will be co-ordinated in the office of Sr. DEE (TRD) and a consolidated statement forwarded to the Senior Divisional Operating Manager concerned, by 12 hours on every Wednesday, for inclusion in the weekly programme of traffic and power blocks.

3. Works of an urgent nature shall be attended to by obtaining emergency blocks and permits-to-work from TPC

4. A weekly programme of work involving traffic blocks, power blocks and permits-to-work shall be prepared in the office of Sr. DOM and dispatched to all concerned (TPC, TLC, Loco Sheds, Station Masters/Yard Masters concerned and Traffic Controller in addition to the departmental officials who asked for the blocks).

5. All the traction sub-stations have two states of traction power transformers and associated switch gear. Maintenance of equipment of the traction sub-station, therefore, does not necessitate total shut down of 25 kV supply at each sub-station. Whenever any maintenance or breakdown is to be attended In the traction sub-station, the permit to work should be obtained by the Supervisor incharge from the TPC and after completing the work, the permit to work should be returned by the Supervisor incharge to the TPC. Similarly at the switching stations

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normally the alternative feed is available to the concerned sub-sector and therefore, does not necessitate the power block but only a permit to work should be obtained from the TPC and after completion of the work, the same should be returned to the TPC. In case of attending to the gantry of a switching station, complete block of the switching station is required for which power block has to be taken from the TPC.

20612 Pre-arranged Power Block

After a prearranged power block has been agreed to be granted and an advice to this effect circulated to all the concerned, the following gives the detailed procedure to be adopted by the Section Controller and the TPC for granting the power block. Assume that power block is required on the Up line between station .......... and ........... on Elementary Section No . ....... at 10-00 hours after the passage of a specified Up train (say ‘X’): -

1. On the scheduled day about two hours before the block period, i.e., at about 8.00 hours, TPC will obtain confirmation from the Section Controller concerned that the trains are running to time and power block will be available as, scheduled, after the Train No. ’X’ Up has passed station at about 10-00 hrs.

2. The TPC will pass on information to the Chargeman of the maintenance gang that the power block, as already arranged, will be available in time.

3. The maintenance gang should arrange to leave the depot in time with all materials and tools so as to be ready at site at about 9. 30 hrs. The OHE staff (in charge of the work) on arrival at site should immediately contact the TPC and inform him of their arrival.

Any person detailed to open an isolator switch for switching off power supply shall also report to TPC of his arrival at site at the required location.

The maintenance gang should carry at least two portable telephone sets and the necessary earthing pole assembly along with them while proceeding to do maintenance work on the OHE.

4. The TPC should maintain continuous contact with the OHE staff at site.

5. As soon ’X’ Up clears the Up track between .......... and ............ Section Controller should inform Station Master on duty at all stations concerned to arrange for "longitudinal" and "cross" protection as laid down in Station Working Rules (see paras 20621 to 20626).

6. The Station Master shall ensure that the protection as specified in the Station Working Rules is carried out and confirm it to the Section Controller with exchange of Private Numbers.

7. The Section Controller on receipt of assurances from the concerned Station Masters will advise TPC that the power block may be given.

8. If the power block message is given by TPC in the prescribed printed form the Section Controller will sign the same and send it to the TPC; if it is given over the telephone, the Section Controller will grant the power block through a message with exchange of Private Numbers.

9. On receipt of the above message TPC will open the interruptors concerned and issue messages to the field staff for operation of the required isolators. On receipt of the confirmatory message that the isolators have been opened, TPC will close the interruptors restoring power supply to all parts, except over the particular elementary section where work has to be done. He WILL then issue a permit-to-work message in the prescribed form to the authorized person in charge of the maintenance gang.

10. After obtaining permit to work, the authorized person may use a flag signal (Yellow flag) to direct the nominated staff to discharge and earth the OHE at two or more points.

11. The maintenance gang will start the work after taking necessary safety precautions to protect themselves,
viz., by earthing, display of banner flags etc. as detailed in General and Subsidiary Rules. 9

Note: On sections with automatic signalling, the signals may be at danger due to earthing of OHE with the rails during the period of the power block. The Station Master shall issue necessary authority as per rules for steam, and diesel trains when these are permitted to be moved over the section under power block.

20613 Restoration Of Supply After a Permit-to-work is Returned

On completion of the work, the person who received the permit-to-work shall ensure that -

(a) all men and materials have been withdrawn from the electrical equipment and its vicinity,
(b) all earths provided for the protection of the working parties have been removed; and
(c) all staff, who have been deputed to work, are warned that the power supply is to be restored.

He should then inform TPC by a message, supported by Private Number, that the work, for which the permit-to-work was issued, has been completed, the men and materials have been withdrawn from the specified section, the earths have been removed and power supply may be restored to the section. This shall constitute cancellation of the permit-to-work previously obtained.

20614 Work by other than Authorized Persons

1. If work is to be carried out on or adjacent to any part of the electrical equipment by other than 'authorized' persons such work shall not commence until the person in-charge of the work is in possession of a written permit-to-work in the prescribed form issued to him by an 'authorized' person.

Such permits-to-work in the prescribed form shall only be issued an 'authorized' person of the Electric Traction Branch not below the rank of a Senior Linesman.

2. The permit-to-work shall first be taken from TPC by an 'authorized' person who shall earth the electrical equipment specified and hand over a permit-to-work card to the person in-charge of the work getting an acknowledgment on the other copy. A duplicate copy of every permit-to-work card shall be retained in the personal possession of the 'authorized' person who issued it.

3. On completion of the work and when all men and materials have been withdrawn from the electric equipment and its vicinity, the person in-charge of the working party shall cancel his permit-to-work card and return it to the 'authorized' person who issued it. The 'authorized' person shall in turn issue a message to TPC to cancel permit-to-work as detailed in para 20613.

20615 Local Cancellation of Permit-to-Work When Telephones are Interrupted

If telephone communication with TPC is interrupted when a permit to work is to be cancelled, the authorized person to whom the permit-to-work was issued shall arrange locally for restoring the normal (live) conditions on the equipment specified in the permit-to-work and for cancelling the power block, if possible. Before this is done the authorized person should satisfy himself that no other party has been given a permit-to-work for the same section.

20616 Multiple Working Parties

1. Whenever work has to be carried out by more than one working party, within a sub-sector or an elementary-to-work shall be issued by the TPC only to one authorized person who alone shall be responsible. Other party or parties may work for all work on the portion of electrical equipment specified in the permit-to-work. Other party or parties on the same portion of electrical equipment only with the permission of this authorized person. The authorized person shall cancel the permit-to-work only when he has satisfied himself that all working parties who have been
permitted by him to work in the section covered by the permit-to-work have withdrawn their men and materials and have removed the earths from the electrical equipment on which they had worked. In the event of telephone communication being interrupted, the person responsible shall take action as provided in para 20615 above for cancellation of the power block.

2. Where the two parties are working far from each other, the party who has to work for a longer period shall take the permit-to-work and then permit the other party to start his work by a message supported by a Private Number. The second party shall inform the party from whom he got the permit-to-work of completion of work and removal of earths and withdrawal of men and material by a message supported by Private Number.

20617 Entries in the Log Book

The number of each permit-to-work issued must be entered in the log book by TPC together with the particulars and time when the equipment is made dead and re-energized after completion for the work, as per information received on telephone from the 'authorized' person concerned.

20618 Work Inside Loco Shed or Car Shed

For work to be done inside the loco sheds or car sheds, the application for permit-to-work must be made to the Traction Foreman, Assistant Traction Foreman or Chargeman (RS) who shall arrange for the issue of the permit-to-work after getting the switch of the inspection bay or the feeders opened. No intimation to TPC is necessary. The permit-to-work must be received for cancellation from the person in-charge of the work by the Traction Foreman, Assistant Traction Foreman or Chargeman (RS) before the switches are closed.

20619 Local Block

Power supply for sidings which do not affect movements of trains on the main lines, for loop lines and reception and despatch yards, is controlled by manually operated isolators. Keys for these isolators are usually in the custody of the Stationmaster concerned. Power blocks on such sidings can be arranged when required by an authorized official subject to the following:

(i) The Station Master, Cabin Assistant Station Master, and others responsible for the movement of traffic, should take measures detailed in para 20621, 20622 and 20625.

(ii) TPC shall be informed. before and after the shut-down is effected.

(iii) Isolators may only be opened after due precautions prescribed in para 20600, 20622 and 20625.

(iv) Earthing of equipment and issue of permit-to-work is done as prescribed in these rules.

Local power blocks shall be recorded in form ETR-4 prescribed for the purpose.

20620 Protective Measures for Power Blocks

It is essential that every Railway official concerned with the movement of trains on the electrified section, have a thorough understanding of the precautions to be taken to ensure safety of staff working on the OHE under power blocks. The reasons for the precautions and the nature of the precautions are therefore given at some length in the following para graphs.

The protective measures are -

(a) Longitudinal Protection: To stop movement of electric rolling-stock running on the same track on which a section has been made dead and power block has been granted.
20621 Logitudinal Protection

1. At all points where interrupters or isolator switches are provided the overhead lines are sectioned and insulated (air gap) overlap span is provided. The arrangement adopted is shown in Fig. 6.01. The OHE from the direction ‘X’ is anchored on mast D while that from direction ‘Y’ is anchored on mast ‘A’. The two systems are held apart by steady arms from masts ‘B’ and ‘C’ and are kept insulated from each other, there being sufficient air gap between them. The two contact wires are, however, running parallel to each other at about the same level between OHE masts ‘B’ and ‘C’. When a locomotive passes from ‘B’ to ‘C’, the pantograph will normally be in contact with and receive power from both the contact wires but when passing either between ‘A’ and ‘B’ or between ‘C’ and ‘D’, it will be in contact with only one contact wire. Since the isolator switch provided is normally in closed position, it connects the two OHE together and, therefore, they are both energized at the same voltage.

2. If a power block has taken on Section ‘Y’ and the isolator switch is in open position, it will be seen that the OHE from direction ‘Y’ (dotted lines) is dead and earthed whereas that from direction ‘X’ is live at a potential of 25 kV. The pantograph of electric rolling-stock while passing between OHE masts ‘B’ and ‘C’ will short circuit the live and dead contact wires. Such a movement will on danger the life of staff who may be working on the dead OHE section ‘Y’, apart from producing destructive arcing resulting in severe damage to the pantograph and the contact wire.

3. To avert such disastrous effects, under no circumstances should electric rolling-stock be admitted into the insulated overlap separating the dead section on which a power block has been taken from live sections.
Transverse or Cross Protection

1. Section insulators have been provided on crossovers to separate and insulate different sections of OHE from each other, e.g., the up track from the Down track, the main line from the siding yard, OHE inside a loco maintenance shed from the yard lines.

2. A section insulator, comprises of a strain insulator, with two runners connected to one of contact wires as shown in Fig. 3.02 (Chapter 111). The runners are at the same height as the contact with the other side, and also shaped so as to allow a smooth passage of the pantograph underneath. It will be seen from Fig. 3.02 that the two runners overlap with the contact wire on the other side for a short distance to ensure that there is no interruption of the current drawn by the locomotive as it passes under the section insulator.

3. Electric rolling-stock with raised pantograph should, therefore, never be allowed to pass below a section insulator if a power block has been given on one of the tracks, as the pantograph will momentarily connect the live OIAE with the dead OHE, while bridging the runners and contact wire. This again energizes the dead section and endangers lives of those who are working on it.

4. In view of its extreme importance the rule is again repeated: Under no circumstances should electric rolling-stock be passed below an insulated overlap span or a section insulator which separates a dead section on which a power block has been granted, from the line section.

Procedure for Arranging Longitudinal and Transverse Protection

1. Before a power block is granted the Section Controller should advise the Station Master, Yard Masters and Cabin Assistant Station Masters concerned to protect the dead sections, both longitudinally and transversely. It is only when all the Station Masters and Cabin Assistant Station Masters concerned have confirmed that this has been done, the Section Controller can advise TPC agreeing to the grant of power block. The Station Master, Yard Master and Cabin Assistant Station Master concerned will continue to maintain protection till the power block is cancelled by the Section Controller.

2. The Section Controller will in turn permit removal of protection only after the power block is cancelled by TPC.

Station Working Rules for Longitudinal and Transverse Protection

1. In view of the large number of possible movements which may accidentally energize a dead section under a power block, the various protective measures to be taken by each Station Master, Cabin Assistant Station Master and Yard Master when power block is granted for the various sectors, sub-sectors or elementary sections should be catalogued in the Station Working Rules for each station. It is the duty of every Station Master, Yard Master and Assistant Yard Master to be thoroughly familiar with these instructions so as to be able to carry out efficiently and quickly the protective measures prescribed.

2. The Station Working Rules should contain:

(a) rules to be generally observed by all stations;

(b) a chart giving exactly what precautions have to be taken for granting power blocks on each sector, sub-sector or elementary section; and

(c) a drawing showing the wired and unwired tracks as well as the sectionalizing arrangements including the position of signals and points referred to in the chart mentioned above.

This drawing is the only valid document to be referred to for the purpose of granting power block. No modification of the installation shall be done without its first being incorporated in the above drawing.
3. In case of large stations, a copy of Station Working Rules may be issued to each cabin.

4. Every Station Master/Yard Master/Asstt. Station master shall be Trained for the purpose and be fully conversant with all the local switches/isolators/cross-overs and special Instructions applicable to the equipment provided the station and as laid down in the Station Working Rules to enable him to operate Isolators under instructions from TPC

**20625 Protection of Dead Section**

The protection of a dead section is achieved by the following means:

(a) In the normal running direction, movements of trains are generally controlled by signals. Protection is obtained by placing a “Red Warning Collar” on the signal lever controlling the concerned signals, painted with inscription “Beware - No Voltage”.

(b) If the points and signals are locally operated, they should be locked and the keys controlling the lever or lever frames should be kept with the Station Master on duty. When the signal cabin or lever frames are controlled electrically by a Station Master or a Cabin Assistant Station Master, the Station Master or Cabin Assistant on duty shall place the warning collars on the relevant slides of electric slide Instruments or on the relevant keys of electric transmitters or Interlocked key boxes.

This action must be taken by the Cabin Assistant may be, in respect of each and every movement completion, confirmation should be given to the power block to be issued by the TPC.

Station Master or the Station Master, as the case prescribed in the Station Working Rules and after Section Controller to enable him to agree for the

In a large yard several warning collars may be required. Sufficient number of warning collars should be kept in each station/cabin. The exact number provided should be indicated in the corresponding Station Working Rules.

(C) Once a warning collar is placed on the signal lever, it shall not be removed except after exchange of messages with private member.

**20626 Shunting Movement Towards Dead Section**

1. In cases where no signal exists for controlling the entry of an electric Train into the dead section, the Station Master should arrange a hand stop signal to be exhibited at the point upto which alone the electric locomotive is allowed to proceed.

If It is necessary for an electric locomotive to carry on shunting movement towards the dead section, the red warning collar placed on a lever may be removed to permit the movement, provided that a hand stop signal as above is exhibited and the Driver Is specifically instructed not to move the loco beyond the point.

An example of this operation is given In Fig. 6.02. As per para 20625 the lever controlling the signals should have “red warning collars” placed on them to give protection to the dead section. However, If It Is essential to carry out a shunting operation with an electric locomotive situated at point ‘A’ on the loop line to move into the main through the turn-out, this may be permitted provided that the shunting movement is carried out only upto limiting mast ‘P’, short of the overlap span, where a hand signal is to be exhibited to prevent all movements beyond the point ‘P’.

2. Train or shunting movements by other than electric locomotives, i.e., by steam or diesel locos, may be permitted to enter the dead section, provided that the Station Master ensures by personal inspection that the Train formation does not include an electric locomotives or OHE Inspection Car or EMU with pantograph raised. The 11 red warning collars may be permitted to be removed to allow such movements.
20627 Movement of Other than Electric Trains

Goods or Passenger trains hauled by other than electric locomotives may be allowed to pass through the dead section subject to the following conditions:

(a) This has not been prohibited specifically in the power block message.

(b) Steam or diesel engine or trains hauled by such engines shall be brought to a stand at the station preceding the station/section at which power block is granted and the Station Master or this station shall satisfy himself by personal inspection that there is no electric locomotive in the train in question.

(c) He shall also give a Caution Order to the Driver of such engine or train warning him of the power block ahead and instructing him to watch for hand signals and observe them.

(d) No Station Master shall give line clear or lower signals for a train to run over a section under power block unless he has received an assurance (supported by Private Number) from the Station Master of the preceding station that there is no electric locomotive or Inspection Car with pantograph raised in the train.

(e) Whenever a "red warning collar" has been removed for permitting a movement as per paras 20626 and this para, it shall be replaced back on the signal control lever immediately after the movement is completed.

For purposes of the above rule the term "Electric Rolling Stock" does not include electric rolling-stock hauled 'dead' as a vehicle or OHE Inspection Car with its pantograph removed or securely locked down.
Typical forms for power block messages are attached at the end of this Chapter.

Form ETR. 1 This has 3 parts and is used for exchange of message between TPC and Section controller when a power block is to be imposed or withdrawn. When TPC and the Section controller are located in adjacent rooms, the messages will be made out in duplicate and sent to the other party obtaining the acknowledgment of the receiving party on a carbon copy. When they are located far apart, the messages K4U. be exchanged on phone, the receiver recording the message on an identical form and repeating it for confirmation.

Form ETR. 2 This has 3 parts and is used for exchange of messages between TPC and the 'authorized persons' taking shut downs. These messages will usually be conveyed on telephone, the receiver recording the message on an identical form and repeating it for confirmation.

Form ETR. 3 This has 4 parts and is used when an authorized person who has taken a power block has to issue a permit-to-work*. Messages in this form will invariably be made out in duplicate and sent to the other party obtaining acknowledgment on the carbon copy.

Form ETR. 4 This has 3 parts and is used when local blocks are to be arranged. Messages in this form also should invariably be written out and sent to the other party obtaining acknowledgment on the carbon copy.

An message exchange over telephone should be supported with exchange of Private Numbers.

Form ETR. 1 Part A.

POWER BLOCK MESSAGE FOR BLOCKING OF LINES FOR ELECTRIC TRACTION PURPOSES

Serial No.
Date ..........................
Time Hr ............ Mts ..........
From, Traction Power Controller
To, Section controller
at ........


Block the following line/s to electric trains /all traffic from Hr. Mts. ............. on ...........
and advise me when this has been done.

State below which line/s and between which limits (Sector, Sub-sector, Elementary Section, etc.) the block is required.

........................................................................................................
........................................................................................................
The block is likely to last for ... Hr. Mts ...

Private No. .................
Sent by ............
Received by .................

(Name) ............. (Name)

*Score out whichever is not applicable.
Form ETR. 1
Part B

POWER BLOCK MESSAGE FOR BLOCKING OF LINES FOR ELECTRIC TRACTION PURPOSES

Serial No. Date ........ ........................
Time Hr . .................. Mts ..................

From, To,
Section Controller Power Controller

From ..........................................

.................(Place) at ................................

Your No .......... Of ...

The following line/s have been blocked to 'electric trains/all traffic: -

Line/s Duration
..............................................................................................................................................
..............................................................................................................................................
..............................................................................................................................................
..............................................................................................................................................
..............................................................................................................................................

Particulars of line/s Reasons .....
..............................................................................................................................................
..............................................................................................................................................
..............................................................................................................................................
..............................................................................................................................................

Private No ..........................

Sent by ..............................
(Name)

Received by ...........................
(Name)

Score out whichever is not applicable

Form ETR. 1 Part-C

POWER BLOCK MESSAGE FOR BLOCKING OF LINES FOR ELECTRIC TRACTION PURPOSES

Serial No. Date ........ ........................
Time Hr . .................. Mts ..................

From, To,
Traction Power Controller Section Controller

at ............................. Section

............................(Place) at .............................

Your No............................... of .............................................(date)

The following line/s have been made alive and the block imposed on these line/s may be cancelled -

Private No ..........................

Sent by ..............................
(Name)

Received by ...........................
(Name)
Form ETR-2  
Part-A.  

............................ RAILWAY  
SHUT DOWN NOTICE ON TRACTION OVERHEAD OR OTHER ELECTRICAL EQUIPMENT

Serial No. ...........................................................................................................
Date..........................

Time Hr ......................... Mts...

From, ................................................................. To, .................................................................

Traction Power Controller
at ................................................. at .................................................................

I hereby declare that the following electrical equipment/s has/ have been isolated. The equipment
shall be earthed according to standing instructions before commencing any work or prior to issue of
Permit-to-work :-

State below exactly which section/s (Sector, Sub-sector, Elementary Section, etc.) of the electrical
equipment has/ have been isolated -

<table>
<thead>
<tr>
<th>Lines isolated</th>
<th>Limits of isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>................</td>
<td>....................</td>
</tr>
<tr>
<td>................</td>
<td>....................</td>
</tr>
<tr>
<td>................</td>
<td>....................</td>
</tr>
</tbody>
</table>

**Line/s to be cleared by**

|.....................|...................|Hr | Mts |
|.....................|...................|Hr | Mts |

Private No .................................................................

Sent by .................................................................
(Name)

Received by .................................................................
(Name)

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME 11 PART 1 [141]
Form ETR-2
Part-B.

............................ RAILWAY
SHUT DOWN NOTICE ON TRACTION OVERHEAD OR OTHER ELECTRICAL EQUIPMENT

Serial No. Date..............
Time Hr . ................. Mts...

From, 
............................ To,
............................ Traction power controller,
at............................ at............................

Your No. ......................... of .........................

Local earths have been applied at the following points:-

............................ Line earthed at structured Nos. .............
............................ Line earthed at structured Nos. .............
............................ Line earthed at structured Nos. .............

The following permit to work have been issued on the authority and I am responsible for the permit to work:-

(1)...........................................(2)...........................................(3)........................................
‘Permit to work’ .................................................................
Nos. ........................................................................................
Date of issue .................................................................
Time of issue .................................................................
Dept. Issued to .................................................................
Person in-charge of work .................................................................

Private No.................................................................
Sent by .................................................................
(Name)

Received by .................................................................
(Name)

INDIAN RAILWAYS – AC TRACTION MANUAL – VOLUME II PART I (142)
Form ETR-2
Part-C

SHUT DOWN NOTICE ON TRACTION OVERHEAD OR OTHER ELECTRICAL EQUIPMENT
Serial No.          Date .................
                   Time
Hr ................ Mts ..............
From, .....................
............................
............................
To,  Traction Power Controller
............................
at ...........................................
at ...........................................
My No. .................
............................

1 hereby declare that the work on or near electrical equipment/s which has/have been isolated has
been completed. All men and materials have been withdrawn and the men have been warned that it
is no longer safe to work on or adjacent to electrical equipments. AN Permits-to-work issued by me
have been withdrawn and cancelled. All local earths have been removed, and the electrical
equipment/s can be made alive.

Private No .................
Sent by .....................
(Name)
Received by ..................
(Name)
Form ETR-3
Part-A.

PERMIT-TO-WORK ON OR NEAR AC TRACTION ELECTRICAL EQUIPMENT
Serial No.          Date .................
From, .....................
............................
............................
To,  ..................................
at ..................................
at ..................................
1 hereby declare that it safe to work on or near the following electrical equipment which is dead,
isolated from all live conductors and is connected to earth.

State below exactly the electrical equipment on or near to which it is safe to work. (Sector, Sub-
sector, Elementary Section, etc.)

ALL OTHER PARTS ARE DANGEROUS.
The equipment shall not be alive until this Permit-to-work is returned duly signed by the person in-
charge of the work.

The No. of the Permit-to-work, date and time Issued has been intimated by me to Traction Power
Controller at ........................................
at ........................................
Hr ................ Mts ..............
. on ................................ (date).

Signature

Name .....................
Designation ..................
Date ............. Hr ........ Mts......

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME 11 PART [143]
PERMIT-TO-WORK ON OR NEAR AC TRACTION ELECTRICAL EQUIPMENT

Serial No.                        Date ..............................

From,                        To, ..............................

at ...........................................  at ..............................

Received the original foil of this Permit-to-work, I fully understand the portion of the electrical equipment which is dead, isolated and earthed and that all other parts are dangerous.

The permit-to-work will be returned by ....Hr. .....Mts. as required.

Signature ......................................................
(of the authorized person)

Name ......................................................

Designation ..............................

Date.........Hr. ........Mts.

FORM ETR-3
Part-C
.............................................. RAILWAY

PERMIT-TO-WORK ON OR NEAR AC TRACTION ELECTRICAL EQUIPMENT

Serial No.                        Date ..............................

From,                        To, ..............................

at ...........................................  at ..............................

I hereby declare that the work for which this Permit-to-work was issued has been completed and all men and materials under my charge have been withdrawn the men have been warned that it is no longer safe to work on or near the electrical equipment covered by this ‘Permit-to-work’.

Signature ......................................................
(of the authorized person)

Name ......................................................

Designation ..............................

Date.........Hr. ........Mts.
PERMIT-TO-WORK ON OR NEAR AC TRACTION ELECTRICAL EQUIPMENT

Serial No. Date..........................
From, To, ............................................. ...............................................
at........................................... at..................................................

1 hereby declare that the ‘Permit-to-work’ is cancelled and all local earths have been removed. The cancellation of this ‘Permit-to-work’ has been Intimated to Traction Power Controller ................... at ...... Hr ...... Mts ......

Signature ................................
(of the authorized person)

Name..............................
Designation.........................

Date............Hr..........Mts......

LOCAL BLOCK

Serial No. Date

Hr ................ Mts ....................
From, To, ............................................. ...............................................
Name ............ ............ Name ....... .............................................
Designation ................................ Designation ..................................

The ................................. The .............................................
*Isolator number *Interruptor number
*at location number *at Switching station
in ..................................................... Yard ..........................................................

will be kept open and overhead equipment of elementary Section/s will be made dead and earthed.
The lines in the above elementary Section/s will not be available for electric stock/all traffic movement from ................. hour until further advice

The block is likely to, last for ....................Hrs. .........................Mts  ..

Signature

Copy to:- (1) Traction Power Controller Section Controller 
(c) Section Controller
Received Message No. .................................................. from ..........................................

At ........................................... Hr. ........................................... Mts ........................................

.................................................................

Signature of the station Master/Yard Master

Place ..............................................................

From,

Name .......................................................... * Station Master/Yard Master

Designation ........................................................

My No ..................................................................

of ........................................................................ (date)

The *Interruptor number
*Isolator number opened by me has been closed and the overhead equipment of the
.............................................................. elementary Section/s. No./s ........................................ have
been made alive and are now available for *electric stock /all traffic movements.

Signature .........................................................

Copy to: - (1) Traction Power Controller Section Controller.
         (2) Section Controller

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME 11 PART 1 [146]
CHAPTER - VII

SIGNALLING & TELECOMMUNICATION AND PERMANENT WAY INSTALLATIONS IN ELECTRIFIED SECTIONS

Para No. Subject
20700 Introduction

I. SIGNALS AND ASSOCIATED EQUIPMENT

20701 Effect of 25 kV Traction on S&T Equipment
20702 Types of Signals
20703 Locations of Signals
20704 Insulation of Wires and Point Rods
20705 Earthing of S&T Equipment
20706 Signalling & Telecommunication cables
20707 Block Instruments and Block circuits.
20708 Track Circuits
20709 Bonding in Track Circuited Zones
20710 Signalling and Inter-locking Circuits

II. TELECOMMUNICATION FACILITIES FOR AC TRACTION

20711 Telecommunication Circuits
20712 Principle of Tapping
20713 Power Supply Arrangement

III. PERMANENT WAY INSTALLATIONS

20714 Major Track Maintenance Works
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CHAPTER-VII

SIGNALLING & TELECOMMUNICATION AND PERMANENT WAY INSTALLATIONS IN ELECTRIFIED SECTIONS

20700 Introduction

The important points concerning the signalling, telecommunication and permanent way installations in electrified sections can be grouped as follow:

1. Signals and associated equipments
11. Telecommunication facilities for ac traction
111. Power supply for S&T installations
IV. Permanent way installations

Various aspects for the general information of electrical staff are covered in this chapter. The rules are covered in the Indian Railways Telecom Manual for the S&T staff and in the Indian Railway Permanent Way Manual for the civil engineering staff.

The safety rules applicable to the staff of S&T and civil engineering departments are given in Chapter IV, Vol. 1 of this Manual.

1. SIGNALS AND ASSOCIATED EQUIPMENT
20701 Effects of 25 kV Traction on S&T Equipment

Any circuit in the vicinity of OHE for 25 kV ac 50 Hz signal phase traction system is influenced by electrostatic and electromagnetic induction. The electrostatic induction is practically eliminated by transferring S&T circuits into underground cables protected with metal sheath. The electromagnetic induction causes currents and voltages to develop in metallic items parallel to the track. The items include the rails, traction return conductor where provided, cable sheath and S&T circuits. The voltages that occur in the metallic items appear as potential gradients. The value of induced voltage depends on various factors such as:

a) length of parallelism between the cable and electrified track
b) soil conductivity
c) Screening efficiency of cable sheath where existing
d) return current through the rails and return conductor where provided.
e) mutual inductance between catenary and cable conductors
f) current carried by the OHE.

Appropriate precautions to overcome the effects of the induced voltage, therefore, have to be taken by S & T department.

Other aspects where S&T equipment is affected are:

i) OHE masts and fittings may come in the way of visibility of signals to some extent and may come in the way of signal.
ii) Restrictions in the path of traction currents on section provided with track circuits.
20702 Types of Signals
In the double line electrified sections, the signalling system shall generally be the colour light signal (CLS) type. But the semaphore signals may be maintained on single line sections (Main or branch) which are taken up for Railways Electrification.

20703 Locations of Signals
1. Signals are so located as to afford maximum visibility to drivers and the signal structures have to be clear of the moving dimensions. In electrified sections, however, the signals should have the required electrical clearance of at least 2m from the live conductor. Detailed instructions on the location of signals have been issued by the S&T Deptt.

2. Where a signal post or its fittings have to be located within 2 m of live OHE, a screen of wrought mesh of approved design solidly connected with the structural work shall be provided between the signal post and the OHE for protection of staff. The protection screen is not necessary when only the technical personnel, such as inspectors and maintainers of the S&T Deptt. are authorised to work on the signals. When a signal post is not provided for any reasons, a caution board of approved design shall be provided on the signal post on the side facing the ladder at a height of 3 m above the rail level to caution such staff.

3. Technical personnel shall exercise particular care to protect themselves while working on signal posts not provided with protective screens. If there is any likelihood of any part of their tools or equipment coming within 2 m of live equipment, they shall take a power block as detailed in Chapter Vi. The same precautions are also required in the vicinity of return conductors, which should be treated as live.

4. To ensure maximum visibility of signals to the drivers, signal Posts should be located on the side opposite to that of traction masts as far as possible. Where this is not possible as in double line sections and station yards, the following steps are taken to achieve maximum visibility from the Driver's normal position in the driving cab.

   i) The distance between the signal post and the traction mast shall be as large as possible. In case the traction mast is located in front of the signal post the distance between the traction mast and signal post should not be less than 30m. No traction mast shall be located beyond the signal post at a distance less than 10m.

   ii) The signal post should be sufficiently high so as to be seen clearly.

111) For deciding setting of mast near signals, para 20.5 of Appendix may be referred to.

iv) On curved tracks or in areas where other obstructions such as buildings, trees, etc. exist the site is individually examined for deciding the most appropriate location of the signal.

V) In all cases a "Signal Siting Committee" which includes a representative of the Electrical Department should be constituted to examine the visibility of the signal before finally deciding its location and height.

20704 insulation of Wires and Point Rods
Normally wires and point rods would be eliminated in the signalling system in ac electrified section. However, where these exist, the wire transmission as well as point rods in ac electrified areas are subject to induced voltage which could reach high values when an OHE fault occurs. This induced voltage or rail voltage is transmitted through the wires and point rods to the lever frame. Insulators are therefore, provided on the wires and point rods for insulating them from rail potentials and induced voltages, in accordance with detailed instructions on the subject laid down in Chapter XXII of Indian Railway Signal Engineering Manual issued by S&T Department.

INDIAN RAILWAYS - TRACTION MANUAL VOLUME 11 PART
20705 Earthing of S&T Equipment

Earthing of the following equipment is essential on sections electrified with 25 kV ac 50 Hz single phase system the earthing being done in accordance with prescribed instructions.

a) Signal posts provided with protective wire-mesh screens.

b) The lever frames and other metallic parts of the cabin in contact with, the lever frame, (This includes rail stagings wherever they are used. Where the electrical conductivity of the joints of the rail staging is doubtful the members are to be bonded at the joints.)

c) Metallic sheaths wherever applicable and armouring of all underground cables. The earthing of the sheath and armouring of main cables at either end is a matter of paramount importance because unless the cables are earthed properly at both ends it will not be possible to obtain the screening effect of the cable from induced voltages.

d) Block instruments working on earth return through the respective block filters.

e) All telecommunication equipment.

f) The surge arresters provided in block filters as well as those provided for telecommunication equipment in switching stations.

The telecommunication equipment may be connected to the same earth as the lever frames. Surge arresters may be connected to the earth for the cable sheath. In all other cases separate earths shall be provided. The resistance of an earth shall not exceed 10 ohms.

20706 Signalling & Telecommunication Cables

The main S & T cable in ac electrified sections are usually of the PVC insulated, screened and armoured type to IRS Specification No.,S-35. These cables are laid in accordance with instructions issued by the S & T Department. Instructions which are likely to affect traction installations are given below

(i) The cable is laid so that it is not less than lm from the nearest edge of the traction mast foundation provided that the depth of the cable does not exceed 0.5 m. When the cable is laid at a depth greater than 0.5 m a minimum distance of 3 m shall be maintained between the cable and the nearest edge of the traction mast foundation. If it is difficult to maintain these distances the cable shall be laid in concrete pipes for distance of 3m on either side from the mast. When so laid the distance between the cable and foundation may be reduced to 0.5m. These precautions are necessary to avoid damage to the cable in the event of the failure of an overhead insulator.

(ii) In the vicinity of traction substations and feeding posts, the cable shall be laid at least lm away from any metallic parts of the OHE and other equipment at the sub-station/ feeding post as well as from the substation earthing system. In addition, the cables shall be laid in concrete pipes for a length of 300m on either side of the feeding post. As far as possible the cable shall be laid on the side of the track opposite to the feeding post.

(iii) In the vicinity of switching stations, the cable shall be laid in the ground at least lm away from any metallic structure of the switching station and at least 5m away from the station earthing system. The distance of 5 m can be reduced to lm provided the cable are laid in concrete pipes.

(iv) Where an independent earth is provided for an OHE mast/ structure i.e., where the mast is connected to a separate earth instead of being connected to the rail, the cables shall he laid ‘at least one metre away from the earth.

(v) Where there are traction masts/structures along the cable route, the cable shall be laid in the trench which should be as far as possible but not less than 5.50 m from the centre of the track.

(vi) Where cables have to cross the track, concrete or GI pipes must be used for the crossing. The use of GI pipes or a form of metallic pipes is prohibited within a distance of 300m from the feeding post. Similarly galvanized iron metallic pipes are prohibited in close proximity to switching station earths or traction masts.
20707 Block Instruments and Block Circuits

On replacement of overhead communication lines with cables, block instruments working with overhead lines with earth return are transferred to special PVC insulated quads in the underground cables. Special protective devices are provided at both ends of block circuits for protection of the instruments as well as the operating staff.

20708 Track Circuits

Any of the following types of track circuits may be used on ac electrified sections :

i) dc single rail track circuits.

ii) ac track circuits working at a frequency other than 50 Hz so as to be unaffected by the latter.

iii) Voice frequency and other forms of electronic track circuits.

The track circuits of (ii) and (iii) above may be either the double rail type or the single rail type.

20709 Bonding in Track Circuited Zones

The track bonding for the passage of traction current requires modifications in the track circuited zones. Appendix 11 may be referred to in this regard.

20710 Signalling and Inter-locking Circuits

In view of the high level of electromagnetic and electrostatic induction in overhead lines, all overhead lines used for signalling and inter locking circuits in ac electrified sections have been replaced by underground cables. The replaced lines, if not dismantled before energization of the OHE, shall be cut into sections and earthed at several places.

The length of a circuit in a cable shall be such that the induced voltage in the circuit does not exceed 120 volts (corresponding to a parallelism of 3.5 km). If for any reason parallelism of a circuit exceeds 3.5 km, a relay is inserted in the circuit so that the physical continuity of the cable is broken and the parallelism of each portion is reduced to less than 3.5 km. If the parallelism in excess of 3.5 km is due to feeding two circuits from a common battery or power supply source, separate batteries are provided to feed the circuit on each side so as to limit the parallelism to less than 3.5 km.

11. TELECOMMUNICATION FACILITIES FOR ac TRACTION

20711 Telecommunication Circuits

The telecommunication facilities provided in electrified sections have been detailed in Chapter 11 of Volume.

On ac electrified sections all overhead telecommunication lines running parallel to the track have to be replaced by underground cables. When the induced voltage in the cable is expected to exceed 60 volts; way station and subscriber's equipment, exchanges are protected from the induced voltage by providing isolating transformers. When transformers are provided it will not be possible to transfer dc. circuits such as CB and auto telephones, dc telegraph circuits etc. , into the cable.

The attenuation of speech in an overhead line of 56.5 kg per km copper is approximately 0.039 dB per km whereas the attenuation in an underground long distance cable is approximately 0.22 dB per km. The telecommunication circuits are therefore subject to about five times the attenuation when transferred to underground cables and consequently repeaters are required for these circuits at intervals of about 50 to 60 km for satisfactory working. Where the cables are laid by the DOT all repeaters and isolating transformers are provided by them.
20712 Principles of Tapping

Traction Power centre, Traction loco Control and emergency telephone circuits are specifically installed for electric traction. Control regarding utilization of these circuits rests with the Chief Electrical Engineer. All tappings of these circuits will, therefore, be provided with the specific approval of CEE. Adequate capacities on all these circuits shall be provided taking into account future requirements. Usually the following tappings are provided:

1. Traction Power Control Circuit
   (1) Traction Power Control of the adjoining Remote Control Centres,
   (ii) All switching stations,
   (iii) All railway traction sub-stations,
   (iv) All grid sub-stations,
   (v) Central repair shop,
   (vi) All OHE, PSI and RC maintenance depots,
   (vii) Offices of all Station Masters/ASMS,
   (viii) Offices of Yard Master who control movement of trains,
   (ix) Offices and residences of Traction Distribution officers,
   (x) Residences of CTFO, TFO/ATFO of OHE, PSI, Substation, RC maintenance depots.

2. Traction Loco Control Circuit,
   (i) All electric loco sheds,
   (ii) All electric loco stabling sidings,
   (iii) Offices of Station Masters of originating, and junction stations,
   (iv) Offices of Yard Masters of large yards,
   (v) Office of CTFR and TFR,
   (vi) Offices and residences of Rolling Stock officers,
   (vii) Residences of CTFO(RS), TFO(RS), CTFR and TFR provided their residences are more than 500m from their offices and no other telephone facilities exist at their residences.

3. Emergency Control Circuit
   (1). At regular intervals along side the track not exceeding 1 km of running track.
   (ii) At all traction sub-stations, switching stations, and maintenance depots.
   (iii) Near booster transformer locations and Isolator switches provided for isolation of OHE.

If the distance between two successive emergency telephone sockets determined as above is less than 100 m, only one socket shall be provided, at such locations.

However, in large yards having more than four tracks which are likely to be occupied most of the time, an additional emergency socket may be provided on the opposite side of the yard near an isolator provided for isolation of traction OHE.

Where the transverse distance between two tracks involves walking of more than 300 m, separate tapping shall be provided for each individual track. If not already done, this circuit should also be extended to the TLC to enable him to guide loco/EMU crew in the event of failures enroute.
3. Railway’s local telephone
   (i) Remote Control Centre,
   (ii) Traction Loco Controller,
   (iii) Traction Power Controller,
   (iv) Offices and residences of all officers of Traction Distribution and Rolling Stock - operation and maintenance
   (v) Offices and residence of CTFO & TFO(RS) and CTFR & TFR,
   (vi) Office and residence of CTFO and ATFO of OHE, PSI and RC maintenance depots,
   (vii) Office and residence of ELC of sub-depot,
   (viii) SEB’s Grid Substation, if feasible.

5. P & T Telephones
   (i) Remote Control Center,
   (ii) All Traction sub-stations,
   (iii) Offices and residences of SR.DEE & DEE(TrD), SR.DEE & DEE(RS), SR.DEE & DEE(RSO), AEE(TrD), AEE(RS) and AEE(RSO).

20713 Power Supply Arrangement
1. To ensure reliability of ac 240V, ac 50 Hz single phase power supply a 25 kV/240V auxiliary transformer shall be connected to 25 kV OHE.

   (a) At a station where a reliable local power is available, the main supply is taken from this source. The stand-by supply is obtained by tapping the 25 kV catenary and installing a 25 kV/240 V auxiliary transformer.

   (b) At stations where no reliable local supply is available, the main and stand-by power supplies are obtained by installing two 25kV/240 V auxiliary transformers, each connected to independent sub-sectors of the OHE.

   (C) At stations where an auxiliary transformer is installed at a traction switching post situated within 350 m of the signal cabin or the station building 240 V supply from the auxiliary transformer is treated as the main supply and a second 2SkV/24OV transformer is installed on another sub-sector for giving the stand-by supply.

2. Following works shall be carried out by the Electrical Department:

   (i) At each way side station, 2 nos. Auxiliary Transformers, one each connected to OHE of UP & DN lines shall be provided. A 2 x 25 MM2 . aluminium cable shall be laid from each AT to ASM’s room and shall be terminated at the CLS supply panel. Local supply, if available, shall also be terminated at the panel as third source. A manual three-position change-over switch shall be provided on the CLS supply panel. The CLS panel shall be provided with MCBs and neon indication lamps for the incoming and outgoing supplies. Change-over shall be effected by ASM on duty. From the CLS supply panel , power supply will be extended to either cabin by S & T department through 2x25 mm² aluminium cables.

   (ii) At big yards, where a number of cabins are located, 2 to 3 cabins shall be grouped together and a set of two ATs, one each connected to OHE of UP & DN lines shall be provided at a convenient location to feed each such group. CLS supply panel having a three-position manual changeover switch shall be provided at one of the cabins by the Electrical Department, from where the supply shall be extended by S&T department to other cabins.
(iii) Provision of 2 nos. Auxiliary Transformers, one each connected to OHE of UP & DN lines, shall be arranged at each level crossing located more than 2 km away from the Railway station. If any other level crossings are located within 2 km of the level crossing where a set of ATs have been provided, then supply from the same ATs shall be extended to these level crossings through 2 x 25 MM² Aluminium cable to be laid by S & T Deptt. The CLS supply cable along with manual change-over switch shall be provided at the gate lodge. Change-over shall be effected by the Gateman on duty.

(iv) In case of IBH, separate set of ATs shall be provided. As IBHs are unmanned, a two-position automatic change-over switch shall be provided.

(v) In single line sections, one AT connected to the OHE will be provided for supply to CLS. The LT supply will be extended from the AT to ASM's room by means of 2 x 25 MM² aluminium cable terminated at the CLS supply panel. Local power supply, if available, will also be connected to this panel, which will be provided with a change-over switch. This arrangement will be adopted for the way side stations, level crossings beyond 2 km. from the nearest Railway Station and at the IBHs.

(vi) At way-side electrified stations, where local supply is prone to prolonged interruptions, an emergency light point shall be provided in ASM's room and in each cabin from the AT supply, through a separate circuit protected by a fuse of proper rating. At non-electrified stations, a separate lighting circuit shall be provided in ASM's room and in each cabin from the AT supply. From the lighting circuit in the ASM's room, one light point each in ASM's room, on the platform outside the station building, at the ticket window/waiting hall and in the cable hut shall be provided. On the lighting circuit at the cabins, one light point each in the cabin, relay room, battery room and cabin basement shall be provided.

(vii) All the power supply installations provided by the Electrical department, as detailed in paras (1) to (vi) above, will be maintained by the Electrical department.

3. Following works shall be carried out by the S&T department

(i) A 2 x 25 mm² aluminium cable will be laid from the ASM's room to each cabin along with the signal control cables in the same trench. An integrated power cubicles including a voltage stabilizer, inverter and battery chargers will be provided in the relay room for signal and relay supplies. A 240 V ac outlet from this power pack will be made available to Electrical Department for provision of light points. Similar arrangements will be made at each level crossing and IBH.

(ii) An 80 Ah battery capacity, sufficient to cater for two hours failure of supply, will be provided at each, cabin and level crossing. One extra 80 Ah battery set shall be provided temporarily at these points until AT supply becomes available. At IBH 200 Ah battery capacity may be provided to cater for four hours failure of supply.

(iii) At large yards, two standby diesel generating sets of 10 kVA rating each will be provided for standby power supply to the signalling installations. The supply from these generators will be brought to the CLS supply panel in the ASM's room or in the cabin, where a change-over switch will be provided by the S&T Deptt. to enable the ASM/Cabinman to affect the change-over supply from the normal mode to the generator mode. A push-button control will also be provided in the ASM's cabin to enable the ASM to start/stop standby diesel generator whenever required.

(iv) On sections where automatic block is planned, S&T will lay a power cable all along the section with suitable feeding arrangements to suit local conditions.

(V) At station where telecom repeater stations are located, a 2 x 25 MM² aluminium cable will be laid from the CLS supply panel in the ASM's room to the repeater station to avail AT supply to work battery chargers and repeater equipments in the event of failure of local supply. Electrical Department will provide a change-over switch at the repeater station between AT supply and local supply. An emergency light point shall also be provided at Repeater stations by Electrical Department from the AT supply.
2. In the event of power block being given on both the OHE sub-sectors from which the signal supply is derived, electric traffic would necessarily have to be suspended on the line. During such periods, colour light signalling will not also be in operation. Such cases are likely to arise very rarely at any station and the duration of the block is not like to exceed one hour at a time. Therefore, no additional power supply arrangement need be made by the Electrical Department at wayside stations. However, to cater for this condition, portable stand-by sets should be kept by the S&T Department to be operated until 25 kV supply is restored. At large stations with considerable shunting movements, a stand-by diesel generator set may be installed by the S&T Department to meet emergencies, if considered essential.

111. PERMANENT WAY INSTALLATIONS

20714 Major Track Maintenance Works

1. An authorised OHE staff should invariably be present, when relaying work or any major work on track is carried out, in order to ensure the following points:

(i) Power block is correctly taken and permit to work is issued;

(ii) The structure bonds, track bonds, cross bonds, longitudinal rail bonds etc. are not disturbed and if disconnected for the work, they are reconnected properly when the work is completed.

(iii) The return feeder connections to the rails at the feeding posts are proper and not disturbed.

(iv) The setting distance of the structure is not affected during slewing.

(v) The track level is not raised beyond the permissible limits during the work;

(vi) Excavation or digging near a mast foundation is done in such a manner that the foundation is not exposed;

(vii) The clearance particularly at overline structure is maintained to the required standards;

(viii) Precautions for the safety of staff working under the OHE are taken correctly.

The Engineering officials in charge of such major work shall ensure that intimation to their counterparts for OHE maintenance work is given with adequate notice.

20715 New Sections to be Electrified

Engineering staff working in section being electrified should be specially trained and instructed in regard to working in electrified sections well in time (Para 20972).
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BREAKDOWNS

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CHAPTER VIII
BREAKDOWNS

1. GENERAL

20800 Knowledge of Rules
All Officers and Supervisors of the Traction Branch should be fully conversant with the "Rules for Reporting Accidents" and other instructions in force for dealing with accidents and breakdowns. The instructions given in the following paragraphs are to be treated as supplementary instructions applicable specifically to traction installations; they should not be taken as nullifying or contradicting the instructions contained in other official manuals.

Electrical accidents are dealt with in the Volume

20801 Types of Breakdowns
The types of break-downs pertaining to electric traction can be broadly divided into the following categories:-

1. Sub-stations and switching stations
2. Remote control equipment and cables
3. OHE feeder lines and transmission lines

20802 Breakdown Gangs
Accidents and breakdowns involving traction installations and electric rolling-stock should normally be attended to by-the maintenance gangs themselves. It is, however, essential that adequate number of experienced traction staff should be selected and housed in railway quarters close to traction installations, so that their services can be utilized at short notice for dealing with breakdowns and accidents whenever required.

In electrified suburban sections, however, 'breakdown gangs' of adequate strength may he located at selected points to deal promptly with OHE failures, particularly during the hours of peak traffic.

20803 Emergency Stores and Breakdown Equipment
1. For each OHE depot/sub-depot, the actual quantity of OHE stores like masts, conductors, insulators, fittings etc. which should be earmarked specially for use in breakdowns will be laid down by Sr. DEE (TrD). To start with, all materials required for 3 kilometres of single line may be kept. Based on experience, the minimum and maximum quantities may be, revised from time to time. An inventory of such OHE stores should be maintained by the supervisor-in-charge of the depot/sub-depot and stocks recouped periodically so as to ensure that the minimum quantity is always available. During periodic inspections by officers, scrutiny of this inventory should be one of the important items in order that the required stores are always made available.

2. OHE Inspection Cars, wiring trains, breakdown lorries and all break-down tools, tackles, straining screws, clamps, ladders etc. shall be maintained in good condition and kept ready for use at all times. Though it will be the primary responsibility of the supervisor in-charge of the OHE depot/sub-depot to ensure that all breakdown equipment is in good working order, supervisors and officers at all levels should specially check their condition during their periodical inspections. A periodic review should also be made regarding the adequacy of such spares and tools.
3. The CTFO (PSI) and CTFO (RC) should also have in their custody spares and tools pertaining to their work as per scale to be laid down by Sr. DEE (TrD) for dealing with breakdowns and accidents.

20804 Record of Staff Movements
TPC should, even when everything is normal, keep a continuous record of the movements of maintenance gangs so that he can contact the gangs immediately whenever required to attend to any emergency. All senior supervisors and officers of the Traction Distribution Branch should also keep the TPC informed of their movements. These Instructions also apply to off-duty hours for officers, senior supervisors and key personnel.

20805 Summoning of Emergency Staff
To enable the TPC to summon staff as required, a register showing the residential addresses of specified staff of the Traction Distribution branch, particularly those residing in railway quarters or close to railway stations, should be maintained station-wise by TPC. The list of office and residential telephone numbers of officers and supervisors should also be kept up-to-date by him for ready reference. In view of the importance of communication facilities in an emergency every telephone should be tested at least once a month.

11. SUB-STATION AND SWITCHING STATION BREAK-DOWNS

20806 Traction Transformer Breakdowns
Breakdown of any one traction transformer or associated circuit breaker at a traction sub-station (whether owned by the Supply Authority or the Railway) should not normally affect the working since 100% stand-by is available for the transformer at nearly all sub-stations.

20807 Central Repair Shop
Failure of traction transformers, requiring the lifting of core and winding are extremely rare. However, repair and overhaul facilities should be provided at a central point on each railway. At each Central Repair Shop, the following facilities are generally required (Reference may also be made to the Appendix VI to this Volume):

1. A crane bay with the railway line leading into it, so that the traction transformer may be brought in directly into it. The crane hook should be high enough to permit unloading of the transformer from the wagons and placing on the floor, and also for lifting the core out of the transformer tank.

2. Two underground transformer oil storage tanks, one for old oil and one for new oil. 3 A 2500 litre/hour, electrically driven oil purification plant with pumps and interconnecting pipes and valves to empty old oil from transformers, to fill new, purified oil into the transformers, to dry out the oil in the transformers etc., as required.

4. An enclosure with oil testing set to test dielectric strength of oil.

5. A small workshop with a few essential machines to carry out urgent repair work.

6. A test-room and laboratory fully equipped with testing equipment for carrying out repair, calibration and testing of all types of relays and instruments used on the traction system.

20808 Mobile Power Van
A mobile power van should also be provided on each railway which has to maintain traction transformers. On this the following equipment should be provided:

1. An engine-generator set rated to deliver 100 kVA at 415 ac 50 Hz, 3-phase 4-wiree along With necessary
oil storage tanks.
2. A 2500 litres/hour electrically driven oil purification Plant.
3. A small mobile, workshop to attend to urgent on-the-spot repair work, comprising a motor driven drilling machine, grinding machine, a power driven hacksaw, a welding machine and oxyacetylene flame cutting equipment.
4. Portable floodlights with trailing cables to light up accident sites to facilitate repair work.

The mobile van can be used for purifying transformer oil of traction transformers in situ when required, eliminating the need for bringing the transformers to the Central Repair Shop. At stations where no 3-phase, 415 V supply is available from a nearby source, the engine set is operated to meet the heater load of the oil purification plant and also to drive the motors. The mobile van would also be useful to flood-light an area such as when there is an extensive OHE breakdown.

20809 Breakdown of Circuit Breakers, Interruptors

If a circuit breaker or interrupter requires major repairs, it should be brought to the PSI maintenance depot after replacing it by a spare one.

20810 Rail and Road Access

Every traction sub-station should have all-weather road access in addition to rail access for transporting heavy equipment to and from the installations. For switching stations too, road access should be provided wherever possible. Suitable fittings and tackle should be available to move an Interrupter or circuit breaker from the PSI maintenance depot on a motor trolley or OHE Inspection Car and unload it by the side of any switching station and take it in. A suitable platform and a firm pathway leading to the gate should be available and maintained well.

111. BREAKDOWNS OF REMOTE, CONTROL EQUIPMENT

20811 Procedure for Manning Sub-Stations And Switching Stations

1. Whenever Remote Control working is not possible due to any fault on the P & T cable or in the remote control equipment concerned or failure of the battery etc. CTFO (RC) or TPC shall suspend remote control operation of the particular section or switching station concerned until the defect is rectified. During this period it is necessary to arrange for manning the switching stations by posting suitably qualified staff, who are authorized to carry out emergency switching operations manually as instructed by TPC. Such staff will be referred to as 'Operator' in the following paragraphs. To meet such emergencies, TPC shall maintain a register of authorized operators, who have been trained, examined and declared by AEE (TRD) as competent.

2. Whenever an operator is placed on duty at a switching post when the remote control equipment is not functioning due to any reason, the following instructions shall be adhered to:-

(a) Before taking over his duty, the Operator shall make himself conversant with the equipment he is required to operate and the rules that are laid down by the Administration for operation of the equipment.

(b) He shall carry out orders issued to him by TPC over the telephones observing the rules laid down for exchange of telephone messages.

(C) He shall maintain a log book showing the details of operations carried out by him in the order in which they were done, interruption to power supply, abnormal occurrences, defects in plant requiring attention, and other information if any. The log will be signed by both the relieving and relieved Operators at every change of shift as a token of having taken over and handed over all equipment correctly.
(d) The Operator shall be responsible for all the plant and equipment, spare parts, stores and furniture (at the sub-station or switching station) during his shift,

(e) Whenever a switching station is manned, the Operators shall work in accordance with the duty rosters exhibited. The regulation of the shifts shall be effected by TPC.

(f) The operator on shift duty is forbidden to leave the post station unless he is relieved by an authorised person. No interchange of duties or variation of duty hours is permitted without the prior permission of TPC and staff who are unable from any cause to take their shift shall at once notify

(g) Whenever an Operator is posted at a switching station or sub-station he shall always be accompanied by another person e.g., a Khalasi, who can use the telephone intelligently.

20812 Restoration of Remote Control

CTFO (RC) shall arrange for expeditious rectification of the defect and restoration of remote control. It is undesirable to continue any controlled post on local control for prolonged periods.

20813 Breakdown of Tele-Communication Between TPC and Sub-Stations, Switching Stations etc.

If the TPC circuit becomes defective for any reason, several alternative channels of telecommunication are available. Should the P & T cable itself break down all circuits through it may be in operative in such cases, essential messages may be passed through P & T telephones, Railway local telephones network, Railway wireless network or microwave network. Urgent messages from TPC to traction sub stations could also be passed through the operators of grid sub stations.

Close co-ordination should be maintained between the officials of the Traction Distribution Branch, S&T branch and DOT authorities to ensure quick restoration of normal communication facilities.

IV. OHE BREAKDOWNS

20814 Importance of Expeditious Repairs

Every breakdown of OHE, even if minor in nature, should be attended to urgently as it is generally interferes with traffic. Since electrified lines carry a high density of traffic, the effect on traffic will be quite severe if restoration is not arranged expeditiously.

20815 Types of OHE Breakdowns

The common types of OHE breakdowns are as under-
1. Uprooting of or damage to OHE masts on account of cyclone, derailments etc.,
2. Entanglement of pantographs with the OHE,
3. Snapping of OHE-conductors,
4. Flash-over or other damage to insulators,
5. Faults on account of stray wires etc.,
6. Theft of OHE conductors.

20816 Look-out for OHE Defects

The engine crew of all trains should keep a sharp look-out and report to the TPC from the nearest station any defects noticed by them in the OHE.
All break-downs or defects in OHE which are likely to affect the train services, noticed by any Railway servant, shall be reported immediately to TPC. If TPC cannot be contacted, the nearest Station Master or Cabin Assistant Station Master shall be advised. The SM/CASM to whom such breakdowns or defects are reported shall convey the information immediately to TPC through the control or other available telephone. The person reporting a breakdown to TPC should give as detailed Information as possible on the nature of the breakdown, its location, if masts have been uprooted or both lines in a double track section have been affected etc.

The person conveying the information to TPC should not leave the vicinity of the telephone without TPC's permission, as the latter may want to contact him again to elicit further information.

**20817 Action to be taken by TPC**

If required, TPC shall direct the nearest available Electrical Department official to proceed to site to obtain full details. Simultaneously the TPC should switch off power supply to the affected lines and inform the Section Controller.

Though initially power may have to be switched off over a whole sub-sector, the faulty elementary section should be identified and isolated as quickly as possible so that power supply may be restored to the healthy sections and normal train operation resumed.

Further, it should be possible in many cases to block the lines for electric locos and EMUs only, permitting movement of steam and diesel trains. It may also be possible to move electric locos and EMUs at restricted speed or to coast through the affected section with pantographs lowered if the damage is only slight. It is for TPC to decide after careful study of information available from the site and in consultation with traffic officials the extent of restriction to be imposed on, traffic.

**20818 Protective Steps**

1. On receipt of information about OHE break-down, the SM/Section Controller shall also take such steps as deemed necessary to regulate traffic on the affected lines and issue caution order where required. Single line working may be introduced, if feasible.

2. It is the duty of every railway servant who notices hanging OHE conductors to take immediate preventive steps to ensure that no person comes into contact with them treating such conductors as live until an authorized person from OHE section arrives at site and makes the OHE dead and earth it.

**20819 Breakdown Staff**

1. On receipt of the first report about the breakdown, TPC shall direct the nearest OHE maintenance gang to proceed to site immediately with available breakdown vehicles for dispatch of staff without waiting for full details of the breakdown.

2. A quick assessment should be made on the basis of information available and where necessary one or more gangs from both sides of the site may be asked to proceed to the site. If the accident spot cannot be reached by railway vehicles on account of the line being blocked by other trains, road vehicles equipped with emergency stores, tools and staff may be directed to the site. In suburban sections with large number of roads running along side the track, this method may help in tackling the repairs much more quickly.

3. If the OHE Inspection Car or wiring train is required to attend to the break-down, the Section Controller, on request from TPC shall arrange for quick passage of the OHE Inspection Car or wiring train to the site of the accident.

**20820 Officers and supervisors to Proceed to Site**

On receipt of information about an OHE breakdown the ATFO(OHE), CTFO(OHE),DEE/AEE(TrD) shall
Proceed by quickest available means to the scene of accident. The Sr. DEE/TRD should also proceed to the site if the circumstances of the case require his personal supervision and direction. In the event of a major break-down likely to result in interruption of traffic for more than 12 h, CEDE should also proceed to the site for supervising restoration.

20821 Assistance to be sought
1. It should be remembered that restoration of traffic in the event of accident or breakdown is the responsibility of the Division as a whole. The Electrical Department Officer in-charge of the restoration work should, wherever required, ask for assistance from the Engineering, Traffic or other Officers as necessary. He should also keep the DRM fully posted with arrangements made and the expected time of restoration.

2. When circumstances warrant, the assistance of OHE gangs of another contiguous Division may be sought for by contacting AEE/TRD or Sr.DEE/DEE/TRD of the Division concerned. The Officers who receive such requests from neighboring divisions should treat the matter as of utmost importance and render all possible assistance.

20822 Continuous Communication with TPC
The Officer or Supervisor in-charge of supervising repair work should maintain continuous communication with the TFIC from the site of breakdown. For this purpose an intelligent person should be posted to man the nearest emergency telephone socket continuously to transmit and receive messages as required. It is very important that the field staff remains on call all the time until normal service is restored, since no provision exists in the emergency telephone circuit for the TPC to ring up the emergency telephone stations at the site.

20823 Detailed Assessment by the First Supervisor/Officer Reaching Site
The first Supervisor or Officer of the Traction Branch reaching the site of the breakdown should make a quick assessment of the extent of damage and the time required for restoration. He will ascertain from TPC the details of break-down gangs and equipment directed to the site and if the circumstances warrant, ask for additional gangs and breakdown equipment to be sent to the site. On receipt of these details, TPC should arrange for additional gangs and equipment to be sent to the site expeditiously. In the meanwhile, isolation and repair works should be started at site.

Further details on the extent of damage and estimated time as obtained from the Supervisor/Officer at the site from time to time will be passed on from TPC to the Section Controller to enable him to review the arrangement for regulating the traffic initially made.

In the event of major breakdowns affecting main line traffic, Sr. DOM/DOM of the Division should personally take over regulation of traffic arrangements.

20824 Preservation of Evidence

When a pantograph gets entangled with the OHE, it is often very difficult to establish whether the damage originated from a faulty pantograph or a defect on the OHE.

The first Officer or Supervisor of the Electrical Department arriving at site of a breakdown particularly those involving entanglement of pantographs with the OHE, should make a very careful note of all relevant details pertaining to the breakdown and also prepare a sketch indicating the particulars. He will also arrange for preservation of such evidence as may be useful subsequently for investigating the cause of the breakdown.

Items to be checked on the pantograph and OHE are indicated in the Annexure 8.01 and 8.02.

20825 Safety Rules to be Observed
While speed is the essence of emergency working, rules prescribed for safe working shall never be infringed.
Repair work may commence only after an emergency power block has been obtained and all other precautions necessary for protection of the staff taken. On completion of the repair work, the power block may be cancelled according to the prescribed procedure.

20826 Temporary Repairs for Restoration of Traffic
In the first instance, repairs to the OHE should be kept to the barest minimum necessary for restoration of traffic with least possible delay. Work must proceed simultaneously at many points. After effecting temporary repairs, the Officer or Supervisor in-charge of the work should personally check the whole area and satisfy himself that the Installations are in order and safe. He may impose such speed restriction as necessary for movement of electric and other than electric trains till permanent repairs are carried out. Permanent repairs should be arranged and speed restrictions removed and normal operation restored at the earliest opportunity.

20827 Clearance of Line for Steam/Diesel Traction
If the breakdown is extensive and restoration of electric traction is unlikely in a short time even with temporary repairs, the line should be cleared for diesel/steam traction as soon as possible, so that traffic may be kept moving until repairs to the OHE are completed. After steam/diesel traction is introduced full precautions should be taken for protection of staff working at site.

20828 Wring Train
If the OHE has suffered extensive damage, the OHE wring train should be requisitioned to speed up the work.

The wiring train generally consists of a stores-cum-tool van, a workshop van, a staff and kitchen van, a reel wagon loaded with one drum of catenary wire and one drum of contact wire, wagon loaded with materials for temporary diversions, a BFR loaded with structures, a hand-operated crane to facilitate erection of masts, a power car with two diesel generator sets for supplying power to the workshop van and for lighting, two brake vans, an adequate quantity of OHE material and flood-lights with trailing cables. The vans have platforms with side-railings to facilitate working on the roof.

20829 Interference with OHE During Restoration
In clearing the line for traffic, breakdown staff are forbidden to disturb the OHE masts or to cut the OHE conductors except under the specific orders of Sr. DEE(TrD)/DEE(TrD). If it becomes necessary to slew the OHE conductors to facilitate crane working, this should be arranged to be done by the Electrical Department staff. It should be borne in mind that indiscriminate cutting of OHE conductors will necessitate Introduction of splices which are not conducive to good current collection. Also introduction of such splices is liable to delay restoration of normal electric services.

20830 Temporary Diversions
Sometimes with derailments and accidents occurring in electrified sections, temporary diversions have to be laid to clear the traffic with other than electric traction. A quick means of wiring such diversions so as to resume electric traction without waiting for the main line to be commissioned is described below.

The constructional details of the arrangement for such diversions on BG may be seen in Fig.8.01.

The portal type structures are made out of 80Ornm diameter GI pipes using two right angled 'T' joints. Guys are used in both perpendicular and parallel directions to the track so as to give extra safety against heavy wind load. The contact wire is suspended with the help of special fittings made of MS flats form the catenary wire stretched between the two uprights of the structure and insulated by two 9-tonne insulators as shown in the figure.

The 80 mm diameter GI pipes are placed in 150mm diameter MS pipes welded on to a 10mm thick 450mm X 450mm MS base plate which in turn is bolted by 10mm diameter through bolts to a 4880mm long crossing sleeper.
put under the rails. The weight of the rails keeps the crossing sleeper and thereby the structure in position. The void between the 80mm diameter and 150mm diameter pipes is wedged by wooden wedges and also filled up with sand and covered by bituminous compound so as to prevent rusting of the GI pipe due to the seepage of water through the sand. Since the whole structure is attached to the track as above, the chances of tilting or sinking of the structure with shrinkage or settlement of the temporary un-consolidated embankment are eliminated.
The contact wire is anchored at both ends at a height of 6 m on existing masts and 'fly guys' are provided from the anchor mast to the base of the next mast so that no separate foundation is necessary for anchoring and also the guy can be removed easily at the time of dismantling.

- The advantages of the above type of construction are as under

1. It is cheap.

2. The structures weigh less than 150 kg and 4 men can easily erect or dismantle them.

3. Since no foundations are required, time is not lost in excavation for foundation and consequently the structures can be erected quickly.

4. The equipment can be dismantled and erected at new sites quickly.

5. The traffic can move at the speed restriction imposed for the permanent way and no extra speed restriction on account of OHE is necessary.

6. The materials used for the work are easily obtainable the new fabrications required can easily be manufactured in workshops and stocked at depots for quick use in emergencies.

**20831 Funds Required for Dealing with Breakdowns**

Funds required for dealing with breakdowns may be obtained from station earnings in accordance with para 7 14 of the Indian Railways Permanent Way Manual reproduced below: -

(1) The Divisional/District Engineer or the Assistant Engineer on his behalf may draw upon the station earnings according to such instructions as prescribed by the Administration under note to para 1405G, for the following purposes:-

(a) Payment to daily labour employed at the site of breach or accident.

(b) Purchase of tools or materials required in connection with accidents which cannot be supplied in time by the Stores Department.

(C) To provide food to engineering labour at the site of breach or accident with the assistance of Station Masters or Inspectors of the Commercial Department.

The supply of food free of charge is permitted in special circumstances at the discretion of the Administration to facilitate expeditious restoration of traffic.

When food is supplied free at the site of an accident to engineering and other labour the expenditure per head per day shall not exceed the prescribed limit.

2. The Accounts Officer should be advised immediately by telegram of each sum taken from station earnings.

In all cases, Engineers obtaining advances from station earnings should, do so under a clear receipt. On the receipt, the object for which the money has been procured should be clearly stated.

A complete account should be submitted at the earliest possible date to the accounts department supported by pay sheets and vouchers.

3. All payments to labour should be witnessed by the Assistant Engineer at site.
20832 Log of Events and Reporting of Breakdowns

1. In all major break-downs TPC, senior officials and Officers concerned shall maintain a detailed log of events in their diaries noting the time and brief details which may help in fixing the responsibility for any avoidable delay in restoration.

2. The DRM should submit to CEE and COM a detailed report covering every major breakdown of OHE or other traction installations giving all essential information including:
   1. nature of break-downs and lines affected with detailed sketch;
   2. chronological account of action taken to effect repairs and restore traffic;
   3. repercussions on traffic and rough estimated cost for repairing the damage;
   4. cause of breakdown and staff responsible, if any;
   5. any other special features including an objective analysis of the time taken for repairs and restoration of traffic with a view to see if these could have been done more expeditiously and if so measures proposed to improve the performance in future.

20833 Protection of Staff

In addition to ensuring that work on OHE is commenced only after obtaining a power block as stated in para 20825 above, the supervisor in-charge shall take all measures for protection of staff and for exhibition of hand-signals as per GR and SR, particularly when the line under repair and the adjacent lines are not blocked for other traffic.

20834 Use of Cranes

Special care is necessary when steam or hand cranes are used at the site of break-downs. The movements of the cranes shall be carefully controlled by the person in-charge so as not to come within 2 m of live OHE, in addition to the usual precautions necessary to prevent infringement of adjacent tracks which have not been blocked for other traffic.

V. ROAD VEHICLES

20835 Use of Road Vehicles during Emergencies

Road vehicles like motor trucks and jeeps available with maintenance officials should be maintained in proper condition at all times, as they are liable to be called for use in attending to breakdowns or emergencies. The essential rules for operation of road vehicles are given in the following paras.

20836 Driver's Duties

1. No person shall drive a vehicle belonging to the railway unless he has a proper license and is duly authorized. No vehicle shall be driven on a public road unless the necessary tax has been paid to the Licensing Authority for the area as prescribed by the Motor Vehicles Act.

2. Every Driver of a vehicle shall familiarize himself and comply with the traffic laws prevailing in the area, where he operates. He shall be liable to disciplinary action for any willful violation thereof.

3. Before operating any vehicle the Driver shall make sure that it is in a proper operating condition as follows:
   (a) Test brakes, steering gear, clutch, horn and lights.
(b) See that the tyres are in good condition and properly inflated.
(c) Check emergency equipment e.g., first aid kit jack and tools.
(d) Ensure that requisite quantities of petrol, lubricating oil and water are available in the vehicle.

Drivers shall test the head and the tail lights before undertaking night driving. They shall not undertake driving until these are in order.

4. If any major defect is noticed during a journey, it shall be reported to the Electrical Foreman concerned immediately, and the vehicle shall not be operated until the defect has been set right.

5. Before filling the petrol tank the engine shall be shut off. The hose nozzle shall be kept in contact with the tank to avoid static sparks.

While filling petrol tanks of the vehicles, smoking and use of open flames shall not be permitted near the vehicle.

6. 'Left-hand-drive' vehicles shall have these words written and displayed conspicuously at the back.

7. All loaded trucks, carrying loads projecting beyond the rear end of the body shall carry red flags of approved type and size when driving during day-time and red lights placed at extreme ends of the loads or trailers at night.

8. Drivers shall not drive vehicles while in a drunken state.

20837 Operation of Road Vehicles

1. When loading or unloading vehicles, the emergency parking brakes shall be applied and the wheels blocked.

2. Equipment, materials and tools carried on vehicles shall be properly secured and arranged so as not to obstruct the view of the Driver or to interfere with his giving traffic signals.

3. The vehicle shall be operated within prescribed speed limits. The speed shall be reasonably reduced, where necessary, due to bad weather, poor visibility, heavy traffic and the conditions of the road and the Driver.

4. Drivers shall keep at a safe distance from vehicles in front. They shall not attempt to overtake any vehicle unless they can see far enough to be sure of passing safely and until the horn signal given for this purpose has been accepted by the Driver of the vehicle in front.

5. Drivers shall not attempt to pass other vehicles on curves, grades, street intersections or such other places where the view is not clear.

6. No motor vehicle shall be driven past school buses that are taking in or putting down children.

7. Drivers shall, at night, dim lights when meeting other vehicles. When blinded by glaring headlights they shall slow down and, if necessary, stop until the vehicle has crossed.

8. When fire department vehicles, ambulances or police patrols are heard or observed approaching from any direction, vehicles shall be stopped at a safe place until these vehicles have passed.

9. When proceeding down a grade the clutch shall not be disengaged. The engine shall be throttled.

10. When approaching railway crossings and road intersections, Drivers shall slow down speed and be prepared to stop.

11. On slippery roads, Drivers, shall operate at a much lower speed and keep a safe distance from vehicles in front to enable them to make a stop within safe limits, leaving the vehicle in gear and applying the brakes until speed has been retarded sufficiently to engage the clutch without danger of skidding.
12. Drivers shall anticipate the intentions of other Drivers and pedestrians and shall themselves give
clear signals of their intentions regarding stopping or turning. They shall make allowance for lack of
skill or improper attitude on the part of other Drivers, pedestrians, children and animals. They shall
not frighten or annoy them by hooting too frequently.

13. When moving a vehicle in reverse direction make sure that the rear is clear and free. Under poor
visibility or an hilly or congested roads, driver shall employ a signal-man.

14. Horns shall be used only when necessary. Use of horn just near the object is dangerous and
shall be avoided.

15. Doors, tall gates, or parts of load of a vehicle shall not be kept dangling when the vehicle is in
motion.

16. The number of persons riding with the Driver shall not exceed the number of seats actually
provided.

20838 Precautions when Transporting Heavy Materials

1. Drivers of trucks carrying heavy structures or long ladders equipped with booms shall not drive
with such equipment in an elevated or partially elevated position.
2. Proper precautions shall be taken at all times to prevent contact with overhead lines, trees or
structures.
3. In transporting material, particular care shall be exercised to see that material mall not shift or
fall from the vehicle.
4. Where poles or the long sections of material projecting beyond the vehicle are to be transported
along public roads, a red. flag in day-time or a red light at night shall be fastened to the end of the
projection.

20839 Transportation of Personnel

1. The number of employees carried in vehicles shall not exceed the prescribed limit and they shall
be provided with proper sitting arrangements.
2. Persons who are not employed in the railway shall not be allowed to use the vehicles unless
specifically permitted.
3. A person shall not put any part of his body outside the vehicles and shall not sit or stand on the
rung-board or other outside projections of the vehicle when in motion to avoid injury from other
vehicles.
4. Employees shall not enter or leave the vehicle when it is in motion.
5. Employees shall not ride on a load of poles or, other material carried on vehicles in a dangerous
way.
6. Vehicles fully loaded with personnel shall not be started or stopped suddenly with a jerk, except
under emergency conditions.

20840 Parking
1. Vehicles should be parked on the correct side close to kerb of the road so as not to interfere
with traffic. Vehicles shall not be parked on bridges, road curves, culverts and Intersections:

2. When parking on a grade, the vehicle shall be in gear, hand-brakes, applied wheels turned
towards the kerb. Bricks or stones shall be placed in the wheel path on the down grade side so that
the vehicle cannot accidentally roll down.

3. When parking along a highway at night, parking lights shall be left on, but dimmed. If any repair
work is to
be done, flares shall be set at opposite ends so as to be visible from a distance of at least 150m to warn other Drivers in advance.

4. When parking on the highway near another vehicle on the opposite side of the road, sufficient clearance shall be kept between the two vehicles.

5. Before leaving a parked vehicle, Drivers shall take with them the ignition key to prevent theft or unauthorized starting of the vehicle.

6. Before changing tyres or making any other repairs along a highway, the Drivers shall pull off the vehicle to the side of the road at a safe distance from the running traffic.

7. When leaving or entering a parked vehicle, kerb side doors alone shall be used. If the doors open on roadside, look back and make sure that no vehicle is approaching from the rear.

8. Before starting a parked vehicle, the Driver shall observe the front and the rear to ensure that there are no persons or objects in the way.

**20841 Maintenance of Road Vehicles**

1. Road vehicles are costly and should be driven carefully and maintained efficiently. The Foreman-in-charge shall inspect every vehicle under his control at least once a fortnight, and arrange to have the defects noticed rectified promptly.

2. Every emergency vehicle shall also be inspected by an AEE once a month and by the DEE once in six months and the observations made recorded in a register.

3. Each vehicle shall be equipped with an approved set of tools and first aid kit and the Driver shall be trained in their use.

4. A first aid blanket shall be carried on every truck and the Driver shall be trained to use it as an improvised stretcher.

5. When vehicles are jacked up for working underneath, sufficient number of wooden blocks shall be put below to protect men underneath, should the jack fail. Goggles shall be worn to prevent dust getting into eyes.

**20842 Procedure in Traffic Accidents**

1. Accidents which may appear trivial often result in claims for personal injury or damage to property. A Driver shall, therefore, always be courteous and helpful.

2. Drivers shall not get involved in an argument as to who was responsible for the accident but endeavor to get all the facts in the case.

3. The following instructions shall be observed by Drivers should an accident occur:

   (a) Stop the vehicle and pull over to the kerb if no other vehicle is involved. The vehicle should not be disturbed should there be a fatal accident, as police may make note of the evidence. Protect the rear and front so as to divert the traffic.

   (b) If any one is injured, render first aid; send for the Doctor and ambulance, if necessary. Render every assistance.

   (c) Do not leave the scene of accident without stopping to identify yourself.
(d) When requested, give your name and address and show your Driver's License to the other party.

(e) Secure name, address and license number of the other Driver, vehicle license number and names and addresses of the vehicle owner, witnesses and the insurance company.

(f) Unless some police officer is available at the scene of accident, notify police station having jurisdiction in the territory.

(g) Sketch the location showing position of vehicles or pedestrians involved and any special condition such as obstructions, parked cars, skid marks.

(h) Try to get the names and addresses of any eye witness and if possible get their statements.

(i) Record date, time of day, weather and road conditions and any other information which you may consider useful.

(j) Submit a detailed report to the superior.

Annexure 8.01

PANTO ENTANGLEMENTS : ITEMS TO BE CHECKED ON PANTOGRAPH

1) Check that the pantograph wearing strips are properly fastened with the panto pan and there are no loose fasteners or bent strip or deep grooves on the strips. Pantograph strip joints must be smooth so as not to hinder smooth gliding of the contact wire on the pan.

2) Check that the grease plate is properly fastened.

3) Check the bow plunger for free sliding while pressing. Check that the split pins are intact.

4) Check the horizontality of the pantograph pan and the vertical movement in force. Check the transverse flexibility of the pan by pulling transversely at the middle cross member with a force of 50 kgf. The displacement of the pan at the middle cross member should be 36 ± 5mm. Check that the positioning link is not bent/cracked or dislocated from the fixing pivots. Check that the split pins are intact.

![Diagram of Panto Type AM-12 and AM-18 with dimensions A, B, C, D]

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<th>B</th>
<th>C</th>
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<td>520</td>
<td>1800</td>
<td>300</td>
<td>380</td>
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FIG. 8.02

INDIAN RAILWAYS — AC TRACTION MANUAL - VOLUME II PART I
5) Check the pantograph frame for signs of bending or cracks. Check the springs for any cracks

(6) if possible, take the measurement of the pan as per the Fig. 8.02.

(7) Check the broken or cracked fittings of the pantograph and see whether the cracks are old or fresh.

II. Annexure 8.02

PROFORMA FOR RECORDING MEASUREMENT/OBSERVATION IN RESPECT OF OHE IN CASE OF PANTO ENTANGLEMENT.

1. Location
2. Height of contact wire of main line above R.L.
3. Height of contact wire of turn-out/cross-over above R.L.
4. Stagger of contact wire of main line,
5. Stagger of contact wire of turn-out/cross-over.
6. Length of steady arm holding main line contact wire.
7. Length of steady arm holding turn-out/crossover contact wire.
8. Position of Registration tube and register arm dropper clip.
9. Track separation at obligatory point.
10. Position at which horn of pantograph jumped above contact wire.
11. Vertical height of steady arm clamp from register arm.
12. Hitting marks on the steady/Registration arm tube, P.G. clamps droppers, contact wire, dropper clip, splices, jumpers, if any.
13. Condition of cracked or broken OHE fittings such as clamps, splices and clips etc. Check whether the cracks are fresh or old.
14. Check free vertical movement of the steady arm.

Above observations will be made on every mast within at least 500 m in the rear of the location of entanglement.
CHAPTER IX

PREPARATION FOR COMMISSIONING

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CHAPTER IX
PREPARATION FOR COMMISSIONING

20900 Introduction

Prior to commissioning new Railway Electrification schemes, detailed preparation work is a necessary pre-requisite. While instructions are issued separately in technical manuals of various equipments, salient points in respect of the following major heads are outlined in this chapter.

I  Traction sub-stations
II  Transmission lines and 25 kV feeders
III  Protective equipment
IV  Switching Stations
V  Remote Control equipment
VI  Overhead equipment
VII  General

This chapter is devoted to the technical aspects of work which call for attention during inspections, tests and trials before energization. Chapter X deals with procedures in connection with energization and commissioning and putting the assets into beneficial use.

20901 Reference to Rules and Statutory Rules

The safety of travelling public, railway staff and property shall be ensured by strict compliance with the rules laid down in.

i) Indian Electricity Act 1910 (latest revision),

ii) Indian Electricity Rules (latest edition),

iii) Indian Railway Act (as amended from time to time),

iv) General Rules for Indian Railways and associated Subsidiary Rules prescribed by Zonal Railways,

v) Indian Railways’ Schedule of Dimensions,

vi) The Rules for Opening of a Railway or Section of a Railway for Public Carriage of Passengers, 1935 (as amended from time to time),

vii) Bonding and Earthing Code, Code for Earthing for Traction Installations and Regulations for Power line Crossings,

viii) Relevant IS or IRS specifications and code of practices for various equipment.
During the preparations for commissioning, the provisions of all these rules shall be kept in view.

Wherever extracts and Appendix etc., of the rules have been included from these rules in the ACTM, the figures and contents would automatically get amended with dates of amendments.

Methods/procedures indicated in the manual are only for guidance and may be modified as per latest methods/standards prescribed by RDSO/approved by CEE.

**20902 Pre-Commissioning Inspections**

1 Pre-commissioning inspections and tests cover two distinct parts, viz.

a) Detailed inspection at the level of the ACE and Senior Subordinates, and

b) General inspection at the level of the Divisional Officers.

These two inspections are primary Inspections covering all the Installations and are independent of any inspections which may be carried out by Administrative officers.

2. Officers and staff of various sections (Departments) in the Division should associate themselves with the field work during construction, acquaint themselves with the Installations, satisfy themselves about high standards and quality of work and get the defects noticed rectified then and there, while work is in progress.

3. The departmental agencies executing the work in the construction organization shall also keep constant liaison with their counterparts on the open line, who will be responsible for the maintenance of assets created by the construction unit.

**20903 Defect and Deficiency Lists**

When the work is declared as having been completed and ready for Inspection, the field officers and Senior subordinates of the open line, along with their counterparts of the construction unit and representative of contractors, if any, will carry out joint checks. The checks should be thorough and cover every part of the Installation. In making these checks the latest drawings should only be used (superseded versions can be misleading and should be positively avoided).

All defects noticed during such joint checks should be rectified before the sections are taken over by the open line maintenance organization. The defects will be categorized in three types and jointly signed lists be prepared accordingly:

Category A - Defects concerning vital safety items and serious shortcomings, which must be rectified before even test charge.

Category B - Defects, not affecting safety though their rectification before commissioning is essential for trouble free working of electric train service.

Category C – Minor defects, which need not hold up commissioning and can be rectified after commissioning in a reasonable time.

During the preparatory period, these lists should be constantly reviewed jointly and progress of rectification to be done by construction organization be watched.
1. **TRACTION SUB-STATIONS**

20904 **Planning of Power Supply**

1. Sub-stations play a vital role in electric traction and, therefore, the need for considerable care during erection and commissioning cannot be over-emphasized. A high standard of workmanship is essential and the pre-commissioning tests should be systematically carried out by competent staff, using dependable and calibrated instruments.

2. When a long stretch of section of the railway is sanctioned for electrification, detailed planning of section by section energizing be undertaken and commissioning for commercial operation of electric traction over appropriate sections with partial change of traction be decided. Keeping in view the fact that 100% traffic cannot be switched over till a viable section of the Railway is completed, the order in which the sub-stations should be brought on line should be decided by CEE in consultation with RE and operating branch. This decision should take into account the reliability of supply for the energized section, the tariff structure and the commitments in regard to contract demand and minimum guarantee to supply authorities.

3. The supply authorities may then be advised the dates by which power supply will be needed at the various sub-stations. Agreements may be entered into at appropriate time to make sure that the supply authorities do not delay the work on their part and have adequate time to complete the construction of their works for connecting the substation to the grid.

4. The phasing diagram, deciding which phases of SEB's transmission lines will be connected at different sub-stations should be finalized in consultation with supply authorities for the entire section of the Zonal Railway planned for electrification, keeping in view power supply on adjacent railway systems. The connection of the substations to the transmission lines should be in cyclic order so that the load due to electric traction on the grid system is well balanced and remain within the permissible limits of unbalance.

5. The power supply to traction substation is connected through transmission line, which often cross the track. The application for the 'Track Crossing' should therefore be processed well in advance through Sr. DEE (G), to avoid delays in the supply connection.

20905 **Commissioning of Traction Transformers**

During the preparation for commissioning of transformers at traction sub-stations In addition to manufacturer's instructions, the following steps shall be taken:

i) Drying out of transformer shall be undertaken as per the procedure laid down. (Refer para 20208)

ii) Tap-changing mechanism shall be checked for being in perfect operating condition, both electrically and mechanically. Ratio test should also be done in this procedure. (Refer para 20206)

iii) Transformer bushings should be paid special attention to ensure that the manufacturer seal is intact and the bushings are in excellent condition. The Insulation Resistance of the bushing should be around 10,000 Meg Ohm.

iv) All gaskets should be properly compressed and tight fitted. No leakage of oil should be visible from valves, pipe joints, gauge glass, radiators or any other parts of transformer. The welded joints should also be checked for for seepage if any.

V) For a sub-station with more than one transformer, they should preferably be identical. The polarity on both should be checked.

Vi) The oil filled in transformer should be fully de-aerated to avoid false operation of Buchholz relay.
vii) The Buchholz relay should be erected as per instructions of the makers and tested for correct operation.

vii) All accessories like silica gel breather vent pipe, explosion vent diaphragm, circulating oil pump and special cooling equipment, if any should be checked.

ix) In addition to Buchholz relay, (Refer para 20214) other protective devices provided for the protection of transformer (Refer para 20212, 20213) should be examined and checked carefully and tested after erection at site.

Y.) Earthing of transformers and its neutral terminal shall be done in accordance with the "Code of Practice for Earthing of Power Supply Installations" (Appendix 111).

20906 Precautions During Commissioning of Traction Transformer

While working on traction transformers, the following special precautions should be taken by all the staff:

1. It is very important that any one working on a transformer with any of its covers open should remove all loose articles from his clothing such as pens, pencils, watches, money, smoking articles, tools particularly if they are oily, as they are liable to slip and fall into the transformer in the course of work. The number of men working on top should be restricted to the minimum. If tools have to be used they should be fastened by lengths of strings to the workers' wrists or to the tank rim.

2. Moisture lowers the dielectric strength of oil, and hence every possible precaution should be taken to prevent its entry. Sweat on hands and face should be wiped off frequently by a dry cloth and tools should be kept clean and dry, especially when coming in contact with oil. Another source of entry of moisture into the tank is by condensation. If at transformer is at a lower temperature than its surroundings, condense will form on the exposed surfaces. Transformer should, therefore, be at or above the ambient temperature before being opened for work at any time.

If any cleaning or wiping is necessary, this should be done with clean, dry oil using soft, non-fluffy cloth, and never by using cotton waste.

20907 Tests on Transformer Windings

(i) Insulation resistance readings should be recorded with a 2500 V or 5000 V megger. The following are the minimum permitted values at an ambient temperature of 30 degree centigrade. Temperature has a material influence on insulation resistance, and therefore the test should not be conducted when oil is hot.

2000 Mega Ohm between EHV winding and earth.
400 Mega Ohm between 25 kV winding and earth.
2500 Meg Ohm between EHV and 25 kV windings.

ii) Test on insulation: The test consists of applying dc high voltage (2500 V or 5000 M, with the help of a megger, continuously between winding and earth, and noting the insulation resistance at the end of 10 sec, 60 sec and 600 sec. To maintain constant voltage, a motor-driven megger is preferable. The polarization ratios R60/R10 and R600/R60 should not be less than 1.4 and 1.2 respectively. (R10, R60, R600 are the Insulation Resistance values after 10 sec, 60 sec and 600 sec respectively).

iii) Phasing out test: This is comparatively easy, as single phase transformers alone are provided at traction sub station: if both the transformers install at a sub station are of identical manufacture the terminal connections will be identical. Nevertheless, the correctness of polarity should be checked applying 400 V across the primaries in an identical manner and measuring the relative voltage between the two secondaries of transformers after connecting one terminal of one secondary with the corresponding terminal of the other.
iv) oil test: The tests on transformer oil should be done in accordance with IS-1866 for oil in use (See Annexure 2.03 Chapter 11).

20908 Circuit Breakers and Interruptors
The installation of circuit breakers and interruptors should be carefully done as per Instruction Manual of makers. The following special checks may be made.

Check, first of all, if the circuit breaker mounting is quite vertical and the base firmly secured. Examine the operating mechanism in the weatherproof housing for cleanliness, free movement of rollers, bearings and sliding surfaces, which should be very lightly oiled. Open and close the breaker several times to check that everything is working smoothly. Make sure that all pins, locking plates and split-pins are in place.

On the electrical side, examine the condition of the wiring, its insulation resistance and tightness of the terminal screws. Check if the opening and closing solenoid or motor when electrically operated does operate satisfactorily with battery voltage 20 per cent less and 10 per cent more than the rated voltage. Check also the manual operation and record the operating time for closing and opening. Examine whether the heater in the equipment cabinet is in working order. Observe if the auxiliary contacts are clean and good and the terminal block well secured.

Select a few circuit breakers at random to inspect the Interior of the arc-extinction chamber to make sure that the main circuit breaker contacts are in excellent condition and their alignment good, but taking care not to contaminate the parts. The parts handled should be washed thoroughly well with good transformer oil and put back and oil level restored.

Check and record the dielectric strength of oil in every circuit breaker, taking out the oil through the sampling cock. If the breakdown voltage (BDM) is less than 40 kV, oil will have to be dried out. This is easily done by a small portable oil purifier having a capacity of 200 liters per hour. After drying-out, repeat the BDV test, taking the precautions described in Chapter 11.

Examine particularly if there is any strain on the circuit breaker porcelain housing because of misalignment or rigidity of the connection from its terminals to the busbars. Usually this is made through flexible connectors; nevertheless, it is wise to check the position of the connecting leads when the bolts are loosened. Make sure also that the metal-to-metal contact is perfect at the terminal connections. Any imperfection here will result in overheating of the terminal which may even lead to eventual fracture of the housing itself. It is best to measure the contact resistance by "Doctor" or similar low-resistance-reading instrument.

Finally, check the general condition of the equipment, finish and weather-proof-ness of the cabinet and whether it is Insect-proof, whether fuses are intact, and if the operation counter, where provided, works properly and if the metal supports and frame are well earthed.

20909 Isolators
Examine the insulators carefully for any surface cracks and make sure if the surface is clean. Check operation of isolator manually to see if the movement is free and smooth, and if the switch blades are fully open or fully closed when the handle is locked at the top or bottom position. Examine the contacts and cheek if the spring pressure is adequate and blades make full contact. Check terminal connections, preferably a "Doctor". Examine whether the interlocking between the circuit breaker and its associated Isolator functions properly and the isolator frame is solidly connected to earth by two independent connections. For interlocking scheme for EHV and 25 kV CBs & isolators, reference may be made to RDSO Drawing(ETI/PSI/5212).

20910 Current and Potential Transformers
Check and record the insulation resistance of primary and secondary to earth and between primary and secondary. Check oil level in PT if it is not of the sealed type as also its dielectric strength. Top up the oil drawn for test. Make
sure that the terminal connections are well made preferably recording the contact resistance of CT connections by a "Ductor". The frames of the PT and CT should be well earthed by two independent connections to earth.

20911 Lightning Arrestors
Make a thorough visual examination of the outer porcelain housing for hair-line cracks and chipped sheds. Clean the outer surface of all dust. The connecting leads to the arrester should be solid and direct. The earth terminal of the lightning arrester should be connected to the general earthing main at the substation, to the transformer tank body and finally to an independent earth electrode provided very close to the arrester.

20912 Shielding and Earthing
Check whether the whole of the sub-station area is well protected against atmospheric surges by screening conductors strung between substation structures and solidly connected to the earth system in accordance with the approved drawing.

Check visually whether the metallic casing of every sub-station equipment and the neutral terminals of the power – transformers are solidly connected to the sub-station earthing grid, and confirm that the "Code for Earthing Power Supply Installations" Appendix 111 is complied with in all respects.

20913 Busbars and Insulators
A careful inspection should be, made of every insulator supporting a busbar to detect any minute cracks on the surface; paint marks or dust should be removed and the surface gloss restored.

Time spent in checking the current carrying joints on busbars and terminal connections will pay ample dividends. The contact surface should be clean, smooth and without any irregularities and burrs, so that when they are tightened the area of contact is large. The pressure should also be adequate. Particular care should be taken when joints are made between two dissimilar metals like aluminium and copper. Special bimetallic fittings should be used in such cases to prevent electrolytic corrosion. Connections should be such as to produce no strain on the equipment.

20914 Clearances

The minimum clearances in mm in air for live equipment shall be as under

<table>
<thead>
<tr>
<th></th>
<th>25 KV</th>
<th>66kV</th>
<th>100kV</th>
<th>132kV</th>
<th>220kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Between phases</td>
<td>-</td>
<td>630</td>
<td>900</td>
<td>1300</td>
<td>2400</td>
</tr>
<tr>
<td>2. Between one phase and earth for rigid connection.</td>
<td>500</td>
<td>630</td>
<td>900</td>
<td>1300</td>
<td>2100</td>
</tr>
<tr>
<td>3. Between any points where man may be required to stand to the nearest (a) unsecured conductor in air (mm)</td>
<td>3000</td>
<td>3500</td>
<td>3500</td>
<td>4000</td>
<td>5000</td>
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<tr>
<td>(b) secured condition in air (mm)</td>
<td>2000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>4. Min. height of busbar</td>
<td>3800</td>
<td>4600</td>
<td>4600</td>
<td>4600</td>
<td>5500</td>
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20915 Auxiliary Power Supply for Traction Substations & Control Room

Whenever possible, a 3 phase, 415 / 240 V, 50 Hz supply up to 100 kVA is obtained to meet the power demands for erection and commissioning of the substation. The LT control board should also have matching capacity. An
auxiliary transformer of 100 kVA, 1-phase 25 kV / 240 V is provided to cater to the substation and control load. The station transformer should also be subjected to detailed inspection and check as for the main transformer. The control room building shall be neat, well ventilated and provided with a strong door. The control panel should have sufficient space all round to provide working space to carry out the necessary tests.

20916 Batteries & Battery Charger
The Battery room should be particularly well ventilated, protected, dust-free and dry. The battery room floor and walls upto a height of 2 m should be painted with anti-sulphuric acid paint. The batteries themselves should be well supported on teakwood stands, painted with anti-sulphuric acid paint and resting on porcelain insulators to prevent leakage. Examine the log book for the period during which the battery was given its first charge and make sure that the manufacturer's instructions have been adhered to as regards the rate of charge and the number of charge and discharge cycles. Make sure there is no possibility of the battery gases reaching the equipment room. Observe the condition of the battery plates “take specific gravity of all the cells and voltage across each cell on load. Check if all the inter-cell connectors are tight and well vaseline. Check finally if the battery fuses are of the correct capacity and there is no possibility of battery supply failure. Make sure that the alarm bell goes off if the supply is interrupted for any reason to the control panels.

The battery charger should be inspected to make sure that its capacity for normal and boost charge as well as trickle charge is sufficient and that it complies with the technical specifications, that the meters provided are indicating properly and it is complete with necessary fuses and indicating lamps. The metal easing should have two independent earths.

20917 General
Inspect the substation area to make sure that it has good drainage, that it has good all-weather road as well as rail access, that the whole area is well fenced-in with lockable gates wide enough to permit entry of a motor truck. Ensure that baffle wall in between traction power transformer and suitable oil drainage arrangement with an oil soak pit has been made in accordance with IE Rule 64 (2). The numbering of transformers, isolators, circuit breakers, Incoming transmission lines and outgoing 25 kV feeder lines should be checked to see if it has been correctly done, and does correspond with the numbering scheme on the control panels at the sub-station control room, and also on the mimic diagram board at the RCC. Fire extinguishers and fire-buckets filled with sand shall be kept ready at hand. Station name-board, Danger and Caution boards, Protected Area board etc. shall be well displayed.

20918 General Inspection of Substations and Commissioning
After defects observed during detailed inspection have all been rectified, the Sr. DEE (TrD) of the open line and the Dy. CEE(PSI) of RE organization shall carry out a general inspection of every part of the sub-station along With the Contractors' representative. Considering that these are high voltage installations, the inspection should be thorough. As many spot checks as possible should be conducted to ascertain the condition of the equipment and the care taken during erection. Particular attention should be paid to the safety aspects like clearances, operation of protective relays and functioning of the trip circuits and earthing. The statutory regulations such as the Indian Electricity Act and Rules should be strictly complied with and the inspecting officers shall each personally satisfy himself by tests and measurements that the installations are fit in every way to be energized and then issue a joint certificate to that effect.

An application should thereafter be submitted to the CEE and the Electrical Inspector to the Railway seeking his permission, for the commissioning of the sub-station, provided power supply will be made available by the supply authority and testing of protective relays has been completed. After his sanction is received and the precautions and procedures detailed in Chapter X are complied with the substation may be commissioned. For the first three days after commissioning, the substation equipment shall be kept under careful observation by a senior and experienced supervisory official. Thereafter daily inspection should be continued for the first fortnight.
Immediately after energization the correct operation of every protective relay shall be checked. The substation should be taken over on RC.

11. EHV TRANSMISSION LINES AND 25 kV FEEDERS LINES

20919 Detailed Inspection of Transmission Lines

As soon as a section of transmission line between two substations is declared by the Contractor as ready for inspection, detailed inspection shall be carried out by the ACE (TrD) and his staff together with their counterparts on the construction organization and contractors’ representatives and a joint note prepared of the observation made and tests conducted. Any defects, whether major or minor, shall be arranged to be rectified immediately so that there may be no delay in energizing the transmission lines.

20920 Compliance with Rules and Approved

The work shall strictly comply with Indian Electricity Act and Indian Electricity Rules, the Contract Specifications and approved including sag-tension charts, particularly in respect to clearances between ground (and other structures) to live conductors.

20921 Visual Inspection

This will cover every mast location and crossing across railway tracks, roads etc., special attention being paid to workmanship, completeness of installations and cleanliness of insulators. The tightness of bolts and nuts in structural steel work and fittings shall be checked. If galvanizing of steelwork has been damaged anywhere, the part affected shall be properly protected by painting with cold galvanizing paint to the satisfaction of the railway. Muffing for each of the tower footings should be checked to make sure that it extends from well below the ground level to at least 380 mm above the ground in irrigated fields, 230 mm above ground level in dry location and 150 mm above the maximum water level in water-logged areas.

Joints in transmission line conductors shall be not less than 15 m from the tower. There shall be no joints in tension lengths of less than 3 spans, nor any in spans over rivers, railway tracks or roads. A few jumper connections between line conductors shall be opened at random to check whether the contact surfaces are good and joint compound has been applied. At the same time, the tightness of all PG clamps should be checked.

20922 Clearances and Sag

The minimum clearances shall be in accordance with 1. E. Rules and Indian Standards. In case of 132 kV lines under maximum temperature condition, in still air, the minimum clearances are indicated below.

1. Open route 6.1m
2. At all roads and accessible places 6.1m
3. Between nearest live conductor and any part of any fences, wall, building or other structure on which a man may stand, or against which a ladder may be placed 4.6m
4. Between the nearest live conductor and the Earth 6.1m
5. Between the nearest live conductor and any tree or hedge in the vicinity 6.1m
6. Minimum spacing between conductors

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<tbody>
<tr>
<td>Vertical</td>
<td>3.9 m</td>
</tr>
<tr>
<td>Horizontal</td>
<td>6.8 m</td>
</tr>
</tbody>
</table>

The minimum clearance between live parts and earthed tower or cross arm members for 132 KV shall be

1. Single Suspension strings 1370mm
   in still air and when deflected by wind by 30 degree from the vertical.

2. Single Suspension strings 1070mm
   in still air and when deflected by wind by 60 degree from the vertical.

3. Strain strings at strain towers 1530mm

4. Jumper connections at strain towers when deflected by wind upto 10 degree from the vertical.

The height of the lowest part of conductor shall be checked and recorded -

1. At mid-spans at typical locations on the open route.
2. Above railway tracks, roads building and public places

Minimum clearance of live parts shall be checked for each of tower at typical locations and recorded. Sag of the earth wires and conductors shall also be checked at selected spans and recorded.

20923 Earthing

Every tower is individually earthed by connecting one of its legs to one or more earth electrodes near by, through a galvanized steel flat 40 mm x 6 mm so that the earth resistance is not more than 10 Ohm before the overhead earth conductor is bonded to the structure. Examine whether the steel flat is properly bolted to the stub-angle iron and well protected below the ground up to the earth electrode.

20924 Insulators and Insulation Resistance

Suspension and strain insulators shall be inspected as closely as possible for any chippings or cracks, for cleanliness, and preface of arcing horns at the line end of each suspension string above the conductor, at both ends of each tension string, and at both ends of each insulator string up to a distance of 1.6 km from the sub-station.

The number of 255 mm dia porcelain discs shall normally be 9 for suspension strings and 10 for tension strings for 132 kV supply. To provide graded insulation, the number of discs will be reduced by one, namely 8 for suspension string and 9 for tension strings up to a distance of 1.6 km from the sub-station.

Duplicate suspension/tension strings shall be provided for all road crossings. For railway crossings, anchor type towers shall be provided on the two sides with duplicate tension insulators, the whole crossing, being in conformity with the ‘Regulations for Power Line Crossing of Railway Tracks’ (Appendix iv)

Insulation resistance for each power conductor shall be measured and recorded from sub-station to sub-station, using a 2500 V or 5000 V megger. It shall be not less than 100 Meg Ohm.
20925 Continuity Test
Continuity of each conductor shall be measured from, substation. To substation using a megger
continuity tester and the results recorded.-

20926 Accessories
During detailed inspection, it should be verified whether every tower is fitted with an: anticlimbing
enamelled number plates. In addition circular enamelled discs coloured red, yellow and blue are to
be provided, on terminal towers to indicate the phases. Danger boards should also exist on the
transmission line towers where they are near roads or other public places.

20927 General Inspection and Energization
After defects noticed during detailed inspection are rectified, Sr. DEE/DEE(TrD) of the open line
together with his counterpart on the construction organization and Contractors' representative shall
carry out general Inspection to make sure that the Installation is in good order. During this
inspection, the inspection party will carry out as many spot checks as possible to confirm that the
detailed inspection has been properly carried out earlier. On the basis of their personal
observations, a joint certificate will be issued by the inspecting officers and contractors' 
representative, confirming that the installation is fit in every respect for energization.

Wide publicity should be given to warn the public that the lines will be energized and of the
accompanying danger to any trespassers. After getting sanctioned of the CEE and Electrical
Inspector to the Railway, and clearance certificate from all concerned in a manner similar to the
procedure for energizing OHE described in chapter X, the transmission line may be energized
provided the sub-station and the connected protective gear have already been tested and
commissioned.

20928 25 kV Feeders
Detailed and general inspection of 25 kV feeder lines should be carried out on the same lines as
described for the transmission lines and the OHE. Here too, each tower is individually earthed by a
separate electrode, in addition to being connected together through the overhead earthing
conductor. The, clearances to, road and rail crossings should be checked with respect to approved
plans, duplicate insulators being provided in each case. No earthed structure, other than the earthed
supporting structure of the 25 kV feeder lines shall be nearest than 2 m from the live OHE.
Tower footing resistance, insulation resistance of both phase and return conductors and through
continuity should all be checked and recorded. If the substation is already energized, the 25 kV
feeder; lines can also be energized on lines similar to procedure described for the transmission lines
and the OHE after taking all precautions for safety of equipment and staff working on contiguous
sections.

111. PROTECTIVE EQUIPMENT
20929 Testing of Protective Relays
Before any traction installation is commissioned, the proper operating of every protective-relay
should be ensured so that it can be fully dependent upon in all circumstances. This is done in three
stages –
-Checking the relay in the laboratory prior to installation.
-Checking after installation and before the substation is commissioned.
-Confirmatory test after energization and before introduction of commercial services.

In carrying out the tests, the Manufacturers' instruction manuals should be studied. The
commissioning engineer should be well acquainted with the principles of operation, constructional
features and the traction load conditions.
so that the relays may be correctly set.

20930 Inspection of Setting of Relays and Calibration of Meters

Protective relays are usually received well packed in separate cases. After opening the case, the relay should be carefully removed, examined for any external damage and taken into the Relay Testing Laboratory. Before removing the cover, remove all traces of dust from the case and the cover. Check the name-plate particulars to see if they are correct. Check carefully the delicate relay movement and make sure if it is quite free mechanically, and all parts are clean and connections tight, taking care not to disturb the settings. See whether the flag operating and reset mechanism is functioning well. Examine the cleanliness and wipe of contacts.

The performance of the relay for different settings should then be checked using standard relay testing equipment, making such adjustments as may be found necessary. A detailed record of the test set up and the calibration curves should be entered in a register as a permanent record. The plug settings are then correctly made to cater for the expected load conditions.

Where relays have both current and potential coils, as in directional and MHO relays particular check should be made to see whether the internal connections of the two sets of coils are correct. If the polarity of one with respect to the other is not right, the relay will fail to operate on a fault, which should, of course, never be permitted to occur.

If everything is alright, the relay cover may be put back, after checking the interior once again and wiping all dust on the cover. It is recommended that the date of calibration should be painted on the case for ready reference. A test certificate should be issued to the field officer for record.

Simultaneously, maximum demand and energy meters should also be got calibrated and sealed in consultation with the Supply Authority.

20931 Protective Devices at Sub-stations

The following protective and indicating devices are provided for each traction transformer:

1. Differential protection
2. Restricted earth fault protection on EHV and 25 kV sides.
3. Buchholz relay with alarm and trip contacts.
4. Winding temperature protection with alarm and trip contacts.
5. Oil temperature protection with alarm and trip contacts.
6. Protection against low oil level.

In addition, a low oil level indicator is provided on the conservator tank. Local Indicators are provided on the transformer tank for excessive oil and winding temperatures, whereas a common indication only is provided on the control panel at the RCC for excessive winding and oil temperatures as well as Buchholz relay.

The following further protective relays are provided for each feeder circuit breakers:

1. Over-current relay for faults close to the substation
2. MHO relay for distance protection.
3. MHO relay for wrong coupling between two substations.

Proper functioning of each of these relays and the contact mechanism of each should be checked individually. At the same time, the correct operation of the following annunciations and the associated cancelling buttons and flag indications should also be checked:

1. EHV transformer circuit breaker auto-trip.
2. Buchholz alarm
3. Buchholz trip
4. Winding temperature alarm
5. Winding temperature trip
6. Oil temperature alarm
7. Oil temperature trip
8. Low oil trip
9. 25 KV transformer circuit breaker trip.
10. 25 kV feeder circuit breaker trip
11. Transformer circuit breaker inter-trip
12. 230 V ac failure
13. 110 V dc low voltage
14. 24 V dc low voltage

Check should be made of all indicating instruments on the control panel to see if the movements are free and the readings are correct. Test plugs where provided for checking relay operation should be examined if they fit properly. Indicating lamps should be functioning properly, but a switch should be provided to cut them out when the station is unattended.

Check should also be made for proper functioning of device provided for tripping CBs in the event of 110 V dc supply failure.

### 20932 Control Circuits and Wiring

After installation of all equipment and completion of control cable connections, a detailed check of the wiring should be conducted. verifying the colour, code and identification tags and markings on the terminal strips on the equipment and the control panels with respect to the approved wiring diagram. Insulation and continuity tests should also be taken and values recorded.

A word of caution is necessary here. The detailed diagrams of control circuit and wiring, of control panel supplied by the Manufacturers should not merely be taken on trust, but subjected to careful scrutiny as to their correctness. Errors do occur in drawings and if they are not detected at the very early stage Itself, they may cause a great deal of confusion and trouble later. The best method of detecting errors in detailed wiring diagram is to prepare a simplified schematic or functional diagram so that the circuit arrangements becomes quite clear and obvious. It will then be known what exactly to do for any test, what links to close or open and what connections to make or break. To restore the connections back to normal after the tests have been successfully completed, a detailed diary should be kept of every change or alteration made for purpose of test. If any modifications are required to correct the errors discovered, the Manufacturer should be advised immediately and his confirmation obtained. When the work is completed, overall operation may be checked by manually closing the relay contacts and finding out whether the appropriate device has operated or not.

### 20933 Fuses

Control circuit fuses shall be of correct rating. If the-trip battery circuit fuse is under-rated, it is liable to deteriorate due to excessive heating and fail ultimately, which could indeed be dangerous. To guard against this possibility, alarms are sometimes provided to draw the attention of the operator in the event of fuse failure. In ac traction, failure of battery fuse is automatically relayed to the RCC but the TPC cannot replace the fuse by RC, someone has to go and replace it which may take considerable time. In view of this, fuses in the control circuit may err by being slightly over-sized. but should never be under-sized. For the same reason all connections in the trip circuit should be well made and the fixing screws kept tight, but not over-tight which may cause excessive pinching of the connecting lead and may eventually cause a breakage.

### 20934 Insulation and Lead Burden Measurement

Insulation resistance to earth should be measured. Any connection to earth and wiring made deliberately such as earthing links on current and voltage transformers and on dc supply should be removed before the test; care being
taken to put them back as soon as the test is over. Measure and record the insulation resistance of the following circuits:

1. Current transformer secondary circuit
2. Potential transformer secondary circuit
3. DC trip circuit wiring.

When measuring the insulation resistance to earth of an individual circuit all other circuits should be normal i.e. earth links closed to ensure that the insulation is satisfactory both to earth and all circuits.

Lead burden should also be measured between current transformer and the relays to ensure that the burden imposed on the CT is within its capacity. This test will reveal if there is any poor contact in the secondary circuit of the CT or if the distance between the transformer and the control panel is too long. With a CT rated at 5 A, lead resistance is particularly important.

20935 Current Transformer Ratio and Polarity Test

Every CT should be individually tested to verify whether the polarity markings on the primary and secondary terminals are correct, using the set up shown in Fig. 9.01.
‘A’ should be a moving coil centre – zero type low range ammeter. A 6 V storage battery may be used to energized the primary winding through a single pole push-button switch. On closing the push button, the dc ammeter should show a positive flick, and on opening a negative flick.

20936 Primary Injection Test

This check is carried out with a “primary injection set”, which is usually arrange for connection to the 240 V supply means and furnishes heavy current at a low voltage. Provision usually exists to connect the secondary windings of the test set either in series or in parallel to get the necessary output. A 10 KVA test set usually permits currents up to 1000 A to be obtained with four secondary windings in parallel and upto 250 A at a higher voltage with the windings in series. When dealing with very large currents, it is essential that the connecting leads and area of contact and contact pressure should be adequate enough; otherwise, higher values of current will not flow.

The merit of primary injection test is that it gives an overall check on the correctness of the entire circuitry.

20937 Voltage Transformer Ratio and Polarity Check

Polarity of the potential transformer could also be checked using the same method described for current transformer testing. In this case, however, care should be taken to connect the battery supply to the primary winding with the moving coil ammeter connected to the secondary winding.

The ratio check can be may when the 25 KV busbars are first made alive. The PT secondary voltage is then compared with that of another PT known to have the correct ratio, after connecting it to the primary bars.

20938 Electrical Operation of Indicators and Associated Devices

All shunt connected indicator, annunciators, internal auxiliary elements, DC auxiliary and master trip relays, should be checked for operation at the minimum voltage stipulated by the Manufacturer. Series-operated indicators or auxiliary relays should be checked at their pick-up values. Confirm that auxiliary relays reset when voltage and current supply is removed after operation.

20939 Secondary Injection Test

These tests are done with a secondary injection test set. Normally, operating times and minimum closing values are checked for induction relays. For instantaneous attracted armature type relays, the minimum closing and resetting values are checked. For directional relays, directional characteristics are checked.

20940 Alarm and Trip Check

Ensure that all fuses, links, trip latches etc. are in normal position. By operating each relays manually, verified if the appropriate circuit breaker trips. Inter-tripping of primary and secondary circuit breakers should also be checked. There should be no normal-operation of any other circuit. In every case of tripping, the appropriate flag indication should take place on annunciator, accompanied by operation of the alarm.

20941 Load Test

After the section is commissioned, a final check should be made of the proper operation of all voltimeters ammeters and relays when normal load currents are flowing through the circuits. For differential circuits, spill currents should be measured to prove that protection will be stable under external faults, by shorting the secondary terminal on one, current,transformer : operation under an internal fault should also be checked The directional features of directional relays should also, be checked This ensures that the,relative polarity of CT and PT is correct.

20942 Confirmatory test of OHE Protective Relays

A short time after OHE has been successfully charged at 25 kV, it is de-energized to conduct final confirmatory test on the operation of OHE protective relays. Although relays would necessarily have been tested on the test
bench at the laboratory and subsequently in the field after erection, a final confirmatory field test is essential before declaring the section as fit for commercial operation to ensure that in the event of a fault the relays do trip.

2. The over current and MHO relays should all be set for instantaneous operation as mentioned earlier. In all, the following three tests are necessary and in each case all the feeder circuit breakers and their associated relays should be tested one after another:
   a) A direct fault on the busbars of the feeding post to test operation of the over-current relays.
   b) A fault at the farthest end of a single line section under emergency feed conditions to check the operation of the MHO relay and also the under-voltage relay at the sectioning post.
   C) Closing the bridging interruptor at sectioning post to check the operation of wrong phase coupling relay.

3. Test (a) can be conducted as soon as the substation and feeding posts are commissioned, without waiting for the energization of the OHE. In carrying out Tests (b) and (c) one must provide and be prepared for the very remote contingency of the MHO relay failing to trip the circuit breaker when it is closed on the fault, due to polarity of the potential coil of the MHO relay not being correct in relation to that of the current coil. Before starting the test, trip circuit operation should be checked by manual closing of the relay contacts. A responsible official should remove the MHO relay cover and be ready to close the relay contacts manually and trip the circuit breaker, should it fail to do so automatically when the circuit breaker is closed on the fault. Should this happen, the connecting leads either of the potential coil or the current coil on the MHO relay should be reversed and the test repeated.

4. For carrying out the short circuit tests, care should be taken to earth the line by a solid flexible, jumper connection (105 mm to an earthed structure. A thin wire such as 14 SWG should never be used for connection to earth, under the mistaken impression that the fuse would blow out and not jeopardize system stability, should the 25 kV circuit breaker fail to trip. It should be remembered that the circuit breaker is designed to clear the fault whereas the improvised fuse is not. When it blows on account of heavy short circuit current, the flash over caused by it can damage the galvanizing of the mast and perhaps shatter any insulator nearby.

5. A point to be ensured in particular is that none of the relays at the grid substation trips during any of these short circuit tests. This can be ensured earlier by proper co-ordination of relay settings at the traction sub-station. Normally, the traction circuit breaker trips out within about 250 milli-seconds from the occurrence of short circuit. The Supply Authorities should be requested to set their relays allowing a time lag of 0.5 seconds to ensure that the substation circuit breaker does not trip for faults on the railway traction system.

6. It is quite possible that in these short circuit tests, more than one relay associated with the feeder circuit breaker may operate; for example, the MHO relay in addition to the over-current relay, even for a fault close to the sub-station. This is quite in order, since this automatically gives back up protection. A note should be made as to which flag indications have operated to ascertain which of the protective relays have operated during each test.

7. When testing the wrong phase coupling relay, it may sometimes happen that the relay at one substation alone may operate and not at both ends, as may be expected. This is possible if the operating times of the two relays differ even slightly. This, however, does not matter at all. Nevertheless if it is required to check the other relay, the relay which has operated may be blocked and the performance of the other relay tested by a second test.

8. The operation of the under-voltage relay at the sectioning post for a fault at the farthest end under emergency feed conditions can be checked by posting someone at the sectioning post. The test could however be postponed by a few days and conducted after introduction of commercial services.

9. Since these confirmatory tests are to be conducted after successful energization of the OHE and before introduction of commercial operation, It is essential to complete the tests in the shortest possible time. However, being the most severe tests these should not be repeated too often. This can be ensured by organizing the work properly by posting testing parties at the right places and controlling all operations through the TPC and by RC.

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IV. SWITCHING STATIONS AND BOOSTER TRANSFORMER STATIONS

20943 Power Supply
Power supply for all switching stations is arranged through the 10 KVA, 25 Kv/240V auxiliary transformers connected to UP and DN line in double line section. If an ac 240 V supply near by is available from the supply authority, a service connection should be taken from the source as well. A 24 hour record of voltage should be taken and the tap switch of the auxiliary transformers correctly set.

20944 Installation of Equipment
The installation of every item of equipment like interruptors, isolators, busbars, lightning arresters and wiring from equipment to the control panel in the switching stations cubicle, 72/110 V and 24 V batteries and battery chargers etc. should be checked, keeping the points referred to in paras 20915 to 20918 in mind, except for the following minor variations.

1. Interruptors are installed for controlling supplies to the sub-sectors. The remarks made under para 20908 are equally applicable, except that no relays are associated with them.
2. Potential transformers for catenary supply indication are mounted on the switching station gantry.
3. 25 kV lightning arrestors are also installed on the gantry.

20945 Clearances
Check whether the following minimum clearances for 25 kV do exist:

1. Height of any live conductors from ground level 3m
2. Distance between any live part (25kV) and earthed part or part likely to be earthed 500m

   (In special circumstances and with the approval of the design office this can be 450mm.)
3. Between any live part (3kV) and earthed part such as return conductor or return feeder 150mm

No live part may project beyond the fenced enclosure except at a height of 6.1m or more. This should be particularly checked to guard against the possibility of danger to any member of the public who may walk by the side of the switching station with an umbrella or a long pole.

Check and ensure that the distance from the centre of the nearest track to the face of the switching station gantry is not less than 3.5 m.

20946 Auxiliary Transformers & Booster Transformers
These should be inspected and tested in accordance with the procedure earlier stipulated under “substation” –part I above.

The mounting of these transformers should be checked to ensure proper fitment and conformity with schedule of dimensions and electrical clearances.

The booster installations, in particular should be checked for correct jumper connections.

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20947 General

Verify whether the erection of fencing is neat and all parts are given a good finish with paint, the gate is provided with a good lock and anti-climbing devices are satisfactory. The area inside the switching station should be leveled at least 10 cm above the surrounding area. Good drainage must be provided so that there may be no possibility of water logging at any time.

To facilitate unloading and loading of heavy materials transported by trolley or OHE inspection car, a suitable loading platform should be provided from which a path-way should be available up to the gate. Wherever possible a jeepable road approach should also be provided from the nearest public road.

When the switching station is at the foot of or at the top of a steep embankment, suitable foot steps should be provided leading up to the gate.

20948 Interlocking

Verify whether the double-pole isolator associated with every interruptor is equipped with an interlock and it is functioning properly. It should not be possible to open or close the isolator unless the interruptor is locked in the open position. It should also not be possible to operate the interruptor either manually or by RC, unless the isolator is locked in the open or closed position. To ensure this, the interlocking device should consist of a lock combined with an electrical contactor on the operating mechanism of the interruptor to make or break the RC circuit and a lock for the isolator operating mechanism, with a common captive interlock key for the two locks.

20949 Feeding Posts

At locations where the traction substation is close to the tracks, the feeding post may be a part of the substation; if, however, it is far away, the feeding post close to the tracks will receive 25 kV supply from the traction substation, with 25 kV feeder circuit breakers located at the substation end.

In either case, the neutral conductor (also called the negative or return conductor) of the feeder line should be solidly connected to the track rails, In addition to being earthed at the traction transformer end. This connection to the rails is vitally important for the proper and safe working of the traction system and it should under no circumstances be broken. To ensure this, the neutral conductor is connected to the rails by eight independent galvanized steel stranded (7/16) cables for a double track section with two conductors for each rail. The ends of stranded cables are brazed or welded on to suitable shoes which are riveted to the rail webs.

Examine all the connections and make sure that the cables are well bonded to the rails with sufficient length left free for flexibility. The down-lead from the terminal tower should be well protected mechanically to prevent its being cut and stolen.

20950 Number Plates and Boards

Check the numbering of the interruptors, isolators, PTs and then jumper connections to the OHE to see if they do correspond to the numbering scheme on the control panel in the switching station equipment room, the mimic diagram board at the RCC and the sub-sector numbers.

Check also if the following boards and fittings are provided at each switching station:

1. Switching station name board,
2. "Danger boards" to caution public,
3. "Protected place" board prohibiting unauthorized entry,
4. Fire-buckets and fire extinguisher inside the equipment room.
5. First aid box and “Rules for Resuscitation from Electric Shock” board inside the equipment room. Essential caution boards and number plates should be painted with fluorescent paint so as to be brightly visible in light at night.

20951 Earthing and Bonding
The structural steel work as well as the neutral conductor of auxiliary transformer, and the metal case of every electrical equipment shall be connected by two independent connection to earth in accordance with the "Code for Earthing Traction Power Supply Installation" vide Appendix III. According to this code, HT and LT earths should be provided separately, but interconnected together by a link. It is equally important to check that the structure supporting the busbars are solidly connected by two independent connections to the none-track circuited rail with single rail track circuit or to the mid point of the impedance bonds where both rails are used for track circuiting.

During detailed inspection, the resistance of each electrode should be measured and recorded by a megger earth tester so that the combined resistance of the HT earthing system is 2 Ohm, or less and of the LT earth 10 Ohm or less, when not connected to the rails.

V. REMOTE CONTROL EQUIPMENT
20952 Importance of Remote Control
Remote Control Center is the nerve center of the traction system, from where full control over every switching operation on the entire electrified route is exercised, its efficient operation is, therefore, of prime importance for successful working of the system. It is desirable to complete all tests and trials on the RC equipment at the RCC and at the switching stations and to make them fully functional before energization of OHE. To achieve this, tests and trials should start about a month earlier, by which time the following item of work should be ready.

1. Derivative cables from the main telecommunication trunk cable should be led and terminated inside the equipment room in RCC, substations and each of the switching stations. Care should be taken to ensure that the metal sheathing of the derivative cable is terminated short of the cable terminating box and kept insulated from earth inside the equipment room and surge arrestors are provided for each terminal.
2. Repeater stations should be fully functioning.
3. All control phones in RCC and TPC telephones in substations and switching stations be installed and commissioned.
4. The air conditioning of the RCC should be complete before the erection of the RC equipment starts.
5. RC equipment should be ready and wired up at RCC control led posts.
6. Batteries and battery charger along with power supply and charging arrangements should be ready.

20953 Manning of Substations and switching posts
When RC equipment is first brought into operation, it will take about 6 months before teething troubles are overcome and equipment stabilizes for trouble free service. During this time, it is necessary to man the substations and switching stations to operate the interruptors manually and give reports to TPC when required. This situation also arises for longer period if the RCC is not ready before energization.

The switching station attendants should be given adequate training in their duties and should normally be available from about a month before the date of commissioning. It is usually possible to introduce commercial service on limited scale, before commissioning of RC equipment.
20954 Level Measurements

Signal levels should be measured and recorded both at the sending and receiving ends at the control center as well as at every substation and switching station. These measurements are of two kinds:

1. Individual levels of every frequency on the 'send' channel. These are measured by a vacuum-tube voltmeter (VTVM) /Transistorized voltmeter (TVM with its selector switch in "high" Impedance position at the oscillator output terminals. These should be about -16 dB.

2. On the receive side, the levels are taken with VTVM in the "high" - impedance position, at the detector Input terminals: this should be between -17 and -25 dBm.

3. Composite levels taken between the terminals of the tele-command and tele-signal cable pairs with a VTVM with selector,switch in the "high" impedance position. Readings may also be taken at the input and output terminals of the repeater station and plotted on a graph sheet.

4. Measurements should be taken of the levels of every channel on send and receive pairs at the control centre using the Selective Level Meter. The levels for the send-channels should not be lower than -22 dBm, and for the receive channels -22 to -30 dBm.

5. After final adjustment of the levels, a note should be made of the values of the attenuation pads included in all the circuits and kept as a permanent record for purposes of comparison and reference.

It may be noted that the line impedance of the send and receive circuits is 1120 Ohm whereas that of the amplifier output only 150 Ohm. A matching transformer is therefore provided between the two. When measurements are taken, care is required to keep the selector switch of the VTVM in the "high" position, as long as the circuits are through, but if the output level is to be measured with the line or equipment disconnected the switch shall be kept at the 150 Ohm or 1120 Ohm position as necessary to achieve matching.

Another point to be kept in mind is that although the individual level of a single channel is say -22 dBm, the level indicated on the line is much higher if measured with VTVM because of the presence of a large number of frequencies each of which has a level of -22 dBm. Thus the correct reading of -22 dBm is indicated when a Selective Level Meter is used with frequency range switch in the "frequency" position; but the same meter would indicate perhaps +5 dBm if there are say 12 channels and the frequency range switch is kept in the "flat" position. Distinction should therefore be made between the individual channel levels and composite level, where all frequencies are present.

20955 Detailed Inspection of RC Equipment

Detailed program of erection of equipment, sequence of preliminary tests to be carried out at the RCC and controlled stations, shall be furnished by the contractor to enable the Railway staff to carry out stage Inspections and testing of individual panels, equipment cabinets and control units at the master station and Remote Terminal units.

When contractor reports completion of erection, commissioning and all adjustments and testing work and notifies that the installations are ready, detailed inspection shall be carried out by AEE (TRD) and open line staff along with their counterparts on construction organization and representative of the contractor. The defects noticed shall be rectified immediately.

Contractor shall also furnish a detailed test program for the final testing of the RC equipment for the approval of the Railway Engineers. These tests will be done jointly by open line officers, RE officers and the contractors' representative. The test program shall cover the proving tests for all the parameters and facilities provided for the operation of RC equipment specified. The tests at site after installation and commissioning shall constitute the acceptance tests, which will be carried out after the detailed inspection and rectification of defects is completed. Thorough checking of all switching operations, correct operation of all alarm, Indications and annunciation facilities, tele-signalling and tele-metering arrangements, mimic diagram displays, VDU displays,
data –logging and data storage, diagnostic facilities etc. shall be done from both control stands of the master station as well as from the remote terminal units. Operating time for various operation shall also be checked and recorded.

All these tests carried out jointly shall be recorded so as to establish, authentic initial record of the performance of the equipment to ensure that the RC equipment is complete and trouble free.

**20956 Interlocking of the Bridging Interruptor**

Interlocks in the RC equipment for the bridging interruptor at the sectioning post provide for the following:

1. When catenary supply is available on both sides of the interruptor, the interruptor should not close.
2. When supply is available only on one side, the interruptor can be closed.
3. When supply is not available on both sides of the interruptor the interruptor can be closed but should trip immediately

This is achieved by utilizing 100 or 110 V ac supply from potential transformers provided for this purpose at the sectioning post.

Provision is also made for the bridging interruptor to trip if the catenary voltage drops too low. This sectioning is adjustable between 15kV and 19kV and should be set at 19kV.

The above interlocks should be thoroughly checked when commissioning RC equipment at sectioning posts.

**20957 General Inspection by Divisional Officers**

After defects noticed during the detailed inspection as above have been rectified, the Sr.DEE/DEE(TrD) of the open line together with the counterpart on the construction organization and Contractors representative’s shall carry out general inspection of the entire installation to make sure that it is in good working condition. During the inspection verification of as many tele-command and tele-signals operations as possible shall be carried out from the control centre. Inspection of the installation at every sub-station as many posts as possible shall also be carried out. Level and frequency measurements should be taken at random at a few points to compare the result obtain with those recorded during the detailed inspection.

The divisional officers will issue a joint certificate if they are fully satisfied with their observations and tests, that the RC installations are fully fit for commissioning. Thereafter, the RC may be put into regular services and its operation closely watched by manning the switching stations and substations as mentioned earlier. Detailed record of every failure shall be maintained by TPC and the maintenance official. Each of these failure should be gone into fully to ascertain the cause of failure, which incidentally would give the staff excellent opportunity to get familiar with the circuitry and fault-find in a procedure.

**VI. OVERHEAD EQUIPMENT**

**20958 Detailed Joint Inspection of OHE**

The importance of OHE arises from the fact that it is extensive, with a very large number of insulators, fittings and component parts, failure of any one of which may result in dislocation of traction services for appreciable periods until the defect is rectified. The adjustment work is particularly important at cross-over and over-lap spans since any wide departures from the standards laid down could cause entanglement of the pantograph with the OHE, with serious repercussions. The need for a very thorough detailed inspection of every part of the installation, post by post, can not, therefore, be over-stragged.

When the OHE contractor reports completion of all adjustment work, detailed inspection will be carried out by the AEE(TrD) and staff of the open line with their counterparts on the construction organization and
representatives of the Contractor, using on OHE inspection car, flat-topped wagon of wiring train, or ladders as may be convenient.

20959 Compliance with Latest

The OHE shall be strictly in compliance with the latest approved General Supply Diagram, Sectioning Diagram, Layout Plan and Structure Erection, particularly in regard to

1. run of conductors; stagger and height;
2. disposition of brackets and clearances;
3. correctness of jumper connections, especially at switching and booster transformer stations;
4. numbering of interruptors, circuit breakers and isolators in relation to the elementary sections, sub-sectors or sectors controlled.

20960 Infringements

None of the wayside or over-line structures shall cause infringement of the Schedule of Dimensions. Every such infringement shall be individually recorded and action taken immediately either to have them removed or, where this is not possible, to obtain sanction from the Commissioner of Railway Safety.

20961 Important Point to be Checked

The following points shall be checked during the detailed inspection:

1. Cantilever Assemblies: Every cantilever assembly shall be adjusted strictly in accordance with the approved structure erection, especially in regard to the positioning of stay arm, bracket tube and register arm. The projection of bracket tube and register arm and the allowance in the stay arm shall be sufficient for slewing of tracks. Normally this allowance is 15 cm to 20 cm from the centre line of catenary suspension bracket to end of bracket tube and 20 cm (min.) for register arms. All nuts should be tightened and locking plates provided with split pins or check nuts. Make sure that all temporary earths provided by Contractor’s men during construction work have been removed.

2. Anchoring Points: The movement of counter-weights shall be free and not obstructed in any way. Flexible steel ropes shall move freely and centrally with respect to the pulley sheaves and not rub against any member. The distance between the pulley centres and the height of counterweight above the muff level, shall be as per the chart in relation to the prevailing ambient temperature. Anti-creeps shall be properly tensioned and positioned.

3. Overlap Spans: Adjustments at insulated and uninsulated overlap spans, turn-outs, crossovers and section insulator assembly shall be correct not only in respect of the run of conductors and jumper connections, but also the height of contact wire. The separation between different OHE and displacement of cantilevers at insulated overlaps should be adequate.

4. Insulators: Insulators shall be perfectly clean. Should the surface be polluted by dust, it should be cleaned and gloss restored. All insulators on out-of-run wires should be so located that they do not foul but are well away from the zone swept by the pantographs: The runners of section insulators should be so located as to be beyond the zone of sweep of pantographs running on adjacent tracks. There should be no undue sag due to the section insulators, the runners should be level and not be tilted to one side so that the pantograph may pass smoothly.

5. Height of Contact Wire: This shall be checked at every structure and at mid-span for regulated OHE. A pre-determined sag in the contact wire of 50 mm or 100 mm at mid-span on a 72 m span
for 50 or 100 mm presag compensated OHE respectively should exist on the open routes. Height of contact wire at level crossings shall not be less than 5.50 m.

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6. **Stagger** : Stagger in tangent track shall be to the left and to the right of the alternatively, not exceeding 200 mm on either side of the centre line of the track, except where otherwise specified in Structure Erection Drawings. Stagger for in-running OHE shall not be more than 300 mm at the mast/structure on the outside of curves except in case of overlap spans and also at the turn-outs. Stagger of contact wire at mid-span in transition portion of the curves shall be within 200 mm.

7. **Gradient of Contact Wire** : On both side of overline structures, tunnels and level crossings, the gradient of contact wire shall be in accordance with the approved profile.

8. **Clearances** : The live metallic caps of insulators on out of run wires shall be at atleast 2 m away from adjacent earthed mast/structure (other than the OHE structure). The distance of these insulators shall be 3 m from the bracket supporting the OHE in case of insulated overlaps. Clearance of 2 m shall normally exist from nearest point of two adjacent elementary sections except at the section insulators. Where clearance of 2 m is not available. It shall be not less than the minimum long duration electric clearance of 320 mm. Whenever the OHEs of two elementary sections cross one another, necessary cut in insulators shall be provided.

9. **Bonding** : Every mast/structure supporting OHE as well as platform structures, foot over bridges etc. shall be properly bonded to the rails and earthed in accordance with the Bonding and Earthing code (Appendix II)

10. **Return Conductors of Booster Transformer Installations** : The return conductor connection both at the OHE and the rail should be checked from the point of view of good electrical contact and security from mechanical damage.

11. **Telephone or Power Crossings** : Keep a close watch for any overhead telephone crossings over the OHE, which may not have been removed by oversight. Immediate steps should be taken to have these removed. High voltage transmission line crossings across the tracks shall be checked against the approved plan authorizing the crossing, particularly the clearance between the OHE and the guard wires, duly recording the results individually. If the crossing is not in accordance with the approved plan, the Supply Authority should be contacted immediately and the infringements should either be removed or necessary relaxation be obtained from CEE and Electrical Inspector to the Railway.

**20962 Notices to be Displayed – Caution Boards and Number Plates**

During the detailed inspection, special attention shall be paid to verify whether the following notices have actually been displayed at the various locations indicated below:-

1. ‘Treatment for electric shock’ boards, giving instructions for treatment of electric shock in English and the regional language, at all railway stations (ASMs or SMs Offices) signalling cabins, PWIs Sub-PWIs and IOWs offices and depots, Signal Inspectors’ Officers and depots. OHE Maintenance depots, OHE inspection car sheds, substations, switching station cubicles, loco sheds etc.

It should be noted that standard printed charts for ‘Treatment for electric shock’ are meant for voltages upto 1100 Volts. A person in contact with higher voltages should be isolated only after ‘switching off power’.
2. General ‘Caution Notices’ regarding danger of high voltage traction wires for public at various entrances to railway station and for staff at prominent places at each station, particularly on stanchions or pillars supporting platform roof.

3. “25 Kv Cautions Boards” shall affixed on to the screens erected on foot over and road over bridges.

4. ‘Danger’ boards on level crossing height gauges.
5. ‘Engine Stop’ boards, at termination of OHE in the sections to be energized.

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6."Caution-Unwired Turn out" boards ahead of all unwired turn-outs or crossovers taking off from wired tracks.
7."Warning" boards for neutral sections.
8.Boards for "Switching on" and "Switching off" of power at neutral sections. Four boards are required for each track as detailed in Chapter 11, Vol. 1.
9."Danger" boards to be installed on OHE near watering stations, if any.
10."25 kV Caution" boards at sub-stations and switching stations.
11."Caution" notices on all diesel, electric and steam locos which work on the energized section, including those owned by private parties.

12."Caution" boards at such signal posts where protective screening cannot be provided for signal and telecommunication staff.

20963 Recording of Defects and Rectifications
During the detailed inspection, defects and deficiency lists as indicated in para 20903 shall be jointly prepared.

As soon as the defects are rectified, the open line officers should be advised and suitable remarks made against each Item of the list. The open line officer and his staff, if deemed necessary, re-check the Installation, to ensure rectification of defects.

20964 General Inspection of the OHE by Divisional Officers

After all major defects observed during detailed inspection have been rectified 'Sr' DEE/DEE (TrD) of the open line and Dy. CEE(OHE) of the construction organization shall carry out a 11 General Inspection" of the entire section proposed for energization, along with the Contractor's representative. For this purpose, an OHE inspection car fitted with pantograph shall be used and run at a speed not exceeding 8 km/h observing all safety precautions laid down, such as earthing the OHE. The pantograph may be used to measure height and stagger of contact wire, which should be test checked at least at two locations per track km.

The object of this "General Inspection" Is to make sure that the OHE and connected installations are in good order and are fit for energization. During this inspection, the whole installation shall be inspected visually observing, in particular, the following details and looking for anything unusual or abnormal in the installation:

1. Cantilever assemblies, positioning of fittings, stagger of contact wire, lift of the steady arm in curves where the radial pull of contact wire tends to move the steady arm upwards, kinks or twists in contact wire, infringement of section insulators and conductors in overlap spans or any deformity suffered anywhere. Any loose wires hanging anywhere or other obstructions shall be observed, and any abnormality removed or rectified immediately.
2. Clearances to live metal parts of insulators on out-of-run wires should be at least 2 m from the adjacent structures (other than OHE). During this inspection, spot checks shall be conducted at as many places as possible to verify whether the detailed inspection by the senior subordinates has been thorough, to confirm that the
defects noticed earlier have been rectified and to make sure that the installations are in excellent order and suitable, for energization subject to final pre-commissioning tests.

**20965 Lapping and Polishing of OHE**

After the OHE is ready in all respect, lapping and polishing of contact wire be undertaken to remove all dirt collected

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on the contact face with the pentograph. For this purposes an electric loco pentograph raised and hauled by a diesel loco may be use at a speed of 15 to 20kmp/h during the first run and not more than 40kmp/h in subsequent runs. Alternatively, an OHE inspection car may be used. It is an advantage if before lapping by pantograph under side of contact wire is manually cleaned by rubbing and wiping with a wet cloth and detergent and finally wipe with clean cloth. Normally 3 to 4 runs for lapping and polishing may be done.

When lapping and polishing is in progress suitable safety precautions to block the section and earthing of the line as per rules, should be taken and work is supervised at a level not less than CTFO.

**20966 Procedure for Final Test of OHE**

After the OHE is declared as fit for energization and all construction staff have been withdrawn from the field, insulation and continuity test shall be conducted jointly by officers of the construction organization and the open line with assistance of senior subordinates. This should be done at least a day in advance of energization. This tests should be conducted for every elementary section. The following preliminary action shall be taken to prepare the circuit for the test.

To carry out the test in a systematic manner, a detailed programme of work should be prepare. A senior, experienced official should be nominated for controlling the movements of all working parties each of whom will be given a copy of the programme with specific instructions as to the sequence of switching operations to be carried out. This preliminary action should be taken atleast a week in advance of the date fixed for the test.

On the day of test, interruptors and circuit breakers at all switching stations shall be taken on ‘local’ control and RC put out of operation. All interruptors and double-pole switches are then opened and locked in the open position’Danger-Men Working’ boards should be attached to the operating handle of each 25 kV isolator at feeding post. All potential and auxiliary transformers at switching stations should be temporarily disconnected from the busbars. All other isolating switches in the various yards and other locations provided for isolation of elementary section also be plays in the “off” position. When all these operation are completed a confirmatory message shall be sent to the TPC.

The test shall be controlled by one senior official who shall continuously remain at the RCC and direct all operations as required. Basically, these tests comprise-

1. Measurement of insulation resistance of every elementary section with respect to earth.
2. Checking electrical independence and insulation resistance between adjacent elementary section and also adjacent sub-sectors.
3. Checking electrical continuity of every sub-sectors.

The test shall be carried out by one party with the assistance of two or more field parties as required. The control party alone will carry with it all test instruments and take measurements. The field parties will merely carry out instructions given. They should have with them necessary jumper connection and earthing poles for earthing the equipment when directed to do so. The field parties are forbidden to carry out any operations on their own. As the different working parties will be working at different locations, independent from one another, they should carry with them portable telephones through which they will remain in continuous contact.
with TPC through emergency telephones circuit. In case the emergency telephone circuit is not available, alternative arrangements shall be made by S&T Department for telephone communication.

Along with the control party carrying out the tests, the Contractors shall attach a work party who will accompany the control party from location to location and rectify any defects which may come to light during the tests.

**20967 Insulation Tests**

Starting from the feeding post, the control party will measure and record the insulation resistance of every elementary section to earth by a 2500 V megger, after arranging with the out-field parties to isolate the elementary section concerned and earth adjacent elementary sections. This test will show -

1. the insulation level of every elementary section; and

2. the electrical independence of the elementary section, from adjacent elementary sections.

If the tests for all elementary sections at that location are satisfactory, the control party may proceed to the next elementary section and carry out similar tests. When all elementary sections at a particular station have been tested, the control party will move to the next station, directing the field parties to do likewise and carry out the tests on each elementary section at that station as before until every elementary section in the sector has been tested.

During the course of construction work, erection staff usually provide temporary earths, using a short piece of binding wire on the OHE at certain locations to safeguard themselves, but after the work is completed these temporary earths may not have been removed by oversight. Such temporary earths on the OHE will give misleading readings during the final insulation test and cause annoyance. To prevent this, Contractors should be particularly instructed earlier to remove all such temporary earths.

**Guide Lines for Minimum Permissible Insulation Resistance**

It is very difficult to lay down any specific rules in regard to the minimum permissible values, as they depend upon a number of factors, which should be taken into account when fixing the value in any given case. Some of these factors are mentioned below.

1. **Voltage rating** has an important bearing on the minimum value necessary, before switching on supply. Obviously, the higher the voltage rating, the greater should be the insulation resistance.

2. **Condition of Equipment**: The insulation resistance for new equipment should necessarily be much more than for the same equipment after a few years of service. Similarly, the value required (after an equipment has been overhauled, cleaned, dried out) before being turned out of the repair shop should be appropriately higher than when the same equipment was in service before being brought into the shops. A unit which is lying idle for some time may show a comparatively low megger reading merely because of absorption of moisture and yet its insulation may be good and it would work satisfactorily when put into service; the absorbed moisture would soon be driven out when it is loaded up and the insulation resistance would automatically improve.

3. **Type of equipment**: It is a fundamental fact that the larger the number of leakage paths, the lower would the insulation value tend to be. Assuming that the voltage rating and the type of insulation provided for two armatures are identical it is obvious that the one with a commutator will have a lower value of insulation resistance, than one with mere slip rings.

For the same reason, the insulation resistance of 25 kV OHE tends to be quite low. Assuming that each support Insulator has a value of 500 megohm, an elementary section may have 50 of them in parallel, bringing down the overall value to 10 meg ohms. Smoke pollution will greatly diminish this too. A single badly polluted section insulator may easily bring down the value to half a meg ohm or
less. While one would not dream of switching on supply to a 3.3 kV transformer showing so low a reading- 25 kV supply is commonly switched on to the OHE even in such cases since the accumulated dust and smoke particles, which are responsible for the low value of resistance, soon get burnt out, and the insulation resistance usually improves greatly after energization.

Size of plant:

Internal wiring 50/number of outlets

Power equipment in general 2Meg/kV desirable
1Meg/kV minimum

Transformer windings 400V-2Meg, 11kV-50Meg
25kV-200Meg, 132kV-2000Meg.

Circuit Breakers -do- -do-

OHE-Elementary Section New installation
-25Meg. desirable
On sections having steam traction
And several section insulators.
-1Meg.
(These, however, would need to be cleaned
to improve IR)

Traction Motors 1 Meg. for motors upto 750 V
and
3Meg for motors of higher voltage (at 75°C)

20968 Continuity Tests

When insulation tests are completed for all the elementary sections, the control party may proceed in the reverse direction towards the feeding posts carrying out continuity tests as described below:

In this test, the various control switches which might have been opened out earlier should be put back to their final positions as indicated in the Station Working Rules, as in normal operation. Any temporary earths provided for earthing adjacent sections shall be removed. When this is done, the various elementary sections are automatically joined up electrically and each sub-sector is made through. The continuity test is then conducted by a low reading ohm-meter by measuring the resistance of each sub-sector from the feeding post and with each sub-sector earthed at the farthest
point towards the neutral section. The through continuity of every sub-sector shall be checked individually. It is important to note that a megger insulation tester is unsuitable for measuring continuity as it may read zero even when the resistance is as high as 1000 ohms.

If the tests show up any defects on the line, they should be rectified at once. Sometimes, it may be found that although the insulation resistance is all right, there is no through continuity on some sub-sectors. The most probable cause for this is a disconnected jumper connection at an overlap span. This should also be immediately traced and rectified.

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**20969 Divisional Officers' Joint Certificate**

The test results shall be recorded and signed by Sr. DEE Open line and Construction and forwarded to CEE, along with other papers for sanctioning energization in his capacity as Electrical Inspector.

**VII. GENERAL ARRANGEMENTS**

**20970 Preparation for Operating Electrified Services**

While the engineers are busy carrying out tests and trials of electric equipment to get everything ready by the target date fixed for commissioning, several steps have to be taken by the Operating Department to be ready to operate the electrified services when the section is commissioned. The DOM of the open line and the DOM of the construction organization shall both be jointly responsible for the following:

1. The Rules and Regulations concerning operation, namely General and Subsidiary Rules, Revised Station Working Rules to come into operation after introduction of electric traction, relevant Chapters of this Manual shall be handed over to every Station Master on the section to be electrified. In addition it is essential that the Implications of these rules and procedures should not only be explained to the concerned staff, but they should be examined verbally to make sure that they do understand them and further, their assurance in writing to that effect should be obtained.

The training of Station Masters, Section Controllers, Cabin staff and other categories in the special rules and procedures applicable to 25 kV traction is best arranged at a short orientation course for the purpose in the Zonal Training School.

2. (a) At every station on the electrified section, a large scale Sectioning Diagram, should be exhibited, with the different elementary sections painted in distinguishing colours to help better understanding, also showing location of isolating switches, wired and unwired lines etc. The meaning of these should be explained to the concerned staff.

(b) A complete sectioning diagram of the OHE for the relevant section should also be exhibited in the office of the Section Controller in a similar manner. These diagram shall be kept up dated by OHE supervisors, marking the changes made from time to time.

3. Sufficient number of 'Yellow Warning Collars' should be supplied to each of the signal cabins; the cabin staff should be instructed regarding their purpose. They should also be told that no electric train or EMU should ever be permitted to enter an unwired line or a section for which power block has been taken. That they understand the new procedures should be confirmed by them in writing.

4. Station Masters and Section Controllers should also be fully conversant with the system of power blocks and the need for longitudinal and cross protection on electrified lines, and the precautions to be taken by them in regard to train movements especially oversize consignments.

5. Station Masters/ Assistant station master should be issued with competency certificates, after giving practical training, to enable them to operate specific isolators under instructions of TPC.
6. First Aid boxes and charts showing resuscitation of persons who have suffered electric shock should be kept at every station. As many persons as possible should be trained in the correct method of rendering artificial respiration, preferably by a doctor.

7. The extreme danger of any one coming near line OHE should be fully explained and widely publicized amongst all staff and members of the public. No one should be permitted to ride on roofs of coaches and locomotives.

8. The rules for watering of carriages should be distributed to all TXR and station staff concerned and the procedure fully explained and assurance obtained from them in writing.

9. On all steam and diesel engines which may enter the electrified section, 'Caution' legends shall be painted on the side panels. Steam engine Drivers and the Firemen should be particularly warned that they should under no circumstances climb up the coal stack on the tender or wield the long steel rake so as to come any where near the OHE and never direct jets of water on the coal in the tenders or towards the traction wires. Experience has shown that In spite of such warnings, many an unfortunate loco Driver or Fireman have suffered electrocution: by force of habit they climb up the coal heap for loco for some work, forgetting the presence of OHE in a newly electrified section. Drivers and Firemen should be repeatedly warned of the danger of death due to such carelessness.

10. Traffic staff should be advised of the provision of emergency telephone sockets and their locations, and instructed in the correct way of plugging in these telephones into the sockets.

After the two DOMs have toured the area and assured themselves that all the above preparatory steps have been implemented, they shall render a certificate to the effect that the section can be opened for public carriage of passengers under electric traction without endangering the safety of the travelling public or of the employees of the railway.

20971 Preparation by the Engineering Department

The Divisional Engineer of the open line and his counterpart on the construction organization shall also warn engineering staff in regard to the precautions to be taken by them while working on electrified sections. The PWIs and the maintenance gangs should be particularly advised that the alignment of the track with respect to the OHE structures should be strictly preserved and maintained. Their attention should be drawn to the instructions contained in Chapter 11 Part 'J' of IR Permanent Way Manual for taking the necessary steps to educate the Permanent Way staff and to equip them with the accessories.

20972 Preparation by the S&T Department

Introduction of ac 25 kV traction involves a considerable amount of work to be done by the S&T Department, to modify the existing circuits, shifting of signals, introduction of colour light signals and laying of appreciable lengths of signal cables apart from providing telecommunication facilities required for electric traction. The precautions to be taken in testing and commissioning the S&T equipment, which should precede electrification, are the responsibility of the S&T Department and is, therefore, not dealt with here.
## CHAPTER X
### COMMISSIONING OF ELECTRIC Traction

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CHAPTER X
COMMISSIONING OF ELECTRIC TRACTION

21000 General

When electric traction is to be introduced for the first time or extended to new section on a Railway, considerable additional responsibility devolves, particularly on the electrical deptt. To discharge these responsibilities, it is essential to have a clear programme of action to be taken in the final stages of completion to ensure that:

1. the works carried out departmentally and by contractors are of high standards.

2. the organization for running the services will be ready by the time the sections are commissioned;

3. as and when installations are energized on 25 kV, they are taken over promptly and operated efficiently.

21001 Preparation by Open Line

The intention of having electrification works carried out by a separate organisation within the Railway is to relieve the CEE of the Open Line of the burden of detailed design, supervision and execution of works, departmentally or through Contractor. It is, however, essential for CEE of the Open Line to keep himself in touch with the developments and progress of works, so that he may take timely action for taking over the installation on commissioning. He will have to arrange every other things.

1. creation of an organization, with sufficient number of trained personnel, to take over the operation and maintenance of the electrified section from the date of commissioning

2. recruitment and training of operating and maintenance staff;

3. close association of Open Line Officers and staff during the final stages of erection and adjustment work to enable them to study the details of installations;

4. carrying out of detailed inspection of the works by Assistant Officers and senior subordinates followed by general inspection by Senior Officers for getting all defects rectified.

5. final tests and trials with rolling-stock;

6. Administrative Officers’ inspection and sanction to the energization of substations, switching stations and OHE by Electrical inspector.

7. final Inspection of OHE and installations by CRS, commissioning and putting into commercial service, and

8. post-commissioning work, operation and maintenance.

21002 Organization for Inspection and Taking Over

The CEE of the open line railway shall set up the organization on the following line:

1. Create all the posts of officers’and staff in accordance with the norms and fill up at least 6 months in advance two post of JAG Officers viz. Sr. DEE/TrD and Sr. DEE/RS along with requisite site staff and supervisors.

2. when electrification is introduced for the first time on the zonal railway, a nucleus set up at the headquarters...
office should also be created.

(3) organize a Training School at least one year in advance/ for the training of maintenance, operation and running staff to man the services.

(4) Recruit maintenance and operating staff and train them to man the services, arrange for selection of running staff from steam and diesel cadre and start their conversion training courses at least a year prior to the date of energization, so as to position adequate number of drivers, assistant drivers and supervisors in time to take over the services.

(5) Position the Inspectorial cadre to ensure compliance with the requirements laid down in para 20970 station by station and to train along with Sr. DSO all the Operating Deptt. staff.

(6) Augment the organizational set up 3 months in advance of the date of commissioning posting additional officer and staff to ensure detailed joint checks and rectification of defects in time.

(7) Expedite the completion of facilities for setting up OHE and PSI depots and workshop' facilities built by the construction unit and arrange to equip the emergency vans, OHE Inspection Cars and other maintenance vehicles to undertake the maintenance and operation.

(8) If a loco-shed is part of the RE project, some officers and staff should be posted at least 6 months before the locos are received so that they can set up the shed facilities jointly with the construction unit, arrange for jigs, fixtures, and other special tools, take over the major plant and machinery such as cranes for light and heavy lifting bays etc. and get themselves organized for the maintenance and operation of the rolling stock.

Having nucleus setup of key officers is an important step which enables establishing a good rapport with, and making full use of the resources of, the construction organisation in creating full facilities for the open line maintenance. Opportunity to select right type of men with skill for different jobs from a number of sources viz. direct recruitment, other open line units and sheds, contractor's skilled labour etc. can be taken by the officers If they are In position in good time. This enables the change of traction from the very first day of energization on trial basis and increase it to a very significant level immediately after CRS's inspection and sanction for carriage of passenger traffic.

21003 Duties of Senior Divisional Electrical Engineer (TrD)

1. Assisted by his DEE/AEE(TrD) he WILL follow up with the Construction Organization to ensure that the following works are ready well in advance of the-date of commissioning:-

(a) Accommodation for the new Sr.DEE(TrD)'s Office together with necessary furniture, office equipment etc.
(b) Central Repair Shops, PSI and maintenance Depots, and Sub-depots with necessary road and rail facilities.
(c) Full stock of spare parts, tools and plant, testing equipment, lifting tackle, emergency vans, motor trolleys, push trolleys, jeeps, motor trucks etc. required for operation and maintenance.
(d) Installation of emergency power plant at the RCC.

2. He will make a detailed study of tariff for power supply and get acquainted with officers of the power supply authorities.

3. He will arrange for creation and timely filling up of all posts required for operation and maintenance.

4. He will arrange for screening and conversion training of staff expected to be rendered surplus due to electrification and recruitment and initial training of the balance requirement of staff.
21004 Duties for Senior Divisional Electrical Engineer (RS)

1. Assisted by his DEE/AEE(RS) he will follow up with the Construction Organization to ensure that the following works are ready well in advance of the date of commissioning: -

(a) Additional accommodation for the new Sr.DEE(RS)'s Office together with necessary furniture, office equipment etc.

(b) Electric loco/EMU shed and out-station maintenance depots with all facilities like travelling crane, pits for inspection, power supply, plug sockets, lighting, storage racks etc.

(c) Installation of the full complement of machinery, tools and plant and testing equipment at all repair and maintenance depots.

(d) Full stock of spare parts and arrangements for stocking, them for recurring consumption.

2. He will also arrange for sanction for necessary posts for operation and maintenance of rolling-stock.

3. He will arrange for screening and conversion training of Steam/Diesel Drivers through all phases including their basic theoretical and practical training in electric rolling-stock, their learning the road and rules for operation of electric stock.

4. He will arrange for preparation of loco link diagrams and Drivers' rosters as well as Trouble-shooting Directory for different types of rolling stock.

5. He will arrange for screening and conversion training of maintenance staff rendered surplus due to electrification and also recruitment and initial training of balance requirements of staff.

21005 Responsibility of Construction Organisation

The Construction Organization is responsible for the execution and completion of works and testing, commissioning and handing over all. installations in proper working condition to CEE of the Open Line and in particular to ensure that:

1. the design of all installation is in accordance with approved standards and where any departure from accepted norms becomes necessary approval of Railway Board/ RDSO/ CRS/ Electrical Inspector is obtained;

2. progressing of works is done to comply with the target dates fixed by the Railway Board and all works executed are to a high standard;

3. procurement of all special stores, transport vehicles including OHE- inspection cars for maintenance, tools, and plant, machinery and testing instruments and their handing over to the Open Line in two stages the minimum required before tests and trials followed by the balance immediately after installation and commissioning in done (refer Appendix VI);

4. the CEE informed of all developments and in consultation With him the programme and date for commissioning of installations is fixed;

5. copies of all approved, specifications, contract documents and Important letters are furnished to the CEE. Sufficient number of copies of all, specifications and manufacturer's instruction booklets should be to the Divisional Officers concerned so that they may be distributed to the maintenance Staff. "As made drawings" or tracings incorporating all modifications during construction, countersigned by the Engineers of the Contractor and construction organization are handed over to CEE of the Open Line for safe and permanent custody;

6. exercising necessary co-ordination with the Supply Authorities to ensure that power supply "I be made
available and with the P & T Department to ensure that all their works will be completed and the necessary clearance given for energization of the lines well in advance; and

7 complying with all the formalities connected with the energization of all sections in accordance with the rules laid down.

**21006 Commissioning of Traction Substations**

1. Energization of traction substations is the first step towards commissioning of electric traction on a new section of a Railway. This can be done subject to-

(a) Power Supply Authorities being ready to give power supply;

(b) detailed inspection of the substations, protective equipment and connected RC equipment having been completed and test being quite satisfactory;

(c) full communication facilities being available;

(d) permission for energization of the substation having been received from CEE and Electrical Inspector to the Railway.

2. Norwilly all sub-stations should be commissioned well before the date fixed for energization of OHE for commercial traffic use. With the sanction of CRS limited trial runs could be undertaken after the sub-station is commissioned.

3. On the appointed day, necessary clearance certificates should be obtained from the Contractors, Dy.CEE(PSI), Officers of the Supply Authority and others who were working at the substation during the construction period, that their staff have been withdrawn and the substation may be energized. The 25kV feeder Isolators at the sub-station and feeding post ends should be opened and locked and the 25 kV feeder conductors solidly earthed by duplicate earths. Readings of the tariff metering equipment should be recorded and the meters jointly sealed by the Open Line Sr.DEE/DEE and the Officers of the Supply Authority. After final meggering of the whole installation, all circuit breakers and isolators are kept in the open position and the 'remote/local' switch put in the 'local' position.

Power supply may then be switched on step by step to the transformers and busbars and the indications on the control panel checked. Subject to everything being in order, operation of the various control-gear can be checked, followed by tripping of circuit breakers by manually closing the contacts of the protective relays. Finally, overall confirmatory test may be conducted of the correct tripping of circuit breakers when close against dead-short circuits on the 25 kV busbar. This test will also confirm if the settings of the grid sub-station relays are properly co-ordinated with the settings of the traction substation relays so that the grid substation CB’s do not trip for a fault on the 25 kV installations.

4. The two transformers may then be kept energized continuously. An experienced supervisory official should be deputed to keep a close watch on the equipment for the first three days, followed by a detailed inspection after a week and then after fortnight.

Should a circuit breaker trip during the period, the cause should be carefully investigated. The annunciator panel should be checked to ascertain which of the relays have operated. Occasionally the Buchholz relay may operate. A probable cause for this when a transformer is energized for the first time is that air bubbles which may have been entrapped between the windings when oil is filled into the transformer tank, may get released when the transformer gets warmed up and may operate the Buchholz. However, a careful check is still necessary to ascertain the cause of every tripping.

5. 25 kV power supply may he extended up to the feeding posts if all work on 25 kV feeders and the feeding posts has been completed in all respects, after taking the usual safety precautions.
21007 Sanction of CEE and Electrical Inspector to the Railway

1. Application shall be submitted at least a fortnight before energization to CEE and Electrical Inspector to the Railway for the following:

(a) Formal approval, if not already received to the design and layout of all high voltage equipment including traction sub-stations, transmission lines, 25 kV feeders, switching stations, booster stations etc.

(b) Approval for energization of HT installations mentioned above including OHE,

2. The following documents shall accompany the application for El's sanction.

(a) Copies for Press cuttings of the Public notification as mentioned in para 21008.
(b) Certificate regarding OHE (proforma 10-03).
(c) Certificate regarding bonding and earthing (proforma 10-04).
(d) Certificate regarding safety instructions and precautionary measures (proforma.10-05).
(e) Certificate by DRM regarding safety precautions (proforma 10-06).
(f) Copies of insulation resistance test results of OHE.
(g) Insulation test results values for auxiliary and booster transformers.
(h) Test results for equipment in switching stations and sub-stations and their safety certificates, if earlier sanction for the energizing this is not obtained separately.
(i) Clearance certificates form Deptt. of Telecommunication.
(j) Any other data, test results and certificates required by the Electrical inspector.

The sanction of the Electrical inspector may be issued in the proforma 10-07.

21008 Notification Regarding Energization of OHE

1. A notification indicating the intention to energize completed section/s of OHE, a month in advance of the approximate date on which the line is expected to be energized, will have to be issued to the following:

(a) The Press.
(b) The CRS and CEE and Electrical Inspector.

(c) General Manager, Chief Operating Manager, Chief Engineer/Construction, Chief Commercial Manager, Chief Mechanical Engineer, Chief Signal and Telecommunication Engineer, Chief Security Officer and Divisional Railway Managers concerned.
(d) Power Supply Authorities.
(e) Posts & Telegraphs Department.
(f) Field Officers of Railway Electrification.
(g) OHE Contractors
(h) Government Railway Police.

The notification shall be issued in the proforma 10-01 appended.

2. Notification regarding level crossing gauges:

At least a month in advance of the energization of a section, a notification in the proforma 10-02 appended shall be issued by the concerned Railway for the safety of public and vehicles using level crossings. This notification shall be published in local papers and also in the Gazettes of Railways and State Govt.

3. Notification for particular section to be energized:

At least a fortnight in advance of the probable date of energization, a notification in the proforma 10-01 shall be issued by the field unit of RE construction, notifying all concerned of the energization of the relevant portion of the section.

21009 Application to CRS

1. Sanction is required from the CRS in respect of

(a) Introduction of electric traction on any railway or section of a railway;

(b) bringing into use any type of electric locomotive or EMU or to operate any in service at speeds higher than those already sanctioned;

(c) For new yard lines/loop lines/sidings being laid down and electrified: Electrification of existing lines on already electrified sections/loops/sidings/yards lines of length not more than 2 km permission to introduce electric traction shall be granted by Electrical Inspector.

2. Prior to the energization of any section, the following certificates and documents shall be submitted to the CRS:-

(a) General Safety Certificate of Works, signed by CEE and CSTE of the Construction Organization.

(b) Safety Certificate for electrical works signed by CEE of Open Line and CPM/CEE/Dy. CEE of the RE Organisation.

(c) Safety Certificate in respect of electric rolling-stock signed by CEE, CME, COM and CE of the Open Line Railway.

(d) Certificate of Open Line Officers about the knowledge of their staff regarding safety rules for electrified sections.

(e) Certificate issued by DRM of Open Line regarding introduction of safety measures, issue of Special Station Working Rules and obtaining assurance of the staff concerned regarding their knowledge of rules applicable to ac traction.

f) Copies of Station Working Rules which have been distributed to the various Station Masters.

21010 Procedure for Energization

1. The inspection of the entire section will be carried out by means of an OHE Inspection car by CRS alongwith CEE or his HoDS, Chief Project Manager (CPM)/RE alongwith their concerned officers and the concerned Divisional Officers. During this inspection particular attention is paid to the safety and operational aspects of the
train movements and that staff are in possession of statutory rule books, Instructions Book, Registers, forms etc. and that transportation, Electrical, P-Way and S&T staff are fully acquainted with their duties after ac traction is introduced. CRS may issue sanction to energize the OHE and authorise trial runs with light electric locomotive as well as a few goods trains.

2. Wide publicity through the Press and posters given earlier would keep the public fully informed about the proposal to electrify the lines and warned to danger of live OHE. The Station Masters should, nevertheless, advise and warn all passengers of the danger of 25 kV OHE and not allow them to ride on the roofs of coaches. All Diesel and Steam engine Drivers should also be advised that they should, under no circumstances, climb over engines or tenders when they are under the OHE, as they will endanger their lives by coming close to the live OHE. Train watering staff should also be cautioned so that they may not inadvertently climb on the carriages, by old habit.

**Energization of OHE.**

3. On the appointed day and hour, all concerned will assemble either at a feeding post or at the RCC assuming it has already been commissioned. The entire energization operation shall be carried out under one Senior Electrical Officer who will be nominated for the purpose. He will first collect the following Clearance Certificates:

(a) Certificate from Contractors working on OHE, switching stations, booster transformer stations, RC and also from other agencies whose staff were engaged on construction works, to the effect that their men have been withdrawn from work, that they have been warned that installations would be energized and that no work be done thereafter without obtaining a permit-to-work.

(b) Joint Certificate by the RE and Open Line Sr.DEEs stating that they have withdrawn their staff and warned them as above and that the installation has been jointly inspected and is fit for energization and also that due precautions have been taken to protect contiguous sections where men may be working.

(c) Certificate issued by S&T Officers that their work has been completed and the OHE can be charged at 25 kV ac.

(d) Certificate of the CEE and Electrical Inspector of the Railway permitting energization.

(e) Certificate of clearance from DOT for energisation of OHE; provided further that no such clearance shall be necessary in cases of additions and alterations to traction Installations on existing electrified routes where CEE and EIG is satisfied that the amount and nature of traction energy transmitted in the system as a whole, will remain unaltered.

Standard forms for issue of typical certificates and notification mentioned in this chapter are appended at the end of this Chapter.

4. The Senior Electrical Officer in-charge of the energization programme will supervise the detailed sequence of operations to switch on 25 kV supply progressively, step by step, starting with 25 kV feeders from the sub-station to the feeding post, busbars of the feeding post, followed by one sub-sector after another until the whole section is energized. It is best to start by keeping all circuit breakers and interruptors in the open position so that one after the other they may be switched on according to a prearranged programme. The merit of this procedure is that a faulty sub-sector, if any, is immediately identified. Alternatively, the whole section covered by a sub-station may be energized at one go. Should the feeder circuit breaker trip, it will be necessary to identify the faulty sub-sector and arrange for its rectification. Before commencing energization, certain essential staff should be kept ready at strategic locations enroute to rectify any faults which may be detected.

5. A short time after the energization of OHE confirmatory tests for proper operation of the protective relays as per para 20931 shall be carried out.
21011 Precautions to be taken for Progressive Energization of OHE

Sometimes it may not be possible to energize the entire length between two neutral sections served by a sub-station, but it is still desirable to resort to progressive energization of one sub-sector after another as an anti-theft measure keeping pace with the completion of work by the Contractors. In such cases of partial energization, it is essential to take special precautions to protect men who may be working on the OHE on sections adjacent to the energized section. This is ensured by maintaining at all times two disconnections in the OHE between the working party and the live OHE. The disconnection may be either an insulated overlap or an isolator or two sections insulators in series on the contact wires with corresponding isolation of the catenary. This double protection is necessary to provide for the possibility, however remote, of an overlap span becoming short circuited because of a stray fault. The action to be taken is illustrated in Fig. 10.01, which shows a single track section but the method applies equally to a double track section.

![Diagram of energization process](image)

**FIG. 10.01**

In the figure:

- **E** - is the section which has already been energized.
- **A** - is the section which is to be energized at 25 kV.
- **B** - represents at least one adjacent OHE section on which the entire work of adjustment, inspection and testing has been completed and is ready for energization. This section should be solidly earthed by a 105 mm² jumper between the OHE and one of the supporting structures solidly bonded to the rails.
- **C** - is the section beyond B on which work may go on freely even after A is energized, since section ‘C’ is fully protected by two air gaps A-B and B-C and two independent earths on B and C as shown. Section C should also be earthed.

21012 Final Inspection by CRS for the Introduction of Commercial Services

1. A special train comprising of an electric locomotive, observation car in the rear and appropriate number of coaches or inspection carriages for officers and staff and Guard’s Brake van, shall be kept ready at an appropriate location to take CRS, CEE, CPM & HODs of RE organisation along with concerned divisional officers of open line and Senior Officers of RE for a final inspection as per a prearranged programme. The officers on the special train shall furnish whatever information/clarification sought by CRS and CEE.

2. During this inspection CRS will particularly examine the safety and operational aspects, inspect the rule-books, registers in possession of staff and test the knowledge of the staff such as engineering gangs, substation staff, transportation staff at stations, cabin etc.
21013 Sanction of CRS
Subject to the trial run being satisfactory, an "all concerned message" may be issued by the CRS communicating his sanction for the introduction of commercial services.

After the receipt of CRS's sanction, commercial services may be commenced either immediately or subsequently. It is, however, desirable wherever possible to check the performance of the electric locomotives and OHE for sparkless current collection at different speeds during night time, when hauling a fully loaded train. These tests may be conducted jointly by Dy.CEE(OHE)(RE), Sr. DEE(TRD) and Sr. DEE (PS) along with representatives of the OHE Contractor. Defective working noticed shall be rectified as soon as possible and on successful completion of the tests, a joint certificate shall be given confirming that full commercial working may be introduced.

21014 Anti-theft Energization
To overcome the problem of copper wire thefts, it may sometimes be necessary to charge the conductors at 2.2 kV. Guidelines for such charging of OHE are given in the Appendix VII to this Volume.

21015 Responsibility for Maintenance and Provisional Acceptance Certificate
1. When a long sections is under Electrification, shorter sub-sections are often energized as an anti-theft measure. Till such time commercial services are not introduced after CRS's inspection and sanction, the OHE and other power supply and switching installations shall be maintained by the construction organisation.

2. With the energization of the OHE and CRS's sanction and introduction of commercial services, all electrical equipment including sub-stations and all other connected equipment are deemed as having been taken over the Open Line of the Railway and thereafter the responsibility for operation and maintenance shall devolve on the Divisional Officers concerned.

However, in order to ensure that all works are completed by the construction organisation, a specific "Handing Over" procedure may be evolved by openline CEE, CSTE & CE to bring out left over work if any, to be completed even after introduction of commercial services. The construction organisation shall have such work completed in a reasonable period.

3. A letter of "provisional acceptance" shall then be issued by the head of the Construction Organization to the various Contractors in respect of the equipment erected and handed over by them. Should the test results for any particular equipment or Installation be unsatisfactory, an extension may be given to the Contractor to have the defects set right and to hand over the installation in good condition. When this has been done, a separate letter of acceptance shall be issued in respect of such equipment. The provisional acceptance certificate shall be jointly signed by the concerned Dy. CEE of the Railway Electrification Organization and Sr. DEE (TrD) and Contractor's authorized representative.

21016 Contractor's Responsibility During Guarantee Period
1. This is defined by the terms of the contract. Norwilly, the Contractor of a "supply and erection" contract guarantees the satisfactory operation of all equipment and Installations for a period of twelve months from the date of issue of "provisional acceptance certificate". The contractor provides the services of an experienced Engineer to maintain liaison with Officers of the Open Line and the Construction Organization and help in rectification of defects observed and investigation of serious breakdowns of equipment, and advise on the maintenance procedures. The contractor is expected to bear the cost of all modifications, additions and substitutions which may be considered necessary due to faulty materials, design or workmanship of the Installations for which he is responsible.

2. Most of the heavy equipment for sub-stations, switching stations, booster stations etc. are usually obtained from different manufacturers against a "Supply Contract". In such cases, the usual guarantee clause provides for suppliers responsibility for a period of 12 months from the date of commissioning or 18 months from the date.
of supply-whichever is earlier. A clear record should, therefore, be maintained of the dates of receipt of the equipment and the dates of energization of each equipment so that the period of responsibility of the Contractor is clearly defined.

3. It is essential for the Electrical Officers and Supervisors concerned to make a careful study of the contract documents so that appropriate action may be taken as circumstances dictate. In regard to the defects noticed during the guarantee period the procedure to be followed for reporting and investigation are described in the next para.

21017 Failure of Equipment After Commissioning and During the Guarantee Period

Although during this period the equipment is operated and maintained by the Open Line Railway Engineers, the procedure described below should invariably be followed to ensure that defects noticed during the guarantee period are rectified by Manufacturers under the Guarantee Clause.

1. Instructions issued by the manufacturers for operation and maintenance should be strictly followed by the Railway. If any modification is required, approval of the Manufacturers should first be obtained. The standard Guarantee Clause provides that the equipment shall be free from defects in material and workmanship during manufacture. The liability of the supplier in this respect is norwilly limited to the supply and installation of replacement parts, free of charge, and repair of defective parts noticed during normal usage of the equipment as also those, attributed to faulty design of the equipment. If the equipment becomes irreparable the supplier will have to replay the same in its entirety.

2. It is essential that any defect noticed is brought to the attention of the supplier without delay. A clear record of defects and deficiencies noticed shall he entered in a register by the Open Line Officer and the date of intimation to supplier recorded against each item.

3. When an equipment fails, the Sr.DEE shall first make an inspection of the equipment on the spot with the least possible delay along-with the representative of the Contractor. The presence of the Manufacturer's or Contractor's representative is essential and should be ensured during the joint inspection to avoid disputes later on. The defective equipment shall not be dismantled or disturbed except with the approval of, or in the presence of, the representative of the supplier, to avoid obliteration of any important evidence which could help in investigation of the defect. After the inspection, a joint report shall be prepared recording the relevant data such as-

(a) Full particulars of the equipment - date received and date commissioned.
(b) Full circumstances in which failure occurred.
(c) Observations and tests made
(d) Probable cause that could lead to the failure.
(e) Recommendations, long term and short term, for preventing such failures in future.

4. -Should there be repeated failures of the same type, the cause of failure should be investigated intensively, taking all connected factors into account such as switching operations carried out, maintenance work done etc. These factors should be statistically analyzed. A report on the failure of the equipment should be sent promptly to the supplier of the equipment endorsing a copy to the COS, Inspection Agency, CEE and RDSO.

In the case of works contracts, too, the same procedure should be followed.

6. According to the provision of the contract, in the event of design defects, the contractor's liability is not only limited to repair/replacement of the components/equipments affected; but also to all other components in similar situation/condition. even though they may not have failed in service, have to be replaced or modified by the supplier. This aspect needs careful study by the Sr.DEEs.
21018 History Sheet

Maintenance of a History sheet for each major equipment is very important as this will give a
connected account of all failures of the equipment and particulars of repairs carried out and will be
of great help in investigating recurring failures.

21019 Final Acceptance Certificates

Immediately after the completion of the guarantee period, a ‘final acceptance certificate’ shall be
jointly signed by the Sr. DEE of the concerned Railway and Contractor’s representative and
countersigned by the head of the Construction Organisation and issued to the Contractor, provided
that the terms of the Guarantee Clause have been fulfilled. With the issue of the final acceptance
Certificates, the responsibility of the Contractor or Supplier ceases, but their advice may still be
sought where it may be considered necessary.

21020 Standard Forms

Typical forms for issue of notifications and certificates mentioned below are appended at the end of
this chapter.

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<th>SN.</th>
<th>Particulars</th>
<th>Proforma</th>
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<td>Public Notification regarding energisation</td>
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<td>2.</td>
<td>Public Notification regarding level crossing</td>
<td>10-02</td>
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<td>3.</td>
<td>Joint Certificate regarding OHE by Sr. DEE(TrD)</td>
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<td>&amp; Dy. CEE(OHE)/RE</td>
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<td>4.</td>
<td>Certificate regarding bonding and earthing</td>
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<td>5.</td>
<td>Joint Certificate by Divisional Officers regarding safety instructions</td>
<td>10-05</td>
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<td>6.</td>
<td>Certificate by DRM regarding safety measures</td>
<td>10-06</td>
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<tr>
<td>7.</td>
<td>Sanction of CEE and Electrical Inspector for energisation</td>
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<td>8.</td>
<td>Certificate by S&amp;T Department</td>
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<td>9.</td>
<td>Clearance certificate by DOT</td>
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<td>Clearance Certificate for 25 KV feeder line</td>
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<td>Clearance Certificate for Booster Transformer Station</td>
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<td>Clearance Certificate for DOT and works</td>
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<td>Clearance Certificate by OHE Contractor</td>
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<td>Clearance Certificate by Switching Station Contractor</td>
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<td>Clearance Certificate by Remote Control Equipment Contractor</td>
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<td>18.</td>
<td>Clearance Certificate by Contractor for Booster Transformer Installation</td>
<td>10-18</td>
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</tbody>
</table>
Notice is hereby given to all users of Railway lines and premises situated on the completed section of the under-noted section of the ............ Railway that the 25000 Volt, 50 Hz., ac overhead traction wires will be energized on or after the date specified against the section. On and from the same date the overhead traction line shall be treated as live at all times and no unauthorized person shall approach or work in the proximity of the said overhead line.

<table>
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<tr>
<th>Section</th>
<th>Date</th>
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<td>4.</td>
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</tbody>
</table>

Chief Project Manager  
Railway Electrification

(To be published in all the leading Newspapers and local Railway Gazette in English, Hindi and local language for one day at least a week before the date of commissioning. Also notices to be pasted at all Railway Stations and Offices to give wide publicity).

Copy forwarded for information to:-

1. The Secretary (Railway Electrification), Railway Board, New Delhi.
2. The Commissioner of Railway Safety.
3. The Chief Electrical Engineer and Electrical Inspector.
4. All other Heads of Departments.
5. The Divisional Railway Managers of the Railway and contiguous Divisions.
6. The General Manager (DOT) Railway Electrification Project,
7. The Postmaster General,
8. The Chief Engineer, State Electricity Board.
10. All officers of Construction Organisation.
11. Contractors engaged in the project.

PLACE: Chief Project Manager  
Date Railway Electrification
"WARNING TO ROAD USERS"

It is notified for information of the Public that in connection with introduction of 25 kV ac electric traction over the section ............... of the ............ Railway, height gauges have been erected at all the level crossings with clear height of 4.67m above road level with a view to prevent loads of excessive height from coming into contact or dangerous proximity to live traction wire.

Public are hereby notified to observe the height specified above for the purpose of loading vehicles and to see that the loads carried in road vehicles do not infringe the height gauges under any circumstances.

The dangers of a load of excessive height are as follows:

i) Danger to the height gauge and consequent obstruction to the road as well as the railway line.

ii) Danger to the materials or equipment carried or the vehicle itself.

iii) Danger of fire and risk of life due to contact with or dangerous proximity to the conductors.

No.

Date           Chief Project Manager
Railway Electrification

(To be given wide publicity through the press and posters well in advance of erection of height gauges).

Proforma 10-03

CERTIFICATE REGARDING OHE

Certified that the OHE in the above mentioned section has been erected as per approved and standard specifications and there are no infringements to the Schedule of Dimensions (including the Rules applicable for 25 kV ac traction) except when approval of Railway Board/competent authority has been obtained. The OHE has been inspected and found to comply with the above requirements.

Sr. DEE (TRD) Dy. CEE(OHE),
RE

PLACE:

Date

Proforma 10-04

CERTIFICATE REGARDING BONDING AND EARTHING

Certified that bonding and earthing of the section have been carried out as per the "Bonding Code" and as per approved drawings.

Dy.CSTE(Signalling) Sr. DEE (TrD) Dy.CEE(OHE), RE

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME 11 PART
Proforma 10-05
CERTIFICATE REGARDING SAFETY INSTRUCTIONS AND PRECAUTIONARY MEASURES

Certified that requisite instructions in connection with working on tracks and areas equipped with 25kV ac traction have been issued to all categories of staff of various departments working on and required to work on the section.

Further, it is certified that all staff have been made fully conversant with the safety and precautionary measures to be taken when working in the electrified areas.

SR.DOM    DSO    SR.DEN    SR.DME
SR.DSTE    Sr. DEE (G)    Sr. DEE (TrD)

Countersigned
Divisional Railway Manager

Proforma 10-06
CERTIFICATE BY DRM REGARDING SAFETY PRECAUTIONS

I do hereby certify that:-

(i) Stations on the electrified sections between ... have been supplied with a copy of General and Subsidiary Rules for 25 kV ac electric traction.

(ii) Special working rules for 25 kV ac electric traction have been issued and supplied to all stations and cabins on the electrified sections.

(iii) The staff have been advised of the necessary safety procedures and precautions as laid down in General and Subsidiary Rules and Manual for ac Traction Maintenance.

(iv) All the sectional running and maintenance staff have also been duly instructed in safety procedure and precautions for 25 kV ac electric traction.

(v) The assurance of the station, running and maintenance staff regarding their knowledge of safety procedures and special working rules has been obtained.

Divisional Railway Manager

IN INDIAN RAILWAYS - AC TRACTION MANUAL; VOLUME 11 PART [217]
Proforma 10-07

To,

Chief Project Manager
Railway Electrification

Sub: Sanction for energization of overhead equipment, switching stations, booster transformer stations etc. on the Section.

Sanction is hereby accorded to energize progressively the completed works for 25 kV feeder lines from traction sub-stations to feeding posts, switching stations, booster transformer stations and auxiliary transformer stations, as and when each section is completed and jointly inspected, measured IR value and certified by Sr.DEE(TrD)/ ................. and DY.CEE (Construction).

Chief Electrical Engineer
and Electrical Inspector,
 ..................... Railway.

Proforma 10-8

Chief Project Manager
Railway Electrification

Reg: Energization of the OHE in the section ........................................................... -Signalling Works.

1. All modifications to mechanical and electrical signalling have been carried out to make the installations suitable for introduction of 25 kV ac traction.
2. Colour light signalling has been installed at ............... stations and the mechanical semaphore signals have been re-sited and/or their heights increased to afford necessary visibility to the engine crews.
3. The existing block and token instruments have been modified to suit the introduction of 25 kV ac traction.
4. All overhead signalling circuits have been transferred to underground cables. Communication installations have been modified to make them suitable for 25 kV ac traction. Traction Loco Control, Traction Power Control and Emergency Control circuits have been introduced with emergency sockets alongside the track as per approved plans.
5. The new signals have been erected and the existing signals re-sited without infringement to the Schedule of Dimensions" except where approval of Railway Board/competent authority has been obtained.
6. Necessary rule books in connection with working in the section energized with 25 kV ac have been issued to the staff concerned. Specified insulated tools have been issued to the S&T staff for working in the above section.
7. The modifications and the new works mentioned above have been done according to the "Manual of Instruction for Installation of S&T Equipment on 25 kV, 50 Hz ac Electrified Sections".
8. The undersigned has no objection to the energization of the section mentioned above with 25 kV ac with effect from ............

Dy.Chief Signal and Telecommunication Engineer (Railway Electrification)
Proforma 10-9
CLEARANCE CERTIFICATE

Chief Project Manager
Railway Electrification

Sub: Energization of OHE in the Section ...................................................

The DOT has completed all its works in connection with electrification of the above section at 25 kV ac and has no objection to; the Railway energizing the OHE with 25 kV ac in the above section.

for General Manager
(Electrification Circle)

Proforma 10-10
CLEARANCE CERTIFICATE FOR ENERGIZATION ON 25 kV

1. 25 kV Feeder Lines

1. Detailed description of installation to be energized:

25 kV double circuit feeder line from... substation to......................... feeding station near the tracks.

It is hereby certified that:

a) The above installation has been jointly checked tested for completeness, electrical clearances, insulation resistance, earthing etc. and found in order. Test results are separately submitted.

b) The works have been completed in accordance with approved and complies in all respects with the requirements of the "Manual of ac Traction Maintenance and Operation", Indian Electricity Rules and special instructions on the subject.

c) All our staff have been withdrawn and warned that the line will be charged at 2.5 kV ac immediately. Clearance Certificate to the same effect have been obtained from all the Contractors working on the above section. No work on the above section will be taken up hereafter without obtaining a power block from an official authorized by Sr. DEE (TrD).

d) All other safety precautions necessary have been taken.

3. The 25 kV feeders referred to above are now clear and fit for energization and may be energized at 25 kV ac.

4. Forwarded to CEE(RE).

...........................................         DY.CEE (OHE)RE
Sr. DEE (TrD)

PLACE.
Date.

INDIAN RAILWAYS - AC TRACTION MANUAL VOLUME 11 PART 219
Proforma 10-11
CLEARANCE CERTIFICATE FOR ENERGIZATION ON 25 kV

2. Overhead Equipment

1. Detailed description of overhead equipment to be energized:

2. It is hereby certified that:

   a) The above overhead equipment has been jointly checked for completeness, electrical clearances and tested for insulation and continuity, electrical independence of different elementary sections as also bonding and earthing etc. and found to be in order.

   b) The work has been completed in accordance with the latest approved generally supply diagram and sectioning diagrams etc. and complies in all respects with the requirements of "Manual of ac Traction Maintenance and Operation" and Indian Electricity Rules.

   C) All our staff have been withdrawn and warned that the line &411 be charged at 25 kV ac immediately. Clearance Certificates to the same effect have been obtained from all the Contractors working on the above section. No work on the above section will be taken up hereafter without obtaining a power block from an official authorized by SR.DEE (TrD).

   d) All safety precautions necessary have been taken. In accordance with "Manual for ac Traction Maintenance and Operation" Sections viz ...................... have also been adjusted, checked and made ready for energization. Solid earths have also been provided on contiguous sections viz. at structures Nos ...................... Isolating switches Nos .............. and interruptors Nos ........... have been opened and kept locked in the open position.

3. The overhead equipment referred to above is now clear and fit for energization and may be energized at 25 kV ac.

4. Forwarded to CEE(RE).

............................
Sr. DEE (TrD)
PLACE ........................
Date ........................
............................
Dy.CEE(OHE),RE

Proforma 10-12
CLEARANCE CERTIFICATE FOR ENERGIZATION ON 25 kV

3. Switching Stations

Detailed description of switching stations to be energized:

a) The above switching stations have been jointly checked and tested for completeness, correct electrical connections including cross-feeder connections, electrical clearances, insulation resistance, earthing and bonding etc. and found to be in order. Test reports are separately submitted.

b) The works have been completed in accordance with approved drawings and complies in all respects with the requirements of the "Manual for ac Traction Maintenance and Operation", Indian Electricity Rules and special instructions on the subject.
C) All our staff have been withdrawn and warned that the line will be charged at 25 kV ac immediately. Clearance Certificate to the same effect have been obtained from all the Contractors working on the above section. No work on the above section will be taken up hereafter without obtaining a power block from an official authorized by Sr. DEE (TrD).

d) All other safety precautions necessary have been taken.

3. The switching stations referred to above are now clear and fit for energization on 25 kV ac.

4. Forwarded to CEE(RE).

Sr. DEE (TrD)  
Dy.CEE(PSI),RE  
PLACE: ..............
Date: ..............

Proforma 10-13  
CLEARANCE CERTIFICATE FOR ENERGIZATION ON 25 kV

4. Booster Transformer Stations

1. Detailed description of Booster Transformer Stations to be energized:
2. It is hereby certified that: -

a) The above Booster Transformer Stations have been jointly checked and tested for completeness, correct electrical connections including cross-feeder connections, electrical clearance, insulation resistance, earthing, bonding, midpoint rail connections and found to be in order. Test reports are separately submitted.

b) The works have been completed in accordance with approved and complies in all respects with the requirements of the “Manual for Traction Maintenance and Operation”, Indian Electricity Rules and special instructions on the subject.

c) All our staff have been withdrawn and warned that the line will be charged at 25 kV ac immediately. Clearance Certificates to the same effect have been obtained from all the Contractors working on the above section. No work on the above section will be taken up hereafter without obtaining a power block from an official authorized by SR.DEE (TrD).

d) All other safety precautions necessary have been taken.

Forwarded to CEE (RE).

Sr. DEE (TrD)  
Dv.CEE(PSI),RE  
PLACE: ..............
Date: ................
Proforma 10-14
CLEARANCE CERTIFICATE FOR ENERGIZATION ON 25 kV

5. DOT and S&T WORKS

1. Description of section for which clearance is given:

2. It is hereby certified that:-
   a) Clearance has been obtained from the DOT, Electrification Circle that the overhead equipment, switching and booster transformer stations on the above section may be energized at 25 kV. ac.
   b) All S & T works have been completed in accordance with approved and instructions, and complies in all respects with requirements of "Manual for ac Traction Maintenance and Operation" and special instructions.
   c) All our staff have been warned that the above section would be charged on 25 kV ac immediately. No work on or within 2 m of the line OHE would be parried out hereafter without obtaining a power block from an official authorized by SR.DEE (TrD).
   d) All safety precautions necessary have been taken, in accordance with "Manual for ac Traction Maintenance and Operation".

3. The sections referred to above may now be energized on 25 kV ac.

......................
Dy.CSTE(Sig.

......................
DY.CSTE (Tele)
PLACE........
Date........

Proforma 10-15

The DY.CEE (OHE).
..................... Electrification Project

Sub: Clearance Certificate by Contractor for energization on 25 kV ac in Section..

Dear Sir,

1. It is hereby certified that all our work on the above section has been completed.

2. It is hereby certified that all our staff have been withdrawn and warned that the above section would be energized on .......... and that no one may henceforth carry out any work on the above section without obtaining a permit-to-work from an official authorized by SR.DEE (TrD).

3. Adequate precautions will also be taken by our staff when working in areas contiguous to the section electrified on ac 25 kV system or on parallel lines.

4. The dead overhead sections contiguous and adjacent to the electrified sections have been and will be kept solidly earthed. The installations on the above section are now ready and safe for energization. They may now be charged at 25 kV ac, 50 Hz, supply.

Yours faithfully,

for M/s ..............
Contractor for OHE.

INDIAN RAILWAYS --- AC TRACTION MANUAL - VOLUME 11 PART 1
Proforma 10-16

To
Dy.CEE(PSI),

..........................Electrification Project,
.......................... ...........................................

Dear Sir,

Sub: Clearance Certificate for energization of Switching Stations in Section .............................................

It is certified that all physical works have been completed on the following FPs, SPs, & SSPs and that these switching stations are fit to be charged with 25 kV ac single-phase, 50 Hz., electrical energy on and from ..............

All men, materials and earths have been removed from the switching stations and the OHE.

FP at ............
SP at .................
SSP at ...............

Yours faithfully,

for M/s ......................................... Contractor for Switching Stations

Proforma 10-17

To
DY.CEE (PSI),

.......................... Electrification Project,
.......................... ...........................................

Dear Sir,

Sub: Clearance Certificate for the commissioning of Remote Control Equipment in the Section..

It is certified that all works in regard to the Remote Control Equipment installed by us for the section .............. have been completed and that they are fit for commissioning.

All men and materials have been removed from the site of the equipment and from the vicinity of the switching stations.

Yours faithfully,

Date

for M/s ......................................... Contractor for Remote Control Equipment.

INdIAN RAILWAYS - AC TRACTION MANUAL - VOLUME 11 PART [223]
Proforma 10-18

To

DY.CEE (PSI),
.................. Electrification Project,
................................................

Dear Sir,
Sub: Clearance Certificate for the commissioning of Booster Transformers installed In the Section

Certified that all works in regard to Booster Transformer Stations installed in the Section ...... have been completed and the installations are fit for energization at 25 kV ac single-phase, 50 Hz., on and from ..........

All men, materials and earths have been removed from the Booster Transformer Stations and from the vicinity of the OHE.

Yours faithfully,
for M/s ....................................
Contractor for Booster Transformer installations

PLACE:

Date :

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME 11 PART 1 [224 ]
## CHAPTER XI

### RECENT DEVELOPMENTS

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CHAPTER XI
RECENT DEVELOPMENTS

21100 2x25 kV Auto-Transformer Feed System

1. Incoming Power Supply

The incoming power supply scheme is similar to 25 kV simple feed system. Power supply for ac traction is obtained from the nearest grid sub-station of the Power Supply Authority. For this purpose duplicate feeders, generally at 132 kV or 220kV, comprising only two phases are provided from the grid sub-station to traction substation.

The loads, however, are 2-3 times higher compared to 25 kV system and therefore Wood-bridge/V-connected transformers are provided in the traction substations to bring down the unbalance within acceptable limits. It is possible to absorb such unbalances without exceeding the permissible limits if the grid system capacity is adequate.

2. Power Receiving Arrangement: Traction Sub-station

The incoming extra high voltage power is stepped down to 2x25 kV by the main traction power transformer. The 2x25 kV supply is then fed to an auto-transformer. One terminal of the auto-transformer is connected to the overhead catenary wires and the other terminal to a feeder wire which runs parallel to overhead contact/catenary wire all along the section and is usually supported from super masts fixed on the OHE structures. The mid point of the auto-transformer is connected to the rail, thus providing a 25 kV supply, with reference to the rail potential, for traction.

The capacity of the auto-transformers and their spacing is decided based on the traffic pattern in the section.

The general arrangement of the scheme for 2x25 kV auto-transformer feeding system is indicated at Fig. 1.0.1 This is for a Scott connected transformer substation.

3. Distribution of Traction Power Supply

Feeding Post (FP)

The arrangement at the feeding post is generally similar to that at the 25 kV conventional system feeding post.

Sectioning and Paralleling Post (SP)

A short neutral section is provided in the OHE opposite the feeding post as well as mid-way between two adjacent traction substations. The feeder wire is also provided with a neutral section by means of two cut-in insulators coincidental in space with the ends of the neutral section.

Sub-sectioning and Paralleling Post (SSP)

The arrangement at the SSP is generally similar to that at the 2SkV conventional SSP system.

Auto-Transformer Post

These are provided adjacent to the track through-out the length of the section. The spacing and capacity of the auto-transformers is decided as a part of system design based on specific requirements and traffic pattern. Typically the spacing is 15 km and capacity 2 MVA. Distribution of current in AT system is shown in Fig. 11.02.
2x25 kV AUTO TRANSFORMER FEED SYSTEM TRACTION SUBSTATION
(SCOTT CONNECTION TYPE)

EHV ISOLATOR
CIRCUIT BREAKER

EHV/50 KV SCOTT CONNECTED TRANSFORMER

CIRCUIT BREAKER
ISOLATOR

FIG. 11.01

INDIAN RAILWAYS – AC TRACTION MANUAL - VOLUME II PART I [227]
2x25 kV AUTO TRANSFORMER FEED SYSTEM TRACTION SUBSTATION
(SCOTT CONNECTION TYPE)

EHV ISOLATOR

CIRCUIT BREAKER

EHV/50 kV SCOTT CONNECTED TRANSFORMER

CIRCUIT BREAKER

ISOLATOR

FIG. 11.01

INDIAN RAILWAYS – AC TRACTION MANUAL - VOLUME II PART I [227]
4. **Overhead Equipment:**

The OHE system is generally similar to that for the 25 kV conventional system except that an additional conductor, called feeder wire, is also run parallel to OHE, all along the length of the track. This feeder wire is insulated at 25 kV from the steel structure and at 2x25 kV from the traction OHE.

5. **Protective System:**

In addition to the relays and protection devices for the transformer protection, a set of following relays are provided at the traction sub-stations specially for 2x25 kV AT feed system.

- Distance relay
- AC failure detection device
- Over-current relay

**21101 OHE Recording-cum-Test Car**

1. For satisfactory current collection, the geometry of the overhead equipment is required to be maintained within very stringent limits. Presently monitoring of various parameters of overhead equipment like height, stagger, wear of contact wire, condition at the cross-overs and overlaps, is being done manually which could introduce errors in measurement due to individual's judgment. Moreover, it is time consuming. For the very high reliability of operation expected of electric traction system, mechanized monitoring of various parameters is essential.

2. Due to increasing demand for freight and passenger traffic, trailing loads and speed of trains are being increased gradually. Heavier freight trains hauled by one or two consists of locomotives will draw heavy currents from the substation. For meeting the requirement of increasing passenger traffic, trains with higher speeds are being introduced. In view of these developments, it is necessary to ascertain potential of the existing OHE and pantograph contact system for effecting requisite improvement and developing newer designs to achieve satisfactory current collection at higher speeds and heavier loads.

3. For achieving these objectives, efforts are on to develop an Overhead Equipment Recording cum Test Car. This car will be used to measure and record various parameters of OHE and pantograph both under static and
dynamic conditions. The proposed car will be of trailer type, suitable for running at speeds of 160 km/h with potential to run up to 200 km/h. The car shall be hauled by locomotive or attached to a train. The car will be provided with on-board computer based data acquisition and processing system. The facility for video recording of arcs generated due to interruption in current drawn by locomotive as a result of loss of contact between pantograph and the OHE is also proposed to be provided.

4. The various parameters proposed to be monitored are:

*Measurements on pantograph:*

a) acrodynamic upward force of the pantograph;
b) contact force between pantograph and contact wire;
c) vertical and horizontal movement of pantograph;
d) quality of current collection - loss of contact;

*Measurements on OHE:*

a) height of contact wire;
b) stagger of the contact wire;
c) gradient of the contact wire;
d) detection of hard spots;
e) checking of crossovers and turn-outs;
f) body vertical acceleration;
g) body lateral acceleration;
h) quality of current collection - loss of contact.

**21102 Rail-cum-Road Vehicle**

Such a vehicle is suitable for propulsion both on the road as well as on the track. Two sets of wheels are provided for this purpose. This vehicle is provided with an extendible swivelling platform. The vehicle can be driven on road to the level crossing nearest to the work site and taken there on the track.

**21103 Transportable Self Propelled Trolley**

This is a self propelled trolley which can be transported by a truck to a point accessible through road, close to the work site, for carrying out work on OHE. The trolley is provided with extendible swivelling platform.

**21104 Dry Type Booster Transformer and Auxiliary Transformers**

Conventional oil filled transformers require lot of care and attention for maintaining the characteristic of oil within the permissible limits to avoid failure of Insulation.

Dry type cast resin transformer is a relatively new technology. The chief advantage of this type of transformer over the oil filled ones is that they are practically maintenance free. The copper in the windings cannot be retrieved from the cast resin and so the risk of theft is eliminated. There being no oil risk of fire and explosion are also absent. Dry cast resin transformers are currently under evaluation for their service performance.
21105 Static Distance Protection Relay for Protection of OHE

1. For the distance protection of the overhead equipment, the relay which is in use is the electromechanical type. This relay has a Mho characteristic as illustrated in Fig. 11.03. The relay is prone to trip on normal over loads because of its inadequate discrimination between load current and the fault current when the fault is at the farther end causing undesirable tripping of the feeder circuit breaker. This problem will be more acute in the future due to the further increase in traffic anticipated and the increase in the traction power transformer capacity at TSS.

2. To overcome the above problem RDSO has developed a static type distance protection relay. This relay is a three zone relay, the first two zones having Mho characteristic and the third zone having a lenticular characteristic with adjustable aspect ratio. The relay characteristic is illustrated in Fig.11.04. While the first zone operation is instantaneous, the second and third zones have adjustable time settings (zero to 1s). The first zone can be set to cover about 80% of the OHE from TSS to SP, the second zone to cover a distance which is slightly shorter than the distance to the adjacent TSS and the third zone may cover the adjacent TSS. By providing a time delay of about 0.4s to 0.5s in the second zone/third zone of the relay, adequate discrimination between faults from TSS to SP and SP to the adjacent TSS can be achieved - the under voltage relay at the SP acting as primary protection and the second/third zones of the distance relay at TSS acting as back up protection for faults beyond SP in case of feed extension. The settings of the various zones of the relay should be based on the RDSO's guidelines in this regard.

3. As an alternative to the static distance relay described above, the static relay with parallelogram characteristic as illustrated in Fig. 11.05 can also be used. At present these relays have to be imported. However, efforts to develop these relays indigenously are on. The advantages of this relay as compared with the electromechanical relay with Mho characteristic are similar to those of the static relay described above. The relay settings for this relay also should be based on the RDSO's guidelines in this regard.

21106 Composite Insulators

The conventional porcelain insulators have poor impact withstand capability. The sheds of such insulators are easily broken during handling and also due to acts of vandalism. The glazed surface of porcelain also does not have good hydrophobic property. These limitations can be overcome to a great extent with the use of composite insulators. The composite insulator comprises a porcelain (alumino) or a resin bonded glass fibre core and moulded sheds of elastomeric/plastic material e.g., silicone elastomer or poly-tetra-fluoro-ethylene (PTFE). The interface between the core and the sheds is sealed with special compound to prevent ingress of moisture and direct tracking along the length of the core. The end fittings are usually crimped to the core. Such insulators have exhibited excellent performance in simulated pollution tests. They also have excellent impact withstand capability. Efforts are on in RDSO to introduce such insulators.
FIG. 11.05

STATIC DISTANCE PROTECTION RELAY
WITH PARALLELOGRAM CHARACTERISTIC
4. Overhead Equipment:

The OHE system is generally similar to that for the 25 kV conventional system except that an additional conductor, called feeder wire, is also run parallel to OHE, all along the length of the track. This feeder wire is insulated at 25 kV from the steel structure and at 2x25 kV from the traction OHE.

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3. For achieving these objectives, efforts are on to develop an Overhead Equipment Recording cum Test Car. This car will be used to measure and record various parameters of OHE and pantograph both under static and
FIG. 11.05

STATIC DISTANCE PROTECTION RELAY WITH PARALLELOGRAM CHARACTERISTIC

LOAD IMPEDANCE
PERMISSIBLE LOAD CURRENT
LINE IMPEDANCE
LOAD ANGLE
SETTING ANGLE
L R
Zp
R
Z BACK OPERATING RANGE
FRONT OPERATING RANGE
X

OPERATING RANGE
LINE ANGLE

INDIAN RAILWAYS – AC TRACTION MANUAL - VOLUME II PART I
CHAPTER XII
TRAINING AND COMPETENCY CERTIFICATES

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CHAPTER XII
TRAINING AND COMPETENCY CERTIFICATES

1. TRAINING

21200 Introduction

Electric traction is a specialized field. Efficient operation and maintenance of the traction installations and equipment is only possible if the staff concerned have acquired an intimate knowledge of the details of construction, adjustments and operation of the equipment. A thorough knowledge of the special rules and procedures on the part of the staff is also essential to ensure safety of equipment and personnel. These requirements call for specialized training for all categories of staff before they can be entrusted with the responsibility for maintenance or operation.

21201 Planning of Training in Advance

Before electric traction is commissioned on any section, adequate strength of weft-trained operating, maintenance and running staff should be kept ready for manning the services. Planning the recruitment and training of such staff well in advance is one of the most important tasks of the open line administration. It is also necessary to establish sufficiently in advance suitable training schools with the facilities for imparting the training by qualified instructors.

21202 Categories to be Trained

Categories of staff for whom special training is required to be organized are generally as under-

1. Degree and Diploma holders recruited directly as Supervisors
2. Apprentice Mechanics to be absorbed as Supervisors
3. Trade Apprentices to be absorbed as, skilled artisans
4. Artisans and supervisory staff to undergo Refresher Courses.

21203 Initial Training

1. Categories of staff mentioned below should receive a period of initial training in a training school before they are posted to working posts-
   a) Directly recruited supervisors;
   b) Traction Power Controllers and Asstt. Traction Power Controllers;
   c) Skilled and semi-skilled artisan staff for maintenance of OHE, PSI and RC equipment;
   d) Any other category as approved by CEE.

2. The period of initial training for typical categories is given below, this may be modified by CEE in accordance with local requirements:
a) Directly recruited supervisors (Degree and Diploma Holders)-

i) OHE          12 months
ii) PSI       12 months
iii) Remote Control     12 months
iv) TPCs/ATPCS     18 months

b) Skilled artisans for maintenance-

i) Direct recruits     60 weeks
ii) To be absorbed from Diesel/Steam or Electric general services  30 weeks

3. In addition to theoretical training, the trainees should receive thorough practical training on the work they will have to perform on completion of training. In all cases they should have a period as under-study to senior and experienced staff in actual execution of the type of work they have to perform on completion of training.

4. For artisan staff the practical training should be so oriented as to enable them to understand and be able to carry out independently skilled work of the type covered by 'Inspection books', 'Inspection charts', 'trouble-shooting charts' and 'technical charts'. Courses of training for each separate branch viz. OHE, PSI and RC should be carefully planned and implemented for each category of staff.

21204 Promotional Courses

1. No employee should be promoted unless he passes the trade test or other prescribed departmental test.

2. Before an employee can be promoted, he should, as a rule, receive training to enable him to discharge his responsibilities in the higher post e.g., a semi-skilled fitter on promotion as a skilled fitter. Such training should precede the departmental tests which determine suitability for promotion. The training should be generally on the same lines as initial training, but the period may be curtailed since the employee would already have a certain amount of background knowledge on account of his experience.

Particular attention should be paid to the older men, who although very proficient in the practical aspects of their work, are unable to pass the prescribed trade tests etc. In regard to the theoretical aspects because of their poor educational background. It often happens in consequence that they are blocked from being promoted although they are fit in every other respect. By paying individual attention to such men and teaching them elementary theory, they could be made sufficiently trained to enable their passing the trade tests. This not only ends their frustration, but boosts staff moral as a whole.

21205 Refresher Courses

1. In accordance with extant instructions current on the subject, refresher courses should be arranged. This is obligatory for those categories of staff dealing with "safety of train operation or having daily contact with the public". The following is an illustrative list of traction distribution staff coming within the scope of these instructions.

-Traction Power Controllers
-Asstt. Traction Power Controllers
-Supervisors of OHE
-OHE Inspection Car Drivers
-linesmen authorized to take power blocks and permit-to-work

2. Refresher courses are also desirable for other categories of maintenance staff. The categories of staff for whom refresher courses are to be arranged can be decided by the General Manager in accordance with para 117(a) of the Indian Railway Establishment Manual.

3. The object of a refresher course is to reinforce and update the knowledge of the staff and bring them up-to-date in regard to the latest rules and procedures and Instructions regarding operation and maintenance in the light of experience gained. The duration of the refresher course for each category may be decided by CEE to suit local conditions. The duration for typical categories is given below for guidance:

   a) Supervisors      3 weeks  
   b) Artisan Staff      2 weeks

4. For categories of staff liable for inter-divisional transfers, programming of refresher courses should be arranged by the headquarters office. For staff confined to a particular division, the programming should be done at the divisional level.

5. Apart from rules and regulations, the refresher courses for the operating staff should lay emphasis on trouble shooting procedures for various types of equipments. Actual drilling during the refresher course will be of great benefit. This involves repetition of the same exercise several times so as to make a lasting impression on the staff and should not be forgotten easily.

6. For Linesmen and Supervisors of the OHE section the main emphasis during the refresher courses should be on standards to be observed in adjustments of OHE, safety rules applicable to OHE work and methods of quick restoration of OHE in the event of breakdowns/accidents.

7. During refresher courses, it will be very useful to arrange group discussions amongst the trainees on specific problems encountered during the course of work. Such group discussions will be of great assistance in view of the opportunity for exchange of information based on actual experience in working.

**21206 Facilities for Training**

1. Facilities have been provided on an All India basis for the intensive specialized training of officers and staff of the Electrical Department. The facilities available should be utilized to best advantage.

2. Training schools for OHE staff have also been set up where the specialized techniques of work on 25 kV OHE are taught to skilled artisans as well as supervisors with particular reference to safety rules applicable to OHE work and methods of effecting emergency repairs. For example a cat-walk at a height of about 5 m from ground level is provided, so that a trainee can climb up a post, walk across the cat-walk and get rid of the fear of height, he can be taught the methods of protecting himself by means of ropes and safety belts, the correct method of testing and earthing, the technique of erecting a mast, the correct method of using the various specialized OHE tools and equipment, the method of splicing various OHE conductors etc.

3. In a training school, the essential equipment to be provided for instructional purposes should include the following:

   a) Special tools and instruments used in electric traction.

   b) Cut-models to show constructional details of equipment.

   c) Circuit diagrams, sectioning diagrams, etc. illuminated and arranged to show the sequence of operations.
d) Samples of damaged equipment with tablets explaining the nature and causes of failures and preventive checks.

e) Publicity boards with slogans and illustrations emphasizing safe methods of working

f) Boards illustrating ‘Do's' and "Don'ts",

g) Preferably full working models.

21207 Training in General and Subsidiary Rules

Supervisors, when required, should receive initial training as well as refresher courses in General and Subsidiary Rules norrilly In the Zonal Transportation Schools, which usually have model rooms to facilitate the proper understanding of the rules and systems of working. In exceptional cases when such training cannot be arranged conveniently in the Zonal Schools, CEE may authorize the training in GRs & SRs to be included in the syllabus for training in TrD Training Schools. Separate Instructors well versed in the subject should, however, be deputed for imparting the training.

21208 Responsibility of Officers and Supervisors

Apart from those in-charge of training schools, other officers and supervisors in-charge of operation and maintenance should also take a keen personal interest in the trainees of all grades attached to them. They should deem it as part of their duty to guide the trainees and watch their progress. Training is a continuous process which helps the officers as much as the trainees not only in developing contacts on a personal level, but also in understanding the finer points of operation and maintenance. A record of progress achieved, the period of training given etc. should be maintained for every trainee.

21209 Examination at the End of Training

All trainees should pass the prescribed examination on completion of training. The scope of examination and the level of officers and supervisor responsible for examining will be laid down by CEE. The examination should have a practical bias.

21210 Specialized Training

1. Selected staff from different categories should be deputed to work with the Contractor's staff during OHE, PSI and Remote Control construction work, so that they become fully proficient in the various operations including erection, final adjustment, testing and commissioning.

2. Similarly when large contracts are entered into for supply of electric traction equipment incorporating new designs and technology, it is usual practice to include in the contract a clause which permits some staff of the consignee railways to be deputed to the manufacturer's works during the production stage for practical training on the equipment, so that they may get thoroughly acquainted with the operation and maintenance of the equipment, taking advantage of the training facilities available with the contracting firms.

21211 Syllabi

Outline syllabi for OHE Linesman is given below as examples. Syllabi on the same lines are prepared for all courses of training.

1. OHE Linesman (Initial Training) - Duration: 60 weeks.
   A. Theoretical:
      (a) Basic principles of electricity - clear understanding of "Current", "Voltage", "Power" "Resistance’
"Impedance" - use of common electrical measuring instruments, micrometer devices.

(b) Power supply arrangements for ac traction.

(c) Understanding the lay-out of OHE at feeding posts, running lines, turn-outs, crossovers, overlaps, neutral sections, yards etc.

(d) Standard values of clearances, setting distances, contact wire height, permissible gradient, stagger etc. applicable to 25 kV OHE.

(e) Detailed study of various fittings used on OHE viz. insulators, cantilever assembly, clamps, splices, section insulators, anchor fittings, isolating switches, jumpers - constructional details of such fittings and details of assembly and installations.

(f) Study of different types of masts and their foundations.

(g) Detailed study of various tools, tackles and other gadgets used in OHE section.

(h) Various types of bonds and earthing connections installed and maintained by OHE section.

(i) Safety rules for OHE work.

(j) Types of power blocks for OHE-work. Detailed procedure for imposition of power blocks and exchange of messages. Precautions to be taken before commencement of work and study of relevant GRs and SRs.

(k) Detailed study of common OHE defects to be looked for during patrolling and inspection.

(l) Prescribed forms for submission of patrol and other reports.

B. Practical

(a) Climbing up different types of masts and walking across a cat-walk at a height of 56 m to get over the fear of height.

(b) Practicing the use of various tools, tackles and gadgets used in OHE work.

(c) Practicing in the repair shop the correct way of assembly and installation of various OHE fittings.

(d) Study of the detailed procedure for imposition of power blocks and precautions to be followed for typical sections by mock drills including speaking over telephones and issue and receipt of messages.

(e) Drills in correct method of earthing the OHE.

(f) Field work with maintenance and construction staff so as to get acquainted with important items of work e.g. erection of mast and cantilever assembly, replacement of Insulators, installing splice-fittings, anchoring of wires, replacement of equipment, recording height and stagger etc.

(g) Patrol given section of OHE to spot out and report on defects.
11. COMPETENCY CERTIFICATES

21212 Authorized Person

An "authorized person" is one who is duly authorized to perform specific duties pertaining to his Employment, the authorization being made by the competent authority empowered for the purpose by, the Railway Administration.

21213 Competency Certificate

Each authorized person will be given a "Competency Certificate", defining the works which he is certified as competent to carry out after he has been trained, examined and found fit.

The following categories of traction distribution staff shall be issued with the certificates by the official indicated against each category after written/oral test as shown:

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<th>Category of certificate</th>
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<td>B. PSI SECTION</td>
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<tr>
<td>10. Supervisor</td>
<td>TR-9</td>
<td>DEE(TrD) after written and oral test.</td>
</tr>
</tbody>
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21214 Qualified Person to be in Charge of Motor Trolley

Officers and certain categories of supervisors of the traction branches will be required to use Motor Trolleys in electrified sections. Only those qualified in accordance With GR and SR and certified for the purpose shall be in charge of motor trolleys.

21215 Period of Training

The period of training mentioned in the following paragraphs may be modified as considered necessary by CEE, taking local requirements into account.
21216 OHE Inspection Car Driver

An OHE Inspection Car Driver should undergo courses of training and tests indicated below before the competency certificate is issued to him:-

1. General and Subsidiary Rules in the Zonal Training School or other approved establishment followed by a written, oral and practical test conducted by the school.

2. An oral and practical test by CTFO(OHE) to see if the employee is fully conversant with the mechanism and operation of the engine and running gear of the Inspection Car, as well as the details of maintenance he is required to carry out.

3. Training for a period of one month to learn the road in the section in which he is required to work the Inspection Car, at the end of such training the employee should sign a declaration that he is fully conversant with the road.

4. A period of practical training for 2 months in the actual driving of the Inspection Car under the supervision of a qualified Car Driver at the end of which a driving test will be taken by DEE(TrD).

5. Prescribed medical examination.

21217 Knowledge of Rules

Competency Certificate No. TR-1 may be issued to unskilled staff after the safety rules pertaining to their work are explained to them personally by ATFO or CTFO who should satisfy himself that the person concerned has fully understood the instructions, in particular what he is not permitted to do. For other categories of staff, copies of the relevant chapters of the "Manual of AC Traction" and other rules pertaining to their work should be issued to the employee along with the certificate and necessary endorsement to this effect made in the office copy of the respective certificate. That they continue to be aware of the rules prescribed and that they do in practice comply with them shall be checked from time to time by the CTFO and AEE and an entry made of such checks in the Register of Certificates (para 21218).

21218 Register of Certificates

A register of Competency Certificates issued shall be maintained in the office of every supervisory official, as per proforma given in Annexure 12.01, showing the names and designations of staff under him who have been issued with the Certificates.

21219 Service Record

An entry should be made in the service sheet of every employee who has been issued with a Competency Certificate.

21220 Inspections

During inspections Officers and Supervisors should make it a point to check the competency certificates in the possession of the staff and also test-check their knowledge of the rules pertaining to their work. -
# Proforma Register of Competency Certificates

<table>
<thead>
<tr>
<th>Name</th>
<th>Designation</th>
<th>Certificate No.</th>
<th>Date of test and issue</th>
<th>Name of the official who conducted the test</th>
<th>Station where the employee is posted at present</th>
<th>Date of periodic check</th>
</tr>
</thead>
</table>

| Annexure 12.01 |

---

**............. RAILWAY ELECTRICAL DEPARTMENT**

**CERTIFICATE OF COMPETENCY No. TR-1**

(For unskilled Class IV staff)

No. ................

Shri ............... S/o shri ............... is authorized to work as an unskilled Khalasi in the OHE/PSI' section to assist skilled staff and supervisors in maintenance, repair and installation work. The safety rules pertaining to his work have been persons explained to him by me. He is NOT authorized to work independently on any OHE line or Power Supply installation except In the presence of and under the direct supervision of an authorized person.

Date............... 

............... CTFO/ATFO

*Strike out item not applicable.
A fresh certificate should be issued when he is transferred to a new section after the safety rules pertaining to the new section are explained to him.

---

**............. RAILWAY ELECTRICAL DEPARTMENT**

**CERTIFICATE OF COMPETENCY No. TR-2**

(For OHE Linesman)

No. ............

Shri ....................................... S/o Shri................. has been examined for his knowledge of rules and is authorized to work as Linemen grade ................ in the electrified section from .......................... to ..........................

He is authorized to*-

- a) Take power block from TPC for 25 kV OHE/66/132/220 kV transmission lines and underground cables
- b) effect shut down in yards and sidings by operating isolator switches;
- c) operate switching stations on local control under instructions from TPC;
- d) carry out repair, installation and maintenance work on 25 kV OHE; duly observing the prescribed rules.

He is NOT authorized to-

- a) issue 'permits-to-work'; and
- c) bring into operation any new installation.

Date .................. 

............... AEE(TRD)

*Strike out item not applicable.
CERTIFICATE OF COMPETENCY No. TR-3
(For OHE Supervisor)

No. ..........................................

Shri ............................................. has been examined for his knowledge of rules and is authorized to work as a Supervisor on the installation, maintenance and repairs of 25 kV OHE and 66/132/220 kV Transmission lines and underground cables. He is authorized to:

a) issue permits-to-work ; and

b) bring into operation new installations after they have been inspected by an officer, duly observing the prescribed rules.

Date ...........

............... DEE(TRD)

CERTIFICATE OF COMPETENCY No. TR-4
(For OHE Inspection Car Driveis)

No. ............ 

Shri ............................................. is authorized to drive an OHE Inspection Car in the section between .............................................. and ..................................................... duly observing the safety rules and standing instructions. His written declaration* dated .................................................. that he is familiar with the road signals in the above section has been noted in issuing this certificate.

He is further authorized to carry out routine maintenance of the OHE Inspection Car in accordance with the prescribed schedules.

Date ..........

............... DEE(TRD)

*This declaration must be countersigned by Driving Inspector and personally scrutinized by the Officer before issue of this certificate. The Driving Inspector before countersigning the declaration, shall orally examine the employee for his knowledge of the road.
CERTIFICATE OF COMPETENCY No. TR-5
(For Skilled PSI staff)

No. ......................

Shri ................................................. has been examined for his knowledge of rules and is authorized
to work as a Fitter in the installation, maintenance and repair of Traction Power Supply installations
at sub-stations, switching stations, booster transformer stations and auxiliary transformer stations.
He is authorized to -

1) .effect shut down on 25 kV equipment under instructions of TPC;

ii) take power block from TPC for working, on 25 kV equipment;

iii) operate equipment at traction sub-stations and switching stations under instructions from TPC,
duly observing the prescribed rules.

He is NOT authorized to-

a) issue permits-to-work;

b) effect shut downs or take power block for extra high voltage (EHA installations and

C) bring into operation any new installation,

..............
AEE(TRD)

CERTIFICATE OF COMPETENCY No. TR-6
(For Supervisors of PSI)

No.................

Shri ................................................ has been examined for his knowledge of rules and is authorized
to work as a Supervisor on the installation, maintenance and repair of 25 kV and extra high voltage
(EHV ) Traction Power Supply Installations at sub-stations, switching stations and booster
transformer stations. In addition to items covered by Certificate No.TR-5, he is authorized to -

a) issue permits-to-work on 25 kV and extra high voltage ((EHV )equipment;

b) bring into operation new 25 kV and extra high voltage installations after they have been inspected
by an Officer, duly observing the prescribed rules.

Date ..........................

..........................
DEE(TrD)
CERTIFICATE OF COMPETENCY No. TR-7
(For staff dealing with Protective Relays and Instruments)

No..........................
Shri ............................................................ (Designation) has been examined for his knowledge of rules as well as his skill pertaining to the maintenance, testing and repair of protective relays and associated circuits and instruments in traction substations and switching stations and is authorized to*

a) work as a skilled artisan to perform the above type of work;
b) supervise the above works.

He is authorized to bring into operation new installations only after they have been inspected by an Officer.

Date. ...........................
...........................................
DEE(TrD)/AEE(TrD)

*Strike out item not applicable.

CERTIFICATE OF COMPETENCY NO.TR-8
(For Skilled staff of Remote Control)

No............................
Shri ................................................. has been examined for his knowledge of rules and is authorised to work as a skilled Fitter in the installation, maintenance and repair of Remote Control equipment*/FMVFT equipment at Remote Control Centre and controlled posts.

He is NOT authorized to work on any 240 V medium or higher voltage equipment.

Date. .........................
........ ...............
AEE(TRD)

*Strike out item not applicable.

CERTIFICATE OF COMPETENCY No. TR-9
(For Supervisors of Remote Control)

No..................
Shri ..................................................... has been examined for his knowledge of rules and is authorized to work as a Supervisor in the installation, maintenance and repair and testing of Remote Control equipment including FMVFT equipment.

He is authorised to bring being into operation new installations only after they have been inspected by an Officer.

Date........................
..........................
DEE(TrD)

INDIAN RAILWAYS - AC TRACTION MANUAL - VOLUME 11 PART 1 [244]
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

INDIAN RAILWAYS
MANUAL OF AC TRACTION
MAINTENANCE AND OPERATION
VOLUME II (PART II)
FIXED INSTALLATIONS (LIST OF APPENDICES)

1994
## FIXED INSTALLATIONS

### LIST OF APPENDICES

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APPENDIX I

PRINCIPLES FOR LAYOUT PLANS AND SECTIONING DIAGRAMMS FOR 25kV AC TRACTION

(This is a re-production of RDSO document No. ETI/OHE/53 issued in June 1988.)

1.0 INTRODUCTION

1.1 These principles for preparation, checking and finalization of overhead equipment lay out plans, have been framed from standardization and guidance of Railways/Railway Electrification Projects. In some cases, the principles are obligatory and should be followed. In other cases, principles have been evolved to standardize designs and to speed up the work. The principles could be relaxed in special cases, after studying individually the implications to arrive at the best solution both from economical and technical points of view. The fundamental aim of design of overhead equipment is to install all the contact wire at the requisite height and to keep it within the working range of the pantograph under all circumstances.

2.0 DEFINITIONS

The technical and other terms used in this book, shall have the same meaning as defined in General and Subsidiary Rules/AC Traction Manual, unless, there is anything repugnant to the subject or context:

2.1 BOND
An electrical connection across a joint in or between adjacent lengths of rail:

i) Bond, continuity – A rail bond used for maintaining continuity of the rail circuit at crossings and junctions.

ii) Bond, cross – A rail bond used for connecting together two rails of a track or rails of adjacent tracks.

iii) Bond impedance – A special rail bond used to bridge an insulated rail joint in ac track circuited sections in areas equipped for electric traction.

iv) Bond rail – An electrical connection across a joint between two adjacent lengths of rail as part of the track return.

v) Bond, Structure – An electrical connection between the steel work of track structures, bridge or station building, to which the traction overhead equipment is attached and the track return.

2.2 Cantilever assembly
It is an insulated swivelling type structural member, comprising of different sizes of steel tubes, to support and to keep the overhead catenary system in position so as to facilitate current collection by the pantograph at all speed without infringing the structural members. It consists of the following structural members.

i) Stay arm – It comprises of dia 28.4/33/7 mm (Small) size tube and an adjuster at the end to keep the bracket tube in position. It is insulated from mast by stay arm insulator.

ii) Bracket tube – It comprises of dia 40/49 mm (Small) or dia. 30/38 mm (standard) bracket tube and insulated by bracket insulator. Catenary is supported from this member by catenary suspension bracket and catenary suspension clamp.

iii) Register Arm – It comprises of dia 28.4x33.7 mm tube to register the contact wire in the desired position with the help of steady arm.
iv) Steady arm assembly – It is 32 x 31 mm BFB section made of aluminum-alloy to register the contact wire to the required stagger and to take the push hp of contact wire. It is always in tension.

2.3 Crossings

The electrically live member/conductor passing over another electrically live member/conductor, without physical contact.

i) Power line crossing – An electrical overhead transmission or distribution line or underground cable placed across railway track(s) whether electrified or not for transmission of electrical energy.

ii) Crossing OHE – Crossing of two conductors of OHE crossing without physical contact.

2.4 Dropper

A fitting used in overhead equipment construction for supporting the contact wire from catenary.

2.5 Electrical Clearance.

The distance in air between live equipment and the nearest earthed part.

2.6 Encumbrance

The axial distance on vertical plane between the catenary and the contact wire at support.

2.7 Feeder

A conductor connecting (a) a substation with a feeding post, or (b) a feeding post with the OHE.

2.8 Height of contact wire

The distance from rail level to the under side of contact wire.

2.9 Interruptor

It is a single phase Vacuum SF6/oil circuit breaker used as load switch to close the circuit on fault but does not open on fault. It is operated either by remote or manually at site. Different methods of connection of interruptors are:

a) Bridging Interruptor – An interruptor which is provided at the neutral section to extend the feed from one substation to the overhead equipment normally fed by the other substation in emergencies or when the latter is out of use. This normally remains in the open position.

b) Sectioning Interruptor – An interruptor which connects adjacent sub-sectors together to maintain continuity of supply. This normally remains in closed position.

c) Paralleling Interruptor – An interruptor which connects overhead equipments of two different tracks. This normally remains in closed position to reduce the voltage drop.

2.10 Jumper

A conductor or an arrangement of conductors for electrical continuity not under tension, which forms electrical connection between two conductors or equipments.
2.11 Mast

A single vertical post embedded in the foundation or otherwise rigidly fixed in vertical position to support the overhead equipment with cantilever assembly. It may be rolled section or fabricated. The uprights of portals and TTCs are also called masts.

Note: Pre-stressed concrete spun poles for traction overhead equipment are under development.

2.12 Neutral Section

A short section of insulated dead overhead equipment which separates the sectors fed by two adjacent substations which are normally connected to different phases.

2.13 Overhead Equipment (OHE)

The electrical conductors over the track together with their associated fittings, insulators and other attachments by means of which they are suspended and registered in position. All overhead electrical equipment, distribution lines, transmission lines, and feeder may be collectively referred to as overhead lines.

2.14 Overlap

An arrangement of overhead equipment over a track where two sets of traction conductors are run parallel to each other for short distance over span(s) providing a smooth passage for the pantograph of an electric rolling stock. In the un-insulated overlaps two sets of conductors are separated by 200 mm and connected by a jumper. In insulated overlaps the two sets of conductors are separated by 500 mm in air. Electrical continuity is provided by an isolator. Interruptor or booster transformer.

2.15 Over line structures

Any fixed structure provided over the track. The prescribed clearance is normally provided as laid down in the Schedule of Dimensions for unrestricted movement of rolling stock.

2.16 Pantograph

A collapsible device mounted on an insulated from the roof of an electric engine or motor coach for collecting current from the overhead equipment.

2.17 Return Conductor

A conductor which carries current from the tracks to the sub-station in the booster transformer system.

2.18 Regulating Equipment

A device for maintaining the tension of OHE conductors constant under all ambient temperature conditions.

Note: Such OHE is called regulated OHE.

2.19 Setting Distance (Implantation)

The horizontal distance from the nearest face of traction mast to the centre line of the track.
(i) For Single Bracket

(ii) For Multiple Bracket

(iii) For Single Bracket on outside curve

FIG. A 101
2.20 Suspension Distance

The horizontal distance from the centre of the eye of catenary suspension bracket to the face of the mast for a single cantilever assembly or to the face of cross arm channel in case of multiple cantilever assembly (Ref. Fig A.1.01)

2.21 Span

The distance between the centre lines of the adjacent supporting masts for overhead equipment/lines.

Clear span in case of portal structure, is the distance between the inner faces of portal uprights.

2.22 Stagger

Stagger of the contact wire is the horizontal distance of the contact wire from the vertical plane through the centre of pantograph plan at the contact surface.

The stagger of the catenary is the horizontal distance of the eye of the catenary suspension bracket from the vertical plane through the centre of the track.

2.23 Section Insulator

A device installed in the contact wire for insulating two elementary electrical sections from each other while providing a continuous path for the pantograph without break of current.

2.24 Supply Control Post

It is general term which refers to an outdoor assembly of control gear, such as interruptors, isolators, potential transformers, auxiliary transformers, etc. including remote control equipment installed in a cubicle, for controlling power supply to overhead equipment.

a) Feeding Post (FP) – It is a supply post where the incoming 25 kV feeder lines from the substation are terminated, and connected to the overhead equipment through interruptors.

b) Sectioning and Paralleling Post (SP) – It is a supply control post situated mid-way between two feeding posts at the neutral section and provided with bridging and paralleling interruptors.

c) Sub-sectioning and paralleling post (SSP) – It is a supply control post where a sectioning and paralleling interruptor is provided.

d) Sub-sectioning Post (SSP)- (For single line section) it is a supply control post where a sectioning interruptor is provided.

2.25 Sector

A section of overhead equipment of a track which can be energized by closing a feeder circuit breaker at the sub-station.

a) Sub-sector The smallest section of overhead equipment which can be isolated remotely by opening of interruptors.

b) Elementary Section – The smallest section of overhead equipment which can be isolated from the rest of the system by manual operations.
2.26 Tension Length

Length of conductor which is stretched between the two anchor points.

2.27 Versine

The versine is the maximum offset of the rail on which spans have been measured (Para 5.1) of the curved track from the chord connecting two points, each opposite adjacent masts.

3. Electrical Clearance

3.1 Clearance

The clearance between 25 kV live parts and earthed parts of fixed structures or moving loads shall be as large as possible. The electrical clearances to be maintained under the worst conditions of temperature, wind, etc. are given below:

a) Minimum vertical distance between any live part of overhead equipment or pantographs and parts of any fixed structures (earthed or otherwise) or moving loads:

   i) Long duration …320 mm
   ii) Short duration …270 mm

b) Minimum lateral distance between any live part of overhead equipment or pantographs and parts of any fixed structure (earthed or otherwise) or moving loads:

   i) Long duration …320 mm
   ii) Short duration …220 mm

Note: I) These clearances may be reduced to 250 mm (long duration) and 200 mm (short duration) with the personal approval of the Chief Electrical Engineer in very difficult locations (Rly. Board’s letter No. 76/RE/240/1 dt. 27.3.80).

   ii) A clearance study should be made for every over line structure/tunnel and, if required, should be referred to RDSO for advice.

3.2 Working clearance

Minimum clearance between live conductor/equipments and such earthed structure/live parts of different elementary sections where men are required to work shall be 2 m. Where the clearance is not obtained the structure shall be protected by earthed metallic screens or prescribed warning boards (refer para 22.2 and 22.3)

4.0 Wind Pressure

4.1 Wind Load

Wind pressures for design of all masts and determination of spans are based on IS: 875-1964 – “Code of Practice for Structural Safety of Buildings – Loading Standards” Vide an amendment issued in 1971 to this specification, wind pressures for structures of height less than 30 m were reduced by 25% Accordingly the standard wind pressures adopted are as follows for all new works for different zones as indicated in the specification:

   i) Green zone (light) …-75 kg/m²
   ii) Yellow zone (medium) …-112.50 kg/m²
   iii) Red zone (heavy) …-150 kg/m²
4.2 Loading calculation

For working out the wind loading the total projected area for the rolled sections, 150% of the projected area for fabricated structures and 2/3rd of the projected area for conductors and other circular member is taken into account.

Note: The safety of masts and portals is checked for two conditions.

   a) At 35 degree C temperature and full wind pressure.
   b) At 4 degree C temperature and 20% of the governing wind pressure.

5.0 Spans

5.1 Measurement

Spans shall be accurately measured by means of a steel tape. On curves, these measurement shall be taken on the outer rail of the middle track in the case of an odd number of tracks and in the case of an even number of tracks on the inner rail of the first outside track (from the centre of the formation). On single track, measurements shall be made on the outer rail.

5.2 Standard Span

Standard spars shall be determined in accordance with:

   i) Drg. No. ETI/OHE/G/00202 for conventional OHE.
   ii) Drg. No. ETI/OHE/G/04201 for regulated tramway OHE and
   iii) Drg. No. ETI/OHE/SK/375 for composite OHE (Aluminum-alloy catenary and copper contact wire)

5.3 The spans shall be as large as practicable, but should enable the contact wire to be erected with permissible stagger. For a stipulated maximum stagger, the length of the span is governed by curvature, blow off of overhead equipment, sway of pantograph and deflection of the mast under wind condition. Standard spans shall be used to maximum extent possible.

5.4 Mid span stagger

Where the two adjacent spans are located on curves of different radius or when the two versines are in opposite directions, the spans shall be determined so as to keep the mid span stagger in the two spans within the limit given in the span and stagger chart (ETI/OHE/G/00202), taking into account the stagger at the common support and the stagger at the extreme supports (see para 8).

5.5 Restrictions

The following restrictions are applicable.

   i) On main tracks, the lengths of two consecutive spans shall not normally differ by more than 18 m.
   ii) The length of spans with unequal encumbrances shall be such that the axial distance between the catenary and the contact wire at the minimum dropper is not less than 150 mm. For example the length of the span with 1.4 m and 0.9 m encumbrances at the two ends shall not exceed 67.5 m. This restriction is applicable to the two spans on each side of the structure, equipping a turnout for the main OHE.
iii) Spans in the vicinity of over line structures with restricted head room shall be determined with reference to the electrical clearances available (See para 3).

iv) The lengths of spans loaded with section insulators may require to be restricted (See para 11).

v) Non-standard spans may be adopted in difficult locations, e.g. in rocky cuttings, on through girder bridges, for locations of masts on bridge piers and within station limits.

vi) With crossed type equipment with actual crossings of OHEs at facing turnouts, the anchor spans shall be restricted to 54 m.

vii) Where earth wire is provided, the maximum span over level crossings should be 58.5 m.

5.6 Overlaps

The spans at insulated and un-insulated overlaps should be designed in accordance with Drg. Nos. ETI/OHE/G/02131/Sheet 1 and RE/33/G/02121 Sh. 1 respectively.

Note: If feasible, overlap shall be avoided under overhead power line crossings.

5.7 Neutral sections

The spans at neutral sections should confirm to Drg. No. ETI/OHE/G/02161 sheet No. 1 and no deviations are normally permissible.

6.0 Masts, Portals, Head Spans and Foundations.

6.1 Types of masts.

OHE conductors are suspended from swivelling cantilever assembly generally erected on individual masts.

6.1.1 Nine types of masts are used. These are designated as 150x150 BFB, 200x150 RSJ, K-100, K-125, K-150, K-175, K-200 K-225 and K-250. The first two are rolled sections and remaining seven are fabricated masts. B-series (Drg. No. ETI/C/0071) masts can be used in lieu of K-series masts.

Note: Sometimes 200x200 (8"x8") BFB have been imported. These are used in lieu of 200x150 RSJ as specified in mast employment schedules.

6.1.2 Selection of masts

The masts for standard applications viz. masts for single OHE, anti-creep and overlaps should be selected from the mast employment schedules. Separate mast employment schedules have been made for each wing pressure zone as under:

a) Conventional OHE (65mm² Cd-Cu catenary and 107 mm² copper contact wire)

| Light wind pressure (75 Kg/m²) | Drg. No. ETI/C/0702 | Sheet 1 to 5 |
| Medium wind pressure (112.5 kgf/m²) | Drg. No. ETI/OHE/G/00153 and 00154, sheet 1 to 4 |
b) Composite OHE (comprising of aluminum alloy catenary and 107 mm² copper contact wire with 1000 Kgf tension in each conductor)

<table>
<thead>
<tr>
<th>Pressure Zone</th>
<th>Drg No.</th>
<th>Sheet</th>
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<tr>
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<td>1 to 4</td>
</tr>
<tr>
<td>Light wind pressure (75 Kgf/m²)</td>
<td>ETI/C/0721</td>
<td>1 to 4</td>
</tr>
<tr>
<td>Medium wind pressure (112.5 Kgf/m²)</td>
<td>ETI/C/0717</td>
<td>1 to 4</td>
</tr>
</tbody>
</table>

The mast employment schedules are prepared only for standard setting distance as given in Drg. No. ETI.OHE/G/00111 Sh. 1. For higher implantations and other locations like masts for turnouts, diamond crossings, umbrella type OHE etc., the load on the mast should be calculated separately for every location and safety of the mast checked in accordance with Drg. No. ETI/OHE/G/00141 sheet 3. The permissible bending moments of the mast are given in Drg. No. ETI/SK/C/122.

6.1.2.1 On long (more than 150m) bridges and within 100m from their abutments on either side and on banks where the height of the catenary above surrounding mean retarding surface is more than 30 m, 25% reduction in wind pressure (para 4.1) should not be taken into consideration. These masts should be designed for full wind pressure i.e.

- Heavy (red) wind pressure zone 200 Kgf/m²
- Medium (Yellow) wind pressure zone 150 Kgf/m²
- Light (Green) wind pressure zone 100 Kgf/m²

The maximum span should be restricted to 54 m for heavy wind pressure zone and 63 m for medium wind pressure zone. In case of curves on the banks of such bridges, the span should be 4.5 m less than the maximum span permitted by relevant span and stagger chart, but should not exceed 54 m for heavy (red) wind pressure zone and 63 m for medium (yellow) pressure zone.

6.2 Two Track Cantilever

In the yards and sidings when the mast cannot be erected near the track to be equipped, it may be erected spanning one or two tracks using a two track cantilever (Drg. No. ETI/C/009, Sheet 1). This is generally used for supporting OHE near turnouts and X-overs. This arrangement should not be used for supporting OHE of two main lines. The OHE can be supported up to a distance of 10.5 m from the upright with this arrangement.

6.3 Portals

On multiple track sections, where adequate track centres are not available and tracks cannot be slewed, portals are used. Each portal consists of two fabricated uprights and one fabricated boom consisting of with or without one central piece and two end pieces.

6.3.1 Three types of portals have been standardized. “N” type portal is used for clear spans of 10 m to 20m (4 track maximum), “O” type portal is for clear span of 20m to 30m (for 6 tracks maximum) and “R” type portal with span of 30m to 40m (for 8 tracks maximum).

6.3.2 Where the upright of standard portals cannot be erected due to limited track centres, “P” type portal may be used in place of “N” type and “G” type may be used in place of “O” type. The width of upright of these portals...
is 300 mm and 250 mm as against 450 mm of ‘N’ type and 550 mm of ‘O’ type respectively. In exceptional cases, BFB uprights of 152 mm width (Drg. No. ETI/C/0026 Sheet 1) may also be used with ‘N’ type portal boom. Special BFB portals with 3 legs (Drg. No. ETI/C/0027 Sheet ) may also be used in exceptional cases where N type portal can not be used.

6.3.3 The cantilevers for the extreme track are provided on the uprights of the portals in accordance with para 19. The cantilevers for the intermediate tracks are provided on the drop arms suspended from the boom (ref. Para 19.6)

6.4 Head spans

In yards where un-regulated/regulated OHE is used head span may also be used to cover more than 6 tracks. Standard head span arrangement is given in Drg. No. ETI/OHE/G/03201. The head span arrangements are not used normally.

6.5 Foundations

6.5.1 Volume charts

The foundation bending moment codes (FBM) for each location are obtained from the mast employment schedules or by actual calculation (Para 6.1.2) Bearing capacity of the soil is determined at the outer toe of the bottom of foundation at a representative number of locations. Where foundations are placed on the slope of banks due to increase in setting distance, the bearing capacity of the soil should be determined on the slope. Bearing capacities determined thus would be considerably less than those determined on the top of formation.

Selection of the type and size of foundation is done from the volume chart. ( Drg. No. ETI/C/0058) on the basis of FBM code, type and bearing capacity of soil/shoulder width and the extent of projection above ground level.

6.5.2. Type of foundations.

The following types of foundations are for OHE mast and portals.

1) For Masts

i) (A) Side bearing
   (Type B) Drg. No. ETI/C/0058 Sh. 1
   
   (B) Side gravity
   (Type BG) -do-

   (C) Pure gravity
   (Type G ) -do-

   (D) Pure Gravity
   For black cotton soil
   (Type WBC) -do-

ii) New Pure Gravity
    (Type NG) -do- Sh. 2A

iii) NBC type foundation for dry black
cotton soil (16500 & 11000 Kgf/m2
  3.0 m depth.

INdIAN RAILWAYS- AC TRACTION MANUAL- VOLUME II PART II [11]
iv) New pure gravity for different soil and site conditions (500 mm exposed) (Type: NG or SPL)

v) New pure gravity for black cotton soil (for 8000 kgf/m² soil pressure, 2.5 m depth. (Type: NBC)

vi) Foundations in soft rock (bearing capacity 45000 Kgf/m²)

vii) Foundations in hard rock (bearing capacity 90,000 kgf/m²).

---

Drg. No. ETI/C/0059

Drg. No. ETI/C/0060.
2) For portals
   
i) In ordinary soil  
   Drg. No. ETI/C/0005/68

   ii) In dry black cotton soil  
   Drg. No. ETI/C/0063

6.5.2.1 In the case of OHE foundations in deep rock cutting the foundation should be below the drain.

6.5.2.2 For all future constructions of pure gravity foundation Drg. No. ETI/C/0058 sheet 2A only shall be followed.

6.5.3. Selection of foundations

Side bearing foundations are used for masts where the soil bearing capacity is 11,000 or 21,500 Kgf./M² and 300 mm wide shoulder is available on the bank. However for overlap inter masts and masts on the inside of curves, 550 mm wide shoulder is necessary ( Drg. No. ETI/C/0023). (Ref. Fig. A1.02).

6.5.4 New pure gravity foundations may be used for masts where soil bearing capacity is 5500, 8000 and 11000 Kgf./M² or where adequate shoulder width as mentioned in para 6.5.3 is not available. In such cases, it should be ensured that foundation is not exposed.

6.5.5 Side gravity foundations may be used for masts where soil bearing capacity is 8000 and 11000 Kgf./M², or adequate shoulder width is not available. No portion of the foundation should be exposed.

6.5.6 Pure gravity foundations (type G) are used for independent masts where soil surrounding the foundations is loose and cannot exert passive pressure on the foundations. G type foundation have been designed for soil bearing capacity of 5500, 8000 and 11000 Kgf./M². Pure gravity foundations (Type P) are used for portals and are designed for soil bearing capacity of 8250 and 11000 Kgf./m².

6.5.7 Foundations in black cotton soil

6.5.7.1 The foundation of the black cotton should be done preferably in dry season i.e. from November to May. Excavations should be avoided as far as possible in case of unexpected rains in dry season also.

6.5.7.2 In black cotton soils. WBC and NBC type of foundations are used. Primarily WBC foundations are to be adopted where swelling/shrinkage is not expected to take place at the founding level and NBC foundations have to be provided where swelling/shrinkage is expected to occur.

6.5.7.3 The safe bearing capacity should be determined in accordance with IW: 6403

6.5.7.4 When in doubt regarding classification of BC soil as to dry or wet, it is preferable to make NBC type foundation.

6.5.8 Where foundations are constructed on the slope of banks, the foundations should be so located that generally no part of it is exposed. The top of foundation may then be brought to the desire level (rail level-500 mm) by providing a super block of length and breadth equal to the top dimension of foundations. The increase in bending moment due to increased setting distance should be calculated and the designation of foundation to allow for this BM should be selected. The arrangement is shown in the Fig. No. A.1.03

6.5.9 The top of foundation should be 50-100 mm above the surrounding ground level. The length of mast below rail level should be minimum 1850 mm for regulated OHE and 1750 mm for un-regulated OHE. A 1350 mm embedment of mast in concrete is necessary. Concrete cushion of 150 mm below the bottom of mast is also necessary. Wherever necessary, these may be achieved by providing a super block of length and width equal to the top dimension of foundation.
However portion of existing pure gravity foundations to Drug. No.ETI/C/0058 She. 1 corresponding to a depth of 500 mm of embankment having slope of 1:2 may be exposed.

6.5.10 Giving due consideration to the above, the most economical type of foundation should be adopted.

6.0 Contact Wire Height.

7.1 Standard height

Normally the height of contact wire (under side surface) above the track plane shall not be less than 5.50 m at any point in the span under the worst temperature conditions. To ensure this, the normal height at the suspension point shall be as under:

Type of OHE  Normal height of contact wire at the support point.

i) Regulated
   a) Normal with 10 cm pre-sag                 5.60 m
   b) Old electrification works with 5 cm pre-sag  5.55 m

Note: 5 cm pre-sagged OHE was provided upto 1968. For new works 10 cm pre-sagged OHE shall normally be provided. However, OHE with 5 cm pre-sag may be provided in long tunnels and through girder bridges to achieve the minimum electrical clearance.

ii) Unregulated
   a) Unregulated OHE designed for areas with a temp range of 4ºC to 65ºC. 5.75 m
   b) Unregulated OHE designed for areas with a temp range of 15ºC to 65ºC 5.65 m

7.2 The height may be reduced under over line structures after a clearance study. The minimum height shall be 4.92 m for the broad gauge and 4.02 m for the meter gauge to permit movement of “C” class ODC without physical lifting of wires. In case “C” class ODC movement is not required, the height could be reduced to 4.80 m (BG). Height may be further reduced to 4.65 m if rolling stock higher than 4.265 m are not allowed on such lines. (Ref. Fig. A1.04)

7.2.1 At electric locomotive sheds and loco inspection pits, the minimum height shall be 5.80 m for the broad gauge and 5.50 m for the metre gauge.

7.2.2 At level crossings, the minimum height shall be 5.50 m for both broad and metre gauges.

7.3 Erection tolerance

A tolerance of +/- 20 mm is permissible on the height of contact wire as measured at a point of support except on either side of an over bridge, here a tolerance of +/- 10 mm will be allowed. But the difference between the heights of contact wire at two adjacent supports shall not exceed 20 mm. In spans with gradient of contact wire, this difference of 20 mm is measured over and above the approved gradient.
7.4 Contact wire gradient

Any change in the height of the contact wire should be made gradually and the slope should not normally exceed 3 mm/m on main lines and 10 mm/m on sidings. In no case shall the relative gradient of the contact wire in two adjacent spans be greater than 1.5 mm/m on main lines and 5 mm/m on sidings.

7.5 Provision for future track raising

The rail level may go up in future by 275 mm (max) due to use of concrete sleepers and strengthening of track structure. Provision should be made for possible lifting of track by 275 mm (max.) (Correction Slip No. 10, Schedule of Dimension, (BG/Metric), 1973). OHE arrangement indicated in Drg. No. ETI/OHE/G/02102, Sheet 3 should be used for the areas where track raising is contemplated. The areas where track is proposed to be raised may be ascertained before commencement of works. No track raising is normally contemplated near over-line structures unless additional head room has been provided.
8.0 Stagger

8.1 Tangent track

On tangent track, the contact wire is normally given a stagger of 200 mm at each support alternately on either side of the centre of the track. This is relaxed in special cases for ensuring requisite clearances in difficult locations such as in the vicinity of signals, subject to stagger at midspan not exceeding the permissible values given in Drug. No. ETI/OHE/G/00202.

8.2 On tangent track, the catenary stagger is zero for masts supporting a single equipment. The catenary is fixed vertically over the contact wire at all supports at which more than one equipment is supported, at flexible head spans and at supports with reduced encumbrance, on tangent as well as curved tracks.

8.3 Curved track

On curves, the stagger of the contact wire at supports should not exceed 300 mm. The stagger of the catenary on curved track shall be determined with reference to Drug. No. ETI/OHE/G/00202. The standard values adopted are 0, +200 and – 200


8.4 Turnouts and diamond crossing

At turnouts, the stagger of the contact wire on the main running line shall be in accordance with Drug. No. ETI/OHE/G/00202. The stagger of contact wire of the branching line shall not exceed 300 mm at any point in the span. This is achieved by selecting a suitable location for the mast near the centre of the turnout in the case of overlap type equipment, or by suitably adjusting the point of crossing of the two contact wires in the case of crossing type equipment.

8.5 Un-insulated overlaps

At un-insulated overlaps, the stagger should confirm to Drug. No. RE/33/G/02121 sheet 1. On non-uniform curves or at other locations where staggers different from those indicated in these drawings are adopted, the following points should be observed.

i) The stagger of the in-running contact wire does not exceed 200 mm on tangent track and 300 mm on curved track at any support, at which only one contact wire is in-running.

ii) In any span at the centre of which only one of the contact wires is in-running (as in 4-span overlap), the mid-span stagger of the in-running contact wire does not exceed the values given in Drug. No ETI/OHE/G/00202

iii) The two contact wires run parallel to each other between the intermediate supports at a distance of 200 mm from each other.

8.6 Insulated overlap

At insulated overlaps, stagger should conform to Drug. No. ETI/OHE/G/02131 Sheet 1. On non-uniform curves and at other locations where stagger different from those shown in this drawing are adopted, the points mentioned against un-insulated overlap spans also apply, with the difference that between the intermediate masts the two contact wires run parallel at a distance of 500 mm from each other.
8.7 Neutral Sections

The stagger at overlap type neutral sections should conform to Drug. No. ETI/OHE/G/02161, Sheet No. 1.

8.7.1 The stagger at section insulator type neutral section should be so adopted that the stagger at the section insulator assembly is within the limit of +/- 100 mm (see para 11.1(iii)).

8.7.2 PTFE type neutral section shall be erected on tangent track only. The stagger shall be zero at support.

9 Encumbrance

9.2 Normal

The encumbrance shall normally be 1.40 m.

9.3 Reduced encumbrance

The preferred values of reduced encumbrance for erection of overhead equipment under over-line structure are:

<table>
<thead>
<tr>
<th>Span under Over-line Structure (m)</th>
<th>Recommended encumbrances for span under over-line Structure (m)</th>
<th>Largest permissible adjacent spans (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>63.0</td>
<td>0.9</td>
<td>67.5</td>
</tr>
<tr>
<td>58.5</td>
<td>0.9</td>
<td>67.5</td>
</tr>
<tr>
<td>54.0</td>
<td>0.75</td>
<td>67.5#</td>
</tr>
<tr>
<td>49.5</td>
<td>0.6</td>
<td>63.0</td>
</tr>
<tr>
<td>45.0</td>
<td>0.6</td>
<td>63.0</td>
</tr>
<tr>
<td>40.5</td>
<td>0.5</td>
<td>58.5</td>
</tr>
<tr>
<td>36.0</td>
<td>0.40</td>
<td>54.0*</td>
</tr>
<tr>
<td>31.5</td>
<td>0.40</td>
<td>49.5</td>
</tr>
<tr>
<td>27.0</td>
<td>0.30</td>
<td>45.0</td>
</tr>
</tbody>
</table>

# Applicable where the encumbrance cannot be increased to 1.40 m in a single span from the value given in column 2. The normal encumbrance of 1.40 m should be provided in subsequent spans. In such cases, the encumbrance may be adjusted in such a way that the lowest point of the catenary does not fall between first dropper and the support.

* See para 5.5 (1)

Note I) The above values are applicable only to regulated OHE with 10 cm nominal pre-sag of contact wire.

II) Special droppers may be required in spans under and adjacent to over-line structures.
9.4 Minimum Encumbrance

Normally, the axial distance between the catenary and the contact wire at the minimum dropper should not be less than 150 mm. Smaller droppers may be adopted in exceptional cases. If the shortest dropper is loop type and more than 150 mm, no speed restriction is called for. But if the dropper is without loop or of rigid type or less than 150 mm, the overhead equipment is deemed suitable up to 90 km/h speed.

9.5 If section insulators are to be installed in spans under over-line structures, special designs will have to be evolved.

10.0 Droppers

10.1 The standard arrangement of droppers assembly shall be as per drawing No. ETI/OHE/P/1190

10.2 The general distribution of droppers on an OHE span shall be as per drawing No. ETI/OHE/G/00161. The arrangement of OHE span should be designed in such a way that standard droppers are used.

10.3 Special droppers arrangement.

The special arrangement of dropper as shown in Drug. No. ETI/OHE/P/1400 may be followed in exceptional cases wherever unavoidable.

10.3.1 The arrangement of the dropper to be adopted on the through girder bridges as shown in Drug. No. ETI/OHE/P/1410, where the OHE is supported on member of girder bridge.

10.4 Rigid dropper

Adoption of rigid dropper (made of contact wire only) should be avoided as far as practicable. It should not be adopted, at all on main running lines.

11 Section Insulators

11.1 Location

Sectional insulators should be so located that the following conditions are fulfilled.

i) At location of section insulator, the axial distance between the catenary and contact wire shall not be less than 450 mm in the case of single-wire section insulator and 600 mm in the case of a double wire section insulator without increasing the encumbrance at the supports beyond 1.40 m.

ii) The section insulator is to be located beyond the point where the centre distance between the two tracks is equal to or more than 1.65 m. If the section insulator is erected with the free ends of the runners away from the centre of the turn out this distance may be reduced to 1.45 m.

iii) The stagger of the contact wire at the location of the section insulator should normally be zero, but in no case should it exceed + 100 mm.

iv) On loops, the section insulator shall, as far as possible, be located close to the first support of the overhead equipment for the loop.

v) The preferred location of section insulator on main running track is 2 to 10 m from the support in the direction of traffic, though its provision on the main line should be avoided.

vi) In double line section, the runners should be in the trailing direction.
11.2 Permissible Speeds

11.2.1 On double line sections, with runners trailing, the section insulator assembly using porcelain sectioning insulators are fit for speeds upto 120km/h provided it is installed within the first one-tenth and one-third of the span.

11.2.2 In case the runners of the section insulator are facing or it is not installed within first 1/3rd of the span the speed should be restricted to 80km/h. (Ref. Fig. A1.05).

\[ \begin{align*}
\text{(i) } & 10 \times \frac{1}{10} \text{ SPAN} < d < \frac{1}{3} \text{ rd OF SPAN} \\
\text{(ii) } & d < \frac{1}{3} \text{ rd OF SPAN} \\
\text{(iii) } & d > \frac{1}{3} \text{ rd OF SPAN}
\end{align*} \]

FIG. A1.05

12.0 Arrangement of Jumpers

12.1 In span jumpers

In span jumpers between the contact and catenary wires are provided at suitable equi-distant intervals as indicated in Drg. No. ETI/OHE/G/05101.

12.2 Turnout jumpers

The arrangement of connections at turnouts and at diamond crossings is indicated in Drg Nos. ETI/OHE/G/05103 and 05106 respectively.

12.3 G-Jumpers

The arrangement of jumpers at un-insulated overlaps is indicated in Drg No. ETI/OHE/G/05102.

12.4 Potential equalizing jumpers

The arrangement of potential equalizer jumpers is indicated in Drg. No. ETI/OHE/G/05104.

12.5 Anti-theft jumpers

The arrangement of anti-theft jumpers should be as indicated in Drg. No. ETI/OHE/SK/432.

INDIAN RAILWAYS — AC TRACTION MANUAL - VOLUME II PART II
13.0 Tension Lengths.

13.1 Regulated equipment

With regulated overhead equipment every tension length is equipped with an automatic tensioning device at each end and an anticreep located approximately midway between the tensioning devices. The distance between the anticreep and the anchor mast/structures on either side should not exceed 750 m or 15 supporting masts.

13.2 Half tension lengths

Half tension lengths of regulated overhead equipment, not greater than 750 m between anchorages, may be adopted where necessary. The equipment is fixed at one end and provided with an automatic tensioning device at the other, the fixed end being determined to suit convenience of erection. The half tension-length on either side of the neutral section should not exceed 600 m when the whole or a part of it is located on a curve. The distance of the axis of a 4 span insulated overlap from the anti-creeps/fixed terminations on either side shall not exceed 600 m.

13.2 Bridges and tunnels

Where the catenary is anchored on the face of an over line structure, the anchor shall be the anti-creep point. Termination of overhead equipment or provision of an anticreep, should be avoided as far as possible, inside the tunnels and on the mast set on bridge piers.

13.4 Masts with three brackets

In the case of masts with three brackets supporting regulated equipment, anticreeps or fixed terminations of the overhead equipment should be arranged so as to keep the relative movement between brackets as low as possible so that the brackets do not foul with each other.

13.5 Unregulated equipment

With unregulated equipment tension, lengths of up to 2000 m between anchors may be adopted on tangent as well as curved track.

13.5.1 Unregulated OHE shall not take off from main running lines

13.6 Linkage of wire-runs

Wire-runs linking two or more main line wire-runs shall be as short as possible. For example, the same wire run may not ordinarily be used for equipping an emergency cross-over and a loop line.

13.7 Anti-creep

Anticreep arrangement: Anticreep is located approximately in the centre of a tension length. The standard arrangement should be in accordance with Drug. No. ETI/OHE/G/02111.

13.7.1 Boom type anticreep arrangement (Drug. No ETI/OHE/G/02113) may be provided on multiple track sections or in other areas where portals have been provided on account of other design considerations, Portals should not be provided specifically for provision of boom type anticreep.
**Anchor Height**

**Crossing of anchoring spans**

Crossing of equipments of different elementary electrical sections in the anchoring span should be avoided as far as possible.

14.2 Crossing of regulated and unregulated equipments should be avoided. This may, however, be permitted if there is sufficient mechanical clearance between the crossing contact wires under all conditions.

**Anchoring near signals**

Anchoring spans in the vicinity of signals, water columns and other fixed structures should be avoided as far as possible.

**Back to back anchors**

Back to back anchoring of two equipments on the same mast may be adopted if both the terminations are of the fixed type (without counter weights).

**Anchor near buffers**

In order to equip the full length of a buffer end siding, the scheme of anchoring as indicated in Fig. A1.06 may be adopted.

![Diagram of anchoring](image)

**Fig. A1.06**

14.6 Anchor height

Where the contact wire is of unregulated equipment and raised from the contact plane and anchored in a single span, the anchor height shall be fixed within limits decided on considerations indicated below. The maximum height shall be such that with the contact wire tension at its maximum, the contact wire of the anchor OHE does not leave the contact plane in the one where it is required to be in-running. The minimum height shall be such that with the contact wire tension as its minimum, there is no possibility of the contact wire sagging too much below the contact plane where it is out of running and getting entangled with the pantograph. In both cases, the anchor height is to be determined with respect to the anchor span if there is no crossing of the two contact wires, and with respect to the distance between...
14.7 In case of regulated equipment, when the equipments to be anchored on a single span, anchor height shall be the standard one to get the regulation of the overhead equipment within the limit travel zone of counter weight assembly. However, single span anchoring should be avoided as far as possible.

14.8 Anchor near buildings

No live anchor or equipment shall be provided near or over any hut/goomty and building. In such cases the overhead equipment should be isolated by providing cut-in-insulator and earthed by connecting it metallycally to the anchor mast without providing the insulator in the anchor assembly.

14.9 Termination

The anchoring arrangement of OHE are given in Drug. No. RE/33/G/03121. In polluted areas, e.g. tunnels, areas near sea-coast, neighbourhood of chemical/fertilizer/cement plants, near loco sheds, ash pits, water columns, etc long creepage path (1050 mm) insulator should be used on the anchoring arrangement.

15.0 Location of overlap

15.1 Platform lines

Overlaps serving platform lines should not be located opposite platform to avoid location of tensioning devices on the platforms. If it is unavoidable, half tension length may be adopted to avoid the provision of the regulating equipment on the platform.

15.2 Protection by signals

In the station area insulated overlaps on main running lines should be located after the stop signals. (Refer to sectioning arrangement of OHE – para 30.)

15.3 Cross over

In the case of emergency cross-overs insulated overlaps in the direction of the trailing end should permit the longest train to be accommodated between the lock bar of the cross over switch and the first intermediate mast of the overlap with a minimum margin of 50m. This distance may be taken as 850 m. the overlap in the rear should be located as close as possible (Refer to sectioning arrangement of OHE – para 30.)

15.4 Span

Location of insulated and uninsulated overlaps should be decided in such way that the maximum span can be adopted to achieve parallel path of not less than 3 m for smooth change over by the pantograph.

15.5 The arrangement of overlaps should be as per standard drawings (see para 5.6

15.6 Feeders to overlaps

Feeding overlaps should be sufficiently away (see para 16.2) from the stop signals to facilitate coasting of trains (with pantograph lowered in the event of extension of feed from either side. Feeders may be run, if required, from the substation which is usually located in the station areas.

16 Neutral Section

16.1 Overlap type

The conventional overlap type neutral section(Drug. No. ETI/OHE/G/02161, Sheet-1) shall be used except in

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suburban and heavily graded sections.

*Short Neutral Section of Section Insulator Assembly type*

In heavily graded section and suburban section where adoption of overlap type neutral section is not feasible, short neutral section of 5 m length, comprising of conventional section insulator assembly may be adopted. The arrangement is shown in the Drg. No. ETI/OHE/G/02161, Sheet 2. Speed under such neutral sections shall be restricted to 100 km/h if the runners are in trailing direction, otherwise to 70 km/h (Para 11.2.1).

Note: Short neutral section should be provided on half tension length not exceeding 500 m.

16.2.1 Adoption of short neutral section with section insulators assembly should be avoided on main running lines due to heavy weight, restricted speed and frequent maintenance requirement.

16.3 *Short Neutral section of PTFE type*

If adoption of short neutral section on main line is unavoidable, short neutral section of ceramic beaded resin bonded glass fibre rod insulators be provided. This is lighter and is considered fit for speeds upto 130 km/h.

Ceramic beaded rod insulator type neutral section equipments have not yet been developed indigenously and are still under trial. Standard drawings will be issued after the indigenous product proves successful.

16.4 Neutral section shall be located away from stop signals, level crossing and shall be on tangent track and on level to the possible extent.

16.4.1 If neutral section is provided after a stop signal, the distance between signal and neutral section shall be such that after stopping, the train shall be able to pick up enough speed to coast the neutral section without any risk of stalling.

16.4.2 If neutral section is provided before a stop signal, the distance between neutral section and signal shall be such that the train shall not cross the signal in an effort to coast the neutral section.

The distance should be preferably 1600 m away on section with gradient upto 1 in 300 and 2500 m with higher gradient upto 1 in 200, if unavoidable.

16.5 The PTFE type short neutral section shall be located on level tangent track at least 400 m after the stop signal and 200 m before the stop signal. Where, however, modifications require to comply with these guide lines are difficult or entail heavy investment, the Chief Electrical Engineer of the Railway may direct any other arrangement to be followed consistent with safety and reliability, and for location on graded section according to para 16.4.1 and 16.4.2. (Ref. Fig. A1.07).

![FIG. A1.07](image-url)
16.2 Location of ‘OPEN DJ’ and ‘CLOSE DJ’ boards.

The indication boards to indicate the approaching neutral section and ‘OPEN DJ’, ‘CLOSE DJ’ boards shall be provided according to drawing No. ETI.OHE/G/02161 Sheet 3.

16.2.1 Separate ‘CLOSE DJ’ boards are required for EMUs and loco hauled trains.

17 Points and Crossings.
17.1 General arrangement

The equipment at points and crossings should preferably be of the overlap type. In unavoidable circumstances it may be of crossed type.

17.1.1 The general arrangement of regulated overhead equipment at turnouts and cross overs is shown in Drug. Nos. ETI/OHE/G/02141 and 02151. For high speed running, the overlap type should be provided.

17.1.2 The general arrangement of unregulated overhead equipment at turnouts and cross overs is shown in Drug. No. ETI/OHE/G/03151 and 03152, Sheet 1 & 2.

17.1.3 The leading dimensions of standard turnouts and crossings are given Drug. Nos. RE/33/G/01104, sheet 1 and 01105, Sheet 1 for the broad gauge and in Drug. Nos. RE/33/G/01104, Sheet 2 and 01105, sheet 2 for the metre gauge.

17.2 Overlap type

In the case of turnouts for high-speed running a mast is located near the centre of the turnout and the contact wire of the secondary track is raised in one or more spans (exclusive of the anchor span) after the centre of the turnouts, before it is anchored. A cross over is equipped in the same manner as two ordinary turnouts.

Note: Overlap type overhead equipment at turnouts taking off from main line shall be provided.

17.2.1 A diamond crossing with or without slips is equipped as two turnouts, the turnout centres being coincident. The mast located near the common centre is, therefore, equipped with three bracket assemblies (See Drug. No. ETI/OHE/G/02151).

17.3 Crossed type

The crossed type equipment for turnouts is normally adopted on secondary tracks but may be used on main tracks, where speeds are less than 100 km/h. The overhead equipment of the secondary track normally crosses the overhead equipment of the main track or does not have any overlapping span before anchorage. The two contact wires are clamped together to prevent relative vertical displacement. For this type of equipment, no support is necessary near the centre of turnout.

17.3.1 In case of diamond crossings with double slips, if crossed type of equipment is provided, doubling of contact wire is necessary (See Drug. No. ETI/OHE/G/03152, sheet 2). Doubling of contact wire is, however, not essential in the case of diamond crossings with single slip. In either case, no mast is necessary at the centre of the crossings.

18 Arrangement of Masts
18.1 Location of masts.

Masts should generally be arranged as far as possible in the same line parallel to the track and in the same line transverse to the track. Normally, no masts should be located between any two main running tracks.
18.2 Umbrella type

Masts may be fitted with bracket assemblies on each side to serve adjacent tracks if the overhead equipment of the tracks belong to the same elementary electrical section.

18.3 Restrictions

18.3.1 Masts serving track of different elementary sections should not normally be located between them and in the same line. If two masts serve tracks belonging to two different elementary electrical sections and are located between them, the masts should normally be staggered by 9 m, though a minimum stagger of 4.5 m is permissible in exceptional cases (Ref. Fig. A1.08(i)).

18.3.2 If one of the masts mentioned is an anchor mast, and the anchor falls between the two masts, they should be staggered by 13.5 m minimum (Ref. Fig. A1.08(ii)).

18.3.3 If both the masts mentioned are anchor masts and both anchors fall between the masts, they should be staggered by 18 m (Ref. Fig. A1.08(iii)).

18.3.4 If one of the masts is an anchor mast and the anchor falls away from the masts and the out-of-run equipment runs close to the second mast, the spacing of masts should be such that sufficient working clearance

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FIG. A 1.08
is available between the overhead equipment and the second mast. (See para 3.2). Cut in insulators or special anchor arrangements may be adopted in special cases (Ref. Fig. A1.08(iv)).

18.4 If masts are located on both sides of a track, they shall be staggered by 4.5 m (Ref. Fig. A1.08(v)).

18.5 Masts for turnouts and diamond crossing should be located at the theoretical centre. If unavoidable, 2 metres is the permissible displacement on either side of the theoretical centre of turnout.

18.6 Wiring of loops in future

Masts should generally be located and designed to permit wiring of unwired loops and extension of electrification in yards and sidings, in future, conveniently. Wherever such provisions is made, future wire-runs should be shown in dotted lines on the layout plans to ensure selection of correct type of masts and foundations.

18.7 Masts with counterweights should be avoided on platforms.

18.8 Ash-pits & water columns

Masts should not be located within 15 m of ash-pits and water columns. Steam engines standing at water columns and ash-pits blow off steam which may cause flash-over of insulators.

---

**Fig. A1.09**

- Turn Out
  - i = 2.75 m. (MG)
  - = 3.00 m. (BG)

- Diamond Crossing
  - i = 2.75 m. (MG)
  - = 3.00 m. (BG)

---

**Fig. A1.10**

- 30 m. (MIN.)
- 10 m. (MIN.)
18.9 Masts shall not be located in front of station entrances.

18.10 Masts shall not be located opposite to trolley refuges, close to culverts, subways and on bridges of length less than 50 m.

18.11 No masts shall be located beyond a signal post at a distance less than 10 m. In case the OHE mast is located in the front of the signal the distance between the OHE mast and signal post should not be less than 30 m (Ref. Fig. A1.10)

18.12 Masts should be located sufficiently far away from level crossings and back of abutments of bridges. The distance between the mast and the end of the level crossing/abutment shall not normally be less than 10 m.

18.13 The sections having more than two tracks, independent masts should be provided if adequate track centres are available or if the tracks can be slewed. Where adequate track centres are not available portals will normally be adopted and they should be located in such a way as to facilitate provision of drop arm/s and bracket assembly.

18.14 In case of bad formations, if it is possible to locate the masts on either side of a track, preference should be given to the side with better stability.

18.15 Support for OHE in tunnels.

In the lines 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.

18.16 Masts on bridges

Core holes for erecting masts on bridges should be provided as per Drug. No. RE/31/0590/63 on both sides of all the piers. Holes on piers which are not used for foundation should be filled with dry sand covered with a concrete slab.

18.17 In case of wiring a petroleum siding special precaution shall be adopted as laid down.

19 Cantilever Arrangement

19.1 Overhead equipment is supported from the masts by cantilever bracket assembly made of galvanized steel tubes. The bracket assembly shall be of the swiveling type.

19.2 Cantilever arrangement

The arrangement of cantilever depends upon the height of contact wire, encumbrance, suspension distance, stagger and super elevations. Standard cantilever arrangements are given in Drug. No. ETI/OHE/G/02106, Sheet 1 & 3.

19.2.1 Platform location

The arrangement of cantilever on platform shall be as per Drug. No. ETI/.OHE/G/-2104, Sheet 2.

19.3 Allowance for adjustment

The bracket assembly shall be such as to permit easy adjustment of the whole equipment after erection to cater for displacement of track during maintenance to the extent of 100 mm on either side of the track centre.

19.3.1 Adjustment on bracket tube

It shall be ensured at the time of selection of bracket assembly that the free length of the bracket tube beyond the
catenary suspension bracket fittings is at least 150 mm to facilitate future adjustment.

19.3.2 Adjustment on stay tube

The selection of stay tube at any location shall be such that its adjuster is free for adjustment of minimum 90 mm in either direction.

19.3.3. In case of curve track when the rail level is raised or the super elevation is changed due to strengthening of track structure, the pantograph axis will be shifted. If this shift is not within the possible adjustment limit of bracket assembly as specified in Clause 19.3.1 and 19.3.2 above, new cantilever may have to be provided taking care that at no stage the contact wire is beyond the specified stagger.

19.4 Size of tubes

The size of stay tube and register arm tube is 28.4/33/7 mm dia. For all cantilever arrangements. The size of bracket tube is either 30/38 mm or 40/49 mm designated as standard or large respectively depending upon the location (See Drug. No. ETI/OHE/G/00158 sheet 1,2 and 3 and 00159 sheet 1,2 & 3).

19.5 Back to back arrangement

More than one cantilevers (on the same side) are provided on the masts for overlap, turnouts, cross over and diamond crossings. The cantilever may be symmetrical (50 cm on either side of the mast) or asymmetrical (65 cm on one side and 35 cm on the other side of the mast).

Note I) Adoption of more than three bracket assembly is not possible on a single cross arm.

II) Cantilever assemblies can be provided on both sides of the masts, if the OHE of the two tracks are of the same elementary section. This is called ‘Umbrella’ construction.

19.6 Bracket assembly on drop-arm.

On portals, bracket assembly for the intermediate track/s is erected on drop arms. Wherever the track centre is inadequate (i.e. suspension distance less than 1.60 m), the equipment should be supported on drop arm of reduced length so that the bracket assembly does not infringe with the swept zone of pantographs. The arrangement is shown in Drug. No. ETI/OHE/G/02108.

19.7 Bridge & Tunnels

Bracket assembly of special design may be adopted on bridges and tunnels after making clearance study.

19.8 Bracket chair

Bracket assembly can be designed up to suspension distance of 3.5 m only. If the suspension distance is more, bracket chair to drawing No. ETI/OHE/P/3050 and RE/33/P/3100 shall be used.

19.9 Insulator for Bracket Assembly

In polluted areas e.g. tunnels, areas near sea coast, neighbourhood of chemical/fertilizer/cement plants, near steam loco sheds, ash pits, water columns etc. long creepage path (1050 mm) insulators should be used on the cantilever assemblies.
20 Setting of Masts

20.1 Tangent Track

The standard setting i.e. the normal distance of the nearest part of the traction mast from the centre line of tangent track shall be 2.50 m for the broad gauge and 2.35 m for the metre gauge. The setting may be reduced to a minimum of 2.36m for the broad gauge and 2.14 m for the metre gauge only in special circumstances such as yards, cuttings and bridges etc. with the approval of the Chief Electrical Engineer of railway concerned. In case of portal uprights, masts carrying more than one OHE and head span masts, the setting should normally be less than 3.00 m for the broad gauge and 2.50 m for the metre gauge.

20.2 Curved track

The minimum setting distance of masts including portals, head span masts etc. on curves is obtained by adding the curve allowance and 150 mm slewing allowance to the setting distance specified for tangent track in para 20.1. For trunk routes and main lines where the speed may be increased in near future, curve allowance should be taken as per table-III. For other routes, branch lines and yards where there is no prospect of increase in above 105 km/h in near future, the curve allowance should be taken as per table- I for Broad gauge and Table-II for metre gauge. Normally, the standard setting distance on broad gauge main lines on curves should not be less than the values given below:

<table>
<thead>
<tr>
<th>a) On outside curves</th>
<th>Standard setting (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Radius of curvature greater than or equal to 875m.</td>
<td>2.50</td>
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<tr>
<td>(ii) Radius of curvature less than 875m.</td>
<td>2.65</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>b) On side curves</th>
<th>Standard setting (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Radius of curvature greater than or equal to 3500m.</td>
<td>2.90</td>
</tr>
<tr>
<td>(ii) Radius of curvature greater than or equal to 2350m. but less than 3500m.</td>
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</tr>
<tr>
<td>(iii) Radius of curvature greater than or equal to 1150m but less than 1150m.</td>
<td>3.25</td>
</tr>
<tr>
<td>(iv) Radius of curvature greater than equal to 300m. but less than 1150m.</td>
<td>3.30</td>
</tr>
<tr>
<td>Degree of curvature</td>
<td>Radius of curvature (metre)</td>
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<td>---------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1 °</td>
<td>1747</td>
</tr>
<tr>
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<tr>
<td>7 °</td>
<td>250</td>
</tr>
<tr>
<td>8 °</td>
<td>219</td>
</tr>
<tr>
<td>9 °</td>
<td>194</td>
</tr>
<tr>
<td>10 °</td>
<td>175</td>
</tr>
</tbody>
</table>

Note: See Drg. No. ETI/OHE/G/00111 Sheet 1, also for this reference.
<table>
<thead>
<tr>
<th>Degree of curvature</th>
<th>Radius of curvature (metre)</th>
<th>Max. permissible speed (km/h)</th>
<th>Super elevation (mm)</th>
<th>Extra clearance between adjacent track (mm)</th>
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<tr>
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<td></td>
<td>Inside curve</td>
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<td>1°</td>
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<td>50</td>
</tr>
<tr>
<td>2°</td>
<td>875</td>
<td>72</td>
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<td>120</td>
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Note: See Drg. No. ETI/OHE/G/00111 Sheet: 2 also for reference.
### TABLE - III

**Curve allowance for maximum speed 200 km/h - Broad gauge***

<table>
<thead>
<tr>
<th>Degree of curvature (metre)</th>
<th>Radius of curvature (metre)</th>
<th>Max. permissible speed (km/h)</th>
<th>Super elevation (mm)</th>
<th>Extra clearance between adjacent track (mm)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Inside curve (mm)</td>
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<tr>
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<td>185 (100)</td>
<td>575 (295)</td>
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<td>1 1/2 °</td>
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<td>155 (160)</td>
<td>185</td>
<td>590 (10)</td>
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<tr>
<td>2 °</td>
<td>875</td>
<td>135 (160)</td>
<td>185</td>
<td>605 (30)</td>
</tr>
<tr>
<td>3 °</td>
<td>583</td>
<td>110 (160)</td>
<td>185</td>
<td>620 (40)</td>
</tr>
<tr>
<td>4 °</td>
<td>438</td>
<td>95 (160)</td>
<td>185</td>
<td>640 (60)</td>
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<td>5 °</td>
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<td>85 (160)</td>
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<td>655 (80)</td>
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<tr>
<td>6 °</td>
<td>292</td>
<td>80 (160)</td>
<td>185</td>
<td>655 (80)</td>
</tr>
</tbody>
</table>

Note: i) Figures in bracket indicates super elevation and curve allowance for 160 km/h speed.
ii) See Drg. No. ETI/OHE/G/00111 sheet 1, for other reference.

* Reproduced from Railway Board’s letter No. 68/WDO/SC/1 dated 15.4.1968.

20.2.1 In yards, where there is no super-elevation of track on curves, the extra clearance indicated may be reduced suitably in locating masts between tracks.

20.3 Masts with counter weights

In the case of masts with counter-weights, the term “Setting” refers to the minimum distance of the counter-weight from the track centre in the worst condition. For this purpose, the displacement of the counter-weight due to wind transverse to the track may be taken ± 50 mm.

20.4 Platform masts

The setting of masts on platforms shall not be less than 4.75 m on the broad gauge and 4.0 m on the metre gauge. As far as possible, masts shall be located in line with other masts or obstructions on platform and shall be of minimum possible dimensions and fit in with the architectural pattern prevailing in the vicinity. Locations of masts opposite to public entrances, exits, staircases, gang ways shall be avoided. No live conductor should be run over platforms.
20.5 Masts near signals

The visibility of signals should be kept in mind while deciding the setting up masts in their vicinity. The following principles should be observed for deciding the setting of masts near signals.

20.5.1 Colour light signals located outside all tracks.

a) Colour light signals without route indicators.

i) Where no approach signal is provided

The minimum setting of mast before signal should be 3.25, 3.10, 3.05, 2.90 and 2.75 m for distance upto 80 m, beyond and upto 110 m, beyond and upto 190 m, beyond and upto 270 m and beyond and upto 400 m respectively.

ii) Where approach signal is provided and for signals other than distant signals.

The minimum setting of masts before the signal should be 3.25, 3.10, 3.05, 2.90 and 2.75 m for distance upto 50 m, beyond and upto 70 m, beyond and upto 115 m, beyond and upto 160 m and beyond and upto 240 m respectively.

b) Colour light signal with route indicators.

i) With horizontal route indicator

The minimum setting of masts before the signal should be 3.72, 3.50, 3.25, 3.05, 2.90 and 2.75 m for distances upto 60 m, beyond and upto 125 m, beyond and upto 170 m, beyond and upto 215 m, beyond and upto 250 m, beyond and upto 310 m respectively.

ii) With other than horizontal route indicator

The minimum setting of masts before the signal be 3.50, 3.25, 3.05, 2.90 and 2.75 m for distances upto 70 m, beyond and upto 130 m, beyond and upto 170 m, beyond and upto 215 m, and beyond and upto 280 m respectively.

Note : 1 See Drg. No. ETI/OHE/G/00112 also. The setting may be reduced in special cases, conforming to Figs. 6 to 9 of ibid.

2) Setting distance may be reduced for starter signals of loop lines and yard lines

20.5.2 Colour light signals located between tracks:

a) Signals without route indicators:

No OHE mast should, as far as possible be located in the same lane as the signal for a distance of atleast 600 m before a signal. Drop arms of portals should also not normally be located in the lane where signals are located, at least for a distance of 600 m before the signal.

Where this is not possible, for any reason, the signal should be mounted on an off-set bracket. In addition, a special study should be made in each such case in respect of three drop arms before the signal, to see whether the drop arms can be off-set from the centre line of the lane in a direction opposite to the off-set of the signal or alternatively, whether it is possible to shorten the drop arms. Reduction in the signals height may also be examined.
b) Signals with route indicators:

The principles mentioned under para 20.5 (a) should be observed in these cases also.

Note: 1 No part of a colour light signal without a route indicator should, as far as possible, be higher than 5.2 m above all level. Great care should be exercised in deciding the locations of colour light signals with route indicators so that the necessary minimum clearances are available between the signals and live out of run conductors, or pantograph sway zone.

2. On single-line sections, signals (colour light as well as semaphore) should, as far as possible, be located on the side of the track opposite to the OHE masts.

20.5.3 For semaphore signals located outside the track:

The minimum setting of masts before the signal should be 3.05, 2.90 and 2.75 m for the first second and next three masts respectively.

Note: For details, See Drg. No. ETI/OHE/G/00112.

20.6 Masts on bridge piers

The setting of masts on piers of bridges will be large as possible and indicated by the Railway.

20.7 Turnouts

The setting of masts located near theoretical centres of turnouts and diamond crossings should be 3.0 m from the nearest track for the broad gauge and 2.75 m for the metre gauge (Ref. Fig. A1.09)

20.8 Portals

Wherever portals are proposed to be used, they shall be selected with standard clear spans (distance between face of the uprights) indicated in the tables IV and V. For this purpose the clear span for any location obtained by adding the proposed setting of the two columns to the centre-to-centre distances of the tracks spanned by the portal shall be rounded off to the next higher standard span indicated in the tables. The setting of the uprights of the portal shall then be adjusted to suit the standard span selected with a minimum setting distance as specified in para 20.2.
<table>
<thead>
<tr>
<th>Nominal range: 10.0 m to 20.0 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.91</td>
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<tr>
<td>10.41</td>
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</table>
### TABLE V

Standard Clear Span for 'O' and 'G' type Portal
Nominal range: 20.0 m to 30.0 m

<table>
<thead>
<tr>
<th></th>
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<th>20.15</th>
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</tbody>
</table>

### 21.0 Over-line Structure

#### 21.1 Clearance

The requisite minimum electrical clearances (See para 3) should be maintained under over-line structures such as over-bridges, signal gantries, platform sheds and tunnels. The location of structures and spans under these structures is, therefore, determined to suit the clearances. A clearance study shall be made for all existing over-line structures. Efforts should be made to provide as large clearance as possible.
21.2 Where adequate clearance is available, the catenary should be erected so as to have maximum clearance from the over-line structure to reduce the possibility of birds perching on the catenary wire and coming in contact with earthed parts.

21.3 The catenary is normally passed freely under over-line structures. Where this is not possible on account of restricted clearances, the following alternatives may be adopted.

i) The catenary may be suspended from the two-faces of the over-line structures.

ii) Suspension from over-line structure

The catenary may be suspended from the over-line structure at an intermediate point.

iii) The catenary may be anchored on to the over-line structure on either side or on to special anchor structures. The anchor point should normally be the anticreep.

iv) Special designs may be adopted inside covered station areas and on through girder bridges, employing even regulated tramway type equipment (contact wire only), where it is feasible.

Note: At over-line structures, the span should preferably be centrally located as far possible and generally should not exceed 54.0 m.

21.4 Polluted zone

Double insulation or insulator for polluted zones shall be used in the following cases:

i) In tunnels (see para 19.9)

For insulators located on the axis of the track in areas where steam traction would be in extensive use or where smoke is likely to accumulate.

22.0 25 kV Feeders

22.1 Suspension

Where a 25 kV feeder is run longitudinally on traction masts, it shall be carried on the masts as shown in Drg. No. ETI/OHE/G/05143. The feeder may be run on either side of a mast. Two 25 kV feeders, or one return conductor and one 25 kV feeder, may be carried on a single mast, if necessary, with one feeder on each side of the mast.

Note: If the 25 kV feeder and OHE are of different elementary sections, ‘Restricted clearance’ board shall be provided.

22.2 Clearances from over head equipment

Where a 25 kV feeder crosses overhead equipment belonging to a different elementary electrical section, the clearance between the feeder and the overhead equipment shall not be less than two metres under any conditions.

22.3 Clearance from line side structures

Normally, no feeder should be erected over huts, cabins, goomties, platforms shed or other covered structures. If unavoidable the clearance between the highest point of a covered structure and a 25 kV feeder passing over it shall be 2 m under all conditions. In the case of a 25 kV feeder passing over an over-line structures which is not covered, a suitable metallic screen shall be provided on the structure underneath the feeder. The clearance between the feeder and the highest point of the screen shall be adequate. A clearance of 2 m is desirable between...
23.0 Cross-Spans at Switching Stations
23.1 Cross span arrangement

All the switching stations have gantry with two or more main vertical supports. Cross span wires/feeders are provided on the gantry to connect the various sections of overhead equipment by jumper connections. The general arrangement is shown in Drg. No. ETI/OHE/G/05124

23.2 Setting distance

The minimum setting distance of the gantry upright which is normally aligned parallel to the track shall be 4.30 m.

23.3 Multiple track

The general arrangement of connections at the switching stations on double track and multiple track section are shown in Drg. No. ETI/OHE/G/05125 and 05126 respectively.

24.0 Tramway type overhead equipment
24.1 Regulated Equipment

In tramway type equipment only contact wire is provided and is auto-tensioned at the anchor by weight. The contact wire is supported by swiveling type of brackets on individual masts as indicated in Drg. No. ETI/OHE/G/04204. Generally the principles applicable to normal overhead equipment are also applicable to regulated tramway equipment except as specified below:

24.1.1 Usage

The regulated tramway type equipment is to be adopted for loop lines, sidings, yards and spur lines excluding the main running line and first loop or lines taking-off from the main running line.

24.1.2 Span

The maximum span is restricted to 63 m. The general arrangement is shown in Drg. No. ETI/OHE/G/04203.

24.1.3 Section Insulators

Where a section insulator assembly is to be provided, the provision of a structure to support the assembly is obligatory. The arrangement is shown in Drg. No. ETI/OHE/G/04207 sheet 1 & 2.

24.1.4 The arrangement of tramway equipment at anti creep and points and crossings are shown in Drg. No. ETI/OHE/G/04205 and 04208 respectively.

24.2 Unregulated equipment

The general arrangement of tramway equipment to be adopted for head span and cantilever type construction is shown in Drg. No. ETI/OHE/G/04101. The principles applicable to normal OHE are applicable to this type of unregulated equipment except as specified below.

The maximum span is restricted to 30m. In station areas, where this type runs side by side with conventional equipment with contact and catenary wires, the maximum span may be increased to 31.5 m.

24.2.1 Where a section insulator is to be provided the provision of a structure becomes obligatory.
25.0 **Booster Transformers**

25.1 100 KVA Booster Transformer wherever necessary for suppression of inductive interference of P&T communication lines running in close vicinity and parallel to 25 kV OHE may be provided separately for each running tracks. The primary winding of the booster transformer is connected in series with the OHE at insulated overlaps. The arrangement of mounting and connection is shown in RDSO Drg. No. ETI/PSI/115.

25.2 The Booster Transformers are located at an approximate spacing of 2.66 km between each other.

25.3 The location of the booster transformer should be decided considering the following aspects:

a) At feeding posts and sectioning and paralleling posts the booster transformers should be located equi-distant on either side so that the mid-point falls in front of these switching stations.

b) In exceptional circumstances where the booster transformers are not placed equi-distant from the feeding post or sectioning post, it must be ensured that the distance of the booster transformer from FP or SP does not exceed 1.33 km

c) The booster transformer should not be located

- In the vicinity of the stop signals to avoid bridging of insulated overlap by locomotives pantograph.
- Within the station limits except for very big stations.

26.0 **Return Conductors.**

26.1 Route

In deciding the route of return conductors the obstructions en-route should be taken into consideration. Besides, adequate physical and electrical clearances should be maintained from fixed structures.

The general objectives is to run the return conductor as close as possible to the associated overhead equipment so as to secure maximum compensation. Subsidiary lines such as sidings, loops etc. are not provided with return conductors.

The return conductor will be normally run on the traction masts on the same side as the overhead equipment. The arrangement is shown in Drg. No. ETI/OHE?/05307. The clearance between the return conductor and the overhead equipment should not be less than 400 mm under the worst conditions.

26.2 Clearance

The static and dynamic clearance to any part of the return conductor from an earthed structure should be 150 mm and 80 mm respectively.

26.3 Return conductors at over-bridges.

At over-bridges return conductors may be run straight through, if possible as on normal structures.

26.4 Return conductors in complicated areas.

In station areas having complicated track layout, it may not be practicable to position the return conductor sufficiently close to the associated overhead equipment to secure the required compensation. In such cases, the route of the return conductor should be decided on the merits of each case. Care being taken to avoid running of return conductor over platforms.
26.5 Tension lengths of return conductors

Return conductors are normally terminated at the masts where the return conductors are connected to the rail. They may be anchored back-to-back at such masts.

26.6 Connections to booster transformers.

At all booster stations, the return conductors for each track should be provided with a cut-in-insulator. The return conductor is connected in series with the secondary winding of the booster transformer and the connections of the return conductor to the booster transformer should be carried out in accordance with Drg. No. ETI/OHE/G/05413.

26.7 (i) The mid-point of return conductor shall be connected to the buried rail as per RDSO’s Drg. No. ETI/OHE/G/05306 and ETI/PSI/611. The mid-point is defined as a mid point between two consecutive booster transformers.

ii) Mid-point of the return conductor before feeding posts shall be connected to the buried rail on either side of the insulated overlap and in case of sectioning posts shall be connected on either side of the neutral section.

iii) In exceptional circumstances, where mid-point does not fall in front of feeding posts and sectioning posts, the two rail links between return conductor and rail should be provided in front of feeding post and sectioning post on either side of the insulated overlap/neutral section. In these cases, mid-point should not be connected to rail.

27.0 LT Supply Transformer

27.1 Low tension power supply

230 V single phase power supply required for operation of sub-station equipment e.g. circuit breakers, interrupters, etc. Lighting of the station yard, tunnels and working of colour light signals, is obtained through 25 kV 230 V, 10 KVA 50Hz. single phase LT supply transformer. It is provided at substations feeding and switching posts, stations, block-huts and at other outdoor locations e.g. level crossings with gate signals.

27.2 Capacity

LT supply transformers are of 10 KVA capacity. More than one transformer are provided at large station, yard etc.

27.3 Protection

LT supply transformers are protected only by a 25 kV, Amp. Dropout fuse on the primary side and 63 A fuse (rewireable d.c. type with 20 SWG tinned copper wire) on the secondary side.

27.4 Mounting Arrangement

The LT supply transformer is mounted on steel platform erected on the OHE mast and connected to the 25 kV OHE through rigid aluminum bus-bar or 50 mm² copper jumper wire. The general arrangement of mounting and connection is shown in Drg. No. ETI/PSI/036

27.5 Substation LT supply.

At substation, in order to provide power to single phase transformer oil centrifuging /filtration plant, 100 KVA, 25 kV/230V 50 Hz. single phase transformers are provided. The general arrangement of mounting and connection is shown in Drg. No. ETI/PSI/0312.
28.0 Mast and Rail Bonds

28.1 Structure Bonds

All traction masts shall be bonded to a non-track-circuited rail as shown in Drg. No. ETI/OHE/P/7000 (see para 29.1). In the case of portals, only one uprights of the portals, and in the case of head spans, both masts of the head spans, shall be bonded to non-track-circuited rails.

28.2 Rail Bonds

The rail bonds to connect the running rails longitudinally across a rail joint shall be in accordance with Drg. No. ETI/OHE/P/7030.

28.3 The cross bonds connecting two rails of track or rails of track or rails of adjacent track shall be in accordance with Drg No. ETI/OHE/G/05251

29.0 Earth Wires

29.1 Sectioning and earthing

In sections where a non-track circuited rail is not available, as in double-rail track-circuited sections, all traction masts shall be connected together by a continuous aerial earth wire supported by the traction masts. The earth wire shall be divided into electrical sections not exceeding 1000 m in length by means of cut-in-insulators. Each section of earth wire shall be bonded to traction mast which should be connected to an earthing station (Drg. No. ETI/OHE/P/7020). With two separate earth electrodes in such a way that the interval between the earthed structures does not normally exceed 500 m as shown in Drg. No. ETI/OHE/G/05201.

29.2 In Tunnels

In case of tunnels, all the traction support structures shall be connected together by a continuous earth wire, which may be supported from tunnel surface. The earth wire shall be made into discontinuous sections not exceeding 1000 m and shall be connected to earth electrodes provided not more than 500 m apart and traction rail at both ends of the tunnel.

29.3 Layout

No earth wire shall cross any track. Where masts required to be connected to an earth wire are located on opposite sides of a track, separate wire-runs shall be used for connecting the masts. In complicated areas, masts may be connected to individual earthing stations.

29.4 Anchoring

Earth wires need be anchored only at termination of wire-runs.

30.0 Sections Arrangement.

30.1 Necessity of sectioning

OHE is divided into electrically isolated sections by provision of interruptors or isolators at overlaps and with section-insulators at turnouts. Sectioning is provided to permit isolation of OHE in small sections for maintenance or to isolate damaged OHE in case of breakdown/accident and to permit diversion of trains from up line to down line and vice-versa. However, the sectioning should be kept to the minimum consistent with operational requirement.
30.2 Protection of isolated sections

Protection by signal of the isolated sections:

Normally a stop signal is provided before the insulated overlap, i.e. isolator so that approaching train is stopped from entering the isolated section. Although the distance between the stop signal and the sectioning points has not been specified in the rules, it is desirable to provide 120 m between the stop signal and the centre line of the insulated overlap/section insulators, i.e., the sectioning point.

30.3 Sectioning arrangements for different types of stations:
Since most of the electrified routes are on the double line section, only double line stations have been considered.

30.3.1 Stations having no emergency cross-over:

The isolation is provided to take a block. The trains are stopped by the stop signal. The sectioning point should be provided 120 m away from the starting signal. This arrangement enables the trains to be received at the station. Fig. A1.11 shows the layout.

![Image](image1)

**FIG. A 1.11**

30.3.2 The first loop line adjacent to the main is normally provided in the same elementary section as that of the main line. No sectioning is, therefore, required between the main line and the loop line. Only where there are group lines comprising of 2 loops or more, sectioning should be provided to include the loop lines in an independent elementary section. In case of large number of loop lines, the chances of damage to the OHE being more, they should be isolated to keep the main line operative. The arrangement is shown in Fig. A1.12.

![Image](image2)

**FIG. A 1.12**
30.3.3 **Stations provided with emergency cross-overs:**

At the stations provided with emergency cross-overs, the diversion of trains from up-track to down-track and vice versa and also the diversion of trains coming on the wrong track to the correct track is possible. Isolation at such stations should be provided in accordance with Fig. A1.13 so that the longest train can be pulled beyond the cross-over before backing. It is advisable to keep the advance starter sufficiently away from the cross-over so that the longest train length can be accommodated between the cross-over and the advance starter. Otherwise, provision should be made in the station working rules for shunting of the trains beyond advance starter.

![Fig. A1.13](image)

**FIG. A1.13**

30.3.4 **Stations provided with emergency cross-over and loop lines:**

At stations having loop lines the isolation arrangement as shown in Fig. A1.14 & A1.15 should be adopted. Where space is available, the insulated over-lap and the isolator should be provided between the points, A & B as shown in Fig. A1.14. Otherwise, the insulated overlap should be provided before the point and a section insulator provided in the loop line as shown in Fig. A1.15.

![Fig. A1.14](image)

**FIG. A1.14**

![Fig. A1.15](image)

**FIG. A1.15**
30.3.5 Sections having one or more common loops situated on one side of the track:

Generally the common loop is situated on one side of the main track. Such common loop can be electrically connected only to the adjoining main line. Stations with such a common loop also have a facing cross-over which can be beneficially used for diversion of trains from one line to the other without reversing. The sectioning should permit diversion of trains from one line to the other in both the directions. The sectioning given in Fig: A1.16 would meet these requirements.

**FIG. A 1.16**

**FIG. A 1.17**

**FIG. A 1.18**

Note: Where space is available the insulated overlap and isolator should preferably be provided between (A) & (B).
For layouts having a group of (common) loops on one side, sectioning arrangement shown in Fig. A1.17 should be followed.

Where an SSP is located the sectioning arrangement as shown in Fig. A1.18 could be adopted. However, this arrangement cannot be adopted at feeding posts because in that case the cross-over would be connected to two different sectors and in case of extension of feed, the section-insulator would be connected to two different phases and subjected to 44 kV. Passage of electric locos in such condition would result in bridging of 2 phases which may damage the section insulator assembly.

30.3.6 **Common loop situated in between the two main lines.**

At some stations, the common loop is provided in between the two main lines. Such stations provided ideal arrangements for sectioning as the common loop can be connected to either up or down main lines through a set of inter-locked isolators. The sectioning arrangement is indicated in Fig. A1.19.

![Diagram of sectioning arrangement showing common loop situated in between the two main lines](image)

*Interlocked Isolators only one can be closed at a time

**FIG. A 1.19**

30.3.7 **Sectioning for the loco sheds and major yards:**

30.3.7.1 Loco sheds and major yards are prone to frequent flash-over of insulators due to pollution caused by steam/diesel shunting locomotives and also due to switching surges from the loco transformer and sparking of rod-gap which result in tripping of feeder breaker affecting power supply to the main line. It is, therefore, advisable to provide a separate feeder with a circuit breaker and required protection for all major yards and electric loco sheds. If the yard/shed is within 4 km from the traction sub-station, a separate feeder can be economically run. If the yard/shed is beyond 4 km the power supply may be given by an interrupter located in the SSP with provision to supply from either UP or DOWN line. In case the circuit breaker or interrupter is out of service for maintenance, alternative arrangement is made to tap the OHE, directly through an inter-locked isolator. These arrangements are shown in drawing No. ETI/PSI/704.

30.3.7.2 Major yards are normally separated in Up and Down yards. Each yard is again sub-divided as Reception yard, Despatch yard, Sorting yard, Marshalling yard, etc. These yards, if electrified, should be electrically independent of each other. Each yard, if it consists of more than four lines, shall be divided into two or more elementary sections consisting of group of 3 to 4 lines each. Each elementary section should be fed by an isolator from a bus connected to the yard interrupter in such a way that interruption to any elementary section should cause minimum upset to the yard working.
31.0 Numbering of OHE Masts

31.1 Necessity

As the P&T overhead telegraph lines on the 25 kv ac electrified routes are replaced by underground screened cable, the OHE masts are used to indicate the kilometerage of the track. The mast number is also used for identification of the section of overhead equipment (OHE) and the line to which it belongs. There are normally 15 to 18 masts in one kilometer and each mast is given a number in serial order starting from kilometer post. The number is scribed in two parts, the kilometer being shown above the line and the mast serial number below the line. For example, (70/1) indicates the first mast from the kilometer post No. 70 on the Up line.

31.2 Single line section

In single line section where there is no chance of future doubling, numbering is done progressively in the direction of increase of kilometerage, i.e. 70/1, 70/2, etc. In case where doubling is anticipated in future the system of numbering will be according to para 31.3.

31.3 Double line section

All traction masts on Up track shall be given odd numbers, i.e. 75/1, 75/3, 75/5 etc. and that on Down track even numbers as 75/2, 75/4, 75/6 etc. 1 and 2 are the serial number of the masts immediately after every kilometer post. Numbering is done progressively in the direction of increase of kilometerage.

31.3.1 Since the OHE masts on Up and Down tracks are normally located opposite each other, the mast numbers 1 & 2 would be in one line, and mast numbers 3 & 4 would be in one line and so on.

31.3.2 In case the spans on the Up and down lines are not equal and the masts are not in one line, the masts shall be numbered in such a way that higher serial number does not occur at a lower kilometerage (see Fig. A.1.20).

![Diagram of mast numbering in station yards](image)

Numbering of Masts of loops and siding in station yards

Fig. A.1.20
31.4 Multiple section

In multiple track section, suffix ‘A’ is to be given to the multiple track mast. For instance in case of a section consisting of Up main, Down main and Up slow and Down slow track the slow track masts shall be numbered as 75/1A, 75/3A, etc. for Up slow line and 75/2A, 75/4A etc. for Down slow line. Uprights of portals, erected in multiple track sections shall be numbered with reference to main line only i.e. 75/1, 75/2 etc.

31.5 Numbering of masts of loops and sidings in station yards.

31.5.1 Individual masts.
Single cantilever and double cantilever mast supporting OHEs of tracks on either side (umbrella type) for loops and sidings shall bear the station code and serial number in one thousands series (1000). The station code shall be given on above the horizontal line and the serial number below it. Masts of Up loops and siding on Up line side shall be given odd number of 1001, 1003, 1005 etc. in the order of progressive chainage, irrespective of the number of loops and the masts on the Down loops and sidings on the Down line side shall be given even numbers 1002, 1004, 1006 etc.

In case several independent cantilever masts for different loops are located at the same chainage, loop mast nearest to the main track should bear the lowest number in the series (see Fig. 10). This system of numbering is applied from one end of a yard in the kilometerage of the starting point and progressively higher numbers is given in the direction of increase in chainage whether it is Up or Down yard. The numbering does not indicate the kilometerage.

31.5.2 (a) In case a portal is provided, the upright of the portal nearest to the main track shall be given a number in 2000 series, the other upright of the portal shall be given a number in 3000 series. In case of 3 leg portals, the farthest leg from the main track shall be given a number in 4000 series.

31.5.2 (b) In case a portal is covering both Up and Down main lines as well as loops and siding, the numbering shall be as for the main line tracks, irrespective of the fact that it also covers loops.

31.5.2 (C) In case of a portal covering Up main line and a number of Up side secondary tracks, the upright which is located near the main track and service the main line shall be numbered with respect to the main track. Other upright shall be given the same number with suffix ‘A’.

31.5.2 (d) The upright of portals in Up yard shall have odd numbers i.e. 2001-3001, 2003-3003 etc. and the upright in Down yard shall have even numbers i.e. 2002-3002, 2004-3004 etc.

31.6 Head span mast.
Procedure of numbering the mast of a head span shall be the same as that for portals detailed in 31.5.2 except that the mast of the head span shall be given numbers in 5000, 6000 and 7000 series as detailed in 31.5.2 (a).

31.7 Branch line masts
All masts on branch lines taking off from the main line are to be given a prefix letter indicative of the branch line, mast e.g. Pradhankanta-Pathardih which takes off from the main line at Pradhankanta is given a prefix letter ‘P’ which is indicating of Pathardih viz. 70/14 P.

31.8 Alternative numbering
Masts on loop/yard lines may also be numbered with a letter/word prefixed indicating the nomenclature of the line e.g. the mast numbers on a goods line in passenger station area may be numbered as G1, G2 etc. below the station code. The mast numbers on engine run-round line may be numbered as EL1, EL2 etc. This method may be adopted when additional lines are provided or wired subsequently.
31.9 Switching station masts

Mast at the switching station are numbered with the station code of the switching station for example KGP/1 which means Kharagpur Switching Station, mast No. 1.

32.0 Numbering of Equipment

32.1 Abbreviation of equipments

To identify the location of the equipments covering OHE and Switching stations a code for identifying the type of equipment followed by a S.No. is given.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>25 KV/230V Auxiliary Transformers</td>
</tr>
<tr>
<td>BT</td>
<td>Booster Transformers</td>
</tr>
<tr>
<td>BM</td>
<td>Interruptor for main lines</td>
</tr>
<tr>
<td>BS</td>
<td>Interruptor for yard lines</td>
</tr>
<tr>
<td>BX</td>
<td>Bus coupler interruptor</td>
</tr>
<tr>
<td>BC</td>
<td>Bus coupler isolator</td>
</tr>
<tr>
<td>CB</td>
<td>Circuit Breakers</td>
</tr>
<tr>
<td>CT</td>
<td>Current Transformers</td>
</tr>
<tr>
<td>DP</td>
<td>Double pole isolators</td>
</tr>
<tr>
<td>LA</td>
<td>Lightening arrestor</td>
</tr>
<tr>
<td>PT</td>
<td>Potential transformer</td>
</tr>
<tr>
<td>SF</td>
<td>Single pole isolator at Switching Station</td>
</tr>
<tr>
<td>SP</td>
<td>Single pole isolator at sub-station</td>
</tr>
<tr>
<td>SM</td>
<td>Isolator for main lines</td>
</tr>
<tr>
<td>SS</td>
<td>Isolator for secondary lines loops and yards</td>
</tr>
<tr>
<td>TR</td>
<td>Power transformer</td>
</tr>
</tbody>
</table>

32.2 Numbering circuit breakers

Each power transformer, current transformer, potential transformer is given a serial number in a Railway starting from 01 except 25 kV circuit breakers which shall be according to para 32.2.2.

32.2.1 High voltage (132/110/66KV) circuit breakers are given two digit numbers progressively increasing in the direction of increasing kilometerage starting from 01. For example, the first high voltage circuit breaker will be numbered as CB/01, 02, 03

32.2.2 25 kV circuit breakers are given three digit numbers - odd nos. e.g. CB/101, 103, 105 etc. for feeder breakers and even nos. CB/100, 102, 104 etc. for transformers circuit breakers.

32.3 The serial number of transformers and circuit breakers also follow geographical sequence within a substation/feeding post. Lower number is given for the equipment connecting at less kilometerage and higher number of for the equipment connected to higher kilometerage.

32.4 Interruptors

The main line 25 kV interruptors numbered serial wise progressively increasing from a datum point on railway. e.g. BM/01, 02, 03 etc.

32.5 Yard interruptors. The yard line interruptors are numbered serial wise on a railway i.e., BS 01, 02, 03 etc. Where there are different yards for Up and Down direction, the interruptor for Up yard is given odd number and that for Down yard is given even number.
32.6 Other equipment

The number of other equipments is serial wise progressively increasing irrespective of up or down line on a railway preferably according to increasing chainage.

32.7 Numbering of elementary section

Elementary section for main line are given a number beginning with the number of interruptor which feeds it (see Fig. A1.21)

32.7.1 The first two/three digits of the number for an elementary section indicate the governing interruptor and last two digit indicate the progressive serial numbers. The progressive serial number for Up line are odd number starting with 01 for example 3401, 3403 etc. and even number for Down line starting with 02 such as 3502, 3504 etc.

32.7.2 Yard elementary sections

The elementary section number of yard lines shall be provided with the number of the isolator which controls the feed of the line/s with a prefix ‘X’ For example, if an isolator, no. 118 controls the feed of the lines of the receiving yard the elementary section number of the lines is X 118.

32.7.3 Elementary section for two sides

If the line/s are fed by an inter-locked isolator numbering of the elementary section should corresponds to the isolator number which normally feeds the line/s.

32.7.4 Type of number plates

The number plates shall be in accordance with drawing No. RE/33/P/7501.
APPENDIX II

CODE FOR BONDING AND EARTHING FOR 25 kV a.c. 50 Hz. SINGLE PHASE TRACTION SYSTEM

(This is a reproduction of RDSO’s Code No. ETI/OHE/7(11/90)

1.0 Scope

This code shall apply to 25 kV a.c. 50 Hz. single phase traction system and covers the requirements for bonding and earthing of overhead equipment masts, structures and associated rails of railway track. The bonding and earthing at traction sub-station including feeding posts, switching stations, booster transformer stations, 25 KV/240 V auxiliary transformer stations and switching gantry as well as Signalling and telecommunication equipments are beyond the scope of this CODE.

2.0 Definitions

The following terms wherever appearing in this Code shall, unless excluded by or repugnant to the context, have the meaning attributed there to and apply as follows:

2.1 Bond’ means an electrical connection between two or more conductors of non-current carrying metallic parts of traction masts or structures or supports and rails.

2.2 “Cross bond” means a bond between two rails of a track or two rails of adjacent tracks. It is also called a transverse bond.

2.3 “Earth wire” means a conductor run on traction masts or structures or supports and bonded to their metallic parts/supports and connected to earth.

2.4 “Earth” means a connection to the general mass of earth by means of an earth electrode. An object is said to be ‘earthed’ when it is electrically connected to an earth electrode, and the object is said to be ‘solidly earthed’ when it is electrically connected to an earth electrode without intentional addition of resistance or impedance in the earth connection. The resistance of the earth electrode shall not exceed 10-Ohm.

2.5 “ Earth electrode” means a metal plate or pipe or any other conductor electrically connected to the general mass of the earth.

2.6 “Impedance-bond” is a bond, installed by the Signal and Telecommunication Department, which provides a low impedance path for the traction return current and a relatively high impedance path for track circuit current.

2.7 “ Rail-bond” means an electrical connection across a rail joint between consecutive lengths of rails. It is also called a ‘Longitudinal bond’.

2.8 “ Rail length” means a continuous length of rail with or without welded joints but with no fish plate joints.

2.9 “Structure bond” means a bond connecting for non current carrying metallic parts of a traction mast or structure or support to the traction rail.

2.10 “Signal bond” means an electrical connection across a rail joint, provided by the Signalling & Telecommunication Department, to facilitate flow of track circuit current.

2.11 “Short direct connection” means a connection for electrical continuity, which shall be of the shortest possible length with minimum bends.

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2.12 “Traction Rail” means a non-track-circuited rail of a wired track, not required for signalling purposes and which may be earthed. In non-track-circuited sections, both the rails of wired track are traction rails and in single rail-track-circuited sections, the traction rail is the non-track-circuited rail.

2.13 “Welded bond” means a bond which is made of standard copper conductors with M.S. ferrules at either end, pressed on the conductors and bent to shape.

2.14 “Wired track” means a track provided with 25 kV a.c. 50 Hz. Single phase overhead equipment.

3.0 Bonding

3.1 In the case of 25 kV a.c. 50 Hz. Single phase traction system, the traction current is drawn from the overhead equipment by the electric rolling stock, operating in a section and passes through the traction rail. The return current flows mostly through the earth leaving the traction rail except in a zone extending over a few hundred metres on both sides of the electric rolling stock in operation in the section or in the vicinity of a feeding station and returns to the traction sub-station. Bonding of all rails is, therefore, not absolutely essential unlike in the case of d.c. traction where practically the whole traction return current flows through the rail and hence bonding of rails is essential. However bonding of rail facilitates passage of the traction return current from the earth to the traction rails which are connected to the rail to earth and vice versa and is, therefore, provided in the vicinity of traction sub-station-feeding posts where the traction return current has to flow back from the earth to the traction rails with are connected to the earthed leg of the traction transformer at the sub-station, through a buried rail opposite the feeding post. Bonding of rails also ensures the spread of flow of return current into the earth and, therefore, reduces the voltage between rail and earth. So bonding of rails is done wherever it is essential to keep the rail voltage low to ensure safety of personnel.

3.2 The traction rail of a wired track when bonded or laid on metallic sleepers provides generally an earth better than an earthing station with earth electrode. If, therefore, any non-current carrying part of an equipment or metallic structure is required to be earthed, it shall ordinarily be connected to a traction rail.

3.3 Track Circuited Sections

3.3.1 In sections equipped with single rail-track circuits, the traction rail shall be bonded to ensure that:
   i) The ac voltage drop along its length is reduced so as to minimize the risk of ac voltage being applied to the track relays.
   ii) As low a resistance path as possible is provided both for traction return as well as signalling currents as fish plate joints cannot be relied upon for low resistance.

3.3.2 In sections with double rail-track-circuits, both rails are longitudinally bonded to ensure a low resistance path for traction return and signalling currents; and also to distribute the return current more evenly in both the rails. Impedance bonds are installed at insulated joints to provide a continuous path to the traction return current. All track-circuited-rails are, in addition, provided with signal bonds.

3.4 Structure bond

All non-current carrying metallic parts of traction masts or structures or supports or metallic parts of concrete/wooden masts, supporting the traction overhead equipment shall be connected by means of a structure-bond to the nearest traction rail or to an earth wire run on the traction masts/structures/supports or to an earth. In the case of a portal structure, only one leg of the portal shall be provided with the structure bond, whereas for head span masts, each mast of the head span shall be bonded to the traction rail nearest to it.

Where traction masts or structures or supports are located on railway platforms and are bonded to the nearest traction rail, a cross bond shall be provided at the location of the structure-bond to connect the rail to the adjacent traction rail.
3.5 Track Bonding
In station yards or elsewhere, where a track is not wired for its entire length, it shall be deemed to be wired for a distance of up to 50 metres beyond the traction mast at which the overhead equipment has been terminated. Rail bond and one cross bond shall be provided for a distance of up to 50 metres beyond the last traction mast.

3.6 Mode of Connection of Bond

3.6.1 All types of bond i.e. rail-bond, cross-bond and structure-bond shall be of mild steel of not less than 200 mm² cross sectional area.

3.6.2 A structure-bond shall be rigidly connected by means of galvanised steel fasteners to the traction rail and the metallic part of traction mast or structure or support.

3.6.3 A rail-bond shall be rigidly connected by means of galvanized steel fasteners longitudinally across the fish plate joint of the traction rail and the track-circuited-rail in a track circuited section except at the insulated joint of the track circuited rail.

3.6.4 A cross-bond shall be rigidly connected by means of galvanized steel fasteners between two traction rails of a track or non-track circuited rails of an adjacent track.

3.6.5 Where it is not possible to provide a rail-bond a welded bond shall be used. The bond shall be connected to the rails by electric or gas welding.

3.6.6 The bond for connecting return conductor to the traction rail through the buried rail shall normally be made with GI nuts and bolts with spring washer and check nuts.

3.6.7 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 mm² copper equivalent.

3.7 Bonding in Single Rail-Track-Circuited Sections

3.7.1 The traction rail in a single rail-track-circuited section shall be provided with rail bonds not only over the entire length up to which the track circuited rail exists but also for a distance of 50 m on both sides of the track circuited length. In addition, the traction rail shall be cross bonded to the traction rails. If any, of adjacent tracks wherever they exist at intervals of not less than 100 m. The traction rails of such adjacent tracks shall also be provided with rail-bonds over the entire length of the track circuits and for further 50 m on both sides. In case the length of a track circuited rail is not more than 350 m, a cross bond shall be provided between the rails of the track immediately outside the track circuited length at both of its end.

3.7.2 In single line section, whether or not doubling of the section is foreseen in the future, provided with single rail-track-circuit, the non-track-circuited rail shall be provided with rail-bond over the entire length and for a further 50 metres on both sides. It shall also be connected to an earth at distances not exceeding 100 metres from each other. The connections of the non-track-circuited rail to each of the earths shall be made by two separate mild steel strips/flats each of cross section not less than 200 mm². The need for providing an earth wire is thus obviated.

3.8 Bonding in Double Rail-Track-Circuited Sections
In a double rail-track-circuited section, both the rails shall be provided with rail-bonds. At insulated joints of the double rail-track-circuit an impedance bond shall be provided. Since no traction rail is available for structure bonding, an earth wire shall be run on the traction mast or structure or support. In case, the length of the earth wire exceeds 1000 metres it shall be made electrically discontinuous by providing a cut-in-insulator so that no.
section of the earth wire is greater than 1000 metres electrically. Each such section of the earth wire shall be connected to an earth at two traction masts or structures or supports at a distance not exceeding 500 m apart.

No cross bond shall be provided between the rails of the same track or between the rails of different tracks in a double rail-track-circuited section.

3.9 Bonding Adjacent to Traction Sub Station/Feeding Post

3.9.1 Commencing opposite to a traction sub-station/feeding post, all the traction rails shall be provided with rail-bonds for a distance of 1000 metres on either side of the traction sub-station/feeding post. In addition, these traction rails shall be cross-bonded at approximate distances of 300, 500, 700 and 1000 metres from the traction sub-station/feeding post.

3.10 Bonding of Rails on Wooden/Concrete Sleepers

A wired track shall be deemed to be on wooden or concrete sleepers if there are not more than six metallic sleepers in any length of track not exceeding 350 m. The traction rails of such a track shall be provided with cross bonds at distance of not more than 350 m apart. No rail bonds shall be provided.

3.11 Bonding of Traction in Loco sheds and Loco/EMU stabling sidings

All traction rails of loco sheds and loco/EMU stabling sidings shall be provided with cross bonds at distance of not more than 100 m apart. Further all sidings and/or dead ends, whether wired or not, shall be connected by rail bonds. The rails on wooden or concrete sleepers/supports in loco/EMU inspection pits shall be provided with rail-bonds for the entire length of the pit and also up to a length of 50 m on both sides and connected to an earth.

3.12 Bonding of Rails in a Tunnel

In a tunnel all the traction rails shall be provided with rail-bonds not only over the entire length inside the tunnel but also for a length of up to 50 m on both sides outside the tunnel. Besides, a cross bond shall be provided between the traction rails at either ends of the tunnel.

Note: If the tracks in a tunnel are track-circuited, the procedure in clause 4.0 shall be followed.

3.13 Bonding of Rails on a Weigh Bridge

Both the rails of a wired track on a weigh bridge shall be provided with rail bonds for a length of up to 50 m on both sides of the weigh bridge. If the rails are on wooden or concrete sleepers/supports, they shall be connected to an earth.

3.14 Bonding at a Level Crossing

All the traction rails shall be provided with cross bonds at only one location which shall be within five metres from either of the transverse edges of the level crossing.

3.15 Bonding at Oil Depot Sidings

3.15.1 Unwired sidings leading to a oil depot or installation shall be provided with duplicate insulated block joints as near as possible to the turn out from the main track from which they take off and before entry into the oil depot or installation.

3.15.2 Where a siding or a secondary loop line is to be wired to serve the purpose of loading and unloading of petroleum products, the arrangements to be made and precautions to be taken are:

i) A neutral zone shall be set up at either end of the length of the siding or secondary loop line over which the vehicles containing the petroleum products are to be berthed and loaded/unloaded. The neutral zone
is created both in the track as well as in the traction overhead equipment (OHE) by provision of insulating joints and section insulators with isolators as done for locomotive inspection pits respectively. The neutral zone is to ensure that the rest of the railway network is kept isolated when the loading/unloading operations are in progress so as to avoid propagation of stray currents.

ii) Both the rails of the siding or secondary loop line shall be provided with longitudinal-bonds. Besides, transverse-bonds shall be provided between the rails at distance not exceeding 30 metres apart.

iii) The rails of the siding or secondary loop line shall be connected to an earth at both ends immediately outside the neutral zone.

iv) An equi-potential link/switch shall be provided between the metallic portions of the petroleum installations i.e. the earth and the rails of the siding or the secondary loop line. This equi-potential link/switch is to be kept closed during the loading/unloading operations.

v) Each and every non-current carrying part of a traction mast or structure or support and other metallic structures in the vicinity of the siding or secondary loop line shall be provided with structure-bonds. Only copper rivets shall be used for connection between the non-current carrying metallic part or rail and the bond.

vi) During the time the loading and unloading of petroleum product is taking place, proper electrical continuity shall be maintained between the petroleum installations, the rails on which the vehicles containing the petroleum products are berthed and the OHE which has already been made dead and connected to the rails.

3.16 Bonding of Girder Bridge

3.16.1 Steel structures of a girder bridge shall be connected to a traction rail or to an earth by means of two mild steel strips/flats or cross section not less than 200 mm² each. The traction rails (where there are two or more such rails) on the bridge shall be connected by cross bonds at distances not exceeding 100 metres apart.

3.16.2 In a single rail track circuited section, the non track circuited rail which is the traction rail shall be provided with rail bonds (refer clause 3.7.1) and connected to an earth at either end of the bridge.

4.0 Bonding of Metallic Parts inside a tunnel

An earth wire connecting all non-current carrying metallic parts which form parts of the supports for the overhead equipment, shall be run inside the tunnel. The earth wire shall be connected to an earth as well as to the traction rails at both ends just outside the tunnel. In case, all the rails are track circuited, the earth wire shall be connected to an earth at both ends just outside the tunnel. If the length of the earth wire exceeds 1000 m, the stipulation in regard to making it electrically discontinuous as contained in clause 3.8 shall be followed.

4.1 Bonding of Over line Structure

The metallic parts of foot or road over bridges or other over-line structures over wired tracks shall be connected either to a traction rail or to an earth by means of two mild steel strips/flats of cross-section not less than 200 mm² each.

4.2 Bonding of Exposed Metallic Parts

All exposed metallic parts such as platform structures/sheds, metallic fencing, wires, pipes and such other items, not likely to come into direct contact with the 25 kV ac overhead equipment and located with a distance of 20 m from the nearest electrified track and running parallel to it for a distance of more than 20 m but less than 350 m shall be connected to an earth or traction rail. If parallelism with the nearest electrified track exceeds 350 m all such exposed metallic parts shall be connected to a separate earth at distances not exceeding 350 m apart.
No special precaution is required in case such metallic parts are fitted on metallic supports directly buried in the ground if the earth resistance of such metallic support is less than 10- Ohm.

4.3 Bonding of Earthing Heel of Isolator Switch

The earthing heel of an isolator switch shall be connected by two mild steel flats of cross-section not less than 200 mm$^2$ each to the supporting metallic traction mast or structure or support. The connection shall be as short and as direct as possible. Such a traction mast or structure or support shall, in turn, be connected to a traction rail or an earth wire and, in addition, to an earth.

4.4 Connection of Return Conductor

A return conductor connecting booster transformers shall be connected approximately at the mid point between the adjacent booster transformer stations to the traction rail of the same track or to the mid point of an impedance bond in the case of double rail track circuited section.

5.0 Drawings

The drawings issued by RDSO in connection with the practices prescribed in this CODE are listed below:

<table>
<thead>
<tr>
<th>SN.</th>
<th>Description</th>
<th>Drawing Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>General arrangement of earth wire on OHE mast.</td>
<td>ETI/OHE/G/05201</td>
</tr>
<tr>
<td>2.</td>
<td>Arrangement of transverse bonds</td>
<td>ETI/OHE/G/05251</td>
</tr>
<tr>
<td>3.</td>
<td>Connection of R.C. to track</td>
<td>ETI/OHE/G/05306</td>
</tr>
<tr>
<td>4.</td>
<td>Structure bonds</td>
<td>ETI/OHE/P/7000</td>
</tr>
<tr>
<td>5.</td>
<td>Earthing station</td>
<td>ETI/OHE/P/7020</td>
</tr>
<tr>
<td>6.</td>
<td>Longitudinal rail bonds</td>
<td>ETI/OHE/P/7030</td>
</tr>
</tbody>
</table>
APPENDIX III

CODE OF PRACTICE
FOR EARTHING OF POWER SUPPLY INSTALLATIONS
FOR 25 kVAC, 50 Hz. SINGLE PHASE TRACTION SYSTEM
(This is a reproduction of RDSO’s CODE No. ETI/PSI/120 (2/91)

1. Scope

1.1 This code of practice caters for general arrangement of system and equipment earthing at 220/25 kV or 132/25 kV or 110/25 kV or 66/25KV traction sub-stations, 25 kV switching stations, booster transformer stations and auxiliary transformer stations. Low voltage (LT) electrical power distribution system, 25 kV overhead equipment system as well as signal and tele-communication equipment do not come within the purview of this code.

2. Terminology

2.0 The following terms wherever occurring in this code shall, unless excluded or repugnant to the context, have the meaning attributed thereto as follows:-

2.1 Combined Earth Resistance: The resistance of an earth electrode (s) with respect to earth, with the earth electrode(s) connected to the metal work of electrical equipment other than parts which are normally live or carry current and the masts/structures but without connection with the traction rail(s).

2.2 Earth: The conductive mass of the earth, whose electrical potential at any point is conventionally taken as Zero.

2.3 Earth electrode: A conductor mild steel (MS) pipe, or group of conductors in intimate contact with and providing an electrical connection to earth.

2.4 Earthing grid: A system of a number of interconnected, horizontal bare conductors buried in the earth, providing a common ground for electrical devices and metallic structures, usually in one specific location.

2.5 Equipment earthing: Earthing of all metal work of electrical equipment other than parts which are normally live or current carrying. This is done to ensure effective operation of the protective gear in the event of leakage through such metal work, the potential of which with respect to neighbouring objects may attain a value which would cause danger to life or risk of fire.

2.6 Mesh Voltage (E mesh): The maximum touch voltage to be found within a mesh of an earthing grid.

2.7 Power supply installation: The electrical equipments and associated structures provided at a Railway Traction Substation or Switching Station, or Booster/Auxiliary transformer Station on the 25 kV over head equipment.

2.8 System earthing: Earthing done to limit the potential of live conductors with respect to earth to values which the insulation of the system is designed to withstand and thus to ensure the security of the system.
2.9 Step Voltage (E step) : The potential difference between two points on the earth’s surface separated by a distance of one pace, that will be assumed to be one meter in the direction of maximum potential gradient.

2.10 Traction Rail means a non track circuited rail of a wired track, not required for signalling purposes and which may be earthed. In non-track circuited sections, both the rails of a wired track are traction rails and in single rail circuited section, the traction rail is the non-track circuited rail.

2.11 Touch Voltage (E touch): The potential difference between a grounded metallic structure and a point on the earth’s surface separated by a distance equal to the normal maximum horizontal reach of a person, approximately one metre.

3. Object of Earthing

The object of an earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose is to ensure that generally all parts of the equipment, other than live parts are at earth potential and that attending personnel are at earth potential at all times. Also by providing such an earth surface of uniform potential under and surrounding the station, there can exist no difference of potential in a short distance big enough to shock or injure an attendant when short circuits or other abnormal occurrences take place. The primary requirements of a good earthing system are:

i) It should stabilize circuit potentials with respect to ground and limit the overall potential rise

ii) It should protect men and materials from injury or damage due to over voltage.

iii) It should provide low impedance path to fault current to ensure prompt and consistent operation of protective devices during ground faults.

ii) It should keep the maximum voltage gradient along the surface inside and around the substation within safe limits during earth faults.

4. Governing Specifications

Assistance has been taken from the following standards/codes of practices in the preparation of this code of practice.

i) IS : 3043 – 1987 Code of Practice for Earthing (first revision)

ii) Indian Electricity Rules 1956 (latest edition)

iii) National Electrical Code 1985 of Bureau of Indian Standards


5. Earth Resistance

At each power supply installation, an earthing system as specified in this code shall be provided.
The combined resistance of the earthing system shall be not more than the following values:

<table>
<thead>
<tr>
<th>SN.</th>
<th>Name of Station</th>
<th>The Limit of combined earth Resistance in Ohms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Traction substation</td>
<td>0.5</td>
</tr>
<tr>
<td>2.</td>
<td>Switching Station</td>
<td>2.0</td>
</tr>
<tr>
<td>3.</td>
<td>Booster transformer station</td>
<td>10.0</td>
</tr>
<tr>
<td>4.</td>
<td>Auxiliary transformer station</td>
<td>10.0</td>
</tr>
</tbody>
</table>

6. **Earth Electrodes**

6.1 The earth electrode shall normally be of mild steel galvanized perforated pipe of not less than 40 mm nominal bore of about 4 m length provided with a spike at one end and welded lug suitable for taking directly MS flat of required size at the other end. The pipe shall be embedded as far as possible vertically into the ground, except when hard rock is encountered, where it may be buried inclined to the vertical, the inclination being limited to 30 degree from the vertical. The connection of MS flat to each electrode shall be made through MS links by bolted joints to enable isolation of the electrode for testing purposes. A sketch for typical arrangement of an earth electrode is shown in Figure 3.01.

6.2 Earth electrodes shall be embedded as far apart as possible from each other. Mutual separation between them shall usually be not less than 6.0 m (which is twice the length of the electrode).

6.3 If the value of earth resistance specified in clause 5 can not be achieved with a reasonable number of electrodes connected in parallel such as in rocky soil of high resistivity, the earth surrounding the electrodes shall be chemically treated. The earth electrode shall be surrounded in an earth-pit by alternate layers of finely divided coke, crushed coal or charcoal and salt atleast 150 mm all round. Though substantial reduction in earth resistance can be achieved by coke treated electrode, yet as this method results in rapid corrosion not only of electrode but also of steel frame work to which it is bonded, coke treatment shall be used only where absolutely necessary and such electrodes shall not be situated within 6.0 m of other metal work.

6.4 IN high embankments, it may be difficult to achieve earth resistance specified in clause 5 even after chemical treatment of electrodes. In those locations, use of electrodes longer than 4 m so as to reach the parent soil is recommended.

6.5 As far as possible, earth electrodes for traction substations/switching stations shall be installed within and adjacent to perimeter fence. At large sites, apart from securing a sufficiently low resistance and adequate current carrying capacity a reasonable distribution of electrodes is also necessary.

7. **Earthing Arrangement at Traction Substation**

7.1 Earthing grid.

7.1.1 An earthing grid is formed by means of bare mild steel rod of appropriate size as indicated in clause 7.1.2 buried at a depth of about 600 mm below the ground level and connected to earth electrodes. The connection between the earth electrode and the grid shall be by means of two separate and distinct connections made with 75 mm x 8 mm MS flat. The connection between the MS flat and the MS rod shall be made by welding, while that between the earth electrode and the MS flats through MS links by bolted joints. The earth electrodes shall be provided at the outer periphery of the grid as shown in Fig. 2. As far as possible the earthing grid conductors shall not pass through the foundation block of the equipments. All crossings between longitudinal conductors and transverse conductors shall be jointed by welding. The transverse and longitudinal conductors of the earthing grid shall be suitably spaced so as to keep the step and touch potentials within acceptable limits; the overall length of the earthing grid conductors shall not be less than the calculated length (refer Annexure-I).
DETAILS OF EARTH ELECTRODE

TYPICAL ARRANGEMENT OF AN EARTH ELECTRODE

FIG. A 3.01
7.1.2 The size of the earthing grid conductor shall be decided based on the incoming system voltage and fault level (refer Annexure). The fault level considered shall take into account the anticipated increase in fault current during the life span of the station. The size shall be as given below:

<table>
<thead>
<tr>
<th>SN.</th>
<th>System Voltage (kV)</th>
<th>Fault level (MVA)</th>
<th>Diameter of the grid conductor (MS rod) in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>66</td>
<td>Upto 4000</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>above 4000 upto 5000</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>above 5000 upto 6000</td>
<td>40</td>
</tr>
<tr>
<td>2.</td>
<td>110</td>
<td>Upto 6000</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>above 6000 upto 8000</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>above 8000 upto 10000</td>
<td>40</td>
</tr>
<tr>
<td>3.</td>
<td>132</td>
<td>Upto 7000</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>above 7000 upto 10000</td>
<td>36</td>
</tr>
<tr>
<td>4.</td>
<td>220</td>
<td>Upto 12000</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>above 12000 upto 16000</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>above 16000 upto 20000</td>
<td>40</td>
</tr>
</tbody>
</table>

7.2 Buried rail

7.2.1 A steel rail of section 52 Kg/m (the one used for the railway track) and length about 13 m shall be buried near the track at the traction substation at a depth of about one metre to form part of the earthing system. Two separate and distinct connections shall be made by means of 75 mm x 8 mm MS flat between the earthing grid and the buried rail. The buried rail shall also be connected by means of two separate and distinct connections with 75 mm x 8 mm MS flat to the traction rail(s) in a single-rail track circuited section and to the neutral point(s) of the impedance bond(s) in a double-rail track circuited section.

7.2.2 In cases where the feeding post is located separately away from the traction substation, the buried rail shall be provided at the feeding post (where one terminal of the secondary winding of the traction power transformer of the substation is grounded).

7.3 System earthing

7.3.1 One terminal of the secondary winding (25 kV winding) of each traction power transformer shall be earthed directly by connecting it to the earthing grid by means of one 75 mm x 8 mm MS flat, and to the buried rail by means of another 75 mm x 8 mm MS flat.

7.3.2 One designated terminal of the secondary of each potential, current and auxiliary transformer shall be connected to the earthing grid by means of two separate and distinct earth connections made with 50 mm x 6 mm MS flat.

7.4 Equipment earthing.

The metallic frame work of all outdoor equipments such as transformers, circuit breakers, interrupters and isolators, as well as steel structures shall be connected to the earthing grid by means of two separate and distinct connections made with MS flat of size as indicated below; one connection shall be
made with the nearest longitudinal conductor, while the other shall be made to the nearest transverse conductor of the grid:

<table>
<thead>
<tr>
<th>SN</th>
<th>Equipment</th>
<th>System voltage</th>
<th>Ground conductor size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>And fault level</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Equipments on the primary side of traction power transformer</td>
<td>66 kV upto 3000 MVA</td>
<td>50mm x 6 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110 kV upto 5000 MVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>132 kV upto 6000 MVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>220 kV upto 10000 MVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>66 kV above 3000 upto 6000 MVA</td>
<td>75 mm x 8 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110 kV above 5000 upto 10000 MVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>132 kV above 6000 upto 12000 MVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>220 kV above 10000 upto 20000 MVA</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Equipments on the secondary side of traction power transformer.</td>
<td>50mm x 6 mm</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Fencing uprights/steel structures</td>
<td>50mm x 6 mm</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Doors/fencing panels</td>
<td>6 SWG GI wire</td>
<td></td>
</tr>
</tbody>
</table>

7.5 Earthing inside control room

An earthing ring shall be provided inside the control room by means of 50 mm x 6 mm MS flat which shall be run along the wall on teak wood blocks fixed to the wall at a height of about 300 mm from the floor level. The earthing ring shall be connected to the main earthing grid by means of two separate and distinct connections made with 50 mm x 6 mm MS flat. The earthing ring shall also be connected to an independent earth electrode by means of two separate and distinct connections made with 50 mm x 6 mm MS flat. The metallic framework of control and relay panels, LT a.c. and d.c. distribution boards, battery chargers, remote control equipment cabinets and such other equipments shall be connected to the earthing ring by means of two separate and distinct connections made with 8 SWG galvanized steel wire. The connections shall be taken along the wall and in recesses in the floor. All recesses shall be covered with cement plaster after finishing the work. Connections between the MS flat shall be made by welding.

7.6 Earthing of lightning arrester.

In addition to the earth electrodes provided for the main earthing grid, an independent earth electrode shall be provided for each lightning arrester. This earth electrode shall be connected to the ground terminal of the lightning arrester as well as to the main earthing grid by means of two separate and distinct connections made with 50 mm x 6 mm MS flat for the 25 kV side lightning arrests, and with 75 mm x 8 mm MS flat for the primary side lightning arresters. The earth electrode shall be provided as close as possible to the lightning arrester and the connections shall be as short and straight as possible avoiding unnecessary bends. For lightning arresters provided for the traction power transformers, there shall also be a connection as direct as possible from the ground terminal of the lightning arrester to the frame of the transformer being protected; this connection shall also be made by means of two separate and distinct connections made with 50 mm x 6 mm MS flat for 25 kV side arresters, and with 75 mm x 8 mm MS flat for primary side lightning arrester.
7.7 Earth screen.
The area covered by outdoor substation equipments shall be shielded against direct strokes of
lightning by an overhead earth screen comprising 19/2.5 mm galvanized steel stranded wire strung
across the pinnacles of the metallic structures. The earth screen wires shall be strung at a height as
indicated in the approved traction substation layouts (not less than 2.5 m above the live conductors)
and shall be solidly connected to the traction substation earthing grid at each termination by means
of 50mm x 6 mm MS flat.

7.8 Earthing of fencing uprights and panels.

Each metallic fencing upright shall be connected to the traction substation main earthing grid by
means of two separate and distinct connections made with 50 mm x 6 mm MS flat. In addition, all
the metallic fencing panels shall be connected to the uprights by means of two separate and distinct
connections made with 6 SWG G.I. wire. All the metallic door panels shall also be connected to the
supporting uprights by means of two separate and distinct connections made with 6 SWG G.I. wire.

7.9 Earthing at the point of 240 V ac 50 Hz. Supply for oil filtration plant.

The 240 V a.c 50 Hz. Distribution board for power supply to oil filtration plant shall be connected to
the main earthing grid by means of two separate distinct connections made with 50 mm x 6 mm MS
flat.

8. Earthing Arrangement at Switching Station

8.1 A minimum number of three earth electrodes (excluding the one to be provided separately for
the remote control cubicle earthing refer clause 8.4) shall be provided at each switching station,
and they shall be interconnected by means of 50 mm x 6 mm MS flat forming a closed loop main
earthing ring. This ring shall be connected by two separate and distinct connections made with
50 mm x 6 mm MS flat, to the traction rail in a single-rail track circuited section and to the neutral
point of the impedance bond in a double-rail track circuited section of the nearest track, so as to
limit the potential gradient developing in the vicinity of the switching station in the event of a
fault.

8.2 System earthing
One designated terminal of the secondary of each potential, current and auxiliary transformer shall
be connected to the main earthing ring by means of two separate and distinct connections made
with 50 mm x 6 mm MS flat.

8.3 Equipment earthing

8.3.1 All masts, structures, fencing uprights, and all outdoor equipment pedestals including
auxiliary transformer tank shall be connected to the earthing ring by means of two separate
and distinct connections made with 50 mm x 6 mm MS flat. All fencing panels shall be
connected to the supporting uprights by means of two separate and distinct connections
made with 6 SWG G.I. wire. All the metallic door panels shall be connected to the
supporting uprights by means of two separate and distinct connections made with 6 SWG
G.I. wire.

8.3.2 The metal casing of potential and current transformers shall be connected to the
mast/structures by means of two separate and distinct connections made with 50 mm x 6
mm MS flat.

8.3.3 The ground terminal of lightning arrester shall be connected directly to the earth electrode by
means of two separate and distinct connections made with 50 mm x 6 mm MS flat. The
earth electrode shall be so placed that the earthing leads from the lightning arrester may be
brought to the earth electrode by as short and straight a path as possible.
8.4 Earthing inside remote control cubicle

An earthing ring shall be provided inside the remote control cubicle by means of 50 mm x 6 mm MS flat; the earthing ring shall be run along the wall on teak wood blocks fixed to the wall at a height of 300 mm from the floor level. The earthing ring shall be connected to the main earthing ring as well as to independent earth electrode by means of two separate and distinct connections made with 50 mm x 6 mm MS flat. The metal casing of LT a.c. distribution board, battery chargers, terminal board, remote control equipment cabinets and other such equipments shall be connected to the earthing ring by means by two separate and distinct connections made with 8 SWG G.I. wire. The connections shall be taken along the wall and in recesses in the floor. All recesses shall be covered with cement plaster after finishing the work. Connections of earth strips to each other shall be made by welding.

9. Earthing of Neutral of Local Power Supply System

At traction substations and switching stations where power supply at 415 V/240 V, ac., 50 Hz is taken from the local supply authority and having neutral earth at some distant point in the premises of the supply authority, the neutral of such supply shall also be earthed by means of two separate and distinct connections made with 6 SWG G.I. wire by connecting to an independent earth electrode.

10. Earthing Arrangement at Booster Transformer Station

10.1 The combined earth resistance at a booster transformer station shall be not more than 10 Ohm. Normally one earth electrode shall be sufficient for a booster transformer station. The earth electrode shall be connected to the lower end of each mast of the supporting gantry by means of two separate and distinct connections made with 50 mm x 6 mm MS flat. In addition each mast of the supporting gantry shall be connected by means of a 50 mm x 6 mm MS flat to the nearest traction rail or to the neutral point of the nearest impedance bond in a double rail track circuited section.

10.2 The booster transformer tank shall be connected to the masts of the supporting gantry by means of two separate and distinct connections made with 50 mm x 6 mm MS flat. These connections shall be as short and as straight as possible without unnecessary bends.

11. Earthing Arrangement at Auxiliary Transformer Station

11.1 The combined earth resistance at an auxiliary transformer station shall be not more than 10 Ohm. Normally one earth electrode is sufficient for an auxiliary transformer station. The earth electrode shall be connected to the mast on which the auxiliary transformer is mounted by means of two separate and distinct connections made with 50 mm x 6 mm MS flat. In addition the mast shall be connected to the nearest traction rail or to the neutral point of the nearest impedance bond in a double rail track circuited section by means of a 50 mm x 6 mm MS flat.

11.2 The earthing terminal on the transformer tank shall be connected to the mast on which the transformer is mounted by means of two separate and distinct connections made with 50 mm x 6 mm MS flat. One terminal of the secondary winding of the auxiliary transformer shall be connected to the earthing terminal on the transformer tank and as well as to the mast by means of 50 mm x 6 mm MS flat. These connections shall be as short and straight as possible and avoiding unnecessary bends.

12. Method of joining

All the joints between the MS flats, MS rods or between MS flat and MS rod shall be made by welding only. No soldering shall be permitted. For protection against corrosion, all the welded joints shall be treated with red lead and afterwards thickly coated with bitumen compound.
13. Painting of MS flats.
For protection against corrosion, all the exposed surfaces of earthing connections (MS flats) above ground level shall be given all around two coats of painting to colour grass green, shade 218 of IS.5

14. Crushed Rock Surface Layer
At the traction substations and switching stations, a surface layer of crushed rock shall be provided to a thickness of about 100 mm. If considered necessary from the point of view of containing the step and touch voltages within the acceptable limits, higher thickness may be provided depending on calculation based on site conditions.

15. Step and Touch Voltages
15.1 The formulae for calculating the tolerable touch and step voltages, estimated mesh and step voltages, earth resistance, earth potential rise, size of earthing grid conductor and length of buried grid conductor are given in Annexure-I.

15.2 The design for earthing grid shall be done separately for each location depending on the conditions obtaining and those foreseen.

16. Drawings
The following drawings (latest versions) issued by RDSO in connection with this code may be used for reference:

i) Typical earthing layout of traction substation ETI/PSI/224-1

ii) Typical return current connection of buried Rail at traction substation ETI/PSI/0212-1

iii) Typical earthing layout of sub sectioning And paralleling station ETI/PSI/201-1

iv) Typical earthing layout of sectioning and paralleling station ETI/PSI/202-1

v) Typical earthing layout of booster transformer station ETI/PSI/211-1

vi) Typical arrangement of an earth electrode at a traction substation ETI/PSI/222-1

vii) Typical earthing arrangement for an auxiliary transformer station ETI/PSI/708
ANNEXURE 1

FORMULAE FOR CALCULATION OF EARTHING GRID BASED ON IEEE GUIDE FOR SAFETY IN AC SUBSTATION GROUNDING, No. ANSI/IEEE Std 80-1986

1.0 Tolerable touch and step voltage

1.1 \[ E_{\text{touch}} = \frac{0.116 \cdot [1000 + 1.5 \cdot \text{Cs}(\text{hs}, \text{K}) \cdot \text{Ps}]}{\sqrt{ts}} \text{V} \] (for 50 kg body)

\[ E_{\text{step}} = \frac{0.116 \cdot [1000 + 6 \cdot \text{Cs}(\text{hs}, \text{K}) \cdot \text{Ps}]}{\sqrt{ts}} \text{V} \] (for 50 kg body)

where,

\[ \text{Cs}(\text{hs}, \text{K}) = 1 \] for crushed rock having resistivity equal to that of oil. If crushed rock resistivity is higher than that of soil, reference may be made to Fig.3 for obtaining the value of Cs.

\[ \rho_s \] = Resistivity of surface material (crushed rock) in ohm-metre.

\[ \rho \] = Resistivity of earth in ohm-metre.

\[ K = \frac{\rho - \rho_s}{\rho + \rho_s} \]

\[ ts \] = Duration of shock current in seconds.

\[ hs \] = Thickness of the crushed rock surface layer in metres.

2.0 Estimated mesh and step voltage

2.1 \[ E_{\text{mesh}} = \rho \cdot \text{Km} \cdot \text{Ki} \cdot \frac{\text{IG}}{\text{L}} \text{V} \]

2.2 \[ E_{\text{step}} = \rho \cdot \text{Ks} \cdot \text{Ki} \cdot \frac{\text{IG}}{\text{L}} \text{V} \]

where,

\[ \text{Ki} \] = Corrective factor for grid geometry, which accounts for the increase in current density in the grid extremities.

\[ = 0.656 + 0.172 \cdot n \]

\[ \frac{\text{IG}}{\text{L}} \] = Average current per unit length of L buried conductor in ampere/metre.

\[ = \frac{1}{2\pi} \ln \left( \frac{D^2}{16 \cdot h \cdot d} + \frac{(D+2h)^2}{8 \cdot D \cdot d - 4 \cdot d} \right) + \frac{\text{Kii}}{\pi} \ln \frac{8}{\pi (2n-1)} \]

\[ \text{Kii} = 1 \] for grids with earth electrodes along the perimeter, or for grids with earth electrodes in the grid corners, as well as both along the perimeter and throughout the grid area.
REDUCTION FACTOR Cs AS A FUNCTION OF REFLECTION FACTOR K AND CRUSHED ROCK LAYER THICKNESS Hs
\[
\frac{1}{(2n)^{2/n}} \text{ for grids without earth electrodes or grids with only a few earth electrodes, none located in the corners or on the perimeter.}
\]

\[
K_h = \sqrt{1 + \frac{h}{h_o}}
\]

\[
K_s = \frac{1}{\pi} \left[ \frac{1}{2h} + \frac{1}{D+h} + \frac{1}{D} \right] (1 - 0.5 n^2)
\]

for values of \( h \) between 0.25 and 2.5 m.

\[
\begin{align*}
\text{ho} & = 1 \text{ metre (reference depth of grid).} \\
\text{D} & = \text{Spacing between parallel conductors of grid in metres (same spacing in both directions).} \\
n & = \sqrt{nA.nB} \text{ for calculating } E_{\text{mesh}}. \\
nA & = \text{nA or nB, whichever is greater, for calculating } E_{\text{step}}. \\
nB & = \text{Number of parallel conductors of grid in transverse direction.} \\
h & = \text{Depth of earthing grid conductors in m.} \\
d & = \text{Diameter of earthing grid conductor in m.} \\
L & = \text{Total length of earthing system conductor.} \\
L_c & = \text{Lc + Lr for grids without earth electrodes or with only a few electrodes located within the grid but away from the perimeter.} \\
L_c & = \text{Lc + 1.15 Lr for grids with earth electrodes along the perimeter.} \\
L_c & = \text{Total grid conductor length in m.} \\
L_r & = \text{Total earth electrode length in m.} \\
\rho & = \text{Resistivity of earth in Ohm-m.} \\
IG & = \text{As defined in para 4.1 below.}
\end{align*}
\]

Note: The estimated values of mesh and step voltage should be less than the tolerable touch and step voltages respectively.

3.0 Ground resistance:

\[
R_g = \frac{\rho}{4} \sqrt{\frac{\pi}{A_g}} + \frac{\rho}{L}
\]

where,

\[
\begin{align*}
L & = \text{Total length of buried conductors in m.} \\
A_g & = \text{Area occupied by the earthing grid in m}^2. \\
R_g & = \text{Station ground resistance in Ohm.} \\
\rho & = \text{Resistivity of earth in ohm-m.}
\end{align*}
\]

Ground Potential rise.

Ground potential rise \( = R_g \times IG \)

where,

\[
\begin{align*}
R_g & = \text{Station ground resistance in ohms.} \\
IG & = CP \times DF \times Ig \\
CP & = \text{Corrective projection factor accounting for the relative increase of fault currents during the station life span; for a zero future system growth } CP = 1. \\
Ig & = \text{r.m.s. value of symmetrical grid fault current in A.}
\end{align*}
\]
\( D_i = \) Derogment factor for the entire duration of fault (to allow for the effects of asymmetry of the fault current wave).

\( = 1.0 \) for fault current duration of 0.5 second or more.

5.0 Size of earthing grid conductor

5.1 \[ A = \frac{I \sqrt{t}}{80} \]

where,

\( A = \) Cross-sectional area of earthing grid conductor in square millimetre.

\( I = \) r.m.s value of fault current in amperes.

\( t = \) Duration of fault current in second (taken as one second).

Note. To allow for the effects of corrosion, the size of the grid conductor selected shall be such that its cross-section area is nearly twice that calculated above.

6.0 Minimum length of buried grid conductor

6.1 \[ L = \frac{K m \times K l \times \rho \times I G \sqrt{t s}}{116 + 0.174 \times C s (t s, K) \rho} \]

for \( E_{p a i n} < E_{t a c k} \)

where,

\( L = \) Minimum length of buried grid conductor including earth electrodes in metres.

\( t s = 0.5 \) second (assumed maximum duration of shock).

\( C s (t s, K), K m, K l, P, I G \) and \( \rho \) have been defined earlier.
SAMPLE CALCULATION FOR THE DESIGN OF EARTHING MAT FOR A 132/25kV TRACTION SUBSTATION

1.0 Data assumed for calculation:

Average earth resistivity of the soil, \( \rho \) = 40 Ohm-m

Fault level at the incoming bus (i.e. 132kV side) = 5000 MVA

Fault current on primary side, \( I_g \) = \( \frac{5000}{\sqrt{3} \times 132} \) = 21870 A

Duration of fault, \( t \) = 3 second to determine the size of earthing mat conductor

0.5 second for determining the safe step and mesh potential.

Resistance of the main earthing mat = 0.5 Ohm (maximum).

1.1 Size of the earthing mat conductor:

\[
A = 12.15 \times 10 \times I_g \times t
\]

\[
= 12.15 \times 10 \times 21870 \times 3 = 460.23 \text{ mm}^2, \text{ say } 460 \text{ mm}^2.
\]

1.2 Margin cater for loss due to corrosion and rusting in the size of earthing mat conductor has been considered 100%.

Therefore, size of the earthing mat = 460 x 2 = 920 mm²

Size of the standard round rod near to 920 mm² are is 36 mm dia rod (1018 mm²). Therefore, 36 mm dia rod is proposed for the earthing mat conductor.

1.3 Approximate length of earthing mat conductor -

\[
L = \frac{K_m \times K_i \times \rho \times I_g \sqrt{t}}{116 + 0.17 \rho_s}
\]

Assuming \( K_m \times k_i = 2.23 \)

\( \rho = 40 \text{ ohm-m} \)

\( I_g = 21870 \text{ A.} \)

\( t = 0.5 \text{ Sec.} \)

\( \rho_s = 3000 \text{ Ohm-m} \)
Therefore, \( L = \frac{2.23 \times 40 \times 21870 \times \sqrt{0.5}}{116 + 0.17 \times 3000} = 2203 \text{m, say 2200 m.} \)

### 1.4 Tolerable touch potential:

\[
E_{\text{touch}} = \left[ 1000 + 1.5 \text{ Cs (hs, k) } \rho_s \right] \times \frac{0.116}{\sqrt{ts}} \text{ V}
\]

Assuming, \( K = \frac{\rho - \rho_s}{\rho + \rho_s} = \frac{40 - 3000}{40 + 3000} = -0.9736 \)

10 cm = 0.1 m

\( Cs = 0.55 \) (from Fig. A 3.03)

Therefore, \( E_{\text{touch}} = \left[ 1000 + 1.5 \times 0.55 \times 3000 \right] \times \frac{0.116}{\sqrt{0.5}} \text{ V} \)

\( = 570 \text{ V} \)

### 1.4.1 Estimated touch potential:

\[
E_{\text{touch}} = \frac{\rho \times Km \times Ki \times IG}{L} \text{ V}
\]

\( = \frac{40 \times 2.23 \times 21870}{2200} = 886.7 \text{ V} \)

As estimated \( E_{\text{touch}} 886.7 \text{ V} \) is more than the tolerable \( E_{\text{touch}} 570 \text{ V} \), hence the length of earthing mat conductor is not adequate. Therefore, the length of earthing mat conductor shall be increased to 3400 m to get:

\( \frac{40 \times 2.23 \times 21870}{3400} = 573.76 \text{ V, say 574 V.} \)

Estimated \( E_{\text{touch}} \) is less than tolerable \( E_{\text{touch}} \).

Hence, length of 3400 m of earthing mat conductor is adequate.

### 1.5 Tolerable step potential.

\[
1000 + 6 \text{ Cs (hs, k) } \rho_s \right] \times \frac{0.116}{\sqrt{ts}} \text{ V}
\]
\[
\begin{align*}
= & \quad [1000 + 6 \times 0.55 \times 3000] \times \frac{0.116}{\sqrt{0.5}} \\
= & \quad [10900] \frac{0.116}{\sqrt{0.5}} = 1788.1 \text{ V}
\end{align*}
\]

1.5.1 Estimated step potential.

\[
E_{\text{step}} = \frac{\rho \times K_s \times K_i \times I_G}{L} \text{ V}
\]

Assuming,

\[
\begin{align*}
\rho &= 40 \ \text{Ohm-metre} \\
K_s &= \frac{1}{\pi} \left[ \frac{1}{2h} + \frac{1}{D+h} + \frac{1}{D} \right]^{n-2} \\
K_i &= 0.656 + 0.172 \ \text{N} \times 0.656 + 0.172 \times 23 = 4.612 \\
I_G &= 21870 \ \text{A} \\
L &= 3425 \ \text{m}
\end{align*}
\]

Therefore, \( E_{\text{step}} = \frac{40 \times 0.376 \times 4.612 \times 21870}{3400} = 446.17 \ \text{V} \)

Estimated step potential is less than tolerable step potential, hence, design of earthing mat is in order.

1.6 Ground resistance.

\[
R_g = \frac{\rho}{\sqrt{4}} \times \sqrt{\frac{\pi}{A}} + \frac{\rho}{L}
\]

Assuming,

\[
\begin{align*}
\rho &= 40 \ \text{Ohm-m} \\
A &= 105.0 \times 66.0 \ \text{m}^2 = 6930.0 \ \text{m}^2 \\
L &= 3400 \ \text{m}
\end{align*}
\]

Therefore, \( R_g = \frac{40}{4} \sqrt{\frac{\pi}{6930.0}} + \frac{40}{3400} \)
\[
\frac{40}{4} \times 0.0213 + \frac{40}{3400} = 0.2247 \text{ Ohm.}
\]

1.7 *Ground potential rise:*

Ground potential rise \( = \) \( R_g \times I_G \)

Assuming, \( I_G = C_p \times D_f \times I_g \)
\[
= 1.1 \times 1.0 \times 21870 = 24057 \text{ A}
\]
 \( R_g = 0.2247 \text{ Ohm} \)

Therefore, ground potential rise \( = 0.2247 \times 24057 = 5405.6 \text{ V} \)

1.8 *Number of earth electrodes used in the earthing mat -*

No. of earth electrodes at the perimeter \( = 23 \times 2 \)
\( + 14 \times 2 = 74 \text{ Nos.} \)

Extra earth electrodes at the 4 corners of the earthing mat \( = 4 \times 4 = 16" \)

Earth electrodes for Lightning Arrestors \( = 10 \times 2 = 20" \)

Earth electrodes for transformer earthing \( = 2 \times 3 = 6" \)

Control room earthing \( = 2" \)

Total earth electrodes \( = 102" \)

1.9 *Total length of earthing mat conductor*

Longitudinal direction \( 105.0 \times 15 = 1575 \text{ m} \)

Transverse direction \( 66.0 \times 23 = 1518 \text{ m} \)

Earthing rod \( 102.0 \times 3 = 306 \text{ m} \)

Total length \( = 3399.0 \text{ m say 3400 m} \)
APPENDIX IV  

REGULATIONS FOR POWER LINE CROSSINGS OF RAILWAY TRACKS  
( ISSUED BY RAILWAY BOARD IN 1987)  

GENERAL  

1. Definitions  

1.1 The following terms wherever occurring in the Regulations shall, unless excluded by or repugnant to the context, have the meaning attributed thereto as under:

“Chief Electrical Engineer “ means the officer designated as such by the Zonal Railway or his successors in office or on whom his duties devolve.

“Power line crossing” means an electrical overhead line or under ground cable placed across railway track(s) for the transmission and/or distribution of electrical energy. It may also be referred to as a “Crossing “ in these Regulations.

“Electrical Inspector” means the officer appointed by the appropriate Government under Section 36 of the Indian Electricity Act, 1910, to exercise the powers and perform the functions under the said Act. On the Zonal Railway, the Chief Electrical Engineer is the Electrical Inspector.

“Owner” means the owner of an electrical crossing.

“Railway” means the Zonal Railway administration in whose territorial jurisdiction the electrical crossing is located or proposed to be located and includes the Chief Electrical Engineer, the Divisional Railway Manager (Electrical) of the Zonal Railway Administration.

“Writing” includes all matters written, typewritten or printed either in whole or in part.

2. Scope  

2.1 The regulations apply to electrical overhead lines and/or underground cables crossing railway tracks operated by the Indian Railways, Railway Companies and Port Commissioner’s Railways, including assisted and private sidings on which rolling stock of Indian Railways may work, unless any special section or railway tracks are exempted from these Regulations by specific written orders of the Electrical Inspector.

Notes:

i) If any existing crossing infringes the provisions of the Regulations at the time of its issue, the infringement(s) shall be treated as permissible infringement(s) provided that necessary relaxation has been granted in respect of the clearances under clause 21 thereof.

ii) The Regulations do not apply to crossing(s) of railway track(s) laid underground/inside tubes and tunnels.

iii) The Regulations do not also apply to Railway Traction systems (1500 V d.c. and 25 kV, 50 Hz. A.c. Single phase) whose feeders/conductors/wires run along or across the tracks for traction purposes.
iv) On sections proposed to be electrified on or to be converted to suit 25 kV, 50 Hz. Ac single phase traction system, the crossing existing at the time of electrification/conversion proposed shall be specially studied with a view to avoiding modifications to the extent possible without jeopardising safety. If any modifications are considered essential to obtain the minimum clearances, specified in clause 21 thereof, they shall be carried out.

v) In special cases, where the Electrical Inspector has specifically permitted reduction in clearances under clause 21 thereof, a clear declaration to this effect shall be recorded in the CERTIFICATE OF COMPLIANCE (in the form at Annexure II) to these regulations.

3. Approval of Works by the Railway:

3.1 i) Designs, Drawing etc.

Before the Owner commences any work on a crossing, he shall obtain the approval in writing, of the Railway for the proposed location, the detailed design and the method of execution of the crossing. For this purpose, the data designs, calculations and drawing(s) relating to the crossing shall be furnished by the owner to the Railway as stipulated in Annexure A 4.01 to these Regulations. On receipt of written approval from the Railway, the owner shall execute an Agreement in the Form at Annexure A.4.02 to these Regulations.

ii) Construction

The owner shall notify the Railway in writing at least 15 days in advance of the date on which he will commence the work of construction of the crossing. The Chief Electrical Engineer, or his representative, may, if he so desires, inspect the site/work of the crossing during its construction to ensure that it is being constructed in accordance with the approved designs and drawings. Only good quality of materials shall be used in the construction of the crossing which shall be executed in a workman-like manner.

i) Bringing crossing into use.

Prior to bringing the crossing into use, the owner shall:

a) Notify the Railway in writing at least 15 days in advance of the date the crossing is intended to be brought into use.

b) Submit to the Railway a CERTIFICATE OF COMPLIANCE, (In the form at Annexure A 4.03 to the Regulations) to the effect that the works have been constructed in compliance with the Recalculations and in conformity with the design(s) and drawing(s) approved by the Railway. Only on receipt of written approval. From the Railway, the crossing shall be energised and brought into use.

4. Compliance with Indian Electricity Act 1910 and Indian Railway Act,1890 and Rules made thereunder etc.

4.1 Except as otherwise provided for in the Regulations the contents of relevant section of the Indian Electricity Act 1910 the Indian Railway Act,1890 and the rules made under these Acts and as amended from time to time and the relevant provisions of Indian Railways Schedule of Dimensions for Broad Metre and Narrow gauges together with the latest amendments thereto shall apply to the crossing.

5. Compliance with Indian Standard Specifications:

5.1 All materials used in the construction of the crossing shall comply with the latest Indian Standard specification(s) relevant and where these are not available, with the latest British standard specification(s) relevant.
6. Works to be executed by the Railway:

6.1 The disturbance of any rail, road or ground or any attachment to any railway structure as may be necessary for the placing and/or maintenance of the crossing shall be effected by or under the direct supervision of the Railway and any conduit, culvert or similar work passing under Railway premises shall be constructed by the Railway in such manner and of such materials as it may approve of and the entire cost of such works shall be borne by the owner of the crossing.

7. Method of Crossing – overhead line or underground cable:

7.1 For tracks already electrified or to be electrified in the foreseeable future:

All low, medium and high voltage up to and including 11 kV crossing(s) shall normally be by means of underground cable(s). While for voltages higher than 11 kV, crossings may be by overhead lines or underground cables, the use of underground cable to the extent possible would be advantageous, particularly for 22 kV and 33 kV system.

8. Protection of Communication Lines:

8.1 The crossing shall in no way interfere with or endanger any Railway communication lines. Approval given by the Railway for placing of any crossing shall not be construed as affecting in any way the requirements of the Indian Post and Telegraph Deptt. In regard to the protection of their communication lines.

8.2 The crossing shall also comply with the stipulations in the “Code of Practice for the protection of Telecommunication lines at crossings with overhead power lines other than Electric Traction Circuits” issued by Central Electricity Authority, Telecommunication Directorate, Power and Telecommunication Coordination Committee (PTCC Unit), Government of India, B-67/19 Safdarjung Enclave, New Delhi-29 and the latest amendments if any, thereto.

9. Maintenance of Crossing:

9.1 No work whatsoever on any crossing shall be undertaken by the Owner without obtaining the consent in writing from the Railway. All such works shall be carried out under the direct supervision of the Railway.

9.2 The crossing shall always be maintained in a state of good repair so as to reduce hazards to life and property. It shall be inspected by the Owner at interval not exceeding 12 months in order to determine its fitness for service. Defects, if any, noticed or as pointed out by the Railway shall be rectified by the owner expeditiously. The decision of the Railway in regard to defects noticed and rectification(s), if any, to be done by the owner shall be final and binding on the owner.

9.3 The crossing span as well as two adjacent spans on either side of the overhead line crossing shall be kept free by the owner from any trees and branches which, if they fall on these spans, would foul with the overhead line. The growth of bushes and wild vegetables shall not be permitted on either side of the overhead line for the same reason.

9.4 Where galvanized steel structures support the crossing span, they shall be maintained free of rust, corrosion, etc.

9.5 If at the instance of the Railway, the crossing is to be shifted or modified or dismantled, the work shall be carried out by the owner at the cost of the Railway. However, in those cases where the need for such works on account of Railway’s anticipated developments/requirements was foreseen in time and the owner had agreed in writing prior to the construction of the crossing to meet the cost of such works. Such works shall
be carried out on a priority basis by the owner within a fixed schedule, as mutually agreed upon between the owner and the railway and to the satisfaction of the electrical Inspector. The Railways shall have the right to claim compensation for any loss and/or inconvenience caused if there is avoidable delay in completing the works.

10. Defects and Failures:

10.1 I) All defects/failures like snapping of conductors in the crossing span, breaking of insulator string in the overhead line crossing or any defect that is likely to affect the safe movement of the railway traffic or the safety of the railway property or personnel shall be reported forthwith by the owner to the Station Master on duty at the railway station on both sides of the crossing as well as to the Chief Electrical Engineer, the Divisional Railway Manager (Electrical), the Electrical Inspector and the Director (Transmission), Central Electricity Board, S 907, Seva Bhavan, R.K. Puram, New Delhi – 66. A detailed report of the failure or defect, shall also be sent to the Chief Electrical Engineer, the Divisional Railway Manager, the Divisional Railway Manager (Electrical), the Electrical Inspector and the Director (Transmission), Central Electricity Board, New Delhi as soon as possible – preferably within 48 hours of the first report.

ii) In the even of an accident to Railway’s tracks/rolling stock in the vicinity of an overhead line crossing, the owner shall, if required by any official acting on behalf of the Railway, expeditiously switch off the overhead line and effectively connect the conductors to earth as long as is necessary to enable Railway’s cranes if any, to work safely in the area.

II OVERHEAD LINE CROSSINGS

11. Angle of crossing

11.1 An overhead line crossing shall normally be at right angles to the railway track, in special cases a deviation of upto 30 degree may be permitted. Deviations larger than 30 degree shall have to be specifically authorised by the Electrical Inspector of the Railway.

12. Structures

12.1 Steel poles/masts fabricated steel structures or reinforced or pre-stressed concrete poles either of the self-supporting type or guyed type conforming in all respects to the Indian electricity Rules 1956 (as amended upto November 1984) and complying with the latest editions of codes of practice, IS 800-1962 for “Code of Practice for use of structural steel in general building construction, IS 875-1964 for “Code of Practice for structural safety of buildings; loading standards” and IS 456-1978 for “Code of Practice for plain and reinforced concrete” shall be used on either side of the track to support the crossing span. These structures shall be of the terminal type. For arriving at the crippling load, the wind loads as detailed in the latest edition of IS 802 (Part I) 1977 for “Loads and permissible stresses “ shall be adopted. The steel structures shall normally be galvanized in accordance with IS 2629-1966 for “recommended practice for hot-dip galvanizing of iron and steel”.

12.2 The minimum distance of the structures (supporting the crossing span) from the center of the nearest railway track shall be equal to the height of the structure in meters above normal ground level plus 6 meters. In special circumstances, the Electrical Inspector may permit a lesser distance being adopted subject to any conditions he deems fit to impose.

12.3 The crossing span shall be restricted to 300 m or to 80% of the normal span for which the structures are designed, whichever is less.

13. Wind Pressure

13.1 The maximum wind pressure for design of the structure shall be as prescribed in IS 802 (part-I)
1977 for load and permissible stresses.

**14. Temperature**

14.1 The maximum and minimum temperatures for design of the conductors and other wires shall be as prescribed in the latest edition of IS 802 (Part I, Clause-4) with necessary correction for conductor maximum temperature.

**15. Provision for Ice/Snow Loading:**

15.1 Where provision has to be made for ice and/or snow loading, it shall be determined in the light of local conditions with the approval of the Railway.

**16. Factor of Safety**

16.1 The factor of safety of all structures, conductors, guards, guys and ground wires used in the crossing shall be as stipulated in the Indian Electricity Rules, 1956 (as amended in November 1984) and the relevant codes of practice.

**17. Clearance between the overhead line and railway track:**

17.1 An overhead line crossing over railway track already electrified shall be located at the middle of overhead equipment span supported by two adjacent traction masts/structures. The distance between any of the crossing conditions and the nearest traction mast or structure under the most adverse, conditions shall not be less than 6 m.

17.2 No overhead line crossing shall be located over a booster transformer, traction switching station, traction sub-station or a track cabin location in an electrified area.

17.3 Vertical Clearance:

The minimum height above rail level of the lowest portion of any conductor of a crossing, including guard wire, under conditions of maximum sag shall be as follows:

<table>
<thead>
<tr>
<th>Sn.</th>
<th>Voltage</th>
<th>Broad, Metre &amp; Narrow Gauges</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Upto and including 11 kV</td>
<td>Normally by cable</td>
</tr>
<tr>
<td>2.</td>
<td>Above 11 kV and upto 66 kV</td>
<td>14.10 m</td>
</tr>
<tr>
<td>3.</td>
<td>Above 66 kV and upto 132 kV</td>
<td>14.60 m</td>
</tr>
<tr>
<td>4.</td>
<td>Above 132 kV and upto 220 kV</td>
<td>15.40 m</td>
</tr>
<tr>
<td>5.</td>
<td>Above 220 kV and upto 400 kV</td>
<td>17.90 m</td>
</tr>
<tr>
<td>6.</td>
<td>Above 400 kV and upto 500 kV</td>
<td>19.30 m</td>
</tr>
<tr>
<td>7.</td>
<td>Above 500 kV and upto 800kV</td>
<td>23.40 m</td>
</tr>
</tbody>
</table>

Note I) While including the above clearance, Railways high tension lines running over the 1500 V DC traction structure in some sections have not been taken into consideration. Where such high tension lines exist, the height above the rail level of the highest high tension line shall be taken into account for calculating the clearances.
Note ii) If for special reason, it is not practical to have an underground cable crossing for systems up to and including 11 kV on sections not likely to be electrified in future, the Chief Electrical Engineer of the Railway may permit the electrical crossing to be an overhead one. In such a case, the clearance(s) specified in clause 21.4 shall be maintained.

Note iii) The working of a Railway crane under an overhead line crossing shall normally be avoided. If it becomes absolutely essential for a crane to work under such a crossing, the minimum clearance required to be maintained between the highest working point of the jib and the lower crossing conductor shall be as under:-

<table>
<thead>
<tr>
<th>Normal System</th>
<th>Min. safe clearance (In Metre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>1.50</td>
</tr>
<tr>
<td>66</td>
<td>2.00</td>
</tr>
<tr>
<td>110</td>
<td>2.25</td>
</tr>
<tr>
<td>132</td>
<td>2.50</td>
</tr>
<tr>
<td>220</td>
<td>3.50</td>
</tr>
<tr>
<td>400</td>
<td>6.00</td>
</tr>
<tr>
<td>500</td>
<td>7.25</td>
</tr>
<tr>
<td>800</td>
<td>11.50</td>
</tr>
</tbody>
</table>

The crane driver/supervisor shall be guided in this regard by the senior most official of the electrical engineering department at site.

18. **Minimum clearances between crossing conductors and any railway structure**

18.1 The minimum vertical and horizontal clearances to be maintained between any of the crossing conductors and any railway building and/or structure.

18.2, other than traction masts and structures and overhead equipment, under the most adverse conditions shall be as specified in Rule 80 of the Indian Electricity Rules, 1956 (as amended upto Nov. 84)

19. **Minimum vertical clearance between power line crossings.**

19.1 The minimum vertical clearances to be maintained between any of the power line crossings at the same or at different voltages shall be as specified in Rule 87 of the Indian Electricity, 1956 (as amended upto November 1984)

19.2 Separate guarding shall be provided above the lower power line in all cases except when the voltage of the higher line is 33 kV and above. Where such guarding is provided, the clearance from the guard wires to the lower power line shall be not less than 2 m and to the upper power line not less than 1.5 m.

20. **Clearance between power line & communication line**

20.1 The minimum clearance to be maintained between a power line and a communication line shall be as prescribed in the “Code of Practice for the Protection of telecommunication lines at crossings with overhead power lines other than Electrical Traction Circuits” (latest edition) issued by Central electricity Authority, Telecommunication Directorate, Power and Tele-communication Coordination Committee (PTCC Unit), Govt. of India.
21. Relaxation by the electrical inspector

21.1 In special cases, the Electrical Inspector of the Railway may permit reduction in the clearance specified in clause 18, subject to the following minimum clearance being maintained between the highest traction conductor and the lowest crossing conductor.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Broad, Metre &amp; Narrow gauge (in Mtr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto &amp; including 33 kV</td>
<td>4.44</td>
</tr>
<tr>
<td>Above 33 kV and upto &amp; including 66 kV</td>
<td>4.44</td>
</tr>
<tr>
<td>Above 66 kV and upto 110 kV</td>
<td>4.75</td>
</tr>
<tr>
<td>For 110 kV and 132 kV</td>
<td>5.05</td>
</tr>
<tr>
<td>For 220 kV</td>
<td>6.58</td>
</tr>
<tr>
<td>For 400 kV</td>
<td>9.71</td>
</tr>
<tr>
<td>For 500 kV</td>
<td>11.45</td>
</tr>
<tr>
<td>For 800 kV</td>
<td>16.67</td>
</tr>
</tbody>
</table>

21.2 If the crossing is provided with a guarding, a minimum clearance of 2 m shall be maintained between the bottom of the guard wire and the highest traction conductor.

21.3 The Railway may evolve, wherever feasible, special design(s) for traction overhead equipment, return conductor, 25 kV feeder or other power line on traction masts/structure keeping in view the need for economy and other requirements, if any.

21.4 In section where the track(s) is/are not likely to be electrified in future, the Electrical Inspector of the Railway may, in special circumstances, permit crossing of systems upto and including 11 kV by overhead lines with the minimum height above rail level of the lowest portion of any conductor including guard wire under conditions of maximum sag being not less than 10.95 metres above highest rail level provided that the owner of the crossing gives an undertaking in writing in the “COMPLIANCE CERTIFICATE” (AS AT Annexure A 4.03 to the Regulations) to the effect that whenever the Railway requires the crossing to be converted from an overhead one to an underground one, the owner will carry out the work at his own cost.

Note (I) The minimum clearances have been derived with an allowance of 2.0 m for maintenance. This allowance may also be reduced by the Electrical Inspector of the Railway, keeping in view the yard remodeling, shifting of structures etc.

22. Insulators

22.1 A double set of strain insulator strings shall be used in crossing span in conjunction with a yoke plate where necessary as illustrated in sketch No. 1 attached to these Regulations. Each string of such strain insulators shall have one insulator more than the number used in a normal span of the overhead line. The factor of safety of each string of insulators under the worst conditions shall not be less than 2. The arrangements of power line crossing shall generally be as shown in sketch Nos. 1, 2 & 3 attached to the Regulations.

23. Guarding

23.1 All overhead power line crossings upto and including 33 kV shall be provided with guarding under the power line. Guarding need not necessarily be provided for overhead power line crossings of voltages above...
33 kV if the transmission/distribution line is protected by circuit breakers of modern design with total trippings times of 0.20 seconds for voltages below 220 kV and 0.10 seconds for 220 kV and above, from the time of occurrence of the fault to its clearance. Wherever guarding is adopted for the crossing span, cradle guards shall also be provided.

23.2 The minimum height above the rail level to the lowest level of any cradle guard or guard wires under conditions of maximum sag shall not be less than the values specified in clause 18. In special cases, however, the Electrical Inspector of the Railway may permit lower heights under the provisions of clause 22 of the Regulations.

23.3 The minimum height between any guard wire and a live crossing conductor under the most adverse conditions shall not be less than 1.5 m.


24.1 Where the voltage exceeds 650 V, the supporting structures, (of the overhead line crossings) on railway land shall be provided with anti-climbing devices. Besides, suitable caution/warning notices shall be erected on all such structures, in the languages as may be prescribed for the purpose. The anti climbing devices and the caution/warning notices shall be approved by the Railway.

25. Protection from Moving Road Vehicles.

25.1 Supporting structures, (of the overhead line crossing) including guys, adjacent to roadways shall be so located that the danger of their being struck by moving road vehicles is avoided or reduced to the minimum. Wherever required, guard rails, suitably painted to make them conspicuous, shall be provided for the purpose.

26. Communication Lines

26.1 The owner of a communication line shall provide adequate safety devices so that no damage is caused in the event of snapping of conductors of a power line crossing. In addition to the safety devices, the owner shall also provide necessary surge absorbers in the system to guard against the effects of surges caused during switching operations or system faults.

26.2 Overhead communication lines may be permitted to be supported on the structures used for the crossing span of a power line crossing, provided the owner of both lines is the same. The factors of safety for conductors and insulators, the clearances above rail level and the method of supporting such crossings shall be not less than those specified for power line crossing.

27. Earthing

27.1 I) Each structure on either side of the crossing span supporting the transmission/distribution line conductors shall be earthed effectively by two separate and distinct earths and connections. At least one separate earth electrode shall be provided for each earth connection.

ii) All guard and stay wires, shall be properly clamped to the structures connected to earth so as to maintain proper electrical continuity to earth.

iii) Where struts are provided, they shall also be effectively connected to earth separately as well as to the main structure earths.

IV) Where the earth resistance of the independent tower/structure is higher than 10 ohms, the owner shall take necessary steps to improve the earth resistance either by providing multiple earth electrodes or by suitably treating the soil surrounding the earth electrode or by resorting to counterpoise earthing. The method of earthing the transmission/distribution line structures etc. for the crossing span shall be approved by the Railway.
V) The earth shall be inspected and tested annually on a hot dry day and results thereof furnished to the Railway for verification and record. If the earth resistance is found to be high, i.e. above 10 ohms, steps shall be taken to reduce it and an advice given to the Railway.

VI) The cross section of the earth conductor/connections for the earthing system shall be adequate for the application. They shall not be damaged or overhead or melt while carrying the short circuit current.

28. Fire Hazards

28.1 Structures supporting the crossing span shall be so placed, guarded and maintained as to be least exposed to bush, grass, rubbish and building fires as is possible.

III CABLE CROSSINGS

29. Cable Crossing

29.1 As far as possible cable crossings shall make use of any existing culverts, sub-ways etc. where track(s) is/are already equipped for electric traction on 25 kV Hz. Single phase ac system, the crossing shall be provided at locations at least 5 metres away from any traction sub-station or switching station or mast or structure erected or proposed to be erected by the Railway for the purpose of supply and distribution of power to the traction over head equipment. The exact locations of such traction sub-station or switching station or mast or structure in any particular area shall be obtained by the owner from the Railway.

30. Type of Cables

30.1 The owner shall specify and obtain prior approval of the Railway for the type of cable he intends to use for the crossing. It shall preferably be armoured. Where cables are suspended from supports and not laid in a protective pipe, they shall be of the armoured and sheathed type.

31. Cathodic Protection

31.1 Cathodic protection of the cables shall not be adopted without the specific prior approval of the Railway.

32. Method of Laying

32.1 Where the cable is laid under railway track(s) it shall be laid through cast iron pipes or spun concrete pipes of suitable diameter and strength. In order to avoid disturbance to the railway track/formation in case it become necessary to lay additional cable(s) in future, it would be advantageous to provide protective pipes of adequate (larger) diameter initially to cater for additional cables. The specifications for the pipes to be used shall be submitted to the Railway for approval. The pipe shall be laid at not less than one metre below the formation level. It shall be possible to withdraw the cable(s) for repair for replacement without disturbing the railway track or formation. Long lengths of pipe shall be laid with gradient to facilitate drainage of water if any. The pipe shall be laid upto the Railway boundary at both ends or upto the point as prescribed by the Railway. The laying of the cable in the Railway premises shall be in accordance with the latest edition of IS 1255-1967 “Code of Practice for installation and Maintenance of Power Cables”.

33. Works Carried out under or near Railway Track.

33.1 Where the cable is to be laid under a railway track(s) the use of case iron or spun concrete pipe for protection of the cable is obligatory and such pipe shall be laid in accordance with the contents of clause-7.

33.2 The armouring and sheathing of the underground cable laid across or near any electrified railway track shall be earthed by independent earths at the two sealing ends of the cable. No further earthing of the armouring and sheathing of the cable shall be done within 500 m of the electrified track. The scheme and
method of earthing shall specifically be approved by the Railway.

34. **Structures on which cable ends are supported and terminated.**

34.1 Where the ends of a cable of an underground crossing are terminated on structures for connection to an overhead line, such structures shall comply with the Regulations in so far as they are applicable to overhead line crossing in respect of structures.

35. **Marking of Crossings**

35.1 Each cable crossing shall be indicated by at least two cast iron cable markers, one at each end of the crossing, within the railway boundaries. The cable marker shall be fixed at both ends of the underground crossings. They shall be of a design approved by the Railway. The following information shall be clearly marked on the markers.

<table>
<thead>
<tr>
<th>ELECTRICAL CABLE</th>
<th>Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER</td>
<td>Cables</td>
</tr>
<tr>
<td>DANGER</td>
<td>In English, Hindi and the vernacular Of the district</td>
</tr>
<tr>
<td>DEPTH OF CABLE</td>
<td>Below track level.</td>
</tr>
<tr>
<td>DEPTH OF CABLE</td>
<td>Below ground level between The toe of bank and railway Fencing.</td>
</tr>
</tbody>
</table>
The following data, designs calculations and drawings together with the application for the proposed power line crossing incorporating the particulars as detailed below – all in duplicate shall be furnished by the owner to the Divisional Railway Manager (Electrical) for approval by the Electrical Inspector of the Railway.

1. **Overhead line crossings.**

   a) **Data and Designs**

   1. Location of the proposed crossing, the names of railway stations on either side of the crossing, the distance of the crossing from the nearest railway station, the painted numbers of Telegraph poles and or traction mast or structures between which the crossing is proposed to be located and the exact location in relation to such poles or masts or structures.

      Note: The alignment of the crossing should, as far as possible be at the mid-point of the span between adjacent traction masts or structures in the case of electrified tracks. (See Cl. 18.1 of the Regulations)

   2. Particulars of the overhead line, including voltage, frequency number of phases, size of conductors etc. and whether the neutral is earthed or not and if earthed, the type of earthing.

   3. **Wind Pressure adopted.**

   4. **Temperature data adopted**

   5. **Particulars of ice/snow loading, if any, adopted**

   6. **Factors of safety adopted in the designs, for conductors, structures, guard wires/cross wires if provided, earth-wire, stay wire, insulator-strings, etc.**

   7. **Design calculations of structures and foundations for the crossing span, communication lines or guarding, if any.**

      Note: If the structures and foundations are of standard type used for the transmission/distribution line concerned, the detailed design calculations shall be furnished.

   8. **Calculations leading to the minimum values under worst conditions of the following.**

      i) Vertical clearance between the lowest crossing conductor, communication lines and/or guarding and the different railway tracks in the crossing span.

      ii) Vertical clearance between the lowest crossing conductor, Communication lines and/or guarding and railway’s conductors of the traction system or other conductors if any.

      iii) Horizontal clearance to railway mast/structure/building, if any

      iv) Lateral clearance to the nearest Railway mast/structure/building, if any.

      Note: Full particulars of the number, size, material and characteristics of various wires and conductors shall be furnished.

10. Details of guarding, size of guard and cross wires and their characteristics. A detailed drawing showing the guarding arrangement, if provided, shall be given.

11. Size and characteristics of guy wire, if provided, and the number of supports.

12. Details of earthing indicating the earth electrode, size of earthing connection, method of connection to the support and the method of article soil treatment if proposed. Details of counterpoise earthing, if contemplated, shall be furnished.

13. Details of protection against moving road vehicles.

14. Particulars of anti-climbing devices, if provided, and warning and caution notices.

15. Detailed scheme of protection for the transmission/distribution line including particulars of relays, operating times etc. and particulars of circuit breakers, if any.

b) Drawings

1. Layout and site plan of the proposed crossing indicating railways boundaries.

2. Longitudinal elevation of the crossing. The drawing shall indicate full particulars of one span on either side of the crossing span with various clearances with respect to the Railway track(s). the drawing shall show the cross section of the railway formation and tracks.

3. Drawing for warning and caution notices.

Note: I) All drawings shall be in standard sizes as prescribed in the latest edition of IS 696-1972 “Code of Practice for General Engineering Drawing.”

ii) All drawings are to be endorsed with a certificate as given below.

I hereby certify that the details of the equipment provided are designed with the object of minimising danger in the event of breakage/fault and in accordance with recognized modern Engineering Practice”, and signed by the owner.

II. Underground cables

a) Data and designs

1. Location of the proposed cable crossing, the names of the railway stations on either side of the crossing the distance of the crossing from the nearest railway station, the painted numbers of telegraph poles or traction masts or structures between which the crossing is proposed to be located and the exact location in relation to such poles or masts or structures.

2. Supply system particulars, particulars of cables, their number, size and number of cores, voltage, type of insulation, armouring etc.

3. Full particulars of the protective pipe for the crossing.

4. Method of earthing of the cable armouring and sheathing, if any.
5. Method of making the cable crossing for identification.

6. Design calculation for masts/structures for supporting and terminating cable(s), and drawings to show that the masts/structures would not foul the railway track(s) in the event of their failure in so far as movement or railway vehicles is concerned.

b) Drawings

1. Layout and site plan including route, location of structures, if any, for supporting and terminating the cable and railways boundaries.

2. Drawings showing cable/crossing marker.

Note I) All drawings shall be in standard size as prescribed in the latest edition of IS 696-1972 "Code of practice for General Engineering Drawings".

ii) All drawings are to be endorsed with a certificate as given below:

“I hereby certify that the details of the equipment provided are designed with the object of minimizing danger in the event of breakage/fault and in accordance with recognized modern Engineering Practice”.

III. Overhead line crossings and underground cables

Along with a reproducible print, eight copies of the drawings showing the completed power line crossing shall be furnished to the Railway along with the “Certificate of Compliance (as at Annexure A 4.03 to the Regulations).
HIGH TENSION CROSSING WITH TERMINAL STRAIN INSULATORS

EARTH WIRE

DUPLICATE STRING INSULATOR UNITS

CROSSING SPAN

FIG. A 4.01
HIGH TENSION CROSSING WITH SUSPENSION INSULATORS

FIG. A 4.02

INDIAN RAILWAYS — AC TRACTION MANUAL - VOLUME II PART II [89]
OVERHEAD LINE CROSSING WITH PIN INSULATOR

LIGHT CONDUCTORS

HEAVY CONDUCTORS

FIG. A 4.03
AGREEMENT FOR ERECTING AND MAINTAINING AN OVERHEAD POWER LINE CROSSING OVER AND ACROSS RAILWAY TRACKS.

An agreement made this.................. day of .................. one thousand nine hindered and .....................................................

Between the President of India acting through the Chief Electrical Engineer/ Divisional Railway Manager/Divisional Railway Manager (Electrical) of the ..........................Railway administration (hereafter called the Railway”) of the one part and  ................       (hereinafter referred to as “the owner” of the other part. Whereas the owner wishes to erect and electric Overhead line and carry out the works connected herewith for transmission of distribution of electrical energy over and across the railway tracks and/or land at Kilometrage .......... in the section...................at..............Railway station, of the Railway, the said overhead line where it crosses the railway tracks and/or land works connected therewith hereinafter referred to as the “Crossing”.

Now IT IS HEREBY AGREED AS folllows:

1. General : the Railway will permit the owner as from the......................day of ......................19, to lay the crossings as per Drg. No. ....................................................approved by the Railway hereunto attached as Annexures, and in compliance with Regulations for Power line crossing of Railway tracks hereunto attached as Annexures hereinafter referred to as the Regulations, for the purposes hereinbefore mentioned subject to the terms and conditions hereinafter contained.

3. Permission to erect and maintain the crossing : - The Railway will, subject to the provisions of clause 3 hereinafter contained, permit the owner to erect and maintain in accordance with the Regulations the crossing over and across the Railway tracks and/or land at the place(s) shown on the said drawing and to execute all repairs in connection therewith when necessary from time to time and all such works shall be executed at the cost of the owner at such times as may be permitted and to the satisfaction of the Railway in all respects.

Provided that if shifting of or modifications to or dismantling of the crossing is required for the proper functioning of the Railway and is to be carried out by the owner as desired by the Railway, the costs of such works shall be borne by the Railway except in those cases where the need for such works on account of railway’s anticipated development/requirements was foreseen in time and the owner had agreed in writing prior to the construction of the crossing to meet the cost of such works.

3.Railway to carry out protection works : - In the event of it being necessary in the opinion of the Railway to support or protect the railway tracks and/or land or works during the erection of the crossing or the execution of any repairs hereto or any removal thereof the work of supporting or or protection the railway tracks or land and resorting the tracks and/or land to its original condition or such part of the said work as the Railway shall deem fit will be carried out by the Railway at the cost of the owner in all respects. The amount of such costs will be determined by the Railway in its absolute discretion and will be paid by the owner to the Rly. On demand. The owner will, if so required, deposit with the Railway prior to the carrying out of the said work such sum of money as may be estimated by the Railway to be the cost of the work required to be done and the amount of the said deposit will be set off against the said cost to be determined as aforesaid and the balance paid as aforesaid.

4. Cost of Supervision of works

All works in connection with the matters referred to in clauses 2,3 and 6 will be subject to such supervision by the Railway as may be considered necessary by the Railway and the owner will pay to the Railway on demand all costs of such supervision including the cost for the staff required to look after the safety of the railway tracks and/or land while all or any of such works are/work is in progress. The costs of such supervision and other costs as aforesaid shall be determined by the Railway in its absolute discretion.

5. Access

Neither the owner nor his employees will at any time enter upon the railway land for any purpose whatsoever in connection with the crossing as aforesaid without the consent in writing of the Railway.
6. **Modification, shifting or removal of crossing.**

If for convenience of operation, unsatisfactory maintenance or for any reason whatsoever the Railway desires special maintenance, repairs, modifications, shifting or removal of the crossing the owner will, subject to the provisions of clause 3 hereof carry out such works or such portion thereof from the date of notice issued by the Railway and to the satisfaction of the Railway within a reasonable period determined by the Railway in its absolute discretion as the Railway shall not under provision of clause 3 hereof proposed to carry out the work. If the owner so desires he may re-erect the same at this own expense but to the satisfaction of the Railway in all respects on such other land or track of the Railway, as it may in its absolute discretion consider suitable and available for the purpose. In the event of the crossing being so re-erected the land on which the same is re-erected will be used and occupied upon the terms of the Agreement mutatis mutandis, as if the same has originally been subject to the Agreement.

7. **Termination of Agreement by the Railway.**

The railway may be any time (and from time to time) be at liberty in its absolute discretion to suspend temporarily and/or terminate this Agreement and all or any of the privileges hereby granted upon the expiration of three months’ notice in writing of its intension to do so being left at or sent to the registered office of the owner/and not withstanding that the owner may have executed any work of a permanent or temporary character and incurred expenses in the execution thereof. The owner shall not be entitled to any damages or compensation by the reason of such termination or suspension.

8. Same as otherwise provided in this contract, all notices to be given on behalf of the President of India and all other actions to be taken on his behalf may be given or taken on his behalf by the Chief Electrical Engineer/Divisional Railway Manager/Divisional Railway Manager (Electrical) of the Railway.

9. **Termination of Agreement by the owner:**

The owner may on giving to the Railway one month’s notice in writing terminate this Agreement and such notice shall be sufficiently served if sent by registered post to the Chief Electrical Engineer/Divisional Railway Manager/Divisional Railway Manager (Electrical) of the Railway or left at his office.

10. **Termination of Agreement for default:**

In the event of the Railway giving notice under Clause 7 hereof for special maintenance, repairs, modifications, shifting or removal of the crossing and the owner failing within the time stipulated to carry out the said works except such position thereof as the Railway may propose to carry out under the provisions of clause 3 hereof or in the event of the owner committing any other breach of this Agreement or any part thereof, the Railway shall be entitled in its absolute discretion (notwithstanding the provisions of clause 8 hereof) to terminate this Agreement all and any of the privileges hereby granted upon the expiration of six months' notice in writing of its intentions to do so being given in the manner provided in clause 7.

11. **Removal of crossing:**

Prior to the termination of this Agreement and subject to the provisions of clause 3 hereof the owner will at his own cost remove the crossing from the property of the Railway and restore the land to its original condition to the satisfaction of the Railway in all respects. In the event of the owner failing to remove the said crossing and restore the land to its original condition in the manner hereinafter provided the Railway will be entitled at its option immediately after the termination of the Agreement to carry out the work of removal of the crossing and restoration of the land without being responsible for any loss or damage whatsoever to the said crossing or any part thereof. In such an event the owner will pay to the Railway on demand all costs incurred by the Railway in connection with such work including supervision charges, the amount which will be determined by the Railway in its absolute discretion. The said crossing and the materials used in connection therewith and belonging to the owner will be and remain the property of the owner but the Railway will be entitled to retain the same but without any liability therefore until the amount of such costs as aforesaid have
been paid by the owner to the Railway.

12. Indemnity

The said crossing will be used at the sole risk and responsibility of the owner. If at any time owing directly or indirectly to such use or to the existence of the said crossing or to the carrying out of the work of erection and/or repair and/or removal of the said crossing and restoring the land to its original condition or to be exercise by the owner of any privileges hereby granted or to any other cause arising out of the operation of the Agreement any damage will be caused to the Railway or to the permanent way and works, Rolling Stock or any other property of the Railway or if in consequence of any of the matters aforesaid or of any default in fulfilling any of the conditions of the Agreement or of any negligence on the part of the owner or any person connected with him, any claim or damage or loss be substantiated by any person or persons against the Railway the Owner will upon demand pay forthwith and make good the same and shall also make good to the Railway all costs and expenses which it may incur in regard to any such claim or damage or loss as aforesaid. In the event of three being any dispute as to what specific loss and/or damage has been caused by reason of any decision hereon shall be final and binding.

13. Railway Accident

The Railway shall not be responsible for any damage to the crossing and other property of the owner due to any accident in the working of the Railway due to any cause whatsoever.

14. Sub-letting

The owner will not sub-let, transfer or assign this Agreement or any of the privileges hereby granted without the previous consent in writing of the Railway.

15. Limitation of rights

Nothing herein contained will be construed as conferring upon the owner or his permitted assignee any rights over the property of the Railway.

16. Cost of Agreement

All costs and expenses incidental to the preparation and completion of these presents including Stamp duty will be borne and paid by the owner.

In witness whereof the parties have hereunto set and subscribed their respective hands and seals the day, month and years respectively mentioned against their respective signatures.

(Seal of the Owner)  (Signature)

Signed at........................................... by Shri.................................
For and on behalf of the Owner in the presence of:

1. Name
   Address

1. Name
   Address  (Signature of witness)

Signed at ....................................by Shri ................................. Signature
For and on behalf of the owner in the presence of
1. Name
   Address          (Signature of witness)

1. Name
   Address          (Signature of witness)

Note 1. In the case of Railway Companies or Port Commissioners Railways, the term Chief Electrical Engineer wherever occurring in this Agreement may be replaced by the designation of the Officer on whom the duties of the Chief Electrical Engineer devolve.

2. The agreement should be signed on behalf of the President of India by an officer duly authorised under Article 299 (1) of the Constitution of India.
AGREEMENT FOR ERECTING AND MAINTAINING AN UNDERGROUND POWER LINE CROSSING ACROSS AND UNDER RAILWAY TRACKS.

An agreement made this ..............................day of ........................... one thousand nine hundred and .......................

Between the President of India, acting through the Chief Electrical Engineer/ the Divisional Railway Manager/Divisional Railway Manager (Electrical) of the ....................... Railway Administration (hereafter called “ the Railway”) of the one part and .............................(hereinafter referred to as “the owner “ of the other part. Whereas the owner wishes to lay an underground cable and carry out works connected herewith for transmission or distribution of electrical energy across and under the railway tracks and/or land at kilometrage.......................In the section .......... at .................... Railway station, of the  Railway the said cable and works connected herewith hereinafter referred to as the “crossing” NOW IT IS HEREBY AGREED as follows

1. General : The Railway will permit the owner as from the .................................. day of ............................ 19, to lay the crossings as per Drg. No. ........................ approved by the Railway, hereunto attached as Annexures and in compliance with Regulations for power line crossings of Railway Tracks, hereunto attached as Annexure hereinafter referred to as the Regulations, for the purpose hereinbefore mentioned, subject to the terms and conditions hereinafter contained.

2. Permission to lay and maintain the crossing:  The Railway, will, subject to the provisions of clause 3 hereinafter contained permit the owner to lay, keep and maintain in accordance with the Regulations the crossing under the Railway tracks and/or land at the place(s) shown on the said drawing and to execute all repairs in connection herewith when necessary from time to time and all such works shall be executed at the cost of the owner at such time as may be permitted and to the satisfaction of the Railway in all respects. Provided that if shifting of or modifications to or dismantling of the crossing is required for the proper functioning of the Railway and is to be carried out by the owner as desired by the Railway, the costs of such works shall be borne by the Railway except in these cases where the need for such works on account of Railway’s anticipated development/requirements was foreseen in time and the owner had agreed in writing prior to the construction of the crossing to meet the costs of such works.

3. Railway to carry out protection works; In the event of it being necessary in the opinion of the Railway to support or protect the railway tracks and/or land or works during the laying of the crossing or the execution of any removal thereof the work of supporting or protecting the railway tracks or land and/or laying or removing the encasing protective pipe to carry the crossing cable and restoring the tracks and/or land to its original condition or such part of the said work as the Railway shall deem fit will be carried out by the Railway at the cost of the owner in all respects. The amount of such costs will be determined by the Railway in its absolute discretion and will be paid by the owner to the Railway on demand. The owner will, if so required, deposit with the Railway prior to the carrying out of the said work such sum of money as may be estimated by the Railway to be the cost of the work required to be done and the amount of the said deposit will be set off against the said cost to be determined as aforesaid and the balance paid as aforesaid.

4. Method of laying: The cable shall be laid as indicated in the said drawing and shall be carried through an encasing pipe in such manner that the cable can be laid, withdrawn without interfering with or endangering the railway tracks and/or land. The costs of providing and laying such encasing pipe for the crossing shall be borne by the owner as aforesaid.

5. Cost of supervision of works: All works in connection with the matters referred to in clauses, 2,3,4,7 & 11 will be subject to such supervision by the Railway as may be considered necessary by the Railway and the owner will pay to the Railway on demand all costs of such supervision including the cost for the staff, required to look after the safety of the railway tracks and/or land while all or any of such works are/works is in progress. The costs of such supervision and other costs as aforesaid shall be determined by the Railway in its absolute discretion.
6. Access: Neither the owner nor his employees will at any time enter upon the railway land for any purpose whatsoever in connection with the crossing as aforesaid without the consent in writing of the Railway.

7. Modification, shifting or removal of crossing: If for convenience of operation, unsatisfactory maintenance or for any reason whatsoever the Railway desires special maintenance, repairs, modification, shifting or removal of the crossing the owner will, subject to the provisions of clause 3 hereof carry out such works or such portion thereof from the date of notice issued by the Railway and to the satisfaction of the Railway within a reasonable period determined by the Railway in its absolute discretion as the Railway shall not under provision of clause 3 hereof proposed to carry out the work. If the owner so desired he may relay the same at his own expense but to the satisfaction of the Railway in all respects on such other land or track of the railway as it may in its absolute discretion consider suitable and available for the purpose. In the event of the crossing being so re-erected the land on which the same is re-erected will be used and occupied upon the terms of the Agreement mutatis mutandis, as if the same has originally been subject to this Agreement.

8. Termination of Agreement: The Railway may at any time (and from time to time) be at liberty in its absolute discretion to suspend temporarily and/or terminate this agreement and all or any of the privileges hereby granted upon the expiration of three month’s notice in writing of its intention to do so being left at or sent to the registered office of the owner and notwithstanding that the owner may have executed any work of a permanent or temporary character and incurred expenses in the execution thereof. The owner shall not be entitled to any damages or compensation by the reason of such termination or suspension.

9. Same as otherwise provided in this contract, all notices to be given on behalf of the President of India and all other action to be taken on his behalf may be given or taken on his behalf by the Chief Electrical Engineer/Divisional Railway Manager/Divisional Railway Manager (Electrical) of the Railway or left at his office.

10. Termination of Agreement by the Owner: The owner may on giving to the Railway one month’s notice in writing terminate this agreement and such notice shall be sufficiently served if sent by the registered post to the Chief Electrical Engineer/Divisional Railway Manager/Divisional Railway Manager (Electrical) of the Railway or left at his office.

11. Termination of Agreement for default: In the event of the Railway giving notice under clause 7 hereof for special maintenance, repairs, modification, shifting or removal of the crossing and the owner falling within the time stipulated to carry out the said works except such portion thereof as the Railway may propose to carry out under the provisions of clause 3 hereof or in the event of the owner committing any other breach of this Agreement or any part thereof, the Railway shall be entitled in its absolute discretion (notwithstanding the provisions of clause 8 hereof) to terminate this Agreement and all and any of the privileges hereby granted upon the expiration of six month’s notice in writing of its intentions so to do being given in the manner provided by clause 7.

12. Removal of crossing: Prior to the termination of this Agreement and subject to the provisions of clause 3 hereof the owner shall at his own cost remove the crossing from the property of the Railway and shall restore the land to its original condition to the satisfaction of the Railway in all respects. In the event of the owner failing to remove the said crossing and restore the land to its original condition in manner hereinbefore provided the Railway will be entitled at its option immediately after the termination of this Agreement to carry out such work of removal of the crossing and restoration of the land without being responsible for any loss or damage whatsoever to the said crossing or any part thereof. In such an event the owner will pay to the Railway on demand all costs incurred by the Railway in connection with such work determined by the Railway in its absolute discretion. The said crossing and the materials used in connection therewith and belonging to the owner will be and remain the property of the owner but the Railway will be entitled to retain the same but without any liability therefor until the amount of such costs as aforesaid have been paid by the owner to the Railway.

13. Indemnity: The said crossing will be used at the sole risk and responsibility of the owner. If at any time owing directly or indirectly to such use or to the existence of the said crossing or to the carrying out of the
work of erection and/or repair and/or removal of the said crossing and restoring the land to its original condition or to the exercise by the owner of any privileges hereby granted or to any other cause arising out of the operation of the Agreement any damage will be caused to the Railway or to the permanent way and works, Rolling stock or any other property of the Railway or if in consequence of any of the matters aforesaid or of any default in fulfilling any of the conditions of the Agreement or of any negligence on the part of the owner or any person connected with him, any claim or damage or loss be substantiated by any person or persons against the Railway, the owner will upon demand pay forthwith and make good the same and shall also make good to the Railway all costs and expenses which it may incur in regard to any such claim or damage or loss as aforesaid. In the event of there being any dispute as to what specific loss and/or damage has been caused by reason of any of the matters aforesaid such dispute will be preferred to the Chief Electrical Engineer of the Railway, whose decision thereon shall be final and binding.

14. Railway Accidents: The Railway shall not be responsible for any damage to the crossing and other property of the owner due to an accident in the working of the Railway due to any cause whatsoever.

15. Sub-letting: The owner will not sub-let, transfer or assign this Agreement or any of the privileges hereby granted without the previous consent in writing of the Railway.

16. Limitation of rights: Nothing herein contained will be construed as conferring upon the owner or his permitted assignee any rights over the property of the Railway.

17. Costs of Agreement: All the costs and expenses incidental to the preparation and completion of these presents including stamp duty will be borne and paid by the owner.

In witness whereof the parties have hereunto set and subscribed their respective hand and seals the day, month and year respectively mentioned against their respective signatures.

(Seal of the Owner)     (Signature)

Signed at............................by Shri................................for and on behalf of the owner in the presence of:

1. Name
   Address
   Signature of witness

2. Name
   Address
   Signature of witness

Signed at ........................ by Shri................................for and on behalf of the President of India in the
   Presence of :

1. Name
   Address
   Signature of witness

2. Name
   Address
   Signature of witness

Note: 1. In the case of Railway Companies of Port Commissioner’s Railway, the term Chief Electrical Engineer wherever occurring in this Agreement may replaced by designation of the officer on whom the duties of the Chief Electrical Engineer devolve.

2. The agreement should be signed by and on behalf of the President of India by an officer duly authorised under Article 299(1) of the Constitution of India.
ANNEXURE A.4.04

CERTIFICATE OF COMPLIANCE

It is hereby certified that the electrical overhead line/underground cable crossing No..........................at Km........ On the section........................Of the Division of the .................Railway has been constructed in compliance with Indian Electricity Act, 1910 and Indian Railway Act., 1890, and the rules made thereunder and as amended from time to time and the Regulations for Power line crossings of Railway tracks, 1987. The crossing has also been constructed in accordance with the drawings approved by the .................Railway and the Electrical Inspector of the .................Railway, the reference of which are given below:

<table>
<thead>
<tr>
<th>SN.</th>
<th>Drawing No.</th>
<th>Title of Crossing</th>
<th>Location of under which Drawing is Approved.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drg.</td>
<td>$</td>
<td>Reference Approving authority</td>
</tr>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. It is also hereby certified that the overhead line crossing specially released as per clause 22.4 of the Regulations for Power Line Crossing of Railway Tracks. 1987' would be modified by the owner, on an approved design whenever Railway will require to modify such crossings due to introduction of electric traction on the section of the Railway.

Along with a reproducible print eight copies of the drawings showing the completed power line crossing is/are enclosed.

(Seal of the owner)

Signature
Name of the owner
Date
Place

Strike off, if not applicable

$ The location of the overhead line crossing or underground cable will be identified by indicating the kilometerage with the painted number of the traction masts/structures and/or telegraph posts, as available, between which the overhead line or underground cable crossing is located.
APPENDIX V

GUIDELINES FOR RELAY SETTINGS AT TRACTION SUBSTATIONS AND SECTIONING POSTS

The following guidelines may be followed for calculating the settings of various protective relays at traction sub-stations and sectioning posts:

1. Ohm Impedances

The following values of OHE impedances may be used for the purpose of calculating relay settings:

- Single track OHE without return conductor: \(0.41 \angle 70^\circ \text{ Ohm/km}\)
- Double track OHE without RC: \(0.24 \angle 70^\circ \text{ Ohm/km}\)
- Single track OHE with RC: \(0.70 \angle 70^\circ \text{ Ohm/km}\)
- Double track OHE with RC: \(0.43 \angle 70^\circ \text{ Ohm/km}\)

- Add booster transformer Impedance at the rate of 0.15 Ohm per booster transformer, where these are provided.

2. Feeding post: Feeder protection

2.1 Distance protection using 'Mho' relay. Type YCG 14.

At present, electromechanical type 'Mho' relays are used for protection against catenary-to-earth faults. Maximum torque angle of this relay is 75\(^\circ\). Its impedance setting may be decided as follows:

i. In the case of single-line sections, the impedance setting of the relay may correspond to 1.25 times the impedance of the OHE from the feeding post up to the adjoining feeding post. The factor 1.25 used here is to cater for errors in the relays, CT & PT. Following relations may be used for calculating the relay settings.

\[
\text{Relay setting} = Z \times \frac{1.25}{1 \cos (\theta - \lambda)} \times \frac{\text{C.T. Ratio}}{\text{P.T. Ratio}}
\]

Where
- \(Z\): Impedance of OHE.
- \(\theta\): maximum torque angle of relay
- \(\lambda\): angle of OHE impedance

ii. In the case of double-line sections, the following procedure may be followed:

a) Calculate the single line impedance of the OHE from the feeding post to the adjoining feeding post; say this is \(Z_1\). Calculate \(X\) from the following relations:
\[ X = \frac{Z_1 \times 1.25 \text{ (C.T. Ratio)}}{\cos(\theta - \delta) \times \text{ (P.T. Ratio)}} \]

b) Assuming single line operation from the feeding post (FP) up to the sectioning post (SP) & double line operation from SP to the adjoining FP, calculate the OHE impedance; say this is \( Z \). Calculate \( Y \) from the following relation:

\[ Y = \frac{Z \times 1.25 \text{ (C.T. Ratio)}}{\cos(\delta - \delta) \text{ (P.T. Ratio)}} \]

a) Assuming an overload of 50% of the traction transformer and that the entire current is fed through one feeder circuit breaker, critical impedance setting of the relay (to allow line operation at maximum loads) is calculated from the following relation:

Critical impedance setting = \( \frac{24,000V}{1.5 \times \text{rated full load}} \)

Where \( \theta = \) maximum torque angle of relay

\( F_i = \) Load angle may be taken as 40 degree

Say, critical impedance setting is \( Z \). For the relay not to operate under the said overload conditions, the impedance setting of the relay must be lower than \( Z \).

b) The impedance setting of the Mho relay should be a minimum of \( Y \) and a maximum of \( X \). The setting should also not exceed \( Z \). In other words, when the value of \( Z \) lies between \( X \) & \( Y \), the relay may be set to \( Z \). If \( Z \) is higher than \( Z \), then the relay may be set to \( Z \). If \( Z \) is less than \( Y \), then the relay should be set to \( Z \). If \( Z \) is less than \( Y \), then the relay should be set to \( Y \).

iii. The relay settings may be calculated by following the procedure given at (i) or (ii) above for the two sides of the feeding post separately. However, the distance protection relays of both the feeders should be set to higher of the two calculated values. This is to ensure that when one feeder breaker is taken out for maintenance, the relay should be able to see the faults on either side of feeding post.

2.2 Instantaneous over-current protection

This relay provides primary protection to the catenary on earth faults in the vicinity of the feeding post. The current setting of the relay may correspond to about 200% of the continuous current rating of the traction transformer. Assuming that a factor of 1.25 will account for the CT and relay errors and relay transient over reach, the relay will allow loads of about 200/1.25 i.e. 160% of the rated load current.

23. Wrong Phase coupling protection using offset MHO type

YCG 14(English – Electric Make)

The impedance setting of the English – Electric make YCG-14 relay is given by \( K_1 \times K_2 \times (K_3 + K_4) \), where \( K_1 \) & \( K_2 \) are plug board settings and \( K \) & \( KK \) are potentiometer setting (Refer Relay Catalogue). The maximum torque angle of the relay is 125 and forward off set is about 10% of \( K \). The WPC relay at that substation where the 25 kV voltage is lagging with respect to the voltage at the substation with which it has been wrongly coupled will operate.

The impedance setting of the WPC relays at TSS – 1 may be determined graphically following the procedure
given below (refer Fig. A 5.01).

a. Draw lines A'A, AB & BB' as shown.

where,

A is the origin of R-X diagram)

A'A = Source impedance at TSS-1 as seen on the 25 kV side.
The impedance angle may be taken as 85° (This includes transformer and transmission line impedances).

AB = Minimum OHE impedance between TSS-1 and TSS-2. The impedance angle may be taken as 70°.
(For a double-line section, this corresponds to the double-line impedance of the section, whereas for a single line section this corresponds to the single-line impedance of the section).

BB' = Source impedance at TSS-2 as seen on the 25 kV side. The impedance angle may be taken as 85°
(This includes transformer and transmission line impedances).

b. Join A' with B'. Construct a right-angle bisector to A'B' and locate points P & Q on the bisector line such that the angles subtended at these points by A'B' are 120° and 60° respectively. P & Q are the WPC points for Case-I (refer Fig. A 5.01).

c. Draw lines AC & CC', where

AC = Maximum OHE impedance between TSS-1and TSS-3. The impedance angle may be taken as 70°.
(This corresponds to the single-line OHE impedance between TSS-1 and TSS-3 irrespective of single-line/double line section).

CC' = Source impedance at TSS-3 as seen on the 25 kV side. The impedance angle may be taken 85°
(This includes transformer and transmission line impedances).

d. Join A' with C'. Construct a right-angle bisector to the line A'C'. Locate points R & S the right-angle bisector such that the angles subtended by A'C' are 120° and 60° respectively. R and S are the WPC points for Case-II (refer Fig. A 5.01).

e. Draw line AO at an angle of 125° with the R axis. This line is the maximum torque angle line for the relay.

f. Draw a circle with centre on the maximum torque angle line such that the points P, Q, R & S are just enclosed by the circle. The circle cuts the maximum torque angle line at D and E. The off-set 'AE' will be equal to 0.1 x K_x x K_y x PT ratio/CT ratio. As K_x and K_y are not known exactly, guess may be made initially. Step (f) may be repeated after going through step (g).

g. Measure AD, say it is 'Z_1'.

Now, the desired impedance setting of the relay at TSS-1, say Z_2

\[
Z_1 \times \frac{CT \text{ ratio}}{PT \text{ ratio}} \times 125
\]

The factor 1.25 used here is to cater for errors in the CT, PT & relay. Values of K_x, K_y, K_1, & K_2 may be suitably selected to get the impedance setting Z. Forward off-set AE may be checked to be around 0.1 x K_x x K_y x PT ratio/CT ratio. If the off-set is different, the circle drawn at (f) may be re-drawn to satisfy this requirement.

INDIAN RAILWAYS - AC TRACTION MANUAL VOLUME II PART II
TWO CASES OF WRONG PHASE COUPLING

MAXIMUM TORQUE ANGLE LINE OF RELAY

OFF SET MHO CHARACTERISTIC OF W.P.C. RELAY

Case I
Wrong phase coupling can take place between TSS-1 and TSS-2

Case II
Wrong phase coupling can take place between TSS-1 and TSS-2

Determination of the setting of Wrong Phase Coupling Relay

Fig. A 5.01

Indian Railways – AC Traction Manual - Volume II Part II
h. impedance settings of wrong phase coupling relay for two sides of the TSS-1 may be calculated individually following the above procedure. The higher of the two values may be adopted for both the WPC relays at TSS-1.

1. Traction sub-station Transformer protection:
   Low Voltage side (25 kV side)
   1. Restricted earth fault relay

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

   ii. IDMT over current relay

   The function of this relay is to act as back up protection to the feeder protection relays. The reach of the relay should be as much as possible. However, to permit overloading of the traction power transformer of the traction substation, the current setting of the relay may be selected to correspond to 150% of the rated current of the traction power transformer.

   The time-multiplier setting of the IDMT relay may be selected such that the relay operation time is 0.4 to 0.5 sec. For an earth fault on the 25 kV bus.

1.2 High Voltage side (220KV/132KV/110KV/66KV side)

   i. Restricted earth fault relay

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

   ii. IDMT over current relay with instantaneous over current element

   The instantaneous element may be set to correspond to a current of 1.25 times the fault current, for an earth fault on the 25 kV bus at the traction substation. The purpose of such setting is to avoid operation of this relay for 25 kV bus faults at the traction substation.

   The current setting of the IDMT relay may be such that it has maximum reach but permits overloading of traction transformer. The setting may, therefore, be selected to correspond to 150% of the rated current of traction power transformer. To have time grading with the IDMT relay on the 25 kV side, the time multiplier setting may be selected such that the relay operating time is 0.8 to 0.9 sec. For earth fault on the 25 kV bus at the traction sub-station.

   iii. Biased differential relay (type DDT)

   The three settings of the relay may be selected as follows:

   a) The percentage bias setting should be so chosen that the relay remains inoperative on differential currents resulting from (1) tap changing on traction transformer, (2) mismatch in CT ratios and (3) difference in CT saturation levels under through-fault conditions. Percentage mismatch 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.

   c) The time multiplier setting may be taken as 1. If mal-operations of the relay are noted on magnetizing in rush but not on through faults, then the time multiplier setting may be increased.
4. Sectioning posts

Under-voltage protection

In case of extended feed, the bridging interrupter at the SP is in closed condition. An under voltage relay is provided to open this interrupter when the OHE voltage falls below a satisfactory operating value.

The under-voltage relay may be set to operate between 19 and 20 kV depending on local conditions.

EXAMPLE-1

The following traction sub-station details are assumed here:

1.1 Traction Power Transformer:
   i) No load voltage:
      Primary side, Vpo  132 kV
      Secondary side, Vso  27 kV
   ii) Secondary voltage at rated output, Vso  25 kV
   iii) Rated output, Vso x Is  13.5 MVA
   iv) Rated secondary current, Is
      \[ Is = \frac{13.5 \text{ MVA}}{25 \text{ kV}} = 500 \text{ A.} \]
   v) Rated primary current, Ip
      \[ Ip = \frac{500 \times 27}{132} = 102.3 \text{ Amps.} \]

1.2 C.T. ratios:

- 25 kV side  500A/5A
- 132 kV side  100A/5A

PT. ratio:

- 25 kV side  25 kV/110V

2. Feeding post: Feeder protection:

2.1 Distance protection using Mho, relay, YCG-14.

The OHE section details assumed here are given in Fig. A5.02.
The calculations given below are for the setting of CB-1. The values of \(Z_1\), \(X\), \(Z_2\), \(Y\), \(Z\) given in the guidelines are calculated as:

\[
Z_1 = (400 + 30 - 10.7 - 5.3) \times 0.41 + (10.7 + 5.3) \times 0.70 + \frac{(10.7 + 5.3)}{2.66} \times 0.15
\]

\[
= 54 \times 0.41 + 16 \times 0.70 + 6 \times 0.15
\]

\[
= 34.24 \, \text{Ohm.}
\]

A BT spacing of 2.66 km is assumed above, giving 6 BTs in each line. The impedance angle of the BT is assumed here the same as the OHE, i.e. 70°.

\[
X = 34.24 \times [1.25/\cos(75^\circ-70^\circ)] \times (500/5) / (25,000/110)
\]

\[
= 18.9 \, \text{Ohm.}
\]

\[
Z_2 = (40-10.7) \times 0.41 + 10.7 \times 0.70 + (10.7/2.66) \times 0.15 + (30-5.3) \times 0.24 + 2 \times 0.53 \times 0.43 + (5.3/2.66) \times 0.15/2
\]

\[
= 29.3 \times 0.41 + 10.7 \times 0.70 + 4 \times 0.15 + 24.7 \times 0.24 + 5.3 \times 0.43 + 2 \times 0.075
\]

\[
= 28.46 \, \text{Ohm.}
\]

\[
Y = 28.46 \times [1.25/\cos(75^\circ-70^\circ)] \times (500/5) / (25000/110)
\]

\[
= 15.7 \, \text{Ohm.}
\]

\[
Z = 24,000 / [1.5 \times 500 \times \cos(75^\circ-40^\circ)] \times (500/6) / (25,000/110)
\]

\[
= 24 / [1.5 \times \cos(35^\circ)] \times 110/25 \times 5
\]

\[
= 17.18 \, \text{Ohm.}
\]

Since the value of \(Z\) lies between \(X\) & \(Y\), the calculated setting for CB-1 = 17.18 Ohm. Similarly, calculate the setting for CB-2, and . say the setting calculated for CB-2 should be = 18.0 Ohm.

Now following the guidelines given in para 2.1(iii), both the 'Mho' relay of CB-1 and CB-2 should be set at 18.0 Ohms.

2.2 Instantaneous over current protections.

The current setting has to correspond to 200% of the continuous current rating of the traction transformer, i.e. 1000 Amps. on the primary side and 10 Amps. on the secondary side of CT. Hence the relay has to be set to 10 Amps. If the rated current of the relay is 5 Amps., this corresponds to 200% setting of the relay.

2.3 Wrong phase coupling protection using off set MHO Relay type YCG-14 (Fig A5.03)
Assumption made in the sample calculation:

i) 3ph. Fault level of TSS-1 & TSS-2 is 1000MVA and TSS-3 is 1500MVA.

ii) Traction transformer impedance is 12% at 13.5 MVA, 27 kV Base.

iii) Double line section without B.T.& R.C.

iv) Distance between TSS-1 & TSS-2 is 60 km.

v) Distance between TSS-2 & TSS-3 is 60 km.

vi) OHE impedance angle = 70°

vii) Source Impedance (Transmission line & Traction Transformer) angle is 85°

viii) Max. Torque Angle of the VCG-14 WPC relay: 125°

ix) C.T. Ratio = 500 A/5A

X) P.T. Ratio = 25000V/110V.

3Phase Fault level of TSS-1 & TSS-2 on 132 kV side = 1000MVA

Transmission Line Impedance per phase of TSS-1 & TSS-2 on 132 kV side

\[
\begin{align*}
\text{Impedance per phase} & = \frac{132^2}{1000} = 17.424 \text{ Ohm} \\
\text{Impedance per phase} & = 17.424 \times \frac{27^2}{132^2} = 0.729 \text{ Ohm}
\end{align*}
\]

3 Ph. Fault Level of TSS-3 on 132 kV side = 1500MVA
Transmission Line Impedance per phase
of TSS-3 on 132 kV side. \[ \frac{132^2}{1500} = 11.616 \text{ Ohm.} \]

Transmission Line impedance per phase of TSS-3 on 25 kV side, say 'B' \[ 11.616 \times \frac{27^2}{132^2} = 0.486 \text{ Ohm.} \]

Impedance of Traction Transformer on 25 kV side, say 'C'. \[ \frac{12}{100} \times \frac{27}{13.5} = 6.48 \text{ Ohm.} \]

As a fault on 25 kV side corresponds to a phase to phase fault on 132 kV side,

Effective source impedance due to transmission line & traction transformer of TSS-1 & TSS-2 on 25 kV side. \[ 2A + C = 2 \times 0.729 + 7.938 \text{ Ohm} \]

Hence, \[ AA' = BB' = 7.938 \angle 85^\circ \text{ Ohm} \]

Effective source impedance due to transmission line and traction transformer of TSS-3 on 25 kV side. \[ 2B + C = 2 \times 0.486 + 6.48 \]

Hence, \[ CC' = 7.452 \angle 85^\circ \text{ Ohm} \]

Since the section assumed here is double line, The minimum impedance of OHE between TSS-1 & TSS2. \[ 60 \times 0.24 = 14.4 \text{ Ohm} \]

Hence, \[ AB = 14.4 \angle 70^\circ \text{ Ohm} \]

The single line OHE impedance between TSS-1 & TSS-3, AC. \[ 2 \times 60 \times 0.41 = 49.2 \text{ Ohm.} \]

Hence, \[ AC = 49.2 \angle 70^\circ \text{ Ohm.} \]

Settings available in YCG-14 Relay:
- \( K_1 \), \( K_2 \), \( K_3 \), \( K_4 \) are continuously adjustable between 0.89 and 1.00.

Assuming, \[ K_1 = 1 \quad \& \quad K_2 = 12 \]

Forward off-set of R-X circle on secondary side. \[ = \frac{10\% \times K_1 \times K_2}{10} \times 1 \times 12 = 1.2 \text{ Ohm.} \]
Equivalent -
Forward offset of R-X circle:
on primary side,

\[ 1.2 \times \frac{25000}{110} \times \frac{5}{500} = 2.7 \text{ Ohm.} \]

Hence,

\[ AE = 2.7 /125^\circ \text{ Ohm.} \]

Draw the circle diagram as per the guidelines as shown in Fig. A5.04.

\[ AD = 12.5 \text{ Cm.} = 12.5 \times 5 = 62.5 \text{ Ohms.} \]

SCALE 1Cm. = 5 Ohms.

Fig. A5.04
Relay setting impedance ‘AD’ from Fig. A 5.04 referred to primary side

\[ \text{Relay setting impedance} = 62.5 \text{ Ohm} \]

referred to secondary side.

\[ \text{Relay setting impedance taking} \]
\[ 25\% \text{ extra for C.T., P.T. \& relay} \]
\[ \text{error compensation.} \]

\[ = 27.5 \text{ Ohm} \]
\[ = 1.25 \times 27.5 = 34.375 \text{ Ohm} \]

Similarly say the setting calculated for the other side of TSS-1 is 30 Ohm. Now the higher of these two settings (34.375 & 30 Ohms) i.e. 34.375 Ohms is the recommended setting for both the WPC relays at TSS-1.

With \( K_1, K_2 \) as already assumed i.e. 1 & 12 respectively and assuming \( K_3 = 1 \) and \( K_4 = 1.87 \)

Impedance setting

\[ = K_1 \times K_2 \ (K_3 + K_4) \]
\[ = 1 \times 12 \ (1 + 1.87) \]
\[ = 12 \times 2.87 \]
\[ = 34.44 \text{ Ohm.} \]

Which is nearly equal to the required relay setting impedance of 34.375 Ohms arrived from R-X circle diagram.

Hence, recommended setting for the WPC Relays at TSS-1 are:

\[ K_1 = 1, \ K_2 = 12, \ K_3 = 1, \ K_4 = 1.87 \]

3. Traction sub-station: Transformer protection:

3.1 Low voltage side (25 kV side)

i) Restricted earth fault relay.

10% of rated current of traction power transformer
(On the secondary side of CT)
\[ = 5A \times 10/100 \]
\[ = 0.5A \]

Hence the relay may be set to 0.5A. If the rated current of the relay is 5A, this corresponds to 10% setting of the relay.

ii) IDMT over current relay, type CDG-16 (3 sec)

Following the guideline, current setting of the relay:
\[ = 5A \times 150/100 = 7.5A \]

Say, the source impedance as seen from the 25kV bus, Z = 6 Ohm (including the transformer impedance)

Fault current for 25 kV bus to earth fault at the feeding post, \( V_{50}/Z_{50} = 27,000 \text{ V}/6 \text{ Ohm}. \)

i.e. \( I = 4,500 \text{ A. (primary side)} \)

\[ = 4,500 \times 5/500 \text{ (Secondary side)} \]
\[ = 45 \text{ A (secondary side)} \]

Hence plug setting multiplier = 45 A/7.5 A = 6

Time of operation of relay at 6 PSM and 1.0 time multiplier setting = 3.9 sec.
Hence time multiplier setting for operation of relay in 0.4 to 0.5 sec. = 0.4/3.9 = 0.1 approximately

Hence the recommended settings of the relay are as follows:
Current rating of relay = 5A
Current setting = 150% (i.e. 7.5 A)
Time multiplier setting = 0.1

3.2 High voltage side 132 kV side)

i) Restricted earth fault relay

10% of rated current of traction power transformer:
\[ \frac{10}{100} \times \frac{102.3 \times 10/100}{10} \]
\[ 10.23 \text{ A} \]
\[ 0.51 \text{ A} \text{ (approximately)} \]

If the rated current of relay is 5 A, then this corresponds to 10% setting of the relay

ii) I/DMT over current relay with instantaneous over current element, type CDG-26(3 sec)

a) Instantaneous element setting.
Fault current on the 25 kV side for 25kV bus to earth fault at the feeding post,
\[ I_f = 4500 \text{A} \text{ (from 3.1 (ii) above)} \]

Hence fault current on the 132 kV side = \[ I_f \times \frac{V_{so}}{V_{po}} \]
\[ 4500 \times \frac{27}{132} = 920 \text{ A} \]

This instantaneous element has to be set to 1.25 times the fault current i.e. setting of the instantaneous element = 1.25 x 920 A (on the primary side of CT)
\[ 1.25 \times 920 \times 5/100 \text{ (on the secondary side of CT)} = 57.5 \text{ A} \]

If the rated current of the relay is 5A, this corresponds to 1150% setting. Hence, the relay may be set to 1100 or 1200%.

b) I/DMT setting:
Current setting = \[ I_p \times \frac{150}{100} \]
\[ = 102.3 \times 150/100 \]
\[ = 150 \text{ A (on the primary side of CT approximately)} \]
Fault current = 920 A x 5/100 (on the secondary side of CT)
= 46 A

Plug setting multiplier = 46 A/7.5 A = 6.13

With PSM of 6.13 and time multiplier setting of 1.0, the time of operation of relay = 3.85 sec.

To have the operating time as 0.8 to 0.9 secs, the time multiplier setting has to be = 0.8/3.85
= 0.2 (approximately)

Hence the setting of the IDMT relay are as follows:
Current rating of relay = 5 A
Current setting = 150% (i.e. 7.5A)
Time multiplier setting = 0.2

iii) Differential relay (DDT-12) - calculations for bias setting CT ratio on primary side of transformer
= 200/5A

CT ratio on the secondary side of transformer = 1000/5.11 A.
Transformation ratio of traction transformer at normal tap = 132/27
Transformation ratio of traction transformer at +10% tap = 145.2/27
Transformation ratio of traction transformer at - 15% tap = 112.2/27

(Note 27 in the denominator is the secondary voltage (kV) of the transformer at no load at all the taps whereas the figures on the numerator are the corresponding primary voltage at respective taps).

The percentage mismatch in the relay current at various taps corresponding to primary and secondary currents at full load can be worked out as under:

1. Normal tap (100%)

Full load current on 25 kV side of transformer = 500 A
Current in the secondary side of CT on 25 kV side = 500x5.11/1000
= 2.555 A

Full load current on 132 kV side = 500 x27/132
= 102.27 A

The current in the secondary of CT on 132 kV side = 102.27 x 5/200 = 2.557 A
Spill over current in the relay = 2.557 - 2.555 = 0.002 A

Percentage differential current
= \frac{0.002 \times 100}{(2.555+2.557) / 2}
= \frac{0.002 \times 100}{2.556}
= 0.078
2. Highest tap (+10%)

The current to the relay from 25 kV side at full load
= 2.555 Amps (as calculated in (1) above.)

The full load current on HV side
= \frac{500 \times 27}{145.2} = 92.97 A

The current in the secondary of CT on HV side
= \frac{92.97 \times 5}{200} = 2.324 A

Spill over current to the relay (2.555-2.324)
= 0.231 A

Percentage of differential current
= \frac{0.231 \times 100}{2.439} = 9.471%

3) Lowest Tap (-15%)

The current to the relay from 25 kV side at full load
= 2.555 A (as calculated in (1) above)

The full load current on HV side
= \frac{500 \times 27}{112.2} = 120.32 A

The current in the secondary of CT on the HV side
= \frac{120.32 \times 5}{200} = 3.008 A

Spill over current to the setting
= (3.008 - 2.555) = 0.453 A

Percentage differential current
= \frac{0.453 \times 100}{2.781} = 16.2%

From the above, it would be seen that the percentage differential current at the lowest tap works out to be 16.2 percent and allowing further for CTs and relay errors etc. the bias setting, therefore, may be made at 30% so that the relay does not operate on through fault currents.

(Notes: Ratio of interposing CTs on both primary and secondary sides is assumed to be same, viz. 2.55a/5A and hence not considered above.

Example-2

The following traction sub-station details are assumed here

1.1 Traction power transformer:

i) No load voltage:

Primary side, Vpo 132 kV
Secondary side Vso 27 kV
ii) Secondary voltage at rated output, \( V_s \)         \( \ldots 25 \text{ kV} \)

iii) Rated output, \( V_{so} \times I_s \)           \( \ldots 20 \text{ MVA} \)

iv) Rated secondary current, \( I_s \)

\[
I_s = \frac{20 \text{ MVA}}{27 \text{ kV}} = 741 \text{ A}
\]

v) Rated primary current, \( I_p \)

\[
I_p = \frac{I_s \times V_{so}}{V_{po}} = \frac{741 \times 27}{132} = 151.5 \text{ A}
\]

1.2 CT Ratios:

- 25 kV side: 750A/5A
- 132 kV side: 150 A/5A

1.3 PT Ratio

- 25 kV side: 25 kV/110-V

2. Feeding Post: Feeder protection:

2.1 Distance protection using Mho relay, YCG-14.

The OHE section details assumed here are same as in Fig. A5.03 of Example 1.

Hence \( Z_1 = 34.24 \text{ Ohm} \) (from example -1)

\[
X = \frac{34.24 \times 1.25}{\cos (75^\circ - 70^\circ)} \times \frac{750}{25000/110} = 28.4 \text{ Ohm.}
\]

\( Z_2 = 28.46 \text{ Ohm} \) (from example 1)

\[
Y = \frac{28.46 \times 125}{\cos (75^\circ - 70^\circ)} \times \frac{750}{25000/110} = 23.6 \text{ Ohm.}
\]

\[
Z = \frac{24000}{1.5 \times 741 \times \cos (75^\circ - 40^\circ)} \times \frac{750}{25000/110} = 17.4 \text{ Ohm.}
\]

Since the value of \( Z \) is lower than \( Y \), the calculated setting for CB-1 = 23.6 Ohm. Similarly, calculate the setting for CB-2, and, say the setting calculated for CB-2 = 20.0 Ohm. Now following the guidelines given in para 2.1(iii), both the 'Mho' relay of CB-1 and CB-2 should be set to 23.6 Ohm.
Instantaneous over current protection

The current setting has to correspond to 200% of the continuous current rating of the traction transformer, i.e., 1482 A on the primary side and 9.88 A on the secondary side of the CT. Hence, the relay has to be set to 10 A if the rated current of the relay is 5 A this corresponds to 200% setting of the relay.

Wrong phase coupling protection using off-set MHO relay type YCG-14.

Assumptions made in the calculations:

i. Traction transformer impedance is 17.8% at 20 MVA, 27 kV base.
ii. C.T. Ratio : 750A/5A,
iii. P.T. Ratio : 25000V/110V
iv. The OHE section details & fault levels are same as in Fig.A5.03 of Example-1

Transmission Line Impedance per phase of TSS-1 & TSS-2 on 25 kV side, A (as calculated in Example-1)

Transmission line impedance per phase of TSS-3 on 25 kV side, B (as calculated in Example-1)

Impedance of Traction Transformer on 25 kV side, say 'C'.

\[
\frac{17.8}{100} \times \frac{27}{20} = 6.488 \text{ Ohm}
\]

As fault on 25 kV side corresponds to phase fault on 132 kV side, Effective source impedance due to transmission line & traction transformer of TSS-1 & TSS-2 on 25 kV side.

\[
\frac{2A + C}{2} = 7.946 \text{ Ohm}
\]

Hence,

\[
AA' = BB' = 7.946 \angle 85^\circ \text{ Ohm.}
\]

Effective source impedance due to transmission line & traction transformer of TSS-3 on 25 kV side,

\[
\frac{2B + C}{2} = 7.460 \text{ Ohm.}
\]

Hence,

\[
CC' = 7.46 \angle 85^\circ \text{ Ohm.}
\]

Since the OHE section assumed here is the same as in example-1.

\[
AB = 14.4 \angle 70^\circ \text{ Ohm.}
\]

\[
AC = 49.2 \angle 70^\circ \text{ Ohm.}
\]

Assuming,

\[
K = K_1 \& K_2 = 12
\]

Forward offset of R-X circle on secondary side,

\[
10 \times \frac{1}{12} \times = 1.2 \text{ Ohm.}
\]

Equivalent forward offset of R-X circle on primary side

\[
1.2 \times \frac{25000}{110} \times \frac{5}{750} = 1.82 \angle 125^\circ \text{ Ohm.}
\]

Hence, AE

\[
= 1.82 \angle 125^\circ \text{ Ohm.}
\]

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Draw the circle diagram as per the guide lines, as shown in Fig. A 5.05.

Relay setting impedance AD
from Fig. A 5.05 referred to primary side.
Relay setting impedance referred to secondary side.
referred to secondary side.
\[ Z = 63.75 \text{ Ohm.} \]
\[ Z = 63.75 \times \frac{750}{5} \times \frac{110}{25000} \]
\[ Z = 42.075 \text{ Ohm.} \]

FIG. A5.05
Relay setting impedance taking 25% extra for C.T., P.T. & relay error compensation.

Similarly, say the setting calculated for the other side of TSS-I is 55 Ohm. Now the higher of these two settings (52.594 & 55 Ohm) i.e. 55 Ohm is the recommended setting for both WPC relays at TSS-I.

With $K_1$ & $K_2$ as already assumed i.e. 1 & 12 respectively and assuming $K_3 = A$ and $K_4 = 3.58$

Impedance setting $= K_1 \times K_2 \times (K_3 + K_4) = 1 \times 12 \times (1 + 3.58) = 12 \times 4.58 = 54.96 = 55$ Ohm.

Which is nearly equal to the required Relay setting impedance of 55 Ohms from the R-X circle diagram.

Hence, recommended setting for the WPC relay at TSS-I $K_1 = 1, K_2 = 12, K_3 = 1$ & $K_4 = 3.58$

3. Traction sub-station: Transformer protection:

3.1 Low voltage side (25 kV side)

i) Restricted earth fault relay

10% of rated current of traction power transformer

\[
\frac{741 \times 5}{750} \times \frac{10}{100} = 0.49 \\mu A = 0.5 \text{ A (approx.)}
\]

Hence the relay may be set to 0.5A. If the rated current of the relay is 5A, this corresponds to 10% setting of the relay.

ii) IMDT over current relay, type CDG 16 (3 sec) following the guidelines, current setting of the relay

\[
\frac{741 \times 5}{750} \times \frac{150}{100} = 7.41 \text{A, say 7.5 A}
\]

Say, the source impedance as seen from the 25 kV bus, $Z_s = 5$ Ohms (including the transformer impedance)

Fault current for 25 kV bus to earth fault at the feeding post, $I_f = \frac{V_{so}}{Z_s} = \frac{27,000}{5} \text{ Ohm}.$

i.e. $I_f = 5400 \text{ A (Primary side)}$

$5400 \times 5/750 \text{ (Secondary)}$

36 A (Secondary side)

Hence, plug setting multiplier $= \frac{36 \text{A}}{7.5 \text{A}} = 4.8$

Time of operation of relay at 4.8 p.s.m and 1.0 time multiplier setting $= 4.4$ sec.

Hence, time multiplier settings for operation of relay in 0.4 to 0.5 sec. = 0.1 (approx.).

Hence, the recommended settings of the relay are as follows:
Current rating of relay = 5A

Current setting = 150% (i.e. 7.5A)

Time multiplier setting = 0.1

3.2 High Voltage side (132 kV side)

1. Restricted earth fault relay

10% of rated current of traction power transformer:

\[ I_p \times 10/100 \text{ (On the primary side of CT)} \]

151.5 \times 10/100

15.15 A

15.5 \times 5A/150 \text{ (On the secondary side of CT)} = 0.50 A.

If the rated current of relay is 5A, then this correspond to 10% setting of the relay.

ii) IDMT over current relay with instantaneous over current element, type CDG-26 (3 sec)

a) Instantaneous element setting

Fault current on the 25 kV side for 25 kV bus to earth fault at the feeding post,

\[ I_f = 5400 \text{ A (From 3.1 (ii) above)} \]

Hence fault current on the 132 kV side

\[ I_f \times (V_{so}/V_{po}) \]

5400 \times 27/132

1105 A

This instantaneous element has to be set to 1.25 times to the fault current.

i.e. setting of the instantaneous element = 1.25 \times 1105 A (on the primary side of the CT).

= 1.25 \times 1105 \times 5/150 \text{ (On the secondary side of CT)}

46 A

If the rated current of the relay is 5A, this corresponds to 920% setting. Hence, the relay may be set to 900%.

b) IDMT Setting:

Current setting = \[ I_p \times 150/100 \]

151.5 \times 150/100 \text{ (On the primary side of CT)}

151.5 \times (150/100) \times (5/150) \text{ (On the secondary side of the CT)}
7.57 A say, 7.5 A

Fault current = 1105 Amps × 5/150 = 36.8 A (on the secondary side of CT)

Plug setting multiplier = 36.8 A / 7.5 A = 4.9

With PSM of 4.9 and time multiplier setting of 1.0, the time of operation of relay = 4.3 sec.

To have the operating time as 0.8 to 0.9 secs, the time multiplier setting has to be 0.8 / 4.3 = 0.18, say 0.2

Hence, the setting of the IDMT relay are as follows:

Current rating of relay = 5A

Current setting = 150% (i.e. 7.5 A)

Time multiplier setting = 0.2
APPENDIX VI

GUIDELINES FOR PROVISION OF MAINTENANCE DEPOTS, TOOL AND PLANTS AND TRANSPORT FACILITIES

1.0 OHE Maintenance Depots

1.1 In the overall interest of minimum capital and recurring costs with electric traction, the number of OHE maintenance depots need be optimized. The general conditions that govern the location and the spacing of the OHE maintenance depots are as under:

(i) The total equipped track kilometres to be maintained by each depot;
(ii) Beat of the depot on either side;
(iii) Traffic density obtained on the section and the time factor in reaching the farthest point;
(iv) The proximity of major yards with considerable equipped track kilometres;
(v) Availability of educational, medical and other infrastructure facilities in the vicinity.

1.2 The total staff required for OHE maintenance for a given section is arrived at, based on the prevalent yardsticks for maintenance and the schedules of maintenance laid down for various equipments. The total staff is distributed amongst the maintenance requirements of OHE under their respective jurisdictions. The staff requirement for the maintenance as per the yardstick is in no way linked with the number of OHE Depots in a particular sections.

1.3 The total equipped track kilometres normally assigned for maintenance to a single OHE depot should be at least 150 track kilometres which amounts to 250 to 300 EETKMs (Electrical Equated Track km) to ensure that the installations to be maintained by a single depot do not become unwieldy. On a normal double line section this would work out to a spacing of 60 RKM between successive OHE maintenance depots. In the case of depots in the vicinity of terminal/major yards (having large wired Tkm.), the spacing would correspondingly get reduced. In view of the concentration of work load in major yards, it will be necessary to locate maintenance depots in or around the vicinity of the major yards.

1.4 The beat of the depot on either side should not normally exceed four block sections (occasionally five) so as to ensure quick transportation of staff to the breakdown spot even if it happens at the farthest end of the jurisdiction of the depot.

1.5 The location of the depot should be such that reasonable educational and medical facilities are available at the place as otherwise the staff would be generally reluctant to stay at such a place.

1.6 The standard lay-outs of OHE depots have undergone several changes over a period of time, with varied concepts like major depots, minor depots etc. emerging to meet specific requirements. The essential difference between major and minor depot is the provision of a tower wagon with its shed and associated track connections and OHE Depot Workshop in a major depot.

1.7 The standard OHE maintenance depot need only be provided with a drilling machine, bench grinder etc. The standard layout of OHE depot with workshop is shown at Fig. A6.01, the schematic layout of Divisional Repair Shop to be provided as an adjunct to one of the OHE depots is shown at Fig. A6.02.
1.8 Secondary activities/facilities in OHE maintenance depots, such as smithy, carpentry, welding etc, can be provided at a central plan either at the Divisional Headquarters or at one of the maintenance depots, depending upon convenience of location. Such a facility will have standard workshop equipments, such as lathe, hacksaw cutting machine, welding set, vertical drilling machine etc. Alongwith the above, a store can be provided where
large quantities of OHE materials which are required for major breakdowns for the entire section can be stored, relieving the other maintenance depots from the responsibility of storing large quantities of materials which are required only occasionally. This would also increase the utilization of staff such as welders, black smiths, carpenters, and incidentally is likely to result in overall savings of the staff in the ancillary categories and equipments.

2.0 PSI Maintenance Depots

2.1 Besides the OHE maintenance depots, PSI maintenance depots are provided for maintaining the various power supply equipments installed at traction substations, switching stations, booster transformer stations, auxiliary transformer stations etc. It is advantageous to locate the PSI maintenance depot alongside the OHE maintenance depot so as to achieve some economy in requirements of T & P, transport and other infrastructural facilities.

2.2 Normally the average spacing between traction substations is 60/70 km. On trunk routes with high traffic densities, where operation of 4500 t trains is to be catered for, sub-stations are provided at reduced spacing of 40 to 45 km. With PSI depots spaced at 60/70 km, each depot will be called upon to maintain one or two traction sub-station and 5 to 6 switching stations, besides booster transformer and auxiliary transformer installations on the sections. A sketch showing the suggested layout for a PSI maintenance depot is shown at Fig A6.03.

2.3 If a Zonal Repair Shop is provided, necessity of transporting the equipments to the PSI depot may not arise. It is desirable and feasible to give all attention that is required for day-to-day maintenance of the equipments at site. For any major attention such as oil circulation of the breakers, auxiliary transformers, booster transformers, interrupters, etc. the equipment can be transported to the nearest traction sub-station, where power supply is available from the 100 kVA auxiliary transformer for working of the oil filtration plant. This results in minimum transportation of these equipments. Major repairs, which cannot be done at the sub-station, should be done only at the Zonal Repair Shop.

2.4 By combining the OHE and PSI depots, the OHE transport facility can be conveniently utilized for PSI work.
as well. A common depot will be cheaper with a common compound wall and security arrangements. Better co-
ordination and supervision can be obtained between OHE and PSI maintenance staff if both the depots are located
together. It is likely to result in faster attention to breakdowns. In addition, it would be desirable to have this
combined OHE/PSI maintenance depot at a station where traction sub-station is also located, wherever it is
feasible, as PSI maintenance work is more concentrated at a traction sub-station.

2.5 Keeping in view the set up outlined above, it should be possible to locate the PSI depots at alternate OHE
depots (instead of locating the same at each and every OHE depot). This would enable a minimum complement
of PSI staff both supervisory and others at each of the PSI depots.

3.0 Scale of T&P for OHE Depots

3.1 The list of T & P items to be procured by R.E. for OHE maintenance given at Annexure A6.01. This annexure
also lists the items to be procured by R.E. for equipping each of the tower wagons as well as the break-down train.

3.2 The T & P recommended to be procured by R.E. for PSI maintenance is given at Annexure A6.02.

3.3 In addition, the T & P recommended to be procured by R.E. for Divisional Repair Shop for OHE is given at
Annexure A6.03. Likewise, the T & P to be procured by R.E. for Divisional Repair Shop for PSI is given at
Annexure A6.04.

3.4 The office furniture to be supplied by R.E. for field offices and depots is shown at Annexure A6.05.

3.5 Besides the above, it is felt that general user items of T & P can be procured by the Open Line and need
not be provided by R.E. A list of such items is given at Annexure A6.06.

4.0 Transport Facilities for Maintenance Including Breakdown Attention

4.1 At present each major OHE Depot is provided with one heavy duty motor truck and one 4-wheeler OHE
Inspection Car. These transport vehicles are adequate for attending to breakdowns and for normal day-to-day
maintenance. For push trolley inspections of OHE by supervisors and officers, each OHE depot is to be provided
with one push trolley. One Jeep with trailer is to be provided for each field officer at his headquarters. One motor
trolley is to be provided for each station where an OHE officer is headquarted.

4.2 One wiring-cum-breakdown train is to be provided for each Division to meet any major OHE breakdowns
which require wiring of OHE.

4.3 Transport facilities recommended for TRD maintenance are summarized at Annexure A6.07.

4.4 On sections with higher traffic density, eight wheeler high speed tower wagons would enable quicker
transportation of men and materials to the site. With increased emphasis on quick restoration after accident,
quicker attention to OHE breakdowns is called for to provide early restoration of OHE power supply.
### T&P Items to be Procured by R.E. for OHE Maintenance Organization

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Major Depot</th>
<th>Tower Car</th>
<th>Break down train</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tirfor 2.5 Tonne/1.5 Tonne</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Tirfor 5 Tonne/3 Tonne</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Pull-lift 3 Tonne</td>
<td>2</td>
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<tr>
<td>4.</td>
<td>Pull-lift 3/4 Tonne</td>
<td>2</td>
<td>2</td>
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<tr>
<td>5.</td>
<td>Dropper making Jig and Wire straightener for 5 mm dropper wire</td>
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<tr>
<td>6.</td>
<td>Dropper making Jig and Wire straightener for 7 mm dropper wire</td>
<td>1</td>
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<tr>
<td>7.</td>
<td>Come-along clamps for Catenary suitable for 19/2.108 mm conductor</td>
<td>4</td>
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<tr>
<td>8.</td>
<td>Come-along clamps for contact wire 107 mm&lt;sup&gt;2&lt;/sup&gt;.</td>
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<td>9.</td>
<td>Come-along clamps for Aluminium “SPIDER” Conductor (20 mm&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>4</td>
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<tr>
<td>10.</td>
<td>Come-along clamps for earth wire (19/2.5 mm) Galvanized steel</td>
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<td>11.</td>
<td>Rail Jumpers with Clamps at both ends</td>
<td>30</td>
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<tr>
<td>12.</td>
<td>Rail Jumpers extension with clamp at one end</td>
<td>30</td>
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<tr>
<td>13.</td>
<td>Earthing discharge rod complete</td>
<td>10</td>
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<tr>
<td>14.</td>
<td>Aluminium straight ladder (8 m) with hook on top</td>
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<td>15.</td>
<td>Aluminium straight ladder extensible (11 m)</td>
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<td>16.</td>
<td>Drilling Machine (25 mm) Motor Driven (Radial or Pillar)</td>
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<td>17.</td>
<td>Bench Grinder (Double end) Pedestal Motor Driven (203 mm) disc</td>
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<td>18.</td>
<td>Portable Welding-cum-cutting Set (Gas) Range Cutting 1-100 mm. Welding 0.5 to 30 mm (Complete with Oxygen and Acetylene Cylinders, Trolley, Helmet etc.)</td>
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<tr>
<td>Sl. No.</td>
<td>Description</td>
<td>Major Depot</td>
<td>Tower Car</td>
<td>Breakdown train</td>
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<tr>
<td>19</td>
<td>Hydraulic Compressor for return conductor splicing</td>
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<td>20</td>
<td>Portable Electric Drill 21.0 mm 1 ph, 230 V (For Drilling rails for bonding)</td>
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<td>21</td>
<td>Honda Welding Generating Set (100/200 A.) with all accessories</td>
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<td>22</td>
<td>Portable Diesel Generating Set 3 kVA, 240 V, 1 ph.</td>
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<tr>
<td>23</td>
<td>Flood Light fitting with 500 Watt Lamps</td>
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<td>4</td>
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<td>24</td>
<td>First Aid Box</td>
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<tr>
<td>25</td>
<td>Stretcher</td>
<td>1</td>
<td>-</td>
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<td>26</td>
<td>Fire Buckets 10 Ltr.</td>
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<td>27</td>
<td>Portable Fire Extinguisher (Cap. 10 Ltr.) Dry Chemical Powder</td>
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<td>28</td>
<td>Portable Fire Extinguisher (Cap. 9 Ltr.) (Foam Type)</td>
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<td>29</td>
<td>Contact Wire cutter 36&quot;</td>
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<tr>
<td>30</td>
<td>Dropper Wire cutter 12&quot;</td>
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<tr>
<td>31</td>
<td>‘D’ Shackles set of one each (1&quot;, 3/4&quot;, 5/8&quot;, 1/2&quot;)</td>
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<td>4</td>
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<tr>
<td>32</td>
<td>Single Sleeve Pulley block 3 1/2&quot; x 1/2 Groove Steel</td>
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<td>4</td>
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<td>33</td>
<td>Single Sleeve Pulley Block 3 1/2&quot; x 1/2&quot; Groove Fiber for drawal of Contact Catenary wire</td>
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<td>4</td>
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<tr>
<td>34</td>
<td>Single Sleeve Pulley Block 6&quot; x 1&quot; Groove Steel</td>
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<td>2</td>
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<tr>
<td>35</td>
<td>Contact Wire twist-cum-bender 6&quot;</td>
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<td>36</td>
<td>Steel Sling with Eye each end 19 mm dia.</td>
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<td></td>
<td>(a) 1 m. long</td>
<td>6</td>
<td>4</td>
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<td></td>
<td>(b) 2 m. long 6 4 6</td>
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<td></td>
<td>(c) 3 m. long 6 4 6</td>
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<tr>
<td></td>
<td>(d) 4 m. long 2 1 1</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(e) 10 m. long 2 1 1</td>
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<tr>
<td>37</td>
<td>Slewing Gadget</td>
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<tr>
<td>38</td>
<td>Contact Wire Splicing Jig</td>
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<tr>
<td>Sl. No.</td>
<td>Description</td>
<td>Major Depot</td>
<td>Tower Car</td>
<td>Break down train</td>
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<td>-------------</td>
<td>-----------</td>
<td>------------------</td>
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<tr>
<td>39</td>
<td>Copper Hammer 2 kg.</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>40</td>
<td>Micro Meter</td>
<td>1</td>
<td>-</td>
<td>-</td>
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<tr>
<td>41</td>
<td>Metric Tape 30m, 15m each</td>
<td>2</td>
<td>1</td>
<td>1</td>
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<tr>
<td>42</td>
<td>Bench Vice 6&quot;</td>
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<td>-</td>
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<td>43</td>
<td>Loaded Trolleys</td>
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<td>44</td>
<td>Engineering Ratchet</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>45</td>
<td>Siren covering distance 1 Km. range</td>
<td>1</td>
<td>-</td>
<td>-</td>
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<tr>
<td>46</td>
<td>Tilly lamps</td>
<td>-</td>
<td>4</td>
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</tbody>
</table>

**TESTING AND MEASURING EQUIPMENTS**

| 1      | Megger 2500 V                       | 1           | -         | -                |
| 2      | Dynamometer (3500 kg x 20 kg) 300 mm dia. | 1           | -         | -                |
| 3      | Earth Megger/Tester                 | 1           | -         | -                |
| 4      | Binoculars                          | 1           | -         | -                |
| 5      | Vernier Callipers                   | 1           | -         | -                |
| 6      | Walkie Talkie sets (2 W output)     | 2           | 4         | 2                |
| 7      | Emergency Telephone                 | 6           | 1         | -                |
| 8      | Multimeter                          | 1           |           |                  |
## T&P for PSI Depots to be Supplied by R.E. Organization

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>2.</td>
<td>3.</td>
</tr>
<tr>
<td>1.</td>
<td>Tirfor 3 ton cap.</td>
<td>3 Nos.</td>
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<tr>
<td>2.</td>
<td>Tirfor 5 ton cap.</td>
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<tr>
<td>3.</td>
<td>Barrel Pump</td>
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<tr>
<td>4.</td>
<td>'D' Shackles 5/8', 1&quot;', 3/4&quot;</td>
<td>3 sets</td>
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<tr>
<td>5.</td>
<td>Steel rope slings 1 m, 3 m each</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>6.</td>
<td>- do -</td>
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<tr>
<td>7.</td>
<td>- do - 10 m.</td>
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<tr>
<td>8.</td>
<td>Chain pulley block 3.0 ton cap.</td>
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<tr>
<td>9.</td>
<td>Pulley single sheave 3.0 ton cap.</td>
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<td>10.</td>
<td>First Aid Box</td>
<td>1 No.</td>
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<tr>
<td>11.</td>
<td>Stretcher</td>
<td>1 No.</td>
</tr>
<tr>
<td>12.</td>
<td>Fire Buckets</td>
<td>4 Nos.</td>
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<tr>
<td>13.</td>
<td>Portable electric blower</td>
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<tr>
<td>14.</td>
<td>Portable electric grinder</td>
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<td>15.</td>
<td>Portable electric drilling machine 13 mm</td>
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<td>16.</td>
<td>Crimping tool upto 6 mm² size</td>
<td>2 Nos.</td>
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<tr>
<td>17.</td>
<td>Aluminium step ladder 8' height</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>18.</td>
<td>Aluminium ladder with hook on top 8'</td>
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<tr>
<td>19.</td>
<td>Aluminium step ladder 16'</td>
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<td>20.</td>
<td>Mobile aluminium ladder 36'</td>
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<td>22.</td>
<td>Earthing Pole Assembly/Discharge Rod</td>
<td>6Nos.</td>
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<td>23.</td>
<td>Drop out fuse pull rod</td>
<td>2 Nos.</td>
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<tr>
<td>24.</td>
<td>Portable diesel engine operated welding set 230 V</td>
<td>1 Nos.</td>
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<tr>
<td>25.</td>
<td>1/2&quot; square drive socket set containing</td>
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<td></td>
<td>19 sockets with 6 attachments</td>
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<td>26.</td>
<td>Acidity testing kit</td>
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<td>Description</td>
<td>Quantity</td>
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<td>26</td>
<td>Mains operated insulation tester 5 kV</td>
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<td>27</td>
<td>Pocket size clip on tong tester)</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>0 -- 5A / 25 A )</td>
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<tr>
<td></td>
<td>0 --150V / 300 / 600V )</td>
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<tr>
<td>28</td>
<td>A.C. Voltmeter 0-150 V</td>
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<tr>
<td>29</td>
<td>A.C. Voltmeter 0-500 V</td>
<td>1 No.</td>
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<td>30</td>
<td>Digital time interval meter 15 - 1000 seconds</td>
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<td>31</td>
<td>Insulation tester 2.5 kV</td>
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<td>32</td>
<td>Earth Tester</td>
<td>1 No.</td>
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<tr>
<td>33</td>
<td>Megger 500 V</td>
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<td>34</td>
<td>Oil testing Kit</td>
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<tr>
<td>35</td>
<td>125 Ltr. cap. oil filtration plant</td>
<td>1 No.</td>
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<tr>
<td>36</td>
<td>Insulation tester 250 V</td>
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<tr>
<td>37</td>
<td>Multimeter</td>
<td>2 Nos.</td>
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<td>38</td>
<td>Auto transformer 2 A Capacity</td>
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<tr>
<td>39</td>
<td>Load cell tester</td>
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<tr>
<td>40</td>
<td>Emergency Telephones</td>
<td>4 Nos.</td>
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<tr>
<td>41</td>
<td>Cycle Pump</td>
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### T&P to be Procured by R.E. for Divisional Repair Shop (OHE)

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<th>Sl. No.</th>
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<tbody>
<tr>
<td>1.</td>
<td>Centre lathe 600 mm centre distance 125 mm height 3 ph, 440 V or 1 Ø 230 Volt</td>
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<tr>
<td>2.</td>
<td>Motor driven hacksaw cutting machine (to deal 75 mm channel)</td>
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<tr>
<td>3.</td>
<td>Drilling machine (25 mm) motor driven (radial or pillar type)</td>
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<tr>
<td>4.</td>
<td>Bench grinder (double end) Pedestal motor driven (203 mm) disc</td>
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<td>5.</td>
<td>Hand driven blower for smithy</td>
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<tr>
<td>6.</td>
<td>Hydraulic compressor for return conductor splicing</td>
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<tr>
<td>7.</td>
<td>3 ph. welding plant (400 Amps)</td>
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<td>8.</td>
<td>Portable welding-cum-cutting set (Gas) complete with Oxygen and Acetylene cylinders, a trolley and helmet etc. range cutting 1 to 100 mm welding 0.5 to 30 mm</td>
<td>1 No.</td>
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<td>9.</td>
<td>First Aid Box</td>
<td>1 No.</td>
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<td>10.</td>
<td>Fire buckets 10 Ltr. Cap.</td>
<td>8 Nos.</td>
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<td>Portable Fire Extinguishers Cap. 10 Ltr. (DCP type)</td>
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<td>12.</td>
<td>Portable Fire Extinguishers Cap. 10 Ltr. (Foam type)</td>
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<td>13.</td>
<td>Portable Honda Generating set 0.75 kVA, 240V, 1 ph.</td>
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<td>Stretcher</td>
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<td>Blacksmith hammer 12 kg</td>
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<td>16.</td>
<td>Blacksmith hammer 10 kg</td>
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<td>Micrometer (mm)</td>
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<td>18.</td>
<td>Metallic tape 30 m, 15 m each</td>
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<td>Blacksmith Anvil 2'</td>
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<td>Sl. No.</td>
<td>Description</td>
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<td>1.</td>
<td>Primary injection testing kit (0-500 A)</td>
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<td>2.</td>
<td>Secondary injection testing kit (0-50 A)</td>
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<td>MHO Relay testing kit</td>
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<td>2500 Ltr. cap. mobile oil filtration plant</td>
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<td>250 Ltr. Cap. oil filtration plant</td>
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<td>Distilled water plant Cap. 50 Ltr.</td>
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<td>7.</td>
<td>5 kV Megger</td>
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<td>2.5 kV Megger</td>
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<td>500 V Megger</td>
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<td>Hydraulic Jack 50 Ton. Cap.</td>
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<td>Auto Transformer 2 Amps. capacity</td>
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<td>Spray painting machine</td>
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<td>Multi meter</td>
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<td>14.</td>
<td>Portable clip tong tester 0-5-25A, 0-150-300-600V</td>
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<td>15.</td>
<td>Oil testing kit</td>
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<td>16.</td>
<td>Acidity testing kit</td>
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<td>17.</td>
<td>R-L-C Bridge to measure resistance, inductance and capacitance</td>
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<td>18.</td>
<td>Variable Rheostat - 1000 Ohms, 1 Amp</td>
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<td>19.</td>
<td>250 Volts Megger</td>
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<td>A/c Voltmeter 0 - 150 Volts</td>
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<td>Chairs without hands</td>
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<td>Stools</td>
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<td>18 Pigeon holes lockers</td>
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<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>Waste paper boxes</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>Officers tables</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>Drawing Cabinets</td>
<td>1</td>
</tr>
<tr>
<td>14.</td>
<td>Steel book case</td>
<td>1</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description of Item.</td>
<td>Major Depot.</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>1.</td>
<td>Bond Press</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>Dekinker</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Swivel Clip Openers</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Portable hand drill 12.5 mm</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Portable hand drill 8 mm</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>Portable hand tap 8 mm</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>DE Spanners sizes (6/7 to 2 7/30 mm) complete set</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>DE Spanner 30 - 32</td>
<td>10</td>
</tr>
<tr>
<td>9.</td>
<td>DE Spanner 24 - 26</td>
<td>10</td>
</tr>
<tr>
<td>10.</td>
<td>DE Spanner 21 - 23</td>
<td>6</td>
</tr>
<tr>
<td>11.</td>
<td>DE Spanner 18 - 19</td>
<td>-</td>
</tr>
<tr>
<td>12.</td>
<td>DE Spanner 16 - 17</td>
<td>6</td>
</tr>
<tr>
<td>13.</td>
<td>DE Spanner 14 - 15</td>
<td>6</td>
</tr>
<tr>
<td>14.</td>
<td>DE Spanner 12 - 13</td>
<td>-</td>
</tr>
<tr>
<td>15.</td>
<td>Ring Spanners set (6/7 to 27/30 mm)</td>
<td>2</td>
</tr>
<tr>
<td>16.</td>
<td>Ring Spanners 30 - 32</td>
<td>10</td>
</tr>
<tr>
<td>17.</td>
<td>Ring Spanners 24 - 26</td>
<td>10</td>
</tr>
<tr>
<td>18.</td>
<td>Ring Spanners 20 - 22</td>
<td>6</td>
</tr>
<tr>
<td>19.</td>
<td>Ring Spanners 18 - 19</td>
<td>-</td>
</tr>
<tr>
<td>20.</td>
<td>Ring Spanners 16-17</td>
<td>6</td>
</tr>
<tr>
<td>21.</td>
<td>Ring Spanners 14 - 15</td>
<td>6</td>
</tr>
<tr>
<td>22.</td>
<td>Ring Spanners 12 - 13</td>
<td>-</td>
</tr>
<tr>
<td>23.</td>
<td>Screw Driver 18'</td>
<td>4</td>
</tr>
<tr>
<td>24.</td>
<td>Screw Driver 16'</td>
<td>4</td>
</tr>
<tr>
<td>25.</td>
<td>Screw Driver 12'</td>
<td>4</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description of Item.</td>
<td>Major Depot</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>26.</td>
<td>Screw Driver 8&quot;</td>
<td>2</td>
</tr>
<tr>
<td>27.</td>
<td>Screw Driver 6&quot;</td>
<td>2</td>
</tr>
<tr>
<td>28.</td>
<td>Insulated cutting Plier (8&quot;, 12&quot;)</td>
<td>4</td>
</tr>
<tr>
<td>29.</td>
<td>Insulated Nose Plier (8&quot;)</td>
<td>2</td>
</tr>
<tr>
<td>30.</td>
<td>Adjustable Pillars Wrench 10&quot;</td>
<td>2</td>
</tr>
<tr>
<td>31.</td>
<td>Adjustable Spanner 12&quot;</td>
<td>2</td>
</tr>
<tr>
<td>32.</td>
<td>Adjustable Spanner 8&quot;</td>
<td>2</td>
</tr>
<tr>
<td>33.</td>
<td>Adjustable Spanner 6&quot;</td>
<td>-</td>
</tr>
<tr>
<td>34.</td>
<td>Set of Screw Driver</td>
<td>2</td>
</tr>
<tr>
<td>35.</td>
<td>Pipe Wrench 12&quot;</td>
<td>1</td>
</tr>
<tr>
<td>36.</td>
<td>Pipe Wrench 8&quot;</td>
<td>-</td>
</tr>
<tr>
<td>37.</td>
<td>Hacksaw frame Adj. 12&quot;</td>
<td>2</td>
</tr>
<tr>
<td>38.</td>
<td>Plumb bob</td>
<td>4</td>
</tr>
<tr>
<td>39.</td>
<td>Spirit level 12&quot;</td>
<td>1</td>
</tr>
<tr>
<td>40.</td>
<td>Spirit level 6&quot;</td>
<td>2</td>
</tr>
<tr>
<td>41.</td>
<td>Allen Key Sizes (2 to 10 mm)</td>
<td></td>
</tr>
<tr>
<td>42.</td>
<td>Detonators Boxes</td>
<td>1</td>
</tr>
<tr>
<td>43.</td>
<td>Banner Flags</td>
<td>2</td>
</tr>
<tr>
<td>44.</td>
<td>Hand Signal Flags (Red &amp; Green)</td>
<td>6</td>
</tr>
<tr>
<td>45.</td>
<td>Hand Signal lamps</td>
<td>2</td>
</tr>
<tr>
<td>46.</td>
<td>Blow Lamp 1/2 Ltr. Cap.</td>
<td>2</td>
</tr>
<tr>
<td>47.</td>
<td>Wall Clocks</td>
<td>1</td>
</tr>
<tr>
<td>48.</td>
<td>Grease Gun</td>
<td>2</td>
</tr>
<tr>
<td>49.</td>
<td>G.I. Pots</td>
<td>2</td>
</tr>
<tr>
<td>50.</td>
<td>Oil Sampling bottles</td>
<td></td>
</tr>
<tr>
<td>51.</td>
<td>Hydrometers</td>
<td></td>
</tr>
<tr>
<td>52.</td>
<td>Thermometers</td>
<td>2</td>
</tr>
<tr>
<td>53.</td>
<td>Crow Bars</td>
<td>4</td>
</tr>
<tr>
<td>54.</td>
<td>Pick Axe</td>
<td>4</td>
</tr>
</tbody>
</table>
### Transport Facilities for TRD Maintenance

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Unit</th>
<th>Type/No. of Vehicles.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Jeep with Tower Car.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heavy duty motor truck</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor Trolley.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Push Trolley.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wiring Cum Break Down</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Train</td>
</tr>
<tr>
<td>1</td>
<td>(a) Each station Where an OHE Officer is based</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Each field officer at his Headquarters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) OHE</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ii) PSI</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>OHE Depot</td>
<td>1*</td>
</tr>
<tr>
<td>3</td>
<td>Zonal Repair Shop</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Divisional Headquarters/Divisional Repair Shop</td>
<td>1</td>
</tr>
</tbody>
</table>

(*) Will also be used by associated PSI Depot.
APPENDIX VII

GENERAL GUIDELINES FOR ANTI-THEFT CHARGING OF OHE

1. General
1.1 In the theft prone area the energisation of OHE at 2.2 kV as an anti-theft measure may be done to avoid theft of contact/catenary wire. As energisation at 2.2 kV is purely for the purpose of arresting the theft of catenary and contact wire and not for train operation, it is not likely to produce any inductive interference affecting signalling and telecom. Installations due to practically no current flowing in the circuit. Therefore, even though certain works like erection of isolators and section insulators, installation of SWS, BTs, Ats adjustment of OHE, SED checks, tower wagons checks, provision of CLS, Telecom, cabling etc. are not completed in all respects, OHE can be charged at 2.2 kV.

1.2 Period of anti-theft energisation will be restricted at night hours only i.e. from 7 PM to 7 AM.

2.0 Works to be completed prior to 2.2 kV Energisation
2.1 The following works are essentially required to be completed prior to 2.2 kV anti-theft energisation of OHE.

2.1.1 Stringing of catenary and contact wire complete with droppering, clipping, and insulation and provision of automatic tensioning device.

2.1.2 Provision of structure bonds in open route and structure and rail bonding in station areas in accordance with the Bonding and Earthing code. In station areas where Bonding and Earthing work has not been completed, the return conductor (RC), if provided, may be used as earth wire and connected solidly to the OHE structures/supports by means of suitable jumpers. At both the ends of the station, RC shall be connected to rails.

2.1.3 All necessary LT modification works

2.1.4 Necessary modification to all HT crossings to meet atleast the requirements for 2.2 kV as per the standards laid down in Appendix IV.

2.1.5 Provision of wire mesh screen on the working platform of existing semaphore signals in case the requisite electrical working clearance of 2 m is not available. No portion of the signal post or its fittings shall be less than 700 mm from the live conductor.

2.1.6 Replacement of existing dc track relays by ac immunized relays.

2.1.7 Conversion of all track crossings of communication lines into cables and removal of overhead wires thereof.

2.1.8 Provision of height gauges and 25 kV caution boards at all level crossings.

2.1.9 Provision of protective screens with 25000 V caution boards on over line structures like ROBs, FOBs Fly Overs etc.

2.1.10 Provision of Public Warning board for 25000 V and shock treatment charts and First-Aid Boxes at all relevant places like stations, cabin buildings, repeater stations, cable huts etc.

2.1.11 Supply of insulated tools to maintenance staff.
2.1.12 Modification to carriage watering arrangements and water columns to suit anti-theft energisation.

2.2 All the relevant rules and precautions in accordance with the Indian Electricity Rules should be complied while carrying out the works.

3  2.2 kV Power Supply Arrangements
2.1 2.2 kV energisation will be done through local supply available at one of the stations through a step-up transformer provided with fuse of suitable capacity with an audible and visual Indication arrangements. A Schematic Diagram indicating the power supply arrangement and the controls and scheme of connection for supply of power at 2.2 kV shall be prepared and submitted to EIG for his approval.

2.2 The 2.2 kV supply arrangement will be manned round the clock by RE. The organisation to be available for manning the feeding installation and duties of the staff and ASMs in case of both normal operation and breakdown/abnormal operation shall be detailed out and issued in the form of a circular.

2.3 As stated in para 1.2 above even though the OHE will be normally kept energised during night, the OHE in the energise section shall be regarded as live at all the times and consequently dangerous to human life. No person except those deputed to work on or near the overhead electrical equipment and who are in possession of a “permit to work”: issued by an authorised representative of RE, shall approach within 2 m from the OHE.

2.4 A joint procedure order indicating the detailed procedure to be followed for taking power block and issue to “permit to work” for issuing notices to drivers, for attending to breakdowns shall be make out and issued to all concerned. This order will be signed jointly by the concerned officers of both RE and Division. A model circular is given in the Annexure A 7.01.

4.Procedure to be Adopted for Energisation
1.1 Publication and display of Notices.
1.1.1 Atleast a month in advance of energisation of any section or sections the following public notifications should be got published in all the prominent dailies in English, Hindi and Local Language and issued to all concerned as normally done for 25 kV energisation, (Reference may also be made to para 21008)

i) General Notification to the users of Railway lines regarding section/sections to be energised.
ii) Notification to the users of level crossings.

4.1.2 Display of general caution notices for public and staff at prominent places at each station, stenciling on the diesel/steam locos warning message to not to climb on the top of locos, caution notices at all steam and diesel loco sheds at which locos working in the energised section are maintained.

4.1.3 The steam/diesel loco drivers/firemen shall be warned not to climb on the roof of the tender and the engine on the section proposed to be energised.

4.2 On completion of the work as mentioned in Para 2 above the following certificates from the concerned officers will be obtained.

i) Certificate regarding removal of L.T. & H.T. infringements by Dy. CEE(G) of the project.
ii) Certificate regarding S&T works
iii) Department of Telecommunications (DOT) clearance certificate for 2.2 kV anti-theft energisation.
iv) Certificate by Dy. CEE(OHE) or DEE(OHE) regarding completion of OHE works.
v) Certificate by OHE Contractors
vi) Certificate by Dy. CE/DEN/RE regarding provision of level crossing gauges and provision of protective screens on ROBs and FOBs
4.3 Besides the certificates regarding completion of works to suit 2.2 kV energisation as mentioned in para 4.2 above, the following safety certificates shall also be obtained.

i) Joint certificate by CEE(P), CSTE(P) and CE(P) regarding safety to traffic as per draft at annexure A 7.02.
ii) Certificate of concerned officers of Division of particular Railway about knowledge of their staff regarding safety.

4.4 EIG Sanction

An application to EIG seeking his approval to the proposal of energisation of OHE at 2.2 kV as anti-theft measure may be made in advance. While applying for sanction, the up-to-date status of works to be completed prior to 2.2 kV energisation should be given and the list of certificates for its completion as well as other safety certificates proposed to be forwarded at the time of seeking EIG” formal sanction may also be indicated, EIG” sanction shall be obtained prior to energisation.

4.5 Checks and Tests prior to Commissioning:

4.5.1 CEE and Electrical Inspector to the Government for the Railway may nominate at his discretion one of his officers preferably Sr. DEE (TRD) for joint check and tests of the section proposed to be energised. For such joint check by Dy. CEE(OHE)/RE will associate from RE side. Alternately he may authorize Dy. CEE(OHE)/RE to conduct checks and tests before energisation. The following checks and test shall normally be carried out.

4.6 Checks

4.6.1 That clearance between live and earthed structures is in accordance with the provision of Schedule of Dimensions.
4.6.2 That earthing and bonding of the OHE have been carried out as per Bonding and Earthing code with exception for station area as specified in para 2.1.2 above.
4.6.3 That height of contact wire at level crossings is proper and that height gauges have been provided
4.6.4 That protective screens have been provided in FOB, ROBs and signalling structure
4.6.5 That the earthing and isolation of overhead equipment adjacent to the section to be energised has been carried out properly.
4.6.6 Ac immunised track relays have been provided
4.6.7 Overhead P&T as well as Rly. Crossings have been cabled and wire removed.

4.7 Tests:

4.7.1 Megger tests for continuity and insulation of the OHE
4.7.2 With the above checks and test and after it is certified either jointly by Sr. DEE/TRD and Dy. CEE(OHE)/RE or by Dy. CEE(OHE)/RE that the section can be energised at 2.2 kV for test purpose, the following fault tests shall be conducted on the section energised at 2.2 kV.

a) By creating earth fault at the farthest end of energised OHE through discharge rod
b) By creating earth fault at the farthest end of energised OHE touching only ballast.
c) By creating earth fault at the farthest end of energised OHE touching only rail.

In all these cases of earth fault, lit should be ensured that fuse provided at the supply point is blown.

4.8 Immediately on the successful completion of the checks and tests of the OHE, OHE can be energised provided that:

a) All the certificates as mentioned in paras 4.2 and 4.3 above are obtained

b) DOTs clearance and EIG’s sanction are obtained.

4.9 Immediately after energisation, a notification to that effect may be issued as normally done for 25 kV energisation.
JOINT OPERATING AND RAILWAY ELECTRIFICATION CIRCULAR NO...........
ANTI-THEFT ENERGISATION IN SECTION...........

The OHE wires, in section are to be kept energised on high voltage continuously, In order to guard the erected overhead equipment against theft. The energising work is being started immediately on (Group) and (Group ) sections. Audible and visual indication arrangements will be made in the office of the Assistant Station Master on duty at and stations. These will be the controlling Masters for anti-theft energisation. Normally a green light will be ON. The alarm will sound a buzzer as well as light a red lamp, whenever a defect, appears on the OHE due to its coming in contact with earth or earthed structure. Immediately when such an occurrence takes place it is necessary to ensure that (a) the equipment damaged does not obstruct the traffic (b) also the line is patrolled, causes of earthing and the defects rectified as quickly as possible. The OHE in the energised section, shall be regarded as being alive at all times and consequently dangerous to human life. No person, except those deputed to work on or near the overhead electrical equipment and who are in possession of a “permit to work” issued by an authorised representative of RE, shall approach to within 2 metres from the OHE.

1. Duty of ASM at controlling stations

1.1 He shall maintain the attendance of operator/lineman. The shift duty of this staff will be fixed by the respective supervisor of RE, who will maintain their muster sheets.

1.2 In the case of abnormality observed through the indicator of Red light provided for the purpose, the ASM on duty will direct the operator to take necessary action as required.

1.3 In the case abnormality indicated by an alarm or red light in any of the indication boards, the ASM shall immediately direct the operator/lineman and inform him of the indication, arrange for calling the respective Supervisor of RE. After the supervisor of RE has declared OHE to be defective, the ASM will advise the Section Controller to issue caution order through the ASMs of the previous train stopping stations where necessary, to drivers of all trains both in Up and Down directions to be on a sharp lookout for the infringement of the track from OHE and to be prepared to stop short of any infringement.

1.4 In addition to this on advice of the Supervisor of RE, the ASM of the station at the other end of the faulty section to send the lineman/operator of RE with staff of the contractor to attend the abnormality/breakdown. The ASM should also inform the Section Controller and the RE Controller about the abnormality/breakdown to convey the message to the supervisor concerned so that the breakdown gang can be moved on the line immediately.

1.5 If any message is received from section controller, or Driver about the location of the fault, he will immediately inform the supervisor of RE and the RE controller.

1.6 When asked by the Supervisor of RE, the ASM make arrangements to stop a train or light engine at the station for the transportation of staff.

2. Duty of RE Controller

2.1 He will assist the Section Controller, in case of any breakdown/abnormality, informing all concerned.

2.2 He will immediately inform DOM/RE and DEE(OHE)/RE concerned, on the autophone and also on P&T phone, if necessary and also the EFO/OHE concerned and the representative of the RE contractor immediately on receipt of breakdown message.

2.3 He will assist the breakdown gang in reaching the site by arranging light engine or train where road facility is not available, in co-ordination with the Section Controller.
2.4 On receipt of the information about wire cutting, he will immediately inform the ASI/RPF concerned as well as local/Railway Police and control/authphone and P&T phone also.

2.5 He will in constant touch with the Section Controller and ASM concerned until the infringement of the OHE is cleared and normal conditions are restored.

2.6 He will pass on the requisition for ‘permit to work’ when received to the supervisor of RE at the station.

3. Duties of Drivers and Guards

3.1 On receipt of caution orders from the ASM that the OHE in the section is faulty, he shall proceed cautiously and shall look out for any hanging OHE wire on Up and Down track.

3.2 In case OHE is found to be hanging and the same does not infringe the standard moving dimensions, the Driver should pass the hanging wire under caution without further damage to the hanging wire, and on reaching the next station he should inform about the location of hanging wires to the ASM.

3.3 In case the hanging OHE wires are infringing the standard moving dimensions, the driver shall stop short of infringements and shall report the location and nature of infringement to the nearest ASM.

3.4 The driver or any other person shall not come in contact with any of the wires laying either on ground or hanging loose and shall prevent others from doing so.

3.5 In case of passenger trains where the Guard is in possession of a portable telephone, the same may be used for giving the information regarding the hanging of wires to the Section Controller. On the energised sections, riding on the top of engine/tender by the crew is strictly prohibited.

4. Duties of the Section Controller

4.1 On receipt of the advice from ASM that there is a defect in the overhead equipment, he shall arrange to give caution orders to all Drivers in the faulty section to be on sharp lookout for any obstruction or wires hanging around, and report the same to the ASM of the station adjacent to the Block Section.

4.2 He should immediately advise the RE controller also for passing on the information to all concerned.

4.3 He should arrange for light engine/or train when asked for the movement of the breakdown gangs of RE.

4.4 If any Driver/Guard/ASM informs him about the locations of hanging OHE wires or breakdown of OHE, will advise the same to the RE controller.

4.5 On receipt of the advice from any of the ASMs or RE controller that the infringement has been cleared, he will arrange for the cancellation of the caution order issued para IV(I) above.

5. Normal Operations

5.1 ‘Permit to work’ for carrying out further construction work on the OHE and for works of other departments viz. Engineering, signalling etc. within two metres of OHE, the energised OHE will have to be switched off. All these works can be carried out only when the “permit to work” has been given by the authorised representative of RE.

5.2 Calculation of ‘Permit to work’ and recharging of OHE: After the work has been finished by the party requiring ‘permit to work’ the party will give back in writing to the authorised representative of RE at site, who originally handed over the ‘permit to work’ to them, that the work in the vicinity of the OHE has been completed and there is no objection for the overhead equipment to be energised. The authorised RE representative will then remove the discharge rods and return the ‘permit to work’ to the Supervisors of RE from whom he has taken in
writing by exchange of private numbers. The Supervisors of RE will ensure that all ‘permit to work’
given by him, has been suitably returned to him. After he has ensured this, he shall remove
discharge rods from OHE, and shall then energise the transformer, thus energising the overhead
equipment on 2.2. kV ac.

6. Abnormal Operations

As already stated the OHE will normally be energised on 2.2. KV/ac and treated as live ty every
body and hence the ‘permit to work’ has to be obtained from authorised supervisor of RE for any
work within two metres of OHE. In case of any accident/abnormality, or in case of miscreants’
activity, if the OHE gets earthed and the L.T. fuse of transformer blows off, the same will be
indicated in the room of ASM by the sounding of buzzer and also by lighting a red lamp. In such
case the ASM should immediately call for the authorised representative of RE posted with him. He
should also send a message to the supervisor of RE who will take charge of the situation. He will
declare the section faulty after further checking if required. He should then, advise the ASM on duty
in writing to send necessary information to the section controller for issuing caution orders to the
Drivers of all up and down trains of the defective zone. The supervisor has to then isolate the faulty
section and send the patrolling party online. The patrolling party incharge will take ‘permit to work’
from the supervisor. The supervisor will not energise the OHE unless and until all the patrolling
parties in section return the ‘permit to work’: by exchanging private numbers or in writing.

7. Authorisation of staff

No body other than the person authorised will carry out Switching operations on OHE and other
installation, issue, receive and cancel ‘permit to work’. Such persons will be authorised only after
duly being tested by DEE/AEE (RE) and shall not be below the rank of skilled artisan.

8. Special Instructions

8.1 Every Railway employee is required to make himself familiar with the methods of first aid to be
rendered in case of Electric shock.

8.2 Proximity of a live conductor has to be avoided; since the risk of direct contact would occur while
working very close to a live conductor.

8.3 It is important to note that induced voltage may appear at any instant in metallic masses in the
vicinity of traction conductors.

8.4 Since there can be presence of return current in rails, use of Rails as a footpath, a seat or for
other purpose is strictly prohibited.

8.5 No persons should go on top of a wagons, Bogie, engine or any other structure, without properly
ensuring that OHE power supply is completely cut-off and the overhead equipment is earthed.
RAILWAY ELECTRIFICATION.....
GENERAL SAFETY CERTIFICATE OF WORKS...

It is hereby certified that all the electrification works to be executed by the Railway Electrification .......... for 2.2 kV single phase anti theft energisation of section from ...... (km.) to ...... (Km.) over.........

Railway have been carried out properly and that the section can be energised without endangering safety of the travelling public or employees of the railway.

CSTE(P)/RE          CPM/RE          CEE/P/RE
APPENDIX  VIII
MODEL CIRCULARS

1. Joint Procedural orders are issued by Zonal railway laying down guidelines for officers and staff of different disciplines to clearly demarcate role and responsibilities among these discipline. Likewise circulars are issued to the all concerned to inform (I) new rules and procedures (ii) changes in procedures due to some alteration in the system; and at times to reiterate extant rules and procedures.

2. Extract from some of the JPO's/Circulars issued by Zonal Railways are appended for illustration and reference.

1. Closing and Securing of Flap Doors of Wagons
Instructions exist that flap doors of the wagons, loaded or empty, should be properly closed and secured before being taken out from goods sheds, siding in yards and on trains. Many cases have, however, been reported when the wagons with open flap and other doors or with doors improperly secured have created situations fraught with danger. Several accidents have taken place in the electrified territories where the OHE masts were struck by the open doors of the wagons causing serious dislocation of traffic. Determined steps should be kept to completely arrest such accidents.

2. Prompt and proper closing and securing of wagons doors and bottom hinged as well top hinged dalas must be ensured while undertaking the following operations:-

a) At loading and unloading points

i) After loading and or unloading of wagons in goods shed lines and other railway sidings, the goods clerk incharge of getting the loading and unloading operations will be responsible for ensuring that all the doors of the dalas are properly closed and secured on completion of work. Services of the train examiner where available will be availed in case of a stiff door or dala.

ii) The shunting Jamadar or the traffic official deputed to draw out wagons from goods shed lines and other sidings will ensure that the doors and dalas are closed and secured before they start drawing out.

iii) Similarly, the incharges of the various departmental siding such as loco sheds, diesel sheds, electric sheds, stores sidings, engineering sidings etc. will be responsible for closing and securing of doors and dalas after loading and unloading of materials, fuels, stores etc.

b) In shunting operations in yards

Before starting the shunting operations in the yards, the shunting Jamadar will ensure that the doors and dalas of all the wagons being pulled are properly closed and secured. He should call for the assistance of a TXR in case of a stiff door or dala. He should observe this while sorting wagons, while attaching wagons on trains, while detaching wagons from trains and in all other miscellaneous shunting movements.

c) On train
The guard incharge of the train will ensure that doors and dalas of all the wagons put on his train are properly closed and secured before he starts his train. He will point out any lapse in this regard to the Station Master/Yard Supervisors on duty well in time so that the same is rectified without any detention to the train. He will observe this while taking charge of an originating train as well as through train taken over from the adjoining railway, adjoining divisions and the adjoining section of the Division.
d) Examination of trains

During the course of examination of a train, the TXR will ensure that all doors and dalas of the wagons on the train are closed and the stiff doors and dalas are rectified and closed by his own staff. The issue of fit certificate for the train should be subject to proper closure of the wagon doors and dalas.

e) Security staff involvement

The security arrangements by the RPF staff should be tightened so that no door or dala of any wagon in the yard and sidings is opened by the trespassers.

Any laxity in observance of the above instructions should be seriously viewed and deterrent action taken against staff at fault. For this purpose, checks should be organized by officers and supervisors, particularly the safety officers and inspectors. Ambush checks should also be undertaken by Sr. DSO/DSO.

2. Movement of Insulated Consignments on Open Wagons

Escorting consignments loaded on open wagons in electrified areas needs caution against electric shock to escorting personnel. Approach to any point within two metres of the live parts of traction equipments is strictly forbidden.

Cases of accident caused by electric shocks to the personnel escorting insulated consignments loaded on open wagons, insulated from the body of the wagons by rubber tyres or wooden logs, etc. are on record. To prevent such accidents the following procedure must be followed.

In cases where the consignment is kept on insulated supports, like military or civil trucks on rubber tyres, over an open wagon shocks due to induced voltage might be caused. Induction causes voltage of a high order on all metallic consignments while being underneath the traction wires. If the exposed metallic surfaces of the consignment are in good electrical contact with the body of the wagon, their potential will be same as at the body of the wagon. Presence of Insulation between the body of the consignment and the wagon will result in dangerously high potential difference being set up between the consignment and the wagon which may cause shock to a person on the wagon escorting the consignment. For the movement of such consignments through electrified sections, therefore, the following precautions are essential.

i) A temporary metallic connection should be made between the body of the consignment and the wagon. For the purpose, standard steel wire or size 7/16 SWG (Cross sectional areas 14.5 mm $^2$) or any other available size higher in cross sections may be used to fasten the metallic portion(s) of the consignment to the wagon at 4 independent points, without tempering the consignment. Steel chains of equivalent cross sections can also be used in lieu. The train examiners of train originating stations will effect and ensure such fastenings prior to issuing fit memos for movement of the consignment.

ii) No train shall leave a train originating point without the above having been provided.

iii) However, prior to entry of such consignments in the electrified sections, the Guard incharge shall check up the provision of such arrangements and ensure onward movement only after confirming the following:

a) The wire fastenings are effected by the TXR staff if available.

b) If item (a) above is not possible, the escorting personnel should be detained from the wagon carrying such consignments till such time the fastenings are provided for by the TXR – staff or by the nearest traction (OHE) staff as indicated in the working time table.

c) On entry into the electrified section the bonding used will be got checked by the TRD staff.
3. **Joint Procedure Order for TPCs, Section Controllers, Drivers and Guards of Electric Traction in the event of Hot Axle or other Abnormality in trains, in OHE, in Track etc. necessitating Switching Off of OHE Supply.**

In the event of Hot axle or other abnormalities in trains, OHE or in track, joint procedure for switching off and switching on of OHE in indicated below:

1. In case any hot axle or any abnormality is seen in a running train in block sections or at stations, power supply to OHE of the affected section shall be switched off immediately by TPC on duty by opening of the feeder C.B. on advice from Section Controller, Station Master or others as the case may be under clear exchange of private numbers.

If the block section is falling in the zone of two feeding posts, then feeder CBs of both feeding posts may be switched off and the section isolated must be reduced to sub-sector after finding out the details of train by TPC.

Regarding switching off of OHE power. TPC shall inform the concerned SCNL in writing and Section Controller shall take immediate necessary action.

2. Station Master and Section Controller should thereafter in consultation with TPC should take detailed information regarding damages, infringements or any other abnormalities of track. Rolling Stock or OHE. Section Controller should ensure that no train is allowed to enter dead section on either one direction to avoid snapping of OHE.

3. Look-out caution to driver of the first train of opposite direction which is likely to enter the affected section will be issued by Section Controller. After issuing of caution order to the first train which is likely to come in the effected section and after ensuring the safe position, TPC will be asked by Section Controller under clear exchange of private number to charge the particular healthy section which was switched off as a precautionary measure.

4. **Joint Procedural Order for TRD, RSO staff and ASMs in Case of any Abnormality on OHE**

1. In case of breakdown of OHE, when it is necessary for a train to proceed cautiously the TFO(OHE) responsible for such notification shall arrange for issue of caution order. An authorised person shall be present at the site and shall be responsible for showing signals.

2. A caution order detailing the kilometers between which such precaution is necessary, the reason for taking such precaution and the speed at which a train shall travel, shall be handed to the driver at the stopping station/other station in such a manner, as prescribed under special instructions.

3. **Showing of Signals**

Whenever due to lines being under repair or due to any other obstruction it is necessary to indicate to the Driver that he has to stop or proceed at a restricted speed, the following signals shall be shown and where prescribed and detonators used, it on a double line the direction from which trains approach, and if on single line in each direction.

a) When the train is required to stop and the restriction is likely to last only for a day or less –

A banner flag shall be exhibited at distance of 600 m on the B.G. and the 3 detonators shall be placed, 10 m apart, at a distance of 1200 m on B.G. from the place of obstruction. In addition, stop hand signal shall be shown at a distance of 30 m from the place of obstruction, at the banner flag and at distance of 45 metres from 3-detonators. The Railway Servant at the place of obstruction shall give proceed hand signal to indicate to the Driver when he may resume normal speed after the train has been hand signalled past the place of obstruction.
b) When the train is required to stop and the restriction is likely to last for more than a day

A stop indicator shall be exhibited at a distance of 30 m from the place of obstruction and a caution indicator at 1200 metres on the B.G. from the place of obstruction. In addition, Termination Indicators shall be provided at the place where a driver may resume normal speed.

c) When the train is not required to stop and the restriction is likely to last only for a day or less

Proceed with Caution hand signal shall be exhibited again at a distance of 30 m and at a distance of at least 800 m shall be suitably increased by special instructions, where required. The Railway Servant at the place of obstruction shall give proceed hand signal to indicate to the Driver when he may resume normal speed after the train has been hand signalled past the place of obstruction.

d) When the train is not required to stop and the restriction is likely to last for more than a day

A speed indicator shall be exhibited at a distance of 30 metres from the place of obstruction and again a Caution indicator at a distance of at least 800 metres shall be suitably increased by special instruction, where required. In addition, Termination indicators shall be provided at the place where a Driver may resume normal speed.

5. **Safety Measures to be Observed in Case of Unusual Occurrences on Electrified Sections.**

1. In the event of an OHE fault, the Traction Power Controller after segregating and isolating the faulty section shall also immediately switch off the power to the healthy section on the adjacent line/lines over the same route length as the faulty section. The TPC shall promptly inform the Section controller details of the isolated faulty section (hereafter called the faulty section), as well as the adjacent healthy section (hereafter called the healthy section) temporarily isolated.

2. On receipt of message from TPC the Section Controller shall take all precaution as per the extent rules, treating this section as under emergency power block.

   a) For the faulty section, the Section Controller shall take all precautions as per extant rules, treating this section as under Emergency Power Block.

   b) For the healthy section, the Section Controller shall take immediate action to inform concerned Station Masters to arrange issue of caution orders to the driver of the first train due to enter into any of the concerned block sections of the healthy section.

   The caution order shall specify a speed restriction of 25 Km/H by day and 15 Km/h by night with instructions to stop short of any obstruction or stop at the next station and report condition of the track and OHE or any other infringement. The driver shall advise at the next station whether the trains following his train should observe any precautions or speed restrictions. As it will not be possible for caution orders to be issued to Driver of trains already in mid-section of the concerned block sections, the caution orders shall be issued to drivers only as and when trains are able to reach stations and are further to proceed through other block sections in the healthy section.

   In case OHE power supply failure exceeds five minutes and the Electric Loco Driver for any reason is unable to establish communication with Section Controller through emergency sockets, the driver shall arrange to check for power supply as laid down in Electric Locomotive Operating Manual and on restoration of power, shall arrange to take the train cautiously to the next station, ready to stop in case of any obstructions. A speed restriction of 25 Km./h by day and 15 Km.h by night shall be observed for this movement to the next station. On reaching the next station, the Driver shall contact SM/Section controller.
3. The Section Controller after exchanging message with Station Masters for issue of caution orders to Driver as laid in para 2 (b) above shall immediately authorize TPC to take action to restore Power Supply to the healthy section, unless based on information received meanwhile from site/stations, it would be necessary to continue to keep the power off from the healthy section.

In the event of any obstruction or abnormality online/OHE is reported to the Section controller, directly from station/site, the Section Controller shall inform TPC to switch off power both on affected line(faulty section) and also on adjacent lines (healthy section) and then proceed as per para 2 above. This safeguard has been stipulated as all obstructions on line may not necessarily reflect as an OHE fault giving indication to TPC.

Based on the no-abnormality report of Drivers who have completed their cautions runs through the block sections on the healthy sections, Section Controller shall arrange to remove the caution orders to subsequent trains passing the healthy section. The Section Controller shall also keep TPC advised regarding resumption of normal traffic on the healthy section.

4. In order to minimize the repercussions to traffic on account of adoption of the above procedures, it is very essential that the emergency telephone sockets all along on the electrified line and emergency telephones provided with drivers/guard are maintained in good fettle. Joint checks of the Emergency Telephone sockets on the line between TRD and S&T inspectors should be made to ensure their operational reliability in case of emergencies.

6. **Joint Procedural Order for TPC, SCNL, ASMs, Drivers & Guards in Case an Animal is Run Over in Electrified Route.**

When cattle or animals are run over, vultures generally assemble on the body nearby the track and sometimes entangle with OHE and/or pantograph causing damage leading to major breakdowns.

Whenever such cases of run over of animals take place or are observed.

a) Drivers and Guards will make effort to advice the same to the SM/ASMs at the next stoppage for relaying the same to SCNL/TPC or TLCs.

b) Other railway staff will immediately advice the same to ASMs, SCNLs, TLCs and Engineering Control.

On receipt of such information the ASM concerned shall take necessary action to remove the body to a safe distance to avoid risk of damage to pantographs of passing trains and OHE.

7. **Joint Procedural Orders for TPCs and ASMs in case of Electric Shocks with 25 kV OHE supply.**

1. TPC shall arrange to cut-off 25 kV OHE supply of concerned sub-sector and also sub-sector of adjacent line to reduce the effect of induction and shall advise all concerned.

2. TPC shall inform nearest electrical department official and simultaneously arrange an authorised person to come to spot and move tower wagon/road vehicle from nearest depot if no authorised person is available near site.

3. TPC shall also inform section controller for regulating the traffic so as to avoid possibility of accidental charging of the section due to Loco entering the section so made dead.

4. TPC shall inform SM/ASM of nearest Railway Station for medical assistance.

5. TPC/SM/ASM shall inform nearest Railway Doctor for Medical assistance with available means of communication.

6. TPC/SM/ASM shall inform GRP/RPF staff to reach site of accident provided RPF/GRP post is located at the stations.

7. TPC shall advise for movement of medical van if situation warrants.
8. On arrival of authorised person on spot, he shall be advised to cordon off the area so that no one else may get injured.

9. TPC shall advise authorised person to remove the victim with the help of some insulating rod.

10. TPC shall also advise authorised person to administer artificial respiration and other help as needed.

11. TPC shall arrange quick shifting of victim from site to nearest hospital by
   a) Stopping first available train
   b) Sending Tower wagon or road Venice from nearest OHE depot.
   c) Sending ambulance/stretcher

12. TPC shall advise controlling officer about the accident and take guidance.

13. On arrival of authorised person on spot, TPC must find out the detailed cause of electrical accident and preserve the documents/materials related to it.

14. TPC shall restore 25 kV OHE supply after confirmation from the site by authorised person or SS/ASM on duty that the victim has been dis-associated from the 25 kV OHE. Authorised person, after dis-association should give it in writing to the nearest SM.

15. TPC shall collect details about the victim i.e. hospital where admitted, percentage of burns injury, his day to day condition and apprise of the position to controlling officer.

16. In case of damage to electrical equipment on this account TPC shall make arrangements to get equipment attended at the earliest to enable restoration of supply.

17. SM/ASM shall also inform TPC of electrical accident or possibility of accident by exchange of private number for making the OHE dead provided SM/ASM is first to get such information.

18. If it is possible to keep the traffic moving by other line, TPC will advise to Section Controller in writing to introduce single line working.


To take timely action for the problem of low/high OHE voltage, following procedure should be strictly followed:

i) The hourly voltage readings recorded by TPCs should be scrutinized by CTPC concerned daily, in case where voltage of feeding point has gone below 23 kV steps should be taken to improve the voltage. The taps of traction transformers should be changed so as to improve the feeding voltage. If the problem still persists the Supply Authorities should be contacted. The concerned Sr. DEEs/DEEs should be informed who will establish contact with officials of the Supply Authority and get the voltage improved.

Normally the tap setting of Traction Transformer at Traction sub-station will be fixed so that daily OHE voltage peaks do not exceed 27.5 kV. This will ensure that the voltage is well above the minimum of 19 kV at the farthest point of the feeding zone.

ii) The cases of low/high voltages observed by the drivers during the run should be reported to the concerned TLC before signing off indicating time, voltage observed and location/section where abnormal voltage observed. The abnormal voltage in this case will be above 27.5 kV and below 19 kV.
iii) TLC would also immediately check the reports of other drivers in the same section and advise the consolidated position regarding abnormal OHE voltage to traction power controller. The TPC/CTPC would then take immediate measures as indicated above at para (2).


1. Before any alteration to alignment or level of electrified track is commenced, due notice of 48 hrs. in advance shall be given to those responsible for the OHE so that OHE may be adjusted to conform to the new condition (at PQRS site, work will be done under the Joint Supervision of Permanent way inspector, Electric Chargeman/TRD, and S&T staff continuously).

2. A permit to work must be obtained, if work is to be carried out or any worker is required to come within 2 metres of the 25 kV live overhead equipment.

3. When unloading the rails along the track, care shall be taken by PWI/PWM or mate to ensure that the rails do not touch each other to form a continuous metallic mass of length greater than 300 m.

4. In case of track renewals, temporary connections shall be provided with the other rail of the track at both ends by TRD staff. In case of renewal of both the rails of track simultaneously, temporary connection shall be provided within rails of adjacent track at both ends by TRD staff.

5. Before fish plates are loosened or removed, temporary electrical connection between the two rails shall invariably be made.

6. In case of defective or broken rails bond, a temporary connection shall be made.

7. In case of “rail fracture” the two ends of the fractured rail shall be first temporarily connected by a temporary metallic jumper of approved design. In all cases of discontinuity of rails. The two parts of the rails shall not be touched with bare hands of uninsulated tools. Gloves of approved quality shall be used.

8. Permanent way staff shall keep clear of the tracks and avoid contact with the rails either when approaching or reaching the work spot when an electrically hauled train is within 250 m.

9. In track circuited area, insulated joints shall not be bridged with bare hands or any metallic articles.

10. Use of steel measuring tapes or long metallic wires is prohibited in electrified sections.

11. Before replacing the rails/glued joints in track circuited area the permanent way inspector will ensure that traction distribution staff and S&T staff are available at site for removing and replacing the “traction bonds” and jumper/bonding connections where required.

In each cases, PWI will cancel the block to resume the normal traffic only after ensuring that the traction bonds cable jumpers, bond wire etc. have been reconnected by TRD staff and S&T staff, TRD and S&T staff should be made available at 48 Hr. notice given by PWI for changing rails in case of planned works and on the same day in case of rail fracture.

12. The Traction Foreman shall see that all insulating sleeves on traction bonds passing under positive rail of track circuits are intact and take prompt action to replace the missing/damaged one.


Since the working of relaying unit involves removal of existing rails along with all the different types of traction bonds, it is absolutely essential that temporary jumpers for passenger of return current are provided till such time the permanent bonds are fixed to the new rails.
Following procedure shall be followed by the site Incharges of both the Engineering and TRD branches associated with Relaying work.

1. Before energizing the OHE after completion of work at the end of each day, temporary jumpers/temporary structure bonds shall be provided on the auxiliary rails and the new rail by the TRD supervisors as per instructions contained in ACTM. This shall be jointly witnessed by the PWI in a register provided for this purpose. TRD supervision shall keep the register in this custody.

2. PWI at site should ensure that temporary rail bonds are connected through auxiliary rail before opening/dismantling of rails joins for replacing the panel.

3. It would be the responsibility of the PWI incharge to ensure the safety of the staff once the TRD supervision has attended to the above work to ensure that temporary bonds jumpers are not damaged by Engineering staff during the course of working.

4. The length of section of track provided with the temporary jumpers shall also be indicated in the above register at the end of each working day.

5. NO bonds/temporary jumpers shall be opened by the Engineering Branch without first informing the TRD Supervisors.

6. Formation of auxiliary track shall also be done in the presence of TRD Supervisor, who shall provide necessary temporary earthing connection to ensuring safety of staff.

7. At the time of dismantalling/replacing track from the site, PWI concerned will provide continuity jumpers as per instructions given in ACTM in addition to other instructions for the precautions to be observed by permanent way staff.

8. The temporary jumpers shall be replaced by permanent bonds in the quickest possible time.

9. The implantation of OHE masts shall be maintained by the Engineering Branch as recorded in the SED.

10. All the staff should be clearly instructed not be interfere with the track after the work has stopped for the day and the entries in the register made.

11. All other bonds would be done by the TRD Supervision as per instructions contained in ACTM.

11. Joint Engineering and Electrical Department Circular.

Consequent upon Electrification of various sections of track on Railway/Division, a number of additional assets have been created. It is therefore necessary to define the responsibilities in respect of maintenance of such assets and precautions to be taken in maintaining existing assets.

1. General

a) Electrification System :

The system of electrification on the Railway is ac, Single Phase, 25 kV, 50 Hz. The sections under electrification are from ..................to..........................

b) Rules :

Subsidiary rules for 25 kV ac traction issued by CEE and COM and Permanent Way Safety Rules issued by Chief Engineer as supplement to Part “ J “ Chapter II of Indian Railway Permanent Manual shall be in possession of every PWI, APWI, IOW. They shall be conversant with all rules and shall also be responsible for ensuring that all staff under them know the rules and follows them strictly.

INDIAN RAILWAY-AC TRACTION MANUAL – VOLII- PART II [149]
c) Safety First Warning to Staff:

All electrical equipment shall be regarded as alive at all times and consequently dangerous to human life, save and except in cases where the electrical equipment has been specially made dead in accordance with the provisions of these rules. All Railway servants other than those deputed to work on or near electrical equipment shall keep away therefrom.

d) Admission to and permit-to-work in the supply control posts:

No person other than authorised traction maintenance staff, their assistants, when accompanying them and persons provided with special permits issued by Sr. DEE/TRD and others is mentioned in SR shall be admitted to supply control posts.

e) Work on electrical equipment in supply control posts and other electrical equipments:

No work shall be undertaken on any part of electrical equipment or adjacent to it until the person has received a permit-to-work card. The PWI or IOW will get this from authorised persons as per provisions of SR.

f) Engineering staff on track patrol shall look for any missing locks on the isolator switches mounted on traction mast along the track and report the same to ATFO or the TPC without delay.

2. Maintenance

a) Buildings:

A number of buildings have been constructed for locating various equipment for maintenance and operation of traction equipment. These include Remote Control Centres, supply control posts (at various points along the track), maintenance depots, OHE inspection Car Sheds etc.

The Engineering Department shall maintain all these buildings in a fit condition. Special care should be exercised to ensure that Remote Control Cubicles along the track and Remote Control Centres are maintained leak proof and vermin proof as these contain costly sophisticated equipment, whose correct operation is vital for safety of staff and equipment on the Railway. The Engineers shall therefore execute all such works that may be required for ensuring the above as expeditiously as possible.

Painting and white washing of the interior of the building housing various equipments will be done by Engineering Staff under the supervisor of Electrical Staff. All repair to fencing at supply control posts around high voltage equipments including painting will also be done by Engg. Staff under the Supervision of Elec. Staff.

b) Tunnel roofs are also to be maintained water proof by the Engineering Department to avoid flashovers and breakdowns to OHE.

c) All OHE supporting masts and their foundations will be maintained by the Electrical Department. Ballast, sand and cement will be supplied by the Engineering Department on demand. Foundations at special locations like bridges will however be maintained and replaced by the Engineering Department as per the requirements of the Electrical Department. The earth work around the foundations block will be maintained by the Engineering Department.

d) Track Bonds:

All bonds between track rails and between rail and traction masts will be maintained by the Electrical Department. During track patrol the engineering staff shall look for any damaged bonds between rail & structure, or those between rail to rail and report such damages as they notice to the TFO concerned without delay.
e) Level Crossing Gauges, Screens etc. on bridges:
The maintenance of level crossing including caution boards thereon will be done by the Engineering Department. Special care shall be taken to prevent the approach road levels going down below the mark given in level crossing gauges, to prevent passage of unsafe road traffic under the OHE. The height of the top member of L.C. gauge above the road shall not exceed 4.67 metres. Similarly all screens provided on foot over, road over bridges etc. shall be maintained by the Engineering staff.

f) Slewing of tracks and alteration to super elevation and heights of rails:

It shall be ensured that the level of rails under foot over bridges, road over bridges, and other overline structures does not exceed the level marked under such structures. Whenever any work on track, which is likely to affect rail bonds, is undertaken by permanent way staff, adequate notice shall be given to the Traction foreman (OHE) to enable him to arrange for bonding staff for removal and replacement of bonds.

Bonding staff when working with a permanent way inspector, sub-inspector or Assistance Inspector shall work under the instructions of Permanent Way Inspector, Sub-Inspector or Assistance Inspector who shall then be responsible for the safety of the track and of the staff.

g) Work involving traffic or power blocks and permits work on traction electrical or overhead equipment:

All departments in the electrified area who require traffic blocks, power blocks, or permits-to-work in the danger zone of the traction equipment or who require overhead line bond/or bonding staff to be present at site for scheduled maintenance works, shall deliver at the office of the Sr. Divisional/Divisional Electrical Engineer (Traction Distribution) not later than 10.00 hr. on every Monday morning, statements in the prescribed form showing (i) the nature of the work and the date on which it is to be performed, (ii) by whom the work is to be carried out, (iii) location of the work and the section of the lines to be blocked (iv) the trains between which the block is required and (v) whether the track will be available for steam of diesel traffic.

The requirement of all departments will be co-ordinated in the office of the Sr. Divisional/Divisional Electrical Engineer (Traction Distribution) and a consolidated statement forwarded to the Sr. Divisional/Divisional Operating Manager concerned at 12.00 hrs. on every Wednesday for inclusion in the weekly programme of traffic and power blocks.

Works of an urgent character shall be attended to by obtaining emergency blocks and permits-to-work from the TPC.

A weekly programme of work involving traffic blocks, power blocks and permits-to-work shall be prepared in the office of the Sr. Divisional/Divisional Operating Manager and dispatched to all concerned by Friday evening, for the week commencing on the following Monday.

h) Work on station roof, signal gantries etc. – Precaution to be taken by staff.

Measuring taps of all kinds, tools and metal articles (such as paint pots, oil case, metal bars) shall not be used where they can be lifted or be dropped or be carried by the wind on to overhead equipment when such overhead equipment is alive.

i) Working on service building and structures in the vicinity of the equipment:
Railway staff when required to carry out work on service, buildings and structures in proximity to overhead equipment, shall exercise special care to ensure that tools, measuring taps, materials etc. are not placed in a position where there are likely to fall, or may contact with electric equipment. Wherever such work has to be carried out under conditions which involve risk to the workmen or other persons, arrangements shall be made for authorised overhead equipment staff to be present, who shall take such precautions as may be necessary for the safety of the persons concerned.
j) Working near cables:

When excavations are being made adjacent to tracks and cable routes in an electrified area adequate precautions shall be taken for the safety of staff and to avoid damage to underground cables and rail bonds.

Markers are placed wherever possible, along the cable alignment and plans are available indicating generally the position of buried cables. Excavation must not be undertaken in the vicinity of cable routes until the exact position of the cables has been ascertained and a representative of the department concerned is present. This is applicable to cables of Posts and Telegraphs Departments also.

If circumstances make it imperative that work be undertaken without sufficient notice. Asstt. Signal and Telecommunication Engineer concerned must be informed by telegram for arranging staff to be present.

k) Working of Cranes:

NO steam or hand-crane shall be worked adjacent to traction overhead equipment unless such overhead equipment is made dead and earthed and authorised OHE staff are present. All movements of the crane jib shall be carefully controlled so as not to foul the traction overhead equipment. Wherever possible the direct blast from the crane funnel to the over-head equipment and particularly to section insulators shall be avoided.

Except in emergency, 24 hours notice of intention to work a crane adjacent to overhead equipment shall be given to the Sr.Divisional/Divisional Electrical Engineer (Traction Distribution) in order to make arrangements for overhead equipment staff to stand by. When possible the working of cranes shall be included in the weekly programme. In an emergency, the Traction Power Controller shall be advised and he shall make arrangements for overhead equipment staff to stand by.

l) Sanded catch sidings:

On sanded catch sidings, the rails shall be kept clear of bond for a length of about 25 metres beyond live overhead equipment of the track.

m) Transport of heavy materials:

In the case of accidents and breakdowns involving OHE, PWIs/APWIs in charge shall arrange at short notice for labour required for carrying heavy materials, erection of structures etc.

n) Caution Boards:

The caution boards at stations warning passengers and staff not to come in contact with the traction installations should also be maintained by the Engineering Department.

o) No blasting is to be done in the vicinity of the electrified lines without the specific sanction of the Sr. Divisional/Divisional Electrical Engineer (TRD)

p) Numbering of traction masts:

The kilometer number painted on the traction masts as well as the signs showing the direction of the nearest emergency Telephone sockets will also be maintained by the Engineer Department staff. The painting of masts themselves, as and when required, will be carried out by the Electrical Department.
### APPENDIX - IX

**LIST OF SPECIFICATIONS AND DRAWINGS FOR EQUIPMENTS AND MATERIALS FOR RAILWAY ELECTRIC TRACTION**  
**CHAPTER – I  RDSO SPECIFICATIONS  
SECTION – I – OVERHEAD EQUIPMENT**

1. Conventional OHE (Cd Cu Catenary + Cu Contact wire)

<table>
<thead>
<tr>
<th>SN</th>
<th>Specification No.</th>
<th>Amend</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ETI/OHE/3(1/83)</td>
<td>2(2/85)</td>
<td>Annealed standard copper conductor for jumper wire.</td>
</tr>
<tr>
<td>2</td>
<td>RE/30/OHE/5(11/60)</td>
<td></td>
<td>Copper busbar</td>
</tr>
<tr>
<td>3</td>
<td>RE/OHE/10(3/66)</td>
<td></td>
<td>Splices and ending clamps.</td>
</tr>
<tr>
<td>4</td>
<td>ETI/OHE/11(5/89)</td>
<td></td>
<td>Steel tubes.</td>
</tr>
<tr>
<td>5</td>
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### 2. Aluminum OHE

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<td>1.</td>
<td>ETI/OHE/54(2/85)</td>
<td>1(11/89)</td>
<td>19/2.79mm all Al. Alloy standard catenary wire.</td>
<td></td>
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<td>2.</td>
<td>ETI/OHE/55(4/90)</td>
<td></td>
<td>Bimetallic (Al-Cu) strip for kV traction OHE.</td>
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<td>3.</td>
<td>AL OHE/101 (8/83)</td>
<td></td>
<td>Al. Alloy grooved contact wire 16.4 mm dia 193/190 mm2 cross section.</td>
<td></td>
</tr>
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</table>

### 3. Civil

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<tr>
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<td></td>
<td>Standard code of practice painting of rolled steel electrification mast.</td>
<td>Not to be used.</td>
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<td>5.</td>
<td>ETI/C/4(5/88)</td>
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<td>Specification for FLO-COAT STEEL TUBES.</td>
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<td></td>
<td>Battery charger for 110 volt battery, 40 Ah.</td>
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<td>2.</td>
<td>ETI/PSI/3(8/75)</td>
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<td>Lightning Arrestor, 7.5 kV</td>
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<td>8.</td>
<td>ETI/PSI15(10/73) Add. Slipno.3 = 2(3/89) (12/81) applicable in case of seal type</td>
<td>25 KV/240 V LT supply transformer 10 KVA</td>
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24. ETI/PSI/31(5/76) Standards for drawings for power supply installations

25. ETI/PSI/35(4/75) Potential transformers, 132 kV

26. ETI/PSI/36(5/75) Current transformer, 132 kV, (Type II)

27. ETI/PSI/37(7/74) Battery charger type I & II for 24 V lead acid batteries for remote control equipment.

28. ETI/PSI/38(1/73) Selective frequency level meter Analyser.


30. ETI/PSI/41(1/73) Double pole & triple pole isolator 110 kV Superseded by ETI/PSI 122(3/89)

31. ETI/PSI/42(8/75) Lightening arrestors 96 kV. Superseded by ETI/PSI 137(8/89)

32. ETI/PSI/43(10/90) Control & distribution panel for color light signalling supply

33. ETI/PSI/44(12/73) Standard for electrical distribution system in Station & Yards where kV ac traction is to be Introduced.

34. ETI/PSI/46(8/90) Single pole vacuum circuits breakers, 25 kV.

35. ETI/PSI/47(9/78) Telemetering equipment for 25 kV ac traction.

36. ETI/PSI/50(8/79) Double pole & triple pole isolators Superseded by ETI/PSI 122(3/89)

37. ETI/PSI/50A(8/79) Earthing blade assembly for double pole & triple pole isolators, 66 kV.

38. ETI/PSI/50B(4/80) Double pole and triple pole motor operated isolators, 66 kV.

39. ETI/PSI/53(8/79) Lightning arrestors 60 kV Superseded by ETI/PSI 137(8/89)

40. ETI/PSI/56(3/80) Potential transformers, 66 kV

41. ETI/PSI/58(8/82) 400 KVA, 25 kV/415V/110V single phase power transformers.

42. ETI/PSI/59(1/81) 25 kV dropout fuse switch & operating pole emergency power supply equipment.


44. ETI/PSI/62(7/82) Insulating transformer oil purification plant (2500 Ltr. Per hour capacity) workable on 230 Vts ac single phase supply for railway ac sub-station.

45. ETI/PSI/63(7/82) Low tension distribution panels.

46. ETI/PSI/65(8/84) Control & relay pane board incorporating static type relay for 25 kV ac traction sub-station.
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68. ETI/PSI/93(5/87) 25 kV ac single pole SF-6 circuit breaker
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69. ETI/PSI/97(6/87) 100 KVA, 25 kV single phase 50Hz. Dry
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70. ETI/PSI/98 (6/87) 150 KVA, 25 kV single phase 50 Hz.,
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71. ETI/PSI/99(6/87) Trivector meter and maximum demand
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72. ETI/PSI/100(10/90) Specification for thyristor switched
      shunt capacitor equipment for railway traction sub-
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73. ETI/PSI/101(8/87) Two zones static relay for distance protection for 25 kV
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74. ETI/PSI/103(7/89) High vacuum type insulating/transformer
      Supersedes
      oil purification plant (capacity 3000 LPH)
      specn. No. for railway traction sub-station
      ETI/PSI/62 (7/82)

75. ETI/PSI/104 (9/87) Re-current surge generator for use in railway
      traction sub-station.

76. ETI/PSI/105(9/87) Gas chromatograph for use in analysis
      of dissolved gases of transformer oil.

77. ETI/PSI/106 (9/87) Capacitance bridge and dissipation factor
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78. ETI/PSI/108(9/87) Power system disturbance recorder.


80. ETI/PSI/PSS/LAB/110 (10/87) Dual trace oscilloscope

81. ETI/PSI/PSS/LAB/112 (10/87) Digital frequency meter

82. ETI/PSI/PSS/114(3/88) Waveform analyser

83. ETI/PSI/PSS/LAB/115 (11/87) Data logger

84. ETI/PSI/116(4/88) 220/132/110/66 kV DP/TP SF-6
      7(3/92) gas circuit breaker.

85. ETI/PSI/117(7/88) Current transformer
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      ii) 132KV, 400-200/5
      iii) 110 kV, 400-200/5
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86. ETI/PSI/118(7/89) Power transformer 20 MVA single
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ETI/PSI/118 (7/89)
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2. 1500 V dc System.

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<td>High speed circuit breakers, 1500 V dc.</td>
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<td>ETI/PSI/206(2/75)</td>
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<td>5.</td>
<td>ETI/PSI/207(5/81)</td>
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<td>ETI/PSI/213(12/72)</td>
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<td>11.</td>
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<td>13.</td>
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<td>ETI/PSI/220/221(8/82)</td>
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**Remarks**

- OBSOLETE: The item is obsolete and no longer in use.
- WITHDRAWN: The item is withdrawn and no longer in production.
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Sent to CORE vide this office letter no. ETI/OHE/DEV/12 dt. 4.4.88. It was proposed that the OHE for 20-25 kms should be erected in the forthcoming groups for trials.
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<td>Details of guide tube attachment for trapezoidal counter weight</td>
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<td>Guide tube bracket angle (welded) attachment on BFB mast and pole (for trapezoidal counter weight)</td>
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<td>Counter weight assembly for Regulating equipment (3:1).</td>
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<td>Counter weight assembly (for tramway type OHE) (1250 kgf).</td>
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<td>Details of regulating equipment (3:1 ratio).</td>
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<td>$ 6000</td>
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<td>Stay arm insulator tube cap.</td>
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<td>Stay arm insulator hook cap.</td>
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<td>Disc insulator (255mm) (clevis type).</td>
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<td>Standard Sectioning insulator for clean areas.</td>
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* = The drawings of regulating equipment are for reference. Minor variation in the manufacturer's drawing may be approved.

$ = These drawings are for guidance only. For full details, specification No. ETI/OHE/15(11/83) should be referred.

@ = Drawings are for guidance only.
3. General Arrangement and Fittings for Composite OHE
   (Aluminium Alloy Catenary and Copper Contact Wire)

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**E. OHE SUPER MAST AND SPS.**

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2. Short super mast channel.  
4. 0.8 m super mast cross arm.  
5. Suspension support angle.  
6. Suspension support angle (modified arrangement).  
7. Suspension support angle.  
8. 1.5 m super mast cross arm.  
9. Batten plate (type - II).  
11. Long super mast channel.  
12. 2.8 m super mast cross arm.  
15. Front clamping angle.  
17. Portal super mast.  
18. Base clamping angle for portals.  
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**F. DROP ARM AND OHE SUSPENSION WITH SPS.**

1. Standard arrangement of supporting cantilevers on the boom of portals and TTC (general arrangement).  

0013 SH-1 | D | 18.1.90 |

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G. **EMPLOYMENT SCHEDULE OF OHE MASTS**

Employment schedule for cantilever masts regulated OHE in Gr. 40 A for TARE section only (wind 150 kgf/m2). caty. 65/cu, cont. 107/cu.

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<td>Employment schedule for cantilever mast regulated OHE caty. 115/Al, cont. 107/cu (WP 150 kgf/m²) for TARE section (Gr. 40A) only with EW and with RC.</td>
<td>0701 SH-4</td>
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<td>11.</td>
<td>Employment schedule for cantilever mast regulated OHE caty. 65/cu, cont. 107/cu (WP 75 kgf/m²) without EW and without RC.</td>
<td>0702 SH-1</td>
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<td>12.</td>
<td>Employment schedule for cantilever mast regulated OHE caty. 65/cu, cont. 107/cu (WP 75 kgf/m²) with EW and without RC.</td>
<td>0702 SH-2</td>
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<td>13.</td>
<td>Employment schedule for cantilever mast regulated OHE caty. 65/cu, cont. 107/cu (WP 75 kgf/m²) without EW and with RC.</td>
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<td>14.</td>
<td>Employment schedule for cantilever mast regulated OHE caty. 65/cu, cont. 107/cu (WP 75 kgf/m²) with EW and with RC.</td>
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<td>15.</td>
<td>Employment schedule for cantilever mast unregulated OHE caty. 65/cu, cont. 107/cu (WP 75 kgf/m²) without EW and without RC at 35 degree C and 28 kgf/m² at 4 degree C.</td>
<td>0702 SH-5</td>
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<td>16.</td>
<td>Employment schedule for cantilever mast regulated OHE caty. 115/Al, cont. 107/cu (WP 75 kgf/m²) without EW and without RC.</td>
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<td>Employment schedule for cantilever mast regulated OHE caty. 115/Al, cont. 107/cu (WP75 kgf/m²) with EW and without RC.</td>
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<td>Employment schedule for cantilever mast regulated OHE caty. 115/Al, cont. 107/cu (WP75 kgf/m²) without EW and with RC.</td>
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<td>Employment schedule for cantilever mast regulated OHE caty. 115/Al, cont. 107/cu (WP75 kgf/m²) with EW and with RC.</td>
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<td>Employment schedule for Tramway type regulated OHE (WP 75 kgf/m²) without EW and without RC.</td>
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<td>21.</td>
<td>Employment schedule for Tramway type regulated OHE (WP 112.5 kgf/m²) without EW and without RC.</td>
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<td>Employment schedule for Tramway type regulated OHE (WP 150 kgf/m²) without EW and without RC.</td>
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<td>Employment schedule for 8' x 8' x 35 lbs BFB (9.5m long) (WP 150 kgf/m²) for TARE section Gr. 40A only.</td>
<td>0707</td>
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<td>Employment schedule for 8' x 8' x 35 lbs BFB (9.5m long) (WP 112.5 kgf/m²) caty. 65/cu and cont. 107/cu.</td>
<td>0708</td>
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<td>Employment schedule for OHE mast overlap central location with 3.0m implantation. Caty. 65/cu and Cont 107/cu. WP 75 kgf/m².</td>
<td>0709</td>
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<td>26.</td>
<td>Employment schedule for OHE mast overlap central location with 3.0m implantation. Caty. 65/cu and Cont 107/cu. WP 112 kgf/m². Employment schedule for OHE mast overlap inter location with 3.0m implantation. Caty. 65/cu and Cont 107/cu. WP 75 kgf/m².</td>
<td>0710</td>
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<td>27.</td>
<td>Employment schedule for OHE mast overlap inter location with 3.0m implantation. Caty. 65/cu and Cont 107/cu. WP 112 kgf/m².</td>
<td>0711</td>
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<td>28.</td>
<td>Employment schedule for 9.5m long 200x200x49.9 kg mast caty 65/cu and Cont 107/cu, WP 75 kgf/m².</td>
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<td>Employment schedule for 9.5m long 200x200x49.9 kg mast caty 65/cu and Cont 107/cu, WP 112.5 kgf/m².</td>
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<td>30.</td>
<td>Employment schedule for OHE mast overlap anchor location with 3.0m implantation. Caty. 65/cu and Cont 107/cu WP 75 kgf/m². Employment schedule for OHE mast overlap anchor location with 3.0m implantation. Caty 65/cu and Cont 107/cu. WP 112.5 kgf/m². Employment schedule for OHE mast (9.5m) wind pressure 112.5 kgf/m² for composite OHE (1000+1000) kgf tension.</td>
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<td>Employment schedule for OHE mast (9.5m) wind pressure 112.5 kgf/m² with 3.0m implantation composite OHE (1000 + 1000) kgf tension.</td>
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<td>----- DO ----- overlap anchor location.</td>
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<td>47.</td>
<td>Employment schedule for prestressed concrete mast (PC 42) 9.5m long, for conventional OHE, normal location (wind pressure 150, 112.5 and 75 kgf/m²).</td>
<td>0725</td>
<td>7.1.88</td>
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<td>48.</td>
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<td>0726 SH-1/4</td>
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<td>DO — for OHE + EW.</td>
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<td>54.</td>
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<td>55.</td>
<td>DO — OHE only.</td>
<td>0730 SH-1</td>
<td>23.12.88</td>
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<td>56.</td>
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<td>0730 SH-4</td>
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<td>59.</td>
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<td>0733</td>
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<td>62.</td>
<td>Employment Schedule for OHE mast (9.5m) Wind-112.5 kgf/m² copper OHE, 1200 kg tensions for high speed 160 km/h.</td>
<td>0734 SH-1</td>
<td>08.09.89</td>
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<td>63.</td>
<td>DO — (OHE+EW).</td>
<td>0734 SH-2</td>
<td>08.09.89</td>
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<td>64.</td>
<td>DO — (OHE+RC).</td>
<td>0734 SH-3</td>
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<td>65.</td>
<td>DO — (OHE+EW+RC)</td>
<td>0734 SH-4</td>
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<td>66.</td>
<td>DO OLC Location with higher Implantation</td>
<td>0735</td>
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<td>67.</td>
<td>DO OLI DO</td>
<td>0736</td>
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<td>68.</td>
<td>DO OLA DO</td>
<td>0737</td>
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<td>Employment Schedule for OHE mast (9.5m)</td>
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<td>wind 112.5 kgf/m² AAA OHE, with 1000 kg tensions</td>
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<td>69.</td>
<td>DO (OHE only)</td>
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<td>70.</td>
<td>DO (OHE+EW)</td>
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<td>71.</td>
<td>DO (OHE+RC)</td>
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<td>73.</td>
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<td>76.</td>
<td>Mast (9.5m) Employment schedule for 2 x 25 kV copper OHE with (1000+1000) tension, wind</td>
<td>0742 SH-1</td>
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<td>pressure 112.5 kgf/m² (OHE+AT Feeder) and without EW</td>
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<td>77.</td>
<td>DO (with extra setting)</td>
<td>0742 SH-2</td>
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<td>78.</td>
<td>DO (OHE+AT Feeder)</td>
<td>0742 SH-3</td>
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<td>79.</td>
<td>DO (OHE+AT Feeder and EW) with extra setting.</td>
<td>0742 SH-4</td>
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<td>80.</td>
<td>Mast (9.5m) Employment schedule for 2 x 25 kV composite OHE with (1000+1000) tension,</td>
<td>0743 SH-1</td>
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<td>wind pressure 112.5 kgf/m² (OHE+AT Feeder) and without EW</td>
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<td>DO (OHE+AT Feeder + EW)</td>
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<td>DO (OHE+AT Feeder + EW) without extra setting.</td>
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<td>Employment schedule for OHE mast (9.5m) 112.5 kgf/m² composite OHE with 1200 kgf tension</td>
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<td>for high speed 160 Kmph (OHE only)</td>
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<td>Employment schedule for cantilever mast</td>
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<td>WP 112.5 kgf/m² without EW and without RC.</td>
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<td>93.</td>
<td>Employment schedule for cantilever mast</td>
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### SECTION - V  SUBSTATION AND POWER SUPPLY.

2. General Arrangement of Substation Layout, Switching Station, BT, Remote Control & Earthing Arrangement for 2 x 25 kV ‘AT’ System

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(As issued by RDSO)

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FOR SEMAPHORE SIGNALS

(NORMAL) 2.50 m  2.75 m  2.75 m  2.75 m  2.90 m  3.05 m  2.50 m (NORMAL)

7   6   5   4   3   2   2   1

SETTING STRUCTURE NUMBER

SEMAPHONE SIGNAL

10 m

DIRECTION OF TRAFFIC

SEMAPHORE SIGNAL

STRUCTURE NUMBER

1   2   3   4   5   6   7

SETTING NORMAL 2.50 m  3.05 m  2.90 m  2.75 m  2.75 m  2.75 m  2.50 m (NORMAL)
### SUITABLE FOR MAX. SPEED OF 200 KM/H

<table>
<thead>
<tr>
<th>DEGREE OF CURVATURE</th>
<th>RADIUS OF CURVATURE (m)</th>
<th>EXTRA CLEARANCE IN mm. BETWEEN STRUCTURE AND ADJACENT TRACK (OTHER THAN PLATFORMS)</th>
<th>EXTRA CLEARANCE BETWEEN ADJACENT TRACKS WHEN THERE IS NO STRUCTURE BETWEEN TRACKS (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INSIDE OF CURVES</td>
<td>OUTSIDE OF CURVE FOR ANY HEIGHT (mm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UPTO 840 mm ABOVE RAIL LEVEL (mm)</td>
<td>FROM 840 mm TO 4420 mm ABOVE RAIL LEVEL (mm)</td>
<td>AT 5410 mm ABOVE RAIL LEVEL (mm)</td>
</tr>
<tr>
<td>1 ⁰</td>
<td>3492</td>
<td>195</td>
<td>245</td>
</tr>
<tr>
<td>1½ ⁰</td>
<td>2328</td>
<td>45</td>
<td>400</td>
</tr>
<tr>
<td>1 ⁰</td>
<td>1746</td>
<td>80</td>
<td>575</td>
</tr>
<tr>
<td>1½ ⁰</td>
<td>1164</td>
<td>90</td>
<td>585</td>
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<tr>
<td>2 ⁰</td>
<td>873</td>
<td>100</td>
<td>590</td>
</tr>
<tr>
<td>3 ⁰</td>
<td>582</td>
<td>115</td>
<td>605</td>
</tr>
<tr>
<td>4 ⁰</td>
<td>436.5</td>
<td>130</td>
<td>620</td>
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<tr>
<td>5 ⁰</td>
<td>349.2</td>
<td>145</td>
<td>640</td>
</tr>
<tr>
<td>6 ⁰</td>
<td>291</td>
<td>160</td>
<td>655</td>
</tr>
</tbody>
</table>

**NOTE:**

1. WHERE ELECTRIC TRACTION IS LIKELY TO BE INTRODUCED, FOR HEIGHT ABOVE 5410mm AND UPTO THE HEIGHT OF TRACTION CONDUCTORS, THE FIGURES IN COLUMNS 5 IS TO BE INCREASED BY 1mm FOR EVERY 12 AND 8 mm INCREASE IN HEIGHT EXCEEDING 5410 mm. TABLE

2. WHERE STRUCTURE IS LOCATED BETWEEN TRACKS THE EXTRA CLEARANCE SHOULD BE PROVIDED ACCORDING TO COLUMNS 3, 4, 5 & 6

3. (A) STANDARD SETTING ON TANGENT AND ON OUTSIDE CURVED TRACKS

   (B) STANDARD SETTING ON INSIDE OF CURVED TRACK FOR 2500 mm

   (i) 3500 m > RADIUS > 300 m
   (ii) 2350 m > RADIUS > 1150 m
   (iii) 1150 m > RADIUS > 150 m

### SUITABLE FOR MAX. SPEED OF 106 KM/H

<table>
<thead>
<tr>
<th>DEGREE OF CURVATURE</th>
<th>RADIUS OF CURVATURE (m)</th>
<th>EXTRA CLEARANCE IN mm. BETWEEN STRUCTURE AND ADJACENT TRACK (OTHER THAN PLATFORMS)</th>
<th>EXTRA CLEARANCE BETWEEN ADJACENT TRACKS WHEN THERE IS NO STRUCTURE BETWEEN TRACKS (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INSIDE OF CURVES</td>
<td>OUTSIDE OF CURVE FOR ANY HEIGHT (mm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UPTO 840 mm ABOVE RAIL LEVEL (mm)</td>
<td>FROM 840 mm TO 4420 mm ABOVE RAIL LEVEL (mm)</td>
<td>AT 5410 mm ABOVE RAIL LEVEL (mm)</td>
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<tr>
<td>1 ⁰</td>
<td>3492</td>
<td>130</td>
<td>170</td>
</tr>
<tr>
<td>1½ ⁰</td>
<td>2328</td>
<td>220</td>
<td>280</td>
</tr>
<tr>
<td>1 ⁰</td>
<td>1746</td>
<td>40</td>
<td>310</td>
</tr>
<tr>
<td>1½ ⁰</td>
<td>1164</td>
<td>70</td>
<td>390</td>
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<tr>
<td>2 ⁰</td>
<td>873</td>
<td>90</td>
<td>420</td>
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<tr>
<td>3 ⁰</td>
<td>582</td>
<td>100</td>
<td>420</td>
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<tr>
<td>4 ⁰</td>
<td>436.5</td>
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<tr>
<td>7 ⁰</td>
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<td>219</td>
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<tr>
<td>9 ⁰</td>
<td>194</td>
<td>180</td>
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**EXTRA ALLOWANCE FOR SETTING OF STRUCTURES ON CURVES**

G00111 SH1
### DROPPER SCHEDULE FOR REGULATED OHE WITH EQUAL ENCUMBRANCE 1.40/1.40

#### FOR 50 mm PRE SAG. - OHE

<table>
<thead>
<tr>
<th>Span in Metres</th>
<th>No of Dopper</th>
<th>Dopper Lengths in mm(L)</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
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</table>

#### FOR 100 mm PRE SAG. - OHE

<table>
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<th>No of Dopper</th>
<th>Dopper Lengths in mm(L)</th>
<th>D4</th>
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</table>

**INDIAN RAILWAYS — AC TRACTION MANUAL - VOLUME II PART II**

(219)
### Span and Stagger Chart

#### Catenary Stagger

- OR + 200 > 400

#### Displacement of Panto Contact Wire Stagger

- QTY

#### Panto Axis

- OF TRACK
- HT OF CONTACT WIRE

#### High Rail

- Super Elevation
- Formation Level

#### Maximum Span Considered on Non-Movement of ELEC LOCO for WP > 75 kgf/m².

<table>
<thead>
<tr>
<th>Radius of Curvature (Metres)</th>
<th>Max. Span (Metres)</th>
<th>Contact Wire Stagger (mm)</th>
<th>Max. Permissible Mid-Span Stagger (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>72.5</td>
<td>75</td>
<td>72</td>
<td>±200</td>
</tr>
<tr>
<td>72</td>
<td>±25</td>
<td>±50</td>
<td></td>
</tr>
<tr>
<td>72x2</td>
<td>±100</td>
<td>±50</td>
<td></td>
</tr>
<tr>
<td>72x3</td>
<td>±150</td>
<td>±50</td>
<td></td>
</tr>
<tr>
<td>72x4</td>
<td>±150/200</td>
<td>±50</td>
<td></td>
</tr>
<tr>
<td>72x5</td>
<td>±200/250</td>
<td>±50</td>
<td></td>
</tr>
<tr>
<td>72x6</td>
<td>±250/300</td>
<td>±50</td>
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</tr>
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<td>72x7</td>
<td>±300</td>
<td>±50</td>
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<td>72x8</td>
<td>±300</td>
<td>±50</td>
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<td>63</td>
<td>±150</td>
<td>±50</td>
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</tr>
<tr>
<td>58.5</td>
<td>±150</td>
<td>±50</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>±150</td>
<td>±50</td>
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</tr>
<tr>
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<td>±150</td>
<td>±50</td>
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<td>±150</td>
<td>±50</td>
<td></td>
</tr>
</tbody>
</table>

#### General Clearance Diagram for Tangent and Flat Curves (Unregulated One)

- For Other Than Overlap Spans
- For Overlap Spans
- Raised Pantograph
- Lowered Pantograph

#### Profile of Maximum Moving Dimensions

- Of 1929 Width 3200 mm (10'6"
- Of 3660mm (12 Foot Stock)

---

**Indian Railways - AC Traction Manual - Volume II Part II**

(220)
SCHEMATIC ARRANGEMENT OF REGULATED & UNREGULATED OHE

TENSION LENGTH 1500 m. (MAX.)

REGULATED OHE

TENSION LENGTH APPROX. 1800 m. (NORMAL) 2000 m. (MAX.)

UNREGULATED OHE

DIRECTION OF TRAFFIC

TYPES OF OHE

SIMPLE TRAMWAY TYPE CONTACT WIRE
(UNREGULATED)
(SPEED 30 km/h)

SIMPLE OHE (UNREGULATED)
(SPEED 80/100 km/h)

SIMPLE OHE (REGULATED)
(SPEED 112 km/h)

SIMPLE OHE (REGULATED)
WITH 50 mm SAG
(SPEED 140 km/h)

SIMPLE OHE (REGULATED)
WITH 100 mm SAG
(SPEED 160 km/h)

STITCHED Catenary
(SPEED >160 km/h)

COMPOUND Catenary
(SPEED >160 km/h)

COMPOUND Catenary
(SPEED 240 km/h)
CANTILEVER ASSEMBLY (NORMAL)

ARRANGEMENT OF OHE ON PORTAL AT 4 TRACK SECTION

END PIECE  CENTRAL PIECE  END PIECE

* FOR HIGH SPEED
TRACTION MAST AND PORTAL (SECTIONS)

1. BFB MAST 6" X 6" 25 lbs (152 x 152)
2. RSJ. MAST 6" X 6" 25 lbs (152 x 203)
3. FABRICATED MAST K.100 (100 x 50), K.125 (125 x 65), K.150 (150 x 75), K.175 (175 x 75), K.200 (200 x 85), K.225 (225 x 80), K.250 (250 x 80)
4. TTC
5. SPECIAL BFB PORTAL (152 x 152 = 25 lbs.)
6. 'G' TYPE PORTAL
7. 'P' TYPE PORTAL
8. 'N' TYPE PORTAL
9. 'O' TYPE PORTAL
10. 'Q' TYPE PORTAL
11. 16 # ROD LACING FOR 6 TRACK
12. 6 # ROD LACING FOR 8 TRACK

INDIAN RAILWAYS — AC TRACTION MANUAL - VOLUME II PART II (227)
3. SPAN UN-INSULATED OVERLAP TANGENT AND CURVED TRACK OF RADIUS > 5000 m (72 > 54 m) (r = 500/400)

4. SPAN UN-INSULATED OVERLAP TANGENT AND CURVED TRACK OF RADIUS > 5000 m (64 > L = 36 m) (r=500/400)

STANDARD ANTICREEP ARRANGEMENT

- JUMPER(G)
- CATENARY (GS)
- SPAN
- ANTICREEP WIRE (GS)
- JUMPER (F)

REGULATING EQUIPMENT CONTACT WIRE (107)

BRACKET TUBE SUSPENSION BRACKET

ANTICREEP WIRE (GS) (Kg=2.5mm, G.M.V. St.)
CATIONARY (GS)
SUSPENSION CLAMP

ENLARGED VIEW OF X

DETAILS OF
FIXED TERMINATION OF TWO OHEs (REGULATED / UNREGULATED)
(TWO OHEs TERMINATED SEPARATELY)

Mast anchor fitting
SINGLE CLEVIS
DOUBLE STRAP
DOUBLE STRAP
ENDING CLAMP
CATenary (65)
EQualizing Plate
Contact Wire (107)
9 Tonne Adjuster
9 Tonne Insulator
Contact Wire (107)
5 Tonne Adjuster
CATenary (65)

For short length of regulated OHE with regulating equipment at the other end.

---

FIXED TERMINATION OF OHE
(REGULATED AND UNREGULATED)

Mast anchor fitting
SINGLE CLEVIS
9 Tonne Insulator
DOUBLE STRAP
EQualizing Plate
CATenary (65)
Contact Wire (107)
9 Tonne Adjuster
Contact Wire (107)
5 Tonne Adjuster

Termination of unregulated OHE
(CONDUCTORS SEPARATELY ANCHORED)

Mast anchor fitting
SINGLE CLEVIS
9 Tonne Adjuster
9 Tonne Insulator
DOUBLE STRAP
Ending Clamp
Contact Wire (107)

For short length of regulated OHE with regulating equipment at the other end.

---

Indian Railways — AC traction Manual — Volume II Part II
(232)
TERMINATION OF TWO UNREGULATED OHEs
(TWO CONTACT WIRES TOGETHER AND TWO CATENAIRES TOGETHER)

(ELEVATION)

TERMINATION OF SINGLE CATENAIY (65)

TERMINATION OF SINGLE CONTACT WIRES (107)
STANDARD SECTION - INSULATOR ASSEMBLY

OHE TERMINATION AT BUFFER END SIDING AND TO AVOID OBSTRUCTIONS (CONTACT WIRE TERMINATION)

(CATENARY WIRE TERMINATION)
STANDARD/LARGE BRACKET ASSEMBLY

STANDARD BRACKET TUBE (Ø 30/38mm)

<table>
<thead>
<tr>
<th>REF NO.</th>
<th>LENGTH OF TUBE 'Y' IN METRES</th>
<th>ASSEMBLED LENGTH 'L' IN METRES</th>
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LARGE BRACKET TUBE (Ø 40/49mm)

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<th>ASSEMBLED LENGTH 'L' IN METRES</th>
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</thead>
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CATENARY DROPPER ASSEMBLY

INFORMATION RAILWAYS — AC TRACTION MANUAL - VOLUME II PART II (236)
WARNING BOARDS

(1) DISTANCE BOARD (2) DISTANCE BOARD (3) SWITCH OFF POWER (4) SWITCH ON

(5) STOP BOARD (6) CAUTION BOARD (7) LOWER PANTOGRAPH (8) RAISE PANTOGRAPH
APPENDIX – XI

ELECTRIFICATION OF PRIVATE AND ASSISTED SIDINGS
(Ref.: R.B. Letters No. 79/W1/SA/34 dated 1-3-82 and 87/W1/SP/28 dated 18-2-88)

1. Rules governing the construction, working and maintenance of Private and Assisted sidings are contained in the chapter XVIII of the Engineering Code.

2. Sharing of Cost

2.1 Private Sidings

a) In the case of new sidings where the line / section is electrified, the entire cost of OHE will be borne by the siding owners, as in the case of track. Maintenance cost will similarly be borne by the siding owners.

b) In the case of new sidings, where the line is not electrified, the siding owners shall be required to give an undertaking that in the event of electrification of the line within a period of 10 years, they will bear the full charges of electrification of the siding. Maintenance cost will be borne by the siding owners.

c) With a view to expending the electrification of existing railway sidings, it has been decided that if financially justified, incentive in the form of sharing of 50% cost by the Railway may be agreed to. In such cases, no departmental charges shall be levied while working out the cost of electrification. The siding agreement shall provide that electrification assets so created will be property to the Railways and maintained by the Railway at party’s cost. In case the siding owner do not agree to bear their share of cost of OHE, the movement to the siding will have to be by party’s own locomotives.

2.2 Assisted sidings

a) The cost of retrievable part of the OHE will be borne by the Railways as in the case of track and the cost of non-retrievable portion will be borne by the siding owner. The interest and maintenance charges will be borne by the siding owner, as in the case of track.

b) In case of new sidings, a provision should be made in the siding agreement that in case electrification of the siding becomes necessary in future, as a result of electrification of the section, the cost of OHE will have to be borne by the party as indicated in para (b) above.

c) In case of existing sidings.

(i) With regard to sections which are being electrified, in case OHE for the assisted siding is considered essential, the cost will be borne by the Railways and party’s concerned as para (a) above.

(ii) Where section is already electrified and OHE is to be provided for the siding the provision of OHE will be at the cost of the Railways and party concerned as para (a) above otherwise, movement to the siding will have to be by party’s own locomotives.

(iii) Where sidings has already been electrified efforts, should be made to recover the cost as in case of para (a) above.
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

INDIAN RAILWAYS
MANUAL OF AC TRACTION
MAINTENANCE AND OPERATION
VOLUME III
ELECTRIC ROLLING STOCK
1994
The "A. C. Traction Manual" containing procedures and practices to be followed uniformly throughout Indian Railways, was published for the first time in 1972.

Considerable experience has since been gained in the operation and maintenance of electric traction assets. Technological upgradation has also been continuously taking place. Microprocessor based SCADA systems for remote control of traction power supply have been introduced with telemetering facilities. Vacuum and SF6 gas circuit breakers have by and large replaced minimum oil circuit breakers. A pilot project of electrification with 2 x 25 kV State-of-art technology on Bilaspur-Bina-Katni section has also been taken up. While earlier supply was being availed at 25 kV from power supply authorities. Railway owned traction sub-stations and transmission lines have come up.

As regards Rolling Stock, 6-axle WAM4 locos introduced in early 70s have given place to 3900 H. P, WAG5 freight locomotives 5000 H. P. WAG7 locos & WAP 1 /WAP3 locomotives with speed potential of 140 km/h for passenger services, A sizeable fleet of dual brake locos has come up to offer better operational flexibility. Thyristors, electronic slip/creep control using Doppler radar sensors, computerised self-diagnostic fault indicating systems have also been introduced.

These developments have given rise to a need for updating the Manual. The present Manual caters to this requirement and is the result of developing efforts put-in by a number of Electrical Engineers of Indian Railways. I hope the Manual, in its revised form will help towards better know-how of the prevalent system in respect of Maintenance and Operation and thereby improve reliability and safety.

(J. Upadhyay)
Member (Electrical)
Railway Board.

New Delhi
December, 1993
INTRODUCTION

The "Manual of AC Traction - Maintenance and Operation" covering the maintenance and operation of 25 kV ac 50 Hz single phase traction installations, electric locomotives and electrical multiple units and other connected matters including railway electrification - was issued in 1972.

The Manual is generally procedural in scope and includes essential technical data of use to the operating and maintenance personnel but does not cover the theoretical and design aspects of the Traction Installations and electric rolling stock as these are contained in documents issued by the RDSO as well as the respective manufacturers.

In the preparation of the Manual all relevant documents, rule books, operating manuals and standing instructions issued by the electrified railways are considered together with the knowledge of procedures and practices as observed during inspections of various Installations on the railways as well as discussions with Chief Electrical Engineers of the Railways and concerned officers and staff as also RDSO.

In what is considered to be the greatest common measure of agreement in regard to the maintenance schedules and their periodicity, the forms and registers in use, the availability of staff and operating conditions obtaining on the Railways the bases have been standardised, subject, of course to the, condition that the Chief Electrical Engineer of the Railway may, where considered essential, authorise deviations to the prescribed procedures and practices to the extent necessary.

Over the years since the issue of Manual in 1972 changes have taken place in certain aspect of the traction installations as well as the electric rolling stock. Keeping these changes in mind, the Manual has been revised and is brought out in three Volumes as indicated below though the style has by and large been retained.

Volume 1 - General is of a general nature and contains descriptions of the traction Installations and electric rolling stock. It indicates the organisation for operating and maintaining the traction installations and electric rolling stock, both in the Headquarters and Divisional offices of the Zonal Railways, describing the functions at various management levels. It also contains the rules and procedures for the staff of other disciplines like Signalling and Telecommunication, Civil Engineering etc. apart from subjects which all electric traction engineers and supervisors should be familiar with and therefore this volume would necessarily be an omnibus one.

Volume II - Fixed Installations has been made in two parts. Part 1 covers the operation and maintenance of traction Installations of fixed Installations as well as procedures for commissioning of new traction Installations while Part II contains various guidelines and procedures Issued by the Railway Board and RDSO in connection with fixed traction installations.

Volume - III - Electric Rolling Stock is exclusive for the maintenance and operation of electric rolling stock - locomotives and multiple units.

In the get up of this Manual the paragraphs are numbered with 5 digits. The first digit indicates the Volume number, the next two digits indicate the Chapter number and the last two digits the specific paragraph number.

It will be appreciated that in a Manual of this nature, it will not be feasible to include material to cover each and every contingency that may arise in the course of working of the traction Installations and the electric rolling stock, though efforts have not been spared to make it as comprehensive as possible. In the event of any contingency that might arise requiring supplementing what is contained in this Manual so as to suit the conditions on - a particular Railway, the Chief Electrical Engineer of the Railway may issue necessary Instructions/orders for the purpose. It would be good practice to copy such Instructions/orders to other Railways as well for their benefit. However, the provisions in this Manual, the Codes,/Manuals issued by various authorities, the General and Subsidiary Rules and any other statutory regulations in force shall not be contravened.
Any comments or suggestions for improving this Manual as well as any advice in regard to errors or omissions if any requiring correction may be sent to the Railway Board.

The making of this revised Manual has been an arduous work and for the efforts put in by a number of senior officers as well as staff of Railway Board, Railways, RDSO/Lucknow and RITES, New Delhi to bring this out, no amount of words of appreciation and gratitude to them will be adequate for the purpose.

It is hoped that the Manual will serve the needs for which it has been made.

New Delhi

NOEL LOBO PRABHU
Advisor (Electrical)
A — Bogie for WAG1 Loco-Athermos axle
WAG1 लोको-एथरमोस एक्सल के लिए बोगी

B — Motorised Monomotor Bogie for WAG1 Loco
मोटरयुक्त-मोनोमोटर बोगी WAG1 लोको के लिए बोगी
Motorised Bogie WAG5

Motorised Bogie WAG5 (side view)
Motorised Bogie WAP1
मोटरपुक्त बोगी WAP1
Motorised Bogie WAP3 Fabricated (side view)
모터부착 봉지 WAP3 빌리피 (소행 내방)

Motorised Bogie WAP3 (Fabricated)
모터부착 봉지 WAP3 (빌리피)
### VOLUME III

**ELICTRIC ROLLING STOCK**

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## CHAPTER I

### GENERAL

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CHAPTER I
GENERAL

30100 Evolution of Electrical Rolling Stock

1 Electrical Concept
1.1 The development of mercury arc rectifier for rolling stock application, wherein the dc motor could be used for traction became a single major factor for large scale application of single phase 50Hz 25kV for mainline electrification. Hitherto the performance of ac traction motor in locomotive had always been considered inferior to its dc counterpart and dc traction was only a compromise solution to save on the cost of OHE. The use of rectifier on the locomotive on the other hand offered an alternative of a superior locomotive to a dc locomotive. Initially water cooled mercury arc rectifiers known as ignitions, (ignited internally through an igniting electrode) were used. Indian Railway purchased two types of locomotives of this type (WAM-1 from Europe &WAM-2 from Japan). But they gave way to neater and more reliable solution of externally fired air cooled rectifiers i.e. excitrons. Excitrons had the additional advantage of reversibility i.e converting dc back to ac and could be utilized for regeneration to a limited extent. Indian Railways imported a few locomotive of this design from Europe (WAG-1) and a sizable fleet was assembled and manufactured at CLW as well. A few Japanese locomotives using silicon retifier were also imported (WAG-2).

1.2 With the development of High Power Silicon Diode Devices the entire technological development of ac traction stock took a new turn and more powerful units of ac locomotives were conceived. The silicon diode is simple to maintain and is extremely reliable. At present bulk of the fleet of Indian Railways consists of such locomotives.

1.3 Both with mercury arc and silicon rectifiers, the voltage control is achieved by an electro-pneumatically operated tap changer. In the locomotives the high tension tap changer has been utilized. Typical power circuit diagrams of WAG-5and WCAM-1 type locomotives are given in Fig. 1.01and Fig.1.02. On some of the WAG-1 and WAM-2 locomotives, silicon rectifier with tap changer control has been replaced by the phase angle controlled thyristor convertor.

1.4 MG locomotives: These locomotives of YAM-1class (Japanese design) are in use in a single isolated section viz. MAS-Villupuram section. They employ silicon rectifiers for conversion. Salient data on electric locomotives is given in Annexure 1.01./A.

1.5 EMU (Electrical Multiple Units) both on MG and BG employ silicon rectifiers for conversion and LT tap changers are used for voltage control. Salient features of EMU are given in Annexure 1.01./B. A typical power circuit diagram of EMU type WAU-4 is also given in Fig.1.03. Phase angle controlled thyristor convertor has also been deployed on a few 25kVac MG EMUs in place of silicon rectifier and LT tap changer on Southern Railway.

2.0 Sources of Electric Locos

2.1 Indian Railways imported 100 WAM-1 Bo-Bo locomotives from Europe, and 36 WAM-2 and 2 WAM-3 Bo-Bo locomotive from Japan. Subsequent to this, 42B-B high adhesion(mono motor bogies) locomotives designated as WAG-1 were imported from Europe and 45designated as WAG-2 from Japan. Ten WAG-3 locomotive of B-B design of higher rating were imported from Europe. Manufacture of WAG-1type of locomotive was taken up in Chittaranjan :Locomotive Works (CLW) and later on CLW switched over to the manufacture of WAG-4 type of locomotives. After completion of 186 WAG-4 locomotives, Indian Railways switched over to 6 axle locomotive of indigenous design and CLW have manufactured a series of WAM-4 and WAG-5 locomotives.
With a view to improving the performance of the locomotive, WAG-5 locomotives with minor variations to suit specific application were also manufactured and designated as WAG-5 with different suffixes.

2.2 Eighteen prototype 6000 HP thyristor control locomotives of 3 type designated as WAG-6A, B&C were imported, six from ASEA and twelve from Hitachi in 1988. A prototype locomotive of 5000 HP capacity with high adhesion bogies, designated as WAG-7 has been designed and manufactured by Chittaranjan Locomotive Works. A new prototype control is under development.

2.3 To meet the specific requirements of higher speeds for passenger services, CLW manufactured WAP type locomotive using Co-Co flexi-coil bogies to work up to a speed of 130km/h designated as WAP-1. This loco has been further upgraded for speed potential of 140km/h by providing improved version of indigenously designed bogies. This loco is designated as WAP-3. A few WAM-2 locomotives were fitted with modified drive and designated as WAP-2 locomotive.

2.4 A chart exhibiting the salient features of ac electric locomotive is enclosed as Annexure 1.01/B sheet No.1&2. Major dimensions of the various locos are shown in Annexure 1.02. Load table for various locomotives are available at Annexure 1.03. Starting tractive effort is limited to 37.5t due to limitation of bridges on Indian Railways. Brief write ups on 6000HP microprocessor controlled thyristor locomotives are given in Annexure 1.04 and 1.05. Functional description of main circuit of thyristor EMU is given in Annexure 1.06.

3.0 Mechanical concepts.

3.1 Four axle locomotives had the following types of drives:
   i) WAM1 : cordon shaft drive
   ii) WAM2 and WAM 3 : WN coupled gear drive
   iii) WAG(1,3and4) : coupled gear drive through cordon shaft monomotor bogie European design and also built at CLW.
   iv) WAG2 : Monomotor bogie with flexible rubber couplings (quill drive) arrangement (Japanese Design)

3.2 The monomotor bogie locomotives had a starting tractive effort of just under 32 tonne with motor power of 790HP per axle. Except for a few WAG 1, WAG 2 and WAG 3 class locomotives the bulk to the series of WAG1 and WAG4 class were manufactured at Chittaranjan Locomotive Works till early seventies. The performance of these locomotives was also not found to be adequate for meeting increased operating requirements.

3.3 WAM4 and WAG5 locomotives which were indigenously manufactured used Co-Co, trimount bogies of ALCO design with axle hung nose-suspended traction motors. Same design of bogie was also used in dual voltage locomotives (WCAM-I). In WAG-6A & B locomotives, with a view to have a high tractive efforts and high speeds (beyond 160 Km/h), 6-axle locomotive having Bo-Bo-Bo arrangement was adopted. WAG-6A locomotives utilise ASEA hollow shaft drive system whereas WAG-6B locomotive uses WN coupling. In WAG-6 locomotives high adhesion Co-Co bogies using unidirectional motor and secondary suspension arrangement was adopted. Indigenous bogies similar to those of WAG-6C locomotives will be used in the prototype WAG-7 & 8 locomotives.

3.4 In WAP-1 locomotives, flexicoil bogie modifying the existing WDM-1 (General Motor Design) has been used. WAP3 loco utilises an improved version of this bogie.
1. मास्टर नियंत्रक (Master Controller)
2. ड्राईवर सीट (Driver Seat)
3. एस-1 कब्जा (AC-1 Cubicle)
4. 4500 ली./मिनट रेस्ट्रक्टर (4500 l/min Exhauster)
5. 1000 ली./मिनट 90 केजी बोगी पर संचालक (1000 l/min at 90 kg/cm² Compressor)
6. 22kW, 380V 41A, 3000RPM TM ब्लॉवर (22kW, 380V 41A, 3000PRM TM Blower)
7. बै-1 पैनल (Ba-1 Panel)
8. 3900 kVA, 2 x 2250A मुख्य ट्रांसफोर्मर (3900 kVA, 2 x 2250A Main Transformer)
9. 400A टैप चेंजर (400A Tap Changer)
10. 1270V, 550A बैंक शंक (1270V, 550A Induction Shunt)
11. 4200 मी./च. 85 मिमी (पानी गैर) समकालीन रीएक्टर (पानी गैर) (4200m/hr, 85 mmwq Smoothing Reactor Blower)
12. अडमिशन नेटवर्क (Damping Net Work)
13. सिलेंडर मोटर / धक्कार 3100 से 3200 मी./च. 45 से 47 मिमी (पानी गैर) (Silicon Rectifier with 3100 to 3200 m/hr, 45 to 47 mmwq Blower)
14. 380/32, 500V, शीर्षवृत्त ट्रांसफोर्मर (380/32, 500V, Head Light Transformer)
15. बै-2 पैनल-2 (Ba Panel-2)
16. अर्नो प्रारंभ प्रतिबंधक (Arno Starting Resistor)
17. 120KVA, 190A, 380वोल्ट (120KVA, 190A, 380V Arno)
18. 110V, 20A बैटरी चार्जर (110V, 20A Battery Charger)
19. एस-2 कब्जा (AC-2 Cubicle)
20. रेस्ट्रक्टर (Exhauster Block)
21. पांटोग्राफ (Pantograph)
22. नम्बर क्रॉस (यांग डाउन) (Flexi Coil Trimount Co-Co Bogie)
1. 3900 kVA 2 x 2250A Transformer (3900 kVA 2 x 2250A Transformer) 1
2. 2700A C.C. Rating Silicon Rectifier (2700A Cont. Rating Silicon Rectifier) 2
3. 110V, 20A Battery Charger (110V, 20A Battery Charger) 1
4. 1250V, 950A, Smoothing Reactor SL42 (1250V, 950A, Smoothing Reactor SL42) 2
5. Master Controller (Master Controller) 2
6. 120kVA, 190A, 380V Arm (120kVA, 190A, 380V Arm) 1
7. 4500 l/min Exhauster (4500 l/min Exhauster) 2
8. 22kW, 380V, 41A, 3000 RPM T.M. Blower (22kW, 380V, 41A, 3000 RPM T.M. Blower) 3
9. 1000 l/min 9.0 kg/cm² Compressor (1000 l/min 9.0 kg/cm² Compressor) 3
10. 2430kW Brake Resistor (2430kW brake Resistor) 3
11. 72V, 616A Excitation Transformer (72V, 616A Excitation Transformer) 1
12. 380/32, 50A Head Light Transformer (380/32, 50A Head Light Transformer) 1
13. Damping Net Work (Damping Net Work) 1
14. 380V, 0.42 Arno Starting Resistor (380V, 0.42 Arno Starting Resistor) 1
15. Pneumatic Cabinet (Pneumatic Cabinet) 1
16. Auxiliary Cabinet (Auxiliary Cabinet) 1
17. Ba-1 Panel Ba-1 Panel 1
18. Ba-2 Panel (Ba-2 Panel) 1
19. Ba-3 Panel (Ba-3 Panel) 1
20. Driver Desk (Driver Desk) 2
21. 110V Battery (110V Battery) 1
22. Pantograph (Pantograph) 1
23. Trimount Co-Co Bogie (Trimount Co-Co Bogie) 2
1. पंटोग्राफ-AM12 25 KV (Pantograph-AM12 25 KV)
2. पार्श-प्रतिसाम (Transition Resistor)
3. श्रेणि श्रृंखला नं. 1 (Switch Group No. 1)
4. ट्रांसफॉर्मर तेल जीतक (Transformer Oil Cooler)
5. रीएक्टर चुक—1.5mH, 1356rms
   (Reactor Choke—1.5mH, 1356rms)
6. फील्ड डाइवर्ट प्रतिसाम (Field Divert Resistor)
7. तेल पंप—0.6 m³/मिन (Oil Pump—0.6 m³/min)
8. सिलिकन दिस्कारी—1280A पर 557Vdc
   (Silicon Rectifier—1280A at 557Vdc)
9. टैपचेंजर—1000 Amp 700V
   (Tap Changer—1000 Amp 700V)
10. श्रेणि श्रृंखला नं. 2 (Switch Group No. 2)
11. ओएफबी दिस्कारी ट्रांसफॉर्मर 1000KVA
    (OFB Rectifier Transformer—1000KVA)
12. मुख्य संपाक—1075 ली/मिनट
    (Main Compressor—1075 L/min)
13. बैटरी बक्स—95 AH (Battery Box—95 AH)
14. बोगी—बीओ—बीओ (Bogie—Bo-Bo)
1. बेरिंग प्लैंज (Bearing Flange)
2. टेपर रोलर बेरिंग (Taper Roller Bearing)
3. वॉल्फेयर सेंटर (Wheel Centre)
4. कार्डीन रिंग (Carden Rings)
5. लिजीला जोड़ समुच्चय (Elastic Articulation Assembly)
6. वाशर (हाइलम शीट) (Washer [Hyam Sheet])
7. हॉलो शैफ (Hollow Shaft)
8. सेंट्रिंग पिन (Centring Pin)
9. वॉल्फेयर कोर्स (Wheel Forks)
### SALIENT DATA OF MIXED/PASSENGER ELECTRIC LOCOMOTIVES

<table>
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<tr>
<th>S.No.</th>
<th>Descriptions</th>
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<th>WAM3</th>
<th>WAM4</th>
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F.S. — Fully Suspended, N.S. — Axle Hung Nose Suspended, T.C. — Tap Changer.
D.D. — Direct Drive

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INdIAN RAILWAYS — AC TRACTION MANUAL - VOLUME III
### SALIENT DATA OF GOODS ELECTRIC LOCOMOTIVES

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*F.S. - Fully Suspended, T.C. - Tap Changer, N.S. - Axle Hng. Nose Suspended
C.G.J. - Coupled Gear Jacobine Drive, A.H.S. - ASEA Hollow Shaft

The performance trial of WAG-7 locomotive is yet to be carried out.
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**WEIGHTS AND DIMENSIONS OF AC LOCOMOTIVES B0-B0 TYPE**
### Weights and Dimensions of AC Locomotives C0-C0 Type

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### Haulage Capacity (Without 5% Acceleration Reserve)

<table>
<thead>
<tr>
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<th>TONNES AT km / h (TANGENT TRACK)</th>
</tr>
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- **MAXIMUM STARTING T.E. = 25.0 t**
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</tr>
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<td>1/100</td>
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<tr>
<td>1/50</td>
<td>625</td>
<td>620</td>
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| LEVEL            | ABOVE 6000 | 4880 | 3665 | 2550 | above 6000 |
| 1/500            | 4050 | 3820 | 3600 | 3360 | 2745 | 2150 | 1600 | 3810 |
| 1/200            | 2170 | 2100 | 2040 | 1940 | 1630 | 1310 | 1000 | 2010 |
| 1/150            | 1720 | 1670 | 1630 | 1570 | 1325 | 1075 | 825  | 1540 |
| 1/100            | 1200 | 1180 | 1150 | 1120 | 955  | 775  | 600  | 1230 |
| 1/50             | 610  | 605  | 595  | 585  | 500  | 780  |     |      |

| LEVEL            | ABOVE 1000 | 760  | 4960 | 740  | 520  | 3520 |
| 1/500            | 990  | 705  | 475  | 330  | 2420 |
| 1/200            | 815  | 570  | 400  | 2060 |
| 1/150            | 950  | 770  | 595  | 415  | 1580 |
| 1/100            | 615  | 603  | 595  | 585  | 400  | 900  |

*MAXIMUM STARTING T.E. = 25.0 t
## Haulage Capacity (Without 5% Acceleration Reserve)

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<td>1/50</td>
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## Haulage Capacity (Without 5% Acceleration Reserve)

### Service: Goods Service - Bogie Wagon (Box)

<table>
<thead>
<tr>
<th>Service</th>
<th>Grade</th>
<th>Tonnage at km/h (Tangent Track)</th>
<th>Start 3.3 t</th>
<th>Start 30 t</th>
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<tbody>
<tr>
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<td>1/500</td>
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<td>4825</td>
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<td>1/200</td>
<td>3940</td>
<td>3850</td>
<td>3070</td>
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<tr>
<td></td>
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<td>1/50</td>
<td>1055</td>
<td>835</td>
<td>695</td>
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### Service: Goods Service - 4-Wheeler Wagon

<table>
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<th>Grade</th>
<th>Tonnage at km/h (Tangent Track)</th>
<th>Start 3.3 t</th>
<th>Start 30 t</th>
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<tbody>
<tr>
<td>Level: Above 600</td>
<td>1/500</td>
<td>4970</td>
<td>3970</td>
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### Service: Passenger Service

<table>
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<th>Start 30 t</th>
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<tbody>
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<td>1/150</td>
<td>900</td>
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<td>955</td>
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<td>810</td>
<td>670</td>
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**Note:**
- Starting tractive effort is 33.8 t.
- Starting tractive effort is limited to 30 tonnes due to bridge limitations.
- Haulage capacity between 50 km/h to 90 km/h being limited by the transformer capacity.
## Haulage Capacity (Without 5% Acceleration Reserve)

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>TONNAGE AT km/h (Tangent Track)</th>
<th>START* WITH 30 t LIMIT</th>
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<tbody>
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<tr>
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<td>1/150</td>
<td>2770</td>
<td>2710</td>
</tr>
<tr>
<td>1/100</td>
<td>1950</td>
<td>1900</td>
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</table>

LOADS ARE LIMITED BY 30 TONNES OF STARTING TRACTIVE EFFORT DUE TO BRIDGE LIMITATION AND CURRENT LIMITATION OF 1100 AMPS
# Haulage Capacity (Without 5% Acceleration Reserve)

<table>
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<th>Start 30 t.</th>
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* Starting loads are limited to 30 t. of tractive effort due to bridge limitations.
### Haulage Capacity (Without 5% Acceleration Reserve)

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* Loads are limited by 30 tonnes of starting tractive effort due to bridge limitation and starting current limitation of 1200 amps.
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* LOADS ARE LIMITED BY 30 TONNES OF STARTING TRACTIVE EFFORT DUE TO BRIDGE LIMITATION AND STARTING CURRENT LIMITATION OF 1200 AMPS.

** WAG-4 SHEET: 8/13 **

INDIAN RAILWAYS AC TRACTION MANUAL VOLUME III
HAULAGE CAPACITY (WITHOUT 5% ACCELERATION RESERVE)

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*MAXIMUM STARTING T.E. = 33.5 t
### Haulage Capacity of WAG-5 Loco with Hitachi T.M. (Full Field) (Without 5% Acceleration Reserve)

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**GOODS SERVICE**

**INDIAN RAILWAYS**

**AC TRACTION MANUAL - VOLUME III**
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MAXIMUM STARTING T.E. = 45.0 t
LOADS ARE LIMITED BY 37.5 t OF STARTING TRACTIVE EFFORT DUE TO BRIDGES
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*MAXIMUM STARTING T.E. = 33.5 t*
Functional description of main circuit of WAG-6A

1. **General Outline**  
   Fig. 1 shows a simplified diagram of the main circuit. The current is taken from the 25 KV 50 Hz overhead line by pantograph and passes through the main circuit breaker to the primary winding of the main transformer, and then through the grounding transformer (GT) to the car body. The purpose of the GT is to ensure that the current going through the car body finally finds its way through the wheels and is then earth via the rails.

In addition to the four traction windings, secondary windings are connected to the auxiliary power system, hotel load and motor field circuit respectively.

As can be seen in Fig. 1, the main circuit is divided into two parts, called traction motor modules. These are controlled individually, depending on adhesion conditions.

2. **Traction motor modules**  
   Fig. 2 shows the armature circuit for one motor module. In the convertors, which are built up from thyristors and diodes, the 50 Hz supply voltage is rectified and fed to the traction motors. To smooth the current from the convertors smoothing reactor is connected in series with each motor.

Connected parallel to each traction winding, the power factor control has the form of three tuned LC-links.

Between the transformer and the convertors, automatically operated module disconnectors (MD) are connected (Fig.2) which also disconnect the field circuit of the module (Fig. 3).

3. **The Convertors**  
   The convertors consist of thyristors and diode to allow a path for the free wheeling current when the thyristors are not fired.

   During acceleration, one bridge only is being fired until shortly before it is fully advanced. Then the two bridges are both fired until the first one is fully advanced, after which the second is further advanced, until it too is fully fired. This procedure is called "overlapping control".

   Phase angle control of the thyristors will introduce harmonics and because of this, both power factor and psophometric current will vary considerably at different speeds. In order to minimize the influence on the supply network, Power Factor Control equipment (PFC) is used.

4. **The Motors**  
   The traction motors are separately excited, bogie suspended dc motors. Each motor is individually fed from a convertor, consisting of two rectifying bridges.

4.1 **The Field Circuit**  
   The field circuit (Fig 3) feeds the motor field windings, each of which is individually controlled. During acceleration from stand still, the field current is kept approximately constant until maximum motor voltage (or maximum available voltage) is reached. In order to further increase the speed, field weakening must take place, which leads to lower tractive effort. At over speed i.e. when slip tends to occur on one axle, the field is weakened, tractive effort of the motor concerned thus lowered, thereby, lowering its armature current and subsequently decreasing the over speed.
Fig. 1 – SIMPLIFIED DIAGRAM OF THE MAIN CIRCUIT

Fig. 2 - ONE MOTOR MODULE
4.2 The PFC System

Parallel to each of the four traction windings of the main transformer, Power Factor Control equipment (PFC) is connected and this has the form of three tuned LC-1 links, switched in and out by two anti-parallel thyristors as shown in Fig. 4. The PFC has two purposes. One is to be a capacitive compensation for the otherwise inductive traction circuit, thus raising the power factor. The other is to filter the harmonics out from the transformer windings, thus further increasing the power factor and, at the same time, the decreasing the psophometric current.

The two purposes are fulfilled by using tuned LC-links, in this case three links showing best filtering performance at 3\(^{rd}\), 5\(^{th}\) and 7\(^{th}\) harmonics respectively. The demand for capacitive compensation and filtering performance varies strongly with the speed and with the tractive effort i.e. with the firing angle of the main thyristors and the current through these. The PFC is controlled so that each locomotive will appear as an inductive or a resistive load, seen from the overhead line at the pantograph. When the ac current to the locomotive tends to go capacitive, one or more the PFC modules are cut to avoid over compensation.

4.3 Safety monitoring and fault detection

For safety and monitoring purposes, current transformers and breakers are used (Fig. 5). To curb over voltage, a lightning arrestor (LA) is used, limiting the maximum voltage over the main transformer. The current in all windings of the main transformers and all motor fields (Fig. 3) is monitored continuously, through the use of current transformer (CT).

Should an over current occur on any of the monitoring transformers, the main circuit breaker (MCB) will open immediately. The potential transformer (PT) is used for monitoring the supply voltage. When the supply is too high or too low, the MCB is opened. To enable the driver to immediately discover any faults in the locomotive and, if possible, reset from the cab, a computerized fault indicating system (FIS) has been incorporated. This system consists of a microprocessor which supervises all running conditions. Together with a display panel in each driver’s cab this gives the driver all the necessary information during fault conditions and also provides possibility to reset most of the faults from the driver’s cab through a push button.
Functional description of main circuit of WAG-6B/WAG-6C

1. General Outline

Fig.1 shows a simplified diagram of the main circuit. The current is taken from 25 Kv 50Hz overhead line by pantograph and passes through the main circuit breaker to the primary winding of the main transformer and then through the ground brushes to wheels and is then to earth via the rails.

In addition to the four traction windings, secondary windings for auxiliary power system, hotel load & motor field circuit have been provided.

2. Traction Motor Groups

Traction motor armature circuit is divided into two groups of three traction motors each. The output from convertor is fed to the traction motors through smoothing reactors in series with each traction motor.

Power factor correction LC banks are connected across the traction windings.

3. The Convertors

The convertors consist of thyristors and diodes to allow path for the free wheeling current when the thyristors are not fired. During acceleration, one bridge only is initially fired untill shortly before it is fully advanced. Then the second bridge is also fired. This procedure is called ‘overlapping control’.

Phase angle control of the thyristors will introduce harmonics and because of this, power factor and psophometric current will vary considerably at different speeds. In order to minimise the influence on the supply network, power factor control equipment (PFC) is used.

4. Traction Motors

The traction motors are compound wound motors having a ratio of approximately 60:40 for the separate field strength to series field strength. Motors are fully suspended in WAG-6B and axle hung, nose-suspended in WAG-6C. Three motors in parallel are fed from a convertor consisting of two sequence control bridges shown in Fig.1

5. The Field Circuit

The field circuit arrangement is shown in Fig.2. There is one field convertor for each of the traction motor groups i.e., three traction motors are fed by one field convertor. During acceleration, the field current is kept proportional to the armature current until maximum motor voltage reference is reached. After this the field current is reduced to get a constant power characteristic till the weakest field strength is reached.

The field convertor also performs the required field current control during rheostatic breaking to get the desired breaking characteristics.

6. Power Factor Correction System

Each traction group has a power factor correction equipment which consists of two independent LC-links which can be switched on/off through thyristors. The arrangement is shown in Fig.3.

When the primary current of the traction transformer reaches about 100A, the switching thyristors switch on the PFC unit No.1 of both traction groups to improve the power factor. If the current increases to about 150A, the 2nd PFC unit is switched on.
7. Safety Monitoring and Fault Detection

For safety and monitoring purposes, current transformers and breakers are used (Fig.4). To curb over voltage, a lightning arrestor (LA) is used, limiting the maximum voltage over the main transformer. The current in all windings of the main transformer & all motor fields is monitored continuously, through the use of current transformer (CT).

Should an over current occur on any of the monitoring transformers, the main circuit breaker (MCB) will open immediately. The potential transformer (PT) is used for monitoring the supply voltage. When the supply is too high or too low, the MCB is opened. To enable the driver to immediately discover any faults in the locomotive and, if possible, the reset from the cab, a computerized fault indicating system (FIS) has been incorporated. This system consists of a microprocessor which supervises all running conditions. Together with a display panel in each driver’s cab this gives the driver all the necessary information during fault conditions and also provides possibility to reset most of the faults from the drivers cab through a push button.

Annexure 1.06
Functional description of the main circuit of Thyristor EMU
1. Power Circuits
2. The power circuits are shown in Fig.1. The symbols appearing in it are listed below together with the location of the equipment.

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<td>Current-monitoring device</td>
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<td>EAS</td>
<td>Earthing switch</td>
<td>Roof</td>
</tr>
<tr>
<td>EFR</td>
<td>Earth fault relay</td>
<td>Contacter case</td>
</tr>
<tr>
<td>ERF</td>
<td>Electronic reference fuse</td>
<td>Rectifier case</td>
</tr>
<tr>
<td>FRS</td>
<td>Forward and reverse switch</td>
<td>Contacter case</td>
</tr>
<tr>
<td>HF1K1-4</td>
<td>High-frequency surge-suppression capacitors.</td>
<td>Rectifier case</td>
</tr>
<tr>
<td>LA</td>
<td>Lighting arrester</td>
<td>Roof</td>
</tr>
<tr>
<td>M1-4</td>
<td>Traction motors</td>
<td>Bogies</td>
</tr>
<tr>
<td>MG1-4</td>
<td>Motor contactors</td>
<td>Contacter case</td>
</tr>
<tr>
<td>MOR1-2</td>
<td>Motor overload relays</td>
<td>Contacter case</td>
</tr>
<tr>
<td>MT</td>
<td>Main Transformer</td>
<td>Underframe</td>
</tr>
<tr>
<td>P</td>
<td>Pantograph</td>
<td>Roof</td>
</tr>
<tr>
<td>POCT</td>
<td>Primary-overload current transformer</td>
<td>Roof</td>
</tr>
</tbody>
</table>
3. Description of Circuit

The supply current is taken from the overhead conductor by the pantograph P, through the air-blast circuit-breaker ABB and the H.T. bushing and cable, to the primary winding of the main transformer MT. The return circuit to the running rails is via an insulated earth cable to the axle earth-brushes fitted on each traction-motor axle-suspension. Also connected to the high-voltage end of the transformer primary winding are a two pole earthing switch EAS and a lightning arrester LA.

A primary-overload relay POR with its associated current transformer POCT protect the main transformer. The main transformer has two equal secondary winding supplying two half controlled asymmetrical bridges T1, T2, D1, D2 and T3, T4, D3, D4 the dc outputs of which are connected in series. The rectifier bridges supply the four traction motors M1-M4 which are permanently connected in series parallel configuration, with their fields and compoles arranged in the centre (virtual earth position). The main smoothing inductor SX is divided into four sections, so that in the event of a motor fault, a high impedance is in circuit and motor cut-out is simplified. The output voltage of the rectifier is controlled to maintain a constant current in the armatures during acceleration, the current being measured by current monitoring devices CMD1-2. Overload protection is provided by the two current-monitoring devices and two motor-over load relays MOR1-2.

A single twin-circuit linear reversing switch FRS is used. Motor isolation is provided by the motor contactors MC1-4 and the motors can be cut out in pairs. Wheel slip detection is provided by voltage-sensitive circuits comprising resistors WSZ1-4 and wheel slip relays WSR1-2.

The power circuit includes four surge-suppression circuits:

1. High frequency surge-suppression capacitors HFSK1-4 connected between each secondary terminal and earth.
2. Resistor/capacitor snubber-circuits connected across each power device in the main bridges.
3. Limiting inductors DX1-2 for rate-of-rise of current.
4. Main surge suppression networks SSF1-4, SSZ1-4,SSK1-4. These networks are connected in pairs across each secondary winding; a failure of any component in these energizes one of the surge-suppression relays SSR1-2

The main rectifier bridges are protected from overload by the secondary-overload-relay circuits SOR, SOCT1-2
CHAPTER II

MAINTENANCE OF ROLLING STOCK – GENERAL

II. Para No. Subject

30200 Shed Organization
30201 Duties of Shop Superintendent/Chief Traction Foreman (Maintenance)
30202 Duties of Electrical Foreman (Planning and Progress Office)
30203 Duties of Section Supervisors
30204 Distribution of Work Load in the Shed
30205 Technical Section
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30209 Demarcation of responsibility between Sr. DEE (RS)/DEE and AEE’s
30210 Job Cards
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30212 Modification of Design for Rolling Stock
30213 Records and Registers to be maintained in Loco/EMU Sheds
30214 Unusual Occurrence Reports
30215 Periodical Review Information
30216 Daily Loco/EMU Position
CHAPTER II
MAINTENANCE OF ROLLING STOCK – GENERAL

III. 30200  Shed Organization

1. At the head of an electric loco (or EMU) shed will be Senior Divisional Electrical Engineer (Rolling Stock) whose duties will be generally as defined in para 10108. He will be assisted by one or more officers in lower ranks depending upon the work load.

2. The organization pattern in a loco shed will be generally as shown below:

Sr. DEE(RS)

<table>
<thead>
<tr>
<th>DEE/AEE(RS)-I (Maintenance)</th>
<th>DEE/AEE(RS)-2 (Maintenance)</th>
<th>AEE/RS (General)</th>
<th>ACOS (Stores)</th>
<th>ACMT (Laboratory)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOH, AOH &amp; Heavy Repairs</td>
<td>Quality Assurance</td>
<td>General</td>
<td>Depot</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inspections, Minor Schedules</td>
<td>works.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2, M6</td>
<td>Light repairs</td>
<td>Machine Shop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E4, E5, E6</td>
<td>Testing and OUT-TURN</td>
<td>Millwright</td>
<td>E7, E8,</td>
<td></td>
</tr>
<tr>
<td>Technical Matters</td>
<td>PPO</td>
<td></td>
<td>M4,M7</td>
<td></td>
</tr>
<tr>
<td>Computer</td>
<td>M1, M3, M5</td>
<td>Drawing</td>
<td>S1, S2, S3</td>
<td></td>
</tr>
<tr>
<td>Utilization</td>
<td>E1, E2, E3</td>
<td>Office</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

30201  Duties of Shop Superintendent/Chief Traction Foreman (Maintenance)

He being supervisor in charge of the loco shed directly under the control of DEE/AEE (RS), as the case may be, will be responsible for the maintenance of locos. His chief duties are:

1. To guide and instruct supervisors and men under him in the correct methods and schedules laid down for maintenance and repairs.
2. To keep a close watch on maintenance so as to reduce the unscheduled withdrawal of locos to the minimum and to watch the performance of equipment involved in frequent troubles.
3. To initiate appropriate steps for recommissioning locos out of service.
4. Execution of various approved modifications and to maintain locos and the loco shed in a clean condition.
5. To keep a watch on the availability of stores for maintenance and modifications and to initiate appropriate steps for timely recoupment.
6. To ensure efficient maintenance of the shed plant and machinery and ancillary services.
7. To coordinate with TLC and TF(R) regarding withdrawal of locos for shed attention, POH and nomination of relief locos from shed.
8. To coordinate with the Training School regarding relief of staff for training and refresher courses.
9. He will be the stock holder of all equipments on locos, assemblies and sub-assemblies and unit exchange spares.

30202 Duties of Electrical Foreman (Planning and Progress Office)

1. To maintain liaison with the operating wing and ensure timely availability of locos from the shed.
2. To plan the scheduled and unscheduled repairs of locos to the shed as required, keeping in view the shed capacity and proper utilization of inspection, lifting and heavy repair berths.
3. To issue job cards and to coordinate the working of the sections so as to ensure timely turn-out of the locos after attention / repair.
4. To maintain necessary documents to enable scheduled attention to various locos and for revision of maintenance practices and instructions.
5. To keep a watch on tests and trials and performance of modified equipment and maintenance of requisite records in this connection.
6. To maintain the History Register, Equipment Cards, Modification Charts and other prescribed records.
7. To coordinate with the workshops regarding release of locos for POH and special shop repairs and to arrange for dispatch of requisite information and records to shops.
8. To maintain statistics of engine-kilometers, failure records etc.
9. To keep a record of wheel wear and to programme for tyre-turning.
10. Furnishing shed statistics to HQ office

30203 Duties of Section Supervisors

Each of the section mentioned in 30200 will be under a supervisor of appropriate rank who will be directly responsible for the following:

1. He will scrutinize the job card for the loco received for inspection/unscheduled repairs, carefully study the work to be carried out and based on his personal inspection, list out additional items of work, if any, for approval as explained in para 30210.
2. He will allot the work to the staff under him with special instructions, if any.
3. He will ensure that the work is carried out within the time allotted and the loco released in time.
4. The supervisor will maintain a record of work done by staff with the purpose of taking corrective action in the event of reported malfunctioning of the equipment immediately after overhaul/repair.
5. He is responsible for drawing, distributing and recording of all stores required by his section, as well as any tools and testing instruments.

6. Before returning the job card in token of having completed the work, he will satisfy himself that all work has been done satisfactorily. To ensure this he will make frequent checks while the work is in progress.

7. He will ensure necessary co-ordination with other sections as well as with PPO.

IV. 30204 Distribution of Work Load in the Shed

Even though the classification of section in different Railways varies, the work load arrangement is typically as under:

E1: a) To carry out preventive maintenance schedule inspections and overhauling schedules on battery charger, rectifier blocks.
    b) Trouble shooting and investigations of Unusual Occurrence Reports (UOR), withdrawal and failures of Electric Locos/EMUs.
    c) To oversee checking and complete testing of Elect. Locomotives nominated for VIP/Superfast trains and special trains.
    d) To oversee checking and complete testing of the nominated locos/EMUs by PPO.

E1 section shall have a Quality Assurance Group consisting of competent supervisors and artisan staff who will carry out superchecking on nominated scheduled/unscheduled locos.

E2: a) Test before and test after of all schedule inspection.
    b) Electrical inspection and repairs (minor) of parts noticed defective during inspections i.e. head lights, flasher lights, electrical equipments in BA panels, TFP, RPS, SL, Programme switches, MP, EMC, DBR, SMGR, CGR, tap changer, cables, cable sockets and cable connections.

E3: a) To carry out scheduled inspection, unscheduled repairs, modifications, overhauling of traction motors.
    b) Connection and disconnection of traction motors before lifting and after lowering.
    c) To carry out scheduled inspection and unscheduled repairs, modifications and overhauling schedule of auxiliary motors.
    d) To disconnect and connect auxiliary motors while removing/refitting during overhauling scheduled and unscheduled repairs.

E4: a) To carry out scheduled inspection, unscheduled repairs, modifications and overhauling schedule on all delicate and precision electrical equipment like relays, speedometers, ammeters, voltmeters and circuit breakers etc.
    b) To disconnect and connect speedometer connection /DJ connections during unscheduled repair.

E5: Major repairs and overhauling of EP and EM contactors, smoothing reactor, RPS, flasher light, MP, TFP oil filtration, CGR, SMGR and tap changer (during IOH schedule/unscheduled visits) and modifications.

E6: a) Removal and fitment of EMCs, EPCs, RPS, DBR during AOH schedule.
b) Removal and fitment of SL, SMGR, Tap changer during IOH schedule.
c) Overhauling of BA panel, head light, TK panel, SB panels, rotary switch board and switches during AOH/IOH schedule.
d) Cleaning of cable junction boxes and cables during overhauling.
e) Overhauling of SMGR and GR during AOH schedule.

E7: Recabling work, partial or full

E8: Electronic labs and PCBs etc.

M1: a) Inspection and running repairs of mechanical parts, under frame, break gear, wheels and axles, buffing gear, body doors and windows, locks, side glasses, look out glasses etc.
b) Special checks
c) Carry out pre-summer, pre-winter and pre-monsoon checks.

M2: AOH/IOH schedule work on i.e. centre pivot, side bearers, roof, buffing gear, cattle guard, rail guard, side glasses, look out glasses, doors, windows and locks.

M3: Inspection, repairs and overhauling of pantograph.

M4: a) To supervise the work of machine shop.
b) To supervise proper functioning of Tool Room and its upkeep.
c) To supervise and execute the re-profiling of wheel sets of electric locomotives on the pit wheel lathe and its preventive maintenance.

M5: a) To carry out scheduled inspection and overhauling schedules on all pneumatic equipment except compressors and exhausters.
b) Testing of all pneumatic equipments on test bench after overhauling.
c) To carry out scheduled inspections, unschedule repairs, modifications and overhauling of compressors, exhausters and auxiliary compressors.
d) Removal and fitment of compressors, exhausters and auxiliary compressors during overhauling, scheduled/unscheduled visits.

M6: a) Mechanical disconnection and connection, lifting and lowering of locomotives.
b) Heavy repairs and overhauling of bogies and other mechanical components like wheel sets, springs, axles boxes etc.
c) Traction motor assembly and dis-assembly.

M7: Remetalling of suspension bearings.

PPO: a) Receipt and dispatch of locomotives/EMUs for their scheduled and unscheduled visits.
b) Planning of scheduled and unscheduled repairs of locomotives / EMUs.
c) Monitoring the performance of development equipment.
d) Maintenance of history books, history cards of equipment fitted.
e) Keeping liaison with RSO regarding calling of locomotives/EMUs for scheduled/unscheduled work.
f) To keep record of wheel wear and to programme reprofiling.
g) To scrutinize Electric Loco/EMUs log books on arrival of locomotives and issuing all job cards to the section supervisor for proper attention to the defects and to ensure that the work is done when the job cards are returned.

S1: All works pertaining to procurement of stores and liaison with HQ for timely procurement of stores and upkeep of custody stores for not-stock items.

S2: Specification updating section.

S3: Tests and Trials sections.

G: a) Electric and mechanical millwright sections.
b) Maintenance of cranes and M&P items
c) General upkeep of shed.
d) Road Transport.

Technical Section

All technical correspondence of the shed i.e. outside and with in shed, updating and feeding of technical data in computer etc.

Laboratory

Physical and chemical testing of all items including ultrasonic testing of axles and shafts.

Drawing office

All drawing work, preparation of office estimates etc.

Computer Section

Operation of computer – collection of data and processing.

V. 30205 Technical Section

The chief responsibility will be:

i) Keeping track of every failure of components. The failure should be analyzed in detail on the basis of which should emerge the analysis of the causes of failure, suggestions for improvements, modifications etc.

ii) Documentation of all technical information.
iii) Keeping a watch that the maintenance instructions issued to the shed staff are up-to-date and ensuring that the instructions are explained to the concerned staff.

VI. 30206 Specification Updating Section

This section will be responsible with the drawing office, to update list of specifications and drawings against which different items are to be ordered and for issuing stocking advices to Stores Department. It should also keep records regarding consumable stores so as to pin-point any abnormal consumption for effective investigation.

VII. 30207 Tests and Trials

The observations regarding tests and trials should be carefully documented for the benefit of improving specifications or modifications to inspection schedules. The necessary documents should be centralized and kept in the PPO.

VIII. 30208 Materials Management

1. This subject is dealt in detail in volume I. A few relevant items are being mentioned here.

A. The various components – sub-assemblies and spare parts shall be purchased from the original/approved supplier of equipment. Railway may however make out a compendium of approved suppliers for each item/equipment, based on RDSO's/production unit’s list. Any variation from the same shall only be permitted personally by Chief Electrical Engineer.

B. For bringing in new suppliers in the compendium of approved suppliers, CEE may personally authorise use of untried and untested equipment for field trials. Special care is needed while approving any new make and type of brushes for traction motors.

C. Storage of Rubber Components.

Storage procedure in general for any type of rubber components are given below:-

i) Rubber components should be kept away from direct sun light preferably in dark place. Direct sunlight causes much faster degradation of the rubber components.

ii) They should be stored in a cool place as far as practicable, preferably below 30°C.

iii) The humidity of the storage condition should not be such that condensation of moisture takes place on the surface of the material.

iv) In the vicinity of these materials, any loose electrical connections should be avoided, as these cause production of ozone which adversely affects rubber.

v) Rubber materials should be stored away from contact with certain materials particularly those containing copper and manganese which act as poisoning agents, aiding their fast degradation.

vi) Under no circumstances rubber materials should be stressed during storage. The portions under stress undergo deformations with permanent set leading to degradation. The materials should be stacked in such a way so that any super-imposed stresses are substantially avoided.

vii) Any contact with grease or oil should be avoided as these cause swelling, softening and deterioration of rubber materials.

viii) French chalk should liberally be applied on the surface of rubber materials.
ix) Great care is to be exercised so that the material is used in the order of their receipt in the stores. The rubber material whether under storage or in use continues to deteriorate. The only difference is that under service condition, deterioration is much faster. Every moment of storing is at the cost of useful life and prolonged storage of the material may render it unserviceable due to progressive deterioration.

IX. 30209 Demarcation of Responsibility between Sr.DEE (RS), DEE and AEEs

The DEE / AEE (maintenance) will be responsible for day to day activities in the shed including unscheduled attentions and scheduled inspections. He will be particularly responsible for induction of any new type of stock in the shed and ensure that the maintenance schedule for such stock are finalized in the shortest possible time.

The Sr.DEE will in addition concern himself with the broader aspects of work and forward planning such as watch-out for organizational shortcomings, indenting and progressing the procurement of forward delivery spares, maintaining a close watch on the functioning of the PPO and above all exercising vigilant technical control over unusual occurrences, recurring failures and unscheduled booking of locos to the shed and shall be in close liaison with Sr.DEE(OP).

X. 30210 Job Cards

For each loco/EMU received in a shed for scheduled or unscheduled attention, the PPO will issue a job card in proforma 2.01 to each section incorporating the following:

a) The nature of inspection (IA, IB etc.) Refer to chapters III and IV.

b) Additional items of work to be carried out on the loco/EMU by the section, based on booked defects, pre-inspection of the loco or planned modification.

c) The time by which the loco/EMU is required to be released.

Based on his own inspection, if the Section Chargeman finds that any items in addition to those mentioned by PPO are required to be attended to, he will get such work approved by TF(M) and get the additional items also entered in the job card by PPO. The job card will thus contain a complete record of all work done on a loco during its visit to the shed. When the work is completed, the Section Chargeman will sign the job card indicating the time of completion of the work and the names of the workers. The loco/EMU should be offered by the PPO for final inspection by E1 only after job cards from all sections have received back duly signed by the respective Chargeman.

XI. 30211 Shed Facilities

Machinery and plant for Loco Sheds

The list of machinery and plant recommended for a loco shed to cater for inspection, maintenance, overhaul and repairs including IOH of locomotives is indicated here under.

List 1 – General Purpose Machine and Tools

A. Machine Section
1. Lathe 250 mm swing, 1500mm between centres 1
2. Lathe 150 mm swing, 1000mm between centres 1
3. Portable tool post grinder for 12mm to 100mm dia wheel 1
4. Radial drilling machine 1
5. Universal milling machine 900mm x 300mm table with index 1
6. Shaping machine, 600mm stroke 1
7. Do-all band saw 1
8. Pillar drill (40mm hole in M.S.) 1
9. Power hacksaw to cut 150mm dia M.S. 1
10. Floor grinder 450mm dia wheels 1
11. Pipe threading machine 1
12. Pipe threading die sets 2
13. Pipe bending machine 1
14. Hand operated shearing machine 1
15. Marking table 1

**Relay Room**

1. Sensitive drill (20mm hole in M.S) 1
2. Watchmaker’s Lathe 1

**Welding and White-metalling Section**

1. Portable welding set 300A. dc. 1
2. Portable transformer welding plant 350A.ac. 1
3. Oxyacetylene welding and cutting set with 25 sets of cylinders for oxygen and acetylene 1
4. Eutectic weld deposit torch set 1
5. Smith’s hearth 1
6. Smith’s anvil and swage blocks. 2
7. Centrifugal white metalling plant (shop made) 1
8. Electric Furnace for melting bearing metal 1

**Painting Section**

Spray guns portable compressor unit and reservoir with 2 spray guns 1

**Tool Room**

1. Portable electric tools : grinder, drills, Wrenches 3
2. Torque wrenches 5set

**Compressed Air**

Air compressor – complete with air drier and filter after-cooler, Reservoir, outlet valves 250cfm, 9kg/cm² 2

**Vaccum cleaning, Water Pumps and Sanding.**

1. Portable vaccum plant 2
2. Filter cleaning plant (shop made) 1
3. Pit dewatering portable electric pump 1
4. Booster pump for washing lines 2
5. sand drying and sieving plant 1

**H. Other Electrical Equipment**

1. Battery charger 2
2. Portable battery charger 1
3. Loading resistor for battery 1
4. Distilled water plant (Electrical ) 2
5. Oil centrifuging and filtering plant 1

*INDIAN RAILWAY S – AC TRACTION MANUAL – VOLUME III* [45]
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Pneumatic crimping tool for power cables</td>
<td>1 set</td>
</tr>
<tr>
<td>7</td>
<td>Hand crimping tool for control cables</td>
<td>2 set</td>
</tr>
<tr>
<td>8</td>
<td>Panto assembly fixture (shop made)</td>
<td>1 set</td>
</tr>
</tbody>
</table>

**List 2 - Special Purpose Machines and Tools**

**A. Bogie wheel sets.**
1. Pit type wheel lathe                                                   | 1        |
2. 50 tonne hydraulic press                                              | 1        |
3. 10 tonne hydraulic press                                               | 1        |
4. Horizontal boring machine 1000mm x 1000mm table                       | 1        |
5. Hack's burners                                                        | 2        |
6. Bogie squaring jig                                                     | 1 set    |
7. Wheel profiling set (tool room)                                        | 1        |
8. Grease guns and lubricating equipment (for each type of oil or grease) | 3 set    |
9. Bearing extractor for transmission gears                               | 1 set    |
10. Lifting beam for locomotive body with stand                           | 2        |
11. Lifting tackle for bogie                                              | 1 set    |
12. Spring testing equipment                                              | 1        |
13. Shock absorbers and snubbers testing rig                             | 1        |
14. 25/30t hydraulic jacks for attending athermos bearing                | 5        |

**B. Traction Motor and auxiliary machine Rewinding section**
1. Pinion extractor                                                       | 2        |
2. Pinion heating oil bath or induction heater                            | 2        |
3. Auto transformer rectifier unit 100V,150Adc                            | 1        |
4. Commutator turning lathe                                               | 1        |
5. Mica undercutting and chamfering machine for armature                 | 1        |
6. Armature banding lathe                                                 | 1        |
7. Dynamic balancing machine for armature                                 | 1        |
8. Vacuum impregnating plant                                              | 1        |
9. Baking oven 200 degree C with trolley                                 | 2        |
10. Baking oven 40-60 degree C with trolley                              | 2        |
11. Baking dynamometer with test bed                                      | 1        |
12. Contactor and relay coil winding machine                              | 2        |
13. Brazing tongs with transformer                                        | 1        |
14. Brazing extractor                                                     | 2 set    |
15. Hand operated shearing machine for insulation                         | 1        |
16. Traction motor assembly fixture, for each type of motor               | 1 set    |
17. Grease guns                                                           | 2 set    |
18. Commutator electric soldering irons                                   | 6        |
19. Surge tester                                                          | 1        |
20. Dynamic balancing machine for auxiliaries                             | 1        |
21. Bearing Extractor and inserter for traction motor and auxiliary machineries | 1        |
22. TIG Welding kit                                                       | 1        |
List 3- Testing and Measuring Instruments and Panels

A  Testing panels.
1.  Test and calibration panel with meters for each type of relay.  1
2.  Test and calibration panel with meters for speedometers  1
3.  Test panel with meters for auxiliary machines  1
4.  Loading dynamometer with test bed for auxiliaries  1
5.  Test panel with meters for contactors, circuit breakers  1
6.  Brake and pneumatic equipment test panel including air compressor 500 litre per min. 15kg/cm²  1
B  Testing and Measuring Instruments
1.  2500v megger  2
2.  500v megger  6
3  Universal multimeter  6
4.  Portable voltmeter dc  3
5.  Portable voltmeter ac  3
6.  Portable ammeter ac  3
7.  Portable ammeter ac  3
8.  Current transformer set 20 to 2000 A  2set
9.  Set of shunts for dc ammeter 75mV 2000A  2set
10. Millivoltmeters 0-75mV  2
11. Vacuum tube volt meter  1
12. Cathode Ray Oscilloscope 10cm display double beam  1
13. High voltage tester 0-75kV  1
14. High voltage tester 0-15kV  1
15. Oil tester 0-50kV  1
16. Current injection set 2000A, 3Vdc  1
17. Silicon diode tester  3
18. Ductors  2
19. Contact pyrometer (0-500º C)  3
20. Ultrasonic crack detector  1
21. Zygro ultraviolet light crack detector  1
22. Brinell hardness tester  1
23. Shore hardness tester  1
24. Spring balance 0-1 kg  2
25. Recording ammeter  2
26. Recording voltmeter  2
27. Spring balance 0-3 kg  2
28. Spring balance 0-5 kg  2
29. Spring tester  1
30. Battery voltmeters  2
31. Anemometer  2
32. Manometer  2
33. Vibration meter  1
34. Capacitance and inductance bridge  1
35. Clip-on ammeters 0-5-10-25-10 250A  2
36. Dial gauges, vernier caliper, micrometers and feeder gauges.  2
37. Revolution counter  3
38. KWh meter with accessories for mounting on loco  2
39. Electric coil tester  1
40. Electric timer  1
41. Portable relay testing kit  1

INDIAN RAILWAYS –AC TRACTION MANUAL –VOLUME III (47)
42. Commutator profile recorder  
43. Stop watch  
44. Illumination meter  
45. Wheat Stone bridge  
46. Distilled water tester  
47. Stroboscope / tachometer  
48. Gear teeth micrometer  
49. Tan-delta measuring instrument  
50. Dissolved Gas Analyser

List 4 – Lifting, Handling and Transport equipment

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 1.</td>
<td>45 tonne electric overhead travelling crane with 6 tonne auxiliary hoist (50 tonne cranes for 132 tonne locomotives)</td>
<td>2 no.</td>
</tr>
<tr>
<td>A. 2.</td>
<td>25 tonne EOT crane with 6 tonne auxiliary hoist</td>
<td>1</td>
</tr>
<tr>
<td>A. 3.</td>
<td>15 tonne EOT crane</td>
<td>1</td>
</tr>
<tr>
<td>A. 4.</td>
<td>1.5 tonne monorail with electric hoist (in Stores Depot)</td>
<td>2</td>
</tr>
<tr>
<td>A. 5.</td>
<td>Lifting tackles for transformer, traction motor armature, ,loco underframe, roof sections, bogie, wheel set, loco, body etc.</td>
<td>1 set</td>
</tr>
<tr>
<td>A. 6.</td>
<td>1 tonne monorail with chain pulley hoist</td>
<td>2</td>
</tr>
<tr>
<td>A. 7.</td>
<td>2 tonne chain pulley hoist</td>
<td>3</td>
</tr>
<tr>
<td>A. 8.</td>
<td>capstan units 3 tonne</td>
<td>5</td>
</tr>
<tr>
<td>A. 9.</td>
<td>Tirfor 3 tonne</td>
<td>3</td>
</tr>
<tr>
<td>A. 10.</td>
<td>Hydraulic jack 50 tonne with traversing bases</td>
<td>1 set</td>
</tr>
<tr>
<td>A. 11.</td>
<td>50. Tonne screw jack with traversing bases</td>
<td>1 set</td>
</tr>
<tr>
<td>A. 12.</td>
<td>20 tonne high lift hydraulic jack with traversing bases</td>
<td>1 set</td>
</tr>
<tr>
<td>A. 13.</td>
<td>Accommodation bogies</td>
<td></td>
</tr>
<tr>
<td>B. 1.</td>
<td>2 tonne fork lift battery truck</td>
<td>1</td>
</tr>
<tr>
<td>B. 2.</td>
<td>1 tonne pallet battery truck</td>
<td>1</td>
</tr>
<tr>
<td>B. 3.</td>
<td>1 tonne material hand trolley platform type (rubber tyres)</td>
<td>3</td>
</tr>
<tr>
<td>B. 4.</td>
<td>1 tonne hand pallet trolley</td>
<td>3</td>
</tr>
<tr>
<td>B. 5.</td>
<td>7.5 tonne trolley on rail (for traction motors)</td>
<td>2</td>
</tr>
<tr>
<td>B. 6.</td>
<td>5 tonne truck</td>
<td>1</td>
</tr>
<tr>
<td>B. 7.</td>
<td>jeep with trailer</td>
<td>1</td>
</tr>
<tr>
<td>B. 8.</td>
<td>Departmental wagon for armature</td>
<td>1</td>
</tr>
<tr>
<td>B. 9.</td>
<td>Departmental wagon suitably modified for transportation of wheels and bogies</td>
<td>2</td>
</tr>
<tr>
<td>C. 1.</td>
<td>weighing machine 1 tonne (Stores Depot)</td>
<td>1</td>
</tr>
<tr>
<td>C. 2.</td>
<td>weighing machine 50 kg (stores Depot)</td>
<td>1</td>
</tr>
</tbody>
</table>
List 5 - Work Benches, Lockers etc.

1. Workmen's tables, battery charging benches, armature trestles.
2. Bench Vices.
3. Individual fitters tools.
4. Locks and keys for workmen.
5. Steel almirahs and stores racks.
6. Steel tables and chairs cardex boards, filing cabinets, index cards cabinets, typewriter, calculating machines for PPO's office.
7. Tables chairs for offices and supervisors, almirahs, filing racks, cabinets, typewriters, duplicator, drawing office, and Ferro printing equipment.
8. Time office equipment, time clock, ticket filing racks, tables and chairs.
9. PCB testing kit.

30212 Modification of Designs for Rolling Stock

Railways should not adopt any new design or modify the existing approved designs except for trials, without the prior approval of RDSO.

Procedure for Initiating and Progressing Modifications

1. One shed which has the bulk of the holdings of a particular class of loco / EMU will be nominated by the RDSO, in consultation with the Railway, as the parent shed for that class of loco /EMU.
2. Each Railway will continue to tackle operating and maintenance problems as hitherto, but will also furnish complete particulars of all problems and failures on each class of loco /EMU to the corresponding parent shed and RDSO together with the modifications evolved by it and further suggestions, if any.
3. The nominated parent shed will then collate all the information in regard to each type of failure, study the merits of the different improvements suggested from all angles and submit recommendations to the CEE of the Railways, giving full particulars of the most satisfactory improvements / modifications after they have been actually tried out in service and found feasible. When any defect is found to be intractable and expert investigation is necessary, a comprehensive note on the subject should be prepared and submitted by the parent shed to the Headquarters Office. CEE will arrange to forward the considered recommendations to RDSO.
4. The recommendations received from the parent Railway will be subjected to a further scrutiny and analysis by the different wings of the RDSO after which final instructions regarding the standard approved method of modification / improvement will be issued to all concerned, giving an identification serial number to each with full details and drawings required for carrying it out.
5. On receipt of the instructions from RDSO, each user Railway will arrange to carry out the modifications on priority on locomotives / EMUs until the work is completed in all locomotives/ EMUs. Progress of implementation of the modifications will be regularly sent to CEEs office by each shed and CEEs office in turn will send a quarterly report of progress to RDSO.

30213 Records and Register to be Maintained in LOCO / EMU Sheds

Particulars of some of the basic records to be maintained by sheds are given below:

1 History Book - For each electric locomotive / motor coach, a History Book should be maintained in the loco / EMU shed by the Planning and Progress Office, (PPO). The History Book should have separate pages allotted for recording the items listed below in the proforma shown against each.
a) Pre-commissioning details:
i) Contract or order number against which received.
ii) Date of despatch/shipment.
iii) Date of receipt by the Railway.
iv) Date put into service.
v) Particulars of tests and trials carried out and reference to reports on these.
vi) Particulars and serial number of major equipment initially provided.
vii) Particulars of any major defects rectified or modifications carried out prior to commissioning.

b) Defects and failures during the Guarantee period:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Date</th>
<th>Nature of Defect</th>
<th>Action taken to rectify</th>
<th>Reference to reports sent to Manufacturers/Production Unit/RDSO etc.</th>
</tr>
</thead>
</table>

c) Statistical failures

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Date</th>
<th>Brief details of failure</th>
<th>Repercussions on traffic</th>
<th>Action taken</th>
<th>Reference to detailed reports.</th>
</tr>
</thead>
</table>

d) Non-statistical failures:
The same proforma should be followed as for (c).

e) Progressive record of kilometres earned:

<table>
<thead>
<tr>
<th>Month and year</th>
<th>Kilometres earned during the month</th>
<th>Cumulative kilometers earned upto end of month</th>
<th>Remarks</th>
</tr>
</thead>
</table>

f) Availability for traffic

<table>
<thead>
<tr>
<th>Month and year</th>
<th>No. of hours available for traffic.</th>
<th>Percentage availability</th>
<th>Remarks</th>
</tr>
</thead>
</table>

g) Modifications (Electrical):

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of modification</th>
<th>Authority</th>
<th>Date of completion on This loco/motor coach.</th>
</tr>
</thead>
</table>

h) Modifications (Mechanical):

This should be as maintained in the same proforma as for (g).

i) Inspections, Overhauls and Unscheduled Repairs.

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Time in</th>
<th>Time out</th>
<th>Particulars of special work Carried out, if any</th>
</tr>
</thead>
</table>

j) Changes in Main Equipments:
PPO should record particulars of replacement of complete units of main equipment such as Traction Motors, Transformer, Rectifier, Pantograph etc., together with serial numbers of the original and substituted items and reasons for replacement.

INDIAN RAILWAYS - AC TRACTION MANUAL VOLUME III [50]
k) Record of mechanical clearances with bearing on safety.

This History Book should be sent along with the loco/EMU to the workshop when the loco/EMU is booked for POH for heavy repairs and should be received back with the loco/EMU. The workshop should enter details of work done and modifications, if any carried out.

2. **Equipment Cards:** In the case of major items such as traction motors, transformers, rectifiers, circuit breakers, pantographs, tap-changers, auxiliary machines, bogies, wheels, etc., “Equipment Card” should be maintained in the shed by the PPO so as to have for ready reference the History of the equipment. Individual Cards should be maintained for each unit of major equipment and the individual cards may be stored grouping them either equipment wise or loco-wise as convenient. The equipment cards should contain details as shown below:

**EQUIPMENT CARD NO. ………………**

<table>
<thead>
<tr>
<th>Description of Equipment:</th>
<th>Serial No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of commissioning:</td>
<td>Loco/Motor Coach</td>
</tr>
<tr>
<td>initially installed</td>
<td>No. in which</td>
</tr>
</tbody>
</table>

**EQUIPMENT MOVEMENTS**

<table>
<thead>
<tr>
<th>Serial No. of Loco / Emu</th>
<th>Date</th>
<th>In</th>
<th>Out</th>
<th>Reasons for movement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HISTORY OF OVERHAULS**

<table>
<thead>
<tr>
<th>Date removed for Overhaul</th>
<th>Date overhaul completed</th>
<th>Particulars of work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HISTORY OF SPECIAL REPAIRS**

<table>
<thead>
<tr>
<th>Date removed for Repairs</th>
<th>Date repairs completed</th>
<th>Nature of repairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**30214 Unusual Occurrence Reports**

A report indicating failure, withdrawal and any other technical abnormality in locomotive/EMU observed on line is called Unusual Occurrence Report (UOR). This should be made in each case recording in full detail as to what has actually happened and what steps should be taken in future to avoid recurrence.

While suitable proforma may be laid down by each Railway to suite local requirements, the UORs should basically contain the following details:

i) Report of Drivers/Motorman detailing all his observations, together with remarks of TF (R) and Officers incharge of operation.

ii) Observations made by Maintenance Organization i.e. Technical Investigation section, Maintenance Foreman and AEE/DEE(RS). A sample proforma is appended (Proforma 2.02).

UORs should be serially numbered for each calendar year to identify the homing shed, class of loco and serial number of the occurrence for the class of loco/EMU during the year e.g. TATA/WAG4/3/90. A copy of all UORs should be forwarded to CEE’s office periodically.
30215 Periodical Review Information

Each homing shed should maintain requisite records and compile the following statistical information for each month. While the report on availability and reliability of the locomotive should be submitted to CEE every month, the report on the cost of repairs and maintenance should be submitted quarterly.

1 Availability and Reliability

Locomotives
1. Average authorized stock (on allotment basis)
2. Average total number on line (on allotment basis)
3. Average number under or awaiting repairs (on allotment basis)
4. Average number effective (fit for use) (on allotment basis)
5. Actual number in good repair stored (on allotment basis)
5a. Average number available for use (on allotment basis)
6. Average number in use
7. Average number of engines on the line for operation
8. Percentage of total engine hours spent
9. Engine km per day per engine in use on individual services
10. Engine km per day per engine on line on individual services
11. Engine km per day per engine in use on all services
12. Engine km per day per engine in use on line (on allotment basis)
13. Engine failure

EMUs
1. Average authorized stock (on allotment basis)
2. Average total number on line (on allotment basis)
3. Average number under or awaiting repairs (on allotment basis)
4. Average number effective (fit for use) (on allotment basis)
5. Actual number in good repair stored (on allotment basis)
5a. Average number available for use (on allotment basis)
6. Average number in use
7. Train km, passenger
8. Hours
9. Vehicle km (in units)
10. Train Usage
11. Vehicle used
12. Motor coach failures
13. Gross tonne km
14. Power used

II Cost of Repairs and Maintenance

1. Engine km
2. Cost of repairs and maintenance per Engine km
3. Cost of repairs and maintenance per EMU stock (in units)

30216 Daily Loco/EMU Position

1. The Daily Loco/EMU position at 00.00 Hr, will be put up to CEE next morning. Over the years various railways have evolved their own proforma depending upon the local operating conditions.
2. The proforma as used on SE Railway indicating the Daily Loco position is enclosed (2.03).
3. The proforma as used by Eastern Railway indicating the EMU position is also enclosed (2.04).
4. Railway may evolve their own proforma based on these proformae.
### Job Card

**Electric Traction Rolling Stock**  
**Proforma 2.01**

<table>
<thead>
<tr>
<th>Job Card No.</th>
<th>Homing Shed No.</th>
<th>Locomotive No.</th>
<th>Location Head of Loco Allocation</th>
<th>Signature of P.P.O.</th>
<th>Working Date of Team No. of Foreman/ELC</th>
<th>Date of Issue</th>
<th>Date of Receipt</th>
</tr>
</thead>
</table>

**Nature of work to be done**

**Particulars of work**

**Details of materials used**

**Approximate Expenditure**

Name of Worker ................................

..............................................

..............................................  Signature of Chargeman  Signature of Elect. Foreman

Signature of Worker………………………
PROFORMA 2.02

UNUSUAL OCCURRENCE REPORT FOR ELECTRIC LOCOS/EMUs

Date..............

A. Driver's Report

1. Loco / Motor coach No.

2. Train No. and Time

3. Place of occurrence

4. Train Load

5. Catenary Voltage

6. Speed of train

7. Gradient at the place of occurrence

8. Weather conditions

9. Brief Description of occurrence

B. Observations of 'Operating Section'

C. Observations of Maintenance Staff / Technical Investigation Section.

D. History of Locomotive / Motor coach Involved

1. Last inspection date:

2. Commissioning / IOH date:

3. Any special repair carried out on this loco / EMU:

4. Kilometers earned after last IOH:

E. Remarks of Sr. DEE / DEE (RS)

1. Findings regarding causes of failure or damage:

2. Responsibility of staff:

3. Recommendations for modifications or improvement to equipment or maintenance schedule or operating instructions:

4. Action taken for rectification:

.........................
Sr.DEE / DEE (RS)
<table>
<thead>
<tr>
<th>DATE</th>
<th>TATA</th>
<th>BNDM</th>
<th>BIA</th>
<th>M/L TOTAL</th>
<th>WAT</th>
<th>OVERALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. NET HOLDING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. AV. AVAILABILITY (PRE. DAY)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) GOODS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) COACHING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) M/U CON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. AVERAGE TR*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. AVAILABILITY AT 4.0 Hrs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) GOODS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) COACHING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. NO. OF LOCOS TR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) SCH. REPAIRS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) UN-SCH. REPAIRS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. LOCO FAILURE (During Day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) STAT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) OTHER LOCO (OL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) MID-SEC. STAT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(e) MID-SEC. OL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) COACHING STAT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) COACHING OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. NO. OF LOCOS TURNED OUT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) OWN LOCOS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) OTHER SHEDS LOCOS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. SCH. INSPI. PRE. DAY/CUM</td>
<td>1A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. TR AT OTHER SHEDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT BIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT TATA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT BNDM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. OUT STN. TR LOCOS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* TR - Withdrawn from Traffic  † MU - Multiple Units
### A. ELECTRIC LOCO AVAILABILITY

**Minm** .............. **At** .............. **Hrs** .............. **Loading** ..............

**GOODS**

**Maxm** .............. **At** .............. **Hrs** .............. **Current** .............. **Date** ..............

**Progressive** ..............

<table>
<thead>
<tr>
<th>HOURS</th>
<th>LOCOS UNDER TR/SCIL</th>
<th>COACHING SERVICE</th>
<th>AVAILABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TATA</td>
<td>BN</td>
<td>BM</td>
</tr>
<tr>
<td></td>
<td>G1</td>
<td>M4</td>
<td>GSA</td>
</tr>
<tr>
<td></td>
<td>TATA</td>
<td>BN</td>
<td>BIA</td>
</tr>
<tr>
<td></td>
<td>ADA</td>
<td>BSP</td>
<td>CKP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>KK LINE TR G 5 B</th>
<th>KK LINE AVAILABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOODS</td>
<td>PASS</td>
</tr>
</tbody>
</table>

### B. SERVICE-WISE LOCO UTILISATION (GOODS)

#### I. THROUGH SERVICE

<table>
<thead>
<tr>
<th>DIVISION</th>
<th>LE</th>
<th>TOTAL</th>
<th>EKM</th>
<th>HOLDING</th>
<th>KM/DAY/IN USE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADA</td>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>Actual</td>
</tr>
<tr>
<td>BSP</td>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>Actual</td>
</tr>
<tr>
<td>CKP</td>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>Actual</td>
</tr>
<tr>
<td>KGP</td>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>Actual</td>
</tr>
<tr>
<td>SER MAIN</td>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>Actual</td>
</tr>
<tr>
<td>WAT</td>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>Actual</td>
</tr>
</tbody>
</table>

#### II. INFERIOR

<table>
<thead>
<tr>
<th>ER LOCO OVER SER VIA ADA</th>
<th>ER LOCO OVER SER VIA KGP</th>
<th>TOTAL ER ON SER</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>OVERALL TERRITORIAL</th>
<th>SER LOCO ON ER VIA ADA</th>
<th>SER LOCO ON ER VIA KGP</th>
<th>TOTAL SER ON ER</th>
</tr>
</thead>
</table>

### C. TRIP INSPECTIONS

<table>
<thead>
<tr>
<th>Engg. Exam Points</th>
<th>Target</th>
<th>Actual</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BURN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BNDM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TATA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KGP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### D. PROGRESSIVE UTILISATION

<table>
<thead>
<tr>
<th>BREAK-UP</th>
<th>EKM</th>
<th>EKM/DAY/IN USE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAIN LINE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KK LINE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### E. MIDNIGHT LOCO DISPOSITION

<table>
<thead>
<tr>
<th>BREAK-UP</th>
<th>VIA ADA</th>
<th>VIA KGP</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SER/ER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ER/ER</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### A. ELECTRIC LOCO INCIDENCES

<table>
<thead>
<tr>
<th>Date</th>
<th>Loco No.</th>
<th>Base Shed</th>
<th>Tr.No.</th>
<th>Driver</th>
<th>Hd.Qr.</th>
<th>Site &amp; Time</th>
<th>Nature of Trouble</th>
<th>Dtn</th>
<th>Last Sch.</th>
<th>Remarks</th>
</tr>
</thead>
</table>

**Proforma 2.03/B**

- **DATE:**
- **TOTAL MID SEC**

---

### B. COACHING PUNCTUALITY

<table>
<thead>
<tr>
<th>(a) MAIL / EXP.</th>
<th>(b) PASSENGER</th>
<th>(c) EMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO. OF MAIL / EXP LOST</td>
<td>NO. OF PASS. LOST</td>
<td>TOTAL EMU LOST UP</td>
</tr>
<tr>
<td>LOST ON ELEC. A/C</td>
<td>LOST ON ELEC. A/C</td>
<td>DN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LOST ON ELEC. A/C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EMU - FAILURE PR. DAY</td>
</tr>
</tbody>
</table>
## PROFORMA 2.04

### DAILY POSITION OF EMU COACHES

**DATE**

<table>
<thead>
<tr>
<th>Availability</th>
<th>HWH SDAH</th>
<th>Punctuality</th>
<th>HWH SDAH</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) No. of units in service</td>
<td></td>
<td>i) Overall</td>
<td></td>
</tr>
<tr>
<td>ii) No. of units under repair</td>
<td></td>
<td>ii) Progressive</td>
<td></td>
</tr>
<tr>
<td>iii) No. of M/Cs sent to KPA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv) No. of T/Cs sent to KPA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v) % ineffective M/C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vi) % ineffective T/C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vii) No. of M/C's with TM isolation &amp; reasons.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CTLC/TLC's Signature
## CHAPTER III

### MAINTENANCE AND OVERHAUL SCHEDULES OF LOCOMOTIVES

<table>
<thead>
<tr>
<th>Para No.</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>30300</td>
<td>Maintenance and overhaul Schedules of Locomotives</td>
</tr>
<tr>
<td>30301</td>
<td>Alterations in Maintenance Schedules</td>
</tr>
<tr>
<td>30302</td>
<td>Scheduled Inspections</td>
</tr>
<tr>
<td>30303</td>
<td>Technical Instructions</td>
</tr>
<tr>
<td>30304</td>
<td>Engine Fitness Certificate</td>
</tr>
</tbody>
</table>
CHAPTER III

MAINTENANCE AND OVERHAUL SCHEDULES OF LOCOMOTIVES

30300 Maintenance and Overhaul Schedules of Locomotives

Indian Railways have gained considerable experience with the maintenance of electric locomotives since 1960. Based upon the safety requirements, various checks have been evaluated and already standardized. Also, based upon investigations into failures instructions (SMIs) are issued by RDSO. Even for new type of locomotives, standard equipment like pantographs, circuit breakers etc., continue to be used and established maintenance practices for such equipments will, therefore, be applicable.

The scope of maintenance work to be followed in each maintenance schedule is arrived at, based upon the following:-

i) Maintenance Instructions supplied by locomotive manufacturer for a new type of rolling stock. Copies of these manuals will be made available for reference by maintenance staff.

ii) Maintenance Instructions that are evolved on zonal railways for standardized equipments.

iii) Specific instructions already laid down regarding safety / fire prevention requirements etc. of the rolling stock.

iv) Experience on the system taking into account environmental conditions in which electric locomotives are expected to perform satisfactorily like temperature, humidity, dust, etc.

On the above lines, maintenance schedules for electric rolling stock of different classes and types already in service have reached an optimum level. However, there may be necessity for marginal changes as dictated by further service experience.

As far as new types of electric locomotives and their sub-assemblies that may be introduced from time to time, the principles enumerated above are to be followed for arriving at optimum scope of work consistent with periodicity of prescribed schedules.

30301 Alterations in Maintenance Schedules

Presently individual railways might have made minor alterations in the schedules based upon their own experience. Considering the wide variations in operating and duty cycles and environments as experienced in different systems, this would be considered logical. However, the recent trend is to enlarge the field of operation of electric locomotives. Thus today electric locomotives of one system are running in other systems. Thus alterations in schedules based upon local experience would have to give way to standardization of schedules so that the locomotives of one system would perform satisfactorily when called upon to operate in other systems.

In the light of experience and improvements based upon trials of modifications, it may become advantageous either to reduce the scope of maintenance work or the periodicity already prescribed and standardized. The following procedure should be adopted for effecting such changes.

1) Those which are connected with safety requirements, a comprehensive proposal indicating the actual experience of the railways, the benefits that are likely to accrue due to proposed changes and the particular reasons for suggesting the change will be sent to RDSO with the approval of the Chief.
Electrical Engineer. Such modifications to the maintenance requirements shall only be implemented after RDSO's approval.

ii) Proposals other than item (i) above: A similar procedure must be adopted excepting that the Chief Electrical Engineer may authorise provisionally the introduction of the change subject to post-facto approval from RDSO. In case RDSO convey an opinion to the contrary, the original schedule shall be brought back. The Railways can however continue to pursue the matter with RDSO and if the latter agrees finally, adopt the change to the extent agreed upon.

30302 Scheduled Inspections

The maintenance and overhaul schedules to be followed for AC electric locos are as under:-

<table>
<thead>
<tr>
<th>Nature of Inspection/overhaul</th>
<th>Place where to be carried out</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Trip Inspection, IT</td>
<td>Outstation shed or homing loco shed as convenient.</td>
</tr>
<tr>
<td>ii) Monthly Inspection, IA + 5 days</td>
<td>Homing or nominated Electric Loco Shed</td>
</tr>
<tr>
<td>iii) Two-monthly Inspection, IB + 5 days</td>
<td>Homing Electric Loco Shed</td>
</tr>
<tr>
<td>iv) Four monthly Inspection, IC + 10 days</td>
<td>Homing Electric Loco Shed</td>
</tr>
<tr>
<td>v) Annual overhaul, AOH + 15 days.</td>
<td>Homing Electric Loco Shed</td>
</tr>
<tr>
<td>vi) Intermediate overhaul, IOH 300,000 km</td>
<td>Homing Electric Loco Shed or Nominated after POH or first commissioning or 3 years Workshop. whichever is earlier + 1 month.</td>
</tr>
<tr>
<td>vii) Periodical overhaul (POH) 600,000 km after commisioning or last POH or 6 years whichever is earlier + 3 month.</td>
<td>Workshop nominated for the purpose</td>
</tr>
</tbody>
</table>

Detailed Instructions for IT, IA, IB, IC, AOH and IOH and POH will be issued by CEE for each type and each series of locomotives keeping in view inspection schedules issued by RDSO. The scope of work is broadly covered in Annexure-3.01.

Inspections as detailed above may need revision based on experience accrued on new types of locomotives. For example with WAG 6A locos the schedules are monthly inspections, 6 monthly inspections, annual inspections and 3 year schedule.

30303 Technical Instructions

A set of the technical instructions relevant to the work of each section should be made available so that they may carry out their work correctly. These can be classified under the following heads: -

i) Inspection Books
ii) Inspection Charts

iii) Trouble-shooting Charts

iv) Technical Charts

i) Inspection Books: These give the scope of work of the various scheduled inspections viz. IT, IA, IB, IC etc. itemizing the works and the order in which they are to be carried out, arranged section-wise. The responsibility of each section supervisor is defined.

ii) Inspection Charts: These charts are prepared for each component individually. These cover a comprehensive list of all the points to be checked, the observations to be made, clearances to be ensured, specifying the conditions under which such verification should be made and the measuring equipment to be used for the purpose.

iii) Trouble-shooting Charts: Clear instructions should be issued in the form of trouble-shooting charts for each type of defect, which detail the checks to be made and the order in which they are to be made. Before the locomotive is given back to service, a competent supervisor should satisfy himself regarding the correctness of the investigations and the rectifications made. In trouble shooting, the investigating team quite often discovers a pattern of failure on the basis of which modifications and improvements to designs may have to be initiated.

iv) Technical Charts: These cover full details of all repairs, major adjustments and refitting of equipment which are to be carried out. Where such repairs are not possible, the item will have to be replaced by a new component. In the technical charts the detailed description of the material, the tools to be used and the procedure to be followed and the defects to be checked after completion of work are detailed.

v) The CEE's office will be responsible for ensuring that (a) the instructions received from RDSO are forwarded to the Loco sheds and (b) the superseded instructions are cancelled, withdrawn and destroyed, preserving one copy only for future reference. Instructions received from RDSO require constant review and a system of generating feedback information on the implementation of these instructions will be followed. Any modifications required in RDSO's instructions should be carried out only after approval from RDSO.

These instructions require constant review in the light of experience. If any modifications become necessary, Sr. DEE (RS) may introduce changes provisionally with the approval of CEE. Such changes should, however, be advised to RDSO for scrutiny and final incorporation in the documents (see para 30301).

30304 Engine Fitness Certificate

Whenever a loco for passenger service is issued from a loco shed or outstation depot after scheduled inspection or unscheduled repairs, an "Engine Fitness Certificate" will be issued, a sample form for which is appended (proforma 3.01 Part A and 3.01 Part B).
PROFORMA 3.01
PART A

RAILWAY

ENGINE FITNESS CERTIFICATE (SPECIMEN)

(Part A: Check by Maintenance Staff only)

Name of Shed/Outstation Depot ................................................................. Serial No. of Certificate A

Engine No. .................................. Date .................................. Time .................. Working Train No. ..................................

(Note: Strike out the observations which are not applicable)

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Title</th>
<th>Nature of test</th>
<th>Conditions</th>
<th>Observations</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Level of lubricants</td>
<td>i) Compound level in all gear cases</td>
<td>Should be seen at least 1 hour after the loco is stabled.</td>
<td>Below minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii) Lubricant level in all suspension bearings</td>
<td>Should be seen after oil settles down</td>
<td>Above minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii) Lubricant level in all compressors</td>
<td></td>
<td>Below minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv) Lubricant level in all Exhausters</td>
<td></td>
<td>Above minimum</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Friction dampers</td>
<td>i) Whether all are provided.</td>
<td></td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii) Whether all are working.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Clearance between rail guard and rail-head.</td>
<td>i) Measure the above clearance and record.</td>
<td></td>
<td>...... cm</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Traction motors</td>
<td>i) Are all inspection covers intact?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Wheels and springs</td>
<td></td>
<td></td>
<td>Have all wheels and springs been tapped and found in order?</td>
<td></td>
</tr>
</tbody>
</table>

(Signature of Electrical Chargeman)

Full name .................................................................

Date ................................................................. Place .................................................................
# PROFORMA 3.01
## PART B

...RAILWAY

## ENGINE FITNESS CERTIFICATE

(Part B: Joint Check by Running and Maintenance Staff)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Title</th>
<th>Nature of test</th>
<th>Condition of test</th>
<th>Observation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Battery voltage</td>
<td>Record the battery voltage with the switch HUBA on “Battery” side.</td>
<td>DJ in tripped condition.</td>
<td>........... Volt</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Functioning of Baby compressor</td>
<td>Switch on the Baby compressor</td>
<td>Working/ Not working</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Functioning of Auxiliaries</td>
<td>1. Is the main compressor working?</td>
<td>Yes/No</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Can the main compressor build up and maintain air pressure in the locomotive?</td>
<td>Yes/No</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Is there any abnormal sound in the auxiliaries?</td>
<td>Yes/No</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. If the answer to Question No. 3 is Yes, indicate the defective auxiliaries.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pantographs</td>
<td>1. PT 1 From Cab No.1 Raising/Not raising</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. PT 2 -do- Raising/Not raising</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Vacuum test</td>
<td>1. Amount of vacuum on dummy. Exhauster No. 1 only working.</td>
<td>............................ cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Amount of vacuum disc with 5/16&quot; (8mm) hole -do-</td>
<td>............................ cm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Amount of vacuum on dummy. **Exhauster No. 2 only working.**

<p>| | | |</p>
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<thead>
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</table>

4. Amount of vacuum on disc with 5/16" (8 mm) hole. **-do-**

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</table>

5. Are both exhausters working at high speed during “Release”?

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<thead>
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</table>

6. **Brake test on loco**

<p>| | | |</p>
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<thead>
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1. Are both bogie isolating cocks in normal position?

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2. Are the brakes applied normally with independent air brake handle?

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</table>

3. Are the loco brakes applied when the vacuum/brake pressure is destroyed by Driver’s brake valve?

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4. Is the Asst. Driver’s emergency brake working?

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5. Is the hand brake working?

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7. **Functioning of SMGR**

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<tbody>
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</table>

1. Does SMGR work with master/emergency electrical control from either cab?

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2. Does SMGR work with manual control? HSM cock should be isolated.

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8. **Safety items**

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1. Whistle of either cab. **Working/Not working**

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2. Headlights/Flasher lights of both cabs **Working/Not working**

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3. Marker lights of both cabs. **Working/Not working**

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4. Speedometers of both cabs **Working/Not working**

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5. Is recording graph paper available? **Yes/No**

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6. Cow catcher **Intact/damaged**

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7. Screw coupling cab 1 end **Fitted/Not fitted properly. Secured/hanging**

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8. Screw coupling cab 2 end **Fitted/Not fitted properly. Secured/hanging**

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<td>---</td>
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<td>---</td>
</tr>
<tr>
<td>9.</td>
<td>Cab 1 end CBC coupler</td>
<td>Fitted/Not fitted Movement is free/difficult.</td>
</tr>
<tr>
<td>10.</td>
<td>Cab 2 end CBC coupler</td>
<td>Fitted/not fitted Movement is free/difficult.</td>
</tr>
<tr>
<td>11.</td>
<td>Fire Extinguishers -</td>
<td>Provided/not provided.</td>
</tr>
<tr>
<td></td>
<td>Cab 1</td>
<td>Provided/not provided.</td>
</tr>
<tr>
<td></td>
<td>Cab 2</td>
<td>Provided/not provided.</td>
</tr>
<tr>
<td></td>
<td>Corridor 1</td>
<td>Provided/not provided.</td>
</tr>
<tr>
<td></td>
<td>Corridor 2</td>
<td>Provided/not provided.</td>
</tr>
<tr>
<td>12.</td>
<td>Safety slings, J-bracket, spacer bolts, nose pin, keeper pins and split pins.</td>
<td>Intact/Damaged/Deficient</td>
</tr>
<tr>
<td>13.</td>
<td>Are the brake hanger pin, brake riggings intact?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>14.</td>
<td>Are the axle box strap bolt, split pin intact? (for plain bearings Loco)</td>
<td>Yes/No.</td>
</tr>
<tr>
<td>15.</td>
<td>Are equaliser, snubber suspension springs healthy?</td>
<td>Free from crack/crack</td>
</tr>
<tr>
<td>16.</td>
<td>Tyres, rivets, fork bolt</td>
<td>Intact/loose/crack</td>
</tr>
<tr>
<td>17.</td>
<td>Gear case bolts/traction motor covers.</td>
<td>Fitted/not fitted properly</td>
</tr>
</tbody>
</table>

9. Special remarks if any on the condition of the locomotive.

---

The above defects have been attended/Not attended?

---

Signature of Driver/Shunter/Engine Turner

Full name..............................
Home Shed..............................
Place......................................
Date......................................
Time......................................

---

Signature of Maintenance Supervisor

Full name..............................
Designation..............................
Place......................................
Date......................................
Time......................................

---

The defects/deficiencies as pointed out above have been attended to.
INSPECTION OF ELECTRIC LOCOS

A. Trip Inspection (TI)

The trip inspection is mainly required for topping of oils, distilled water in batteries and attention to various minor defects which have been recorded in the log book. In addition certain checks are necessary mainly due to severe environmental conditions (hot, humid and dusty) existing in the country.

1. Periodicity of trip inspection shall be as follows:

<table>
<thead>
<tr>
<th>Type of service</th>
<th>Periodicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Passenger/Mail/Express Train locos</td>
<td>Every 2500 km or one trip whichever is later.</td>
</tr>
<tr>
<td>ii) Freight locos</td>
<td>5000 km or 10 days whichever is earlier.</td>
</tr>
</tbody>
</table>

2. During trip inspection the Engine Examiner will ---

a) Carry out detailed checks in regard to any unusual occurrence reported by the drivers in the loco log book.

b) Visually inspect the auxiliaries for satisfactory starting and operation.

c) Feel by hand the temperature of axle roller bearings.

d) Visually inspect mechanical components like springs, equiliser pin, dampers etc. and the brake rigging to detect any abnormality.

e) Check the controls and indication and alarm circuits for correct functioning.

3. Specific items to be attended in TI are--

a) General roof inspection: Check the roof generally for any foreign materials such as wire pieces; clean the insulators and check visually for cracks or chips; Check for abnormalities such as flashovers;

b) Pantographs: Check for copper deposition, grooving of strips and proper lubrication; visually check springs and articulation and also test raising and lowering;

c) Air Blast Circuit Breakers / Vacuum Circuit Breaker: Check for satisfactory operation.

d) Return Current Shunt: Check the shunt connections between the body / bogie frame / axle boxes, traction motor/axle are intact, tighten if necessary.

e) Bogies: Remove foreign matter and dirt picked up on run. Visually inspect for loose, defective or missing parts.

f) Battery: Check and record battery voltage; top up cells as required.

g) Auxiliaries: Check all auxiliaries for correct operation;

h) Oil level: Check and top up oil in suspension bearing, exhausters, compressors, auxiliary compressors and gear cases and record in the log book.
4. Wherever time and facilities are available, the passenger locomotives should immediately be washed.
5. Test the locomotive on HT and LT and record observations on the test proforma.

B. IA, IB, IC, AOH Inspections.

The following tests should be carried out before and after inspection of a locomotive:

a) Preliminary tests with 25 kV supply on

i) Measure and record battery (BA) voltage.

ii) Measure and record Generator (GE) or battery charger voltage.

iii) Check time taken to build up compressed air pressure from 1 kg to 8 - 9 kg/ cm$^2$.

iv) Check cut in and cut out pressure of compressor Regulator (RGCP).

v) Check blowing out of safety valves.

vi) Check vacuum obtainable with Driver Braking control Valve (MPF) on 'run' and quick release positions.

vii) After building up vacuum, check for vacuum leakage for 5 mt.

viii) Check vacuum drop required for brakes to apply.

ix) Note pressure gauge reading when brakes are applied.

x) Check working of braking electro-valve VEF.

xi) Check working of blowers under 'direct' and 'automatic' starting conditions.

xii) Note and record air leakages for one minute in main reservoirs and brake cylinders.

xiii) Test headlights.

xiv) Test working of cab heaters and fans.

b) Preliminary tests with 25 kV supply off

i) Measure and record time required for raising and lowering both the pantographs.

ii) Measure and record time taken for various time-delay relays.

iii) Test functioning of Auxiliary Circuits, Earth Relay (QOA) by creating an earth fault.

iv) Test functioning of Power circuit Earth Relay (QOP) by creating an earth fault.

v) Check functioning of all lights.

vi) Check wind-screen wipers and horns.

c) Test under High Tension before and after inspection successively from cab 2 and cab 1.

i) Raising of pantographs.
ii) Working of Auxiliary Compressor motor (MCPA), Arno and Generator (GE), particularly observing behaviour during starting and for abnormal noise.

iii) Working of main compressor, charging time of main reservoir from 0 to 10 kg/cm\(^2\) and from 8.5 to 10 kg/cm\(^2\) with one compressor working. Record rate of leakage in reservoir and brake pipe and brake and feed pipe pressure.

iv) Check up proper functioning of autodrain, HS\(_4\), HB\(_5\), RS, D\(_1\), emergency valve and air flow indicator.

v) Record rate of vacuum leakage and vacuum on test plate and dummy.

vi) Check up all brake cylinders for leakage from exhaust port and record brake cylinder pressure.

vii) Working of both exhausters for various positions of exhausters isolating switch and driver braking valve.

viii) Working of blowers particularly watching for abnormal noise.

ix) Observation of contactors for abnormal sound and sparking.

x) Observe deviation of main ammeters taking two traction notches in forward and reverse directions.

xi) Test differential (QD), progression and regression relays.

xii) Test electro-valve VEF.

xiii) Measure and record depression in loco with all blowers functioning.

d) *Low tension test before and after inspection -*

i) Testing of master controller for notch by notch progression and regression and total time for regression.

ii) Test VER

iii) Test working of sanders

iv) Test working of Exhauster isolating lever (ZPV)
General Guidelines for inspection of WAP1, WAM4 & WAG-5 class electric locomotives are given as under:-

**IA, IB, IC, AOH Inspections**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>IA</th>
<th>IB</th>
<th>IC</th>
<th>AOH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Maintenance Group - E1**

1. Loco roof and body
   - Blowing of loco before inspection
   - Cleaning of loco roof & body
   - Trouble shooting
   - Tightness of all bolts on roof
   - Condition of look-out glass, gasket, sunvisors
   - Check fixation of door hinges, shutters

2. Silicon rectifier and Supervisory control equipment.
   - Checking of tightness of cells with torque wrench
   - Dusting and cleaning
   - Checking the clearances to earth
   - Visual check of connections and cleaning
   - Diode checking with cell tester
   - Check string fuses
   - Check potential dividing resistance visually
   - Check RC network (with instrument)
   - Check functioning of Sperkog units

**E-2 Section**

1. Batteries:
   - Conduct cyclic charge and discharge test
   - Tighten the terminals
   - Apply vaseline to the terminals studs and nuts

**To be attended to**

<table>
<thead>
<tr>
<th>EB</th>
<th>E</th>
<th>E</th>
<th>E</th>
</tr>
</thead>
</table>

**Not to be attended to**

[-]
- Check electrolyte level, top up if necessary  
- Clean all the insulators  
- Check the individual cell voltage with all lights ‘ON’ and baby compressor working  
- Check the plates and container for buckling, swelling, corroding, cracking, etc. Conduct capacity test  
- Check, container for cracks  

2. Battery charger  
- Clean the dust and dirt  
- Check the connections  
- Cleaning preferably done by compressed air  
- Adjust the CHBA voltage 110 + 1.0 V with nominal trickle charge 3 to 5 A  

3. CGR Assembly  
- Measure contact gap, check wear limit, if necessary replace contact  
- Check contact pressure  
- Lubricate mech. joints/pins  
- Play of cam on cam shaft  

4. Auxiliary contacts  
- Visual inspection cleaning  
- Lubrication  

5. Transformer  
- Capacitors and resistors: Cleaning of condenser tube, surge absorbers, capacitors and resistors by dry cloth and checking up of connections  
- Clean and tight connection of RCAPTFP  
- Oil level indicator  
- Functioning of QPH relay  
- Functioning of Air flow relay QVRH
- Check acidity, dielectric strength and carry out dissolved gas analysis and if necessary filter the oil
  E
- ETTFP/1 & 2
  Check the fixation of shunts E E E E E
  Check and adjust the gap - - E E
  Position and proper fixation of ETTFP - - E E
- Breather (PHGR)
  Check the proper working of PHGR E E E E E
  Overhaul PHGR - - - - E
6. Tap changers
- Check up the condition of selector - - E E
- Tangential play of moving contact - - E E
- Dismantle contact system & clean - - E E
- Carry out inspection of wearing parts and renew, if necessary.
  - E E
7. SMGR:
- Quick inspection of SMGR - - E E
- Switch angle should be check – up - - - E
- Overhaul - - - - E
8. Electro-Pneumatic contactors L1-L6 and and shunting contactors
- Lubrication - - - E
- Dusting of insulating parts - - E E
- Checking up of connections, nuts & bolts E E E E E
- Lubrication of articulation points E E E E E
- Change rubber gasket/Buckets - - - E
- Check for air leakage E E E E E
- Check up the condition of coil for overheating E E E E

INDIAN RAILWAYS — AC TRACTION MANUAL — VOLUME III
- Check coil Q factor and reject if difference is above ± 8% and also check proper bedding, auxiliary contacts, arc chute.
- Check the contact gap and pressure of main and auxiliary contacts
- Overhaul

9. Electro-magnetic contactors
- Check the condition of coil for overheating and arc chute
- Check the tightness of connections
- Check contactor bedding, contact pressure of auxiliary and main contact and contact gap
- Check Q factor

10. ZPT
- Dusting and cleaning and check for free movement, proper contact and finger pressure

11. CTF and J:
- Check for any air leakage
- Check the shunt condition and tightness
- Tighten all nuts and bolts of switch
- Check the condition of rubber buckets and replace, if necessary
- Check the contact gap and pressure of main and auxiliary contacts and contact bedding
- Lubricate servomotors and cams
- Overhaul

12. Master controller
- Check the tightness of connection and tightness of couplers
- Slight lubrication of pins of articulation of interlocking mechanism
- Grease interlocking cams
- Dusting and cleaning
- Overhaul
13. SL, SJ and ATFEX
   - Check the tightness of connections - - E E
   - Blow through side cover - - E E
   - Clean Teflon piece, remove bottom cover and blow - - E E
   - Check for the overheating marks - - E E
14. MU couplers - Dusting & cleaning - - E E
15. Driver's switch desk
   - Check the condition of BL/ Switches - E E E E
   - Check the condition of pilot lamp holders and connections check RS1-2 E E E E
   - Lubricate the rollers and actuating bars - - E E
   - Check limit switches, switches of BL Box and replace worn out contacts and clean - - E E
16. Headlight
   - Check the functioning, holders and connections E E E E
   - Clean reflector, etc. - - - - E
17. Switch Board
   - Dusting and cleaning, check the condition of switches and connections, check the condition of fuses and fuse boards. - - E E
   - Lubricate the rollers and actuating parts or pin - - E E
18. Terminal board
   - Checking cleaning and tightness - - E E
19. All resistances :
   - Checking the condition, connections and cleaning- E E E E
20. Auxiliary programme switches
   - Check the contacts for flash mark and proper contacts E E E E
21. Body side filter
   - Remove, clean and re-fit E E E E
   - Change supporting gaskets - - - E
22. Dynamic Brake Resistor
- Examine insulators and supports. E E E E
  Wipe insulators with a clean dry cloth
- Check tightness of nuts, bolts and screws - - E E
- Blow out resistor bank with dry compressed air - - E E
- Inspect resistor for damage, overhaul and record resistance - - - E

23. Check connection tightness of VEPT, VESA, VEF - - E E

E3 Section:

1. Traction Motor
Commutator:
- Examine thoroughly with the help of torch light E E E E
- Commutator surface for grooves and high mica E E E E
- Commutator riser for solder run out creep E E E E
- Clean Commutator cleaning with spirit and cloth - - E E
- Inspect visually commutator end banding and rises for abnormality - - E E

Brush gear:
- Measure spring testion and check up condition - - E E
- Examine the condition of pig tails and replace carbon brushes if reached to condmening size - - E E
- Check up spring pins by hand - - E E
- Rotate rocker arm and check brush holders and insulators - - E E

Brush holder:
- Free movement of brush in holders - - E E

Inspection cover:
- Existence and condition E E E E

Arcing horns:
- Condition of arcing horns and clearance E E E E
- Checking arcing ring condition for any signs of burning - - E E
- V cone cleaning - - E E
Terminals:
- Checking of connections
- Check flexible assembly

Interpole:
- Out going lead for crack

Brush holder insulator:
- Examine the holder insulator for proper glaze
- Grease both end bearings
- Overhaul

2. Auxiliary machines:
- Check looseness of cooling fan blade
- Check the alignment and realign the driving and driven shaft
- Check the duct for cracks and fixing bolt

Couplings:
- Adjustment, alignment and lubrication
  Replace on age-basis.
- Check foundation bolts and terminal connections
- Grease the bearings
- Overhaul

3. Amo convertor:
- Check up tightness of terminal connections and foundation bolts
- Check visually for top circulating ring of rotor and its top position of rotor bars for cracks.
- Grease bearings
- Overhaul

Blower motor for DBR & Aux. Compressor
- Measure the brushes and replace, if necessary.
- Measure spring tension of brush holder and record. E E E E E
- Check the looseness and cracks of cooling fan blade and lubricate bearings. - - E E

**E4 Section**

1. Air-blast circuit breaker
   - Apply thin oil film of BBC 909 oil on main contacts E E E E
   - Remove main contacts, check worn out F & C contacts, replace if necessary - - E E

Isolating switch :
- Check the pressure on fixed contact by spring balance. - - E E

Lubrication :
- Lubricate the isolating contacts by graphite grease E E E E
- Lubricate the pin insulator with right oil E E E E

Control block :
- Checking of mechanism pin and various clearances - - E E
- Overhaul - - - E

2. General purpose relay :

Auxiliary contacts :
- Check contact, contact pressure and wipe E E E E
- Visually examine and clean contacts, terminals and contact support, bus bar connectors E E E E
- Check and tighten all wiring terminals - E E E
- Check hardware for tightness - E E E
- Check proper alignment and bedding of contacts - - E E

Coil :
- Check coil for electrical or mechanical damage - E E E
- Dusting - all relay parts

Bolts, nuts, screws and wiring terminals:
- Tighten the nuts and fixing screws

Time delay relay:
- Check the time setting and operation
- Overhaul all relays and test

3. Speedometer:
- Calibrate
- Lubricate gear box
- Check collector comb, dropping resistance and multicore cable. Clean and polish collector comb and replace carbon brush if necessary.
- Overhauling of speedometer

4. HOM
- Check operation
- Clean and lubricate

M3 Section

1. Pantograph
- Clean insulators and check for any damage
- Check static pressure
- Check contact pressure as per SMI-64 and SMI-72
- Nuts and bolts tightness
- Check copper shunts for loose connection, plunger for free movement and lubricate
- Check roof bars connection
- Lubricate all bearings and moving parts
- Check and change graphite grease
2. **VESAT, VEPT, VEF**
   - Overhaul, throttle valve VEPT, VESA & VEF
   - Check for any air leak in the pipe line
     |   | E | E | E | E |
   1. **DAB/MPF/A9/SA9**
   - Overhaul and check the free operation
     |   |   | E | E |
   2. **Filters**
   - Check all the filters including filter
     cum silencer and clean
     | E | E | E | E |
   - Check gaskets and replace if necessary
     |   |   | E | E |
   3. **Isolating cocks**
   - Lubricate and check free movements
     |   |   | E | E |
   4. **Non-return valves, reducing valves**
   and check valves
   - Clean and check the function
     |   | E | E | E |
   - Overhaul and replace gaskets
     |   |   | E | E |
   5. **Wiper and servomotor**
   - Check operation
     | E | E | E | E |
   - Overhaul servomotor
     |   |   | E | E |
   6. **Vacuum and air hoses**
   - Check condition and replace
     if necessary
     |   |   | E | E |
   7. **PV**
   - Check foundation bolts, breather valve
     coupling, fan and its blade and clean
     the equipment and tray
     | E | E | E | E |
   - Check function of oil pump
     | E | E | E | E |
   - Lubricate couplings
     | E | E | E | E |
   - Fill oil
     | E | E | E | E |
   - Check suction and drain pipe
     | E | E | E | E |
   - Overhaul complete unit and replace
     worn out components and gaskets
     |   |   |   | E |
8. CP and CPA
   - Check foundation bolts, fan and its blade and clean the equipment and tray
   - Check coupling and lubricate
   - Check intercooler, after cooler
   - Check drain pipe of trays and suction pipe
   - Lubricate bearings
   - Overhaul

9. DJ non-return valve
   - Overhaul

10. DJ pneumatic connections
    - Check for leakage

11. Vacuum release valve
    - Overhaul

12. Cotton filters
    - All cotton filters to be cleaned
    - Replace cotton filter

13. D24 (B), D 24 (F)
    - Overhaul

14. Air admission valve
    - Check function and ensure proper length of spindle

15. Safety valves
    - Overhaul and adjust setting

16. Sanding valves
    - Overhaul

17. HS4, HB5, F1, VA-1B, MU-2B
    - Distributor valve
    - Checks function
- Overhaul

18. Overhaul all valves and replace gaskets, match seating
   - Overhaul and replace rubber components

19. Horns and Horn valves
   - Check diaphragm, O' ring and rubber seat
   - Overhaul and replace rubber components

20. Gauges
   - Check all gauges
   - Overhaul and calibrate

Section M1

1. Bogie frame/Loco underframe :
   - Thorough cleaning of bogie frame, washing with the compound
   - Check for critical section cracks

2. TM axle suspension bearing
   - Oil samples to be tested for presence of moisture and dirt
   - Check TM axle cap bolts for tightness

Felt wick :
   - Remove complete wick assembly and clean wicks by soaking them in specified lubricants.
   - After soaking, remove the foreign material from lubricating surface with soft bristle brush; do not use wire bristle.

Oil pump
   - Dismantle and overhaul

3. Traction Motor Nose suspension
   - Check the condition of nose suspension bolts, etc., and inspect for wear on nose suspension wear plate.
4. Bogie pivot casting and side mounting pads
   - Check visually for any cracks as far as practicable. If necessary, by magnetic particle/dye-penetrant method
   - Check centre pivot side housing for cracks; check side bearer cover for proper seating

5. Buffers:
   - Lubricate
   - Check wear plate under buffer for wear and tightness of bolt

6. Equaliser:
   - Check for free runs of equaliser pin and condition of wear liners
   - Check equaliser for cracks

7. Suspension springs
   - Visually inspect springs for any cracks or breakage

8. Friction snubbers
   - Check the snubber assembly for broken springs by inserting a stiff wire from bottom seat

9. CBC coupler and transition screw coupling
   - Check CBC coupler for proper working and presence of locking pin
   - Check transition screw coupling for crack
   - Check the wear plate under CBC coupler and replace, if worn out.

10. Wheel and axles
    - Check wheel for crack and other defect
    - Measure and record wheel flange root wear, wheel dia. and reprofile, if necessary.
    - Measure wheel gauge
    - Ultrasonic testing of axle
11. Axle boxes and roller bearings

- Check grease condition 
- Check the fixation screw of bearing end plate
- Remove old grease - replace with fresh
- Check the lateral and longitudinal clearances between axle boxes and pedestal horn liners of all axles
- Check the condition of liners and replace, if necessary
- Grease suspension roller bearings

12. Brake Gear

- Give a general check on the brake rigging for loose nuts, pins, cylinder piston working
- Clean brake cylinder and check for proper working
- Check for wear on brake shoes and replace the shoes. Check the piston strokes after fitting new brake shoe.
- Observe for any leak in the bogie hose pipe connection and rectify.
- Check the fixing bolts of brake cylinder
- Overhauling of brake cylinder

13. Gear Case

- Check gear case for any damage to felt seal and oil leakage.
- Check gear case bolts for tightness. Check oil leakage; if so, rectify
- Check oil level top up if necessary

14. Earthing Brush

- Check condition of earthing shunts and ensure proper tightness
Check the condition of earthing brush mounted near the traction motor oil pump; replace brush, if necessary.

15. Slack adjuster
- Lubricate slack adjuster
  E  E  E  E

16. Hand brake
- Clean the hand brake parts and check visually for any looseness
  E  E  E  E
- Apply the hand brake and ensure that the brake shoes are binding on the wheels
  E  E  E  E
- Lubricate hand brake parts, brake gear pins and bushes with oil
  E  E  E  E

17. Sanding
- Check and fill the specified grade of sand in all the boxes
  E  E  E  E

18. Rail Guard and Cattle Guard
- Check cattle guard for proper fixing
  E  E  E  E
- Check rail guard for proper fixing and its proper height, adjust
  E  E  E  E

C. Intermediate Overhaul (IOH)

1. IOH of locos may be done at the horning shed itself or at workshop nominated for the purpose.

2. During IOH, in addition to thorough inspection of all mechanical and electrical items detailed under AOH, the following items also should be attended to:

2.1 Remove all electrical equipment including pantograph, circuit breaker, tap changer, SMGR, rectifiers, smoothing reactors, traction motors, auxiliary machines along with blowers, compressor and exhaustors from the locomotive. Overhaul and replace all worn out items and rubber components.

2.2 Take out transformer oil sample for check up of dielectric strength, dissolved gas analysis and acidity. Dismantle transformer, clean winding and transformer tank with transformer oil jet, inspect for any overheating sign, loosening of cleats, nuts and bolts, condition of insulation. Centrifuge the transformer oil and measure the IR values and acidity and if it is found beyond the permissible limit, replace the transformer oil. Carry out all the tests after assembly.

2.3 Remove all brake equipment and electro-pneumatic valve from the locomotive and clean the pneumatic pipe with the help of pressurised air. Overhaul and replace worn out items and rubber components, if any, match metallic seating of pneumatic valves and test them for their proper function.
2.4 Clean the cable trenches. Examine for any damage to cable, lugs and repair it. Provide proper cable sheathing and cleats. Measure and record insulation resistance of all HT and LT cables. Tighten all the terminal connections.

2.5 Dismantle bogie, brake riggings and clean the bogie in washing tank. Check up for any crack and weld it as per the instructions laid down by RDSO. Overhaul these equipment and replace all worn out components. Ensure squareness of bogie frame. Overhaul axle box bearings and all wheels should be reprofiled.

2.6 Overhaul all traction gears and check up their P and K values and record them.

2.7 All approved modifications which can be executed in the shed should be carried out.

3. On complication of IOH, the loco should be subjected to detailed HT and LT testing and should also be given a short trial run before it is declared fit for traffic.

D. Periodical Overhaul (POH)
1. The nominated POH workshop should issue a programme for POH of locos at least six months in advance giving the individual numbers of locos to be called in, each month. The homing shed will then send to the workshop a list of the important points to be specially attended to during POH and the list of modification to be carried out. This will enable the workshop to plan the POH work and arrange for the procurement/shop manufacture of components required.

2. The loco should be sent on its own power from the homing shed to the workshop under escort and along with its History Book. A complete list of all deficiencies in the loco should be handed over to the workshop representative who should jointly check the loco along with the shed representative.

3. All electrical, mechanical and pneumatic equipment should be taken out of the locomotive and overhauled during POH. All worn out rubber components and bearings should be replaced.

4. All panels should be removed from the locomotive and cleaned/overhauled. They should be tested for their proper functioning.
5. All the dimensions of the under frame should be recorded. The deformation, if any, should be set right.

6. Super structure and underframe should be thoroughly cleaned. Corroded and damaged portion should be rehabilitated. All body joint gaskets should be replaced.

7. All axle and axle boxes should be overhauled and rediscing/retyring should be done. All wheels should be reprofiled.
8. All reservoirs should be cleaned and tested for their safe working.

9. All approved modifications should invariably be carried out during POH. Deferment of any item may be done only with the personal approval of CEE controlling the POH shops in concurrence with the CEE controlling the homing shed and under advice to the homing shed. In addition to all the items indicated against IOH renewal of liners, bushes, etc. should be done so as to ensure clearances and tolerances mentioned in 'F' with adequate margin for wear in service till the next POH.

10. In addition to complete LT and HT testing of the locos on completion of POH, individual items should also be subjected to detailed tests after overhaul and repair. Detailed test schedules should be laid down for each item, for mechanical as well as electrical tests, and standard proformae should be available for recording the test results for each equipment. A typical list of tests to be carried out on equipment is given below.
a) Rotating Machines: Insulation resistance by megger, no load tests, full load tests (except for traction motors) drop test of armatures, resistance measurement of field coils, temperature rise measurement.

c) Transformers: For small transformers in control circuits, ratio test and insulation resistance measurement.
For main transformer, testing of oil for BDV and acidity, insulation resistance measurement, ratio test of regulating windings and auxiliary windings, induced high voltage tests if any repairs have been carried out.

c) Relays: Measurement of resistance and insulation values for operating coils, pick-up and drop-off values of voltage/current/temperature, time delay where applicable, opening and closing of contacts.

d) Contactors: Measurement of pick up and drop-off values for operating coils, check for simultaneous closing of all phases where applicable, leakages from valves and cylinder in the case of electro-pneumatic contactors.

e) Cables: Insulation and continuity test, high voltage tests for rewired panels.

f) Resistors, condensers and reactors: Measurement of insulation resistance and ohmic values of resistance/reactance.

g) Air-blast circuit breaker: Insulation resistance of coil-windings and live parts, minimum pick up voltage for operating coils, opening and closing time for primary and secondary contacts, minimum pressure for locking in sequence of opening and closing of auxiliary contacts.

h) No-fuse breakers (MCBs) Tests for tripping at rated instantaneous trip value.

i) Tap-changer: Insulation resistance, BDV and acidity testing of oil, correct functioning with minimum air pressure, correct progression and regression sequence.

j) Silicon Rectifiers: Forward voltage drop, inverse resistance, HV test for complete assembly, voltage sharing between diodes, testing of cell-check device.

k) Compressors and exhaustors: Volumetric efficiency and leakage tests.

l) Speedometers: Calibration by comparison with a standard meter.
m) Meters and Gauges: Calibration with sub-standard instruments.

11. On completion of POH, the loco should be taken over by a representative of the homing shed after a joint inspection at the workshop. Details of work done and modifications carried out should be entered in the History Book which should be returned along with the loco.

12. On completion of POH, the loco should be subjected to detailed HT and LT testing and should be given a short trial run. Loco will be returned working on its own power, and if possible working as a train, after POH to the Homing Railway.

E. Rebuilding and Recabling of Locomotive

1. During every alternate POH, depending upon the cable/pneumatic pipe condition, which will be advised by Sr. DEE of the Shed, the locomotive will be recabled and repiped. Recabling and replacement of air and vacuum pipe during the third POH will be an essential item if it could not be replaced during 2nd POH. The workshop should therefore plan these works well in time.
2. During every 4th POH, mechanical components and traction gear may need rehabilitation. Some of the major components will also need replacement. POH shops should plan for such works. Opportunity should be taken to upgrade the parts and use the state of art equipment during such extensive repairs.

F. Mechanical Inspection of Locos

i) Locos provided with renewable steel tyres will have tyres as per Specifications IRS – R15-64 - Oil quenched with tensile strength of 100-110 kg/mm².

ii) Locos provided with solid wheel disc will conform to Specifications IRS M2-65 and IS 1030-1962.

2. All springs should be checked up for any crack and damage. Free height and loaded height should be recorded. Only matched tested springs should be provided in the locomotive bogies.

3. An important part of the maintenance of the locos is the checking, at prescribed intervals, of important mechanical clearances and dimensions which have a bearing on safe and efficient operation, to ensure that they are within the prescribed limits. Such measurements should be recorded suitably either in registers or on printed cards and preserved so as to be readily available for reference in the PPO at all times. The items and interval at which they are to be checked up are indicated. Limits will be specified for each type of locomotives by the CEE based on the manufacturers/RDSO recommendations.

Clearances

SNo.                        | Items to be checked                           | Periodicity of check up |
---------------------------|------------------------------------------------|------------------------|
1                          | Clearance of spring plank from rail level     | IC, AOH, IOH, POH      |
2                          | Buffer height                                 | IA, IB, IC, AOH, IOH, POH |
3                          | Coupler height 1105 (max.), 1030 (min.)      | IA, IB, IC, AOH, IOH, POH |
4                          | Clearance between top of axle box and bogie frame | IB, IC, AOH, IOH, POH |
5                          | Clearance between bogie horn check and axle box horn face | IB, IC, AOH, IOH, POH |
6                          | Clearance between bottom of axle box and horn stay | IB, IC, AOH, IOH, POH |
7                          | Distance between two parallel beam of equaliser | AOH, IOH, POH |
8                          | Clearance between safety bracket and equaliser | IC, AOH, IOH, POH |
9                          | Clearance between spring seat face and equaliser | AOH, IOH, POH |
10                         | Clearance between two equalisers on middle axle box | IC, AOH, IOH, POH |
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>Clearance between axle box collar and inside horn faces</td>
<td>IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>12.</td>
<td>Clearance between axle box liner at horn faces</td>
<td>IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>13.</td>
<td>Clearance between spring and spring seat</td>
<td>AOH, IOH, POH</td>
</tr>
<tr>
<td>14.</td>
<td>Clearance between spring and top cap</td>
<td>AOH, IOH, POH</td>
</tr>
<tr>
<td>15.</td>
<td>Clearance between spring and equaliser</td>
<td>AOH, IOH, POH</td>
</tr>
<tr>
<td>16.</td>
<td>Clearance between equaliser and bogie frame at all sides at horn location</td>
<td>IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>17.</td>
<td>All clearances of plain bearings for suspension and axle boxes</td>
<td>IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>18.</td>
<td>Clearance between bogie frame and axle</td>
<td>IB, IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>19.</td>
<td>Clearance between bolster and bogie frame</td>
<td>IB, IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>20.</td>
<td>Clearance between bogie end stops and under frame</td>
<td>IB, IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>21.</td>
<td>Clearance between traction pads on bolster and bogie frame</td>
<td>IB, IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>22.</td>
<td>Clearance between axle collar and bearing brass (end float)</td>
<td>IB, IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>23.</td>
<td>Clearance between axle box flange and horn leg</td>
<td>IB, IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>24.</td>
<td>Clearance between side stops</td>
<td>IB, IC, AOH, IOH, POH</td>
</tr>
<tr>
<td>25.</td>
<td>Clearance between stops on bogie and under frame</td>
<td>IB, IC, AOH, IOH, POH</td>
</tr>
</tbody>
</table>

* These items are applicable to Bo-Bo and Monomotor bogies.
4. Wheels: Check the following.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Items to be inspected No.</th>
<th>Periodicity</th>
<th>Permissible clearance Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tyre profile to be</td>
<td>IA, IB, IC</td>
<td>6mm for freight 4 mm for passenger loco.</td>
</tr>
<tr>
<td></td>
<td>Root wear Y checked</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flange wear X with</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>condemning gauge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Flats on the running</td>
<td>All inspection</td>
<td>50mm for locos having speed less than 100 km/h. 40mm for locos having speed of 100 km/h and more.</td>
</tr>
<tr>
<td></td>
<td>surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>'A' proud metal at the</td>
<td>-- do --</td>
<td>Less than 6mm.</td>
</tr>
<tr>
<td></td>
<td>edge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>'B' thickness of the</td>
<td>Condemming=40 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>flange</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard "thick" and "wear adapted" profiles are shown in the Fig. 3.01 and Fig 3.02. The condemning wheel profile is shown in the Fig. 3.03.

G. Bogies

1. Squaring of bogies.

Due to heavy mechanical stress and impacts suffered by bogies in service, some of them get out of shape and distorted. During IOH and POH, it is essential to restore the bogies to their correct shape and alignment. To check this, at every major shed and POH shop, a test rig with a substantial foundation should be provided over which the bogie can be placed and the amount of distortion which has taken place accurately measured. By application of adequate pressure at appropriate points either hydraulically or by other means, frame distortions should be corrected as required, so as to ensure proper mechanical alignment of all parts assembled over the bogie.

2. Cracks on Co-Co bogies.

The bogie shall be thoroughly cleaned as per RDSO's recommendations. The extent of cracks shall be located by visual inspection as well as with magnetic particle/dye-penetrant method. After marking out the full extent of the cracks, arrest-holes of suitable size of minimum dia. 10 mm shall be drilled at least 25 mm away from the vicinity of the cracks. The entire cracks shall be eliminated by opening the affected section right up to the bottom. The removal of defective area shall be done by grinding/arc gouging/chipping. The section thus opened out shall extend into the arrest holes and shall be checked up with the help of dye-penetrant or magnetic particle technique to ensure freedom from any other cracks. The welding shall be carried out as per the procedure laid down by RDSO with the help of specified electrodes. It shall be also ensured that all modifications recommended by RDSO are carried out during POH on the bogies.

H. Axle Roller Bearing

These bearings are used on electric locomotives using trimount Co-Co bogies. The assembly consists of two cylindrical axle roller bearings capable of taking radial as well as axial thrust loads. The bearing is composed of inner and outer race along with rollers and cages. The cages while carrying no load keep the rolling elements axially apart and also prevent the latter from failing out while handling. The outer ring is slide fit in the axle box housing while the inner ring is an interference fit on the axle journal forming part of the axle when in place. The rollers
are plain, straight, solid cylinders and are flat on both ends. These bearings should be maintained as per RDSO Maintenance Instructions No. MPMT-98/81, March 1981.

The riding properties of these locomotive fitted with Co-Co bogie have been further improved upon by using axial resilient thrust unit on axle 1, 3, 4 and 6. Axle 2 and 5 are provided with float bearings so as to permit negotiability over sharp curves and turn-outs. This arrangement involves changes in bogie frames and axle boxes. Axle box roller bearings fitted with resilient thrust units should be maintained as per RDSO's Maintenance Instructions No. MT. 04.004.

Proper service tools should be used for servicing and maintenance of axle roller bearing which are also indicated in the Maintenance Instructions. Whenever bearings are removed for overhaul, inspection, repairs replacement or lubrication, proper precautions should be taken to avoid ingress of dust, metal contents, etc. Grease specified by RDSO should only be used.

I. Suspension roller bearing

In WAG-5 with Hitachi motor, axle suspension roller bearing have been used. In this arrangement, taper roller bearings are used on either end of the suspension tube. The maintenance of these bearings should be done as per approved instructions. While overhauling, various defects due to stains, discolouration, spalling smearing, indentation, brinelling and electrical burns etc., should be examined. Proper precaution should be taken to ensure that bearings are overhauled in dust-free environment and all clearances should be maintained as given in the Maintenance Instructions.
1676 मिमी. नेभ लोको के लिए तैयार मोटे आई आर एस फ्लेंज प्रोफाइल
FINISHED THICK IRS FLANGE PROFILES FOR 1676 mm GAUGE LOCONS

IN fig. 3.01

133
63.5
1 IN 20
6
50
28.5
16R
16R
60°
85.5
3.01
WEAR ADAPTED WHEEL PROFILE FOR 1676 mm GAUGE LOCOS
### MECHANICAL INSPECTION OF ELECTRIC LOCO - WHEEL BO-BO

<table>
<thead>
<tr>
<th>SL</th>
<th>ITEMS TO BE INSPECTED</th>
<th>PERIODICITY</th>
<th>PERMISSIBLE CLEARANCE</th>
<th>SKETCH SHOWING THE CLEARANCES TO BE CHECKED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>VARIATION IN THE DIAMETERS OF TWO WHEELS - (A) ON THE SAME AXLE (B) ON THE TWO AXLE OF THE SAME BOGIES (C) ON THE TWO AXLE OF DIFFERENT BOGIES</td>
<td>IC, A O'H</td>
<td>0.5 mm FOR FT &amp; MT 1.0 mm FOR FT &amp; MT 6.0 mm FOR MT 20 mm FOR FT AND MT</td>
<td><img src="image1" alt="Sketch" /></td>
</tr>
<tr>
<td>2.</td>
<td>TYRE PROFILE (TO BE ROOT VERY CHECKED WITH FLANGE WEAR COND X EMNNG GAUGE</td>
<td>IA, IB, IC</td>
<td>5 mm 3 mm</td>
<td><img src="image2" alt="Sketch" /></td>
</tr>
<tr>
<td>3.</td>
<td>FLATS ON THE RUNNING SURFACE</td>
<td>ALL INSPECTION</td>
<td>60 mm FOR LOCOS HAVING SPEED LESS THAN 100 KMPH HAVING SPEED OF 100 KMPH AND MORE LESS THAN 6 mm</td>
<td><img src="image3" alt="Sketch" /></td>
</tr>
<tr>
<td>4.</td>
<td>A' PROUD METAL AT</td>
<td>DO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 3.03A**

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### MECHANICAL INSPECTION OF ELECTRIC LOCO - WHEEL CO-CO

<table>
<thead>
<tr>
<th>SL</th>
<th>ITEMS TO BE INSPECTED</th>
<th>PERIODICITY</th>
<th>PERMISSIBLE CLEARANCE</th>
<th>SKETCH SHOWING THE CLEARANCES TO BE CHECKED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>VARIATION IN THE DIAMETERS OF TWO WHEELS - (A) ON THE SAME AXLE (B) ON THE TWO AXLE OF THE SAME BOGIES (C) ON THE TWO AXLE OF DIFFERENT BOGIES</td>
<td>IC, A O'H</td>
<td>6.5 2.0 16.0</td>
<td><img src="image4" alt="Sketch" /></td>
</tr>
<tr>
<td>2.</td>
<td>TYRE PROFILE (TO BE ROOT VERY CHECKED WITH FLANGE WEAR COND X EMNNG GAUGE</td>
<td>IA, IB, IC</td>
<td>6 mm 3 mm</td>
<td><img src="image5" alt="Sketch" /></td>
</tr>
<tr>
<td>3.</td>
<td>FLATS ON THE RUNNING SURFACE</td>
<td>ALL INSPECTION</td>
<td>60 mm FOR LOCOS HAVING SPEED LESS THAN 100 KMPH HAVING SPEED OF 100 KMPH AND MORE LESS THAN 6 mm</td>
<td><img src="image6" alt="Sketch" /></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td>DO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 3.03 B**

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Indian Railways — AC Traction Manual - Volume III
II. Annexure 3.02

Dual Brake System on Electric Locomotives

WAG-5 and WAP-1 & 3 locomotives manufactured at CLW are fitted with twin pipe dual brake system. Railways have also converted some WAG-4 locomotive to twin pipe dual brake system. Dual brake system is designed for hauling stock equipped with either graduated release type single pipe or twin pipe air brakes or vacuum brakes.

The instructions contained herein are in supplement to GR and SR. Simple schematic diagram explaining the principle of operation of dual brake system, vacuum brake system and charging of main reservoir is attached as Annexure 3.02 A, 3.02 B, 3.01 C.

1. **Description of the brake system**

The main features of the system as fitted on these locos are:

1.1 Self-lapping type independent brakes on the locomotive, i.e., the brakes on locos can be applied and released in steps with pressure maintaining feature in all positions.

1.2 Braking of air braked passenger/freight trailing stock and at the same time proportional brake application on locomotive through distributor valve.

1.3 Braking of air braked passenger/freight trailing stock fitted with graduated released type of brake equipment, and at the same time proportional brake application on locomotive through distributor valve.

1.4 Dynamic brake interlock to prevent simultaneously application of automatic air brakes and dynamic brakes on loco. Automatic brake application of brakes on loco and trailing stock in case of failure of dynamic brakes.

1.5 Multiple unit operations with locos fitted with similar type of brake system.

1.6 In an emergency, brake pipe and vacuum train pipe can be directly vented simultaneously by the emergency brake valve provided in front of assistant driver's seat.

1.7 Loco brakes can be released independent of the train brakes.

1.8 Provision for freight/passenger change-over cocks to regulate locomotive air brake application timings depending upon the type of stock to be operated by locomotive.

1.9 Provision for the driver to apply independent brakes on leading loco in MU operation in case of parting between locomotives.

1.10 In case of very heavy leakage in the feed pipe or failure of feed pipe inter-coupling equipment, twin pipe brake system on trailing stock can be worked as single pipe system by simply isolating the feed pipe of trailing stock from locomotives.

1.11 Power cut off during emergency brake application.

1.12 Visual indication on driver's cab through air flow indicator device during train parting, alarm chain pulling or Guard's emergency brake valve operation or loco parting while hauling air braked stock.

1.13 Audio/visual indication in driver's cab to indicate the failure of D-24B feed valve which feeds air pressure for electrical controls.
2. Compressed air system: (Ref.: SKDP-2350 Alt. 4)

2.1 Compressed air delivered by the motor driven compressors is stored in the main reservoirs after being cooled by after coolers. Three safety valves set at 11.5 kg/cm² are provided to safeguard the compressors against build up of air pressure to a very high value, in case of failure of check valves. The compressors are controlled by electro-pneumatic governor, to cut in at 3.5±0.1 kg/cm² and cut out at 10±0.1 kg/cm² pressure. One more safety valve set to blow off at 10.5±0.1 kg/cm² is fitted between the second and the third main reservoir in case the pressure governor fails to operate.

2.2 Compressed air at reduced pressure of 8 kg/cm² is stored in the control reservoir. This air is supplied for all electrical contactors. A pressure switch provided after the feed valve gives an audio visual indication through a buzzer and an indication lamp in each cab, in case pressure in the control reservoir falls below 6.0±0.1 kg/cm² and cuts off the audio visual indication when the pressure rises to 6.0±0.1 kg/cm².

2.3 In release position of the A-9 automatic brake valve, main reservoir air flows to the regulating portion of auto brake valve, where it is reduced to a predetermined pressure. The regulated air pressure flows through the auto brake valve to the C-2 relay valve to charge the air brake pipe. The air brake pipe pressure can be adjusted by adjusting the regulator of auto brake valve.

3. Independent brakes

3.1 Self-lapping SA-9 type independent air brake valve is provided in each cab for application and release of air brakes on locomotive. The leakage in the brake cylinder is automatically compensated and air pressure in the brake cylinders is automatically maintained between zero and maximum value depending upon brake valve handle position.

3.2 Isolating cocks are provided in the air supply and delivery pipes of the independent brake valve to isolate the defective or unused brake valve in the inoperative cab(s).

4. Vacuum system

4.1 Two exhausters, are provided to create vacuum in the vacuum system of the loco and the vacuum trains pipe (VTP) for operating vacuum braked trailing stock. Normally one exhauster is run to maintain vacuum in the system. Two exhausters can also be operated, if necessary.

4.2 Exhauster(s) create vacuum in the V.T.P. through VA-1-B control valve when A9 (drivers automatic brake valve) is placed in "release" position. The vacuum in the V.T.P. is limited by two vacuum relief valves set at 60 cms max. with hose pipe on dummy. Exhausters are protected against ingress of dirt and dust by GD/80-H type oil bath filters. Leakage of atmospheric air through the idle exhauster is avoided by non-return valve. Vacuum relief valves in the exhauster line protect the exhauster(s) against high vacuum when the VA-1-B control valve is the disconnected from train pipe during brake application. The desired vacuum in the VTP during release position is controlled by the HS-4 control air valve. In release position of the automatic brake valve A9, VA-1-B control valve is actuated by the air brake pipe pressure and the control valve piston is moved down to connect the exhauster to the VTP.

5. Operation of brakes on trailing stock equipped with air brake equipment

5.1 In ‘release’ position of A-9 automatic brake valve, main reservoir air flows to the regulating portion of automatic brake valve at a predetermined pressure, normally 5kg/cm². The regulated air pressure flows through MU-2B valve to the C-2 relay valve. This control pressure actuates C-2 relay valve which in turn connects main reservoir to brake pipe and charges the brake pipe and the connected system to the same pressure level through out the train. Any leakage in the train system is automatically compensated by this relay valve.

5.2 When the brake valve handle is moved to minimum reduction position, reduction of pressure in brake
pipe by 0.2 to 0.5 kg/cm² (3 to 8 PSI) is achieved and proportional application of brakes on loco and trains takes place. In full service position of the automatic brake valve handle, the BP pressure is reduced to 3.5 kg/cm².

5.3 The A-9 automatic brake valve handle when placed in emergency position, vents brake pipe pressure at a very fast rate to atmosphere to initiate an emergency brake application. Regression of power also takes place due to the actuation of H-5 relay air valve. Reduction in pressure in the brake pipe actuates the distributor valve on the loco and trailing stock to apply brakes.

5.4 The C-3-W distributor valve provided in the brake circuit, is connected to the brake pipe and responds to the variations of pressure in the brake pipe. It applies proportionate brake application on loco- motive when train brakes are applied either through Automatic or Emergency brake valve. The C-3-W distributor has a built in Goods/Passenger changeover cock to regulate brake cylinder pressure depending on whether it is hauling Passenger or freight train.

5.5 32 mm feed pipe throughout the train is charged from the first two main reservoirs, through duplex check valve and feed valve set at 6.0 ± 0.1 kg/cm² and is used for filling auxiliary reservoirs of the trailing stock initially as well as after the air from these reservoirs has been consumed during braking. The main advantage of this additional pipe is to reduce the release and recharging time of the train after brake application.

6. Operation of brakes on trailing stock equipped with vacuum brake equipment

6.1 In release position of the automatic brake valve handle, the brake pipe is charged to 5.0 kg/cm² and vacuum in vacuum train pipe is created through VA-1-B control valve. When the brake valve handle is moved from release position towards application position, the brake pipe pressure and vacuum in VTP is reduced and maintained to a value depending on the handle movement.

6.2 The reduction in brake pipe pressure operates the VA-1-B control valve to admit atmospheric air into the vacuum train pipe, to apply brakes on the vacuum braked trailing stock. During application, the exhaustor connection with the vacuum train pipe is cut off by the VA-1-B control valve. After the desired degree of brake application has taken place, depending upon the extent of brake pipe pressure reduced the valve laps and maintains automatically the vacuum level against normal vacuum train pipe leakage.

6.3 When the driver feels that it is not necessary to apply brake on a loco, during automatic application the brake release pedal switch is pressed to release the loco brakes. The D-1 pilot air valve is energised to cut off automatic air brakes on the loco while train brakes remain applied on the trailing stock.

6.4 During train parting while hauling vacuum braked stock, the vacuum in the train pipe falls suddenly, with a drop of vacuum by about 10 to 15 cm an unbalance in the VA-1-B control valve is created allowing controlled air pressure to actuate HB-5 relay air valve to operate pressure switch through double check valve for regression of power.

7. The operation of emergency brake
Valve D-1 provided in each cab, near the assistant driver's seat, directly connects the vacuum train pipe and air brake pipe to atmosphere thereby applying brakes on loco and trailing stock at the quickest possible rate. The circuit for auto regression of the loco power due to the actuation of H-5 relay air valve is also automatically made. This relay valve also regresses power if the BP pressure drops due to any reason.

8. Dynamic brakes
D-1 pilot air valve cuts off loco brakes.

8.1 While controlling train with dynamic brakes, if the dynamic brakes fails, brakes on the loco and train will be applied automatically.
9. Air flow indicator

9.1 Air flow indicator, a relay valve, one pressure switch and two flow indicator gauges (one in each cab) have been provided to give an indication of the air flow rate in the brake pipe of the train. Any abnormal increase in air flow in the brake pipe because of train parting, loco parting, alarm chain pulling, heavy leakage in brake pipe, guard van valve application or bursting of air brake pipe hose would give visual indication to the driver by air flow gauge needle and by glowing of a bulb in the cab. On getting the indication driver should apply brakes through A-9 automatic brake valve/D-1 air/vacuum emergency valve depending upon the condition of the train and the emergency.

10. Multiple unit operation

10.1 When two or more locos are to be coupled together in multiple unit operation, the brake pipe, the feed pipe, vacuum train pipe (if vacuum braked stock to be operated), the main reservoir equalising pipe and brake cylinder equalising pipe hoses must be coupled between the locos, and the respective angle cocks shall be opened.

10.2 The compressors and exhausters of the trailing locos would also be working during multiple operation. The automatic and independent brake valve handles in the trailing loco and on the unused cab of the leading loco shall be kept in 'Release' position and the isolating cocks provided near both brake valves should be closed.

10.3 MU-2-B valve provided to supply MR air to VA-1 release valve (11) and F-1 selector valve should be kept in 'lead' in the leading loco and in 'Trail' position in the trailing locos. Isolating cock in the brake pipe charging line should be kept in lead position (open) in leading loco and trail position (close) in the trailing loco(s).

11. Gauges

There are five gauges in each driving cab. These gauges indicate BC, MR, FP, VTP, Air Flow, BP pressures to the driver. Apart from these, three single Pressure gauges are provided. One single pressure gauge is fitted near the panto reservoir. The second gauge is provided in the brake pipe line to show the brake pipe pressure. One single pressure gauge is provided to indicate the pressure in the control side of the VA-1-B control valve, which is regulated by HS-4 control valve.

12. General

12.1 It should be noted that whenever the vacuum setting is done- through the vacuum relief valve, this should be done by seeing the single vacuum gauge fitted in driver's cab.

12.2 The first two main reservoirs are provided with auto drain valve and the condensate is automatically drained off during the "cut out" and "cut-in" cycle of the compressor governor. All the other three main reservoirs are provided with manual drain cocks to drain off periodically the condensate collected in the reservoirs.

12.3 The main reservoir also supplies compressed air to auxiliaries such as wipers horns and sanders. The MR equalising pipe is charged from the main reservoirs through a duplex check valve set at 5.0±0.1 kg/cm².

12.4 The main reservoir also supplies compressed air to electrical auxiliaries such as pantographs, tap changers, Board of graduator etc. At the time of initial energisation of loco or when there is insufficient pressure in pantograph reservoir to raise the pantograph, battery driven auxiliary compressor is operated to build up pressure in the pantograph reservoir and auxiliary circuit to energise the loco. The pantograph reservoir is protected against pressure leakage by a diaphragm operated cock. One safety valve to cut out at 8.5 ± 0.1 kg/cm² has been provided to safeguard the baby compressor from excessive pressure.
VACUUM CREATION AND DESTRUCTION WHILE HAULING

VAC. BRAKED STOCK
### MAINTENANCE AND OVERHAUL SCHEDULES OF EMU’s

<table>
<thead>
<tr>
<th>Para No</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>30400</td>
<td>General</td>
</tr>
<tr>
<td>30401</td>
<td>Scheduled Inspections</td>
</tr>
<tr>
<td>30402</td>
<td>EMU Fitness Certificate</td>
</tr>
<tr>
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CHAPTER IV

MAINTENANCE AND OVERHAUL SCHEDULES OF EMUs

II. 30400 General

Para 30300, 30301 and 30303 will be applicable to EMU mutatis-mutandis as well.

III. 30401 Scheduled Inspection

IV. The motorman, after overnight stabling of EMUs, while taking over shall ensure draining off of the air reservoirs to expel accumulated water.

a) The Maintenance and Overhaul Schedules to be followed for AC EMUs will generally be as under-

i) Daily Inspection

ii) Trip Inspection (IT)

iii) Monthly Inspection (IA)

iv) Quarterly Inspection (IB)

v) Half Yearly Inspection (IC)

VI) Intermediate Overhaul (IOH)

VII) POH

b) The daily inspection is essentially an inspection to be carried out by the ‘Running’ Section. It may also be carried out in a shed if convenient or at an outstation when the unit is stabled overnight away from the shed. IT, IA, IB, IC and IOH should be carried out in the homing shed for each EMU whereas POH should be carried out at the workshop nominated for this purpose for each railway.

c) The details of work to be done during each schedule require periodical review in the light of local conditions and operating experience with each type of EMU. The details given in Annexure 4.01 are for guidance only.

V. 30402 EMU Fitness Certificate

Instructions contained in Chapter III (Para 30304) for locos will apply mutatis-mutandis for EMU as well. (Proforma 4.01).

VI. 30403 Testing of Air Brakes

A brief description of Electro-pneumatic brakes is given in the Annexure 4.02, Test procedure for the air brakes is however given below:

1. Before an EMU train is issued for traffic from a shed after scheduled inspections, POH or unscheduled repairs, a supervisor of the M5 section should test the air brakes of the complete train formation. The brakes should be tested from the driving cabs at both ends of the train formation.
A list of items to be checked in the case of Westinghouse brakes of ICF EMUs is given below for guidance. Detailed check lists on similar lines should be prepared for different types on EMUs and units fitted with Knorr brakes. These should be in the form of printed forms. The completed forms duly signed by the supervisor of M5 should be preserved in the PPO for a period of six months.

Check

i)     that all inter-car hose connections are made and all coupling, isolating the drain cocks are in the normal position.

ii)    that MR pressure is maintained between 5.8 and 7 kg/cm$^2$ and the compressors start and stop respectively at these values of pressure.

iii)   that when the Driver's control switch, EP brake switch and isolating valve switch are put on, the green indicator light in the driving cab glows.

iv)    that the brake pipe pressure builds up to 4.57 kg/cm$^2$ in approx. 90 seconds.

v)     that when the brake controller handle is moved from position I to position II step by step (a minimum of 6 steps should be used), the brake cylinder pressure builds up to the value proportional to the handle position and is maintained at this value by the self-lapping mechanism. In position II the pressure should be 3.5 kg/cm$^2$ for cast iron brake blocks and 1.5 kg/cm$^2$ and 2.0 kg/cm$^2$ for motor and trailer coaches respectively provided with composite brake blocks. When brakes are applied the orange lamp should light-up to prove the application of brakes in all the bogies.

vi)    that when the handle is moved back from position II to position I step-by-step (a minimum of 6 steps should be used) the brake cylinder pressure is reduced to the value corresponding to the handle position and is maintained at this value by the self-lapping mechanism.

vii)   that when the handle is quickly moved from position I to position II, the brake cylinder pressure will rise to the maximum set value.

viii)  that on moving the controller handle from position II to position I, the brake cylinder pressure drops to zero.

ix)    that during EP application and release the brake pipe pressure is not affected.

x)     that when controller handle is moved from position I to position III and then to IV, the brake pipe pressure drops gradually with sound of escaping air, and brake cylinder pressure rises correspondingly. When the controller handle is moved back to III, the drop in brake pipe pressure and the rise in brake cylinder pressure should be arrested.

xi)    that when controller handle is moved from position I (after allowing full BP pressure to build up) quickly to 'Emergency' position V, brake pipe pressure is reduced rapidly and brake cylinder pressure rises to slightly more than 3.9 kg/cm$^2$ within 2.5 seconds.

xii)   that with the brake controller in the driving cab in position II the brake cylinders on each bogie are functioning and there is no leakage. Check also that the manual release valves have wires attached to them to facilitate operation from the sides of the train.

30404 Maintenance of Vacuum Brakes

A brief description of vacuum brakes is given in the Annexure 4.03. Instructions regarding maintenance of vacuum brakes are contained in TXR Manuals, the salient points of which are summarized below:-

Periodical Examination of Vacuum Brake Gear:

1. All vacuum brake cylinders shall be lowered, examined, cleaned and necessary repairs and renewals of rubber fittings effected, once in every 12 months. The code of the examining station making such an examination, the date and words “EXD” shall be painted in white on the cylinder thus: EXD-JTJ- 1 0- 1- 1 970.
2. In fitting up vacuum brake cylinders it is important to see that the lever of the brake shaft is exactly parallel with the trunnions on which the cylinder swings so that no side or cross strains are set up.

3. When putting a rolling ring on to a piston, care should be taken to ensure that the ring is not twisted. Around the ring a seam line will be found, which should lie evenly and horizontally all-round when in the groove. The correct alignment can be secured by pulling the ring slightly away from the drum of the piston on the opposite sides with the thumb and finger of each hand. A good rolling ring is one which when allowed to hang from the finger will hang straight. Whereas, if a ring twists when being suspended it should be rejected. An air tight fit is made between the piston and cylinder by the rolling ring.

4. (i) The stuffing box, gland and brass bush should be examined to ensure that they are intact in all respects. Excessively worn gland will cause air leak below the piston and hence should be renewed.

(ii) The gland is held in position by a brass ring having groove at top and bottom edges. When the stuffing box is tightened the rubber gland is squeezed into the grooves. On creating vacuum, the gland packing gets tightened, due to atmospheric pressure acting over the outside of it.

(iii) The brass bush must be examined for wear, as this part has the important function of maintaining the piston rod steady in its movement. When the bush is worn excessively the travel of the piston becomes unsteady and jerky.

5. The joint ring between the flanges of the vacuum chamber and cylinder should be in correct position. To retain the joint ring in exact alignment while the cylinder is being lifted into position, clips made out of split pins could be used.

6. While tightening up the joint, the nuts should be screwed up evenly all-round and not too tightly or haphazardly.

Unequal tightening of the nuts may cause the cylinder being drawn out of shape. This should be avoided. The correct procedure is to tighten up opposite nuts while assembling. On creating vacuum the nuts should be tightened up finally.

7. The release valve has a flat valve head which normally remains seated cutting off all direct communication between the body of the valve and the vacuum chamber or top of the piston. This can be opened by pulling the release valve lever by hand. A defective seating washer or a diaphragm washer will allow air to enter above the piston when vacuum is destroyed and the vacuum cylinder will not function properly. Such defective washers should be changed.

8. Cleaning: When dismantling a cylinder for cleaning all rubber parts should be removed and kept clear of oil or any other solvent likely to damage the rubber. French chalk may be used for cleaning or dressing the rubber fittings, or the working surfaces of the cylinder and piston.

If it is found necessary to use a solvent to remove dirt from working surfaces of the metal parts all traces of this solvent must be removed before replacing rubber parts, otherwise deterioration and failure in service are liable to occur. These working surfaces are coated with a special red rust-preventing varnish and the solvent must be of a nature which will not affect this varnish. Emery paper or cloth should never be used to clean the piston and cylinder.

9. The piston travel should be limited to a maximum of 4" (100 mm) to ensure effective brake power.
1. Daily Inspection

During this inspection, the Engine Examiner should-

a) carry out detailed checks in regard to any unusual occurrence reported by Motormen in the log book.

b) visually inspect the auxiliaries for satisfactory starting and operation.

c) feel by hand that the temperature of axle bearings is normal,

d) visually inspect mechanical components like traction bars, pendular suspension, springs, dampers etc. and the brake rigging to detect any abnormality; and

e) check the controls and indication and alarm circuits for correct functioning.

Every unit should be checked under the supervision of a Train Examiner (Traction), generally during night stabling. Similar inspection (in addition to attention to the unscheduled repairs) should also be carried out in a unit called to the shed for unscheduled attention, before it is declared fit for traffic.

The important items to be checked are

i) Tap all wheels to detect for loose tyre and tyre cracks. Visually inspect all wheels for defects such as cracked tyres, flats etc. and also bogies and running gear for any abnormalities.

ii) Feel all axle boxes by hand immediately after stabling. Check axle box covers.

iii) Check axle guide helical springs for breakage.

iv) Check brake blocks. Renew badly worn or cracked blocks. Adjust slack adjusters, if required, to obtain clearance of 12 mm between brake blocks and wheels. Look for broken or damaged parts of brake rigging. Check the application of the brakes.

(v) Check bolster helical springs, visually.

vi) Check look-out glasses and head code glasses. Clean look-out glasses.

vii) Cushions to be checked and badly damaged cushions to be replaced

viii) Test check passenger alarm chain for operation from at least 2 coaches in a train.

ix) Visually check the pantographs for any defect.

x) Check oil-level of air compressors and suspension bearings, top up if required.

xi) Check operation of automatic drain valve of main reservoirs. Drain all other reservoirs.

xii) Test the horns at both ends.

xiii) Check for noticeable air leakages in compressed air system.

xiv) Check inter-unit air hose couplings.

xv) Test wind screen wipers (in rainy season),
xvi) Test brake controller at each driving position for correct operation. Particularly observe the brake-pipe pressure.

xvii) Test deadman's device in each driving cab

xviii) Test pantograph raising and lowering push buttons in each driving cab.

xix) Check Master Controller in each driving cab.

xx) Test auxiliary compressor.

xxi) Check battery voltage and trickle charge current.

xxii) Test signal bells.

xxiii) Clean the compartments and cushions. Clean driving cabs.

xxiv) Test headlights, flasher lights and tail lights including emergency lights.

xxv) Check that all the safety straps are in position

2. **Trip Inspection**

The chief object of this inspection is to renew the worn-out brake blocks if necessary usually at intervals varying from 5 to 8 days particular attention being paid to differential rate of wear between motor coaches and trailer coaches.

The periodicity of this inspection will depend upon a number of factors such as daily kilometreage, proportion of 'fast' and 'slow' trains, quality of brake blocks etc. The periodicity should be decided by each Zonal Railway depending upon its actual operating requirements. It is essential to ensure renewal of brake blocks before they reach condemning thickness.

3. In addition to replacing brake blocks and the items listed against Daily inspection, carry out the following checks:

   i) Visually inspect the bogie frame for cracks or other damages.

   ii) Check helical springs of axle guide for breakage.

   iii) Check axle guide for excessive oil leakage

   iv) Check tightness of axle guide oil filling cap.

   v) Check axle guide safety strap.

   vi) Inspect axle suspension bearings of traction motors and check oil levels, particularly check pressure and tightness of drain plug and filler cap. Tighten bolts.

   vii) Check gear-box for lubricant level and tighten bolts.

   viii) Adjust brake pull rod, rigging and slack adjusters.

   ix) Inspect brake rigging components thoroughly particularly bushes, pins, split-pins and cotters.

X) Check centre pivot.
xi) Inspect 'Schaku' couplers for cracks, deformation and damage.

xii) Inspect buffers and lubricate buffer plungers.

xiii) Lubricate screw couplers.

xiv) Check all doors and windows, door handles, foot-steps, window safety bars and hand rails.

xv) Check that protective screen for look-out glasses, where provided, is properly secured.

xvi) Clean driving cab window panes and swab clean cushions.

xvii) Inspect pantographs for flash-marks, wear of strips and cleanliness of Insulators. Lubricate articulation joints, bearing joints and pans.

xviii) Check compressor crank case breather pipe.

xix) Check oil level of auxiliary compressor and top up, if required.


xxi) Check transformer oil level and top-up if required. Check transformer for oil leakages.

xxii) Check colour of silica gel and replace if required.

xxiii) Open inspection covers and make a quick inspection of traction motors for flash-marks, broken brushes, damaged pig-tails or other damages.

xxiv) Check that the auxiliary machines are running without any unusual noise.

xxv) Make a quick examination of all electro-magnetic contactors and relays.

xxvi) Make a quick visual examination of air-blast circuit breaker and test its operation.

xxvii) Battery: Clean vent holes of filler caps, check intercell and main connection, record specific gravity and voltage of pilot cells, top up with distilled water if required and smear cell connections and terminals lightly with petroleum jelly after cleaning.

xxviii) Check and attend to all defects of lights and fans.

xxix) Clean underframe equipment particularly at locations where fire is possible due to accumulation of oily matter; also clean filters, as required.

xxx) Check the correct operation of RGCP.

xxxi) Check self lap feature of the EP brakes.

3. **Monthly Inspection** (IA)

In addition to the items listed against Daily and Trip inspections, the main items to be attended to during Monthly Inspections are -

i) Measure tyre (root wear and flange wear) and record. (Refer to Annexure 3.01 item F) and reprofile if required and ensure that variation of diameters are within permissible limits.
ii) Check axle boxes for leakage of grease, specially from back dust-guard and for any cracks or other damages.

iii) Inspect reversible gear-box of speedometer.

iv) Check suspension bearing housing fixing bolts for tightness.

v) Check gear-case securing bolts for tightness.

vi) Check motor coach friction damper liners and pads.

vii) Check shock-absorbers for oil leakages.

viii) Check centre-pivot bottom cover with its fixing bolts and nuts.

ix) Inspect side-bearers for excessive oil leakage.

x) Inspect buffers for cracks and damages and tightness of fixing bolts.

xi) Check cattle guard for security of fastening, deformation and clearance from rail level.

xii) Check all seats, luggage carriers, strap hangers and door locks.

xiii) Check for leakages from roof (particularly prior to and during rainy season).

xiv) Check that hand-brake are functioning effectively.

xv) Gauge and change if necessary, pantograph strips and clean all roof insulators.

xvi) Inspect and clean suction strainer and centrifugal dirt collectors.

xvii) Overhaul and test reducing valves and check that correct brake pipe pressure of 4.57 kg/cm² is built up.

xviii) Check complete compressed air system for leakage.

xix) Test EP, Auto and Emergency application from each driving position and brake cylinder pressure in each coach. Check Guard's Emergency valves in driving cabs.

xx) Remove the arc chutes and inspect all EP contactors for flash-marks, contact wear, contact wipe etc. Check for air leakage at control valves. Lubricate cylinders.

xxi) Check pressure in control air reservoir.

xxii) Check operation of all pneumatic governors.

xxiii) Check reversers for operation, finger pressure, wear of contacts, functioning of auxiliary contacts and for air leakage at magnet valves.

xxiv) Inspect silicon rectifier cubicles and clean cubicles with dry compressed air.

xxv) Check cell-check device.

xxvi) Check traction motors for condition of commutators, arcing horns, brush holders, wear of, carbon brushes and condition of earth-return brushes. Renew brushes, if required.
xxvii) Examine all other DC motors also as above.

xxviii) Lubricate the bearings of auxiliary motors.

xxix) Clean air intake filters for traction motors and compressors.

xxx) Check tightness of all main cable connections.

xxxi) Check the contacts and auxiliary contacts of circuit breakers.

xxxii) Check for functioning of all indication circuits and lamps;

xxxiii) Check voltage stabilizer.

xxxiv) Check all lights and fans individually and test emergency lights.

xxxv) Check the speedometers.

xxxvi) Wash coaches internally and externally by hand scrubbing.

xxxvii) Check head light focussing.

Train formation should finally be checked by EI and MI sections before release for traffic.

4. Quarterly Inspection (IB)

Items given below are required to be attended to in addition to the items listed against Daily, Trip and Monthly Inspections

i) Check all axles with ultrasonic flaw detector.

ii) Check distance between wheel faces using prescribed gauge.

iii) Check axle guide oil level,

iv) Check condition of axle guide spring lower rubber pads.

v) Check condition of speedometer reversible gear box.

vi) Traction motor suspension bearing lubrication pads to be checked.

vii) Measure and record radial and lateral clearances of suspension bearings.

viii) Inspect traction motor nose suspension bolts

ix) Inspect bogie frames, swing links and bolsters carefully, particularly welded, rivetted and bolted joints.

x) Check friction damper spring assembly.

xi) Check compressed height of swing bolster springs.

xii) Inspect draw-gear rubber pads.

xiii) Uncouple 'Schaku' couplers and inspect the assembly. Lubricate the couplers as prescribed.
xiv) Measure and record buffer heights.

xv) Body panels to be checked for rust, corrosion and damage.

xvi) Check passenger alarm device in each coach.

xvii) Clean the suction strainers of auxiliary air compressor.

xviii) Inspect all brake cylinders; tighten foundation nuts.

xix) For all EP contactors check air gap between main contacts, auxiliary contacts and spring pressure of auxiliary contacts. Clean all insulating surfaces. Check magnet valve stem with condemning gauge.

xx) Check reverser and changeover switch “WCO.

xxi) In silicon rectifier cubicles, slide out each rectifier tray and clean the cooling fins. Clean all air ducts, check power connections, check capacitor for oil leakage and inspect HRC fuses, particularly terminal connections.

xxii) Open and inspect Master Controllers. Wipe dry all insulating surfaces and check contacts.

xxiii) Clean supporting insulators and check tightness of connections of transition resistances.


xxv) Check main compressor foundation bolts for tightness.

xxvi) In all electromagnetic contactors check the air gap between contacts, conditions of flexible shunts, knuckle spring pressure and hinge pins.

xxvii) Inspect all push button switch contacts and terminal connections.

xxviii) Check all knife switches.

xxix) Check current limit relay LT supply continuity.

xxx) Inspect voltage stabilizer transformer.

xxx) Clean headlight reflector.

xxxii) Inspect commutator and carbon brushes of all fans. Renew carbon brushes if required.

xxxiii) Examine axle boxes. If required change the grease. (This item is normally required to be done during every third IB).

5. Half Yearly Inspection (IC)

In addition to the items listed against the earlier inspections, the important items to be attended are

i) Check pantographs for upward pressure.

ii) Renew oil in compressor crankcase and change the oil filter element assembly. Check oil pressure.

iii) Decarbonize the valve assembly.

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iv) Renew crank-case oil of auxiliary compressor.

v) Safety valves in compressed air system including brake cylinder safety valves to be tested.

vi) Check the suspension arrangement of all under-slung equipment.

vii) In the brake controller, check self-lapping mechanism for correct functioning, regrease fulcrum pins and rollers and examine moving and fixed contacts.

viii) Clean and regrease pilot valve in Master Controller.

ix) Test and adjust operating pressure of all pneumatic governors.

x) Check the condition of cones and rollers of all EP contactors, measure knuckling springs tension, renew Gaco washers and inspect flexible shunts. Check tightness of power connections.

xi) Attend to reverser and changeover contactor WCO as above.

xii) Test oil sample from conservator, reactor tank and transformer tank of main transformer for dielectric strength and filter the oil if BDV is below 40 kV for one minute.

xiii) Disconnect all inter-vehicular couplers and examine male and female pins.

xiv) In the main rectifier cubicle clean all insulators and examine for cracks. Check individual diodes for tightness with a torque wrench.

xv) Examine Master Controller, lubricate interlocking mechanism and notching cam roller, check Contact gap, contact pressure and cam to roller gaps.

xvi) Check traction motor brush spring pressures. Lubricate armature bearings.

xvii) In MG set check bearings for grease leakage and lubricate bearings.

xviii) Overhaul and test all EP brake valves replacing all rubber component on a complete unit basis.

6. Intermediate Overhaul (IOH)

The following items should be attended to in addition to the items listed against earlier inspections.

i) Reversing gear-box for speedometer to be overhauled and speedometer to be tested on test bench.

ii) Check ‘Schaku’ couplers for wear and damage and lubricate.

iii) Overhaul servomotor of pantograph and check all adjustments,

iv) Overhaul and test pantograph EP valves.

v) Remove main and auxiliary compressors and overhaul on bench. Test volumetric efficiency.

vi) Overhaul and test brake cylinder.

vii) Overhaul the motors of all AC and DC auxiliaries.

viii) Remove air blast circuit breaker, overhaul and test on bench.
ix) Check the setting of all relays and test their operation manually.

x) Overhaul all coach fans.

xi) Remove battery set to battery room, examine carefully and subject the set to two cycles of charge and discharge. Take capacity test at normal rate of discharge.

xii) Doors, windows and seats to be checked individually and all defects attended to. Upper-class cushions to be repaired and badly damaged cushions to be replaced.

7. Periodical Overhaul (POH)

The POH of EMUs should be carried out in the nominated workshop. The work content and procedure to be followed should be on the same lines as for locos (Item D of Annexure-3.01 of Chapter 3).

8. Mechanical Safety Checks
The Train Examiner of EMU coaches will generally follow the manual and guides of TXR as modified from time to time for application to EMU coaches. The principal clearances as mentioned in (Item F of Annexure-3.01 of Chapter 3) should be checked.

9. Rebuilding and Recabling of EMUs

Activities as mentioned in (Item E(1) of Annexure-3.01 of Chapter 3) above may be carried out on EMUs during every 4th POH and activities mentioned in (Item E(2) of Annexure-3.01 of Chapter 3) may be carried out during every 8th POH.
ELECTRO-PNEUMATIC BRAKES

1. All BG EMU stock have been provided with 'self-lapping electro-pneumatic combined with automatic' compressed air brakes. Two makes of equipment are in use viz. Westinghouse and Knorr-Bremese. Though the details of equipment differ appreciably, both systems are quite similar in principle. The description given below pertains mainly to the Westinghouse equipment provided in ICF-built EMUs.

2. Electro-pneumatic braking is normally employed for service stops. The 'automatic brakes' are used under the following circumstances:

(a) For automatic application of brakes on both halves of a train in the event of a parting.

(b) For application by the Guard in an emergency.

(c) For automatic application due to operation of the dead-man's device.

(d) For service stops by the Driver in the event of failure of control supply for EP brakes.

3. When Driver makes an emergency application both EP and Auto brakes apply.

4. The main components of the equipment are as under:

(a) A main reservoir system consisting of a compressor in each motor coach feeding into main reservoirs on motor coaches and supplementary reservoirs on trailer coaches interconnected from end to end of the train by a main reservoir pipe with flexible couplings at ends of coaches. The main reservoir is maintained at a pressure of 5.8 to 7.00 kg/cm² by means of pressure governors controlling each compressor. All the compressors in a train are synchronized to start and stop together.

(b) A 'brake pipe' from end to end of the train with flexible inter-connections between coaches. The pressure in this pipe is maintained at 4.57 kg/cm² to keep the automatic brakes released.

(c) A 'brake unit' in each coach consisting of the control valves for control of EP and auto brakes.

(d) The brake cylinders on each bogie with automatic slack-adjusters and associated brake rigging. Usually the number of brake cylinders is four per bogie on motor coaches and two per bogie on trailer coaches.

(e) A brake controller in each driving cab. The controller in the driving cab in use being made operative by means of an 'Isolating valve switch' operated by the Driver's key.

(f) A brake application relay in each driving cab, the one in the operative cab responding to the operation of the brake controller to control the supply to the brake control train wires carried along with the other control wires in the inter-vehicular couplers.

(g) Five train wires, viz. EP supply wire, brake application wire, brake holding wire, brake indication wire and EP return wire.

(h) A warning system to indicate to the Driver if EP brakes have applied and to warn him if a failure takes place.

(i) A pilot valve and emergency valve to operate the brakes if the deadman's device is released.

(j) Isolating cocks, pressure gauges and control switches.
Release valves for manual release of brakes in individual bogies.

5. Each coach has an 'EP brake unit' which houses the control valves for both EP and auto-brakes. The 'pipe- bracket' arrangement is used where by the valves are bolted on to a casting which has the requisite inter connections between valves by means of cored passages in the casting itself, the only external pipe connections being from the main reservoir and brake pipes and to the brake cylinder and atmosphere.

6) The brake controller handle has five positions as under-

(a) I           .. .. ..              Release and Running.
(b) II       ...........  Full service EP.
(c) III    ............. Lap(for auto application)
(d) IV    ................       Service automatic
(e) V          .................      Emergency.

Lower brake cylinder pressures with self-lapping feature as explained later are obtainable for intermediate positions of the handle between positions I and II, the actual brake cylinder pressure being dependent upon the degree of handle movement away from position I.

7. Fig 4.01 is a block diagram explaining the functioning of the EP brakes. When an EP application is to be made, the controller handle is moved from position I towards position II. First the holding train wire is energized which energizes the holding magnet valves throughout the train, thus closing the exhaust, from the brake cylinders. The application valves are then energized via the application train wire. This causes compressed air to flow to the brake cylinder from the main reservoir pipe, the rate of flow being controlled by a choke (not shown in the figure). If the application valve remains energized, the pressure in the brake cylinder builds up to 3.5 kg/cm², any rise of pressure beyond this value being prevented by the 'limiting valve'.

8. Between positions I and II the self-lapping mechanism controls the brake cylinder pressure. Fig 4.02 shows the self-lapping mechanism schematically. Movement of the controller handle towards II compresses a spring in a small control cylinder, the amount of compression depending upon the degree of handle movement. This spring acts on a piston at the back of which air pressure from the brake cylinders of the leading bogie is applied. When the brake cylinder pressure exceeds the value corresponding to the controller handle position, the mechanism de-energizes the application train wire, thus limiting the brake cylinder pressure to the value corresponding to the handle position. If the brake-cylinder pressure drops on account of leakage etc. the application wire is re-energized. If the handle is moved backwards, the holding wire is de-energized till the brake cylinder pressure drops to the required value. The self-lapping mechanism thus automatically controls the brake cylinder pressure at a definite value corresponding to the handle position and enables graduated application and release. In. position II and V the application and holding circuits are energized by 'positive acting' contacts bypassing the self-lapping mechanism, the pressure then being limited by the limiting valve as explained earlier.

9 Two indication lamps are provided on the Driver's desk—a green lamp to indicate that EP brake control supply is available and an orange lamp which lights up when brake application is made if pressure has built up in all the bogies, which is detected by a pressure switch, the pressure switches in all the coaches being connected in series. The extinguishing of the green lamp indicates total failures of EP brakes necessitating use of the automatic brakes to control the train. Failure of the orange lamps to light up when brakes are applied indicates partial failure of the EP brakes. The Driver has then to be very vigilant and should be prepared to control, the train, if required, by using auto brakes.

10. Fig 4.03 is a block diagram explaining the function of the automatic brakes. When the brake controller in the driving cab is in position I and the controller is put into operation by putting on the 'Isolating valve switch', compressed air is fed to the brake pipe from the MR pipe via a reducing valve in the brake controller which ensures that the pressure in the brake pipe is built up and remains steady at 4.57 kg/cm².
The vital component in the automatic brake system is the 'triple valve' which forms a part of the EP brake unit in each coach. Its functions are:

(a) When pressure in the brake pipe is 4.57 kg/cm$^2$, it opens the brake cylinder to atmosphere thus releasing the brakes and at the same time connects the brake pipe to an Auxiliary Reservoir in each coach storing compressed air at a pressure of 4.57 kg/cm$^2$ in the Auxiliary reservoir.

(b) When pressure in the brake pipe is reduced either voluntarily by the Driver or the Guard or due to parting of train or operation of the deadman's device etc., it closes the exhaust from the brake cylinder and connects the auxiliary reservoir to the brake cylinders, allowing the stored air in the reservoir to flow into the brake cylinders. The volume of the auxiliary reservoir is so chosen that the maximum pressure in the brake cylinders is limited to 3.5 kg/cm$^2$. The triple valve also has a 'lap' position whereby it is possible to control the brake cylinder pressure to values below 3.5 kg/cm$^2$ by holding the brake pipe pressure at intermediate values making use of position III on the brake controller.

(c) When the brake pipe is recharged by moving the controller to position I, the triple valve returns to the position indicated in (a), thus releasing the brakes and storing air in the auxiliary reservoir in readiness for the next application. Not shown in Fig 4.03 is a 'triple valve stabilizing valve' which ensures that the triple valve does not react to small pressure pulsations.

11. In position V (i.e., 'emergency') of the brake controller, both EP and auto brakes apply together. Rapid application of the automatic brakes is obtained by quick venting of the brake pipe to atmosphere. A safety valve in the brake unit on each coach prevents excessive pressure in the brake cylinders. This valve is normally set at 3.9 kg/CM$^2$.

12. Release of the deadman's device by the Driver results in quick venting of the brake pipe to atmosphere via an 'emergency valve' resulting in full auto application.

13. A valve is provided in each driving cab to enable the Guard to vent the brake pipe to atmosphere and thus cause brake application. A gauge is provided close to this valve to indicate the brake pipe pressure to the Guard.

14. A pressure switch usually called the 'control governor' connected to the brake pipe prevents application of power to the traction motors till the brakes are kept ready. This control governor opens and cuts off traction control supply if the brake pipe pressure is reduced.

15. A 'duplex' pressure gauge is, provided in the driving cab to indicate to the Driver the pressure in the main reservoir and brake pipes. Another duplex gauge indicate to him the pressure in the brake cylinders of the two leading bogies.

16. Isolating cocks are provided to isolate a defective brake unit form the MR and brake pipes and also to isolate brake cylinders in individual bogies.

17. The brake cylinders are equipped with automatic slack-adjusters to take up the slack in the brake rigging with wear of brake blocks, thus ensuring fairly constant piston stroke and obviating the need for manual adjustment of the brake-rigging between visits of the units to the shed. This is an essential feature of brake equipment for suburban services, when the brake block wear is quite high on account of frequent application of brakes.

18. The Knorr system is quite similar to the equipment described above. In this system, however, the automatic brakes become operative automatically on failure of the EP system. With this arrangement the brake controller has only three positions viz., 'release', 'full service application' and 'emergency'.
VACUUM BRAKES

1. Vacuum brakes are provided in some EMU (MG). A description of the brake equipment together with some details on general maintenance of vacuum brakes in goods and passenger vehicles is therefore included here. Fig 4.04 give the schematic diagram of the system as adopted in MG EMUs.

2. When vacuum is created in the train pipe, the ball valve establishes communication between the chamber above the piston and portion of cylinder below the piston. With equal vacuum above and below the piston, the piston comes down" by gravity and the brakes are released. When vacuum in the train pipe is reduced by admission of air, the ball valve closes and the pressure of air below the piston moves it up, the piston movement being assisted by the rolling ring. The amount by which the vacuum is reduced in the train pipe determines the braking force.

3. When a cylinder has to be manually released the 'release valve' is operated to establish communication between the chamber and the portion of cylinder below the piston. With equal vacuum on both sides of the piston, the piston comes down by gravity and the brakes get released.
Proforma 4.01  
(Refer para – 30402)  
RAILWAY  
E.M.U. CAR SHED  

Note:- Test before and after Inspection, Overhaul of BG AC EMU.  
Coach No......................................Date .....................................Time of starting of work … … … … ..  
Time of completion of work………………………...  

<table>
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<tr>
<th>SL. No</th>
<th>Parts to be inspected</th>
<th>Specific points require attention</th>
<th>Any abnormality noticed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Checking</td>
<td>1. Check negative Binding and ensure tightness</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>2. Check up battery voltage. Normal value-110v.</td>
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<td></td>
<td></td>
<td>2. Check up charging voltage with auxiliary compressor</td>
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<td></td>
<td></td>
<td>3. Check up the charging current 5 to 8 A.</td>
<td></td>
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<tr>
<td>3.</td>
<td>Auxiliary compressor</td>
<td>1. Check up time taken to build up 6.3 kg/cm² pressure . Normal time –12mnts.</td>
<td>Governor (GRCPA): Check up cut in pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Governor (GRCPA): Check up cut out pressure</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Main compressor</td>
<td>1. Check up time taken to build up 7kg/cm² pressure Normal time 9 mnts.</td>
<td>Governor (GRCP): Check up cut in pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Check up blowing pressure of safety valve</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Check up cut out pressure</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Brake Pipe</td>
<td>1. Check up time taken for initial building of 5kg/cm² pressure. Check up time taken for rebuilding up of 5kg/cm² pressure.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Pressure Switch</td>
<td>1. Check up cut in pressure Normal value –5.2 kg/cm².</td>
<td>Check up cut out pressure Normal value-4.5kg/cm²</td>
</tr>
<tr>
<td></td>
<td>for ABB (Gov. ABB)</td>
<td>2. Check up cut out pressure</td>
<td></td>
</tr>
<tr>
<td>SL. No</td>
<td>Parts to be inspected</td>
<td>Specific points require attention</td>
<td>Any abnormality noticed</td>
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<tr>
<td>7.</td>
<td>Control Governor</td>
<td>1. Check up cut in pressure</td>
<td>Normal value – 4.2kg/cm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Check up cut out pressure</td>
<td>Normal value – 3.2kg/cm²</td>
</tr>
<tr>
<td>8.</td>
<td>Pressure Switch for Equipment Reservoir</td>
<td>1. Check up cut in pressure</td>
<td>Normal value 4.2kg/cm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Check up cut out pressure</td>
<td>Normal value – 3.3 kg/cm²</td>
</tr>
<tr>
<td>9.</td>
<td>Check leakage in Air pneumatic Pipe line.</td>
<td>1. MR Pipe leakage with E.P. Unit(BP Isolate)</td>
<td>Normal value – 0.1kg/cm² per 5 mnts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. BP Pipe leakage with auto unit.</td>
<td>Normal value – 0.1kg/cm² per 5 mnts.</td>
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<tr>
<td></td>
<td></td>
<td>3. MR Pipe line with B.P. Pipe line</td>
<td>Normal value – 0.1kg/cm² per 5mnts.</td>
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<tr>
<td></td>
<td></td>
<td>4. MR Pipe line, B.P. Pipe and B.C. applied with full E.P.</td>
<td>Normal value – 0.8kg/cm² per 5 mnts.</td>
</tr>
<tr>
<td>10.</td>
<td>Check up Air Pressure gauge</td>
<td>1. Main reservoir gauge,</td>
<td>Normal value – 7.0kg/cm²</td>
</tr>
<tr>
<td></td>
<td>Readings to check Functioning of gauges</td>
<td>2. Control pressure (B.P. pressure) gauge</td>
<td>Normal value 5.0 kg/cm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Equipment reservoir pressure gauge</td>
<td>Normal value 4.8 kg/cm²</td>
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<td></td>
<td></td>
<td>4. Emergency reservoir gauge</td>
<td>Normal value – 6.3kg/cm²</td>
</tr>
<tr>
<td>11.</td>
<td>Check up Air pressure of brake blocks</td>
<td>1. Check up Air pressure for cast iron brake blocks( B.C. pressure)</td>
<td>Normal value – 3.5kg/cm²</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Normal value – 1.5kg/cm² and 2.0 kg/cm² for motor</td>
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<tr>
<td>12.</td>
<td>Pantograph</td>
<td>1. Check up raising time 6-10 sec.</td>
<td>驾驶室</td>
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<td></td>
<td></td>
<td>2. Check up lowering time 3-11 sec.</td>
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<td>13.</td>
<td>Check up working of :-</td>
<td>1. Driving Cab</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(i) Wind screen wipers</td>
<td>1. Driving Cab</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) Horns</td>
<td>1. Driving Cab</td>
<td></td>
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<tr>
<td></td>
<td>(iii) Alarm Bell</td>
<td>1. Motor Coach “B”</td>
<td></td>
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<tr>
<td></td>
<td>(iv) Signal Bell</td>
<td>1. Driving Cab</td>
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Coaches respectively with composite brake blocks.
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<td>14.</td>
<td>Check up function of Lights and Fans:</td>
<td></td>
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</tr>
<tr>
<td>(i)</td>
<td>Head Lights</td>
<td>1. Driving Cab</td>
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<td>(ii)</td>
<td>Tail Lights</td>
<td>1. Driving Cab</td>
<td></td>
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<tr>
<td>(iii)</td>
<td>Head Code Lights</td>
<td>1. Driving Cab</td>
<td></td>
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<tr>
<td>(iv)</td>
<td>Compartment Lights</td>
<td>1. Motor Coach “B”</td>
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<tr>
<td></td>
<td>Light Normal</td>
<td>2. Trailer “A”</td>
<td></td>
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<td></td>
<td>and Emergency</td>
<td>3. Trailer “D”</td>
<td></td>
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<tr>
<td>(v)</td>
<td>Cab Lights</td>
<td>1. Motor Coach “B”</td>
<td></td>
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<tr>
<td></td>
<td>Compartment Lights</td>
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<tr>
<td>15.</td>
<td>Sequence and Inter lock tests:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A)</td>
<td>On power</td>
<td>1. Trip NFABB and see if ABB trips.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Open reverser bos and earth on reverser terminal with the special insulated test rod and see if RFN sets and ABB trips see for the flag indication.</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>3. Press panto lower switch and see ABB trips first (ON L.T.)</td>
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<tr>
<td>(B)</td>
<td>L.T. test</td>
<td>1. Close E.A.S.</td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Operate silicon Switches</td>
<td>1. Only one bridge see if blue lamp glows</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rectifier Trip</td>
<td>2. Two bridge see if CBAR picks up and indicating lamp glows.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Manually operate OLP, OL5,OL6 , FERA2, BIR relays and see if ABB trips.</td>
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</tr>
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<td></td>
<td></td>
<td>4. Manually operate TSS and see if ABB trips</td>
<td></td>
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<td></td>
<td></td>
<td>5. Manually operate (a) OL1, OL2 and see if M-1 and M-2 trips (b) OL3, OL4 and see if M-3 and M-4 trips.</td>
<td></td>
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<td></td>
<td></td>
<td>Manually operate AOV R and see if progression is affected</td>
<td></td>
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6. affected during full power
7. progression is affected
16. Check functioning of relays and trip switches

Manually operate CLR1 and CLR2 and see if...
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<td>17.</td>
<td>Final check up after inspection</td>
<td>1. Visually examine roof equipment Panto ABB Other Equipment 2. Visually examine underframe 3. Check up brake application and proper release of brake 4. Check motor cut out switches to see whether all the traction motors are “Cut in”. 5. Check indication bulbs</td>
<td></td>
</tr>
</tbody>
</table>

Name of worker______________________  Signature of worker__________________  Section Supervisor’s Remark and Signature__________________  Dated__________________

Remarks and

Signature__________________  Dated__________________

PPO Supervisor’s

Dated__________________
FIG. 4.04 VACUUM BRAKE EQUIPMENT YAU1 EMU

1. DUMMY COUPLER
2. HOSE COUPLING
3. GRARD'S EMERGENCY BRAKE VALVE
4. DUPLEX VACUUM GAUGE
5. DRIVER'S VACUUM BRAKE
6. MASTER CONTROLLER
7. DEAD MAN'S VALVE
8. NON-RETURN VALVE
9. DEAD MAN'S RELAY VALVE
10. GOVERNOR FOR VACUUM BRAKE
11. LAP VALVE
12. SNIFTER VALVE
13. BRAKE CYLINDER
14. EXHAUSTED
15. SILENCER
16. VACUUM CHAMBER
# CHAPTER V

**OPERATION OF ROLLING STOCK**

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CHAPTER V
OPERATION OF ROLLING STOCK

30500 Divisional Organization

Senior Divisional Electrical Engineer /Divisional Engineer (Operations) assisted by junior officer / officers is responsible for operation of Electric locomotives and Multiple Units in a division.

30501 Duties of Chief Traction Foreman-Running (CTFR)

In addition to overseeing work of the ATFR, he will

1. exercise overall day-to-day control over staff incharge of electric loco operation and outstation maintenance;

2. ensure day to day availability of electrical running staff for train services and exercise control over the booking of such running staff;

3. arrange supply of uniforms, rule books consumable stores and tools to the running staff;

4. arrange periodical vision tests of running staff as prescribed and maintain records for the same;

5. maintain ‘Road Knowledge Register’ for running staff and ensure that no person is booked to work a train until he has thoroughly learnt the road and has signed a certificate that he is fully acquainted with the road;

6. investigate and report cases of time lost on loco account whenever reported by the Traffic Controller; depute Driving Inspector whenever required to investigate and collect more details as required

7. educate staff under his charge on safety rules and test their knowledge of such rules;

8. arrange relief of running staff as required for refresher courses and other training schemes;

9. ensure upkeep of running rooms so as to ensure that staff get adequate rest in the running rooms and are satisfied with the same this may involve liaison with other departments;

10. arrange for outstation inspection of locomotives in accordance with the instructions laid down; also carry out minor repairs at outstation depots to the extent feasible;

11. arrange drawal, distribution and accountal of stores and tools required for outstation maintenance of electric locos and ensure that the prescribed tools, equipment and log books are available in good condition on the locos;

12. exercise control and maintain liaison, with operating department over terminal detention in the yards viz. turn-out of locomotives in time for working trains and timely availability of the staff;

13. investigate and report irregularities and signal defects noticed in train working and reported by running staff;
14. ensure that the Combined Driver's and Guard's Report are received back after return of the crew to HQ.;

15. scrutinize forms submitted by driving staff to the Statistical Branch;

16. arrange adequate representation in minor joint inquiries in regard to accidents, detentions etc.

17. accompany relief trains in case of accidents involving electric rolling stock and supervise relief operations at site;

18. ensure that the speedometer charts are regularly sent to loco Inspector (TELOC) sitting at Divisional headquarters-100% for passenger locos and 25% for goods loco, and take appropriate action in regard to the irregularities. (A suitable cell may be set up for this purpose). After removal the charts may be preserved at least for a week;

19. arrange to ensure filling of dry sand in sand boxes of locos and EMUs and availability of dry and clean sand as per RDSO specifications at all places nominated by Sr. DEE/DEE(OP).

30502 Duties of Assistant Traction Foreman - Running (ATFR)

ATFR will

1. ensure that the staff reporting for duty are sober and not under the influence of alcoholic drinks. All incoming staff will be subjected to breath-analysis before being allowed to perform the duty.

2. ensure that all running staff possess the valid competency certificates.

3. display of temporary speed restrictions in prominent manner at the booking offices.

4. notify the driver regarding existence of Short Neutral Section to avoid raising of both pantographs.

5. arrange relief for running staff whenever asked for by the Traction Loco Controller (TLC) to avoid running staff performing more than the prescribed hours of duty at a stretch.

6. ensure that the outgoing locos / EMUs are provided with full complement of tools, emergency telephones, fire extinguishers and other essential consumable stores.

7. ensure filling of sand in sand-boxes of locos and EMUs and availability of dry and clean sand at all outstations and booking points.

8. investigate and report cases of time lost on loco account whenever reported by the Traffic Controller; depute Driving Inspector whenever required to investigate and collect more details as required.

9. arrange inspection of incoming and outgoing locomotives at the “bhar’ coordination with the maintenance staff that booked repairs are carried out.

10. report to TLC the details of locos to be attended to at outstation sheds and the defects which require attention at shed; the cases of unusual occurrences should also be reported.

11. prepare position of issue and return of Combined Driver's and Guard's report in the proforma at Annexure 5.01

12. ensure that the staff are availing adequate rest at headquarters and outstations.
13. ensure proper upkeep of "sign ON" and "sign OFF" register and see that every running staff reporting for duty in his office signs in this register.
14. supervise call boy and Box Porter and instruct them suitably for calling the crew and sending the boxes respectively.

30503 Loco Control Organization

Personnel manning the TLC Organization should be adequately trained. In addition they should be sent for refresher courses to the Training Schools and Sheds periodically as specified to keep themselves familiar with the current problems on locos so as to be able to guide loco crew effectively.

30504 Duties of Assistant Traction Loco Controller (ATLC) & Traction Loco Controller (TLC)

ATLC / TLC will
1. maintain a list of passenger fit locos and watch the running of passenger Trains, report after necessary investigation all cases of time lost on loco account as well as time made up by drivers;
2. plan in consultation with the PPO of the shed and move, the locos to the shed for scheduled inspections and unscheduled repairs and obtain forecast of locos likely to be made fit by the sheds and plan the movement of such locos for clearing traffic, in coordination with the Traffic Controller;
3. watch the detention to electric locos as well as, electrical running staff in yards and, Sections and take remedial action in coordination with the traffic Controller;
4. maintain liaison with contiguous divisions in respect of "balancing" of crews;
5. watch train operation in order to avoid excessive waiting duty for running staff and take remedial action as required in coordination with the Traffic Controller;
6. guide staff in trouble shooting if they are stuck up on line;
7. send back to the homing shed of foreign Railway loco due to scheduled inspection;
8. study cases of running staff performing more than prescribed hours of duty at a stretch and take necessary remedial action to avoid recurrence;
9. Prepare the locomotive charts.

30505 Duties of Chief Loco Controller (CTLC)

In addition to overseeing the work of ATLC/TLC he will
1. check of loco link charts, booking records and control charts and report all cases of avoidable detentions to electric locomotives in yards and sections;
2. update the list of speed restrictions and advise different crew booking points on the division:
3. organize suitable relief loco in consultation with Section Controller in case of loco disablement;
4. scrutinize daily loco operating statistics;
5. organize trials of electric locomotives;
6. arrange escorting staff for trains carrying VIPs and other important trains as per procedures specified by the Railway.

30506 Duties of Driving Inspectors

The Driving Inspectors will report to CTFR and their main duties will be as given in subsequent paragraphs.

30507 Duties of Junior Driving Inspector (JDI)/Senior Driving Inspector (SDI)

He will

1. plan out in advance that train drivers and other running staff put under their charge 'learn the road' and become fully familiar with all the signals and layout of the track, en route and in yards; test the running staff for their knowledge of road as detailed in para 30615 and arrange for issue of Competency Certificate to them;

2. train running staff in the correct methods of trouble-shooting, correct manner of operation of electric locomotives, inspection of locomotives in accordance with the prescribed rules;

3. maintain records in respect of running staff allotted to his charge indicating the training imparted, refresher and promotional courses gone through, knowledge of safety rules, knowledge of trouble-shooting procedures etc.; watch running staff of poor calibre with a view to improve them and in exceptional cases when a person fails to make the grade, submit report to TFR;

4. make himself fully aware of the competence of each of the crew under his control. He should also be familiar with their habits, like drinking etc., traits, state of health and other personal problems. It is the responsibility of driving inspector to ensure that he has counselled all the crew under his control at least once a month. For this purpose he will maintain a proper calendar /diary;

5. keep high morale of the driving crews and keep on reporting about the same to superiors;

6. conduct enquiries into accidents, detention cases, disciplinary cases, etc., as directed by his supervisors;

7. carry out any other duties assigned by Sr. DEE/DEE/AEE(OP).

30508 Duties of Senior Loco Inspector (SLI)

In addition to the duties assigned by Sr. DEE/DEE/AEE (OP), he will

1. carry out trials and checks on speed, signal visibility, riding quality of locomotives; test staff of other departments as prescribed for their knowledge of rules applicable to operation of Electric Locomotives and report to SR. DEE/DEE/AEE(OP), if any irregularities are noticed;

2. inspect locomotives particularly in regard to safety items and take necessary action to get the defects attended by the home or outstation shed.

A nominated loco Inspector designated as Senior Loco Inspector (TELOC) will collect and scrutinize the speedometer charts regularly- 100% for passenger locos and 25% for goods locos and bring irregularities to the notice of Sr. DEE/DEE/AEE(OP) for appropriate corrective action.

The assigned SLI shall keep a watch on duty hours of the Running Staff and report the matter to Sr. DEE/DEE/AEE (OP) for taking suitable corrective measures.
1. All running staff are required to be periodically examined to ascertain their fitness in A-1 medical category and other special prescribed tests, if any. Running staff who are below 45 years of age are required to be examined once in 3 years and those who are over 45 years are required to be examined, once a year. At the headquarters station of the running staff, a register as per proforma placed below should be maintained to record particulars of periodical medical examination:

**VISION TEST REGISTER**

(Category of staff i.e. Driver /Asstt Driver /Motorman)

<table>
<thead>
<tr>
<th>SNo.</th>
<th>Name</th>
<th>Date of Birth</th>
<th>Date of examination</th>
<th>Medical category</th>
<th>Certificate No.</th>
<th>Next Due Date</th>
<th>Whether passed with spectacles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

2. Separate registers will be maintained for each category of running staff. No member of the running staff should be allowed to become overdue vision test, and any person who is overdue vision test should not be booked out on running duties. If during the periodical medical examination a person is declared unfit for A-1 medical category he should be forthwith withdrawn from running duties.

3. On transfer from another section, particulars of last medical examination should be obtained and entered in the Vision Test Register before the employee is booked out for running duties, including road learning.

**30510 Running Staff Passed Fit with Spectacles**

1. A list of Drivers, Assistant Drivers, Shunters and Motormen who have been declared fit for A-1 category with glasses should be prepared with the names of staff of each category arranged separately and in alphabetical order. This list should be exhibited prominently in the booking office for each category of staff, who are likely to be booked from his station. The TFR should ensure that this list is complete and updated in all respects. For this purpose he should make 100 percent cross check of all the names in the list with details entered in the Vision Test Register at least once in six months.

2. Each member of the running staff who is declared fit for A-1 category with glasses must constantly use, glasses on duty and in addition should carry a spare pair of spectacles with them always when on duty. During Inspections, check should be exercised by officers and supervisors to ensure compliance.

3. Running staff passed fit with spectacles are also required to sign a ‘Spectacle Register’ on reporting for duty in token of being in possession of two pairs of spectacles.

**30511 Rules Applicable to Running Staff**

The General Rules and the Subsidiary Rules issued by the Zonal Railways prescribe the duties of train crew. Running staff will also be abided by all the rules given in Operating Manual of Zonal Railways about their call, booking and liability for duty, etc.

**30512 Acknowledgment of Circulars etc.**

In addition to thorough familiarity with the General and Subsidiary Rules, Rules, Manual of AC Traction, Accident Manual, Working Time Table (in particular the permanent speed restrictions), Operating Manual for various types of electric locomotives and departmental circulars issued from time to time, every member of the, running staff shall, when signing on duty, study circulars, notices, instructions, copies of the Gazette etc. displayed on the
notice board or in the registers provided for the purpose. They shall particularly acquaint themselves with details of temporary speed restrictions imposed in the section in which they have to work, details of caution orders and advice of defective signals. If any person has not understood any of the instructions, he may seek clarification from the ATFR on duty.

30513 Availability of Dry Sand

All electric locos and EMUs are fitted with sanding equipments to improve adhesion and prevent wheel-slipping when starting under difficult conditions e.g. up-gradients or when rails are wet. Sanding is effected by means of electro-pneumatic valves to sand the front axles of each bogie in the direction of motion, the control being achieved by a pedal switch in each cab. Means are provided to adjust the height of the sanding nozzles. In modern locos automatic sanding takes place on the onset of incipient slipping.

The sand to be used should not cake in the sand box and should be dry, free from clay, loam, mica and other foreign materials. A detailed specification for the sand has been issued by RDSO. Facilities should be available in all loco sheds and such outstation depots as considered necessary for ensuring an adequate supply of screened and dry sand. Special care is also required during inspections to ensure the water-tightness of sand box covers.

30514 Seasonal Precautions

1. A few essential precautions required to be taken prior to the commencement of the monsoon, pre-summer season and pre-winter season are listed below. Local instructions may be issued to supplement these lists as required.

2. The pre-monsoon precautions

   a) Test the water-tightness of loco/EMU body including roof by means of a high pressure water jet and seal all leakage points. (It must be ensured that the loco / EMU is well away from live OHE to prevent the water jet coming into contact with live wires).

   b) After the first rain the loco /EMU should be Inspected thoroughly to detect and attend to leakage points. Special attention should be paid to the following water leakage points -

      i) Body joints
      ii) Joints of the mounting bases of the roof equipment.
      iii) Joints of marker lights.
      iv) Joints of look-out glasses and side glasses.

      v) Door gaskets.

      vi) Sand-box joints.

      vii) Roof gaskets.

      viii) Head light gaskets

   c) The wind-screen wipers should be tested and attended to.

   d) Roof joints with super-structure-roof gasket should be in good fettle.

   e) Joints of side body filter with super structure.
f) Ensure cleanliness of roof gutter.
g) Proper functioning of sanders should be ensured.

3. The pre-summer precautions:

a) Clean all filters and check depression with a water manometer to ensure that the cleaning has been thoroughly done.
b) The loco interior should be thoroughly cleaned of any accumulation of oil and dust.
c) Axle boxes should be thoroughly examined.
d) Drivers must be alerted to feel the axle boxes as often as possible.
e) Fans in the driver's cabs should be attended to.
f) Relay covers are properly provided and sealed to avoid ingress of dust.

4. The pre-winter precautions:

a) Heaters: It should be ensured that all the four cab, heaters are in working order
b) Window Shutters: The window shutter sealing gaskets should be checked and made air tight.
c) Doors: Ensure that cab doors and corridor doors locking handles are in working order. The door sealing gaskets should be held tight in the position.
d) Cab Ventilators: Ventilator cover sealing should be perfect.
e) TFP: Main power transformer and Tap changer breather silica-gel condition should be checked and replaced if necessary. Oil levels in TFP & GR to be checked and oil tested for DE.
f) Oil Baths: Main compressor and exhausters oil baths should be checked and oil replaced, if necessary.
g) Sanders: Sand boxes should be checked: wet sand removed and dry sand filled.
h) Traction Motors: TM inspection cover sealing gaskets should be checked to ensure that there is no air leakage
i) Pantograph: The servomotor of pantographs should be drained off and regrease. Roof and panto insulators should be applied with a coat of silicone grease
j) SMGR: Tap changer servomotor cylinders should be cleaned and regrease.
k) Battery: Terminals should be checked for sulphation, cleaned and petroleum jelly applied on the terminals.
l) Brake cylinder: Adjustment should be carried out and regreasing done.
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<th>Desig.</th>
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<th>Ticket No. &amp; dt. of return</th>
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### CHAPTER VI

**OPERATION OF LOCOMOTIVES**

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OPERATION OF LOCOMOTIVES

30601 Trailing Loads Assigned to Various Locomotives.

1. The trailing loads assigned to various types and classes of locomotives will be governed by the Load Chart issued by RDSO. (refer Annexure 1.03). These loads are worked out taking the theoretical site condition and the track geometry specified in the drawings. Actual site condition and the track geometry may differ. The ruling gradient of the section may differ from the declared grade and the section may have curves, the radius of which may be different from the radius taken in the calculation of the assigned load. Further, partial brake binding, capability of an average driver combined with adverse weather condition may affect the actual load that can be hauled by a locomotive in a particular section. Therefore, before the loads of a particular class of locomotive are fixed for various sections, the actual trials with specified loads on these section should be carried out. The trial would ensure the ability of the locomotive to start and haul the nominated load on the ruling gradient.

2. For multiple operation, separate trials should be carried out with 2, 3 or 4 locos in multiples as required in actual operation. These need not be exact multiples of loads with a single loco, since the sharing of loads by the locos may not be equal due to various manufacturing tolerances, varying wheel diameters etc.

3. The nominated loads both for single and multiple operation should be determined for each section, loco class-wise and tabulated.

4. Loads for each section with multiple operation should be given in the table as mentioned above and also when the motors or pairs of motors have been cut out.

5. The loads will be fixed section wise for each class of locomotive by CEE in consultation with COM.

30602 Time Tabling and Loco Link Diagrams

To achieve maximum utilization of locomotives, loco link diagrams should be prepared in such a manner that the locomotives are kept on the run for the maximum number of hours each day with the minimum detentions at terminal stations. This work has to be done by close co-ordination between Sr DOM/DOM and Sr DEE(OP)/DEE(OP).

30603 Assessment of Operating Staff for Electric Locos.

1. For mail, express and passenger services running staff links are prepared based on the time table and keeping in view the prescribed minimum rest to be given at out-stations and headquarters station. This will give the bare number of sets of running staff required. Each set will consist of one grade A Driver and one Assistant Driver. For Rajdhani/Shatabdi Expresses or other high speed trains the assessment of crew will be modified suitably since the function of Asstt. Driver are performed by a Co-driver booked to assist the train driver.

2. Requirement of running staff for goods services is arrived at on the basis of the "turn-round" method. The turn-round of a Driver is "signing on time" to "signing off time" and includes waiting duty at both ends.

- The average turn-round time 'T' hours for a Driver is equal to average time from signing on at the starting station till commencement of journey plus average journey time plus average time from arrival at destination to signing off.

- If there are N trains to be run per day, the total Driver hours per day will be equal to Tx N hours.
At an average of 104 hours of duty for 14 days per driver, the number of drivers required will be \( \frac{TxN}{104/14} \).

Each set of staff to operate goods train will consist of a grade ‘B’ or ‘C’ Driver and one Assistant Driver.

3. The detailed procedure for assessing the Running Staff requirement has been given in Operating Manual of Zonal Railways. Running Staff requirement and its review shall, therefore, be carried out as per instructions laid down in that Manual.
   a) leave reserves in the appropriate category as per prescribed percentages;
   b) special and non-scheduled trains;
   c) loco shed working;
   d) overlapping crew at out stations;
   e) relief crew en route;
   f) trainee reserve in the prescribed category;
   g) other special duties.

30604 Duties of Electric Loco Drivers
In addition to the duties laid down for Drivers in Chapter IV Of General and Subsidiary Rules, Drivers shall be responsible for the following:

1. On taking over, a driver must study the log book and inspect the locomotive / EMU as laid down in the Operating Manual of the particular class of loco. If he finds any abnormality, he shall work in accordance with the instructions laid down in the Operating Manual.

2. When looking out he shall pay particular attention to the state of OHE of his own line & lines in proximity.

3. While examining the under-gear or attending to any part of the under-gear he shall keep the brake of the train (or in the case of a light engine the locomotive brakes) fully 'ON'.

4. Before examining or carrying out any work on equipment in the high tension compartment, he must lower the pantograph and earth the locomotive in accordance with prescribed instructions.

5. The driver shall not permit any un-authorised person to travel in any cab or corridor of the locomotive. Apart from the engine crew, only authorized supervisors of the traction branch and those specifically authorize in writing by Sr. DEE/(OP), DEE(OP) shall be allowed to travel in any of the cabs of the electric loco. When working the train, the Driver shall not enter into discussions or conversation with persons travelling in the cab.

6. The Driver shall ensure cleanliness of the locomotive. He may make use of Asstt. Driver.

7. The Railways may issue special instructions locally for the checks to be performed by the drivers/assistant drivers on the locomotives when the halt at a station exceeds 10 minutes. This will depend upon the nature of the section and severity of the service.

8. In the event of any abnormality on the run, he shall carryout the instructions in the Operating Manual of the locomotive. He shall also keep a detailed record of unusual occurrences or abnormalities experienced and submit

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report in the prescribed proforma to the TFR. If he is unable to localize and repair any fault on line, he shall make use of the emergency telephone to seek the advice of TLC.

9. The Driver / motorman shall keep a special watch on the pantograph of his own train as well as passing electric trains and report any abnormality as soon as possible to TPC/TLC. If he notices any serious defect in the pantographs which are likely to cause damage to OHE, he shall stop the train forthwith and convey details to the TPC/TLC on duty.

10. He will report any speed restriction if put near the Neutral Section which is likely to result in stalling of train in the dead zone.

11. Before signing ‘off’ duty, the Driver shall submit reports as prescribed by local instructions including any abnormality in signals, speed restrictions and trains along with the unusual occurrences observed in the locomotive during trips worked by him to ATFR.

12. He will report for duty with a neat appearance in proper uniform.

13. He will perform any other duty assigned to him from time to time by ATFR.

14. The driver shall exchange signals enroute with assistant driver, station staff and guard of the train as specified in GR & SR.

30605 Duties of Assistant Drivers

In addition to the duties laid down in Chapter IV of the General and Subsidiary Rules, the Assistant Driver shall be responsible for the following:

1. Cleanliness of the locomotive.

2. During the run he shall examine the following items from time to time:

   a) Battery / generator voltage.
   b) Charging current
   c) Transformer oil level and temperature.
   d) oil level in compressors and exhausters.
   e) Functioning of blowers and auxiliaries.
   f) Target indicator of relays.

3. Assistant Driver shall assist the Driver to enable him to carry out instructions as detailed in para 30604 and sub-para 4 of 30634. He shall also watch out for any unusual smell or abnormalities.

4. He will report to duty with a neat appearance and proper uniform

5. He will perform any other duty assigned to him by the Driver and ATFR.

6. For Rajdhani /Shatabdi Express or similar high speed trains the functions of Asstt. Driver will be performed by the Co-driver provided to assist the train driver.

7. He will assist the driver in attending any irregularities on line like ACP, HPD etc.,

8. He will ensure draining of cocks to expell moisture whenever the train stops for more than 15 minutes.
9. He will be responsible for maintaining a log of times and detentions enroute.

10. He will exchange signals with driver, station staff and guard of the train as per instructions laid down in GR and SR.

30606 Checks by Driver on Taking Over
Every time a locomotive is taken over from a shed after scheduled inspection or repairs or from a stabling line after maintenance or repair work has been carried out, it is the responsibility of the Driver to check and ensure that the locomotive he has taken over is fit and safe in every respect for service on the line. He shall operate it with due care taking personal interest in its upkeep. He shall also make a note of the defects observed in operation and report them to the maintenance officials for attention.

30607 Cleanliness of Loco
The Assistant Driver is responsible for the cleanliness of the driving desk, cab, look-out glasses and glass windows during preparation before departure, changing of crew and inspection on arrival. The maintenance staff who carry out the scheduled inspections are responsible for the cleanliness of HT room, cubicles and corridors. The washing gang at the home shed is responsible for the cleanliness of the roof and body sides during every washing schedule. In particular care should be taken to keep the interior of the loco quite clean. Oil drippings should be cleaned out and leaky valves attended to at the earliest possible opportunity to eliminate fire hazards.

30608 Unauthorised Persons in the Loco
No person shall be permitted to enter any locomotive or to handle any apparatus contained therein unless he has been authorised to do so by the Sr. DEE/DEE/(OP).

Only Drivers certified for electric locos must be allowed to drive the locomotives. The Driver must not allow any one to enter any of the driving compartments, other than those who are authorised to do so under the rules or hold a permit issued by Sr DEE/DEE/(OP).

Normally not more than three persons other than running staff will be permitted to travel in the cab.

A Driver who is off duty is not permitted to enter or travel in any of the driving compartments unless authorized by TLC and that too for travel towards headquarters after being relieved en-route. This will be permitted only in the non driving cab/cabs.

30609 Interference with Equipment.
Drivers and Assistant Drivers will not tamper with the measuring instruments, speed recorder and protective relays. Relays or other sealed equipment should not be opened or wedged except as authorized in the trouble shooting manual. If a driver opens a relay or breaks the seal of any equipment, full particulars should be noted in the loco log book. Particular care is also necessary while putting back metallic covers of relays to avoid inadvertent shorting of live terminals.

30610 Checks on the Run by the Driver
On the run, the Driver shall be primarily concerned with keeping a sharp look-out for signals and watching the road. However, he should, from time to time, keep an eye on the vacuum and pressure gauges, the voltmeters and ammeters as well as the speedometer and notch indicator, to assure himself that everything is in order.

Apart from keeping a close watch of signals ahead, and signals from the Guard, the Assistant Driver shall keep a special watch on the battery voltage and the battery current. In addition as often as possible, he shall check the working of the blowers and keep a watch on the transformer and tap changer oil level.

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The Assistant Driver should not normally leave the driving cab to inspect the equipment in the corridors when the train is approaching a station or at locations where speed restrictions exist.

30611 Change of Locomotive Crew at Stations

The relieving Driver should make a general inspection of the underframe, drain the main reservoir and feel by hand the axle boxes and motor bearings to make sure they are not hot, before entering the cab. The relieved Driver shall acquaint the relieving Driver about any abnormalities noticed during the preceding run. The relieving Driver shall note and initial the entries in the log book. The relieving Assistant Drivers should take over the loco tools.

30612 Service Troubles on Line

Every locomotive Driver is expected to be fully trained to deal with troubles which may be experienced while a locomotive is on the run. Drivers should keep themselves fully conversant with fault finding procedures so that they are able to identify the fault, isolate it, give first aid attention to the equipment to keep the locomotive functioning, until it arrives at the next station. The Driver may consult the Operating Manual for the type of loco where necessary to refresh his memory.

Should a locomotive fail completely and the Driver is unable to start it on his own, he should seek the help and guidance of the Traction loco Controller by plugging the portable telephone set to the nearest emergency telephone socket within 20 minutes.

30613 Entering Equipment Compartment

If the Driver or Assistant Driver has to enter the equipment compartment of a loco he should take care to see that the cab doors and drop windows on both sides are closed before opening the corridor door, to prevent dusty air being drawn into the equipment compartment.

30614 Driver's Duty when Stabling a Loco

When stabling a loco in the loco shed or a stabling line, the Driver assisted by the Assistant Driver shall carry out the following operations:

1. Drain all reservoirs.
2. Ensure that the emergency reservoir is charged to the specified pressure and then close the isolating cock of the emergency reservoir.
3. Trip the circuit breaker.
4. Lower the pantograph and check that it is fully lowered.
5. Open the battery main switch.
6. Put on the hand brake.
7. Close all doors and windows.
8. Enter in the loco log book the kilometre reading, particulars of the last trip, of any defects or abnormalities to be attended to, any unusual occurrences during the previous trips and any other particulars required in accordance with local instructions.
9. Hand over the log book and keys of the loco in the TFR/ ATFR's office before signing off.

When a locomotive is stabled on a pit line, the Driver shall also carry out under-gear and roof Inspection in
accordance with detailed instructions in the Operating Manual for the type of loco and make necessary remarks in the log book.

30615 Knowledge of Road

1. Every Driver (as well as Assistant Driver, and Shunter) shall have a good knowledge of the section before he is allowed to work a train in the section. He shall be fully conversant with the maximum permissible speeds, gradients and landmarks on the section, the block and non-block stations on the section, type and location of each individual signal and the line referred to by each signal, the speed restrictions to be observed and neutral sections. For learning road as mentioned above, he should be allowed a period of training at the end of which he shall be orally tested by the Driving Inspector. He should also sign a declaration stating that he is fully conversant with the road. The declaration should be witnessed and countersigned by the Driving Inspector and scrutinized by the officer concerned before issue of the Certificate of Competence.

2. When a Driver, Assistant Driver or Shunter has been absent from duty for a continuous period of six months, he shall not be permitted to work a train until he has again learnt the road and his Certificate of Competency revalidated after oral examination by the Driving Inspector and a fresh declaration. The period of six months prescribed above may be reduced, if necessary, by local instructions issued by Sr DEE(OP) /DEE((OP). These instructions shall be equally valid if the driver did not have the opportunity to work on the section whatsoever be the reason. However, in extreme emergency such a driver can be permitted to work the train with a pilot driver who is conversant with the road.

3. Road Knowledge Registers shall be maintained for all sections on which running staff headquartered at a particular shed are required to work trains. Separate registers should be opened for each individual section and each category of staff. The register should be in the following proforma:

ROAD KNOWLEDGE REGISTER
(Section ... to ....)

<table>
<thead>
<tr>
<th>SNo.</th>
<th>Name of Driver/ Asst Driver (or Motorman)</th>
<th>Signature in token of possessing necessary road knowledge on section concerned</th>
<th>Date of signature of Driving inspector</th>
<th>Signature of the ATFR</th>
<th>Signature of TFR/</th>
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30616 Speed Restrictions

1. Drivers and Assistant Drivers must be fully conversant with permanent as well as temporary speed restrictions. Permanent speed restrictions are indicated in the working time table.

2. Temporary speed restrictions will be made known to the running staff at their booking office as under:

a) Every Driver should study "Temporary Speed Restrictions" bulletin issued by the Division and sign
the prescribed register in acknowledgment of having read and understood the same.

b) Temporary speed restrictions imposed by the Engineering, Signal and Electrical Departments are communicated to the running office through messages and are displayed on the notice boards at the booking points.

c) Caution orders as prescribed in the General and Subsidiary Rules will be issued for all temporary speed restrictions.

30617 Driver's Personal Equipment

While working a loco every Driver must have with him the following personal equipment -

1. Driver's personal log book.
3. Operating Manual Part II for the type of Loco. (Trouble Shooting Directory)
4. General and Subsidiary Rules Book
5. General and Subsidiary Rules for 25 kV ac Traction.
6. Working Time Table.
7. Watch in good working order
8. Screw driver 150 mm one
9. Adjustable wrench 150 mm one
10. Driver's pocket book
11. Torch
12. Hand signal lamps*
13. Red and Green flags*
14. Detonators* - 12 Nos
15. Washers - 5 Nos
16. MU Washers - 2 Nos.
17. Teflon tape - 2 m.
18. Any other items prescribed under local instructions.

Items marked * are sometimes made part of loco tools and equipment referred to in para 30619.
30618 Personal Effects to be Carried by Assistant Driver

While working a loco, the Assistant Driver shall carry the following personal tools and equipment:

1) Red and Green flag - one each
2) A rough journal book
3) A watch in good working order
4) Working Time Table
5) A duster
6) A torch
7) Asstt Driver's log book

30619 Tools and Equipment in Locos

1. Tools

Each electric loco when on line shall carry the following tools in a locked tool box or tool locker to be issued to the Driver:

i) Cotton rope 2 m long for Panto
ii) Wooden blocks
iii) Monkey wrench
iv) Vacuum hose pipe
v) Air hose pipe
vi) Screw coupling
vii) Chisel
viii) Hammer
ix) Headlight bulb
x) Marker light bulb
xi) Pilot lamp bulb
xii) Spare fuses of different sizes
xiii) Halon fire extinguisher

2 of 4 kg each or 4 of 1.25 kg each.
2. Equipment

The following equipment depending upon the type of locos will be issued to the Driver on taking over a loco or may form part of loco equipments -

i) Loco Keys - BL Key, Panto Selection Key and, Reverser key

ii) Portable Telephone

iii) Hand brush

iv) Loco log book

30620 Loco Log book

1. A separate log book is required to be maintained for each individual loco. It will be issued to the Driver along with the tools of the loco and will be returned by him to the Running office when signing off or handed over to the relieving Driver. The Log Book will have machine numbered pages.

2. For each trip the Driver should enter the following particulars -

i) Date

ii) Train Number

iii) From................To. .................

iv) Load of train (in terms of vehicles)

V) Driver's and Asstt. Driver's name

Vi) Brief description of unusual occurrence and failures, if any.

vii) Kilometre reading at the end of trip.

viii) Energy meter reading to be recorded if meters are provided,

ix) Quantities of oil and lubricants added during inspections.

3. The details of repair carried out should be entered to by the PPO of the shed or the TFR/ ATFR before the loco leaves the shed.

4. Running and Shed supervisors will also enter in the log book particulars of any item to be specially watched by the Driver.

5. At '0' hours on the last day of each month the corresponding kilometre reading should be entered in the log book by the Driver if the loco is in service and by the shed/ depot supervisor if the loco is under repairs or is stabled.

6. Every time a loco is taken for the scheduled inspection, the type of inspection and the date on which it is done should be entered in the log book by the PPO. PPO will similarly enter details of unscheduled withdrawals of the loco for repairs, as well as particulars of modifications carried out.

7. Completed loco log books should be serially numbered for each loco and preserved in the Planning and Progress Office for a period of one year.
8. Officers and supervisors of the Rolling Stock section, during their cab inspections, will also record their observations regarding performance of the loco in the log book.

30621 Driving Crew’s Pocket Books

Every Driver and Assistant Driver will be provided with a pocket book to be carried by him while on duty to enable Inspectors and Officers to record their observations regarding his working as noticed by them during their cab inspections. This book should have machine numbered pages. All entries should be in ink. Erasers or alteration of the entries made or tearing off of pages will be viewed as serious misconduct by the crew.

30622 Detailed Preparation of Locomotives

The operations listed for a particular type of locomotive should be carried out in the sequence indicated, every time a locomotive is taken over from a shed or from a stabling line. These operations should be carried out from the driving cab. The preparation schedule presently adopted is detailed below.

1. Preliminary Check: Make sure that the loco is stabled on a wired track. Check the air reservoir drain cocks, and close if found open. In locos meant for multiple operation, check tightness of electrical couplers, air hose pipes and vacuum hose pipes and if standing on a pit he should carry out under gear examination.

2. Energization of Control Circuit: Check the relay targets and condition of fuse-free breakers (MCBs).

Check the following:

i) Battery voltage

ii) After unlocking the lever box for auxiliary switches, see that the indication lamps for air blast circuit breaker (red), battery charging generator (green), tap changer (blue) reverser (yellow), rectifier (white) and for wheel slip (red) are glowing and the tap changer notch indicator is in position '0'. In some locos a push button is required to be pressed to check rectifier and wheel slip lamps. In some locos the pilot lamps have been replaced by LEDs. The driver should ensure that the corresponding LEDs are glowing.

iii) That all fuses are in position on the fuse rack and/or all fuse-free breakers are switched 'ON' and spare fuses are in good condition.

iv) That the earthing switch for control circuits is in 'ON' position.

v) That the oil level of tap changer and transformer motor is normal.

vi) That the auxiliary isolating switches motor cut out switches and earth fault shunting switches are normal.

vii) That the drain cocks for air blast circuit breaker and pantographs are closed.

viii) That the isolating switch/isolating handle for tap-changer operation is normal.

ix) That the earth-fault isolating switches for traction circuit and auxiliaries circuit and their relays are in normal position and the switch for pressure relay for main circuit breaker is normal. If an isolating switch is not in the normal position, check the locomotive log book for any remarks in this respect and report to the shed/depot.

x) Notice if any relay target shows red indication? If so reset relay till white indication appears and report to shed/depot.

xi) That the isolating switches for rectifier block are normal.
xii) That the position of Master Controller, Driver's Vacuum Brake handle, Independent Brake Valve handle and Asst. driver's brake valve handle are normal in rear cab.

xiii) That the oil levels in compressor(s) and exhausters are normal.

3. Examination of Loco Log Book: When a Driver takes over a loco he shall check entries in the log-book before starting the train, and take note of remarks made during the last run and repairs carried out, and, whether he is required to keep a special watch.

4. Traction Motor Cut Out: If the log book shows that any traction motor has been isolated during the previous run, the Driver shall check the position of the isolating switch for that motor. If no mention of repairs has been made, the matter shall be brought to the notice of the shed supervisor. In regards to restrictions regarding working a loco with motor / motors cut out, instructions given in the Operating Manual for the particular type of loco shall be followed.

5. Compressed Air Supply: If the air pressure in the main reservoir is not sufficient, the battery operated compressor should be used to build up the required pressure in the auxiliary reservoir. Once the pantograph is raised, the circuit breaker should be closed.

6. Closing of the Circuit Breaker: On closing the air blast circuit breaker, the auxiliary machines should start and the indication lamps or the corresponding LED for air blast circuit breaker (red) and battery charger generator (green) will be off. The main compressor should now be switched on to charge the air reservoirs.

7. Starting of the Exhausters: With the Driver's vacuum brake valve on running/release position, switch on the exhauster and check if 53 cm vacuum is built up when the hose pipe is connected to a disc with 8 mm, (5/16") hole.

8. Brake Test:
   a) Hand Brake: Apply the hand brake hard and check if the brake blocks are effectively gripping the right side wheels of the two front axles. Release the hand brakes and check that the brake blocks are free.

   b) Air Brake: Apply the Independent air brakes of the loco and ascertain whether the application of the brake is effective on all the wheels. This should be ensured by physical examination of the effective gripping of the brake blocks on the wheel tread. Check if the maximum brake cylinder pressure as indicated on the gauge is 3.5 kg/cm$^2$. Release the air brake and check that the brakes are released on all the wheels.

   c) Vacuum Brake/Air Brake: The tests should be carried out after coupling with the train as per instructions laid down for the purpose (para 30623 and para 30625).

9. Blowers and Traction Test:
   (i) Switch on the traction motor blowers and check their working and apply independent loco brakes.

   (ii) Set the reverser in forward position and ensure that yellow lamp goes off.

   (iii) If the white lamp or the corresponding LED for rectifier is extinguished indicating that there is no fault on the rectifier system, notch forward by one notch and check if traction motor ammeter needle moves from zero and ensure that tap changer lamp (blue) is extinguished.

   (iv) Switch off master controller and repeat test for the other running direction.

   (v) The blowers may now be switched off and air brakes be released after repeating the test for reverse direction.
10. Pantograph Test: Check raising and lowering of the front and rear pantographs one after another, making use of the selector switch. Finally keep the rear pantograph raised for normal operation.

11. Quick Inspection of Mechanical and other parts

Check the following:

i) Operation of sanders and level of sand in sand boxes.

ii) Working of marker and headlights and flasher lights in both the cabs.

iii) Buffers and couplers.

iv) Speed Recorder/Speedometer transmitter.

v) Springs, dampers and other underframe mechanical parts and make sure there is no abnormality.

vi) Oil level in gear cases, suspension bearings and pivot.

12. The testing of the locomotive shall be carried out from both cabs. He shall also ensure isolation of isolating cocks of the brake of rear cab before moving the locomotive.

Note:

1. When taking over a loco on which no repair or maintenance work has been carried out, inspections in the sub-para 11 above may be omitted if time does not permit.

2. If the Driver notices some defect or abnormality likely to affect the working of the loco, he shall bring it to the notice of the Engine Examiner on duty.

30623 Check of Vacuum Before Starting

1. Based on the gradient and other factors in the section in which electric locos have to work each Zonal Railway should issue instructions regarding the minimum vacuum that should be indicated in the loco and the Brake Van gauges. If the minimum prescribed vacuum is not obtained, the Driver shall not start the train.

2. On attaching the locomotive to a train, if the vacuum stipulated cannot be created and maintained by the exhausters, the train should be examined by the train examining staff and leakages should be attended to so as to obtain the prescribed minimum vacuum before starting the train.

3. Other checks of the vacuum brakes as laid down in General and Subsidiary Rules and in the Brake Power Rules of the Zonal Railway shall also be carried out.

30624 Minimum Brake Power

The running staff shall abide by all rules regarding the minimum brake power on the goods and passenger trains, issued by the Railways. For the purpose of working out the percentage brake power, the "piped" vehicle should be deemed to have inoperative cylinder/cylinders. An operative cylinder is one in which the vacuum / pressure can be created / destroyed by control from the engine and which moreover satisfy the stipulation that its piston should remain up for not less than 20 minutes after the vacuum / pressure is destroyed.

30625 Operation of Air Braked Stock

For operation of air braked stock guidelines appear in the Annexure 6.01 to this Chapter.
30626 Master Controller

1. The progression or regression from one traction notch to another (and similar progression or regression during braking in the case of locos with regenerative or rheostatic braking) is controlled by the Master Controller from each driving cab. The Master Controller has two 'stable' and two 'unstable' positions for traction notches as under:

<table>
<thead>
<tr>
<th>Notch</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (zero)</td>
<td>Stable position</td>
</tr>
<tr>
<td>- (minus)</td>
<td>Unstable position</td>
</tr>
<tr>
<td>N (neutral)</td>
<td>Stable position</td>
</tr>
<tr>
<td>+ (Plus)</td>
<td>Unstable position</td>
</tr>
</tbody>
</table>

First release the mechanical locking of the Master Controller by moving the Reverser Controller to Forward or Reverse position. Then move the Master Controller to Neutral position. By moving the controller momentarily to (+) and back to N, the tap changer would be notched by one step. Notch-by-notch progression is effected by repeating this operation. In a similar manner notch-by-notch regression is possible by moving the Master Controller to (-) and back to N.

2. A blue indicating lamp or the corresponding LED glows in the driving cab when the tap changer is at "0". The position of the tap changer at any instant is indicated to the Driver by a Notch Indicator. It takes a few seconds (the exact time interval varying for different types of locos) for the tap changer to return from full 'on' to full 'off' position when the Master Controller is switched off. The blue lamp re-lights when the tap changer has returned to '0'.

30627 Use of Pantographs

1. The rear pantograph of the loco (in the direction of motion) should normally be used by the Driver. The leading pantograph may be used only if the rear pantograph is defective or damaged or specially instructed.

2. Loco should not be worked with both the pantographs raised.

3. For normal lowering of pantographs the Master Controller should be switched off and the circuit breaker tripped before the panto-selector is moved to position '0'. In an emergency when the locomotive is in motion, the pantograph may be lowered by using the panto-selector switch, even without tripping the circuit breaker but after bringing Master controller to '0' position.

30628 Regenerative and Rheostat Braking

1. The regenerative / rheostat braking is also controlled by the Master Controller. For braking, the Master Controller is moved in the opposite direction. The Master Controller positions corresponding to such dynamic braking are:

(a) Stable positions

<table>
<thead>
<tr>
<th>Notch</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ............</td>
<td>Common for traction and braking</td>
</tr>
<tr>
<td>P ............</td>
<td>Preparation for braking</td>
</tr>
<tr>
<td>N ............</td>
<td>Neutral</td>
</tr>
</tbody>
</table>

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b) Unstable positions

+ (Plus) ... Notch-by-notch progression during braking.

- (Minus) ... Notch-by-notch regression during braking.

Notch-by-notch or continuous progression and regression are effected during braking, in the same manner as during traction, but using the above mentioned positions of the Master Controller.

30629 Starting of a Train

1. The starting of a train is effected in two stages as under

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st stage</td>
<td>Initial starting</td>
</tr>
<tr>
<td>2nd stage</td>
<td>Acceleration</td>
</tr>
</tbody>
</table>

When everything is ready for the train to start, set reverser handle for the forward direction, switch on traction motor blower and progress the master controller notch by notch until the locomotive starts and moves forward with the train. During this period, keep an eye on the traction motor current to see that it is within permissible limits. Watch particularly for any signs of slipping of wheels. At the first sign of slipping notch back and press the sanders pedal and notch forward once again.

2. When accelerating from rest, the traction motors are liable to be overloaded. Notch-by-notch progression of the tap-changers should be so controlled as not to exceed the overload (current and time) ratings of the traction motors laid down for each type of loco. The permissible overload limits are exhibited in each driving cab.

3. At the first available opportunity at the commencement of journey by a fresh crew, driver will test the brake power of the train. The test should be repeated wherever the load composition is altered.

30630 Starting on an Up-gradient

When "attacking" an up-gradient, the Driver shall attain sufficiently high speed at the foot of the gradient so as to enable him to negotiate the full length of the gradient without any stoppage en route, ensuring at the same time that the maximum permissible speed for that section is not exceeded. If for any reason, the train comes to a stop on an up-gradient, the train shall first be held from rolling down by the application of the pneumatic brakes. While re-starting, the following sequence of operations shall be carried out -

1. Apply the independent air brakes on loco.

2. Release the vacuum brakes by using both exhausters for about 3 minutes initially followed by the normal running position of the vacuum brake valve for about 2 minutes.

3. When the brakes are almost fully released the train will tend to roll back giving a slight jerk on the loco. Just then notch forward 2 to 4 steps, simultaneously releasing the independent loco brakes (as laid down in the Operating Manual for the type of loco) so that the locomotive starts hauling the trailing load. Use sanders as required to improve adhesion.

4. Particular care should be taken to prevent sudden jerks due to excessive acceleration.

5. Continue notching forward as far as adhesion will permit and without exceeding the prescribed limits of current, observing the precautions during initial starting (para 30629- sub para 2).

5. If the locomotive is not able to pull the load, the Driver shall apply independent air brakes and make a fresh start. If this too fails he shall take appropriate steps as laid down in General Rules and Subsidiary Rules.
30631 Speed control

Once the current drawn falls below the continuous rated current, speed may be regulated by notching forward or backward so as to catch up with the "deserving notch" necessary to meet service conditions. The aim should be to maintain the speed as close to, but never exceeding the maximum permissible speed over each section. After the maximum voltage has been reached, speed control can also be effected by using the field shunting controller.

Field Weakening Switch: After the maximum voltage for the motor has been attained, field weakening may be effected if it is necessary to raise the speed further. This is done by operating the 'Shunting Lever'. Care must be taken to see that sufficient time is allowed for train to accelerate before going to the next step. The current ratings prescribed for each type of loco should not be exceeded. Too fast a rate of field weakening could cause a flashover of traction motors and should not, therefore, be attempted.

30632 Operation of the Reverser for Braking

Operation of the reverser to stop a train when the loco is in motion is strictly forbidden.

30633 Manual Control of the Tap Changer

1. Provision exists in all the locomotives for manual operation of the tap changer, should normal electrical operation through the Master Controller fail. In some locomotives, manual control is possible from the driving cab itself. In some others manual operation has to be done by the Assistant Driver in the corridor in response to signals from the Driver. In some types of locos, in addition to manual control through the Master Controller, separate electrical push-button control is also provided.

2. The manual control located in the corridor should be used only to clear the block section and if directed by TLC, the driver can go to the nearest loco changing point. The loco should be withdrawn from service at the earliest opportunity.

30634 Slowing down and Stopping

Depending upon local conditions, Railways may issue local instructions indicating a given stopping point identified by a board / OHE mast etc. in the event a particular signal ahead at danger. The driver should follow these instructions. While slowing down and stopping the following guidelines may be observed.

1. Before a scheduled stop or an unscheduled stop which can be anticipated by the Driver, coasting should be resorted to the maximum extent possible, taking into account the gradient of the section.

2. Before application of brakes, the Master Controller should be in the "OFF" position and the tap-changer should have returned to '0' notch as indicated by glowing of the blue pilot lamp or the corresponding LED. In locomotives fitted with regenerative or rheostatic braking, the electrical brakes should be made use of to the maximum extent possible.

However if the driver is negotiating the down gradient, he can apply loco brakes till he prepares for regenerative/ rheostatic braking to keep his train under control, if necessary.

3. After a stop, the blowers for traction motors and transformer should continue to run for 15 minutes especially after long runs with heavy trains to cool the motors.

4. The place and duration of stop permitting, the Driver or Assistant Driver shall check the following:

a) Axle box, traction motor and gear box bearing temperature (by feeling). In case the running staff observes abnormal temperature, he will report the matter to TLC for suitable action. TLC will arrange its checking through maintenance staff at the appropriate point.

b) Working of all blowers.
c) Oil level of main transformer and tap changer and temperature of main transformer whenever possible.

The air reservoirs shall also be drained off to expel accumulated water.

30635 Locos in Multiple Operation

1. Some series of locomotives are designed for multiple operation of two, three or four locos. This will be indicated in the Instruction Manual of each type of locomotive. The condition of the apparatus on the leading and trailing locos, the electrical and pneumatic connections to be made between the locos and all other details of preparation of the locos for multiple operation shall be in accordance with detailed instructions for each type of loco. Similarly the driving and other instructions for the individual types of locos as laid down should be followed.

2. Differences in wheel diameters of different locos in a multiple consists will be within the tolerances specified and the consist will be treated as a single unit for operation purposes.

3. In case of failure and break down of a loco in a consist the entire consist should normally be withdrawn from services.

4. One important check to be exercised by the Driver when operating locos in a multiple unit is to verify that the pantographs of the rear locos respond to the lower/raise operation, when negotiating sections where the pantographs are required to be lowered and subsequently raised.

5. Coupling of locos
   a) All the hose pipes i.e. brake pipe (BP), feed pipe, Vacuum hose pipe, Main reservoir (MR) equalizing pipe and brake cylinder (BC) equalizing hose pipes should be connected between the locos and the angle cocks are fully opened. The angle cocks of outer ends of MR and BC equalizing angle cocks are kept closed in addition to BP & FP angle cocks of front end.
   b) The three electrical jumpers on one side only should be connected between the locos. The auto brake valve handles (A9) and independent brake valve handles (SA9) should be kept at "Release" position in all the cabs but the cut-out cocks must be kept open in driving cab only. The cocks in all cabs in each loco must be kept closed. The isolating cock (A-8) should be kept in lead position (open) in leading loco and trail position (closed) in all the trailing locos. The position of MU2B Valve should be "Lead" on leading loco and "Trail" on all the trailing locos.

The compressors may be put in service as per requirement depending upon the number of wagons of the train. Care should be taken to put at least one compressor in service in each of the trailing locos.

6. Energizing of Multiple Units

The battery switch of all the locos should be put ON and the air pressure built up in emergency reservoir of each loco. The pantograph of all the locos may be raised and circuit breaker should be closed from leading loco. The compressors of all the locos should be started.

7. Precaution while changing driving cab

The changing of Cab means the changing of driving loco. Care should be taken to change the position of cut. Out cocks of A9 and SA9 Lead and Trail Cocks and MU2B valve while changing the driving cab.

8. Loco Faults

It is possible that a fault may develop in any of the locos in Multiple Operation. It may be detected with help of
six pilot lamps and two additional lamps. A lamp in the ceiling of the Cab called “LSGRT” (group loco lamp) glows only on the faulty loco. The other lamp provided on driving desk called “LSOL” (other loco lamp) glows in good loco indicated that the fault is in other loco. When fault is diagnosed on a particular loco, it is necessary that the train is stopped on a station and the remedial action is taken on the faulty loco. In case the fault can not be removed and it is not possible to keep the faulty loco in service, it should be made dead to run as a vehicle.

30636 Double Heading
1. Operation of a train with two locos in front, both coupled together and to the train, but operated independently by separate crew is known as double-heading. The two locos can be of different types.
2. Subject to compliance With all speed restrictions, the maximum speed of a double headed train shall not exceed the lower of the maximum speeds of the two locos individually.
3. Each loco must be manned by a Driver and Assistant Driver who are qualified to work the type of loco and have learned the road over which the train is working. The driver of the leading loco, known as the “Train Driver” must be qualified to work the class of train and will be responsible for working the train in accordance with rules.
4. It is the duty of the leading Driver to satisfy himself that the exhauster of the second loco, if running, is suitably isolated from the train pipe and does not create vacuum in the train pipe. Except in an emergency, the leading Driver only will apply the brakes. Under no circumstances may the second Driver release the brakes on his loco or the train or apply the brakes independently on his loco.
5. When starting power may be applied by both locos as required. The leading Driver who is in charge of the train will notch up until the train moves. The rear Driver will assist as required.
6. While running, power may be applied as often as necessary but gradually by the rear Driver.
7. The rear Driver may switch off power using his discretion and with due regard to locality, gradient etc. The rear Driver must frequently observe his vacuum gauge and be prepared to stop.
8. It is the duty of the train Driver to ascertain that the second Driver is acquainted with the contents of all caution orders and special instructions etc. which he may receive while working the train.
9. Instructions issued by local Railways regarding coordination amongst the two crews should be followed.
10. All rules in regard to switching off power at neutral section, lowering of pantograph in the event of emergency feeding etc. shall be observed. The Driver of the rear locomotive will be signalled by the Driver in the leading locomotive to carry out these operations, as required, by means of code whistles. The code to be used for such occasions shall be laid down under local instructions.

30637 Banking
1. On a gradient sections, sometimes banking locos are used in the rear of the train to assist the leading loco/locos to negotiate the gradient. The banking locomotive, must be coupled to the train.

The vacuum hose/air brake pipes of the banking loco should be coupled to the last vehicle, but on no account should the exhauster of the banking loco be run. In the event of banking air braked trains, MUZ 8 valve of banking loco shall be kept in trail position. The Driver of the banking loco will keep a watch on the vacuum gauge and take necessary action to assist the leading Driver when brakes are applied.

2. All rules in regard to switching off power at neutral section, lowering of pantograph in the event of emergency feeding etc. shall be observed. The Driver of the rear locomotive will be signalled by the Driver in the leading locomotive to carry out these operations, as required, by means of code whistles. The code to be used for such occasions shall be laid down under local instructions.

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3. When working a train up a gradient with the assistance of an electric banking loco, the following procedure should be followed:

a) When the signal is lowered the leading Driver will give the prescribed code whistle. The banking Driver will acknowledge the whistle and notch up quickly so as to obtain the maximum permissible starting current, simultaneously releasing the loco brakes. The sanders should be used to avoid wheel slipping.

b) The leading driver should take 2 to 3 notches, releasing the loco brakes simultaneously and using the sanders as required.

c) The leading and banking Drivers should keep a watch on their respective ammeters and maintain the current at the continuous rating.

d) If a "Stop" signal is encountered in the gradient section by the leading Driver, he should switch off the Master Controller and bring the train to a stop applying the brakes to the extent required. He will also use code whistle for the banking driver. This will increase current in the banking loco. The banking loco driver should regress the Master Controller so as to maintain the current at the continuous rated value till the train stops. On stopping, both the leading and banking Drivers should apply independent air brakes to avoid rolling down.

e) When re-starting after a stop signal, the same procedure as in (a), (b) and (c) should be followed.

f) At the point where the rising gradient ends, the Banking Driver should switch 'off' the Master Controller and stop pushing. A board is provided to indicate this point.

30638 Inability to Haul Goods Trains - Stalling

The most common causes for inability of electric locos to haul goods trains are as under :-

1. Inclement weather can result in poor adhesion. Some sections on Indian Railways during autumn season in forest areas are subject to track being covered by semi-dry leaves which turn into a wet paste by movement of wheels and is a serious cause for failure of adhesion.

2. Passage of salt laden trains with leaking wagons can also affect the adhesion.

3. The total trailing load exceeds the permissible load for the type of loco, either due to increased number of wagons or due to the cumulative effect of excess loading of a number of individual wagons.

4. The drag caused by brake-binding on rakes equipped with vacuum brakes which may be due to one or more of the following causes.

   a) Trains hauled by diesel locos sometimes have a high degree of vacuum. An electric loco subsequently attached may not be able to create as much vaccum. Unless every cylinder is manually released, some brake binding will occur.

   b) Many forms of temporary expediencies are used to reduces leaks while forming a load. The load may thus start initially with a good vacuum. The various methods used to prevent leakage may give way on the run and the brakes may begin to bind.

   c) Initially the brakes may be released fully by working both exhausters. If, however, there are leaks in the train line, the vacuum is lost gradually as soon as normal single exhauster working is resumed.

30639 Heavy Haul Trains

Such are the trains which can not be accommodated in the existing loops of the section. Railways operating such trains will issue special instructions and the driving crews should be made familiar with various problems anticipated to be countered with such operation. Some of these trains may have locomotive/locomotives sandwiched in between. Their operation too will call for special set of instructions.
30640 Neutral sections

It is essential to switch off power of locomotives when passing through a neutral section to prevent the possibility of arcing at the OHE and possible damage to it. To ensure this following boards are provided on the OHE masts (Refer Chapter II - Vol.I).

i) 500 m warning board - Be alert and ensure main reservoir pressure is at maximum limit. Close direct switch for compressor if necessary.

ii) 250 m warning board - Master controller to be brought to zero and ensure that the glowing of Blue lamp for tap changer. Get ready to open the circuit breaker.

iii) Open circuit breaker board - open circuit breaker before passing the board and ensure that glowing of red lamp for circuit breaker. If the circuit breaker does not trip at "Open Circuit Board" the panto must be lowered immediately.

2. After passing through the neutral section, the Driver should close the circuit breaker at the "close circuit breaker" board and resume normal working thereafter.

3. As a normal rule the train should coast through a neutral section. However, if for some reason it becomes necessary to stop the train in the vicinity of a neutral section, the Driver must try his best to stop the locomotive after crossing the neutral section. Only in an emergency or to avert an accident, may the locomotive be brought to rest within the neutral section. If a locomotive comes to a stop within the neutral section and the train cannot restart, special arrangements will have to be made to push or pull it by means of another locomotive.

4. Before tripping the circuit breaker at a neutral section, the main compressor should be worked "direct" for some time to build up enough pressure in the reservoir, otherwise there is possibility that the air-blast circuit breaker may fail to reclose after passing the neutral section due to low pressure.

5. If the speed of the train while approaching a neutral section is 30 km/h, the Master Controller should not be switched off at the 250 m board. Power may be kept on till the circuit breaker is tripped at the "open circuit" board.

6. Passing a Neutral Section with Multiple Loco Unit
The bipolar Switch BSLN provided in driving cab to open the circuit breaker and to lower the pantograph of trailing locos, should be put on at 250 m warning board after putting master controller to 0. The circuit breaker of leading loco may be opened at open CB board with the help of BLDJ. After passing the Neutral Section the circuit breaker of leading loco should be closed first and then BLSN should be put off. The pantos of trailing locos will make contact within 10 sec. circuit breakers of trailing locos may now be closed and traction resumed.

7. Short Neutral Section

In such a section both the pantographs should not be raised under any condition.

30641 lowering Pantographs Under Emergency Feed
When power supply from one substation is interrupted and feed is extended from the adjacent substations, it will be necessary for the Driver to lower the pantograph at least 2 or 3 spans before arriving at the overlap span opposite the substation which is out of operation. Such an eventuality may also arise when some portion of OHE is defective. When any of such contingencies arise the Drivers are advised by a "Caution Order" either at the starting point or through Station Masters enroute. Where this restriction is to be observed emergency "lower pantograph" and "raise pantograph" boards may be provided (Chapter II - Vol. I).

30642 Unwired Tracks
1. In station and goods yards only certain tracks are equipped with OHE. Special sign-boards are exhibited at
points where unwired tracks take off from wired tracks. Drivers/Motormen should keep a careful
lookout for unwired tracks when entering or running through stations and goods yards. Should per
chance an electric train be signalled erroneously to enter an unwired track, the Driver should stop
short of the turnout and draw the attention of the cabin. Drivers should also report such cases with
details to the TLC immediately.

2. If in case a Driver notices that he is going on an unwired track and cannot stop, he should lower
the pantographs immediately. This will minimize damage to the pantographs.

30643 Coasting Down-gradients
1. Drivers are expected to be well conversant with the road and to make the best use of down-
gradients to effect maximum possible saving in energy consumption.

2. In level sections and particularly in suburban sections, coasting should be resorted to as much as
possible and brakes applied only when essential to control the speed or to stop the train. To help
Drivers "coasting boards" are fixed in some sections.

3. In undulating country, speed may be allowed to drop down when going up a short up-gradient. After
passing over the crest, the train will automatically pick up speed with power off on the other
side when going down-hill, so that it attains maximum permissible speed on the section when it
arrives at the foot of the next-up-gradient. This feature should receive special emphasis during
learning the road period.

4. When going down a long, steep gradient, brake shoes are liable to get very hot and in these
circumstances, brake power will be reduced. With the reduction of brake power, speed may rise to
dangerous levels. To prevent this possibility, Drivers are required to maintain the speed within the
limits prescribed and sometimes even to halt a train at certain points to prevent the possibility of a
run away speed and consequent serious accidents. Drivers are required to adhere strictly to
standing instructions issued by local authorities in this regard.

30644 Loco Running Light

Before starting a light loco the Driver should personally verify that the loco brake isolating valves are
closed in rear and open in the driving cab. When a loco is run light; the free ends of the vacuum
coupling hose pipe shall be secured firmly to the dummy and one of the exhausters may be kept
working. The driver should, however, satisfy himself that the air-brakes on the loco are effective. He
should normally stop the loco during light run by independent air-brake valve, but the Assistant
Driver may apply the brakes by operating emergency brake valve, if the situation warrants.

30645 Wheel Skidding

Wheel skidding in locomotive takes place whenever braking force exceeds the limit of adhesion.
The braking force could be higher due to incorrect setting of automatic brake valve, independent
brake valve and pressure limiting valve or due to malfunctioning of proportionate valve, distributor
valve and C2 relay valve. This can also however happen if the pressure gauges are not calibrated
properly.

Wheel skidding is also noticed under adverse adhesion conditions caused by oil and grease on rail
table, wet rails and falling of tree leaves and salt on the tracks. Poor brake power of the train can
also result in wheel skidding of the locomotive, in certain condition.

To avoid wheel skidding, it is necessary to maintain the brake equipment in perfect working order
and ensure setting of equipments at designed value. Locomotive brake should be applied
judiciously. In case the poor brake power of the train is observed by the Driver, he should advise
control for joint checking and corrective action as laid down in Operating Manual and ensure
pressing of PVEF switch while applying train brakes.
Annexure 6.01
OPERATION OF AIR BRAKED STOCK
1.0 Operation

The running of air braked stock is subject to the following stipulations:

1. 1 Electric Loco used for hauling air braked stock have the provision of IRAVB-2 (twin pipe) graduated release air brake system.

1.2 Before attaching locomotives to trains, the engine should be thoroughly tested to ensure that it is free from any leakage and the valves are in working order.

The A-9 valve should be set at 5 ± 0.1 kg/cm² and effectively sealed. The flow meter should be in working order.

1.3 Procedure for Checking Capability of Locomotive Compressors for Charging/Releasing of Train Brakes

N.B.: This test should be carried out on single locomotive if only one locomotive is used for hauling the train or on the foremost loco of a consist of locomotives, unless otherwise stated.

1.3.1 Place the Driver's automatic brake valve handle in emergency position.

1.3.2 Start the locomotive compressors for building up of main reservoir pressure.

1.3.3 Allow the main reservoir pressure to build up to the maximum stipulated limits for the particular type of locomotive.

1.3.4 Close the angle cock for the brake pipe, couple 7.5 mm diameter leak hole special test coupling fabricated to RDSO design with the brake pipe coupling of the locomotive. In case of MU consist coupling should be fitted on the rearmost locomotive of the consist.

1.3.5 Move the Driver automatic brake valve handle from emergency position to release position to charge the brake pipe to 5 kg/cm².

1.3.6 Open the angle cock for the brake pipe. The brake pipe pressure should fall from 5 kg/cm².

1.3.7 Check the brake pipe pressure with the help of the gauge fitted in the locomotive, it should not fall below 4 kg/cm² with in 60 second.

1.3.8 The test shall be carried out with the number of compressors considered adequate by the driver for operating the train.

1.3.9 Generally the number of compressors used shall be governed by the number of wagons hauled and the leakage rate -

A general guide line is given here under -

<table>
<thead>
<tr>
<th>No of wagon in train</th>
<th>Less than 50</th>
<th>50-80</th>
<th>80-90</th>
<th>90-100</th>
<th>More than 100</th>
</tr>
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<tr>
<td>Compressed air require-ments in Litres/Min.</td>
<td>2000</td>
<td>3000</td>
<td>4000</td>
<td>5000</td>
<td>6000</td>
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</table>

Each compressor on an Electric loco has a capacity of 1000/1500 litres/minute.
1.4 Procedure for checking the leakage rate of the air brake system of the Locomotive with Auxillaries in the circuit

1.4.1 Charge the system fully with MR pressure charged to 10 kg/cm². Keep the brake in released position.

a) There after with automatic brakes applied in full, shut down the compressors. The drop in MR, FP pressure should not be more than 0.3 kg/cm² in 4 min.

b) With independent brake applied in full, shut down the compressors. The drop in MRFP and brake pipe pressure should not be more than 0.3 kg/cm² in 4 min.

c) With both independent and auto brake released, shut down the compressors. The drop in MRFP and BP pressure should not be more than 0.3 kg/cm² in 4 min.

1.5 Procedure for checking the leakage rate of the air brake system without Auxillaries in the circuit

1.5.1 Charge the system fully with MR pressure charged to 10 kg/cm². Keep the brakes in released position.

1.5.2 Shut down the compressors. Close the isolating cock of panto circuit line C-6 and BA panels isolating cock C20 on the wind screen wipers and the horn circuit. The drop in pressure in any of the circuits should not exceed 0.2 kg/cm² in 4 min.

1.6 Procedure for checking the leakage in BP circuit

1.6.1 Charge the system fully Make 0.6 kg/cm² reduction in BP by automatic brake valve. Close isolating cock A 15 in BP control line (Lead/trial cock). The pressure drop in BP should not exceed 0.7 Kg/cm² in 5 minutes.

1.6.2 Charge the system fully. Make 0.6 kg/cm² reduction in BP pressure by automatic brake valve. Close isolating cock A-8 provided near the BP charging C-2 relay valve A-31 (locomotive nominated for long haul operation have this provision). The pressure drop in BP shall not be more than 0.7 Kg/cm² in 5 minute.

1.7 Procedure and checking to leakage in FP circuit

1.7.1 Charge the system fully with FP charged to 6 Kg / cm². Close isolating cock A-21 provided before the feed valve A52. The pressure drop in feed pipe should not exceed 0.7 kg/cm² in 5 minute.

1.8 Starting of Train

1.8.1 Blow off the angle cocks before coupling to expel dust etc.

1.8.2 Check the position of angle cocks of air hoses of the leading and trailing locomotives and of the first wagon of the load.

1.8.3 Ensure that the brake pipe and the feed pipe connections are not mixed up either between two locomotives or between the locomotive and the first wagon of the load.

1.8.4 Ensure that brakes of the train are fully released by TXR otherwise while starting skidding or even breakage of coupling will occur. At non-TXR stations this job has to be done by the Driver.

1.8.5 Ensure that BP gauge in the loco is showing 5 ± 0.1 kg/cm² and FP gauge is showing 6 kg/cm² and then after ensuring the continuity of air pressure sign the brake power certificate jointly with the TXR. Do not disturb the setting of A-9 valve under any circumstances.
1.8.6 In the flow indicator gauge, set the red needle to coincide with the white needle after the needle has established. Do not disturb the red needle thereafter, through-out the run.

1.8.7 Move one engine length to get a feel of the train. Thereafter start the train smoothly.

1.9 While on Run

1.9.1 As far as possible, the train should be stopped only by minimum application of brakes. In other words, full service application or over reduction or emergency application should be used in genuine emergency only, and not in normal circumstances, as otherwise heavy braking force will result in skidding and excessive wear of wheels. After over reduction or emergency application, to have the brakes fully released, wait for 3 to 4 minute.

1.9.2 If the train is running heavy, stop immediately and investigate the cause. Any delay in investigation may cause skidding of wagon wheels or other damages.

1.9.3 CBC of loco and wagons can break due to high coupler force which can arise either while stopping, starting or accelerating. To avoid breakage of couplers, therefore, instructions regarding application of brakes given herein should be followed rigidly.

1.9.4 In case of heavy leakage or mal-functioning of distributor valve (if brake binding is noticed) pull the quick release valve lever of the distributor valve of the wagon. In case brake binding problem is repeated, the DV of the concerned wagon should be isolated by putting the isolating cock handle to off position and the quick release valve of DV pulled till the brakes are fully released.

1.9.5 In case of disconnection of air hose enroute, attention be given by closing the angle cocks and if necessary by replacing air hose by removing from either the front end of loco or rear end of the brake van. After this is done and the air hoses are correctly coupled, the angle cocks should be opened and the system fully charged, brakes released and the train started as mentioned in para 1.8.

1.9.6 The braking technique shall be as under:- Minimum application / release / minimum application / release. A series of minimum application/ release operations should be done for controlling the train.

1.9.7 After stop, even with minimum application wait for two minutes before restarting. Start only after the white needle on the flow-meter coincides with red needle.

1.9.8 Report all problems and unusual events noticed on run in respect of air brake functioning and wagon movement etc. to TXR concerned.

1.10 Brake Binding on run

1.10.1 If during run the train comes to a halt and brake binding is observed, sound locomotive horn with a whistle code prescribed for alarm chain pulling. This will give an indication to the Guard that the train is held up due to brake binding and the Guard should take action as prescribed for him.

1.10.2 If the locomotive is fitted with an air-flow indicator locating the trouble is easier, Check as follows-

If the white needle has moved up only slightly, it indicates leakage in the train brake pipe, source of leakage should be traced. If the white needle moves by a big margin, it indicates heavy discharge of air from the brake pipe. This could be due to an angle cock in front of a wagon being closed. It could also be due to a disconnected brake pipe or a burst hose pipe.

1.10.3 If there is no flow indicator, look carefully at the brake pipe pressure gauge. Originally the pressure should have been 5 kg/cm² on the locomotive and minimum of 4. 8 kg /cm² in the brake van. If at the time of occurrence the pressure is less than the original value, this could be due to additional leakage in the train brake pipe or train
parting. The driver shall therefore ensure that his full train is intact, otherwise take action as if train parting has occurred.

1.10.4 If there is brake binding but no drop of BP pressure, it could be due to rear angle cock of a wagon being closed.

1.10.5 Examine the train along with guard to find out the cause of brake binding. If the brake binding is due to a closed angle cock, open the angle cock fully.

If any distributor valve is defective, isolate the same and release the brakes of that wagon and record the same in the train journal as well as on the brake certificate.

If the leakage is due to a burst hose pipe (which is very rare), release the brakes in rear of the burst pipe after closing the rear angle cock of the last unaffected wagon and clear the block section cautiously at a slow speed with partial brake power.

After obtaining Guard's observations and taking corrective action, record on the journal and also report the problem to the section controller indicating the wagon number affected.

1.10.6 In case, the leakage or cause of brake binding is not located, destroy the brake pipe pressure completely through A9 close the angle cocks of the loco, release the brake of the complete train and work the train as non-braked, cautiously at a slow speed to clear the block section.

1.11 Stopping of a Train

1.11.1 Braking technique to be observed should be as detailed in sub-para 1.9.

1.11.2 Stopping of train should be smooth (without jerks) which is to be done by releasing the brakes just before final step. The handle of drivers brake valve should be put to release position when the speed is about 5km/h prior to stopping.

1.11.3 When stopping at a station on a down grade, the dynamic brakes be kept in ON position and should only be cut off after the application of independent brakes.

2.0 Action to be Taken in Case of Loco Failure with Air Braked Stock

1. During double headed operation, if the rear loco fails, the train is to be worked by the leading loco and the block section cleared. If, the load cannot be cleared by one loco, assistance is to be given by any other loco, preferably from rear, only for the purpose of clearing the block section. But when the block section is being cleared by a loco equipped with vacuum brakes, the loco driver has to be extra cautious to stop the train at the stop signal.

2. During double headed operation, if the leading loco fails, the train is to be stopped, isolation cock A8 in the brake pipe charging line and MU2B in the trailing loco are to be put to normal position in order to feed the BP pressure to the load and application of brakes from the rear loco and the block section cleared in the same manner as explain in sub-para above.

3. In the event of non-availability of loco fitted with air brakes (either electric or diesel) the brakes of the entire rake have to be released in the block section and an ordinary loco (vacuum braked) attached to clear the block section. In this event, the train is to be worked at a restricted speed of 15km/h as it shall be controlled only by the loco brakes. This load is to be received on the main line. If it is not possible to receive the train on the main line, it should be received on the loop line, provided the trailing end of the loop is set for the main line, so that in case of loss of control, the train does not get derailed on the trap point or goes in to the sand hump.

4. In the event of failure of both the locos and non-availability of a loco fitted with air-brake the train can be worked with an unmodified Diesel or electric loco, at a restricted speed of 15 km/h.
CHAPTER VII

OPERATION OF EMUs

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CHAPTER VII
OPERATION OF EMUs

30700 Duties of Motor Man

1. Rules 30604, 30606, 30608 to 30616 and 30620 for Drivers in connection with operation of loco will be equally applicable to Motormen.

2. Motorman will also be responsible for cleanliness of the EMU cabs.

30701 Motorman’s Personal Effects

Motormen of suburban trains should carry the following equipment while working trains:

1. Special keys for operation of the Master Controller, reverser, controls switch etc. 1 set
2. Hand signal lamp (at night) 1
3. Green and red flags 1 set
4. Working Time Table 1
5. A watch in good working order 1
6. Detonators 12
7. General and Subsidiary Rules AC Traction Manual and Operating Manual for the type of EMU 1 copy each
8. Rough journal book 1
9. Screw driver, universal pliers and any other tools prescribed under local instructions 1 set
10. Any other items in accordance with local instructions

30702 Check for Motorman on Taking Over

1. The Motorman taking over an EMU train will carry out checks as detailed below when –

(a) a train is taken over from and EMU shed or stabling line after maintenance or inspection;
(b) a train is taken over for its first trip of the day or after stabling at a station siding for more than one hour.
2. The duties prescribed in the paras mentioned above for the Motorman will devolve on the Shunters or Engine Turners when the train is worked by a Shunter or Engine Turner from the shed or stabling line to the station platform and the Motorman takes over the train on the platform. The joint brake test prescribed in para 30708 shall, however, be carried out only by the Motorman who works the first trip.

3. Instructions given in this section are of a general nature applicable to all types of EMUs and should be treated as complementary / supplementary to detailed instructions issued by respective railways for each class of EMUs.

**30703 Preliminary Checks**
The Motorman should -

a) check that the entire train is on a wired track so that by inadvertent raising of the pantograph on an unwired track, no damage is caused.
b) he is in possession of the correct set of keys for operation of the reverser, control switch, pantograph selector switch and doors and
c) go through the defects register to acquaint himself with the defects noted earlier and the action taken by the maintenance staff to set right such defects.

**30704 Checks Before Starting Trains**

1. In the entire train the Motorman will check the following :-

a) that the coaches are mechanically coupled properly and the electrical/pneumatic/vacuum connections between coaches are correctly made;
b) that all the drain cocks are closed and pneumatic isolating cocks are in normal position
c) that the intermediate driving cabs not in use are properly locked;
d) at the ends of the train the pneumatic and vacuum (wherever applicable) pipes and electrical couplers are correctly placed in the dummy sockets and dummy hooks respectively;
e) the headlights, tail lights, marker lights, head-codes and tag-boards are in order;
f) hand-brakes are released;
g) that fire extinguishers and alarm resetting rods are available.

2. In each motor coach he shall check that :-

a) none of the overload relays are in tripped position;
b) all fuses are in order and fuse-free breakers are "ON",
c) all traction motors are cut in for normal service;
d) the control cut-out and battery switches are "ON" and battery voltage is normal;
e) the cut-out switches for pneumatic governors are in normal position;
f) the transformer oil level is normal;
g) the main earth switch is "OFF" and interlock keys are in the proper position.
3. In the leading driving cab i.e. the driving cab to be used for the first trip, check that

a) all fuses are in position and fuse free breakers are "ON";

b) the deadman's device is functioning normally;

c) wiper, hooter, headlight (including emergency headlight), head code light and tail light (including emergency tail light) are functioning correctly;

d) the main reservoir and brake pipe pressures are normal;

e) all indicating instruments are normal.

4. In addition motorman will conduct checks for each type of EMU as required in the respective Operating Manuals.

30705 Familiarity with automatic brake application

In EMUs provided with electro-pneumatic and automatic brakes, normally the braking system made use of by the Motorman for service stops is the electro-pneumatic system. Though primarily meant for use in emergency and for automatic application in the event of train parting, the automatic air brakes are capable of graduated application for service stopping of EMU trains. This graduated application of automatic brakes, however, requires some practice on the part of motormen. Once during every trip they should, therefore, control the train and bring it to a stop making use of the automatic brakes. In the event of failures of electro-pneumatic brakes it will be quite safe to keep the units in service using the automatic brake system till the train can be conveniently withdrawn from service.

30706 Dead Man's Handle

1. Since an Electrical Multiple Unit train is operated by a motorman alone, it is necessary to provide means of applying the brakes and bringing the train to a stop in the event of the motorman getting incapacitated in any manner. This is arranged by means of a dead man's device associated with the master controller. With the reversing key in the 'forward' or 'reverse' position, the handle of the master controller has to be kept continuously depressed by the motorman. If the pressure on the handle is released on account of the motorman fainting or getting incapacitated in any manner, power for the traction motors is cut off and the brakes are automatically applied.

2. Deadman's device should be tested before commencement of every trip. An EMU train should not be considered fit for service if the dead man's device in any of the end driving cabs of a train formation is inoperative. In the event of the dead man's device becoming defective when a rake is in service, it should be either promptly withdrawn from service or a Guard, Train Examiner or some other person conversant with the operation of the brakes in an emergency should travel with the motorman.

3. The dead man's device will be operative when the train is in motion only if the reversing key is in 'forward' or 'reverse' position. If the reversing key is returned to the off position when the train is in motion, the dead man's device is rendered inoperative with consequent serious danger of accident in the event of the Driver fainting or getting incapacitated in any other manner. Motormen are, therefore, forbidden from moving the reversing key to the 'off' position when the train is in motion.

4. It is essential to impress upon Motormen (during their initial training and whenever they attend refresher course), the importance of this rule. Frequent checks are also essential to ensure that the rule is being strictly observed by motormen during their working. This is one of the primary responsibilities of the Driving Inspectors. Officers and other senior supervisory staff should also, during their cab, inspections specially check on the Motormen's observance of the rule. Any disregard of, the rule should be dealt with severely and promptly.
30707 Auxilliary Warning System (AWS)

This system ensures extra vigilance on part of the drivers and in case of driver becomes momentarily inattentive it gives a warning bell and then applies the brakes automatically. Power is cut out and brake operation also take place in case driver crosses a stop signal at danger. The driving crew operating with the system should be made fully conversant with the same before being put on loco /EMU, while working trains operating on sections fitted with such system.

30708 Joint Testing of Brakes by Guard and Motorman

1. Before an EMU train is brought on to a running line after inspection or maintenance in an EMU shed or stabling line, the brakes of the train shall be jointly tested by the Motorman and the Guard to ensure that the electro- pneumatic, automatic brakes and vacuum brakes (whichever is applicable) are functioning normally and the brake pipe is continuous throughout the train.

2. This joint test shall be conducted in accordance with detailed local instructions laid down for the purpose in the Operating Manual for the particular type of EMU.

3. As far as possible this joint test should be carried out before the EMU train leaves the shed or stabling line. However, if specially authorized jointly by CEE and COM, the brake test may be taken on the platform before commencement of the first trip.

30709 Duties of Guards of EMU Trains

In addition to the normal duties prescribed for them in General and Subsidiary Rules and other instructions, Guards of EMU trains shall be responsible for the following:

a) Joint brake test with the Motorman as detailed in para 30708.

b) Switching on the lights and fans when required and making a general check at the commencement of the trip that lights and fans are in good working order in the train.

c) Conveying information to the maintenance staff regarding failures and defects of lights and fans in the compartments.

30710 Defects in EMU Trains

1. Motormen are expected to be fully trained to rectify minor defects and in the method of isolation of faulty equipment. Detailed instructions on the method of trouble-shooting and rectification of minor defects are contained in the Operating Manual of the respective type of EMU. Motormen are expected to keep themselves fully acquainted with details of these instructions and to rectify such defects themselves.

2. Defects such as failure of fans or lights, leakages in air pipes etc. will be attended to on arrival of the units in the Car shed or Stabling Depots.

30711 Defects Noticed During Run with Special Reference to EMUs

1. In the event of defects which affect the punctual and safe running of trains and require early attention by the maintenance staff, the Motorman will convey a message indicating the exact nature of defect to the Traction loco Controller through the Station Master of the nearest station and will abide by the instructions given by the TLC. Depending upon the nature of defects, the TLC will decide whether the units are fit to be retained on line or should be withdrawn from service.

3. In the event of isolation of faulty traction motors, failure of auxiliaries etc., the maximum speed and other restrictions subject to which the train may be worked are detailed in the Operating Manual for each type of EMU.
The Motorman should abide by these instructions strictly.

30712 Turn-round Time at Terminal Stations

At terminal stations a minimum turn-round time of 6 minute should normally be allowed. This is necessary since normally the brake pipe pressure should be reduced to zero or vacuum destroyed in case of vacuum braked EMUs at the end of the trip and normal pressure/vacuum built up again when the train starts in the opposite direction. In exceptional circumstances, justified by local requirements, the CEE and COM jointly may permit a shorter turn-round time in which case it will only be possible for a partial reduction in brake pipe pressure/partial destruction of vacuum to be effected at the end of the trip.

30713 Stabling of EMU Trains

1. When stabling an EMU train in the car shed or on a stabling line, the Motorman or Engine Turner who has taken over the rake will carry out the following essential operations:
   a) Switch off the lights and fans.
   b) Trip the main circuit breakers and drop the pantographs.
   c) Destroy the brake pipe pressure or vacuum (as applicable), isolate the brake controller and return brake controllers to the "release" position
   d) Apply the hand brakes fully in the driving cabs at both the ends.
   e) Put off the main battery switch in the motor coaches.
   f) Lock the equipment compartments; and driving cabs.
   g) Any other operations prescribed under local instructions.

2. When a rake is to be stabled, the Motorman should invariably be at the leading driving cab. Backing an EMU rake to a siding with the motorman at the rear cab is strictly forbidden.

3. After stabling an EMU train or handing it over to the Engine Turner, the Motorman before going off duty should convey to the supervisor-in-charge of the Car Shed or stabling line (or to the TLC) any defects or abnormalities noticed during the previous trips requiring immediate attention.

30714 Coasting with Special Reference to EMU Operation

In order to keep down the energy consumption for operation of EMU trains, it is necessary to resort to coasting to the maximum extent feasible. The running time between stations given in the Time Table is after allowing for sufficient coasting. For guidance of Motorman, Coasting Board indicating the point at which power may be cut off normally are fixed on the OHE masts facing the direction of the train movement. When the distance between a pair of stations is long, sometimes power may have to be applied in two spells. In such cases additional boards indicating at what point power has to be switched on a second time and the point at which power may be switched off again are also provided.

It is an important duty of a Motorman to observe the Coasting Boards to the maximum extent feasible when the train is running on time. To make up time when a train is running late, the Coasting Board may be disregarded and power kept on for a longer time, taking care not to exceed the permissible speed of the section.

It must be remembered that if the "switch-off" Coasting Board is not observed when the train is running to schedule, apart from waste of electrical energy, there will be greater wear and tear of brake block. The location of the Coasting Board on each line should be decided by Sr. DEE / DEE (RS) after taking actual trials. A register
should be maintained in the Office of Sr. DEE / DEE (RS) as well as TFR showing the locations of the Coasting Boards provided. These locations should also be advised to the ATFO (OHE) of the section who should ensure that the Coasting Boards are not shifted for any reason by OHE staff. A periodic check-that the boards are located correctly in accordance with the register should also be carried out by the Driving Inspectors.

30715 Operation with Traction Motor(s) Cut Out

a) Normally an EMU should be operated with all the traction motors in position.

b) In case it is important to operate an EMU with motor(s) cutout as a long term measure, the EMU should be operated at a restricted speed and coasting restricted and a revised time table should be issued, if necessary.

c) For temporary cut out operation, motorman should inform the TLC and operate the train as directed i.e. to clear the section or to haul to destination or to complete the link till the EMU touches the maintenance shed. No EMU should normally leave the shed with any motor cut out.

30716 Working of Trains when Tracks are Flooded

1. The speed at which an EMU train may be worked with various heights of water from rail level shall be laid down for each type of EMUs under local instructions and incorporated in the respective Operating Manual.

2. It must also be ensured that in areas liable to flooding, special gauges (as laid down in para 716 of Indian Railways Permanent Way Manual) are provided to indicate when different types of EMU stock and electric locos have to be stopped.

30717 Push pull Operation

Some of the suburban trains are equipped with a locomotive in the centre not at each end. The operation of such train is similar to EMU operation and the maintenance of the locomotive should be carried out in a loco shed and the various schedules as laid down should be followed.

30718 Long EMUs

a) At times it may be necessary to haul long EMU train say two or more of 8 coach or 9 coach trains as one unit. In such an event Railways will issue local instructions in the matter.

b) It will be necessary to ensure that controls on each 8/9 coach trains are fed from the battery of the leading motor coach of the same train.

c) CRS sanction may be required for such an operation.
## CHAPTER VIII

### COMMISSIONING OF NEW ELECTRIC LOCOMOTIVES AND EMUs

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CHAPTER VIII

COMMISSIONING OF NEW ELECTRIC LOCOMOTIVES AND EMUs

30800 Sanction of CRS

Sanction is required from the CRS in respect of -

1. Introduction of electric traction on any railway or section of a railway.

2. Bringing into use any new type of electric locomotive or EMU or to operate any in service at speeds higher than those already sanctioned. The term "New Type" includes:

   a) any alteration made in the existing rolling stock which will have an effect on the riding characteristics of the rolling stock. Generally, the points to be considered are axle load, unsprung mass, primary and secondary suspension systems and load transfer arrangements between body and bogies and bogies and wheel sets.

   b) any alteration in the traction electrical system which is likely to interfere with signalling system.

30801 Commissioning of New type of Rolling Stock

When any new prototype loco/EMU are received for the first time from a manufacturer, the following are required to be ensured for inducting the rolling stock into services safely:

First Stage: One time movement of the Rolling Stock

The new prototype needs to be certified fit for movement, based on an application made to the COM of the Railway over which the loco is to be moved. The application is supported by -

a) Certificate from RDSO regarding its overall dimensions, axle loads, curve radius etc. for fitness to move on IR tracks.

b) Certificate from manufacturer of the locomotive from site of unloading/ interface with the zonal railway that the vehicle is fit to be moved.

c) A note on origin, destination, route and special conditions of speed, escort, etc. under which the loco is to be moved.

The COM of the zonal railway issues a movement order authorizing the movement of the locomotive, based on the application, and any other conditions which he may find essential to stipulate.

Second Stage: Provisional running

a) RDSO at the first instance shall furnish Provisional Speed Certificate for the particular loco type. In this certificate RDSO will indicate the maximum provisional speed of the rolling stock permitted to run with a particular type of track, nature of curvature, type of bridges, axle load, length of the rolling stock, ODC dimensions if any and type of traction installations. RDSO will also furnish the infringements for which the loco is over dimensional and Board's condonation for the same is required to be obtained.

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b) On receipt of the Provisional Speed Certificate, an application is made by the Chief Engineer of the concerned Railway to the concerned CRS for obtaining sanction. This is accompanied by Safety Certificate issued by CEE, CE, CSTE and CME. This certificate details restriction imposed and precautions to be observed for the movement of the loco. CRS in turn will then forward the same to the Secretary (Works), Railway Board along with his recommendations. Engineering Directorate at the Railway Board will finally communicate the sanction based on the safety certificate issued by CEE, CE, CSTE, COPS and CME and comments of the concerned CRS for the provisional running of the rolling stock.

Third Stage: Instrumented trials

RDSO will furnish the details of test and trials to be carried out on the rolling stock, generally, consisting of the following..

a) Oscillation trials: The trials are carried out for assessing the speed potential, the riding quality and stability at different speeds on straight and curved tracks of concerned sections. The parameters which are generally measured on the oscillograph car are lateral forces, lateral and vertical accelerations. Dynamic augment, bogie rotation and other parameters are derived. These trials are repeated for leading and trailing bogies with new and worn out wheel diameters.

b) Braking Distance Trials: RDSO will conduct the braking distance trials with the loco hauling prescribed loads at different speeds.

c) Tests regarding Interference with Signalling Circuits: The tests also will include measurements to determine the interference to signal and telecommunication circuits..

d) Performance trials: RDSO will conduct the trials to assess the performance ratings of the locomotives as per the extant instructions laid down.

Fourth Stage

Based upon the results of trials RDSO will issue a Final Speed Certificate indicating the maximum speed for which the new stock is considered fit, mentioning therein special precautions to be observed, if any. Based upon this certificate, the user Railway will issue a speed certificate signed jointly by CE, CEE, CME and CSTE and send the same to concerned Commissioner of Railway Safety (CRS).

Final Stage

Sanction of the Railway Board for commercial exploitation of the rolling stock is accorded.

30802 Trial Runs on Open Line

Subject to the condition that the operation of the particular new type of locomotive has already received the sanction of the CRS, trial runs on the open line may be undertaken, taking all the usual precautions. The Driver should be a senior and experienced man who has acquired the “feel” of the type of locomotive in question, as he would be in a better position to give his reactions as to the performance of the locomotive. Initially the locomotive should be run for short lengths at low speeds and subject to various equipment continuing to operate satisfactorily, the length of run and the speed may be progressively raised over a period of, a few days. Test in particular how the brakes function under the normal and emergency conditions. At the conclusion of each trip a detailed examination should be made of the equipment, particular attention being paid to the temperature rise, lubrication, protective devices etc. Every new rolling stock after initial run for a period of 15 to 20 days will be called back to the home shed and will be given a thorough inspection of all undergear equipment with special attention to loosening of bolts. These bolts will be re-tightened and secured before the rolling stock is put back into the system.
30803 Commissioning of New Electric Rolling Stock

1. Locomotives and EMUs do undergo, before dispatch, detailed tests and trials at manufacturing units which include tests prescribed by RDSO. Nevertheless, it is necessary for officers and staff of open line to check up the equipment thoroughly before they are put into commercial operation.

Sr. DEE/ DEE(RS) and the staff should make a detailed inspection of all parts of the rolling stock, one equipment after another, keeping a full record of defects observed and action taken to rectify. The inspection shall be broadly based on IC schedules. In any case, a report should be forwarded for every loco or EMU tested, to manufacturers and to RDSO so that they may in turn improve the design, revise the testing procedure and tighten up for final inspection. Such checks should also be normally carried out before commissioning a loco / EMU after an IOH/ POH by the shed / workshops.

2. Test certificates bound in book form issued by the Manufacturers / Production Units should be available in duplicate. These should contain results of actual tests and measurements carried out on the different components, duly countersigned by the Inspecting Officers. One copy should be preserved for reference in the loco shed and one copy in CEE’s office.

3. The manufacturer is also required to submit guarantee / warranty of the loco components / sub-assemblies wherever applicable. Whenever a new type of equipment / sub-assembly is inducted into the locomotive, operation and maintenance instructions shall be furnished by the manufacturer, in advance, before dispatch of the locomotive.

30804 Electric Multiple Units

The contents of paras 30801 to 30803 apply equally to every electric multiple unit, except that, in addition to the electrical equipment of the driving unit, the interconnecting pneumatic pipe connections and the brake equipment in each coach should be subjected to detailed examination for detection of leakage and proper operation. Similarly the control cable connections between coaches should be checked for proper sealing at the ends to make them weather-proof. The running gear and brake equipment in all motor and trailer coaches should also be tested.

Insulation resistance of the through wiring in the coaches, and internal wiring for lights and fans within the coaches should also be checked and recorded. Verify that the different circuits are provided with individual fuses and the fuses are of the correct rating. All tests and trials should be conducted with the EMU without any passengers, except for the officials in-charge for testing, loading of the train may be done by sand box, etc.

30805 Additional Precautions Before Commencement of Commercial Operation

1. During trial runs, very close watch should be kept of the performance of new loco or EMU put into normal service. For the first few runs, the Driving Inspector, together with a few key personnel, should accompany the loco or EMU and examine the equipment at frequent intervals and arrange for rectification of any defects which may show up. A separate History Sheet should be maintained for every electric locomotive or EMU.

2. The “trouble-shooting directory” should be got ready well in advance of introduction of a new type of loco/ EMU and the running staff adequately trained in the trouble shooting methods and operation of the type of loco/ EMU.
CHAPTER IX

SAFETY, BREAKDOWNS AND DISASTER MANAGEMENT

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CHAPTER IX

SAFETY, BREAKDOWNS AND DISASTER MANAGEMENT

30900 General

The safety precautions to be taken have been dealt with great length in various parts of the Manual particularly in Chapters 2 to 7 dealing with Operation and Maintenance of Rolling Stock. The compliance of these rules should be ensured.

Various instructions given under this Chapter are in addition and over and above to the ones already mentioned elsewhere in this manual and other relevant manuals issued by the railway.

Drivers/ Motormen should be fully trained to protect not only their train but also the trains running on other tracks in case of any infringement suspected as laid down in General and Subsidiary rules.

30901 Knowledge of Rules

All officers and supervisors of the Rolling Stock section should be fully conversant with the "Rules for Reporting Accidents" as given in the Accident Manual and other instructions in force for dealing with accidents and breakdowns. The instructions given in the following paragraphs are to be treated as supplementary instructions. They should not be taken as nullifying or contradicting the instructions contained in other official manuals.

30902 Emergency Stores and Break Down Equipment

At electric loco sheds and EMU sheds and at selected stations in the electrical sections, tools and equipment such as special lifting jacks, traversing jacks, etc. for dealing with accidents to electric rolling stock will be maintained. Sr. DEE / DEE incharge of sheds will be responsible for proper upkeep of such equipment. They should inspect the same periodically and ensure that the same are kept in working order and maintained properly. The list of tools and equipment to be maintained specially for dealing with breakdowns of electric rolling stock in use on the railways will be issued by CEE.

30903 Use of Hydraulic Re-railing Equipment of Electrified Tracks

In case of electrified tracks whenever the restoration is to be carried out and infringements are required to be removed which in most cases will be the Rolling stock i.e. locomotive, coaches and wagons, it will be mandatory to use hydraulically operated jacks. The use of overhead crane will be resorted to in case the hydraulic operated rerailing equipment, is unable to carry out restoration. Use of overhead crane for restoration of services on electrified sections will only be permitted with the personal approval of DRM.

30904 Break Down Gangs

It is essential that adequate number of selected, experienced staff of all categories should be housed in railway quarters closed to loco sheds / EMU sheds, outstation depots and EMU stabling lines etc. so that their services can be utilized for dealing with breakdowns and accidents whenever required.

30905 Record of Staff Movements

Senior Supervisors of the Rolling Stock section should keep Traction Loco Controller advised of their movements to enable him to contact them in the event of an emergency of any breakdown involving electric rolling stock.
30906 Summoning of Emergency Staff

Addresses and telephone numbers of officers and staff of the Rolling Stock Section should be available with TLC. Station Masters should also keep the residential addresses of staff residing nearby especially those who have no residential telephones, so that they can be summoned when required. Where special sirens are installed in railway colonies to summon emergency staff in the event of breakdowns or accidents, a special code signal may be employed for such summoning. The adequacy and proper observance of these instructions should be checked at least once in every six months by sounding the alarm and recording the time taken for the key staff to turn up.

30907 Expeditious Clearing of Track

In the event of a failure of locomotive or EMU, the primary objective should be to clear the line as quickly as possible so that the repercussions on traffic are minimal. The Driver should follow the detailed instructions given in the respective trouble-shooting manuals. He should seek guidance from TLC wherever necessary.

In such cases it may be necessary to disconnect / disengage and even cut out the drive due to wheel sets getting jammed. For expeditious clearing of the track, the locomotive may have to be driven at a reduced speed to be decided in consultation with the engineering staff. If the Driver is unable to move the locomotive or EMU on its own power, he should ask for a relief engine or assisting train as the case may be.

30908 Emergency Telephone

The driver of every locomotive shall carry with him a portable emergency telephone set, so that in the event of a serious breakdown enroute in mid-section, he could contact the TPC/TLC from the nearest emergency telephone circuit. To help the Driver arrow marks are painted on the faces of OHE masts indicating the direction in which the nearest emergency telephone socket lies. Every Driver shall be fully conversant with the method of plugging the portable telephone to its socket and establishing communication with TPC/TLC.

In case telephone is not working the Driver will arrange to communicate the incident to the nearest railway station either himself or through Guard or Asstt Driver. In busy suburban sections, motormen of disabled EMU trains can send messages to the nearest station through the Motorman or Guard of trains on adjacent track, which may be stopped by him for the purpose by showing hand signals. In case telephone is not working the Driver will arrange to communicate the incident to the nearest Railway Station either himself or through Guard or Asstt. Driver.

30909 Flasher Lights

These lights are provided on all locomotives and EMUs. As soon as the train stops due to emergency application of brakes not initiated by the crew, the driver should assume that some portion of his train has derailed and should put on the flasher light to warn the driving crews of the oncoming trains on the opposite track. The operation of the flasher lights may be suspended only after the crew have verified physically that the neighbouring track is not infringing. Similarly the crew observing the flasher light should take immediate action to stop the train even with emergency application of brakes if necessary and should only restart after the physical verification of the infringement.

30910 Access to the Roof of Electric Locos and EMUs

On Line
a) Access to the roof of electric locos and EMUs is authorized only under the conditions that the OHE has been made dead and earthed on both sides of the loco /EMU by the OHE staff in accordance with procedure laid down. The power block will be taken by the OHE staff.

b) On locomotives a ladder is provided for gaining access to the roof. The ladder is normally kept locked.
To remove the ladder from its locked position the Driver should operate the main isolating switch and take out the key for unlocking the ladder. When the operations on the roof of the locomotive are over the Driver should put back the ladder in its proper place. After locking the ladder he can release the key for operating the main isolating switch.

c) When required, for climbing from rail level, portable ladders are provided in each EMU. These ladders are fixed at a height at the ends of motor coaches. Though no special interlocking is provided to prevent the ladders being used, the Motorman must ensure that the condition of para (a) above is satisfied before going on to the roof.

d) After the Driver/Motorman has completed his work, he shall ensure that everything is in order and advise the OHE staff to energize the line.

In Sheds

The supervisor incharge of maintenance gang shall ensure that OHE supply is switched OFF and earthed before any staff is authorized to go on the roof of a locomotive/EMU. For this purpose, the OHE shall be made dead and earthed by opening the controlling isolator(s) fitted with earthing heels. He will ensure physical contacts of earthing wheel and provision of padlock in this condition. Where the isolators are not provided with earthing heel, the line shall be earthed at both the ends of the locomotive with the help of discharge rod. Having ensured this, he will allow the staff access to the roof who in turn will follow the following procedure:

a) Each of the staff will collect padlock(s) with key(s) and will sign in a register maintained for this purpose.

b) Handle(s) of the controlling isolator(s) already opened by the supervisor incharge will be further secured by providing individual lock(s) by the staff. Keys of the locks will be retained by the staff till such time the work is completed.

c) After completion of the work and when the last staff has removed his padlock(s) from the isolator(s) and signed the register again; the concerned supervisor, after satisfying himself that all staff, tools etc. and the earths provided have been removed, may re-energize the OHE.

30911 Precautions to be Followed While Despatching Locomotives as Vehicle

Electric locomotives should not be worked as dead vehicles unless an authorised railway employees has taken all the measures detailed in the respective Operating Manuals. Essentially these measures are lowering and isolating the pantographs, making all electrical equipment of the loco dead, releasing the brakes of the loco and closing the corridor and cab doors. In such cases, the loco must be attached as the first vehicle of the train next to the engine. Para 30912 may also be referred in this regard.

30912 Hauling a Damaged Locomotive

1. If a damaged electric locomotive which is stabled on the open line or at a station is to be hauled as a dead vehicle, it must be certified by the Driver or EXR and must be accompanied by competent staff. In case of damage to the traction motor or transmission gear, the locomotive must be examined by an engine examiner and certified as fit for movement. The speed at which the damaged locomotive may be hauled in such cases should be as specified by the engine examiner.

2. On dead locomotive all the circuit breakers and battery knife switch shall be off and such other steps to ensure that the dead locomotive cannot be started inadvertantly.

3. Care shall be taken to ensure that traction motor reversers are physically placed and locked in the neutral position. For long distance movement of dead electric locomotives, the traction motor brushes shall be lifted and secured before the loco is dispatched.
4. The locomotive brakes shall be fully released. The brake pipe and main reservoir pressure shall be fully discharged or the vacuum fully destroyed. The MU2B valve, if fitted, shall be lifted and properly secured.

5. The dead locomotive shall be accompanied by a competent person not lower than an Asstt Driver when attached to a passenger train and also when attached to the rear of a goods train. When attached to the rear of a goods train, it will be the duty and responsibility of this person to apply the hand brakes judiciously in case of run away occurring on a graded section.

6. The train driver shall be informed that he should work the train carefully as the dead locomotive will have no brake power at any time. If the dead loco is to be hauled by a light engine, the speed may be required to be limited on account of limited brake power available on the light loco. This will be laid down by the CEE of the railway.

7. The Assistant Driver of a train to which a dead electric locomotive has been coupled should keep frequently looking back to watch for any signal from the staff accompanying the dead locomotive.

30913 Haulage of a Disabled EMU Train

1. Instructions contained in Para30912 for haulage of damaged loco shall apply mutatis-mutandis for movement of a disabled EMU as well.

2. An EMU train which cannot move on its own power but is otherwise fit to be moved, may be hauled by another EMU train or a steam, electric or a diesel locomotive till it can be conveniently side-tracked into a siding. Special adopters are provided to enable such emergency haulage of EMU trains fitted with automatic couplers by means of locomotives. Drivers must be familiar with the procedure for fitting such adopters. The speed at which a disabled EMU train may be hauled under such conditions will be as laid down in local instructions.

3. The relevant General and Subsidiary Rules for moving disabled EMU trains should be rigidly observed.

30914 Movement of Electric Trains under Conditions of Flooded Tracks

When the tracks are flooded, the restrictions regarding movement of electric locomotive and EMU trains shall be in accordance with local instructions (see also para 30716).

The traction motor and associated parts including gear case, etc., are designed to permit propulsion of rolling stock at 10 km/h through water upto a level of 200mm above rail level. Further, the traction motors are made completely water-proof to a standing water depth of 760mm above rail level.

30915 Accidents involving Electric Rolling Stock

The Traction Loco Controller should immediately inform the Officer-in-charge of operation of Electric Rolling Stock in the event of any accidents involving Electric Rolling Stock. An Officer or Senior Supervisor of the Electric Rolling Stock section should be invariably associated with restoration work when derailment or other accidents to Electric hauled trains are involved. Before restoration commences the shed supervisor shall make measurements/ checks jointly with the engineering staff to help investigation into the cause of accident later. For this purpose proforma prescribed in the Accident Manual or issued under the local orders of the railway should be used. Action shall be taken to preserve the evidence as far as possible. The restoration work of locomotive and train shall only be started after the TrD gives clearance.

The checks to be carried out are detailed in the Annexure 9.01

30916 Look out for OHE Defects

The engine crew of all trains shall keep a sharp look out and report any defects in OHE noticed by them to the TPC from the nearest station. Such defects need not be confined to the line on which train is moving but in the entire vicinity. They should give as detailed information as possible on the nature of the breakdown, its location;
whether the masts have been uprooted, whether both lines in a double track section have been affected etc. The OHE defects as observed by the driver may be of any one of the following classification.

1. Uprooting of or damage to OHE masts on account of cyclone, derailments etc,
2. Entanglement of pantographs with the OHE.
3. Snapping of OHE conductors.
4. Flash-over or other damage to insulators.
5. Faults on account of stray wires etc.
6. Theft of OHE conductors.

**30917 Pantograph Entanglement**

The officer or supervisor of the Electrical Department arriving first at site of a breakdown, particularly those involving entanglement of pantographs with the OHE, should make a very careful note of all relevant details pertaining to the break-down and also prepare a sketch indicating the particulars. He will also arrange for preservation of such evidence as may be useful subsequently for investigating the cause of the breakdown.

Items to be checked on the pantograph and OHE are indicated in the Annexures 9.02 and 9.03.

Maintenance Staff, after ensuring that OHE is dead, and earthed in association with OHE staff will climb on the roof of the locomotive. They will remove the HPT links of the damaged pantograph and earth it and will secure the pantograph with wire rope from the base frame of the pantograph in such a manner that it does not come in contact with OHE during the run.

**30918 Protection of Train in Case of Loco Failure and/or OHE Supply Failure**

1. When overhead supply fails, the Driver shall endeavor to proceed on the momentum of the train and see whether he can reach the next station otherwise he will stop the locomotive close an emergency socket. To help the Driver, arrow marks are painted on the faces of OHE masts indicating the direction in which the nearest emergency socket lies. If power supply is not restored within 5 minutes after stopping the train, he should make use of his portable telephone to ascertain from the TPC through the emergency telephone socket the time when the supply is expected to be restored. If it is likely to be more than 15 minutes then the Driver should apply air and hand-brakes on the loco and pin down brakes on 10 wagons immediately behind the loco in the case of goods trains and all available hand brakes in the case of passenger trains.

If the Driver is unable to stop the train close to the emergency telephone socket, and is likely to take more than 15 minutes to ascertain the time of restoration of the overhead power supply from TPC he must first protect the train against rolling as indicated above and then contact the TPC.

The same instructions shall be observed in case of electric loco failure when it becomes necessary to make the loco dead and call for assistance.

2. In addition, the precautions prescribed in General and Subsidiary Rules for protection of trains when stopping out of course should be observed.

3. If after power is restored, the Driver experiences tripping again, he shall not energize the locomotive until he has personally satisfied himself that there is no abnormality on his locomotive.

4. The locomotive will not be left unmanned in such an eventuality.
30919 Parting of Trains

1. Failure of inter-vehicle couplers can cause train partings. This can be due to sudden acceleration or braking causing jerky motion of vehicles. Such jerks cause waves of alternate compression and tension in inter-vehicle couplers passing down the train length and the weakest coupler is liable to break.

2. Drivers will observe following precautions to avoid parting of trains:

a) When starting a train, tractive effort should be applied gradually to ensure that all the couplings are fully tight.

b) Pick up speed notch by notch and start train smoothly.

c) Do not release brakes too fast after destroying vacuum by using double exhausters.

d) It is not enough to be guided solely by the vacuum gauge. Sufficient time (3 to 5 mt.) should be allowed for full release of vacuum brakes.

e) Do not use loco independent air brakes to stop trains.

f) Ensure engine coupling is properly tightened / locked before starting a train.

3. When a parting occurs the driver (in the front portion) should not endeavour to stop the front portion of the train, but should allow the portion to move forward to the extent possible to prevent the possibility of the rear portion colliding with the front portion. The automatic brakes applied on parting may not be effective equally on both the halves of the parted train.

30920 Firefighting Appliances for Electric Rolling Stock

1. Every electric locomotive should be provided either with 2 number of 4 kg capacity or 4 number of 1.25 kg capacity halon type fire extinguishers to IS: 11108, one in each cab and remaining in each corridor. The fire extinguishers shall be fixed on brackets at approved points in the cabs and corridors. The ATFR on duty will be responsible for ensuring that the locos leave with the full complement of fire extinguishers. Sufficient number of spare fire extinguishers should be available with the ATF(R) to replace defective and damaged fire extinguishers. In exceptional circumstances CEE may authorize change in complement and / or type of the fire extinguishers.

2. On EMU, 2 number of 2.5kg. capacity Halon type fire extinguisher should be provided in each of the cabins occupied by motorman and Guard and also one number of Halon type extinguisher of the same capacity should be provided in each motor-coach of EMU. As in the case of other passenger trains, the Operating Department will be responsible for custody of the fire extinguishers and their issue to the Guard at the originating station of each EMU rake.

3. All the staff of electrical department connected with the running and operation of trains should be duly trained for fire fighting and use of fire extinguishers within the locos and EMUs.

4. The staff should be trained in taking necessary precautions as enumerated in para 30921

30921 Fires in Electric Rolling Stock

Preventive Maintenance and Inspection

1. The presence of a large quantity of oil in the transformers and tap-changers of electric locos and EMUs makes it possible for even minor fires to spread and assume serious proportion. Leakage of oil from exhausters and compressors results in accumulation of oil on the loco flooring causing spread of fires. An essential step in
prevention of fires in locos is, therefore, to control the leakage of oil from exhausters, compressors and pipe lines and to arrange periodic cleaning of the locos to remove accumulated oil. Always use funnel of proper shape for tapping of oil to prevent spillage.

2. The arcing horns should be properly attended to during inspections. The arc-chute should be properly secured and the securing arrangement periodically checked. The arc-chute should also be cleaned during inspections.

3. In addition to periodic cleaning of the bogies and underframe to remove oily dust, it is also important that rheostatic and regenerative braking, where provided, is kept in working order and drivers trained to make use of these on graded sections, obviating the need for heavy mechanical braking as far as possible thus preventing sparks from brake blocks.

4. Rating of fuses particularly of low voltage dc circuits are to be checked periodically to eliminate the possibilities of the fire due to shot circuits/ overloads etc. Always ensure that the proper sizes and types of fuses are used for replacement. Check calibration of MCBs during POH. Use MCBs and fuses of only approved supplier as laid down by RDSO.

5. Ensure that all the Protective relays are in good working order and are properly calibrated. Do not bypass any protection on the rolling stock.

6. A loose connection is a potential source of fire. Proper tightness of all the connections is, therefore, to be ensured and this point is to be given particular attention during inspections. Coaches commissioned after POH or new coaches after commissioning should be thoroughly checked up for loose connection as during the first few days, loose connections will show up. Ensure that all the connections secured with a nut and bolt are provided with a set of plain and spring washers.

7. Insulation failures can result from surface flash overs due to presence of dirt and dust. It is, therefore, essential that proper cleaning of terminal connections, bus bars, insulators and equipment is done during schedules as laid down to remove oil and dust.

8. Fires in control equipment cubicles are a problem and usually lead to considerable damage. A particular difficulty is the detection of fire and, therefore, the fire is likely to get a good hold before it is noticed. Ensure that proper maintenance of the equipments inside the cubicles is done and the equipments are carefully looked at during inspection for any developing faults.

9. Batteries constitute some fire or explosion risk when they are being given a heavy charge. Heavy charging can be either due to malfunction of the charging equipment or carelessness when charging from the shop floor rectifier. It is therefore important to check that the ventilation provided in the battery box is not choked. The staff should, therefore, be made aware of the danger of overcharging.

10. Use only approved quality of cables and furnishing material for repairs. Proper care should betaken while laying down the new cables so that no damage to the insulation is caused.

11. In order to monitor healthy condition of insulation of wiring and equipment, insulation resistance should be measured periodically in sheds and during POH in shops, and records kept.

12. In the event of fire it is essential that the main circuit breaker is tripped and the battery fuses of locomotives and EMUs are immediately removed to eliminate the continued feeding of the fault by the battery.

30922 Technical Investigation into Fires

Every case of fire minor or major, irrespective of the location, whether in power, auxiliary or control circuits, should be investigated very carefully, even though an inquiry in accordance with the Accident Rules may not be called for. The causes as established by the investigation should be analyzed by the Sr. DEE / DEE personally to identify areas requiring further investigation and to tighten up preventive measures. A report on each case of fire should
also be furnished to CEE. The general guidelines to check up the items in locomotive in the event of fire, is given Annexure 9.04

30923 Fire Accidents

1. Fires in trains, whether carrying passengers or not, resulting in loss of human life or injury to any person or loss of or damage to railway property to the extent of or more than the value prescribed are required to be treated as “accidents” and have to be inquired into in accordance with the "Rules for Reporting and Inquiring into Accidents". Fires in other railway premises resulting in damage to railway property of the prescribed value or over are also to be treated as "accidents". Fire accidents involving loss of human life or injury to persons or damage to railway property estimated to cost equal to or over a prescribed value have also to be reported as soon as possible on telephone to the Railway Board by the General Manager through Operating (Safety) Branch. Procedure laid down in the Finance Manual should be followed.

2. When electrical installations or electric rolling stock are involved or when there is possibility that the fire was caused by electrical short circuit or due to defect or malfunctioning of electrical equipment, a representative of the Electrical Department should invariably be a member of the inquiry committee. Rules also require that a representative of the Security Department should be associated with all inquiries into fire accidents. On arrival at the site of fire they will collect necessary evidence and make out a joint report in consultation with the representative of the security department.

3. The composition of the inquiry committees and the method of disposal of the report of the inquiry committee will be as laid down in the "Rules for Reporting and Inquiring into Accidents" issued by the Zonal Railways.

30924 Electrical Safety

Procedure for reporting of electrical accidents and action to be taken have also been laid down in Vol. I of this manual. The various authorities to be informed in case of injury / death due to accidental contact with live installations have also been indicated.

Following guidelines are specifically meant for Electrical Rolling Stock. These are to be observed and in no way nullify or counter any of the instructions laid down elsewhere by the CEE in his capacity as Electrical Inspector to the Government of India.

1. All Loco / EMUs sheds should ensure that the various interlocks provided on the high tension compartments are effective and it is not possible to open HT compartment until the pantograph is in lowered position and is fully earthed.

2. Drivers / Motormen should not enter the HT compartment unless the pantograph has been lowered and fully earthed.

3. Drivers / Motormen should be fully trained in operations necessary to ensure electrical safety.

30925 Rehabilitation of Fire/Accident Damaged Rolling Stock

The items need to be checked up before the electric rolling stock is taken for rehabilitation for its suitability is given is Annexure 9.05.
ITEMS TO BE CHECKED ON ELECTRIC LOCO AFTER DERAILEMENT/ACCIDENT

Loco No ........................................... Homing Shed .........................................................

Date of Accident .......................................................... Train No. .............................. Stn ........................................

1. Cab Equipment
   1.1 Position of notch repeater (NR).
   1.2 Position of master controller, SMGR, tap changer.
   1.3 Flasher lights, Head lights and Horns.
   1.4 Condition of speedometer.
      (The Teloc chart should be removed and sealed after the joint signature)
   1.5 Brake equipment
      1.5.1 Single loco:
         (a) Position of MPF/A9, loco independent brake valve/SA9, Assistant Driver, Emergency brake
             valve RS/D1 and hand brake in both the cabs.
         (b) Condition of various gauges.
         (c) Whether any of the bogie brakes is in isolated condition; if so, since how long?
         (d) Position of angle cock (of BP and FP of locomotive).
         (e) Position of lead/trail cock of MU2B valve and 3/4" isolating cock A8.
         (f) Whether the circuit for automatic brake application is effective in case dynamic brake fails or not.
      1.5.2 Multiple locos
         (a) All the items mentioned under item 1.5.1 above.
         (b) Position of MPF/A9, loco independent brake valve/SA9, Assistant Driver emergency brake
             valve RS/D1 and hand brake of both the cabs in rear locomotives.
         (c) Position of lead trail cock of MU2B and 3/4" isolating cock A8 of all rear locos.
         (d) Loco brake isolating cocks position in all the rear locos.
         (e) Whether interconnecting pressure pipes are properly connected and isolating cocks are in open
             position.

2. Under-frame Equipment
   2.1 (a) Wheels measurement

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Wheel No.</th>
<th>Wheel gauge</th>
<th>Tyre thickness diameter</th>
<th>Root wear</th>
<th>Flange wear</th>
<th>Visual abnormality including hitting/flash mark on wheel face thread</th>
</tr>
</thead>
</table>
   (b) Journal condition
   (c) Lateral clearance of axle box
   (d) Proud metal of wheel disc.

2.2 Cattle guard.
2.3 Draw bar coupler.
2.4 Traction gear.
2.5 Equaliser beams/safety brackets.
2.6 Bogie frame.
2.7 Primary & secondary suspension springs.
2.8 Gear case bolts.
2.9 Traction motor suspension unit bolts.
2.10 Safety strip.
2.11 Brake rigging components.

3. Miscellaneous
   3.1 Hitting marks on cattle guard and other undergear equipment.
   3.2 Any other deficiency in the under-gear equipment.
PANTO ENTANGLEMENTS : ITEMS TO BE CHECKED ON PANTOGRAPH

1) Check that the pantograph wearing strips are properly fastened with the panto pan and there are no loose fasteners or bent strips or deep grooves on the strips. Pantograph strip joints must be smooth so as not to hinder smooth riding of the contact wire on the pan.

2) Check that the grease plate is properly fastened.

3) Check the bow plunger for free sliding while pressing. Check that the split pins are intact.

4) Check the horizontality of the panto pan and its free vertical movement. Check the transverse flexibility of the pan by pulling transversely at the middle cross member with a force of 50 kg. The displacement of the pan at the middle cross member should 36 ± 5mm. Check that the positioning link is not bent/cracked or dislocated from the fixing pivots. Check the intactness of split pins.

5) Check the pantograph frame for signs of bending or cracks. Check the springs for any cracks.

6) If possible, take the measurement of the pan as per the Fig. 9.01.

7) Check the broken or cracked fittings of the pantograph and see whether the cracks are old or fresh.

\[
\begin{array}{|c|c|c|c|}
\hline
\text{PANTO TYPE} & A & B & C & D \\
\hline
\text{AM-12} & 520 & 1800 & 300 & 380 \\
\text{AM-18} & 632 & 2032 & 306 & 384 \\
\hline
\end{array}
\]

Fig. 9.01
1. Location

2. Height of contact wire above main line.

3. Height of contact wire of turnout/cross-over above R.L.

4. Stagger of contact wire of main line.

5. Stagger of contact wire of turn-out/cross-over.

6. Length of steady arm holding main line contact wire.

7. Length of steady arm holding turn-out/crossover contact wire.

8. Position of Registration tube and register arm dropper clip.

9. Track separation at obligatory point.

10. Position at which horn of pantograph jumped above contact wire.

11. Vertical height of steady arm clamp from register arm.

12. Hitting marks on the steady/Registration arm tube, P.G. Clamps droppers contact wire, dropper clip, splices, jumpers, if any.

13. Condition of cracked or broken OHE fittings such as clamps, catenary suspension bracket, splices and clips etc. Check whether the cracks are fresh or old.

14. Check free vertical movement of the steady arm.

Above observations will be made on every mast within at least 500 m in the rear of the location of entanglement.
ITEMS TO BE CHECKED UP AFTER THE FIRE IN A LOCOMOTIVE

1. Position of master controller, SMGR drum and tap position of tap changer.
2. Condition of DJ, whether locked or in open condition?
3. Whether relays, particularly QLM, QRST, QOP, QOA, are in tripped condition or normal?
4. Condition of HOBA, HQOP and HQOA knife switches.
5. Condition of fuses.
6. Condition of CGR1, CGR2, CGR3 and RGR.
7. Arc-chute of CGRs, line and shunting contactors, auxiliary circuit contactors.
8. Condition of contactors - whether found in wedged or welded condition.
9. Possibility of loose connections at the terminal points.
10. Possibility of overheating due to poor thimbling.
11. Identify the location of the cable where globules are found formed.
12. Identify the area / zone where the damage to the locomotive is extensive due to fire.
13. Condition of 25 kV bushings of the transformer- whether burnt after bursting or simply burnt or not damaged.
14. Possibility of transformer oil splashing with special attention to any sign of oil in conservator.
15. Condition of tap changer with particular attention to splashing of oil and flash-over of the taps.
16. Condition of other electrical equipment like rectifier block, inductive shunt, auxiliary machines and traction motors for any abnormality entailing fire in the locomotive.
17. Polarity of the smoothing reactor, if not damaged fully.
18. Condition of brake blocks, wheel disc for over-heating and melting of brake blocks. Search out molten pieces of brake blocks, if any on SL.
19. Whether the fire took place when dynamic brake was in applied condition. If so, whether thermal relay of DBR was in working order. Examine the condition of DBR resistances.
20. Presence of any inflamable material like jute, rubber etc.
21. Abnormality, if any already indicated in the log-book by the driver which could lead to fire.
22. Take this statement of crew and other personnel travelling on the locomotive about how the fire originated.
23. Whether specified fire extinguishers were available in the locomotive and used by the driver and how many of them were found effective?
ITEMS TO BE CHECKED UP BEFORE TAKING UP SPECIAL REPAIR OF FIRE/ACCIDENT DAMAGED LOCOMOTIVE

All the items given below need attention for a locomotive involved in a major accident, affecting the under-frame. However, checking up of only under-frame and item 3 is necessary in case a major fire damaged locomotive is taken for rehabilitation.

1. Electrical equipment
1.1 Condition of tap changer plate, oil level in the gauge glass.
1.2 25 kV condenser bushing for physical damage and oil leakage.
1.3 Fixing/foundation bolt of all equipment.
1.4 Visual inspection for any damage.

2. Mechanical equipment
2.1 Under-frame
(a) Visually inspect the underframe main sills for crack/local deformation/squareness.
(b) Measure height of couplers/buffers
(c) Measure important dimensions of the underframe and examine for any bend/twist. The typical dimensions which are required to be recorded for WAG-5 class of locomotive are given in Fig. 9.02 (Sheet 1, 2).
(d) Measure camber by running a piano cord from end to end of the locomotive. If there is a negative camber, the under-frame is likely to have under-gone a permanent set. It is normally not possible to set right such deformation except when it is localised or is on a non-stress bearing member.
(e) Any separation between underframe and shell.
(f) Coupler, coupler pin, draft lugs (inside the coupler pocket) for crack/deformation.
(g) Holding arrangement of each equipment and shear checks, etc.

2.2 Bogie and Brake rigging
(a) Visually examine the bogie frame and brake rigging for any damage with special attention to cracks.
(b) Measure all dimensions of bogie frame and examine for its deformation/squareness.
(c) Condition of the interfaces of the bogie frame with underframe.
(d) Condition of axle box roller bearing and horn liners.
(e) Bending of axle and traction motor shaft.
(f) Cracks/deformation of equaliser beam, spring and spring seats.

3. Miscellaneous
Visual inspection of all equipment of locomotive for any damage and deficiency.
## TYPICAL DIMENSION OF UNDERFRAME

<table>
<thead>
<tr>
<th>S No.</th>
<th>Test</th>
<th>भाग</th>
<th>Dimension (mm)</th>
</tr>
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<tbody>
<tr>
<td>क.सं.</td>
<td>परीक्षा</td>
<td>पृष्ठ</td>
<td>आयाम (मि. मी. में)</td>
</tr>
<tr>
<td>1</td>
<td>B₁</td>
<td>बी₁</td>
<td>1568 ± 5</td>
</tr>
<tr>
<td>2</td>
<td>B₂</td>
<td>बी₂</td>
<td>1568 ± 5</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>दी</td>
<td>12580 ± 1.5</td>
</tr>
<tr>
<td>4</td>
<td>E₁</td>
<td>इ₁</td>
<td>219 ± 0.5</td>
</tr>
<tr>
<td>5</td>
<td>E₂</td>
<td>इ₂</td>
<td>219 ± 0.5</td>
</tr>
<tr>
<td>6</td>
<td>F₁</td>
<td>एफ₁</td>
<td>238</td>
</tr>
<tr>
<td>7</td>
<td>F₂</td>
<td>एफ₂</td>
<td>238</td>
</tr>
<tr>
<td>8</td>
<td>F₃</td>
<td>एफ₃</td>
<td>238</td>
</tr>
<tr>
<td>9</td>
<td>F₄</td>
<td>एफ₄</td>
<td>238</td>
</tr>
<tr>
<td>10</td>
<td>P₁</td>
<td>प₁</td>
<td>9529 ± 1</td>
</tr>
<tr>
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<td>P₂</td>
<td>प₂</td>
<td>9529 ± 1</td>
</tr>
<tr>
<td>12</td>
<td>r₁</td>
<td>आर₁</td>
<td>1270 ± 2</td>
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<td>A₁</td>
<td>ए ₁</td>
<td>18704 ± 10</td>
</tr>
<tr>
<td>15</td>
<td>A₂</td>
<td>ए ₂</td>
<td>18704 ± 10</td>
</tr>
<tr>
<td>16</td>
<td>G</td>
<td>जी</td>
<td>282 ± 2</td>
</tr>
<tr>
<td>17</td>
<td>H</td>
<td>एच</td>
<td>1400 ± 4</td>
</tr>
<tr>
<td>18</td>
<td>J</td>
<td>ज</td>
<td>2078 ± 4</td>
</tr>
<tr>
<td>19</td>
<td>K₁</td>
<td>क₁</td>
<td>3050 ± 5</td>
</tr>
<tr>
<td>20</td>
<td>K₂</td>
<td>क₂</td>
<td>3050 ± 5</td>
</tr>
<tr>
<td>21</td>
<td>L₁</td>
<td>एल₁</td>
<td>3185 ± 1</td>
</tr>
<tr>
<td>22</td>
<td>L₂</td>
<td>एल₂</td>
<td>3185 ± 1</td>
</tr>
<tr>
<td>23</td>
<td>M₁</td>
<td>एम₁</td>
<td>203 ± 2</td>
</tr>
<tr>
<td>24</td>
<td>M₂</td>
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<td>203 ± 2</td>
</tr>
<tr>
<td>25</td>
<td>U₁</td>
<td>उ₁</td>
<td>1956 ± 4</td>
</tr>
<tr>
<td>26</td>
<td>U₂</td>
<td>उ₂</td>
<td>1956 ± 4</td>
</tr>
</tbody>
</table>

**Height of the rail guards from rail level:**
- रेल पट्टी से रेल गादी की ऊंचाई:

| Cab-1 कैब-1 | LH बाई ओर | 115 +3 |
|             | RH दाई ओर | 115 -0 |
| Cab-2 कैब-2 | LH बाई ओर | 115 +3 |
|             | RH दाई ओर | 115 -0 |
CHAPTER X

<table>
<thead>
<tr>
<th>Para No.</th>
<th>Subject</th>
</tr>
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<tbody>
<tr>
<td>31001</td>
<td>Annual Statements</td>
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<td>31002</td>
<td>Monthly Statements</td>
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<tr>
<td>31003</td>
<td>Daily Position</td>
</tr>
<tr>
<td>31004</td>
<td>Shed-wise Performance</td>
</tr>
<tr>
<td>31005</td>
<td>Combined Driver's and Guard's Report.</td>
</tr>
<tr>
<td>31006</td>
<td>Nomination for Foreign Railway.</td>
</tr>
</tbody>
</table>
Utilization (Territorial Basis) E Km/day in use
a) Goods (Through)
b) Passenger
c) All services

7. Total Engine km/per day earned
(Average for the month)
a) Goods services
b) Passenger services

31005 Combined Driver's and Guard's Report

The only basis of the operating statistics which give the vital performance index of a particular type of locomotive or the shed emanates from Combined Guard's and Driver's Report Part - I and Part - II (attached). This report in addition to being an instrument of payment of wages, running and overtime allowances to the crew, also becomes the basis of operating statistics. This goes to the statistical office and gets coded in the coded sheet for operating statistics. It is therefore important that the ATFRs should check very particularly all the details given in the joint report so that the operating indices of the shed are not vitiated.

31006 Nomination for Foreign Railway

In addition, the locomotive nominated for foreign Railway shall be issued with Trip Card, a sample proforma is attached. The trip card is also sent to the statistical office after the loco touches the homing shed. This also helps to keep correct record of the performance of the locomotive.
**CUMMINS GUARD'S AND DRIVER'S REPORT-PART II**

**NOTE:** ONE REPORT IS TO BE MADE FOR EACH COMPLETE DRIVER'S RUN

---

### TO BE FILLED IN BY DRIVER

<table>
<thead>
<tr>
<th>TIME</th>
<th>NO. OF MINUTES</th>
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<tbody>
<tr>
<td><strong>ARRIVAL</strong></td>
<td><strong>DEPARTURE</strong></td>
</tr>
<tr>
<td>STATION</td>
<td>ROUGHED TIME</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### TRAVEL

1. **TIME ENGINE LEFT SHED OR WAS TAKEN OVER**
2. **TIME ENGINE COUPLED TO TRAIN**
3. **TIME ENGINE UNCOUPLED FROM TRAIN**
4. **TIME ENGINE ARRIVED AT STATION SHED OR ON COMPLETION OF DUTY OR WAS HANDED OVER**
5. **TOTAL TIME ENGINE WAS EMPLOYED ON SERVICE**
6. **TIME TRAIN ENGINE WAS EMPLOYED ON SHINING**
7. **AT STARTING STATION BEFORE DEPARTURE OF TRAIN**
8. **AT TERMINATING STATION AFTER ARRIVAL OF TRAIN**
9. **TIME DRIVER CAME ON DUTY**
10. **TIME DRIVER WENT OFF DUTY**

---

### SUMMARY OF TIME LOST AND MADE UP

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<th>DESCRIPTION</th>
<th>196</th>
<th>MSA</th>
<th>DESCRIPTION</th>
<th>196</th>
<th>MSA</th>
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<th>TRAVEL SYSTEM</th>
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</tr>
</tbody>
</table>

---

### DRIVER'S SPECIAL REPORT

1. **NO. OF VACUUM BRAKE WAGONS OPERATIVE**
2. **NO. OF CAUTION SIGNS ATTACHED**
3. **NO. OF AUTHORITY, ETC. ATTACHED**
4. **DROPING SIGNAL**
5. **NO SIGNALS AT NIGHT**
6. **SIGNALS WHICH HAVE BECOME OBSCURED BY TREES OR HAVE BAD BACK GROUND**
7. **BAD SPOTS IN THE TRACK**
8. **IRREGULAR WORKING OF RAILWAY STAFF**

---

**TOTAL NO. OF DOCUMENTS ATTACHED**

**CERTIFIED THAT THE ENTRIES IN RESPECT OF DRIVERS SHOWN IN THE REPORT ARE CORRECT**

**SIGNATURE OF DRIVER**

**PAYMENT CALCULATED AND ENTERED ON REPORT**

**SIGNATURE OF GUARD**

**SIGNATURE OF LOCO FOREMAN**

**SIGNATURE OF CLERK**

---

**REMARKS FOR DETENTION**

---

**TIME LOST BY**

---

**TIME MADE UP BY**

---

**KILometres / TRAVEL ALLOWANCE**

---

**AN ALLOWANCE IN TERMS OF KILOMETRES**

---

**OVERTIME ALLOWANCE**

---

**SPECIAL COMPENSATORY ALLOWANCE**

---

**BREADTH OF NECK ALLOWANCE**

---
## COMBINED GUARD'S AND DRIVER'S REPORT-PART-II
(NOTE: ONE REPORT IS TO BE MADE FOR EACH COMPLETE DRIVER'S RUN)

**TO BE FILLED IN BY GUARD**

<table>
<thead>
<tr>
<th>TRAIN NO.</th>
<th>SERVICE</th>
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<tbody>
<tr>
<td>GAUGE</td>
<td>DIVISION</td>
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<tr>
<td>FROM STATION</td>
<td>TO STATION</td>
</tr>
<tr>
<td>DISTANCE</td>
<td>DATE</td>
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</tbody>
</table>

**DRIVER'S NAME**

**ENGINE NO.**

**CLASS OF ENGINE**

**HOME SHED**

**ENGINE NO. OF ASSISTING REQUIRED**

**ATTACHED TO TRAIN (IF ANY)**

1. **NAME OF STAFF**
2. **STAFF NO.**
3. **HEAD QUARTERS**
4. **STATION WHERE TRAIN TAKEN OVER**
5. **STATION WHERE TRAIN HANDED OVER**

**ARE TAIL BOARDS AND TAIL LAMPS COMPLETE?**

**ARE ELECTRIC LIGHTS AND FANS IN ORDER?**

**ARE SAFETY FITTINGS IN UPPER GLASS IN ORDER?**

**IS FIRE EXTINGUISHER COMPLETE AND IN WORKING ORDER?**

**IS A COMPARTMENT IN EACH CLASS RESERVED FOR LADIES?**

**HOW IS THE TRAIN FILLED?**
- A: CROWDED
- B: WELL FILLED
- C: NOT WELL FILLED

### TRAIN LOADS IN TERMS OF FOUR-HEALED AND IN TONNES

<table>
<thead>
<tr>
<th>STATIONS</th>
<th>PASSENGER COACHES</th>
<th>OTHER COACHES</th>
<th>COMPO.</th>
<th>TANKS</th>
<th>TOTAL COACH COACHING VEHICLES (CODE 370-1)</th>
<th>WEIGHT TONS</th>
<th>TANKS</th>
<th>BINS</th>
<th>BOX</th>
<th>OTHER TYPES</th>
<th>TOTAL COLUMN DUE TO 15</th>
<th>TANKS</th>
<th>BINS</th>
<th>BOX</th>
<th>OTHER TYPES</th>
<th>TOTAL GOOD LOADS (CODE 370)</th>
<th>TANKS</th>
<th>BINS</th>
<th>BOX</th>
<th>OTHER TYPES</th>
<th>TOTAL GOOD LOADS (CODE 370)</th>
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<th>BOX</th>
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**SIGNATURE OF GUARD**

(1)  
(2)
## CHAPTER XI

TECHNOLOGICAL ADVANCEMENTS

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</tr>
<tr>
<td>31106</td>
<td>Other Developments on Hand</td>
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CHAPTER XI
TECHNOLOGICAL ADVANCEMENTS

31101 Introduction

Some of the recent technological innovations introduced by Foreign Railways are discussed below. Advantages offered by these innovations in respect of operating performance and maintainability have also been indicated. With a view to use developed technology of 3-phase drives system on Indian Railways, import of 3-phase drive system locomotives with technology transfer for subsequent indigenous manufacturer is on hand.

31102 Conversion Equipment

1. With the availability of thyristor of higher power handling capability use of tap changer is being eliminated making the equipment entirely static. This will not only reduced attention required but also enhance reliability. Other very important benefit achieved by the thyristors is the capability they offer to control individually the supply to each motor permitting full utilization of the adhesion existing between the wheels and the rails.
2. Indian Railways have imported 12 locomotives from Japan and 6 from Sweden with this technology (WAG6 series). Earlier a few experimental thyristor units were also fitted in existing locomotives, some of them with indigenous know – how. Indian Railways have also imported 25 sets of thyristor control traction equipment for fitment on 25kV ac MG EMUs from UK. These are being fitted on 25kV ac MG EMU coaches at ICF, Madras. Seven such thyristor controlled EMU rakes are presently in operation on MG Section of Southern Railway.

31103 Controls

With the advent of solid state devices in general, and microprocessors in particular, more and more sophistication has become possible. Other things remaining the same, with stepless control and consequent non-pulsating torque offered by such controls, higher average tractive effort can be achieved. The solid state control is fast acting and methods are now available to detect incipient slip and take corrective action before the slippage becomes uncontrollable and curative action is called for by reducing the tractive effort applied. Thus the locomotives can be made to develop tractive efforts to very high levels of adhesion co-efficient.

31104 Drive

1. One of the severe restrictions imposed on the capability of electric locomotive is the dc series motors. These motors have limitations on their use because of windings on the rotor and assembly of commutators, making it vulnerable against centrifugal forces and requirements of satisfactory commutation. The 3-phase asynchronous motor with a bar rotor does not have the surface speed limitations. The useful portion of its speed torque characteristics is only near its synchronous speed. This useful portion can be spread over a wide range by varying the synchronous speed through frequency control.

2. With the advent of Gate Turn Off (GTO) thyristor problems associated with conversion of dc into multiphase ac system have been eliminated and use of 3-phase synchronous/ asynchronous motor has become feasible. “Variable Voltage and Variable Frequency” (VVVF) control has been developed and use of induction motors as traction drives has been tried successfully on the different railway systems. With induction machines a maximum surface speed of 100 m/s is achievable and an rpm level of 4500 has been accepted in the railways systems in Europe. This considerably increases the output power of the traction motor for the same size. This state of art technology has yet to arrive in our country.
3. Typical power circuit along with brief details of locomotive fitted with asynchronous motors is shown in Fig. 11.01.

31105 Power Rating

1. Necessity for increasing the throughput resulted in the design of BOX "N" wagons. With these wagons, a trailing load of 4700 t has been optimized. Further improvements are under consideration which may result in a maximum trailing load of 5100 t on the existing loop lengths. Also efforts are on hand to increase the maximum speed of these stock to 100 km/h. For trailing loads of 4700t, a 6000 HP locomotive with 45 t starting effort was taken as an optimum. Once the trailing load is increased to 5100 t and the speed potential to 100 km/h, the horsepower requirements further go up to 8000 with a starting tractive effort of 50 t. Indian Railways will require a 8000 HP loco to meet the increasing throughputs of freight traffic.

31106 Other Developments on Hand

1. Indigenous development of multiplexing and locotrol for use on long passenger and heavy-hauled goods trains.

2. Indigenous development of on board power factor correction equipment for improving power factor of locomotive.

3. Indigenous development of fault diagnostics for locomotive
ELECTRIC LOCOMOTIVES WITH 3-PHASE DRIVES

1. Introduction

Till electronics came into the field of traction recently, the best suited drive for traction application was the dc series motor because of its inherent characteristics to give high torque at low speeds and vice-versa. The dc series motor was the best solution found for meeting the actual service as well as control requirements. On a fixed frequency, the asynchronous motor has a characteristic which is not well suited for traction application. However, this motor is of rugged construction when compared to a dc motor and requires much lower inputs for maintenance. Therefore its choice as a traction motor will always be preferred if control of the motor to suit the service requirements is possible. With the development of GTO thyristors, power electronics and micro processor control, controlling of any drive to suit specific requirements has become quite easy. In the circumstances, adoption of 3-phase induction motor for traction application has been tried for the past 10 years and has now become commercially viable proposition. The control is being achieved through variable voltage and variable frequency briefly referred to as VVVF. Originally thyristors were used with commutation requirements for cut off. With the advent of GTO, the control has been made much simpler and more efficient thus use of 3-phase asynchronous motors for traction could also become financially viable.

A locomotive With 3-phase asynchronous motor drive has the following advantages:
- higher power capability due to high power/weight ratio,
- regeneration capability over a wide speed range,
- lesser maintenance,
- unity power factor at pantograph,
- higher adhesion.


The speed/torque characteristic of an induction motor supplied from a 3-phase voltage source of fixed frequency ‘f’ is of the form shown in Fig. 11.02.

It may be seen that at low speed, the torque is small and the stator current is high. The zone normally usable lies at the extreme from the point of maximum torque, in the vicinity of synchronous speed. For traction applications a high TE is necessary for starting and accelerating the train. Therefore, when constant torque is required, it is necessary to obtain whole series of characteristics curves such as shown in Fig. 11.03. This calls for change in synchronous speeds and therefore variable frequency.

3. Control scheme for induction motors:

The control of the ac induction motor drive in traction application is achieved in 3 stages.

1) Constant torque mode: The torque developed by a motor is proportional to the product of the magnetic flux in the air gap and the rotor current. The applied voltage is proportional to the synchronous frequency and the magnetic flux in the air gap. To keep the magnetic flux constant, therefore, the applied voltage to the traction motor is, to be made proportional to the synchronous speed.

The rotor current depends upon the slip frequency of the rotor. By keeping this constant, the rotor current is also kept constant. This is possible till the voltage is increased to the rated terminal voltage of the traction motor. Thus in this mode the control is achieved by increasing the voltage and frequency uniformly with respect to the actual speed of the rotation of the rotor and the required slip frequency.
ii) Constant power mode: In this mode the voltage is already reached to the rated voltage. By increasing the frequency, the magnetic flux in the air gap is reduced proportionately. By keeping the slip frequency constant, the motor current is kept constant. Thus the motor is made to give constant power output till the maximum service speed is reached.

iii) Balancing speed stage: Once the maximum pre-determined speed is achieved, the same power output from the traction motor may not be required and the output is to be matched to meet the resistance of the train for running at the balancing speed. This is achieved by suitably reducing the terminal voltage of the traction motor.

These functions are performed through micro processor control giving various inputs of parameters like voltage, current and speed.

iv) Convertor/Invertor System: In order to achieve the above control requirements, the convertor/ invertor system with a dc link is adopted. The convertor rectifies the ac voltage to dc and feeds it to the dc link. The dc link supplies power to the invertor. The convertor output power is controlled by controlling the output current keeping the dc link voltage constant. The invertor output power is controlled by varying the terminal voltage initially till the full voltage is achieved. However the motor output current is kept constant.

The control of output current of the convertor and output voltage of the invertor is achieved by pulse width modulation control.

The Power circuit diagram of a typical 3-phase locomotive fitted with asynchronous motors is shown in Fig. 11. 01.
SPEED vs TE CHARACTERISTICS OF INDUCTION MOTOR

FIG.11.02

SPEED/ TORQUE CHARACTERISTICS WITH V/f CONSTANT

FIG.11.03
## CHAPTER XII

### TRAINING AND COMPETENCY CERTIFICATE

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CHAPTER XII
TRAINING AND COMPETENCY CERTIFICATES

I. TRAINING

31200 Introductory

Electric traction is a specialized field. Efficient operation and maintenance of the traction installations and equipment is only possible if the staff concerned have acquired an intimate knowledge of the details of construction, adjustments and operation of the equipment. A thorough knowledge of the special rules and procedures on the part of the staff is also essential to ensure safety of equipment and personnel. These requirements call for a degree of specialized training for all categories of staff before they can be safely entrusted with the responsibility for maintenance or operation.

III. 31201 Planning of Training in Advance

Before electric traction is commissioned on any section, adequate strength of well-trained operating, maintenance and running staff should be kept ready for operating the services. Planning the recruitment and training of such staff well in advance is one of the most important tasks of the open line administration. This applies in particular to steam/diesel running staff who would become surplus to requirements on introduction of electric traction and hence have to be absorbed as running staff to operate electric rolling-stock. Timely release of such staff for training should be pre-planned and ensured by the Electrical Department in co-ordination with the Mechanical Department. It is also necessary to establish sufficiently in advance suitable training schools with qualified instructors and facilities for imparting the training.

IV. 31202 Categories to be Trained

Categories of staff for whom special training is required to be organized are generally as under-

1. Degree and Diploma holders recruited directly as Supervisors.
2. Apprentice Mechanics to be absorbed as Supervisors.
3. Trade Apprentices to be absorbed as skilled artisans.
4. Diesel/Steam Drivers to be trained as Drivers of electric locos and EMUs.
5. Artisans and supervisory staff to undergo Refresher Courses.
6. Running staff to be posted as TLCs etc.

V. 31203 Initial Training

1. Categories of staff mentioned below should receive a period of initial training in a training establishment before they are posted to working posts-
   a) Directly recruited supervisors.
   b) All categories of running staff, whether directly recruited or absorbed from steam/diesel sections.
   C) Skilled and semi-skilled artisan staff for maintenance.
d) Any other category to be approved by CEE.

2. The period of initial training for typical categories is given below, which may be modified by CEE in accordance with local requirements:

   a) Direct recruited supervisors (Degree and Diploma Holders):
      
      i) Electric Loco Section 18 months
      ii) EMU Section 12 months

   b) Steam/Diesel Drivers to be absorbed as Electric Running Staff:
      
      1) Asst. Drivers 12 weeks
      ii) Grade 'C' 20 weeks
      iii) Grade 'B' or 'A' 48 weeks

   c) Skilled artisans for maintenance:
      
      i) Direct recruits 60 weeks
      ii) To be absorbed from Diesel/Steam or Electric general services 30 weeks

3. In addition to theoretical training, the trainees should receive thorough practical training on the work they will have to perform on completion of training. In all cases they should have a period as under-study to senior and experienced staff in actual execution of the type of work they have to perform on completion of training.

4. For artisan staff the practical training should be oriented to enable them to understand and be able to carry out independently skilled work of the type covered by 'Inspection books', 'Inspection charts', 'trouble-shooting charts' and 'technical charts'.

VI. 31204 Promotional Courses

1. No employee can be promoted unless he passes the trade test or other prescribed departmental test. The purpose of the semi-skilled category is to enable a man to study under the skilled man and take the trade test in due course.

2. When an employee is promoted, he should, as a rule, receive a period of training to enable him to discharge his responsibilities in the higher post e.g., a semi-skilled fitter on promotion as a skilled fitter. Such training should precede the departmental tests to determine suitability for promotion. The training should be generally on the same lines as initial training, but the period in most cases can be curtailed since the employee would already have a certain amount of background knowledge on account of his experience.

   Particular attention should be paid to the older men, who although very proficient in the practical aspects of their work, are unable to pass the prescribed trade tests etc. in regard to the theoretical aspects because of their poor educational background. It often happens in consequence that they are blocked for promotion although they are fit for promotion in every other respect. By paying individual attention to such men and teaching them elementary theory, they could be made sufficiently proficient to pass the trade tests in full. This not only ends their frustration, but boosts up staff morale as a whole.

INDIAN RAILWAYS - AC TRACTION MANUAL VOLUME III
VII. 31205 Refresher Courses

1. In accordance with instructions current on the subject, refresher courses should be arranged. This is obligatory for those categories of staff dealing with "safety of train operation or having daily contacts with the public". The following is an illustrative list of staff coming within the scope of these instructions:

- Drivers, Asst. Drivers, Motormen, Shunters, Engine Turners, Supervisors and Artisans responsible for examination and certification of fitness of running gear of locos and EMUs.

- TLCs and Driving Inspectors

2. Similar refresher courses are also desirable for other categories of maintenance staff. The categories of staff for whom refresher courses are to be arranged can be decided by the General Manager in accordance with para 117(a) of the Indian Railway Establishment Manual.

3. The object of the refresher courses is to reinforce the knowledge of the staff and bring them up-to-date in regard to the latest rules and procedures and instructions regarding operation and maintenance in the light of operating experience. The duration of the refresher course for each category may be decided by CEE to suit local conditions. The duration for typical categories is given below for guidance:

   - a) Supervisors: 3 weeks
   - b) Drivers/Asst. Drivers: 3 weeks
   - c) Artisan Staff: 2 weeks

4. For categories of staff liable for inter-divisional transfers, programming of refresher courses should be arranged by the headquarters office. For staff confined to a particular division, the programming should be done at the divisional level.

5. Apart from rules and regulations, the refresher courses for running staff should lay emphasis on trouble-shooting procedures for various types of locos and EMUs. Drivers have to deal with some types of failures only rarely and hence they tend to forget the details. Though such details are given in the Trouble-Shooting Manuals, actual drilling during the refresher course will be of great benefit. This involves repetition of the same exercise several times so as to make a lasting impression and not to be forgotten easily.

6. During the refresher courses, it will be very useful to arrange group discussions amongst the trainees on specific problems encountered during the course of work. Such group discussions will be of great assistance in view of the opportunity for exchange of information based on actual experience in working.

VIII. 31206 Facilities for Training

1. Facilities have been provided on an All India basis for the intensive specialized training of officers and staff of the Electrical Department. In addition the facilities available with the different Zonal Railways have to be utilized to best advantage.

2. Training schools for Drivers are attached to major electric loco sheds. These schools should be used to a limited extent for training of artisan staff and supervisors. Apart from cut-models, charts, circuit diagrams etc. the training schools should contain 'simulators' to demonstrate the functioning of locos, the circuit combinations resulting from operation of the master controller etc. These simulators should be used to drill the trainees in the correct method of operation and systematic trouble-shooting.

3. The 'simulator' provided consists of the HT and LT control apparatus as provided in the locos and working models of items such as pantograph, tap-changer etc. A driving cab similar to the cab in a loco is available, complete with master controller, brake controller, control switches, gauges, indicator lamps etc. From this driving position...
the equipment in the simulator can be operated to demonstrate the functioning of the various components. By actually handling the controls, the trainees can learn the correct sequence of operation and get a ‘feel’ of the equipment as actually functioning.

The Instructor can reproduce faults similar to those occurring in actual practice e.g., tripping of circuit breaker due to overload, earth faults, traction motor faults etc. The trainees can get familiar with the correct method of trouble-shooting as detailed in the trouble-shooting directory and by repeated practice become fully acquainted with the correct procedure.

4. In any traction training establishment, the essential equipment to be provided for instructional purposes should include the following-

a) Special tools and instruments used in electric traction.

b) Cut-models to show constructional details of equipment.

c) Circuit diagrams, sectionalising diagrams, etc., preferably illuminated and arranged to show the sequence of operations

d) Samples of damaged equipment with tablets explaining the nature of failures and preventive checks.

e) Publicity boards with slogans and illustrations emphasizing safe methods of working,

f) Boards illustrating ‘Do's' and ‘Dont's'.

g) Preferably full working models.

IX. 31207 Training in General and Subsidiary Rules

Electric running staff as well as supervisors, when required, should receive initial training as well as refresher courses in General and Subsidiary Rules normally in the Zonal Transportation Schools, which usually have excellent model rooms to facilitate the proper understanding of the rules and systems of working. In exceptional cases when such training cannot be arranged conveniently in the Zonal Schools, CEE may authorize the training in GRs & SRs to be included in the syllabus for training in Loco Training Schools. Separate Instructors well-versed in the subject should, however, be provided invariably.

X. 31208 Responsibility of Officer and Supervisors

Apart from those in-charge of training establishments, other officers and supervisors in-charge of operation and maintenance should also take a keen personal interest in the training of all grades of staff attached to them. They should deem it as part of their duty to guide the trainees and watch their progress. Training is a continuous process which helps the officers as much as the trainees not only in developing contacts on a personal level, but also in understanding the finer points of operation and maintenance. A record of progress achieved, the period of training given etc. should be maintained for every trainee.

XI. 31209 Examination at the end of Training

All trainees should pass prescribed examination on completion of training. The scope of examination and the level of officers and supervisor responsible for examining will be laid down by CEE. The examination should have a practical bias. The examination of Drivers, for instance, should include practical tests in trouble shooting as well as correct driving and braking techniques.
XII. 31210 Specialized Training

1. Selected supervisors and officers from the user railways should be deputed to CLW and ICF to be associated with the production of each batch of electric loco and EMU stock. Such association of the maintenance staff at the production stage will be of great help in giving them an insight into constructional details of the equipment.

2. Similarly when large contracts are entered into for supply of electric traction equipment incorporating new designs and technology, it is usual practice to include in the contract a clause which permits some staff of the consignee railways to be deputed to the manufacturer's works during the production stage for practical training on the equipment, so that they may get thoroughly acquainted with the operation and maintenance of the equipment, taking advantage of the training facilities available with the contracting firms.

XIII. 31211 Syllabi

Guidelines for syllabus of two categories of staff are given below. Syllabus on the same lines shall be prepared for all courses of trainings.

Driver Grade ‘C’ (Conversion from Steam/Diesel)

Duration: 20 weeks.

A. Theoretical:
(a) Basic principles of electricity - clear notions about voltage, current, power, resistance etc. - use of electrical measuring instruments for measuring voltage, current and insulation resistance - clear notions about ac and dc simple electrical circuits.

(b) Principles of ac and dc generators, transformers, rectifying devices - tap-changers, lead acid and alkaline cells, relays, magnetic and pneumatic contacts.

(C) Study of power and control circuits of different types of locos used in hauling freight trains familiarization with the names, symbols and physical location of all equipment.

(d) Essential details of mechanical equipment of different types of locos used in freight trains.

(e) Details of pneumatic and brake equipment.

(f) Procedure for preparation of locos for service - principles of driving, acceleration, speed control, use of gradient marks, procedure to be followed at neutral sections, correct use of electrical and mechanical brakes.

(g) Study of rules specially applicable to electric traction.

(h) Safety precautions, prevention of wheel-slip and parting.

(i) Procedure for obtaining emergency power block for roof inspection.

0) Rules regarding fire fighting in electrical installations and practice use of common types of fire extinguishers.

(k) Study of standing instructions.

(B) Practical:
(a) Work with the maintenance staff to get familiar with equipment.
(b) Detailed study of trouble-shooting directory for each type of loco and actual practice of each case.

(c) Practice inspection of outgoing and incoming locos in shed.

(d) Driving under the supervision of a senior and experienced Driver after learning road.

2. Supervisor (Electric Loco) - Direct Recruits - Degree or Diploma Holders

Duration: 18 months.

A. Theoretical:

(a) General principles of 25 kV traction Installations and rolling stock.

(b) Detailed study of mechanical and electrical details of all types of locos in the railway including bogies and suspension, power transmission, braking system, hauling capacity, power and control circuits and details of all traction and auxiliary equipment. Become thoroughly familiar with circuit diagrams, symbols and physical location of all equipment.

(c) Maintenance organization in the shed- section-wise distribution of work with particular reference to responsibility of each supervisor in the shed, functioning of PPO, Maintenance schedules, inspection books, inspection chart, technical charts etc.

(d) Work done during POH of loco.

(e) Rolling-stock operation-outstation maintenance, loco links, control over running staff, Traction Loco Control.

(f) Procedure for indenting and accountal of stores T & P Register.

(g) Rules and regulations - Factories Act, HOER, Payment of Wages Act, Workmen's Compensation Act, Leave and Pass Rules, Rules for Overtime Working etc.

B. Practical.

(a) In the shed some time should be spent in each section to study details of maintenance carried out by designated workmen and some time to understudy the section supervisor. When attached to E1 and M1 sections, the trainee should undertake trouble-shooting independently.

(b) In the POH shop, in a similar manner as above in each section.

II. COMPETENCY CERTIFICATES

XIV. 31212 Authorized Person

An "authorized person" is one who is duly authorized to perform specific duties pertaining to his employment, the authorization being made by an official of the Railway Administration empowered for that purpose.

XV. 31213 Competency Certificate

Each authorized person will be given a "Competency Certificate", defining the works which he is authorized to carry out after he has been trained, examined and found fit.
The following categories of rolling stock staff shall be issued with the certificates by the official indicated against each category after written/oral test as shown:

1. Asstt. Driver (Elec. Loco) TR-10 DEE(RS)/DEE(OP) after Written, oral and practical tests as prescribed.
2. Driver (Elec. Loco) TR-11 -do-
3. Motorman (EMU train) TR-12 -do-
4. Shunter/Engine Turner TR-13 -do-

XVI. 31214 Period of Training

XVII. The period of training mentioned in the following paragraphs may be modified, if considered essential by CEE, taking local circumstances into account.

XIX. 31215 Drivers, Asstt. Drivers and Motormen

XX. Drivers, Asstt. Drivers and Motormen should undergo courses of training and tests indicated below before they are issued with the Competency Certificates:

XXI. 1. A prescribed course of training in General and Subsidiary Rules in the Zonal Training School or other approved training establishment followed by a written, oral and practical test.

XXII. 2. A course of training as indicated in paras 31203, and 31211 in the Electric Loco School in the operation of the particular types of locos/EMUs he is expected to work, including trouble-shooting procedure to be followed by written, oral and practical tests.

XXIII. 3. Training for a period of one month to "learn the road" in the specified section, at the end of which the employee should sign a declaration that he is fully conversant with the road.

XXIV. 4. Practical training for a period of 2 months in the actual driving of the particular type of Loco/EMU under the supervision of a qualified Driver or Driving Instructor followed, by a driving test by Sr.DEE(RS)/Sr.DEE(OP).

XXV. 5. Prescribed medical examination.

Fresh training to the extent authorized by CEE and tests as per items (2) and (4) above will be required before the employee is allowed to operate any other type of Loco/EMU.

XXVI. 31216 Register of Certificates

XXVII. A register of Competency Certificates shall be maintained in the office of every supervisory official, as per proforma given in Annexure 12.01, showing all staff working under him who have been issued with the Certificates:

XXVIII. 31217 Service Record

An entry should be made in the service sheet of every employee who has been issued with a Competency Certificate.

XXIX. 31218 Inspections

XXVIII. During inspections Officers and Supervisors should make it a point to check the certificates in the possession of the various staff and also test-check their knowledge of the rules pertaining to their work.

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RAILWAY
ELECTRICAL DEPARTMENT

No.

CERTIFICATE OF COMPETENCE No. Tr-10
(For Asst. Drivers of Elec. Locos)

Shri. is authorized to work as an Asst. Driver in the Section between and on the following types of Electric Locomotives:

His written declaration dated that he is fully familiar with the signals in the above section has been noted in issuing this certificate.

He is NOT authorized to operate a locomotive independently.

Dated

DEE(RS)/DEE(OP)

* This declaration must be countersigned by Driving Inspector and personally scrutinized by the officer before issuing this certificate. Before countersigning the declaration, the Driving Inspector shall orally examine the employee for his knowledge of road.

RAILWAY
ELECTRICAL DEPARTMENT

No.

CERTIFICATE OF COMPETENCE No. TR-11
(For Drivers of Elec. Locos)

Shri. is authorized to work as a Driver of Elec. Locomotives of the following types in the section between and on Goods/Passenger/Mail and Express trains.

His written declaration dated that he is fully familiar with the signals in the above section has been noted in issuing this certificate.

Date

DEE(RS)/DEE(OP)

* This declaration must be countersigned by Driving Inspector and personally scrutinized by the Officer before issuing this certificate. Before countersigning the declaration, the Driving Inspector should orally examine the employee for his knowledge of road.
RAILWAY
ELECTRICAL DEPARTMENT

No............

CERTIFICATE OF COMPETENCE No. Tr-12
(For Motormen of EMU trains)

Shri...................... is authorized to work as a Motorman in the Section between ............... and ............. on the following types of EMU trains:—

His written declaration* dated.............. that he is fully familiar with the signals in the Section has been noted in issuing this certificate.

Dated................

DEE(RS)/DEE(OP)

* This declaration must be countersigned by Driving Inspector and personally scrutinized by the Officer before issuing this certificate. Before countersigning the declaration, the Driving Inspector should orally examine the employee for his knowledge of road.

RAILWAY
ELECTRICAL DEPARTMENT

No............

CERTIFICATE OF COMPETENCE No.TR-13
(For Shunters/Engine Turners of Elec. Locos and EMUs)

Shri...................... is authorized to work as a Shunter/Engine Turner of Electric Locos/EMU trains in the electrified yards and sidings of the section between ............... and .............

His written declaration* dated.............. that he is fully familiar with the signals in the above yards and sidings has been noted in issuing this certificate.

He is NOT authorized to operate Electric Locos/EMUs outside the limits of the above yards and sidings.

Dated................

DEE(RS)/DEE(OP)

* This declaration must be countersigned by Driving Inspector and personally scrutinized by the Officer before issuing this certificate. Before countersigning the declaration, the Driving Inspector shall orally examine the employee for his knowledge of road.
### Proforma of Competency Certificates

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## APPENDIX- I

### CODE ABBREVIATIONS FOR ELECTRIC LOCO COMPONENTS

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<td>Air flow indicator</td>
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<td>Arno convertor</td>
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<td>ATFEX</td>
<td>Transformer for breaking excitation</td>
</tr>
<tr>
<td>BA</td>
<td>Battery</td>
</tr>
<tr>
<td>BCR 1-2</td>
<td>Buzzer for air brake reservoir pressure</td>
</tr>
<tr>
<td>BL 1-2</td>
<td>Auxiliary contacts on the switch boxes cab 1, cab 2.</td>
</tr>
<tr>
<td>BL 1-2 CP</td>
<td>Automatic compressor switch</td>
</tr>
<tr>
<td>CPD</td>
<td>Compressor direct switch</td>
</tr>
<tr>
<td>DJ</td>
<td>High voltage circuit breaker switch</td>
</tr>
<tr>
<td>PRR</td>
<td>Rear head light</td>
</tr>
<tr>
<td>LF</td>
<td>Marker &amp; Desk’s Lamps</td>
</tr>
<tr>
<td>LM</td>
<td>Compartment Lamp switch</td>
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<tr>
<td>PR</td>
<td>Head Light dim switch</td>
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<tr>
<td>PRF</td>
<td>Front head light switch</td>
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<tr>
<td>PV</td>
<td>Vacuum pump switch</td>
</tr>
<tr>
<td>QPV</td>
<td>Switch for high speed of the Exhausters cab-1, cab-2.</td>
</tr>
<tr>
<td>RA</td>
<td>Heating switch</td>
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<tr>
<td>RDJ</td>
<td>High voltage circuit breaker resetting Switch.</td>
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<tr>
<td>SN</td>
<td>Neutral section switch</td>
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<td>VMT</td>
<td>Traction motors blowers switch</td>
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<tr>
<td>ZLF</td>
<td>Marker (red &amp; white) lamps switch</td>
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<tr>
<td>BP1DJ</td>
<td>Push button for testing DJ opening</td>
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<tr>
<td>BP2DJ</td>
<td>Push button for testing DJ closing</td>
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<td>CODE ABBREVIATION</td>
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<tr>
<td>BPLSGE</td>
<td>Push button for testing VSGE</td>
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<td>BPPI-2</td>
<td>Push button operating GR motor in progression</td>
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<tr>
<td>BPQ 100</td>
<td>Push button for Q 100</td>
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<tr>
<td>BPRI-2</td>
<td>Push button operating GR motor in regression</td>
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<td>BV</td>
<td>Auxiliary Contacts of HOM Switch</td>
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<td>BVGR 1-2</td>
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<tr>
<td>BPT</td>
<td>Push button for self check of signal lamps</td>
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<tr>
<td>C 101</td>
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<tr>
<td>C 105</td>
<td>3-pole contractor for the Traction Motor Blower No.1</td>
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<tr>
<td>C 106</td>
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<td>C 145</td>
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<td>CCA</td>
<td>Fuse for aux. control circuit</td>
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<tr>
<td>CAPTFWA 1-2</td>
<td>Condenser for TWFA</td>
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<tr>
<td>CAPTFP 1-2</td>
<td>Condenser for TFP</td>
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<td>CAPTFP 3-6</td>
<td>Condenser for TFP terminals a3-a6</td>
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<tr>
<td>CCBA</td>
<td>Fuse for batteries</td>
</tr>
<tr>
<td>CCCHBA</td>
<td>Fuse for batteries charger</td>
</tr>
<tr>
<td>CCGE</td>
<td>Fuse for Generator</td>
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<tr>
<td>CCDJ</td>
<td>Fuse for EFDJ or MTDJ circuits</td>
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<tr>
<td>CCLC</td>
<td>Fuse for Cab corridor H.T.</td>
</tr>
<tr>
<td>CCLS</td>
<td>Lighting and Wall Sockets</td>
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<tr>
<td>CCTFS</td>
<td>Fuse for Marker and PC/Lamps</td>
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<tr>
<td>CCUA</td>
<td>Fuse for control circuit</td>
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<td>CCLF 1-2</td>
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<tr>
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<td>CCVT</td>
<td>चैन पंख बोटेर के लिए पूजा</td>
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<td>CGR 1-2-3</td>
<td>टेप चेंजर सस्पेंडिंग</td>
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<td>उच्च तूलता परिष्कर विभेदक के लिए अभिविरोध</td>
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<td>छत्र प्रोफेक्टर निषेधक</td>
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<td>HVS1 1-2</td>
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<td>LSAF 1-2</td>
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<td>Lamps for voltmeter U1-2 (Traction Motor voltage)</td>
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<tr>
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<tr>
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<tr>
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<td>MVMT 1-2</td>
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<td>MVT 1/1-1/2</td>
<td>Cab fan motors cab 1</td>
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<td>PCLX 1-3</td>
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<tr>
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<td>Q48</td>
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<td>स्लिपिंग शक्ति व्यवस्था रिले</td>
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<tr>
<td>QVSL 1-2</td>
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<tr>
<td>QWC</td>
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<td>RA 2/1-2/2</td>
<td>कैब हीटर कैब 2</td>
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<tr>
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<td>प्रवाह परीक्षा ध्वस्तकोष प्रतिरोध</td>
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<td>RSI 1-2</td>
<td>सिलिकन डिटेक्टर क्षेत्र 1-2</td>
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<td>शीर्षवैसी बोल्टमीटर प्रवाह</td>
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<td>QF 1-2 रिले के लिए शंक</td>
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<td>अभिगाही सेल्सिन</td>
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<td>SMGR</td>
<td>टेप चेंजर वायु मोटर</td>
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<td>SMGR VE 1</td>
<td>टैक्सिंगर वायु मोटर के लिए इलेक्ट्रोवॅल्व &quot;अप&quot;</td>
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<td>SMGR VE 2</td>
<td>टैक्सिंगर वायु मोटर के लिए इलेक्ट्रोवॅल्व &quot;डाउन&quot;</td>
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<td>SON 1-2</td>
<td>अभिगाही बजल के लिए सोन-चंडियां</td>
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<tr>
<td>TFCF (TFVT)</td>
<td>कैब पंख के लिए ट्रांसफॉर्मर</td>
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<td>TFWA</td>
<td>साथीक परायण के लिए मुख्य ट्रांसफॉर्मर कुंडली</td>
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<td>TFILM</td>
<td>उच्च वोल्टेज भाग ट्रांसफॉर्मर</td>
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<td>TFS</td>
<td>सेल्सिन ट्रांसफॉर्मर</td>
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<tr>
<td>TFP</td>
<td>मुख्य ट्रांसफॉर्मर, द्वितीय कुंडली पावर-परिपत्र के लिए</td>
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<td>TFWR</td>
<td>वोटल्टेज निवारण के लिए मुख्य ट्रांसफॉर्मर कुंडली</td>
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<td>क५गं मोटर के लिए वोल्टमीटर</td>
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<td>सहायक परिपत्र वोल्टमीटर</td>
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<td>UBA</td>
<td>बैटरी वोल्टमीटर</td>
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<td>स्वच्छता निकास जुड़वाला भाल्क</td>
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<td>VEF</td>
<td>ब्रेकन के लिए इलेक्ट्रोवॅल्व</td>
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<td>पेनोप्राफ 1 के लिए इलेक्ट्रोवॅल्व</td>
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<td>VEPT 2</td>
<td>पेनोप्राफ 2 के लिए इलेक्ट्रोवॅल्व</td>
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<td>सैंडिंग नियर दिशा 1 और 2 के लिए इलेक्ट्रोवॅल्व</td>
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<td>VGR 1-2</td>
<td>सर्विकलित नियंत्रण साधन</td>
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<td>कर्षण मोटर के लिए ब्लासर</td>
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<td>VRF</td>
<td>ब्रेकन प्रतिरोध के लिए ब्लासर</td>
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<td>VRH</td>
<td>तेल शोक्तक के लिए ब्लासर</td>
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<td>व्लासरिंग डायोड</td>
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<td>बैटरी चार्जिंग व्लासरिंग डायोड</td>
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<td>सिल्कन विपरितस्थि के लिए ब्लासर</td>
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<td>समक्रिय प्रतिक्रियावान के लिए ब्लासर</td>
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<td>VT 1/1-1/2</td>
<td>केब 1 केब पंखा</td>
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<td>VT 2/1-2/2</td>
<td>केब 2 केब पंखा</td>
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<td>ZCPA</td>
<td>सहायक संपीड़क के लिए स्विच</td>
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<td>ZLC 1-2</td>
<td>केब बद्दल के लिए स्विच</td>
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<td>ZLE 1-3</td>
<td>प्रवेश और एसी 2 पेंटल स्लायम के लिए स्विच</td>
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<td>ZPT 1-2</td>
<td>पेंटोग्राफ के वर्ण के लिए स्विच</td>
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<td>रेंक के वर्ण के लिए स्विच</td>
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<td>RTPR के लिए स्विच</td>
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<td>ZSM-GR</td>
<td>टैपनेकर बायु मोटर के वैक्युम और बाद एवं विद्युत प्रदान के लिए स्विच</td>
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<td>ZSM-S</td>
<td>GR बायु मोटर के लिए नियंत्रण परिषद की सहायता हेतु पैको स्विच</td>
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<td>ZVT 1-2</td>
<td>केब पंखों के लिए स्विच</td>
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**APPENDIX - II**

**डब्ल्यूएजी-6 इंजन के प्रमुख पुज्जों के लघु-नाम**

**IMPORTANT ABBREVIATIONS FOR WAG-6 LOCO COMPONENTS**

Only those abbreviations which have not featured in Appendix I are listed below.

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<th>ITEM</th>
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<tbody>
<tr>
<td>ABA</td>
<td>बैटरी/एमीटर</td>
<td>बौधारीतित 100 यों, 50 हर्दिस 2 फेज</td>
<td>Battery Ammeter</td>
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<tr>
<td>ACG</td>
<td>प्रत्यावर्तित 100 यों, 50 हर्दिस 2 फेज</td>
<td>Alternator AC 100V 50 HZ 2 phase</td>
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<tr>
<td>AUX</td>
<td>सहायक पात्र स्पाइट क्वाक</td>
<td>Auxiliary power supply Cubicle</td>
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<tr>
<td>AVR</td>
<td>डीपी/डीपी परिवर्तित</td>
<td>DC/DC Converter</td>
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<td>AVR.G</td>
<td>ACG के लिए AVR</td>
<td>AVR for ACG</td>
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<tr>
<td>BELL*</td>
<td>आग तुचंतना के लिए पंडी</td>
<td>Bell for fire accident</td>
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<td>BP*AUT</td>
<td>स्थिर गति नियंत्रण प्रणाली के लिए विच</td>
<td>Switch for constant speed control operation</td>
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<td>BP*EM</td>
<td>आगाटी स्थित</td>
<td>Emergency switch</td>
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<td>BP*RS</td>
<td>नियंत्रण रेषेट स्थित</td>
<td>Control reset switch</td>
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<tr>
<td>BP*T</td>
<td>वुधव बली के लिए टेस्ट स्थित</td>
<td>Test Switch for indicator light</td>
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<td>BP*RSVG</td>
<td>सरकाता पेन्न ड्रेक रेषेट स्थित</td>
<td>Vigilance penalty brake reset switch</td>
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<tr>
<td>BP*VG</td>
<td>सरकाता टेस्ट स्थित</td>
<td>Vigilance reset switch</td>
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<td>COIL*</td>
<td>प्लेटेज सेक्टर के लिए बुंदली</td>
<td>Coil for flange lubricator</td>
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<td>C*PFC</td>
<td>PFC के लिए संग्रामि</td>
<td>Capacitor for PFC</td>
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<td>DCPT*</td>
<td>कर्तार मोटर वैकल्पक के लिए DCPT</td>
<td>DCPT FOR traction motor voltage</td>
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<td>कर्तार मोटर के लिए DCCT</td>
<td>DCCT for traction motor</td>
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<td>D.FLUB</td>
<td>प्लेटेज सेक्टर नियंत्रण युनिट</td>
<td>Flange lubricator control unit</td>
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<td>D.LVDC*</td>
<td>DC 110 परिक्षण के लिए वोल्टता सूचक</td>
<td>Voltage detector for DC 110V circuit</td>
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<td>Diode for WH counter</td>
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<td>डायोड सूचना के लिए प्रदर्शन</td>
<td>Display for fault indication</td>
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<td>Fault indication terminal</td>
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<td>JB.SG*</td>
<td>संदर्भ जनक के लिए वंदना बब</td>
<td>Junction box for pulse generator</td>
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<td>L1*PFC</td>
<td>PFC के लिए प्रभावित</td>
<td>Reactor for PFC</td>
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<td>CSC प्रणाली के लिए सूचक बली</td>
<td>Indicator light for CSC Operation</td>
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<td>मेट्रिक्स डायोड पेन्न</td>
<td>Matrix diode panel</td>
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<td>MVR*</td>
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<td>Motor voltage regulator</td>
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<td>ACG निर्माण के लिए प्रमुख ध्रुव योजक</td>
<td>Fuse free breaker for ACG output</td>
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<td>AGG पील्ड के लिए FFB</td>
<td>FFB for AGG field</td>
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<td>NFAVR</td>
<td>AVR.G के लिए FFB</td>
<td>FFB for AVR.G</td>
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<td>DCCT फाउ दप्तर के लिए FFB</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>FFB for DCCT Power Supply</td>
</tr>
<tr>
<td>NFGP</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Switch for Goods/Passenger changeover</td>
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<tr>
<td>NFMVR</td>
<td>MVR के लिए FFB</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>FFB for MVR</td>
</tr>
<tr>
<td>NFPFC</td>
<td>PFC के लिए FFB</td>
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<tr>
<td>NFSIAC</td>
<td>परिवर्तित दोष समुच्छ ाक परियोजन के लिए FFB</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
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<td>PS*CS</td>
<td>CSC प्रणाली के लिए दश स्विच</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Pressure switch for CSC operation</td>
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<td>QA.AUT</td>
<td>एक समान गति निवारण के लिए सहायक रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Aux. Relay for constant speed control</td>
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<tr>
<td>QA.CT</td>
<td>DCCT के लिए सहायक रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Aux. Relay for DCCT</td>
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<td>Q.AUT</td>
<td>CSC प्रणाली के लिए रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Relay for CSC Operation</td>
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<td>QB</td>
<td>CSE प्रणाली के लिए रिले (ब्रेकिंग)</td>
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<td>QBL</td>
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<td>Q.CFIL</td>
<td>एसी फिल्टर संचारित के लिए दोष रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Fault relay for AC filter capacitor</td>
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<td>QF</td>
<td>MVR के लिए दोष रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Fault relay for MVR</td>
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<td>QF.ACG</td>
<td>ACG के लिए बोटन/आयूक्ति संचारित रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Voltage/frequency detect. relay for ACG</td>
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<td>Q.FAU</td>
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<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Fault relay for FAU</td>
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<td>Q.FCS</td>
<td>CSC प्रणाली निर्माण के लिए सहायक रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Aux. relay for CSC operation output</td>
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<tr>
<td>QF.PFC</td>
<td>PFC के लिए दोष रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Fault relay for PFC</td>
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<td>QF.SG</td>
<td>डेट विफलता के लिए रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
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<td>गेट स्टार्ट रिले (ब्रेकिंग)</td>
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<td>Q*GST</td>
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<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
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<td>Q.INH</td>
<td>नीयी नीयी बन्द के लिए अन्तर्वाहित रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Inhibit relay for VCB closing</td>
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<td>QLSD</td>
<td>धीरी गति संचारित</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
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<td>QLSD 1</td>
<td>धीरी गति संचारित</td>
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<td>Low Speed detector</td>
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<td>Q.OS</td>
<td>लोको अन्तर्वाहित रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
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<td>QOV.G</td>
<td>ACG के लिए अंतर्वाहित रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Over voltage relay for ACG</td>
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<td>Relay for CSC Operation (Powering)</td>
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<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Auto relay for Speed control</td>
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<td>QPB.AUT</td>
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<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Relay for CSC operation</td>
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<td>QT*RS</td>
<td>निर्धारण सॉसेट के लिए समय विकल्प रिले</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Time delay relay for control reset</td>
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<tr>
<td>R*DCPT</td>
<td>DCPT के लिए अनुकूल प्रतियोगिक</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Series resistor for DCPT</td>
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<td>RE*</td>
<td>इलेक्ट्रॉनिक टाइमर के लिए प्रतियोगिक</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Resistor for electronic timer</td>
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<td>RF*PFC</td>
<td>PFC निर्माण वाहक</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
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<tr>
<td>R*PFC</td>
<td>PFC प्रतियोगिक</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
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<td>S*BLN</td>
<td>निर्धारण के लिए निम्न स्थिति</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Output switch for blending</td>
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<td>S*CFL</td>
<td>AC फिल्टर के लिए दोष समुच्छ स्थिति</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Fault detection switch for AC Filter</td>
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<td>S*FIR</td>
<td>अभ्यन्त संचारित स्विच</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Fire detection switch</td>
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<tr>
<td>SG*</td>
<td>गति सेंसर</td>
<td>माल/प्राप्त क्व प्रतिविन्दु के लिए स्वच</td>
<td>Speed sensor</td>
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<td>CODE ABBREVIATION</td>
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<td>S.TEST</td>
<td>अनुक्रम परीक्षण दिवान</td>
<td>Sequence test switch</td>
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<td>TF.DCCT</td>
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<td>Transformer for DCCT</td>
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<td>TF.DCPT</td>
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<td>VT*MVR</td>
<td>MVR के लिए पंखा</td>
<td>Fan for MVR</td>
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<td>WH</td>
<td>उर्जामीटर के लिए ट्रांसडिंग्कर</td>
<td>Transducer for energy meter</td>
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<td>WHM</td>
<td>उर्जामीटर के लिए कांटर</td>
<td>Counter for energy meter</td>
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*mark for numerical symbol
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<th>कूट लघू नाम</th>
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<tr>
<td>ABB</td>
<td>वायु पूर्ण वियोजक</td>
<td>वायु पौधा वियोजक रिले</td>
<td>Air Blast Circuit Breaker</td>
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<tr>
<td>ABR</td>
<td>वायु पौधा वियोजक रिले</td>
<td>वायु पौधा वियोजक रिले</td>
<td>Air Blast Circuit Breaker Relay</td>
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<td>ARR</td>
<td>वायु पौधा वियोजक रिले</td>
<td>वायु पौधा गवनर</td>
<td>Air Blast Circuit Breaker Reset Relay</td>
</tr>
<tr>
<td>ABG</td>
<td>वायु गवनर</td>
<td>वायु गवनर</td>
<td>Air Blast Governor</td>
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<td>ASR</td>
<td>सहायक संचालन में विद्युत</td>
<td>सहायक पुत्र</td>
<td>Auxiliary Supply Rectifier</td>
</tr>
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<td>AFI to AFIi</td>
<td>सहायक पुत्र</td>
<td>सहायक पुत्र</td>
<td>Auxiliary Fuses</td>
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<td>BIS</td>
<td>बैटरी विल्यम स्विच</td>
<td>बैटरी विल्यम स्विच</td>
<td>Battery Isolating Switches</td>
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<td>BIR</td>
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<td>बुकलेज़ संयुक्त रिले</td>
<td>Buchholz Indication Relay</td>
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<td>बुकलेज़ यंड</td>
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<td>बैटरी प्लाज</td>
<td>Battery Fuses</td>
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<td>बैटरी चार्जिंग संपर्किंग</td>
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<td>धारा सीपा रिले</td>
<td>धारा सीपा रिले</td>
<td>Control Fuse</td>
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<td>CLR 1, CLR 2</td>
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<td>धारा सीपा रिले</td>
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<td>CBR</td>
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<td>CC 1</td>
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<td>मुख्य संयुक्त संपर्किंग</td>
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<td>CG 1</td>
<td>मुख्य संयुक्त प्रवृत्ति</td>
<td>मुख्य संयुक्त प्रवृत्ति</td>
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<td>CG 2</td>
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<td>पात प्रवृत्ति</td>
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<td>भूमी प्रवृत्ति</td>
<td>भूमी प्रवृत्ति</td>
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<td>DMH</td>
<td>अनेक प्रवृत्ति हल्दा</td>
<td>अनेक प्रवृत्ति हल्दा</td>
<td>Dead Man's Handle</td>
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<td>EFR</td>
<td>अपवाद प्रवृत्ति</td>
<td>अपवाद प्रवृत्ति</td>
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<td>सहायक परियोजक</td>
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<td>भूमि प्रवृत्ति</td>
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<td>अपवाद प्रवृत्ति</td>
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<td>कंप्यूटर गवनर के लिए गवनर</td>
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<td>उपयोग गवनर के लिए गवनर</td>
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<td>HEFRA 1</td>
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<td>TM 1 एवं 2 के लिए विपरीती सिनच</td>
<td>Reversing Switch for TM 1 &amp; 2</td>
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<td>K 2</td>
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<td>Radiator Fans</td>
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<tr>
<td>LA</td>
<td>प्रोक्सिम अपवर्तक</td>
<td>Surge Diverter</td>
</tr>
<tr>
<td>LTR</td>
<td>कम तन शूविंग रिले</td>
<td>Low Tension Proving Relay</td>
</tr>
<tr>
<td>M 1 to M 4</td>
<td>मोटर संपकित</td>
<td>Motor Contactors</td>
</tr>
<tr>
<td>SBC</td>
<td>वैटी चौर</td>
<td>Static Battery Charger</td>
</tr>
<tr>
<td>BCFR</td>
<td>चौर वैटी चौर</td>
<td>Battery Charger Failure Relay</td>
</tr>
<tr>
<td>MCS 1</td>
<td>TM 1/2 के लिए काटवाट सिनच</td>
<td>Motor Cut Out Switch for TM 1/2</td>
</tr>
<tr>
<td>MCS 2</td>
<td>TM 3/4 के लिए काटवाट सिनच</td>
<td>Motor Cut Out Switch for TM 3/4</td>
</tr>
<tr>
<td>MSLW</td>
<td>मोटर सिनच सफेद बल्टी</td>
<td>Motor Switch White Light</td>
</tr>
<tr>
<td>MC</td>
<td>प्रमाण नियंत्रक</td>
<td>Master Controller</td>
</tr>
<tr>
<td>NR 1, NR 2</td>
<td>नोटिंग रिले</td>
<td>Notching Relay</td>
</tr>
<tr>
<td>NVR</td>
<td>नोल्लर रिले</td>
<td>No Volt Relay</td>
</tr>
<tr>
<td>OL 1 to OL 4</td>
<td>से के लिए अवशेष रिले</td>
<td>Over Load Ready for TM 1 to 4</td>
</tr>
<tr>
<td>OL 5</td>
<td>वैटर करे अवशेष प्रतिसृति रिले</td>
<td>Rectifier Over Load Protection Relay</td>
</tr>
<tr>
<td>OL 6</td>
<td>अवशेष प्रतिसृति रिले</td>
<td>Transformer Over Load Protection Relay</td>
</tr>
<tr>
<td>OLP</td>
<td>अवशेष प्रतिसृति रिले</td>
<td>Over Lead Primary Relay</td>
</tr>
<tr>
<td>OP</td>
<td>तेल पंप</td>
<td>Oil Pump</td>
</tr>
<tr>
<td>RF</td>
<td>रेडियेटर पंप</td>
<td>Rectifier Fan</td>
</tr>
<tr>
<td>RFR</td>
<td>रेडियेटर पंप प्रोविंग रिले</td>
<td>Rectifier Fan Proving Relay</td>
</tr>
<tr>
<td>RFA</td>
<td>रेडियेटर पंप सहायक रिले</td>
<td>Rectifier Fan Auxiliary Relay</td>
</tr>
<tr>
<td>SL</td>
<td>समसारी रेडियेटर</td>
<td>Smoothening Reactor</td>
</tr>
<tr>
<td>SR</td>
<td>प्रवर्तित रिले</td>
<td>Starting Relay</td>
</tr>
<tr>
<td>T 1 to T 9</td>
<td>प्रवर्तित संपकित</td>
<td>Tap Changing Contactors</td>
</tr>
<tr>
<td>TL</td>
<td>प्रवर्तित प्रतिरोधक</td>
<td>Tap Changing Reactor</td>
</tr>
<tr>
<td>TSS</td>
<td>परीक्षण अनुक्रम सिनच</td>
<td>Test Sequence Switch</td>
</tr>
<tr>
<td>TT</td>
<td>ट्रांसफार्मर थ्रॉमोडेट</td>
<td>Transformer Thermostat</td>
</tr>
<tr>
<td>TTR</td>
<td>ट्रांसफार्मर थ्रॉमोडेट रिले</td>
<td>Transformer Thermostat Relay</td>
</tr>
<tr>
<td>W 1</td>
<td>कंडली समूहन</td>
<td>Winding Grouping</td>
</tr>
<tr>
<td>W 2</td>
<td>सिनच संपकित</td>
<td>Switch Contactors</td>
</tr>
<tr>
<td>WGR</td>
<td>कंडली समूह रिले</td>
<td>Winding Grouping Relay</td>
</tr>
<tr>
<td>BR</td>
<td>ब्रेक रिले</td>
<td>Brake Relay</td>
</tr>
<tr>
<td>A</td>
<td>अम्म्टर</td>
<td>Ammeter</td>
</tr>
<tr>
<td>CODE ABBREVIATION</td>
<td>मद</td>
<td>ITEM</td>
</tr>
<tr>
<td>-------------------</td>
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</tr>
<tr>
<td>AOV R</td>
<td>शहयक अतिवोल्ट्स रिले</td>
<td>Aux. Over Voltage Relay</td>
</tr>
<tr>
<td>ARS</td>
<td>एमोटर रोटरी शंट</td>
<td>Ammeter Rotary Shunt</td>
</tr>
<tr>
<td>AS</td>
<td>एमोटर शंट</td>
<td>Ammeter Shunt</td>
</tr>
<tr>
<td>EFRP</td>
<td>भूतोप शिल पावर</td>
<td>Earth Fault Relay Power</td>
</tr>
<tr>
<td>ETO</td>
<td>बूसंपक्</td>
<td>Earth</td>
</tr>
<tr>
<td>HEFRP</td>
<td>भूतोप शिल पावर स्विच</td>
<td>Switch for Earth Fault Relay Power</td>
</tr>
<tr>
<td>EFRA</td>
<td>सहयक परिय संके ने भूतोप शिल</td>
<td>Earth Fault Relay for Aux. Circuit</td>
</tr>
<tr>
<td>NC 1 to NC 4</td>
<td>भूणामक संपरिवर्त</td>
<td>Negative Contactors</td>
</tr>
<tr>
<td>HOBA</td>
<td>अतिलोड रिले</td>
<td>Earthing Switch for Battery</td>
</tr>
<tr>
<td>OVR</td>
<td>बैटरी के लिए भूसंपक्क स्विच</td>
<td>Over Voltage Relay</td>
</tr>
<tr>
<td>PFD</td>
<td>स्वायी पील्ड डाइवर्ट प्रतिसंगठक</td>
<td>Permanent Field Divert Resistor</td>
</tr>
<tr>
<td>REFRP</td>
<td>EFRP के लिए प्रतिसंगठक</td>
<td>Resistor For EFRP</td>
</tr>
<tr>
<td>ROVR</td>
<td>OVR के लिए अनुक्रम प्रतिसंगठक</td>
<td>Series Resistor for OVR</td>
</tr>
<tr>
<td>RPP</td>
<td>EFRP के लिए प्रतिसंगठक</td>
<td>Earth Resistor for EFRP</td>
</tr>
<tr>
<td>REFRA 1</td>
<td>EFRP सहा 1 के लिए भूसंपक्क प्रतिसंगठक</td>
<td>Earth Resistor for EFRP Aux. 1</td>
</tr>
<tr>
<td>REFRA 2</td>
<td>EFRP सहा 2 के लिए भूसंपक्क प्रतिसंगठक</td>
<td>Earth Resistor for EFRP Aux. 2</td>
</tr>
<tr>
<td>RHOB A</td>
<td>बैटरी भूसंपक्क स्विच के लिए प्रतिसंगठक</td>
<td>Resistor for Battery earthing switch</td>
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<tr>
<td>RPEFRA 1</td>
<td>EFR सहा 1 के लिए प्रतिसंगठक</td>
<td>Resistor for EFR Aux. 1</td>
</tr>
<tr>
<td>RPEFRA 2</td>
<td>EFR सहा 2 के लिए प्रतिसंगठक</td>
<td>Resistor for EFR Aux. 2</td>
</tr>
<tr>
<td>S</td>
<td>स्पीडमीटर</td>
<td>Speedometer</td>
</tr>
<tr>
<td>SH 1 to SH 4</td>
<td>मोटर 1 से मोटर 4 के लिए प्रेक्ष प्रति</td>
<td>Inductive Shunt for Motor 1 to Motor 4</td>
</tr>
<tr>
<td>SU</td>
<td>प्रेक्ष प्रमय दाब यूनिट</td>
<td>Surge Suppression Unit</td>
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