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(रेलवे बोर्ड)

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ए सी कर्षण नियमावली
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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
RAILWAY BOARD

INDIAN RAILWAYS
MANUAL OF AC TRACTION
MAINTENANCE AND OPERATION
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INDEX

CHAPTER-1
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

a. Central Railway

   i. Bombay VT-Kalyan (main line)

   ii. Bombay VT-Kurla (Harbour Branch)

b. Western Railway

   i. Churchgate-Virar

2. Ghat Sections of Central Railway

a. Kalyan-Pune

b. Kalyan-Igatpuri

3. MG Suburban Sections of Madras

a. 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 FerFrancais, 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 31.03.22, a total of 52247 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). However, 1500 DC system has also been converted into 25 KV, 50HZ traction system in Mumbai area. This IR has now only one traction system at 25 KV, 50HZ

10101 Principal Chief Electrical Engineer (PCEE)/Zonal Railway

PCEE 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, Electrical General Services and Energy Efficiency Management. 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.

PCEE 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.

In regard to electric traction installations, in his capacity as Electrical Inspector, PCEE 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 PCEE.

10103 Duties of Administrative Officers

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

Administrative Officers will:

1. 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;
2. On behalf of PCEE, 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;
3. 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;
4. 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;

5. Maintain liaison with the Power Supply Authorities at Headquarters level in regard to continuity of supply, tariff and policy matters;
6. Keep a close watch over the day-to-day performance of traction services and tighten up preventive maintenance where required;
7. 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;
8. Plan and review the organizational set-up required for satisfactory maintenance and operation of the electric traction services;
9. Plan the recruitment and training of staff for maintenance and operation;
10. Exercise effective technical scrutiny over items for inclusion in the M&P, Works and Rolling Stock Programmes and progress items approved in the programmes;
11. 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;
12. Arrange for standardization of stores as required and preparation of drawings and specifications to facilitate procurement;
13. Study and analyze the periodic statistical returns on electric traction and initiate appropriate remedial measures as required to improve efficiency;
14. 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;
15. Ensure the prompt submission of periodical returns to the Railway Board and RDSO;
16. Budgeting and control over expenditure, particularly in regard to repair costs, energy bills and maximum demand charges;
17. 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;
18. Keep in touch with modern technical developments with a view to identify applicability in railway installations to reduce operation and maintenance cost;
19. Maintain liaison with the Railways for quick return of overdue locomotives;
20. Maintain close co-ordination with production units and POH workshops for supply of shop manufactured items, reducing POH time and improving reliability;
21. Liaison with State/Central transmission utilities, Generators and Railway`s consultants for NOC for open access procurement and import of power for traction and non-traction purposes and referring disputes if any to regulatory bodies for redressal;
22. Assisting Regional Power Committee, Regional Load despatch centres etc. in the pursuits of black start restoration in the event of regional grid failures.

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 Principal 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 PCEE 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 PCEE'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:-

   i. Detailed visual inspection of the OHE by OHE Inspection Car as often as possible;

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

   iii. 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;

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

   v. 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 PCEE obtained before the works are executed. Designs for major works will, however, be worked out in PCEE'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 breakdowns, 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 Divisional Electrical Engineer (TrD)

DEE/ADEE(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 :-

   i. 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;

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

   iii. 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;

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

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

   vi. 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 PCEE 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 short-comings 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 PCEE, 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 asset and staff in the shed;

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

2. DEE/ADEE (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 Loco Pilots 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 PCEE 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 Loco Pilots 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;

vi. 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 DEE/ADEE(OP)

The duties of DEE(OP) /ADEE(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, Traction Training School

He is in-charge of Training School of Zonal Railway for training of electric traction, maintenance and operating staff.

The Principal, Traction 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 :-

1. 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 budgeting 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;

2. Anticipated changes in tariff and possibility of application of such changes with retrospective effect;
3. Assessment of additional requirements of operating staff based on the traffic expected;
4. Provision for training of additional staff based on anticipated expansion of services;
5. Careful assessment of the cost of special procurement of stores for normal maintenance and heavy repairs;
6. Provision for clearing back-log of repairs, if any.

10112 Electrical Department - Budget Demands

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

Demand No. 3	General Superintendence and Services of Railways Main Head 700 - Electrical Management
Demand No. 5	Repairs and Maintenance of Motive Power Main Head 500 - Electric Locomotives
Demand No. 6	Repairs and Maintenance of Carriages and Wagons Main Head 400 - Electrical Multiple Unit Coaches Main Head 500 - TL, Fans & AC on Coaches.
Demand No. 7	Repairs and Maintenance of Plant and Equipment Main Head 400 - Plant and Equipment - Electrical
Demand No. 8	Operating Expenses - Rolling Stock and Equipment Main Head 300 - Electric Locomotives Main Head 400 - Electrical Multiple Units
Demand No. 10	Operating Expenses - Fuel Main Head 300 - Electric Traction.

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CHAPTER-2
GENERAL DESCRIPTION OF FIXED INSTALLATIONS

I. 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/power distribution and Transmission companies 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 substation, 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 sub-stations 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

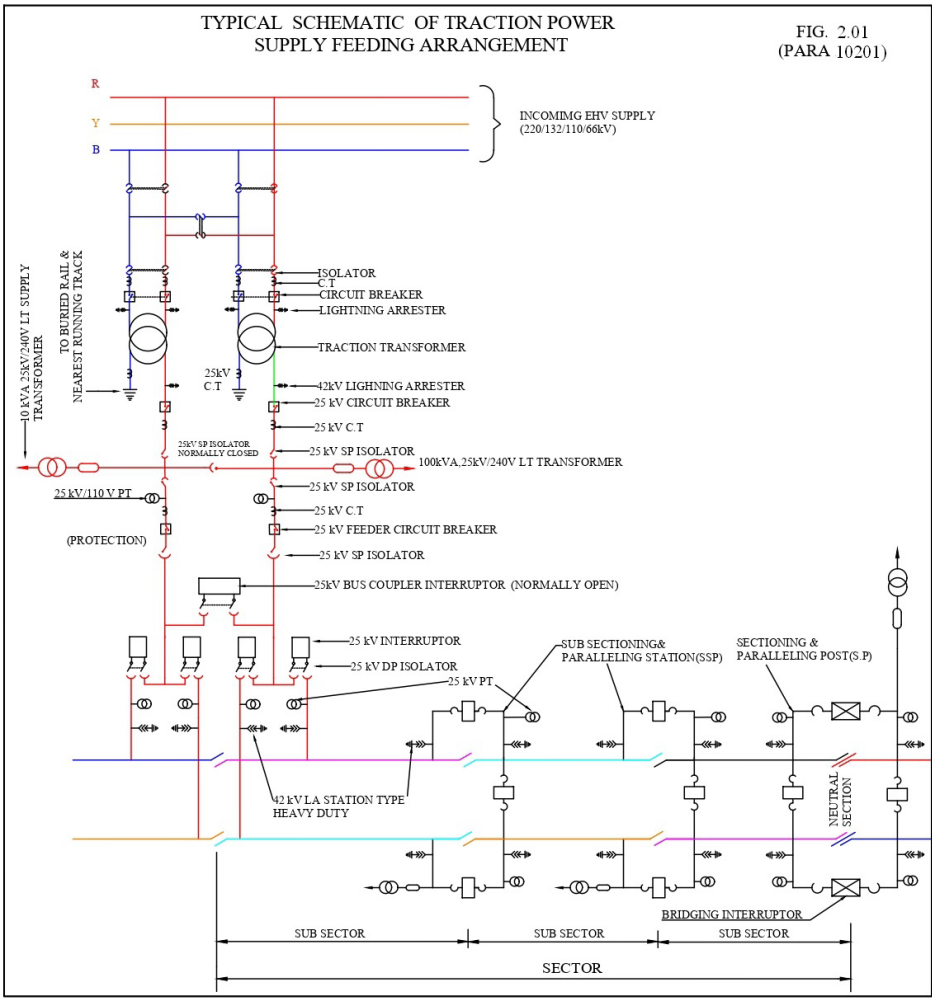
-5% i.e., between 27,500 V and 23,750 V. The tappings on the transformers are on on the secondary winding and are set to ensure that the voltage is maintained as high as possible but not exceeding 27.5 kV at the feeding post at any time.

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.

TYPICAL SCHEMATIC OF TRACTION POWER SUPPLY FEEDING

ARRANGEMENT



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:-

Voltage Unbalance	(%)
Instantaneous	5
2 hours	3
Continuous	2

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 substations. 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 interrupters' usually rated at 600A are provided. The shortest section of the OHE which can be isolated by opening interrupters alone is called a 'sub-sector'. Each sub-sector is further sub-divided into smaller 'elementary sections' by provision of off-load type manually/Remote 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, isolator with an earthing device in the off position 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 interrupters controlling supply to the individual lines. Thus, for a two track line, there will be four interrupters 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 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 Loco Pilot 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 interrupter is provided at each 'SP' to parallel the OHE of the up and down tracks of a double track section, 'bridging interrupters' 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 interrupters 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 interrupters 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 interrupters and other similar equipments.

II. POWER SUPPLY FOR SIGNALLING

10210 Supply Arrangements

1. To ensure reliability of ac 240V, supply through 25 W/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 interrupters at the various switching stations as well as the feeder circuit breakers (and other switchgear 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, ADEE (RS), Sr DEE/DEE/ADEE (OP), Traffic Control Offices, SSE(TRD) 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 substations, 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 PCEE, 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 to whom 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 to

talk to 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 Wires

1. The overhead equipment above the tracks comprises of the following :-
   a. A stranded cadmium copper wire of about 65 mm2 section or stranded aluminium alloy wire of about 116 mm2 section for catenary (Aluminium alloy catenary wire is not in use at present).
   b. A grooved hard drawn copper contact wire of 107 mm2 cross-section (when new) supported from the catenary by means of droppers of 5/7 mm diameter spaced not more than 9m 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 5.60/5.55 m (with 10/5 cm presag for 72 m span) above rail level. For unregulated OHE in areas with a temperature range of 40C to 65oC, this figure is 5.75 m and in areas with a temperature range of 15 0C to 65 0C, it is 5.65 m. In certain cases, such as under over-line structures, the height may be as low as 4.690 m on BG. 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/structure 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 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 :-

1. 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.

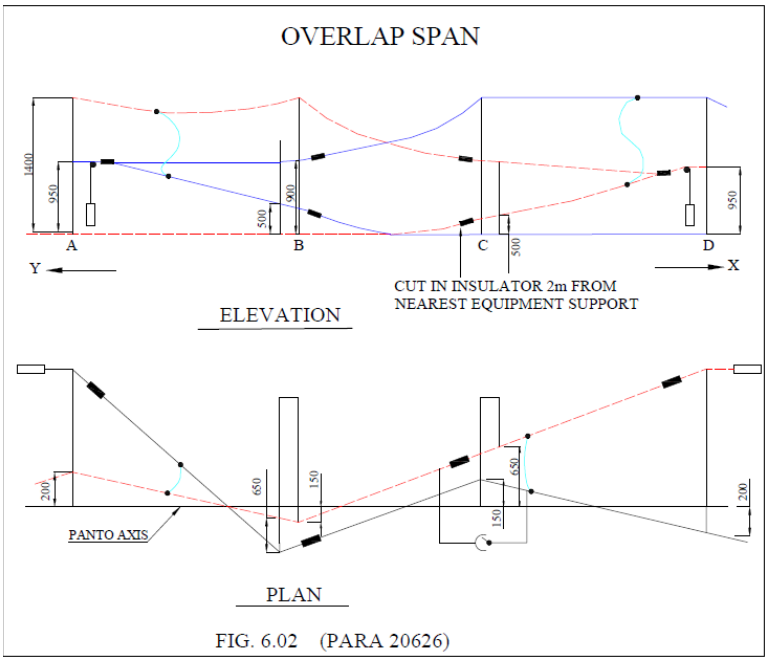


FIG. 2.02 (PARA 10218)

2. 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 mal-adjustment of the OHE of one track will not, therefore, affect the performance of the other.

10222 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.

10223 Maximum Speed

The OHE with maximum span of 72 m and with presag of that span of 100 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

10224 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 Loco Pilot 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 cabin man not to admit electric locomotives on the unwired track.

10225 Warning Signals for Neutral Sections

To indicate to the Loco Pilot 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.

10226 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.

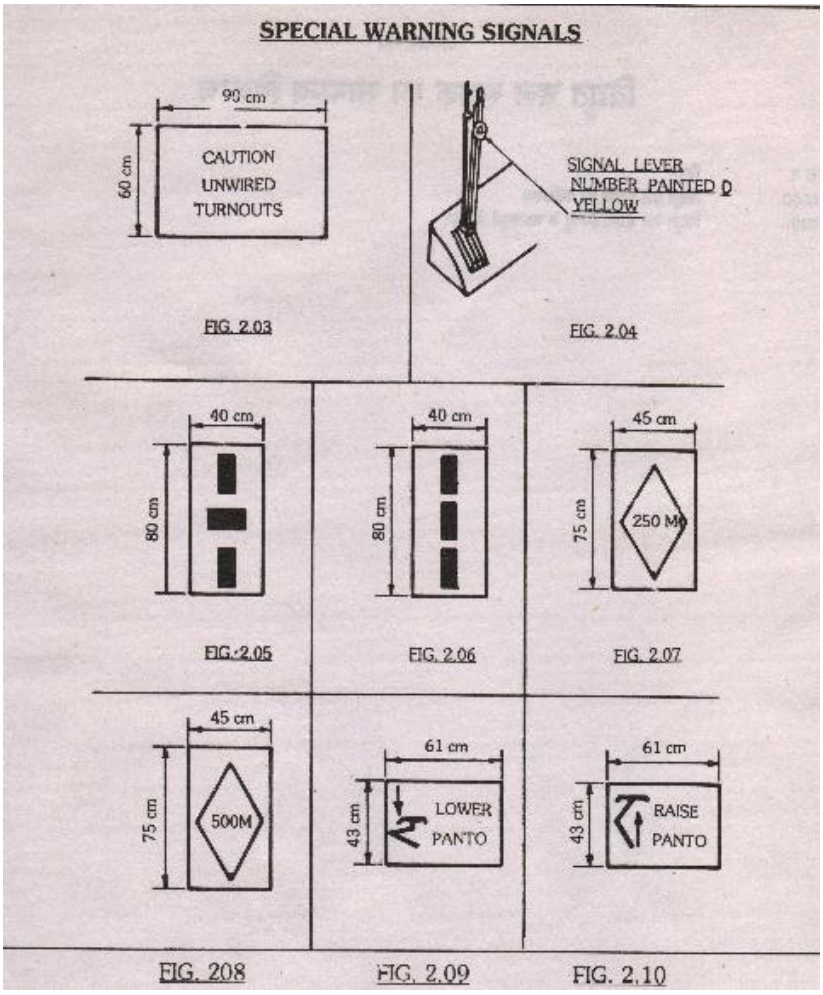
After a break-down on OHE normally only temporary repairs permitting electric locomotives to pass with their pantographs lowered are carried out in attending to break-downs, so that the traffic may not be dislocated unduly. Permanent repairs are done as soon as possible thereafter by taking a pre-arranged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

10227 Special features of Traction Installations in Waltair - Kirandul section of East Coast Railway (formerly South Eastern Railway)

Waltair -Kirandul section of East Coast Railway is about 471 km long, having large number of tunnels and gradients as high as 1 in 60 and sharp curves of 80. The configuration of traction distribution system in the section is as under :-

1. 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.

SPECIAL WARNING SIGNALS



The balance section of 142 km has got standard OHE. The neutral sections provided in OHE are short neutral sections with section insulators.

Power Supply Arrangement- At present there are 18 traction sub-stations, of these 8 traction substations 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

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CHAPTER-3
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 Locos- WAG5, WAG6, WAG7,WAG7H, WAG9, WAG9H, WAG9HC, WAGC3 (converted from diesel to electric loco) WAP1,WAP4, WAP5, WAP7,WAP7HS,WAM4

(b) AC/DC Locos-WCAM2, WCAM3, WCM6(AC), WCAG1

(c) AC EMUs-3 Phase EMU WAU4.

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. AM 12 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 upto 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.

1.3 High Reach pantograph (RDSO Spec RDSO/2007/EL/SPC/0054 Rev-2)

The pantograph uses state-of-the art technology (air springs in lieu of mechanical coil spring) for its raising and lowering, thereby ensuring improved dynamic behaviour during current collection. The pantographs are suitable for working on High Rise OHE of DFC and IR as well as under the existing OHE of IR and provide satisfactory current collection at varying heights from 4.58m and up to 7.57 meter of contact wire. Width of panto pan of High Reach pantograph is 2030mm in place of 1800mm as in Conventional pantographs.

High Reach Pantographs consists of Base Frame, Air Bellow with Cam & Rope Assembly, Lower Arm, Control Rod, Parallel Rod, Upper Arm and panto pan Assembly and Pneumatic Control. Pneumatic Control consists of Air filter, Pressure Regulator with Gauge, Lowering and Raising speed regulation valves.

High Reach Pantograph is equipped with Auto Dropping Device (ADD) and Over Reach Detection (ORD) system. The basic purpose of Auto Dropping Device is to initiate the immediate lowering of the pantograph in the event of collector head failure to avoid further damage to pantograph and OHE due to entanglement. Over Reach Detection (ORD) Device operates when the working height goes beyond limits:-

a. Due to snapping of contact wire in mainline: In such case locomotive may be worked with another pantograph and pantograph may be re-setted after clearing the trip.
b. In unwired section of yards: In this case it will require re-setting after taking Power Block. The Over Reach Detection Device performs a very important function in this case.

Mechanism assembly insulator is not used in High Reach Pantograph thereby reducing the failures and improving the reliability.

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 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.

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.

3.2 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 WAG1 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 converters, the design of the traction transformer has undergone simplification with the deletion of regulating winding. The transformer for thyristorised converter 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 purpose 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 converters 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 GTO/IGBT converters 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.

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 classification of insulating material has also been changed and classification of material as generic type or chemical identity is not considered justified. With a view to classify the new insulating material correctly additional classifications are added.

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:60034-18 and IEC 60505/1999 to evaluate the typical service life under functional test and the influence of thermal, electrical, mechanical and environmental stresses.

5.5 Due to the converter technology, it is possible to use asynchronous brushless motor which have the advantages of being maintenance free with smaller dimensions and a very favourable power to weight ratio. The control of the motor is executed by the motor converter which generates a voltage proportional to frequency-rate. Upto the rated point the frequency is approx. proportional to the voltage rate from the rated point to max speed the voltage remains constant. Wheel slip and torque are accordingly defined by comparing the frequency of the rotating field and the motor speed. A positive slip generates traction forces, a negative one brake forces. (Ref: 3-Phase Loco Mannual)

5.6 DC series motors namely TAO 659 & HS15250A are being used in 25 KV, AC conventional electric locomotives whose capacity is 585 KW & 630 KW respectively. With the introduction of GTO/IGBT based VVVF converters, 3-Ph asynchronous motors namely 6FRA6068 (850 KW) and 6FXA7059 (1150 KW) with increased power rating are being used in 3-ph drive locomotives. (Ref ; CLW Spec No. 4 TMS.096.081)

6. Arno Converter

6.1 Arno Converter is a special duty machine for conversion of single phase in-coming supply into 3 phase out- put 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 Converter is to supply 3 phase power required for these auxiliaries.

6.2 Arno Converter of ACEC make initially imported for WAM-1/WAG-1/ WAG4 were of horizontal construction. Indigenously developed Arno Converter 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 Converters.

6.3 The performance of indigenously manufactured Arno was not up to the level of the performance of ACEC make Arno converter, 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 Converters.

6.4 DELETED

6.5 Static Inverter (SIV) (RDSO Spec No. RDSO/2018/EL/SPEC/0140 Rev .01)

As the Arno Converter offers an inherent voltage unbalance ie. from 290 V-500V, and no provision of soft start etc IR went for 180 KVA Static Inverter (SIV). 180 KVA Static Inverter (SIV) of M/s Siemens, M/s AAL, M/s Hind Rectifiers, M/s Medha, M/s ABB and M/s Bombardier are working presently, it consists of a rectifier section, DC link, inverter section and battery charger. Single phase 830/760Vac from the auxiliary winding of locomotive transformer is provided as input to the rectifier section of the static converter. The rectifier converts the input ac voltage from the locomotive transformer to an intermediate DC link. The DC link voltage is converted into 3-Phase, 415 Vac, 50 Hz by the inverter section. The PWM output of the inverter section is further converted into sine wave by the sine filter. The filtered output is used for all the auxiliary loads and battery charger.

But due to failures for any reasons like electronic cards failure, fan failure etc, it was decided to develop 2 x 130 KVA SIV with redundancy feature. 2x130 KVA SIV consists of two identical 130 KVA SIV, each consisting of a rectifier section, DC link, inverter section and battery charger. Single phase 830 Vac from the auxiliary winding of locomotive transformer is provided as input to the rectifier section of the static converter. The rectifier converts the 830 Vac from the locomotive transformer to an intermediate DC link. The DC link voltage is converted into 3-Phase, 415 Vac, 50 Hz by the IGBT based inverter section. The PWM output of the inverter section is further converted into sine wave by the sine filter. The filtered output is used for all the auxiliary loads and battery charger. As there are two identical 130 KVA SIV so when one inverter fails then the total load of 3-Phase, 415Vac auxiliary loads is shifted automatically to the healthy SIV through contactors provided inside the SIV within 20 seconds.

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 Pneumatic 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 oh 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 solvent less varnish were adopted. The reliability of the auxiliary motors have improved considerably due to these steps.

8. Brake System for 3 phase Electric Locomotives. (RDSO Spec No. RDSO/2017/EL/SPEC0126 Rev 0)

Brake System is an essential, safety & critical equipment of Locomotives. In the beginning the Brake System was controlled through several pneumatic valves/subassemblies/components fitted at various locations of Locomotive. Brake application, Brake release& safety operations during normal brake operation as well as unusual operation were completely governed through pneumatic valves by means of control pressure such as Auto Brake valve (A9), Independent Brake Valve (SA9), C2 Relay valve etc.

The Brake System governed by the electronics/ microprocessors was introduced with three phase locomotives by ABB. The pneumatic valves/subassemblies/components were fitted on a panel made with three plates. The middle plate was grooved as per requirement of pneumatic circuitry by IR. Pneumatic valves/subassemblies/components etc were fitted on front and rear plates. The system is equipped with several safety/operational features controlled through electronic/digital signals by means of brake electronics, pressure transducers, pressure switches etc. Various fault diagnostic features were introduced like Low MR/FP pressure, BP pressure dropped, Regenerative braking failure, BC pressure, Fault in Brake Electronics etc. Emergency brake is activated in case of unusual occurrence such as train parting, VCD, over speeding, emergency push button etc. To monitor the alertness of crew members, the vigilance control device (VCD) was introduced with brake system.

With Further developments of technologies, the Computer/microprocessor controlled Air Brake System with advanced features is under development with existing as well as new vendors as per RDSO's specifications No. RDSO/2017/EL/SPEC/0126, Rev '0' for three phase electric locomotives. This brake system shall be interfaced with advanced safety features such as TCAS, TPWCS, DPWCS, ACD, EP brake etc. There shall be provision of Back up Brake Valve to run train with limited speed through only pneumatic operation control in case of failure of brake electronics. Such system shall also be compatible for serial communication with Vehicle Control Unit (VCU) of locomotive.

9. VCD in conventional electric locomotives.

Vigilance control device (VCD) is safety equipment provided in locomotives to monitor the alertness of crew during run. VCD consists one main unit and two cab units, one in each cab. During run cab unit of active cab remains active, however VCD cab unit of inactive cab remains in rest. Loco pilot has to acknowledge the VCD after each 60 seconds by either VCD Ack foot switch or through any operation linked with VCD acknowledgement features. If loco pilot fails to acknowledge as mentioned above the device shall operate a video alarm (Lamp flicker) for 8 seconds followed by an audio alarm (Buzzer) for next 8 seconds. If loco pilot still not responds then emergency braking activated in loco as well as in stock & VCB will be open, pantograph will be lowered loco shall be shut down and dead stop. The VCD cannot be reset for a period of 32 seconds after emergency brake activation. VCD remains suppressed when speed is less then 2KMPH/stand still condition of locomotive. There is provision to put VCD off when there is malfunction or defective but loco pilot should mention proper reason of isolation in log book.

10. Microprocessor based control & fault diagnostic System (MPCS) (RDSO Spec No. EL/RS/ SPEC/MPC/ FDS/0001 Rev 03)

Conventional tap changer electric locomotives working on Indian Railways are provided with control based on electromechanical and Electro pneumatic relays/ contactors. Such controls involve large number of interlocks, contacts, inter connections and cabling, which are not only maintenance intensive but are unreliable too. It was proposed to modify the existing electric locomotives by providing microprocessor-based control & fault diagnostic System (MPCS). This is intended to replace most of the existing conventional relays, reduce cabling and provide additional fault diagnostic information with improved overall reliability.

Presently, two versions (Ver-2 & Ver-3) of MPCS fitted on WAG-7, WAG-5, WAP-4 & WAM-4 class) of 25 kV conventional tap changer type electric locomotives are working in Indian Railway.

MPCS (version-2) -This system has 64 digital input signals from DJ, GR, MP, CTF, Reverser, switches, valves, contactors etc. After the logical analysing of the status of the inputs, the processor energises the 48 digital outputs connected to it which energises contactors, DJ, Valves, Signalling lamps, buzzers and also produce fault messages in the display unit provided in each cab depending on the fault. This system has inbuilt notch indicator & Analog inputs measurement.

MPCS (Version-3) -This system has 128 digital input signals with some more Analog inputs. This version of MPCS has notch position with Traction/braking indication in 10.4" TFT colour display with extended feature of in built loco bi-lingual TSD, VCD & ESMON, real time monitoring with GPS location, measurement of safety parameters like speed, BP & BC pressures, TM currents & voltages. This also has the soft arrangement for wedging/bypassing the important relays and devices and fault messages along with complete background data to analyse the performance & improve reliability of the MPCS system.

11. Traction Converter (3 Phase Loco Manual)

The Indian Railways procured 3-Phase AC electric locomotives with GTO based drive system from M/s ABB, Switzerland on Transfer of Technology (TOT) basis with GTO based Traction converter, Auxiliary converter and MICAS based Vehicle Control Unit (VCU) in 1993. As per the TOT agreement the manufacturing of locomotives started in India at CLW, Chittaranjan since 1995. The product mix of three phase locomotive consists of WAP-5, WAP-7, WAG-9 and WAG-9H types.

Considering the obsolescence of GTO technology and benefits of inherent property of Insulated Gate Bipolar Transistor (IGBT), Indian Railways planned to induct IGBT based Traction Converter and Auxiliary Converter in 3-Phase locomotives. Development of IGBT based traction converter and auxiliary converter along with VCU with open control system was taken up in Sept-2004 as per the guidelines from Railway Board vide letter no. 2003/Elect(Dev)/440/18/17 dated 05-09-2004

Traction converter converts single-phase 25 KV AC supply into 3 phase AC, with Variable Voltage (max 2180 V) and frequency (from 65 to 132 Hz) while traction mode and fed it to traction motor group-1. As such there are two traction converter i.e. Traction converter-1 for TM 1-2-3 and Traction converter-2 for TM 4-5-6 (In case of WAP-5, traction converter-1 for TM 1-2 and Traction converter-2 for TM-3-4). While electrical braking the traction motor works as a generator and fed generated 3-phase supply to Traction converter. This converter now act in reverse manner i.e. it converts 3 phase AC supply into single phase AC supply and fed it to Transformer. Further main transformer steps up this supply and fed back to OHE. In this way 3-phase loco works as a small powerhouse, which generate supply and share the load by feeding it back to OHE. SR is cooled by two separate oil cooling unit.

The traction converter has three main sub parts:

1) Line Converter, 2) Intermediate DC link, and 3) Drive converter.

One spy glass is provided on each SR to check the oil level.

Line Converter: The line converter converts the alternating current supplied from the main transformer into direct current (motoring) and forwards this direct current to the intermediate DC-Link. However, it is also able to convert direct current from the intermediate DC-Link into alternating current and to supply this alternating current in turn to the main transformer (braking). Both functions are activated by the traction converter control electronics.

DC Link: The intermediate DC-Link performs two main tasks. Firstly, it smoothes the direct current

that flows through. Secondly, it also performs the storage function, thus covering the peak current demand of the line converter or of the motor. It works as a electrical buffer between ASR and NSR

Drive Converter: (RDSO Spec No. RDSO/2008/EL/SPEC0071 Rev 05)

The drive converter converts the direct current from the intermediate DC-Link into three-phase current for the drive motors (motoring). Conversely, it is also able to convert the three-phase current generated by the drive motors into direct current for braking. The construction of the motor inverter valve set is identical to that of the line converter. The complete assembly of line converter No.1, DC link and drive converter No.1 is termed as "TRACTION CONVERTER NO.1" which in turn converts 1-phase AC supply of main transformer into 3-phase AC supply with variable voltage and frequency and fed to the 3-phase traction motor.

Technical Data of Traction Converter

Coolant oil	SHELL DIALA DX (GTO), Ethylene Glycol & Water (30:70) (IGBT)
Input voltage (RMS)	2 x 1,269 Volt
Input current (RMS)	2 x 1,142 Amp
Input frequency	50Hz
DC-Link circuit nominal voltage (Ud)	2,800 Volt
Output voltage (line-line voltage, RMS)	2,180 Volt
Output current (per phase, RMS)	740 Amp
Output power	2,105 kW
Output frequency	65-132 Hz

12. Auxiliary Converter (RDSO Spec No. RDSO/2008/EL/SPEC0071 Rev 05)

As stated in Traction Converter part, auxiliary converter was initially GTO based and further IR migrated to IGBT based system together with Traction Converter.

Auxiliary converter receives single-phase AC 1000 volts supply from auxiliary winding of main transformer. This single-phase supply is fed to rectifier module auxiliary converter where it converts into DC supply. This DC supply is fed to DC link to suppressed AC pulses in DC. The pure DC supply then fed to inverter module auxiliary converter where it converts DC supply to 415V, 3-phase AC supply with variable amplitude of voltage and frequency and then fed to different 3-phase auxiliaries.

There are three, auxiliary converters which get single phase 1000 volts AC input supply from common auxiliary winding and fed 3-phase 415 volt output to different 12 auxiliaries and one battery charger. Auxiliary converter-1 is placed in cubicle called BUR-1 situated in machine room no-1 whereas aux converter no. 2 and 3 are placed in cubicle BUR-2, which is situated in machine room no. 2.

OUTPUT

1. **AC, 3 phase**
   a. AC voltage (L-L) : 415V±5%
   b. Nominal Output Frequency : 50Hz±2%
   c. KVA output : 130 KVA
   d. Total harmonic distortion (THD) in : Less than 10%

2. **DC output:** 110V, 80A with current ripple less than 5% and voltage regulation ±5%, with battery current maximum of 110A

Salient Data of Mixed/Passenger Electric Locomotives

TABLE NO. 3.01

Salient Data of Mixed/Passenger Electric Locomotives

(DATA BOOK Of Electric Locomotives RDSO /2016/EL/PUV/0001 Rev 00)

S. No.	Type of Loco	Type of Traction	Gauage (mm)	Axle load Max. (t)	Weight Total (t)	Brake system	Max T.E. (t)	Max Speed (km/h)	Horse Power (HP)
1	WAM-1	25 kV ac	1676	18.64	76	Air	25.00	100	2800
2	WAM-2	25 kV ac	1676	19.00	76	Air	25.24	100	2790
3	WAM-3	25 kV ac	1676	19.00	76	Air	25.24	100	3640
4	WAM-4	25 kV ac	1676	18.80	112.8	Air Rheo	33.84	120	3640
5	WAP-1	25 kV ac	1676	18.05	108.3	Air	32.49	130	3800
6	WAP-2	25 kV ac	1676	19.00	76.0	Air	25.24	110	2790
7	WAP-3	25 kV ac	1676	18.05	108.3	Air	32.49	140	3800
8	WCAM-1	25 kV ac	1676	18.80	112.8	Air	ac-33.84 dc-23.20	110	ac-3640 dc-2930
9	YAM-2	25 kV ac	1676	13.00	82	Air	19.50	80	1630
10	WAP-4	25 kV ac	1676	112.8	112.8	Air	30.8	140	5050
11	WAP-5	25 kV ac	1676	78.0	78.0	Air Regen	25.89	160	5400
12	WAP-7	25 kV ac	1676	123.0	123.0	Air Regen	32.37	130/140	6120

TABLE NO. 3.02
Salient Data of Goods Electric Locomotives
(Refer Volume III Chapter I)

TABLE – 3.03
Important data of Electrical Multiple Unit Stock

S. No.	Descriptions	3 PHASE EMU	3 PHASE EMU	3 PHASE EMU (Indigenous)	WAU4 BG AC EMU	WAU4 MEMU
1.	Coach Builder	ICF	ICF	ICF	ICF	RCF
2.	Manufacturer of traction equipment	Siemens	Bombardier	Medha	BHEL (Conv. Electrics)	BHEL (Conv. Electrics)
3.	Unit formation	1DTC+1MC+1TC	1DTC+1MC+1TC	1DTC+1MC+1TC	1 DMC+2TC	1 DMC+3TC
4.	Train formation	3/4/5	3/4/5	3/4/5	3/4/5	2/3/4/5
5.	No. of Driving Cabs per unit	2	2	2	2	2
6.	Type of Traction	25 KV AC	25 KV AC	25 KV AC	25 KV AC	25 KV AC
7.	Propulsion System	3- Phase IGBT base (air cooled)	3- Phase IGBT base (water cooled)	3- Phase IGBT base (air oooled)	TFP/Rectifier (Conventional	TFP/Rectifier (Conventional
8.	Auxiliary System	Aux. Converter/ Inverter (IGBT)	Aux. Converter/ Inverter (IGBT)	Aux. Converter/ Inverter (IGBT)	TFP Aux. Windings / Aux. Rectifier	TFP Aux. Windings / Aux. Rectifier
9.	SEC(KWH/1000GTKM)	< 29	< 28	< 30	48	36
10.	Energy Regeneration	>30%	>30%	>30%	NA	NA
11.	Wheel Arrangement	Bo-Bo	Bo-Bo	Bo-Bo	Bo-Bo	Bo-Bo
12.	Axle Load(t)	MC – 20.32 TC—20.32	MC – 20.32 TC—20.32	MC – 20.32 TC—20.32	MC – 20.32 TC—20.32	MC – 20.32 TC—16.25
13.	Pay Load (t)	MC – 26.76 TC— 34.0 DTC – 28.0 NDTC -34.0	MC – 26.76 TC— 34.0 DTC – 28.0 NDTC -34.0	MC – 26.28 TC— 33.78 DTC – 32.77 TC (H) – 31.45	MC – 21.72 TC—35.46	DMC – 12.42 TC—21.12

S. No.	Descriptions	3 PHASE EMU	3 PHASE EMU	3 PHASE EMU (Indigenous)	WAU4 BG AC EMU	WAU4 MEMU
14.	Tare weight(t)	MC – 51.2 TC— 30.8 DTC – 31.55	MC – 53.86 TC— 36.77 DTC – 39.06 NDTC– 37.93	MC – 54 TC— 37 DTC – 39 TC (H) – 38	MC – 59.0 TC—'C' -36 TC – 'D' - 37	DMC -61.0 TC-- 35
15.	Wheel Diameter(New) (mm)	952	952	952	952	952
16.	Gear Ratio	5.71	4.44	4.478	20:91	20:91
17.	Max. Service Speed (Kmph)	100	110	110	100	105 / 110
18.	Traction motor power (KW)	240	247	286	167	167
	Make / Type	Siemens 1TB2022-0TA03	Bombardier Mitrac TM 1800S	TME 48-45-6 (Medha Traction)	BHEL4601 BY BHEL4303/CGL1005	BHEL4601 BY BHEL4303/CGL1005
19.	KVA Rating of Transformer excluding Aux. Load	1250	1216	1300	1000	1000
20.	Primary / Sec. traction winding / Aux .(Volt)	22500/ 2X855	22500 / 2x833	22500/2X855	25000/782 Aux.1 -266 Aux.2 - 141	25000/782 Aux.1 -266 Aux.2 - 141
21.	Line side converter (KW)	1240	1178	2X612	NA	NA
22.	Motor side converter (KVA)	1070	1172	2X576	NA	NA
23.	Auxiliary converter in put DC Voltage (Volt)	1800 KW	1800	1800	NA	NA
24.	Normal DC Link voltage (Volt)	1800 AC mode 1500 DC mode	1650 DC	1800	NA	NA
25.	Auxiliary converter Max output power(KVA)	115	134.5	79.2 (415, 3ph) 18.57 (110 V, 1 Ph AC) 10.85 kW (110 V, DC)	NA	NA
26.	Primary Suspension	Coil Spring	Coil Spring	Coil Spring	Coil Spring	Coil Spring
27.	Secondary Suspension	Air Spring	Air Spring	Air Spring	Air Spring	Air Spring

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CHAPTER-4
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, power lines 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 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.

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 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 neighbourhood 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 shut 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 interrupters or isolators shall be provided for controlling supply to each watering section. Keys for such interrupters/isolators shall be provided with metal tags on which the numbers of the interrupters/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 interrupter/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 super masts.

10412 Sequence of Interlocking and Operation

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

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

2. If an interrupter is provided, on its frame is mounted the opening key which is accessible only after the enclosure to the interrupter is opened. This ensures that no one can open the interrupter, 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 interrupter frame. It can be extracted from the lock only after the interrupter is opened to switch off supply to the watering section. Similarly, when an isolator is provided it can be opened only by the Technician on receipt of its key from the ASM on duty. For opening the (main) isolator 'L' the additional precautions detailed in the Chapter VI of Vol. II 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 interrupter '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 interrupter '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 interrupters. The same principles however apply for watering sections controlled by manually operated isolating switches, though the details vary somewhat between installations at different stations.

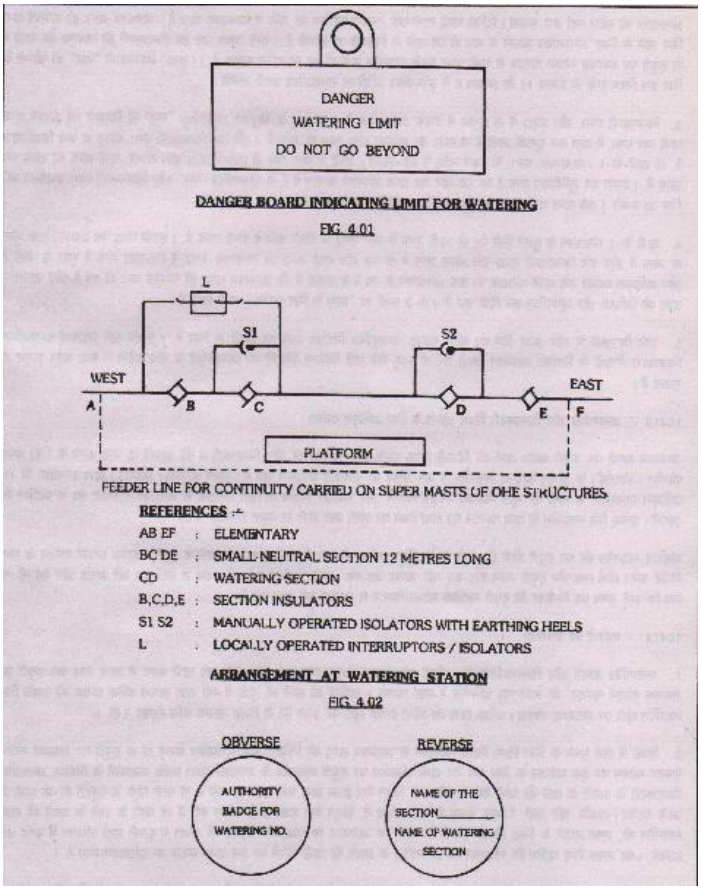


FIG. 4.03 BRASS BADGES FOR AUTHORISED PERSONS

10413 Persons Authorised to Open Interrupters and Isolator Switches

Lineman working under the SSE (OHE) is authorised to open or close the interrupters or isolators controlling Power supply to the overhead traction wires in the watering section.

However a Literate Khalasi having minimum three years of working experience is also authorized to operate isolator under instruction of TPC following all extant procedure/rules issued in this regard.

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

It will be the duty of the Technician/Assistant concerned to report to the ASM on duty at least half an hour before the scheduled arrival of a train. No Technician/Assistant 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 interrupter 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 interrupter/ isolator of the platform to the Technician 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 Technician 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 interrupter enclosure to the Technician 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 Technician 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 Technician 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 interrupter opening key may then be taken out and inserted in the key hole of the interrupter lock and turned after which operation the interrupter should be closed. The interrupter 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 Technician 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 Technician. 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 Technician
7. Time returned
8. Signature of the Technician

9. Brief reasons for delay if any
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 interrupter 'L1 and isolator switches S1 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

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 net-work 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. Fuelling 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 which are reproduced below:-

10421 Need for Precautions

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

1. 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.
2. Build up of potential due to return current in rails: The return current in the rails may cause a potential difference-
   a. between rail and the surrounding mass of earth;
   b. between the two ends of a fractured rail;
   c. between the two rails at an insulated joint;
   d. between earth and any other metallic mass.
3. Building up of potential due to induction in metallic bodies situated close to 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 as 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 a 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 the clearance. The responsibility of wholesole cutting of tree i.e. cutting of tree trunks will rest with the Engineering Department. In Electrified territories, however cutting of these trees shall be done by Engineering Department in the presence of authorised Tr.D staff to ensure safety and satisfactory completion of work. The day to day trimming of tree branches, wherever required to maintain the 4m safety clearances from OHE shall be done by authorised Tr.D staff and supervisors.

In case of dispute, the decision whether to cut or trim a tree, shall be taken through a joint inspection of Engineering and Electrical officials.

The modalities to be adopted for cutting/trimming of trees i.e. contractually or departmentally, may be decided by respective departments based on local conditions. Accountal and disposal of trees cut wholesale will be done by Engg. Department while the proposal of trimmed tree branches will be the responsibility of the TrD department. The expenditure for cutting/trimming of trees to maintain safe clearance for OHE, shall be debited to revenue grant of TrD department. (ACS 9)

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 or 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.

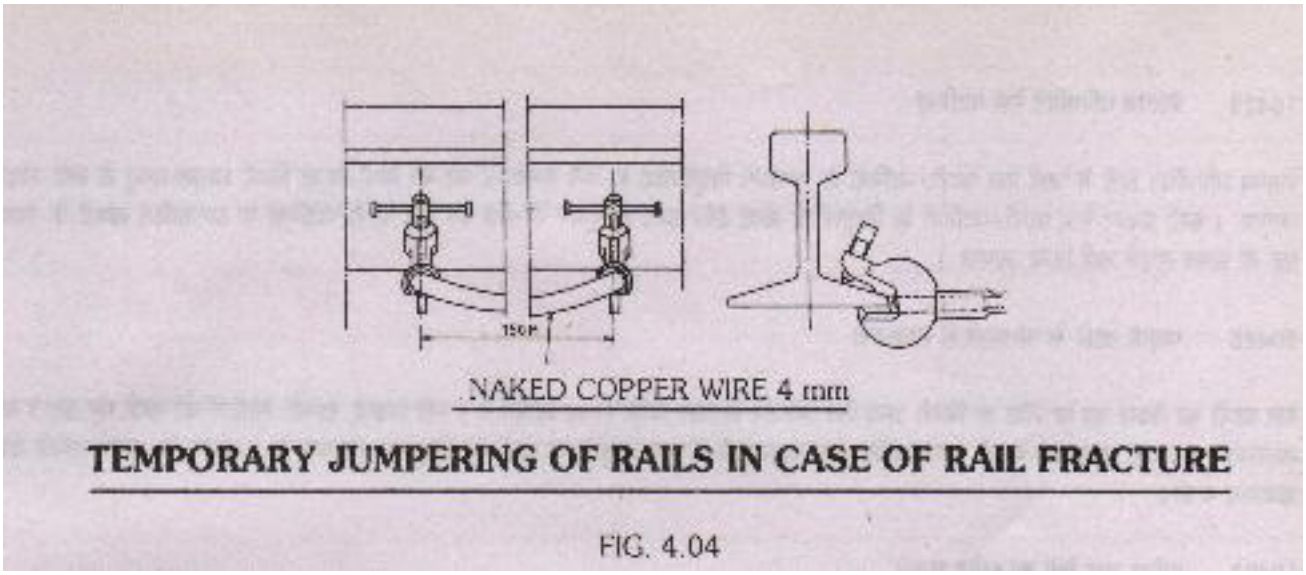
10423 Continuity of Track

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, temporary metallic jumpers of approved design shall be provided as under :-

1. 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.
2. In the case of track renewals, temporary connections shall be made as shown in Fig. 4.05.
3. In the case of a defective or broken rail bond, a temporary connection shall be made as mentioned in (a) above.
4. Before fish-plates are loosened or removed, temporary connections shall be made as in (a) above.

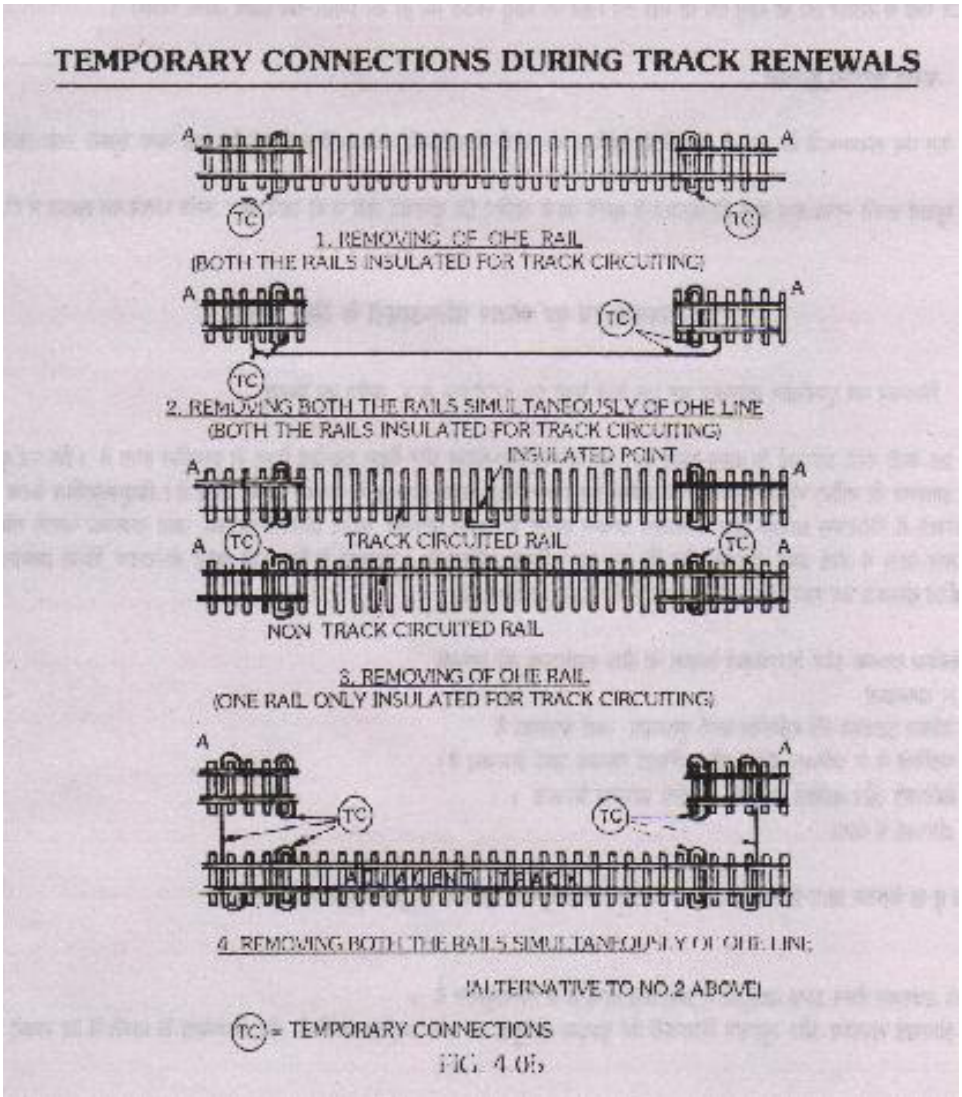
10424 Permanent Way Tools

Permanent Way tools along with the gloves shall be used in the manner as approved by the Principal Chief Engineer of the Railway.



NAKED COPPER WIRE 4 mm

Fig. 4.04 TEMPORARY JUMPERING OF RAILS IN CASE OF RAIL FRACTURE



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

Fig. 4.05 (TC)= TEMPORARY CONNECTIONS

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, ladders, 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 Foundations

1. The top of foundation blocks of traction structures shall be kept clear of all materials and kept tidy.
2. While excavating, 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 25 kV 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 structure 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 signalling of the section shall immediately proceed to the site and test all signalling circuits and allied equipment paying particular attention to the outdoor signalling 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 undertake 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 or 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 Principal 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 currents 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 staffs 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:

1. Rubber gloves and tools with insulated handles should be used.
2. 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.
3. 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.
4. 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 Consignment (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:

Dimensions	BG	MG
1. Length	13716 mm	12192 mm
2. Height	.	.
a. at centres	2743 mm	2540 mm
b. at corners	2134 mm	2134 mm
3. Width	2997 mm	2540 mm
4. Top width	610 mm	610 mm

10435 Classification of ODCs

ODC's are classified as under:

'A' class ODC having clearance (i.e. clearance measured under stationary conditions) of 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 and above and less than 228.6 mm from fixed structures.

'C class ODC having clearance of less than 152.4 mm but more than 101.6 mm from fixed structures. (As per RBd L.No.2014/CEDO/SR/04 Dt.20.10.2014 for the clearance of B & C class ODC)

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 be 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. A Special speed restriction is not required when the gross clearance is more than 250 mm.
   b. Speed must be restricted to 15 km/h when the clearance is between 250 mm and 200 mm. (ODCs would not be stopped under critical locations i.e. where clearance is between 250 mm to 200 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 200 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 clearances 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 clearances 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 PCEE 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 as indicated below should be observed" :

Section	Location	Height of contact wire	Power "ON" or 'OFF'	Speed Restriction in km/h
1	2	3	4	5

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 or other traffic official incharge 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 area 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 in 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, Sr.DCM 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 those staff who have undergone the course in Electric traction are posted in electrified areas.

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CHAPTER-5
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 or discontinuity of the earthling 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 earthling 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 break-down 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.

c. 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 (SSE/JE), shall first check and make 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 SSE/ JE 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 by general or special order, direct.
2. The appropriate Government may, if it thinks 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 of 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 Principal 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 dated 10th June 1961. All matters in regard to the functions of Electrical Inspector shall be referred to him.

10504 Reporting of Accidents

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

In cases 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 an 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 PCEE. CWE.DRM etc.

10505 Accident Inquiries

Every electrical accident shall be inquired into by an officer and a report submitted to the Principal 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 to 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 :-

Date	Time	Brief description of the accident	Date issue of accident telegram	Date accident report submitted

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 PCEE 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 pares 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 and 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 his 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.

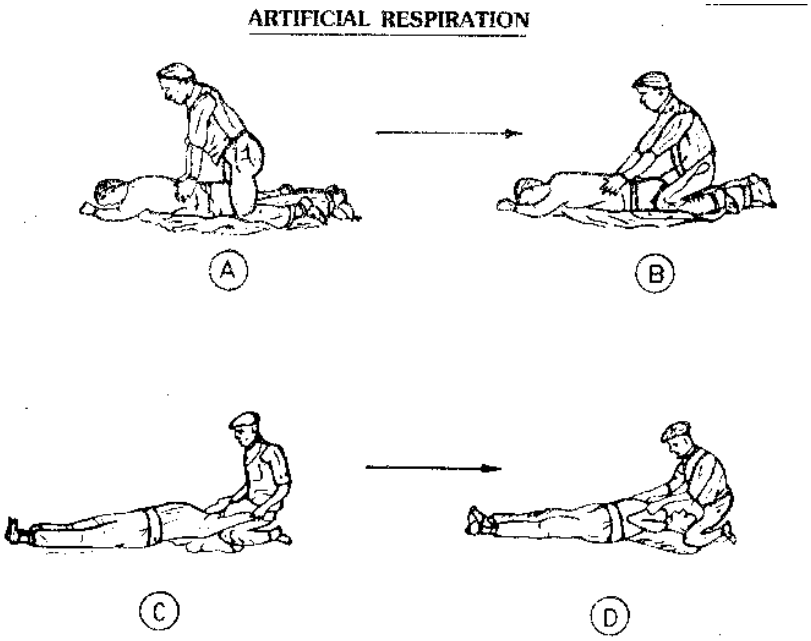

FIG. 5.01
(PARA 10510)

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. An Assistant 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-stations, 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 Technician 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 3.66m. The Technician 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 interrupter. Shutdown was effected on both the elementary sections and the interrupter 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/interrupters 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 JE (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 JE'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 Technician received a severe shock when working on an isolator. Before commencing the work one earth had been placed on each side of the isolator. However, during the course of the work, the isolator was opened when the Technician received a shock. The possible cause is that one of the discharge rods was not making proper contact with the result that the 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 had failed. An unskilled Assistant was sent by the Technician to check up and renew the high voltage fuses. The Assistant attempted to do this without getting a permit to work, accidentally came into contact with live 25 kV 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 Technician 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 Technician, closed the circuit breaker. This 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 cut 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.

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CHAPTER-6
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.
   c. Whether close liaison is maintained by the local official with the Fire Fighting Organization and telephone numbers of Fire Station are properly displayed.
   d. 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 extinguishments.

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,

haloginated 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 there from 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. shall 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

SN	Type of Extinguishers	Type of Fires			
		A	B	C	D
(1)	(2)	(3)	(4)	(5)	(6)
1.	Fire Extinguisher, soda acid (see IS: 934)	S	NS	NS	NS
2.	Fire Extinguisher water type, gas cartridge (see IS: 940)	S	NS	NS	NS
3.	Water Type bucket Pump (see IS: 6234)	S	NS	NS	NS
4.	Water type stored pressure (see IS: 6234)	S	NS	NS	NS
5.	Fire Extinguisher chemical foam (see IS: 933)	S	S	NS	NS
6.	Fire Extinguisher dry powder (see IS: 2171)	NS	S	S	NS @
7.	Fire Extinguisher carbon dioxide type (see IS: 2878)	NS	S	S	NS
8.	Fire Extinguisher USING Dry chemical powder (DCP)	S	S	S	S

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 home) 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.
4. Dry Chemical powder (DCP) type Fire Extinguisher should be used having the following specification:
   a. Dry Chemical powder type Fire Extinguisher should conform to IS-2171 of 1985.
   b. Dry Chemical powder should conform to IS 4308 of 1992.
   c. Gas cartridge should conform to IS 4947 of 1985.

10604 Training of Staff

1. Sr. DEEs concerned should ensure that categories of staff listed below are adequately trained in fire precautions:-
   a. Loco Pilots, Motormen, Asst. Loco Pilots, 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.
   b. 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 be 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 analyzed 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 PCEE 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 Principal 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 expellant 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 Prevention of Fires of EMU/MEMU stock No. RDSO/PE/CP/EMU/0001-2003(Rev.0) of August-2003 with Amendment No.-1 of July 2006 or latest Revision, updated.

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.

10610 Guidelines for prevention of fire on Electric locomotive issued by RDSO (REPRT No. ELRS /PR/0113-Rev 0)

Guidelines for prevention of fires on Electric locomotives - Refer Annexure 3.03A & 3.03B of Volume III Chapter III. **(REPRT No. ELRS /PR/0113-Rev 0)**

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CHAPTER-7
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 Principal 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 transformer 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. Loco Pilots/ 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 Loco Pilots 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 downhill, 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.
3. On Board Power factor correction Equipment on Electric Locomotive.

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CHAPTER-8
TRACTION STORES AND THEIR ACCOUNTAL

10800 Introduction

The Indian Railway Code for the Stores Department (herein after 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 PCEE's Office. When a new item is required to be standardized, the Sr. DEE concerned should send a preliminary proposal to PCEE 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 PCEE'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 PCEE. 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.
   e. 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 PCEEs 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 lay 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.

10810 Preparation of Indents

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

1. 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.
2. 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.
3. The quantity should be invariably given in words and figures in the respective columns.
4. 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.

5. 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.
6. 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.
7. 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.
8. The chargeable head of account should be correctly indicated.
9. 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 :-

   a. 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, upto certain limits are 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.

   b. 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.

   c. 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).

   d. 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 PCEE'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 colours, 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 OHE 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.
3. 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.
6. In the event of rejection, a letter should be addressed to the firm forthwith detailing the reasons and duly countersigned by the controlling officer. 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 break-down stores should be kept earmarked for use in break-downs 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.

10815 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-over, 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.
4. 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 a 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 incharge 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 pares 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-

1. Locking and sealing of stores,
2. Custody of keys and
3. 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

1. The general rule governing the condemnation of assets is contained in para 716 of the General Code, Volume I, 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 average 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 PCEE and PCME following the procedure prescribed for the purpose and obtaining PFA's concurrence. Similarly PCEE and PCME 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 PCEE and PCME and concurrence of PFA.

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

1. Instructions for verification of stock by stock verifiers of the Accounts Department are contained in the Code.
2. Each stock holder 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 recondition able 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/ADEEs should carry out such test verification of stores of all their subordinates at least 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 Computerised Stores Accounting

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

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CHAPTER-9
QUALITY ASSURANCE & RELIABILITY-ENGINEERING

10900 General

It shall be endeavor 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 asset plays a vital role in their reliable operation. Quality of a product/ equipment defined as compliance with the following:

1. The specifications as established by the purchaser and accepted by the supplier;
2. The design details as declared by the supplier and accepted by the purchaser; and
3. 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, and indices for acceptance is given in the Annexure - 9.1 for reference.

10902 Purchase of Spares

The following guidelines have been laid down for purchase of quality spares: (ref. Board's letters nos. 73/RS(G)/ 30/RII 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 Principal 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 everyone in the organisation, management, workers towards improving performance at every level to build an organizational culture where the quality improvement are embedded into the work and the activities.

Annexure 9.1

NOTE ON QUALITY MANAGEMENT

A. 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 form 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.

B. 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.

C. 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 possess 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 alldifferent from the corresponding situation in the production shop.

Acceptance Sampling

1. Introduction

1.1 Acceptance Sampling is the process by which decisions are taken either to accept

1.2 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.

1.3 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 defectives in each sample, constitute what is known as the Sampling Plan.

1.4 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.

1.5 The following Indian Standards must be studied by all Engineers concerned with Inspection and Quality Control.

a. IS 397 - Methods for 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-105D" 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 be low (seeFigure 9.01). In some tables, this probability is known as the consumer's risk designated as Pc 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 consumeractually gets depends on actual quality in the lots before inspection, and on the probability of acceptance.

2.3 Indifference Quality Level (IQL):

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).

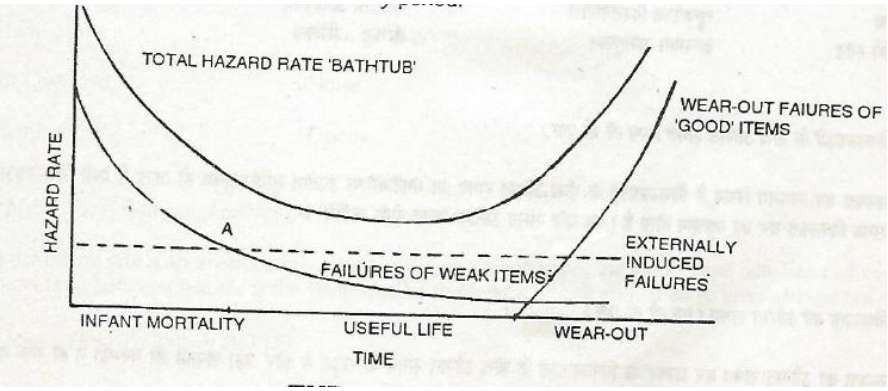

FIG. 9.01 QUALITY INDICES FOR SAMPLING PLANS

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):AOQ= pPa. 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 manufacture'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 riot 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 :

Lot Size	Sample Size	Sample Percentage
100	20	20
1000	12.5	1.25
3000	200	6.7

6. Limitations of Acceptance Sampling

6.1 The limitations of Acceptance Sampling are as follows :

1. 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.
2. 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.
3. 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.

Annexure 9.2

NOTE ON RELIABILITY ENGINEERING

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 loco- motives, 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:-

$$\text{Reliability at time t} \quad = R(t) \quad = \frac{\text{Number of surviving at present}}{\text{Number at start}}$$

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:

1. 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.

2. 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.

3. 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 characteristic(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.

4. 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 bath tub curve because of its shape. It divides into three periods as follows:

1. 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:

   a. manufacturing fault
   b. design faults
   c. misuse

The period is also referred to as infant mortality period.

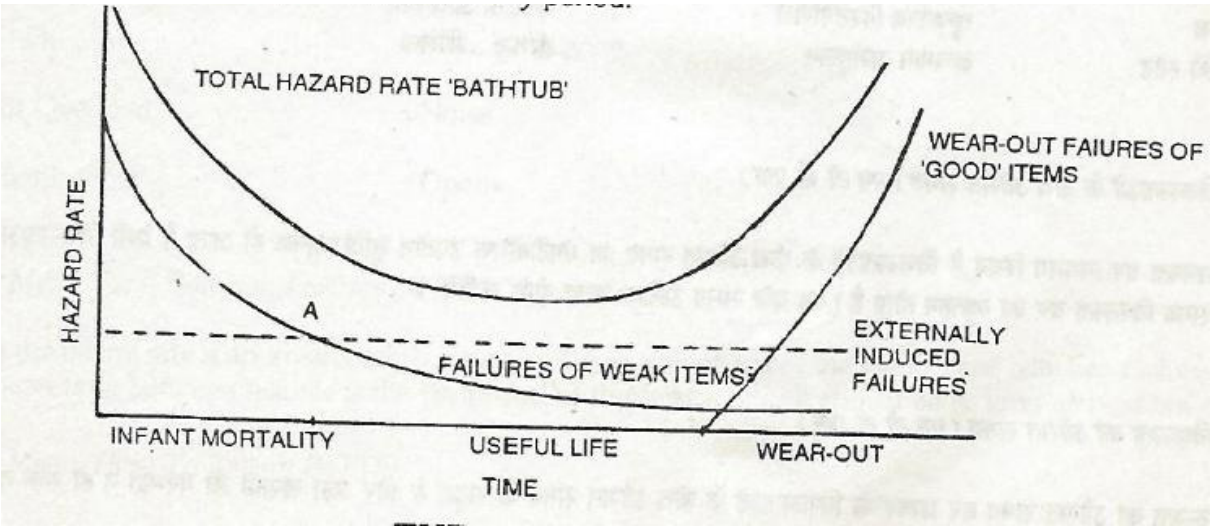

FIG. 9.02 THE BATHTUB CURVE

2. 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.

3. 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 :

Adherence	Deterioration	Piezo electric effect
Arcing	Diffusion	Radiation
Backlash	Drift and shift	Secondary
Bleeding	Dynamics out of limit	Seizure
Carbonisation	Electric Breakdown .	Silver migration
Composite behavior	Erosion	Slip
Contact bounce	Fatigue	Smearing
Contamination	Fretting or galling	Sublimation
Corona	Frequency effects	Voltage Breakdown
Creep	Leakage	Voltage Overload
Creep rupture	Magnetic hysteresis	Wear
Cross talk	Mass unbalance	
Current Overload	Noise	
Decarbonisation	Opens	

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 cannot 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:

$$\text{Availability} = \frac{\text{MTBF}}{\text{MTBF+MTTR}}$$

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

1. F-MECA method is used very widely at the design stage for estimating the reliability ofany new system or product and, more importantly, for evolving more reliable designs through the identification of vulnerable or failure prone components.
2. 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.
3. 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.
4. 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.
5. Although F-MECA methods as defined in MIL-STD-1629 were originally developed for the purpose of evaluation of reliability of electronic equipment's 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 every day. The overall picture so produced will help the top management firstly to determine the most effective application of available resources and secondly to assess the effectiveness of measures taken to prevent any type failure.

4. Failure Reporting and Corrective Action Systems (FRACAS)

1. 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.
2. 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.
3. 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.

4. 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.
5. 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.
6. 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.
7. Failure report forms should be designed to cover all the above details as also any other relevant data specific to the equipment in question.
8. 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

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

1. It is always not possible to visualize every thing at the drawing board stage. When the manufacture of the prototype is undertaken, various problems may be exposed, particularlyin 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.
2. As far as the actual method is concerned the best way in the long run 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

1. 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.
2. 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.
3. 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

1. 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

1. 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.
2. 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:-

1. The value of production/service lost through breakdowns,
2. 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)
2. A Practical Approach to Reliability by R.H. Caplen (Published by Business Books Ltd.)
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.
6. *MIL-STD-781 : Reliability Qualification and Production Approval Tests.
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.

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CHAPTER-10
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 proposed remodelling plans, track 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 centers 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.

3. General Power Supply.
   a. Modification to track crossings
   b. 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 avers, 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 sheds etc.Checking of position of over line 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 Tractions', 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-

1. The construction or purchase of material for new works or assets,
2. The renewal and replacement of existing works or assets,
3. The scrapping, dismantlement or abandonment of existing works or assets,
4. The repairing or reconditioning;
5. Temporary and experimental works;

should be scrutinized by the authority competent to sanction them before any expenditure or liability is incurred thereon.

Broadly estimates are of two types :-

1. Abstract Estimates
2. 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 thereto 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. 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 to sanction, shall be submitted to the Principal 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.

b. 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-

..... RAILWAY

REGISTER OF ESTIMATES

Department..... .....Office .....Station.....

S. No.	Esti mate No.	Name of work	Plan No.	File No.	Estimated cost	Charged to					
						CAP	DF	DRF	OLWR	ORDY REV.	DEPOSIT

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.

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CHAPTER-11
DOCUMENTS FOR REFERENCE

11100 Books of Reference

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

The Principal Chief Electrical Engineers' and Sr. Divisional Electrical Engineers' offices should be equipped with adequate number of copies of each publications. 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, PCEE, 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 PCEE'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 -1

DOCUMENTS FOR REFERENCE

List of Books for Reference

Offices which should be equipped with copy of the publication.

Item No.	Publication	For the Personal use of such officers and supervisor as may be prescribed	Sr.DEE DEE	AEE	Traction Foreman/ Asst. Traction Foreman				TPC	TLC	Electrical Chargeman			
					OHE	PSI	RC	RS			OHE	PSI	RC	RS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Act, Indian Boilers and Manual of Boiler Inspections as issued.	..	1	..	..	..	..	..	..	..	..	..	..	..
2.	Act. Indian Electricity, Rules issued and State Government publications.	1	1	1	1	1	1	1	1	1	1	1	1	1
3.	Act, Indian Explosives and State Government publications.	..	1	1	..	..	..	..	..	..	..	..	..	..
4.	Act, Indian Factories and State Government publications.	..	1	1	1	1	..	1	..	..	..	..	..	..
5.	Act, Indian Railways	..	1	1	..	..	..	..	..	..	..	..	..	..
6.	Act, Land Acquisition and State Government publications.	..	1	..	..	..	..	..	..	..	..	..	..	..
7.	Act, Payment of Wages with Notifications as issued.	..	1	1	1	1	1	1	..	..	..	..	..	..
8.	Act, Workmen's Compensation.	..	1	1	1	1	1	1	..	..	..	..	..	..
9.	Act, Indian Lifts.	..	1	..	..	..	..	..	..	..	..	..	..	..
10.	Act, Indian Mines and State Government Publications.	..	1	1	..	..	..	..	..	..	..	..	..	..
11.	For later additions													
12.	Act, Indian Petroleum	..	1	1	1	1	1	1	..	..	..	..	..	..
13.	For later use													
14.	Alphabetical list of Railway Stations.	..	1	..	..	..	..	..	..	..	..	..	..	..

DOCUMENTS FOR REFERENCE

List of Books for Reference

15.	Code, Indian Railway for Engineering Department.	1	1	..	..	..	..	..	..	..	..	..	..
16.	Code, Indian Railway for Stores Department.	1	1	..	..	..	..	..	..	..	..	..	..
17.	Code, Indian Railway for Mechanical Department.	1	1	..	..	..	..	..	..	..	..	..	..
18.	Code, Indian Railway for Accounts Department.	1	1	..	..	..	..	..	..	..	..	..	..
19.	Code, Indian Railway Establishment.	1	1	1	1	1	1	..	..	..	..	..	..
20.	Code, Indian Railway General.	1	1	..	..	..	..	..	..	..	..	..	..
21.	Code, Telegraph.	1	1	1	1	1	1	1	1	1	1	1	1
22.	Code of Practice for Earthing, IS 3043.	1	1	1	1	1	1	1	..	..	..	..	..
23.	Code of Practice for Selection, Installation and Maintenance of Transformers IS 10028.	1	1	..	1	..	1	..	..	..	1	..	1
24.	Code of Practice for Installation etc. of Cables, IS 1255.	1	1	1	1	1	..	..	..	1	1	..	..
25.	Code of Practice for Maintenance etc. of insulating oil, IS 1866.	1	1	..	1	..	1	..	..	..	1	..	1
26.	Code, National Electric.	1	1	..	..	..	..	..	..	..	..	..	..
27.	For later additions												
28.	- do-												
29.	Conference Regulations	1	1	..	..	..	1	..	..	..	..	..	1
30.	Manual, Indian Railways Establishment.	1	1	1	1	1	1	..	..	..	..	..	..
31.	Manual Indian Railways Permanent Way	1	1	1	..	..	..	1	..	..	..	..	..

DOCUMENTS FOR REFERENCE

List of Books for Reference

32.	Manual, Indian Railways Works	..	1	1	1	..	..	..	1	..	..	..	..	..
33.	Manual, Indian Railways Track	..	1	1	1	..	..	..	..	..	..	..	..	..
34.	Manual, Indian Railways Bridge	..	1	1	1	..	..	..	..	..	..	..	..	..
35.	Manual, Indian Railways Signalling.	..	1	1	1	1	..	..	..	..	..	..	..	..
36.	Manual, Accident and Circulars pertaining to accidents.	..	1	1	1	1	1	1	1	1	1	1	1	1
37.	Manual, ac Traction Maintenance & Operation	1	1	1	1	1	1	1	1	1	1	1	1	1
38.	Manual, Operation for various types of Rolling-Stock.	..	1	1	..	..	..	1	..	1	..	..	..	1
39.	Manual, Maintenance for various types of Rolling-Stock.	..	1	1	..	..	..	1	..	1	..	..	..	1
40.	Loco Inspection Books	..	1	1	..	..	..	1	..	..	..	..	..	1
41.	Inspection Charts	..	1	1	..	..	..	1	..	..	..	..	..	1
42.	Trouble Shooting Charts	..	1	1	..	..	..	1	..	..	..	..	..	1
43.	Technical Charts.	..	1	1	..	..	..	1	..	..	..	..	..	1
44.	Price List of Stores, stores nomenclature and circulars as applicable.	..	1	1	1	1	1	1	..	..	1	1	1	1
45.	List of Approved Suppliers.	..	1	1	1	1	1	1	..	..	..	..	..	..
46.	Regulations, Hours of Employment, with Notifications as issued.	..	1	1	1	1	1	1	1	1	1	1	1	1
47.	Regulations governing the Crossing of electric transmission lines across and underground cables under railway track.	..	1	1	1	1	..	..	1	..	1	1	..	..

DOCUMENTS FOR REFERENCE

List of Books for Reference

48.	Regulations for safe working on electrical equipment.	..	1	1	1	1	1	1	1	1	1	1	1	1
49.	Rules for the opening of a Railway for the Public Carriage of passengers.	..	1	..	..	..	..	..	..	..	..	..	..	..
50.	Rules, General and Subsidiary	1	1	1	1	1	1	1	1	1	1	1	1	..
51.	Rules regarding leave, passes and PTO's.	..	1	1	1	1	1	1	1	1	1	1	1	1
53.	Safety First Rules.	..	1	1	1	1	1	1	1	1	1	1	1	1
54.	Schedule of Dimensions.	1	1	1	1	1	1	1	1	1	1	1	1	1
55.	Schedule of Powers.	..	1	1	1	1	1	1	..	..	..	..	..	..
56.	Special orders on matters of general importance concerning the staff, as issued.	..	1	1	1	1	1	1	1	1	1	1	1	1
57.	Standing orders- Engineering Department.	..	1	1	..	..	..	..	..	..	..	..	..	..
58.	Standing orders- Operating Department.	..	1	1	..	..	..	..	1	1	..	..	..	..
59.	Specifications, IS on relevant subjects.	..	1 set	..	..	..	..	..	..	..	..	..	..	..
60.	Working Time Table and Appendix thereto.	1	1	1	1	1	1	1	1	1	1	1	1	1
61.	Code of Practice for Prevention of fires of EMU stock	1	1	1	..	..	..	1	..	..	..	..	..	1

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CHAPTER-12
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 PCEE.

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 railway men, 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, OHE 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 PCEE should also be kept informed of all important cases reported to the Security Department.

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/ADEE, 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:

1. All losses, on their detection, should be entered in a register by the officer in-charge. A similar register is also required to be maintained by the Accounts and Security Officers.
2. At the end of each quarter, the figures in their respective registers should be totalled up by the official in-charge, the Security Officer and the Accounts Officer.
3. 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 specialised 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/ADEE.
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 ot 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. SSE's or Sr. DEE's Office. The T&P register for each item should show the distribution of copies of its operating instructions.
3. 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 ofinstruments, 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 recognised 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.

COLOUR PHOTOGRAPHS&DESCRIPTION

OF

AC, AC & DC LOCOMOTIVES AND EMUs

Co-Co TYPE WAG-5 CLASS ELECTRIC LOCOMOTIVE

First locomotive of this type was built by CLW to the design of RDSO in 1980. This class of locomotives is not being produced in Railway. Board has taken a decision to produce only 3-phase locos.

The locomotive is powered by six axle-hungs, nose suspended, ventilated TAO-659 (CLW) or HS-1050/10250 (Hitachi) dc traction motors. Speed control is achieved by connecting the motors in parallel combination. Field weakening of motors was provided in subsequent series of manufacture at CLW.

These locomotives utilized silicon rectifier for conversion of ac power into dc.

This can be used for a multiple operation to a maximum of four locomotives. Compressed air brakes for the locomotive and dual brake for the trains are provided. In addition, these locomotives are provided with rheostatic braking.

PLATE No. 3.01

Bo-Bo-Bo TYPE WAG-6A CLASS ELECTRIC LOCOMOTIVE

These 6-axle locomotives have been ordered on ASEA by IR for service under arduous climaticconditions with ambient temperature reaching 50˚C.

Multiple connection of the locomotive is possible and they are pared for a future increase of the speed upto maximum 160 km/h. by have a micro-computer based control and indication system which assist the driver and the maintenance staff. Micro-processor control has been used not only for switching the thrusters but also for continuous monitoring of vulnerable equipment, thereby also providing diagnostic system and fault indication system (FIS) with facilities for automatic isolation of faulty equipment & answer back display on cut off operation to check whether emergency counter measures were correctly taken. FIS has facility for storage of the last 100 faults which can be printed along with details of conditions which existed when fault occurred. The creep control system using Doppler radar sensors, comparing wheel speed with true ground speed gives instant feed back & regulates the power to each individual axle, permitting maximum utilization of the available adhesion. Thysistor-switched power factor correction is incorporated. ASEA hollow-shaft traction motor drive tern has been adopted for transmission of power. Air and dynamic brake system exists on the locomotive while it can haul air brake stock only.

PLATE No. 3.02

WAG-6B CLASS ELECTRIC LOCOMOTIVE

A total of 12 Thysistor controlled electric locomotives built by M/s Hitachi/Japan were procured by lR in 1988. Out of these, 6 are having Bo-Bo-Bo bogie arrangement and are designated as WAG-6B class.

Special design features like fully suspended traction motor with WN coupling drive in WAG-6B class and unidirectional axle-hung, nose-suspended traction motor in WAG-6C have been incorporated to achieve higher adhesion.

Speed control is through phase angle control of thruster bridges combined with a separate control for field current. Automatic control is realised through a microprocessor based control system. Freon cooling for thyristor converters has been provided.

The design provides for a future increase in speed upto a maximum of 160 km/h.

The locomotives have air and dynamic brake system and are designed to haul air brake stock only. A maximum of four locomotives can be used in a multiple operation.

PLATE No. 3.03

WAG-6C CLASS ELECTRIC LOCOMOTIVE

A total of 12 thyristor controlled electric locomotives built by M/s Hitachi/Japan were procured by IR in 1988. Out of these, 6 having Co -Co bogie arrangement have been designated as WAG-6C class.

Special design features like fully suspended action motor with WN- coupling drive in WAG-6B class and unidirectional axle-hung, nose-suspended traction motor' in WAG-6C have been incorporated to achieve higher adhesion.

Speed control is through phase angle control of thyristor bridges Combined with a separate control for field current. Automatic control is reutilized through a microprocessor based control system. Forced air cooling for thyristor converters has been provided.

The design provides for a future increase in speed upto a maximum .of 60 km/h.

The locomotives have air and dynamic brake system and are designed to haul air brake stock only. A maximum of four locomotives be used in a multiple operation.

PLATE No. 3.04

Co-Co TYPE WAG7 CLASS ELECTRIC LOCOMOTIVE

First Prototype of this class of locomotive turned out by CLW in 1992 based on RDSO design. High adhesion bogies with uni-directional, axle hung, nose suspended traction motor has been used on this locomotive to achieve high tractive effort. A higher rated smoothing reactor type SL-30 to suit the higher current has been used. Hitachi traction motor type HS 1250A have been permanently connected in parallel and speed control is achieved through a tap-changer and by field weakening. Four locomotives can work in "Multiple Operation". Locomotive is provided with air and dynamic brake.

PLATE No. 3.05

Co-Co TYPE WAP1 CLASS ELECTRIC LOCOMOTIVE

Five prototype locomotives of this type were ordered on Chittaranjan Locomotive Works to the design of RDSO. First prototype locomotive was put in service in 1981.

The locomotive is powered by six axle-hungs, nose-suspended forced ventilated type dc traction motors. Speed control is achieved by grouping in 2S-3P combination and by field weakening of the motor

These locomotives utilise silicon rectifier for conversion of ac power into dc.

These locomotives are being converted to make them suitable for multiple operation.

Compressed air brake for the locomotives and vacuum brake for the train are provided. Brakes system is being modified to make them suitable for dual brakes.

PLATE No. 3.06

Co - Co TYPE WAP4 CLASS ELECTRIC LOCOMOTIVE

Prototype of this type was manufactured by CLW to the designs of RDSO. First locomotive put on line in September 1994. The continuous Rail Horse Power of the locomotive is 5050hp at 72kmph. The locomotive is powered by six axle hung nose suspended forced ventilated type dc traction motors. Speed control is achieved by grouping in 6P combination and by field weakening the motors. The locomotive utilises high capacity silicon rectifier for conversion of ac power to dc. The loco is having higher underframe of 300t buffing load. Cast bogie Mark-I flexicoil suitable for 149kmph service speed. The locomotive has been provided with Aluminium chequered plates. Reduced number of sanders, high under frame etc. as to keep weight of loco 112.8 tonnes max.

The locomotive was developed after a previous class WAP 1 was found inadequate to haul the longer, heavier express trains (24-26 coaches) that were becoming the mainstay of the Indian Railways network. It was introduced in 1994, with a similar body shell to the WAP-1 class, but with Hitachi traction motors. Electricals are traditional DC loco type tap changers, driving six traction motors arranged in Co-Co fashion. This locomotive has proved to be highly successful. Latest locomotives of this class have been fitted with microprocessor-controlled diagnostics, static converter units (instead of Arno Converter) and roof-mounted dynamic (rheostatic) brakes.

PLATE No. 3.07

Co-Co TYPE WAM4 CLASS ELECTRIC LOCOMOTIVE

Five hundred and fifty three locomotives of this type were built by Chittaranjan Locomotive Works to the design of RDSO. First prototype locomotive was put in service in March, 1971.

The locomotive is powered by six axle-hungs, nose-suspended forced ventilated type dc traction motors. The traction motors are grouped either in 3S-2P or 2S-3P in these locomotives. The speed control is obtained through HT tap changer and by field weakening of the traction motor.

These locomotives utilise silicon rectifier for conversion of ac power into dc.

This can be used for a multiple operation to maximum of four locomotives.

Compressed air brake for the locomotive and vacuum brake for the train are provided. In addition these locomotives have been provided with Rheostatic braking.

PLATE No. 3.08

Co-Co Type WAG9 Class of Three Phase Electric Locomotives

20 Locomotives (6 Fully assembled +7SKD+7CKD Plus two(CKD) locomotives to serve as bank of spares of this type were ordered by IR on M/s ABB, Switzerland as per RDSO's specification no. E-17/08, first locomotive was received in 1996.The continuous horse power of the locomotive is 6120.The locomotive is powered by 6 axle hung nose suspended forced ventilated 3-phase Traction Motors. Speed Control is achieved through Converter-Inverter Control using GTO Thyristors which is now being done by IGBT. Multiple connection upto two locomotives is possible. These locomotives have Micro-Processor Based Control & Fault Indication System. Air & Regenerative brake system for locomotive and Air brake for the train are provided.

PLATE No. 3.09

Co-Co Type WAG9H Class of Three Phase Electric Locomotives

The WAG9H loco is a heavier version of the WAG9 locomotive. The weight of the locomotive is 132t. The higher adhesive weight makes it suitable for hauling heavier freight rakes. The Horse Power is 6120 HP same as WAG9.

PLATE No. 3.10

Co-Co Type WAG9HC Class of Three Phase Electric Locomotives

This is modified version of WAG9H loco with conventional brake rigging in place of TBU/PBU. All other features are same as that of WAG9H locomotive.

PLATE No. 3.11

Co-Co Type WAGC3 Electric locomotive

WDG3A diesel locomotives have been converted to electric locomotive jointly by DLW, RDSO & CLW. This converted locomotive has been designated as WAGC3. The General Arrangement of twin WAGC3 loco is as per drawing no. SD.DL-4794. The axle load of the locomotive is 20.5t and horse power of twin WAGC3 locomotive is 9600 hp (2x4800hp). The WAGC3 locomotive is consist of two locomotives connected with the help of CBC coupling and each loco will comprise of one cab. Each loco is having one pantograph & equipped with the feature of dynamic braking (re-generative). Standard equipments of WAG5/WAG7 & WAM5 has been used in WAGC3 locomotives.

The basic features of the twin Co-Co WAGC3 locomotive are as under:

1. Weight of twin WAGC3 loco = 2x123t=246t
2. Axle load = 20.5t
3. Adhesion = 35%
4. Starting Tractive Effort(kg) = 86000
5. Continuous tractive effort(kg) = 52800
6. Maximum Sanctioned speed = 80kmph
7. Horse Power = 9600hp
8. Gear Ratio = 18:74
9. No. of transformer = 2
10. Type of traction motor = TM4907BZ(BHEL)
11. Rating of traction motor(continuous) = 750V,900A,600kW(800hp)

Haulage Capability= WAGC3 locomotive in twin mode can start & haul 1 in 100 up-gradient with load of 58BOXN (CC+8+2t) i.e. 5294t with balancing speed of 34km/h.

PLATE NO. 3.12

Bo-Bo Type WAP-5 Class of 3-phase Electric Locomotive

10 Locomotives plus one locomotive to serve as bank of spares of this type were ordered by IR on M/s ABB, Switzerland as per RDSO's specification No. E-17/08. First locomotive was put in service in 1996.The continuous Horse Power of locomotive is 5440.The locomotive is powered by four bogie mounted forced ventilated 3-phase traction motors, speed control is achieved through converter – inverter control using GTO/IGBT. Multiple connection upto two locomotives is possible .These locomotives have Micro-Processor based Control and Fault Indication System. Air & Regenerative brake system for loco and Air brake for the train are provided.

PLATE NO. 3.13

Co-Co type WAP-7 Class of 3-phase Electric Locomotive

The WAP 7 is a three phase AC electric passenger locomotive. It is a passenger variant of the freight locomotive WAG 9(Gear Ratio 5.133) with a modified gear ratio (3.6) to pull lighter loads at higher speeds. It is capable of hauling 24 coach trains at speeds upto140 km/h.

PLATE No. 3.14

Co-Co type WAP-7HS Class of 3-phase Electric Locomotive

WAP-7HS loco is upgraded version of WAP-7 loco. The existing speed of WAP-7 loco has been upgraded to 160kmph by changing the gear ratio from 3.6 to 3.18 & reducing the weight by 14.5t approx besides other software changes. Upgraded WAP-7 loco (designated as WAP-7HS) can haul 24 coach train at 160kmph.This will reduce the journey time & will improve line capacity. Prototype unit of WAP-7HS locomotive has been manufactured by CLW. Railway Board has accorded sanction to run this loco upto maximum speed of 160 kmph. This is the first indigenously developed high speed & high horse power electric locomotive under 'Make in India' ideology.

PLATE No. 3.15

PLATE No. 3.16

25 KV AC THREE PHASE
INDIGENOUS PROPULSION & OTHER EQUIPMENTS FOR EMU

MAIN EQUIPMENTS

Pantograph: Pantograph is an apparatus which mounted on the roof of electric train to collect power through with an overhead tension wire.

LCB: This device is used as line circuit breaker to open and close the power circuit and also to break the circuit in case of for overload or short circuit protection

Earthing Switch: The earthing switch mounted on the vehicle roof connects both ends of the line circuit breaker (LCB) to earth in order to provide safe access to the high voltage system

Surge Arrestor: The primary surge arrester (3a) in front of the line circuit breaker will protect every following HV components including the transformer primary winding from incoming transient over voltages. A secondary surge arrester (3b) between the line circuit breaker and the main transformer will protect the transformer primary winding from overvoltage generated by the LCB. This arrester is designed for low energy input and reacts slower than the primary surge arrester because of his response characteristics.

Primary Current Transformer: The function of the PCT is to measure the line current in the high voltage circuit. The PCT measures the line current feeding to the MT primary winding

Primary Voltage Transformer: The primary voltage transformer is mounted on the vehicle roof. It is used to measure the catenary voltage and frequency for supervision and control purposes

Transient Inductor: The main transformer and the propulsion system are protected from fast transient voltages generated when switching the line circuit breaker by a transient inductor.

Main Transformer: The purpose of the main transformer is to transform the catenary voltage to voltage levels suitable for supplying the propulsion and auxiliary power supply systems

Traction Converter: Traction Converter convert single phase AC input to a stable DC link bus voltage. A combination of one or more inverters converts this DC bus voltage to 3-phase power controlling one or more traction motors each.

Auxiliary Converter: Auxiliary converter forms part of the auxiliary drive system in the Motor coach which is primarily used for supplying power to loads such as fans, blowers, lighting the cabin and also charging the locomotive battery.

Traction Motor: The traction motor transforms electrical power into mechanical power during tractive mode and transforms mechanical power into electrical power during braking.

ECC: The main task of ECC is to distribute 3 phase 415V AC +/-5% & 110V DC +/-5% to all consumer load

EDC: The main task of the EDC is to convert the 850V AC/50Hz provided by the auxiliary inverter located in the TCC into adequate voltages for the supply of all consumers load situated in the ECC with 3-phase 415V AC +/- 5%.

BBR: The brake blending resistor (BBR) is designed to dissipate the dynamic brake energy during the transition from full ED braking to full EP braking. It is operational only in case the overhead line is not receptive to brake energy flow back, in order to avoid fluctuation in the brake force

Refer TABLE – 3.03 for main data of 3 – Phase EMUs

PLATE No. 3.17

WAU-4 BG EMU STOCK

Presently WAU4 BG EMUs are running over Indian Railways with 1MC+ 2 TC of 15 Car rake formation and MEMUs are running with 1DMC + 3TC of 16 Car rakeformation. EMUs and MEMUs having air spring in secondary suspension. These units are provided with Electro pneumatic brakes system. EMU and MEMU motor coaches are provided with LED based head code and tail light. ESMON and PA system is provided in EMUs whereas ESMON is provided in MEMU coaches.

Refer TABLE – 3.03 for main data of EMU / MEMU of CHAPTER III of this volume

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