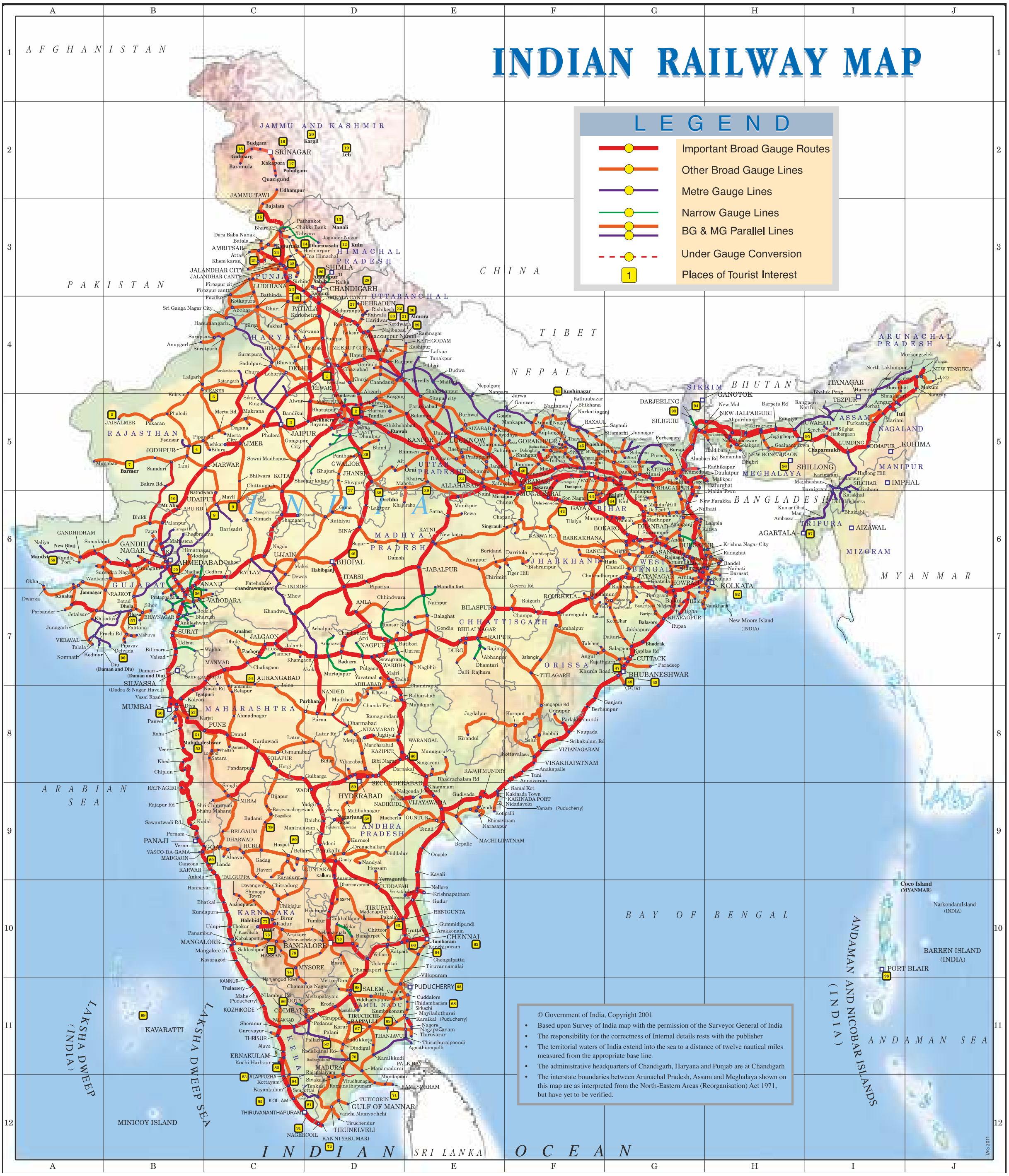
ज्ञान ज्योति से मार्गदर्शन

To Beam As A Beacon of Knowledge

Handbook
for
Track Maintenance

May 2016

Indian Railways Institute of Civil Engineering
Pune - 411001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PORT BLAIR
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The responsibility for the correctness of Internal details rests with the publisher
The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line
The administrative headquarters of Chandigarh, Haryana and Punjab are at Chandigarh
The interstate boundaries between Arunachal Pradesh, Assam and Meghalaya shown on this map are as interpreted from the North-Eastern Areas (Reorganisation) Act 1971, but have yet to be verified.

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FOREWORD

The laying and maintenance of Track are specialized activities, which need to be undertaken as per well laid down procedure and practice. For quite some time, need was being felt for a reference book containing comprehensive instructions with illustrations and sample calculations for easy understanding by engineers at grass-root level associated with laying and maintenance of track. This Handbook is the first step in this regard to facilitate easy understanding of subject for field P. Way engineers.

This type of Handbook requires to be updated regularly based on experience, feedback and comments from field engineers as well as to incorporate new developments and improved maintenance practices. As such, the up-dation of this Handbook at regular interval of 2-3 years needs to be done.

I hope that procedures and practices illustrated in this “Handbook for Track Maintenance” will help field engineers in laying and maintaining track to better standards ensuring safety, economy and efficiency.

(V. K. Gupta)
Member Engineering
Railway Board

New Delhi
May 2016.

PREFACE

The instructions for laying and maintenance presented in lucid manner and supported by illustrations & examples for easy understanding by field engineers is essential requirement for effective maintenance system.

With implementation of Track Management System and mechanization of track maintenance and laying, need was felt that the same need to incorporated in a handbook form for proper guidance of field engineers.

With the aforesaid background, under the guidance of Shri V. K. Gupta, Member Engineering, Railway Board, a "Handbook for Track Maintenance" has been prepared, which contains instructions in simple language with illustrative sketches and examples all given at one place for better understanding.

Bringing out this "Handbook for Track Maintenance " was possible with active and laudable efforts of following officers of Zonal Railways, RDSO and Faculty at IRICEN associated with the preparation of various chapters and active support of Shri S.S. Narayanan, AM/CE and Shri Satish Kumar Pandey, EDCE(P) from Railway Board.

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IRICEN will be glad to consider any comment and suggestions from Railways. Any errors or omissions found may be brought to the notice of IRICEN

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Pune,
May 2016.

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Chapter 1

Track Maintenance Planning

101. System of Maintenance:

The track should be maintained either by mechanised maintenance system or by conventional system. The track consisting of concrete sleepers, should normally be maintained by heavy on-track machines.

102. Details of Maintenance System :

(1) Conventional System of maintenance :

In conventional maintenance system, normally deployed on tracks consisting of other than PSC sleepers, involves following major maintenance activities undertaken by sectional gangs.

(a) Through packing *(Para 409)*

(b) Overhauling *(Para 407)*

(c) Picking up slacks *(Para 408)*

(2) Mechanized track maintenance system :

The maintenance of track consisting of concrete sleepers should normally be by mechanized means.

Three tier System of mechanized track maintenance should be adopted progressively for carrying out maintenance.

Tier 1 : On-track Machines Unit (OMU)

Tier 2 : Mobile Maintenance Units (MMU)

Tier 3 : Sectional gangs.

(a) On track machines unit (Tier - 1) : OMU consists of heavy on track machines for regular track maintenance including systematic packing of ballast by tamping machine for plain track and turnout, ballast cleaning machine (BCM) for deep screening and shoulder ballast screening during overhauling operation, dynamic track stabilizer, ballast regular etc. These machines are to be deployed to carry out the following jobs:

(i) Systematic tamping of plain track as well as Points & Crossings;

(ii) Intermediate attention to plain track as well as Points & crossings;

(iii) Ballast profiling/redistribution;

(iv) Track stabilization;

(v) Shoulder ballast cleaning;

(vi) Periodical deep screening of ballast.

(b) Mobile Maintenance Units (Tier - 2) :

(i) The functions of MMU shall be as below:

- Need based spot tamping;
- In-Situ rail welding
- Casual Renewal and repairs except planned renewals
- Overhauling of Level Xings
- Replacement of glued joints
- Rail cutting/drilling and chamfering
- Permanent repairs to fractures
- Creep or gap adjustments involving use of machines
- Destressing of LWR/CWR
- Loading/Unloading of materials
- Any other functions assigned.

(ii) The mobile maintenance units (MMU) normally consist of following

- Road Vehicle : One for each SSE (P-Way) In-charge
- Rail Borne Maintenance Vehicle (RBMV): One for each ADEN
- Utility Vehicle (UTV) for handling / transportation of P.Way Materials : one for each Sr. DEN/DEN
- Multipurpose Tamper (MPT) : One for each Sr. DEN/DEN for spot attention.

Rail Borne Maintenance Vehicle (RBMV): ***(Fig. 1.01)***

RBMV is a self propelled, 8/4 wheeler rail bound vehicle having cabin on both sides and it runs at maximum speed of 105 kmph. It will have hydraulic crane of 1 MT. capacity which can work without power block. RBMV can carry 2 nos 60 kg 13 m long rails / 1 set switch / other P.Way material. Seating capacity of RBMV is 12 persons and has space for, racks, boxes for small track machines, tools and consumable materials.

Fig 1.01 - *Rail Borne Maintenance Vehicle (RBMV)*

Multipurpose Tamper (MPT) ***(Fig. 1.02)***

MPT is capable of lifting, lining & tamping. It is used for tamping plain track, turn out and special locations. It also has one telescopic crane of 1 MT capacity which can lift crossing, rails and sleepers etc. Seating capacity of MPT is 12 workmen.

Fig. 1.02 *- Multipurpose tamper (MPT)*

(iii) For performing functions mentioned in para 102(1)(b)(i) above, the MMU shall be provided equipment as listed in *Table no. 1.01*

Table 1.01 - *List of equipment for MMU*

Sl. No.	Name of Equipment	Qty.
1	Walkie Talkie	4 sets
2	Field Telephones	4 sets
3	Abrasive Disc Cutter	1 set
4	Rail Cutting Machine	1 set
5	Rail Drilling Machine	1 set
6	Chamfering kit	1 set
7	Hydraulic Rail Tensors	1 set
8	Wooden mallets & Rollers	1 set
9	Welding Equipment set	2 sets
10	Portable Weld Trimmer (with 52 kg & 60 kg shoe)	1 set
11	Rail Profile Weld Grinder	1 set
12	Off Track Hand Held Tamper with Generators	1 set
13	Non infringing Mechanical Lifting Jack of 15T cap.	4 no.
14	Lifting-cum-Slewing Device	2 no.
15	Insulated Rail Dolly with attachment to transport concrete Sleepers	6 no.
16	Mono Rail Wheel Barrow	2 no.
17	Turfer of suitable high capacity	2 no.
18	Inspection tool kit	1 set
19	Gauge cum level	1 no.
20	Rail Thermometer	1 no.
21	Gas cutting set	1 no.
22	Lighting arrangements (Inflatable tower type or similar)	1 no.
23	Heavy duty hydraulic extractor for jammed Pandrol clip	1 no.
24	Gang warning device	1 no.
25	Hydraulic sleeper spacer	1 no.
26	Hydraulic Track Jack	1 no.
27	Concrete sleeper drilling Machine	1 no.

(c) Works to be done by Sectional Gangs: (Tier - 3)

The sectional gangs, under 3-tier system of track maintenance shall perform the following functions:

(i) Patrolling of track:

- Keyman's daily patrol
- Hot/cold weather patrolling
- Monsoon Patrolling

(ii) Watching vulnerable locations

(iii) Attention to emergencies viz. temporary repairs of fractures.

(iv) Need-based attention to bridges, turnouts, SEJs and approaches of level crossings.

(v) Greasing of ERCs, lubrication of joints, casual renewal of rubber pads and other fittings.

(vi) Minor cess repairs.

(vii) Cleaning of drains and boxing of ballast.

(viii) Attention to loops.

(ix) Creep and gap adjustment not involving use of machines.

(x) Cleaning of crib ballast for effective cross drainage.

(xi) Pre & post tamping attention.

(xii) Assistance to MMU & OMU as required.

(xiii) Any other functions assigned.

(3) In both the systems of maintenance, track is required to be overhauled periodically with the object of restoring it to best possible condition, consistent with its maintainability. Periodicity of overhauling depends on several factors, such as type of track structure, its age, volume of traffic, rate of caking up of ballast, maximum permissible speed, system of traction, condition of formation etc. Irrespective of the system of track maintenance adopted, it is obligatory to overhaul specified lengths of gang beat annually. The length of the section to be overhauled shall be such that complete overhauling of track will be accomplished within a period of 3 to 5 years.

(4) In both systems of maintenance it is necessary to allot certain number of days in a week for 'picking up slacks' to ensure that whole gang length is in safe condition for passage of trains.

103. Record Keeping :

(1) Record of Gang Work :

(a) Each Mate (Track Maintainer Gr. I) should be supplied with a gang chart and a gang diary. In the gang chart, details of track maintenance work done over the gang length on a day-to-day basis shall be recorded by the JE/SSE (P.Way), according to extant instructions. The work set to the gang should also be indicated in the gang chart by suitable notations. A typical Gang Chart & Gang Diary is enclosed as *Annexure 1/1 and 1/2.* In the gang diary weekly programme of work should be entered by the JE/SSE(P.Way). At the end of the week, the JE/SSE (P.Way) should carry out a quantitative and qualitative assessment of the work done during the week after thorough inspection and make suitable observations in the gang diary. Each gang chart/diary should be adequate for recording the work during the complete year. Temporary gangs employed in work allied to track maintenance, should also be supplied with gang diary, wherein the details of the work set and the work carried out will be entered. Details of maintenance work carried out by these gangs should be entered in the gang chart of respective permanent gang. Gang charts/diaries should be scrutinized by the ADENs and DENs during their inspections. They should record their observation in the gang diary.

(b) On withdrawal of gang chart/diary and supply of fresh ones, the JE/SSE(P.Way) should carefully analyse the work done and take notes of kilometerages that frequently gave trouble during the previous year, with a view to formulating such special measures as may be necessary. Action may be taken to preserve the gang charts for a period of FIVE YEARS.

(c) Maintenance attention given to the signaled loop lines and turnouts should be recorded on the chart.

(d) Whenever the gang equipment are checked by JE/SSE (P.Way), the same should be recorded in gang chart against the date on which such inspection is done. Inspecting officials should initial against the date on the chart and also make suitable entries in gang diary.

(e) Six months after the end of each year, the gang charts will be collected by the SSE/PWays and maintained as record. Thus, for the overlapping period of six months, the gang will have two gang charts with them. A six months record will, therefore, always be available with the gang for reference. Normally, this record should be kept for at least five years.

When a particular kilometer or section is under special observation, the record may be maintained for a longer period at the discretion of PWay officials.

(f) In addition to gang chart and gang dairy, JE/SSE(P.Way) shall also enter the day to day working of Gang in relevant TMS module. A sample of relevant TMS window is shown in *Fig 1.03.*

Fig.1.03 – *Daily Gang Work entry in TMS*

(2) Attention to Inspection Notes: Notes on inspections carried out by officers whether on foot, by push or motor trolley, on foot plate of the locomotive or by rear carriage of fast trains, should be uploaded in TMS within specified period from date of inspection, for necessary action.

The JE/SSE(P.Way) should enter the compliance reports on the TMS as early as possible.

(3) Record of Work of Artisans and Other Workmen Employed: Each artisan/ workman will be supplied with a diary in which entries will be made by the artisan/workman showing his movement by train and the details of daily work performed by him. The JE/SSE (P.Way) will scrutinize the work during his inspection and make suitable observations in the artisan's/ workman's diary. JE/SSE (P.Way) shall upload the work on TMS. At the end of the month these diaries will be sent to the Office of the SSE (P.Way).

(4) SSE(P.Way)'s Section Register:

(a) Each SSE(P.Way) incharge shall update asset in TMS within 15 days of change. He shall maintain a Section register containing all important information including a brief history of the section. Entries shall be brief and categorised under various sections as indicated below:

(i) Administration –

- Details of incumbency of JE/SSE (P.Way) and Clerks.
- Change in jurisdictional details

(ii) Permanent Way –

- Track structure, method of maintenance, details of particular locations giving frequent trouble and remedial measures adopted (if any).
- Ballast – Kilometerages where there is deficiency of ballast and details of recoupment done. Particulars of deep screening carried out year-wise.
- Formation – Sections giving frequent trouble with brief history and remedial measures adopted, if any.
- Grades – Re-grading done, with brief details of lifting or lowering of track.
- Curves – Realignment and/or transitioning of curves.
- Details of kilometerages of track laid as short welded panels, long welded rails, continuous welded rails, etc. incidence of buckling, maximum and minimum rail temperatures observed, behaviour of S.E.J. and buffer rails.
- Creep Adjustment – Details of Creep adjustment done and action taken to reduce creep - Details of Gap survey carried out and adjustment done.
- Permanent Way renewals – Major renewal carried out as relaying, TRR and TSR; large scale renewal of track components at a section should also be shown.
- Station yards and sidings – Extension or alteration to sidings, platforms, and renewal of points and crossings.
- Details of fracture prone areas. Rail failures – Brief particulars of all types of rail failures, Tongue rails, SEJ, GJ etc including weld failures should be noted in the section register,

connecting references to the failure reports.

- Rail Testing and Renewals – Records of rail testing by Ultrasonic Testing Method - Brief details of all rails removed with reasons for removal. This will form the basis of justification for through rail renewals/ casual renewals.
- Brief particulars of fish-plate failures with details of fish plates and reasons for failure.
- Corrosion prone areas : Particulars of work done with dates each year.
- Material under trial: Brief particulars - Connect reference to notes in the 'Materials-under-trial' register.
- Summary of TRC results

(iii) Bridges and Floods –

- Yearly record of rainfall showing month wise distribution.
- List of distressed bridges, Important repairs and renewal to bridges, details of extensive repairs to bridges, dismantling and rebuilding bridges, strengthening of girders, renewal of girders, extension of bridges and through renewal of sleepers, should be shown. Ordinary repairs need not be recorded.
- Damage due to floods: Extent of damage with particulars of rainfall, arrangements made for labour and material, time and labour spent for restoration and approximate cost. Cause of damage and notes on remedial measures
- List of Railway affecting Works with brief history.
- List of vulnerable locations, where stationary watchmen are to be posted.

(iv) Miscellaneous –

- Availability of labour in section for works.
- Infringement particulars
- Accidents attributable to Permanent Way with details
- Encroachment and steps taken to remove them.
- List of reference books available in the section.
- Any other important information necessary.

- The entries made in the section registers shall be brought up-to-date from time-to-time and these shall be scrutinized in the beginning of every year by the ADEN

(5) Permanent Way Plans and Diagrams:

(a) The ADENs shall have in their office complete sets of the following:

- The I.R.S. Track manual or I.R.S. type plans, pertaining to track sections and turnouts extant over their jurisdictions.
- Plans and longitudinal sections of the line, to a scale of 50 meters to 1 cm horizontal (1/5,000) and 5 meters to 1 cm vertical (1/500) and Index Plans and sections to a scale of 0.5 kms to 1 cm horizontal (1/50,000) and 10 meters to 1 cm vertical (1/1,000) showing the physical features, alignment, grades, location of bridges and level crossings.
- Drawing of bridges, level crossings and protective works and yard layouts over their jurisdiction.
- Working drawings or diagrams pertaining to track and components on their sections, issued from time-to-time.

(b) The Permanent Way track diagram:

The Permanent Way diagram of the railway line showing the type of track and fittings, when laid, type of ballast, type of formation with classification of soil (to be carried out as per RDSO's Circular No : GE1-May 2003), blanket thickness, type of formation trouble (if any) and indication of how the railway boundary is demarcated. Change points in the track diagram shall be indicated correct to the nearest meter. Track diagram is available in TMS module. Track diagram should be saved in information dump and kept ready at the time of inspection of higher authorities.

(c) The Permanent Way diagrams of station yards showing complete dimension of running lines, sidings, type of track and turnouts can be seen from TMS.

(d) The SSE (P.Way) shall have in their office complete sets of drawings and diagrams as mentioned in item (5) (a) above pertaining to their jurisdictions ; he shall have in his possession the land plans pertaining to his jurisdictions covering those between stations and unimportant station yards.

(e) Plans pertaining to their jurisdictions shall be maintained up-to-date by the ADEN and SSE(P.Way) incharge.

104. Jurisdiction and Ground Features Demarcation :

(1) Section Limit Boards :

(a) Boards at jurisdictional limits should be provided at the cess perpendicular to the track. The details should be written on the board back to back as under

(i) End of Divisions:

BB DIVN.	BSL DIVN.
D.E.N./BB	D.E.N./BSL
A.D.E.N./IGP	A.D.E.N./MMR
SSE(P-Way)/IGP	SSE(P-Way)/DVL

(ii) End of Sub-Divisions:

A.D.E.N. / TNA	A.D.E.N. / KYN
SSE (P.Way) / KYN	SSE (P.Way) / VSD

(iii) End of the Sections:

SSE (P.Way) / TNA	SSE (P.Way) / KYN

(iv) End of Gang lengths:

G-3
1+1+14

G-4
1+1+13

(b) If the gang beat ends in a curve the beat should be so adjusted that the entire curve lies in one of the beats. Similarly in case of yards gang beats should be so adjusted that the yard is maintained as far as possible by one gang, exception being in the case of big yards where the yard may have to be maintained by more than one gang.

(c) Suitable boards should also be provided indicating the state and district boundaries.

(d) When a board has to be located at an exact kilometer, it should be fixed by the side of the kilometer post.

(e) The boards, which may be of scrap iron or R.C.C. should throughout a division be fixed on the cess on the same side of the line. The letters and figures should be painted in black on white background

(2) Kilometer and Gradient Posts: These may preferably be of R.C.C. of suitable dimensions and fixed at right angles to the track on the cess so as to be distinctly visible. The figures, arrows and letters should be painted in black on a white background.

(3) Hectometer posts:

(a) Hectometer post should be provided at every 100 meters from kilometer post in non electrified territory.

(b) Figures should be painted in black on white background

(c) On double line section where one line is located away from the line along which the hectometer posts are provided and from where the figures on the hectometer posts cannot be easily read, separate posts should be provided for both the lines.

(4) Telegraph post / OHE mast Numbers : On electrified sections the kilometrage is indicated on the structure posts. The responsibility of providing number plates or painting kilometrage on the Electric structure lies with the Electrical Department.

105. Standard Dimensions:

(1) Infringement: The JE/SSE(P.Way) should refer any work resulting in infringement of standard dimension to the ADEN for instructions. Work involving permanent infringement should be referred to the Railway Board for sanction through the Commissioner of Railway Safety.

Permanent way staff shall be on the alert to prevent occurrence of:

(a) Slacks in platform line causing the platform heights to exceed the standard dimension.

(b) Errors in alignment causing the minimum distance to adjacent structures infringed, for example, platform coping, water hydrants, over-bridges, O.H.E. structures, signal post etc.

(c) Excessive lifting of the track, causing minimum height to overhead structure to be infringed, for example, underside of over-bridge, roofs of tunnels, overhead contact wires.

(2) Verification and preparation of yearly statements of infringements:

Once a year, the standard dimensions over their sections shall be verified personally by the SSE(P.Way) according to the profiles shown in the schedule of dimensions and statements of infringements, if any, submitted to the ADEN by the end of March. The ADEN after scrutiny should forward these to the DEN.

The statement shall briefly indicate against each infringement the reasons for its continuance together with reference to the sanction of Railway Board/ Commissioner of Railway Safety. The DEN after scrutinizing the yearly returns will issue necessary instructions to the ADEN. Important items should be referred to the Chief Engineer.

106. Felling of Trees Obstructing View:

Trees and bushes that interfere or tend to interfere with the view from a train or trolley, of signals or level crossings or along the inside of curves, shall be trimmed /cut. When cut, it should be ensured that they do not foul the track. Trimming of tree branches obstructing visibility of Signals or affecting OHE installation are to be done by S&T and TRD Departments respectively. When trees and bushes require to be cut in terms of sub-para above, on private lands, action should be taken as laid down in Section 14 of the Railways Act 1989 reproduced below : —

(1) Where In the opinion of railway administration:

(a) There is imminent danger that any tree, post or structure may fall on the railway so as to obstruct the movement of rolling stock; or

(b) Any tree, post, structure or light obstructs the view of any signal provided for movement of rolling stock; or

(c) Any tree post or structure obstructs any telephone or telegraph line maintained by it, it may take such steps as may be necessary to avert such danger or remove such obstruction and submit a report thereof to the central Government in such manner and within such time as may be prescribed.

(2) In case of emergency the power mentioned in sub-section (1) may be exercised by a railway administration without the permission of a Magistrate.

(3) Where a tree felled or otherwise dealt with under sub-section (1) or sub-section (2) was in existence before the railway was constructed or the signal was fixed, any Magistrate may, upon the application of the persons interested in the tree, award to those persons such compensation as he thinks reasonable.

(4) Such an award, subject, where made in a presidency town by any Magistrate other than the Chief Presidency Magistrate, or where made elsewhere by any Magistrate other than the District Magistrate, to revision by the Chief Presidency Magistrate or the District Magistrate, as the case may be, shall be final.

(5) A Civil Court shall not entertain a suit to recover compensation for any tree felled or otherwise dealt with under this section.

107. Inputs for Maintenance Requirement :

(1) Every JE/SSE (P.Way) should prepare a perspective maintenance plan of his section in advance based on various track recording results and exceptions reports from TMS. This plan should also match with the availability of track machines as per Track Machine Deployment Plan in his section so that optimum utilization of various resources, track machines, traffic blocks, and labour etc. is possible. He should also ensure that arrangements are made for adequate materials, tools, labour, man power and necessary caution orders/ blocks, as may be necessary.

(2) The regular maintenance cycle and need based maintenance are elaborated as under.

(a) Regular track maintenance based on annual maintenance cycle:

In annual maintenance cycle, attention to entire beat has to be given as per following schedule. *(Table 1.02)*

***Table 1.02** - Annual Maintenance Cycle.*

Period	Work
i) Post-Monsoon attention: For six to seven months after end of monsoon	The first job is to pick up slacks/ attend to run down lengths by on track/off track tamper in the entire gang beat to restore the section to satisfactory standard. Having done this in first fortnight after end of monsoon, the schedule of works shall be as under for *(A) Other than concrete sleeper track:* (i) Attention to run down lengths in the entire gang beat to restore the section to good shape. (ii) One cycle of conventional systematic through packing/systematic directed track maintenance from, one end of the gang length to the others including overhauling of nominated sections as detailed in para 203 (2) *(B) Concrete sleeper track:* (i) Annual systematic attention 1 to 2 days in a week. (ii) Picking up slacks 1 day in a week. (iii) Shallow screening of specified lengths and points & crossings. (iv) Over hauling of specified level crossings. (v) Destressing of specified lengths. (vi) Scattered/ Casual renewal of rail/sleeper/points & crossings. (vii) Lubrication of rail joints. (viii) Cold weather patrolling. (ix) Carrying out pre-tamping, post-tamping works and to accompany machine during tamping of track by on track machines.

Period	Work
ii) Pre-Monsoon /Hot weather attention: For two to three months prior to break of Monsoon	*(A) Other than concrete sleeper track:* Normally 2 to 4 days in a week should be devoted to clearing of side and catch water drains, earthwork, repairs to cess, clearing water ways and picking up slacks. In the rest of the days normal systematic maintenance will be carried out. *(B) Concrete sleeper track :* (i) Picking up slacks 2 days in a week. (ii) Boxing and dressing of ballast including de-weeding and removal of vegetation growth. (iii) Cleaning and repairs to side and catch water drains and cleaning of waterways. (iv) Attention to yard drainage. (v) Pre monsoon measures for track circuited areas. (vi) Hot weather patrolling. (vii) Isolated (say 1 in 30) renewal of rail/ sleeper/ points & crossings. (viii) Carrying out pre-tamping, post-tamping works and to be with machine during tamping of track by on track machines.
iii) Attention during Monsoon for three months	*(A) Other than concrete sleeper track:* Attention to track as required. This will consist primarily of picking up slacks and attention to side and catch water drains and water ways. During abnormally heavy rains, patrolling of the line by gangs should be carried out in addition to regular monsoon patrolling.

Period	Work
	(B) Concrete sleeper track : (i) Picking up slacks 2 -3 days in a week. (ii) Normal track maintenance of loop lines and yards lines. (iii) Attention to Yard drainage. (iv) Cleaning, removal of loose boulders and muck, dressing of side drains in case of track in cutting and tunnels to ensure free flow of seepage water. (v) Hot weather patrolling if needed. (vi) Patrolling of the line during abnormally heavy rains by the gangs in addition to regular night monsoon patrolling. (vii) Scattered/ casual renewal of rail/ sleeper/ points & crossings. (viii) Carrying out pre-tamping, post-tamping works and to be with machine during tamping of track by on track machines. (ix) Repairs to trolley refuges and earthwork to repair cess towards the fag end of the monsoon. (x) Trimming of branches affecting visibility at LC, inside of curve and Engg. Indicators.

Note: Provisions/restrictions relating to LWR (Chapter 7) must be observed for carrying out all above works.

b) Inspection based maintenance:

There are two types of inspections i.e. direct inspection and indirect inspection

(i) Direct Inspection: On foot inspection, Push trolley inspection, inspection of Points & Crossing, curve, level crossing, LWR, glued joint, sand hump etc.

Above inspections will be entered in TMS by JE/SSE (P.Way)/ADEN. Based on result of inspection, exception will be generated in TMS which can be seen in report (A-L) "location needing attention" as shown below.

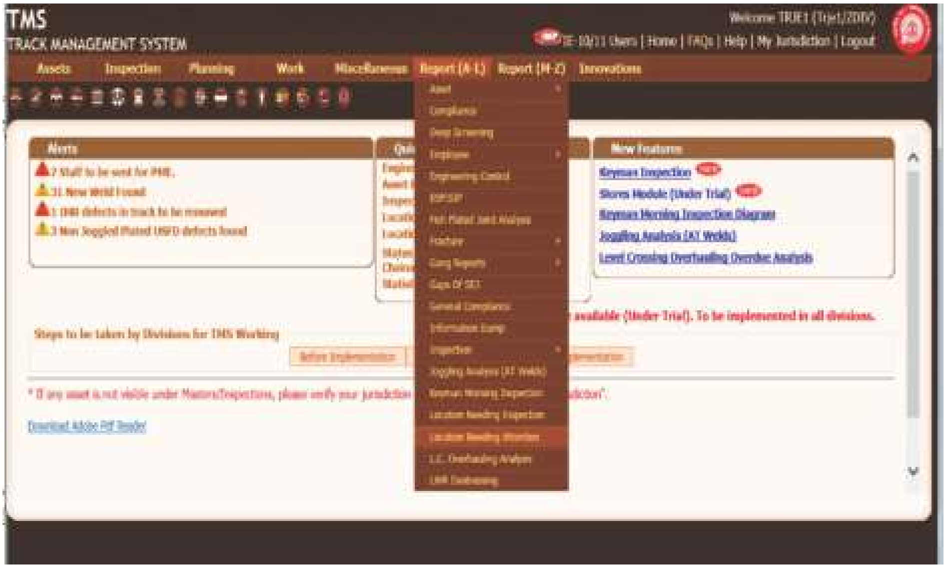


***Fig. 1.04** - Location needing attention.*

TMS report should be used for planning attention.

(ii) Indirect inspections: Foot plate inspection, Rear/Last vehicle inspection, OMS (portable accelerometer) and Track recording car.

Result of foot plate and last vehicle inspection will be entered in TMS by inspecting officials. Bad spots noted during foot plate and last vehicle inspection can be seen in report (A-L) under "location needing attention".

Result of OMS and TRC are to be entered by TRC administrator of the division. Based on the result of OMS / TRC, reports will be generated in TMS under drop down menu "Location needing inspection" as shown below.

***Fig. 1.05** - Location needing inspection*.

(iii) Special track maintenance:

Apart from routine maintenance, many special maintenance operations are also required hence prospective programme for special track works shall also be prepared for the year. This will include works like deep screening, realignment of curves, renewal of points & crossings, renewal / repairs to cupped welds, creep adjustments, de-hogging of rail joints, through end cropping, through renewal of welds, casual renewals of rail/ sleeper, painting of rails, heavy repairs to track including lifting, formation treatment and major repairs to sand humps and cess. For track laid on concrete sleepers, works like destressing, through fitting renewal, through rubber pad & metal/GFN liner renewal shall also be included in the program. Schedule / criteria for different special maintenance works like shallow screening, deep screening, painting of rails, realignment of curve etc. are described in relevant chapters.

108. Planning for Execution of Maintenance Work:

Track Maintenance may be manual or by track machine. SSE (P.Way) should plan in a proper way for timely and effective execution of work i.e. from commencement to completion. Generally all maintenance works should be carried out during post monsoon season. In case of machine maintenance, planning for stabling of machine and fueling, men, material & accommodation should be done in advance. In case of machine working, assessment of traffic blocks should be worked out by SSE (P.Way). While planning for traffic blocks in LWR territory (including that for de-stressing), maintenance temperature limits also should be kept in mind. In certain maintenance works, where contractual labour is required contract should be finalized well in advance.

109. Preparatory Arrangement for P.Way Materials:

Before starting the work JE/SSE(P.Way) should ensure that all materials required for maintenance work are arranged at site / depot as per the general guidelines mentioned hereunder. A location wise imprest of USFD tested rails should be maintained by each JE/SSE(P.Way) to attend emergencies.

Table 1.03 *- Material requirement for maintenance operation.*

	Maintenance operation	Material required
1	Through packing /Through tamping	Ultrasonically tested Rails and sleepers for scattered renewal, Grooved Rubber pads, Liners and ERCs for recoupment or replacement
2	Shallow screening, Deep Screening, Lifting / lowering	Ballast for recoupment, spare sleepers for replacement, grooved rubber pads, liners and ERCs for replacement/ recoupment.
3	Gauge face lubrication of outer rail of curve	Grease graphite 10.00 kg/Km
4	Lubrication of joints	Grease graphite (0.10 kg/joint), Black oil, Spare fish plates and Bolt.
5	Lubrication of ERCs only	Grease graphite ‘O’ (60 kg/TKM), spare ERCs, Liners and Grooved Rubber pads for replacement/recoupment
6	Lubrication of ERCs and sealing of liner contact area for inside liners only	Grease graphite ‘O’ (110 kg/TKM), spare ERCs, Liners and Grooved Rubber pads for replacement/recoupment
7	Lubrication of ERCs and sealing of liner contact area for all liners.	Grease graphite ‘O’ (160 kg/TKM), spare ERCs, Liners and Grooved Rubber pads for replacement/recoupment
8	Lubrication of SEJ	Grease graphite 0.30 kg/SEJ
9	Lubrication of plate screws on Points and Crossings.	Grease graphite 2.00 kg/Point

10	Lubrication of points and Crossing including Turn in curve	Grease graphite 1.00 kg / unit
11	Destressing of LWR	Grooved Rubber pads for replacements (100%) if out lived prescribed life. Liners and ERCs if required to be replaced
12	Attending Points & Crossings	Required fittings like chairs, blocks, plates screws, grease etc.
13	Replacement of defective rails.	Rails, fish-plates / welding portions

110. Arrangement for Tools & Plants :

SSE (P.Way) shall ensure that all tools & plants required for maintenance works are available with gang in working condition. SSE/JE (P.Way) should examine every month and replace, when necessary, worn out/damaged tools and plants. They should also check the accuracy of the spirit level/gauge and straight edge every month, the result of this examination should be entered in the Gang diary.

Each track maintenance unit should have the following minimum equipment:

Table 1.04 *-Tools for Maintenance Work*

	Item	Quantity
i.	Level-cum-gauge.	1
ii.	Hand signal flags.	(3 red + 3 green)
iii.	Detonators.	10
iv.	Steel scale 30cm long.	1
v.	Straight edge 1m long.	1
vi.	Tri-square.	1
vii.	Nylon chord	1
vii.	Keying and spiking hammer.	1 each
ix.	Rail thermometer.	1
x.	Feeler gauge.	1
xi.	Whistle thunderers.	2
xii.	Shovel, phowrahs, beaters, crow-bars, ballast-forks or rakes, mortar pans or baskets.	As per manpower

xiii.	Hand gloves.	As per manpower
xiv.	Electrical jumper in electrified sections.	2 short and 1 long
xv.	LED based tri-colour torch/lamps.	2
xvi.	Banner flags with rods & clamps.	2 set
xvii.	Fish bolt spanners.	2
xviii.	Marking chalk.	-

In addition to the above, SSE (P.Way) should also ensure that following small track machines / equipments are available in his depot/MMU-1 and are in working condition. *(Table 1.05)*

Table 1.05 *- Small Track Machine list*

i.	Abrasive Rail cutter	2 per JE / SSE (Sectional)
ii.	Rail cutting machine (saw type)	1 set per JE / SSE (Sectional)
iii.	Rail drilling machines	1 per JE / SSE (Sectional)
iv.	Hand held off track tampers	1 set per JE / SSE (Sectional)
v.	Hydraulic Rail tensor	2 Sets
vi.	Hydraulic Rail bender	1 per JE / SSE (Sectional)
vii.	Welding set complete	1 set per JE / SSE (Sectional)
viii.	Hydraulic/Mechanical Jack	2 per JE / SSE (Sectional)
ix.	Rollers for destrssing work	1200 nos. for one destressing of 1 km track (Side rollers will also be required for detressing of curved track depending upon degree of curve.)

Note: These are important small track machines, which are required for day to day maintenance work.

111. Arrangement for Manpower:

The strength of each maintenance gang is decided based on annual programme of regular track maintenance in vogue and the laid down policy for works to be included in the regular track maintenance. Normally, situation should not arise for the works of regular track maintenance to fall in arrears for want of manpower if the manpower for regular track maintenance work is made available as per yardsticks for items of work included in regular track maintenance. However, in case annual regular track maintenance works fall in arrears for want of manpower due to large scale absenteeism/vacancies and/or unusual loss of manpower on account of exigencies not catered for in determination of strength of maintenance gang, some activities may be outsourced with the personal approval of Chief Track Engineer. For this purpose, a month wise record is to be maintained by each In-charge P.Way Engineer for man days lost on account of absenteeism/leave and labour utilized on jobs other than those earmarked in regular track maintenance works. JE/SSE (P.Way) should ensure that sufficient manpower is available at site.

Following routine maintenance works will be done by sectional gang-

(i) Through packing or attending bad spots

(ii) Casual renewal of rails / sleepers

(iii) Attending points & crossing

(iv) AT welding during defective rail renewal

(v) Casual renewal of fittings

(vi) Lubrication of joints / SEJs

(vii) Pre-tamping attention to track

(viii) Post-tamping attention to track

(ix) Minor repairs to cess

(x) Cleaning of Side drain / catch water drain /Yard drainage

(xi) Water way cleaning of small culverts

(xii) Stacking of materials

(xiii) Patrolling

Note: The above list is only indicative and not exhaustive.

In case of special maintenance work like, major realignment of curve, major repairs gangs can be clubbed.

112. Arrangement for Traffic Blocks:

Generally for regular manual maintenance, like through packing, shallow screening, minor lifting etc traffic block is not required. Special maintenance work like deep screening, major lifting / lowering, realignment of curve will require imposition of speed restriction and for other work like tamping, deep screening by BCM, BRM, distressing, welding etc complete block is required.

JE/SSE (P.Way) shall submit requirement of speed restriction and traffic block for coming week to DEN/Sr. DEN through ADEN. The requirement of all the sections of division will be compiled at divisional level and discussed with operating department. For track circuited and electrified section, presence of S&T staff and OHE staff should also be ensured in advance, wherever required.

113. Records of Material Under Trial

(a) CTEs of Zonal Railways may order limited trials of simple items which do not infringe with existing provisions of standard specification or instructions laid down in Manuals/codes. Before undertaking the trial, complete scheme of trial should be well chalked out including the parameters to be periodically measured/checked, official to measure/ check, periodicity of measurement/checking and proforma in which measurements/ observations to be recorded. CRS shall also be kept informed about such trials.

(b) The Zonal Railways should periodically inform RDSO about such trials to maximize advantage.

(c) Details of Material under trial should be entered in TMS as illustrated below.

(d) Trial Lengths - Material under trial should, where practicable be laid near ADEN's headquarters.

(e) Indication Plates - Materials under trial should be indicated by plates of suitable dimensions fixed on the cess at either end of the trial length, the description and number of item, date laid and kilometerage, being shown thus :

composite sleepers
Bridge No.31
Nos 36, November 2012
Km.822/23-25

(f) Removal of materials under trial - In every case where sleepers or other materials under trial have to be removed because of relaying or alterations or any other reason, the Assistant Divisional Engineer concerned should report to the Divisional Engineer and ask for disposal instructions. When material is removed for any reason, a full note should be made by the ADEN on its condition after thorough examination. When materials under trials is removed and re-laid in anotherADENs length, the previous history of the material shall be copied in TMS

(g) SSE(P.Way)'s Records - The SSE(P.Way) shall maintain in manuscript form record of all materials under trial on his length with necessary particulars. Notes should be made thereon at regular intervals. The ADEN shall scrutinize the records during his inspections and enter in TMS also

(h) The DEN should take interest in the trials in progress in his jurisdiction and ensure that the stretch where such material is laid, is maintained to the desired standard.

(i) Periodic site inspection for material under trial should be carried out by Dy. CE of headquarters to insure that the trial scheme is followed regularly and proper records maintained.

Annexure 1/1 {Para 103 (1)}

GANG CHART

DIVISION ______________ SUB-DIVN. [redacted]

SUB SEC. __________ SECT BET ____________ AND _______________

1	CHART FOR GANG No	________
2	KILOMETRE	________
3	MATE (NAME)	________
4	GANG STRENGTH	________
5	RAILS	________
6	SLEEPERS	________
7	FASTENINGS	________
8	DEPTH OF BALLAST CUSHION BELOW SLEEPER (mm)	________
9	DEEP SCREENING	________
10	OVER HAULING	________
11	DESTRESSING	________
12	GAP SURVEY & RECTIFICATION	________
13	DETAILS OF CURVES/BRIDGES	________
14	L-XING & SEJ	________

OVERHAULING	WORK SET WORK DONE	
ORDINARY THROUGH PACKING	WORK SET WORK DONE	TP TRP
PICKING UP SLACKS	WORK SET WORK DONE	
ATTENTION TO PTS. & XING	WORK SET WORK DONE	
PRETAMPING OPERATION	WORK SET WORK DONE	PRT PRT
MACHINE TAMPING OPERATION	WORK SET WORK DONE	MT (MT)
POST TAMPING OPERATION	WORK SET WORK DONE	POT POT
MISC/SQUARING JOINTS	WORK SET WORK DONE	
CLEANING SIDE DRAINS	WORK SET WORK DONE	SD SD
ATTENTION TO CESS REPAIRS	WORK SET WORK DONE	CR CR
PULLING BACK CREEP	WORK SET WORK DONE	
REALIGNMENT OF CURVES	WORK SET WORK DONE	
CASUAL SLEEPER RENEWAL	WORK SET WORK DONE	CSR (CSR)
CASUAL RAIL RENEWAL	WORK SET WORK DONE	CRR CRR
OVERHAULING OF L XING	WORK SET WORK DONE	(LC) (LC)

ATTENDANCE | SIGNALLED LOOP LINES | T/OUTS ON RUNNING LINES

M	K	G	TOTAL	KILOMETER → LOOP No.	T/OUT No.

Annexure 1/2 {Para 103(1)}

Pro-forma for Gang Diary

Date	Present Strength	Location (Km)		Details of Work done	Inspecting official's remarks & signature
		From	To		

- *Though made of steel and concrete, P.WAY doesn't like man-handling. (Always go for mechanized means for maintaining P.WAY).*

■ ■ ■

Chapter 2

Track Management System (TMS)

201. General :

Track Management System is a central server based web enabled software application. TMS integrates various track structure data, inspection data, work data, etc. to assist Railway in ascertaining the correct level of maintenance and renewal inputs to be given at requisite location with the objective to maximize benefits of inputs given to track. Concept of need based track maintenance has been used in the system for optimum utilization of resources. TMS uses the data produced by measurements to show whether the track is improving or deteriorating over time, and/or what is it's trend. It shows the trend along with information about the work history of the particular segment. TMS provides detailed diagnostic, outcome of which is track maintenance plan including proposals for tamping and renewals. TMS also undertakes diagnostic procedure based on geometric condition of track recorded by TRC, OMS and routine inspections. This provides listing of locations requiring inspection as well as attention. Thus defect once noticed will not be lost sight of. Through this automation of maintenance process, time can be saved and accurate information on Railway track can be provided. This will help engineers to use good data to make objective judgments in selecting maintenance strategies. The system is so designed that database to be used for any information is common from top to bottom. This ensures transparency and correctness of information produced.

202. TMS Methodology :

The software has been developed in modular fashion in such a way that modules developed in future can be easily integrated into it. Master data of section details, various components of track structure e.g. rail, sleepers, fastenings, ballast, formation, gradient, special features like points and crossings, level crossings, bridges, LWR etc. are entered into the system. Data on condition of various components are also stored and updated by various manual and mechanized inspection data, work data and material change data. TRC & OMS data are electronically transferred in the system while other inspection data are fed manually into TMS. This updates condition data of various components. To avoid duplicate entry of inspection data in registers and TMS, forms have been developed so that officials can record their inspection directly into net books (small laptops) and then upload them into TMS. Works carried out in field by sectional gangs, machines and through special works are also fed into TMS. This updates condition data of various components. Flow Chart depicting TMS linkage is given in *Fig. 2.01.*

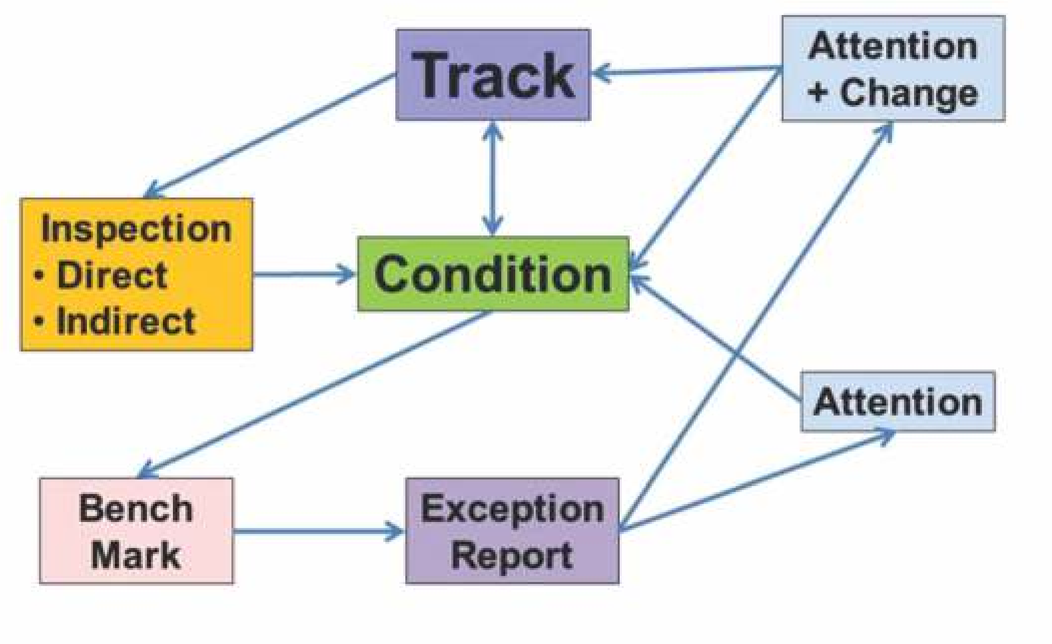


Fig. 2.01: *Track Maintenance and linkage in TMS*

TMS database is quite extensive and includes administrative data comprising information about the Railway network, its administrative organization and information concerning the lines that make up the network, layout data (curves, gradients, switches, L.C. and bridges etc.), operational data (GMT, axle load, speeds), track structure and formation details, geometry measurement data, various inspections and measurement data (ballast condition, rail wear, corrugation, fastening condition, sleeper condition, rail/weld failures), formation data, machine work details, gang work and special work details and speed restriction etc. Using this database, up to date Track diagram is available giving visual representation of all the track components with their exact location and all the characteristics (e.g. types of rails, sleepers and ballast with date of laying and cumulative GMT, etc). In addition, Gang work planning and process of current year and the previous year is also available. History of track maintenance works is maintained in the system.

203. TMS Software Design :

TMS software is web enabled central server based software application developed in J2EE platform. Effort has been made to develop TMS "user-friendly", as a means to overcome implementation problems. To make TMS easy to accept by the users, care has been taken so that the process flow built in TMS corresponds to flow of organizational processes. The name &meaning and the form & format of input and output data items correspond to those of the documents presently used in Indian Railways so that user finds it easy to use. User interface of the TMS is also designed to match user capabilities. User feedback has been evaluated and incorporated into the system. TMS has been designed keeping in focus the functions user performs in track Maintenance activities. TMS has been developed as a web enabled software which can be accessed through internet. This will make it easy for the user to access it. The window has been divided into functions the user has to perform.

Asset tab allows the user to input track asset details which include rail, sleeper, fastening, weld, joint, blanket/ballast, formation, catch water drain, longitudinal drain, switches, switch expansion joint, long welded rail, bridge, level crossing etc.

Inspection tab permits user to record inspection of track geometry, track components and track features. All manual (including USFD) and machine based inspections can be fed into TMS through this function.

Results and various analysis of Track Recording Cars and Oscillation Monitoring Systems are also available.

Location needing inspection/attention provide a tool to the user to assign resources (man & machine) and report compliance.

Details of sectional gang work, special work and machine works can also be fed into the system through different function.

Report tab gives the user opportunity to take out standard reports on TRC results, OMS results, inspection records, track component condition details and track asset details.

204. Input and Output of TMS :

TMS provides various management information report to help management to take decisions. It also provides a decision support system like machine deployment plan etc. It provides tool to identify repeated defect locations and identifying input for its rectification. Various inputs taken and outputs generated by TMS are summarized in the *Table-2.01.*

Table 2.01 – *Input & Output of TMS*

Input	Output
Track structure data i.e. rail, sleeper, fastening, joint, weld, ballast, blanket and formation details.	Track diagram and Assets Register with various reports based on different parameters.
Track Geometry data from TRC and OMS.	Locations needing inspection / attention & various reports based on TRC/OMS results.
Inspection Data.	Locations needing attention/inspection and reports based on various parameters recorded.
Unusual occurrence (Rail fracture, Weld failure).	Standard Reports and various analysis.
USFD Inspection.	Locations needing attention, reports on section due/overdue for testing and other analysis.
Work report data (Sectional Gangs, Machine work and Special Works by Agency).	Track maintenance planning and machine deployment chart.
Data on special features like Points and Crossings, SEJ, Bridges, Level Crossings and their inspection.	Locations needing attention based on various parameters recorded.

205. Various Modules and Reports :

a) TMS Modules

1.	Rail	
2.	Track Type	
3.	Weld	
4.	Sleeper	
5.	Fastening	
6.	SEJ	
7.	LWR	
8.	Points & Crossing	
9.	Curve	
10.	Buffer Rail	
11.	Ballast	
12.	Formation	
	a)	Formation
	b)	Protection Work
	c)	Drainage Work
	d)	Erosion Control Measures
	e)	Weak Formation
	f)	Formation Treatment
13.	Level Crossing	
14.	Land Boundary	
15.	Glued Joint	
16.	Sand Hump	
17.	Fish Plated Joints	
18.	Cross Over/Emergency Crossover	
19.	OHE Mast	
20.	Loop Line/Yard Line/Siding	
21.	Bridge	
22.	Tunnel	
23.	Railway affecting works(RAW)	
24.	Track Spacing	

b) Track Stores Module :

1.	Master	
	a)	Ledger Master
	b)	Opening Balance
2.	Gate Pass	
3.	Issue Note W/O Gate Pass	
4.	DMTR Issue	
5.	DMTR Register	
6.	ART	
	a)	Receipt in ART
	b)	Gate pass from ART
	c)	Issue note W/O Gate pass
	d)	Consume from ART
	e)	Report of Scale & Deficiency
7.	Material/Ledger Transfer	
8.	Ledger Adjustment	
9.	Acknowledge rejected issue note	
10.	Non TMS issue note verification	
11.	Material Identification	
12.	Material Break	
13.	Material Join	
14.	Prepare Adjustment Memo	
15.	Acceptance Adjustment memo	

c) Reports :

	Asset		
1.	a)	Register	
	b)	Pending for confirmation(Asset Change)	
	c)	Pending for forwarding(Asset Change)	
	d)	Reports Asset Change	
	e)	I.	Rail Change
		II.	Sleeper Change

		III.	Ballast Change
		IV.	Fastening Change
	f)	Asset Lock/Unlock Status	
2.	Bridge		
	a)	Inspection Analysis	
	b)	Year Wise All Bridges	
	c)	Component Wise History	
	d)	Bridge Wise History	
	e)	Bridge Wise ORN/URN	
3.	Compliance		
4.	Deep Screening		
5.	Employee		
	a)	Staff Details	
	b)	PME Over Due	
	c)	Training Over due	
6.	Engineering Control		
7.	Engineering Scale Plan / Signal interlocking plan		
8.	Fish Plated Joint Analysis		
9.	Fracture Analysis		
	a)	Keyman wise Fracture Analysis	
	b)	KM wise Fracture Analysis	
	c)	LWR wise Fracture Analysis	
10.	Gang Reports		
	a)	Gang Missing Data Entry	
	b)	Gang Strength	
	c)	Gang Usage	
	d)	Gang Work	
	e)	SE/SSE vs Gang Jurisdiction	
	f)	List of works	
11.	LWR/SEJ		
12.	General Compliance		
13.	Information Dump		

14.	Inspection		
	a)	Inspection Analysis	
	b)	Inspection Chart	
	c)	Inspection Planning	
	d)	Inspection Register	
	e)	Inspection Over due	
	f)	Inspection due	
	g)	Gaps Between Inspection & Confirmation	
	h)	Offline Inspection Analysis	
	i)	Offline Inspection Survey	
	j)	Keyman Inspection	
	k)	Inspection Top sheet	
	l)	Track Machine	
	m)	Small Track Machine	
15.	Joggling analysis (AT Welds)		
16.	Keyman Morning Inspection		
17.	Land		
	a)	Land Management	
	b)	Vacant Land Parcel	
	c)	Way Leave	
		I.	Summary
		II.	Pending/approval Cases
		III.	Case Not Registered
		IV.	Timeline- Analysis – Pending/Approval Cases
		V.	Application Status
		VI.	Search All Cases
		VII.	Complete Application Detail
18.	Location Needing Inspection		
19.	Location Needing Attention		
20.	L. C. Overhauling Analysis		
21.	L.C. Supplementary data		
22.	LWR Destressing		

23.	Master Data Entry Status	
	a)	Bridge
	b)	Data Entry Status
	c)	KM Length/OHE Mast
24.	Material Master	
25.	Material Under Trial	
26.	Monsoon Reserve Report	
27.	Miscellaneous Register	
	a)	Creep Register
	b)	Critical Location
	c)	ERC Toe Load Register
	d)	Gap Survey
	e)	Gradient
	f)	ODC
	g)	Rain Fall
	h)	Speed Restriction
	i)	Temperature
	j)	External Agency Work
	k)	GMT Details
	l)	Circular Viewed
28.	OMS	
29.	OHE Mast	
30.	PCDO	
31.	PME Overdue	
32.	Purchase Order	
33.	Railway Affecting Works	
	a)	RAW Master Analysis
	b)	RAW Manuals
	c)	RAW Manuals zone/state wise
34.	Special Incident	
35.	a)	Special Incidents Analysis
36.	b)	Special Incidents Report

37.	Scrap Reports	
	a)	Scrap Lot Report
	b)	Scrap Summary
38.	Track Diagram	
	a)	Abridged
	b)	Detailed
	c)	Abridged -2
39.	Track Machine	
	a)	Progress Machine Wise
	b)	Progress Detailed
	c)	Progress Summary 1
	d)	Progress Summary 2
	e)	Machine Idle
	f)	Missing Data Entry
	g)	Missing Data Summary
	h)	Progress On Date
	i)	Progress in Mega Block
	j)	Machine: Progress & Availability
	k)	Machine Type Wise
	l)	Machine Utilization
	m)	Night Working
	n)	Progress Target Vs. Actual
	o)	Yearly Summary
	p)	Machine Under Repair
	q)	Tamping Chart
	r)	Machine availability Summary
40.	Track Maintenance Planning	
	a)	Track Degradation Model
	b)	Last Tamping Details
	c)	Due/Overdue Tamping
	d)	Tamping Chart
	e)	Statistics Based On Condition
	f)	Track Health Monitoring

	g)	Rail Analysis
	h)	LWR wise weld input
41.	Track Network	
42.	Technical Suggestion	
43.	Track Statistics	
	a)	Route/Track Kilometer
	b)	Turnout Statistics
44.	TRC	
	a)	TRC Analysis
	b)	TRC Reports
45.	User Analysis	
	a)	Inspection & Work Summary
	b)	Performance Report
	c)	System Usage Analysis
46.	USFD	
	a)	DFWR Analysis
	b)	USFD Defects
	c)	USFD Due/Overdue
	d)	USFD Defect History
	e)	USFD Progress
	f)	USFD Report
	g)	USFD Team Report
	h)	USFD Test Analysis
	i)	USFD Test Free Length
47.	Welder	
	a)	Agency Welder Certificate
	b)	Welder Certificate over Due
	c)	Welding Performance Analysis
48.		Stores
	a)	Stores Register Reports
	b)	Periodic Returns
	c)	Material Master Report
	d)	Release Order List
	e)	Report of scale and deficiency

206. Data Communication :

Data connectivity of users with central server is essential for various data entry, analysis and report viewing. Reliable and efficient communication link is the back bone of the entire scheme for successful adoption. Considering that users are widely spread over entire railway network, internet has been chosen for ensuring data communication from field units to central server. Field units are to be provided with internet connectivity. JE/P.Way is to be provided with mobile data card connectivity. SSE/P.Way, USFD and ADEN are to be provided with land line broadband internet connectivity in office and mobile data card connectivity as well.

- *P.WAY, though looks simple, yet keep a tab on its complex behaviour with the exception reports generated from TMS.*

Chapter 3

Track Recording, Analysis and Monitoring

301. Introduction :

Inspection by foot, trollies, locomotives and rear vehicles enable the Permanent Way staff to carry out assessment of the quality of track. These inspections, though important, are qualitative and enable assessment based on individual experience. Objective assessment of track is done by track recording cars, Oscillograph cars and portable accelerometers.

302. Track Recording Equipment :

The following track recording equipment are in use.

(1) Track Recording Cars

(2) Oscillograph Cars

(3) Portable Accelerometers

303. Track Recording Car :

Track recording cars consist of track parameter measuring and analyzing systems mounted on a passenger coach like ICF, LHB, etc. It records the track parameters while running at maximum permitted speed of the section under loaded condition as distinct from manual measurements done in the floating condition. These cars are run at specified frequency (duration) depending on the maximum permissible speed of the section.

304. Types of Track Recording Cars (TRC) :

(1) Two types of Track Recording Cars, one having Contact type sensors *(Fig. 3.01)* and other having LASER based contactless sensors *(Fig. 3.02)* are used on IR. Contact type sensors called sword sensors are mounted on measuring frame which in turn is mounted on the axles of rear bogie of the coach. In contact less TRC, LASER based sensors are mounted on a sensor beam fixed on the rear bogie of the coach. Both types of TRCs have

computerised recording, storing and analyzing systems. They measure track geometry parameters and report these on user selectable chords ranging from 2 to 20 meter long. Measurement of track profile is chord independent. Chords for reporting are decided by RDSO and they can be selected while programming the TRC. One chord is termed as short chord and other is termed as long chord denoted with suffixed 1 & 2 respectively.

***Fig. 3.01** - Measuring Frame used in contract type TRCs*

***Fig. 3.02** - Optical Assembly used in contactless Type TRCs*

(2) Salient Features of TRCs :

(a) The sampling interval of TRCs is user selectable in the range of 20 to 60 cms.

(b) Both types of Track Recording cars are based on the inertial principle of measurement i.e. unevenness and alignment values are derived and computed from the measurement of acceleration experienced at the coach using accelerometers, rate gyros and displacement/optical transducers duly corrected for other movements. Gauge is measured directly through contact/contactless sensors and twist is derived from cross level/unevenness.

The Speed potential of Contact sensor based TRCs is 100 Km/h whereas for LASER contactless sensor based TRCs it is 160 Km/h

305. Route Data :

Route data of the section comprises of track features and details like the kilometer numbers, kilometer post location, Telegraph post/OHE Mast/Hectometer post location, length of each kilometers, chainages of track features like start of curve, end of curve, points and crossings, level crossings, bridges, ROBs, Tunnels – entry and exit, SEJs etc. These files can be prepared using special equipment like RDPS (Route Data file Preparation System) mounted on trolleys or by TRC run at slow speed. GPS based route data systems are also in use on Indian Railways. A route data file of each route of Indian Railways is to be fed into the track recording cars, which enables automatic reckoning of distances and features. Route data of route to be recorded is uploaded in the TRC. If route data file for a route in not available then manual pressing of each km is to be done during the run. It is however advised as a good practice to press km input at 25-30 kms to enable synchronization till automated synchronization systems are in place.

306. Running of TRC :

(1) Frequency of Track Recording Car Run : The Broad Gauge routes should be monitored by TRC as per the frequency as given in *Table 3.01* (except for the routes where track recording is to be dispensed with) -

***Table 3.01** – Frequency of Track Recording Car Run*

SN	Route	Frequency
(i)	Routes with existing speeds above 130 Km/h	Once in 2 months
(ii)	Routes with existing speeds above 110 Km/h & up to 130 Km/h	Once in 3 months
(iii)	Other Group 'A' and 'B' routes	Once in 4 months
(iv)	Group 'C', 'D' and 'D Spl.' routes	Once in 6 months
(v)	Group 'E' and 'E Spl.' routes	Once in 12 months

(2) Actions to be taken in the event of non-running of Track Recording Car/Oscillograph Car on Rajdhani Route :

(a) If Railway fails to run the TRC within 3 months of the date of the last run, foot plate inspection shall be carried out on Rajdhani Express by Sr.DEN/ Dy.CE nominated by CTE. Report and a certificate will be issued by the officer nominated for the inspection. Based on that CTE will issue an order permitting the continuation of Rajdhani Express at normal speed for the 4th month. A copy of the order will be sent to CRS for information.

(b) If Railway fails to run the TRC within 4 months of the date of the last run, foot plate inspection shall be carried out on Rajdhani Express by SAG officer nominated by PCE. Report and a certificate will be issued by the officer nominated for the inspection. Based on that CTE to issue an order permitting the continuation of Rajdhani Express at normal speed for the 5th month. A copy of the order will be sent to CRS for information.

(c) If Railway fails to run the TRC within 5 months of the date of the last run, foot plate inspection shall be carried out on Rajdhani Express by CTE. Report and a certificate will be issued CTE. Based on that CTE will issue order permitting the continuation of Rajdhani Express at normal speed for the 6th month. A copy of the order will be sent to CRS for information.

(d) In the event of the TRC not being run within 6 months of the date of the last run, the speed on the Rajdhani Route on expiry of 6 months, should be brought down to 110 Km/h but the Rajdhani Express itself should be booked to run at the speed of 100 Km/h only.

307. Measurement & Reporting :

TRC measures the following parameters and reports the results as listed below in *Table 3.02.*

Table 3.02 *- Measurement and Reporting of TRC results*

SN	Parameters measured	Reporting				
		Chords for reporting	For each 200 m stretch (block) of track			For 1 Km of track
1.	Unevenness of Left Rail & Right Rail	3.6m 9.6m	SD values for Left and Right rail on both the chords	Uneven-ness Index	Track Geometry Index	1. Peak exceedances 2. Categorization in A, B, C & D for Short Chords and W, X, Y & Z for Long Chords 3. Values of peaks (defects) for alignment, unevenness, twist and gauge, with distance (location) from start of kilometer
2.	Alignment of Left & Right Rail	3.6m 7.2m	SD values for Left and Right rail on both the chords	Align-ment Index		
3.	Twist	3.6m 4.8m (Base)	SD values for Left and Right rail on both the bases	Twist Index		
4.	Gauge	-	SD | 50m moving average	Gauge Index		
5.	Vertical and lateral accelerations	-	Values exceeding 0.15g or 0.2g for different speeds	Ride Index Values – Vertical and Lateral		Peak (value) of accelerations exceeding threshold limits with distance (location)

308. Desired Values of Peak and Standard Deviation for Good Riding Comfort :

(1) Peak Values :

(a) Track categories for various Parameters – Imperfections in the form of peaks and the magnitude of the peaks are an indication of the extent of the defect. For each track parameter, track should be classified kilometer-wise based on the number of peaks exceeding the pre-defined threshold values occurring in that kilometer. The specified values for different categories specified by RDSO for various parameters are given in *table 3.03* below.

Table 3.03 - *Peak values of defects for A, B, C & D category for Short Chords and W, X, Y and Z for Long chords*

SN	Parameters	Chord	Category	Extent of irregularities
	PEAK VALUES ON SHORT CHORDS			
1.	Unevenness	3.6m	A B C D	0-6 mm (inclusive) 6 mm (exclusive) to 10 mm (inclusive) 10 mm (exclusive) to 15 mm (inclusive) Above 15 mm
2.	Twist	3.6m	A B C D	0.0-5.0 mm on chart (up to and inclusive of 1.4 mm/m) 5.0-7.5 mm on chart (1.4 mm/m to 2.1 mm/m inclusive) 7.5-10.0 mm on chart (2.1 mm/m to 2.8 mm/m inclusive) Above 10.0 mm on chart (above 2.8 mm/m)
3.	Alignment	7.2 m	A B C	Up to 3 mm versine (inclusive) More than 3 mm and less than 5 mm versine (inclusive) 5 mm versine and above
4.	Gauge	-	A B C	Up to and + 3 mm (inclusive) ±3 mm to & + 6 mm (inclusive) Above ± 6 mm
	PEAK VALUES ON LONG CHORDS			
1.	Unevenness	9.6m	W X Y Z	0-10 mm (inclusive) 10 mm (exclusive) to 15 mm (inclusive) 15 mm (exclusive) to 20 mm (inclusive) Above 20 mm
			W	0.0-7.0 mm on chart (up to and inclusive of 1.5 mm/m)
2.	Twist	4.8m	X Y Z	7.0 -12.0 mm on chart (1.5 mm/m to 2.5 mm/m inclusive) 12.0-15.0 mm on chart (2.5 mm/m to 3.1 mm/m inclusive) Above 15.0 mm on chart (above 3.1 mm/m)
3.	Alignment	9.6m	W X Y	Up to 10 mm versine (inclusive) More than 10 mm and less than 14 mm versine (inclusive) More than 14 mm and less than 20 mm versine
4.	Gauge	-	Same as in Short Chord being chord independent	

Note:(i) 10 peaks exceeding the outer limit of an irregularity under each category is allowed in 1 Km. length of track. If more than 10 peaks in one Km. cross the outer limits of 'A' category the kilometer is classified 'B' and so on. Based on the number of peaks and extent of irregularity the track is classified into 'A', 'B', 'C', and 'D' categories separately for each parameter, gauge, twist, unevenness and alignment.

(ii) The number of peaks in each kilometer exceeding the outer limit for the 'B' category is indicated as a suffix as seen in the results of TRC.

(b) Peak values for speed above 100 Km/h and up to 140 Km/h – The following limits of track tolerances are prescribed for the guidance of the Engineering officials on the suitability* of standard of maintenance of track for sanctioned speeds above 100 Km/h and up to 140 km/h on BG track.

(i) Alignment defects - (versine measured on a chord of 7.5 meters under floating conditions)

On Straight Track - 5mm; values up to 10mm could be tolerated at few isolated locations**.

On Curves- ± 5mm over the average versine, Values up to ±7mm could be tolerated at few isolated locations**. Total change of versine from chord to chord should not exceed 10mm.

(ii) Cross Level Defects - No special tolerance limits. As regards cross levels, the track should be maintained, to standards generally superior to that at present available on main line track on which unrestricted speeds up to 100 Km/h are permitted.

(iii) Twist- (to be measured on a base of 3.5 m)

On straight and curve track, other than on transitions - 2mm/meter except that at isolated locations**, this may go up to 3.5mm/m.

On transitions of curves – Local defects should not exceed 1mm/meters, except that at isolated locations** this may go up to 2.1 mm per meter.

(iv) Unevenness rail joint depressions (versine measured on a chord of 3.5m) - 10mm in general and 15mm for isolated locations**.

(v) Gauge variations - No special specifications. The maximum limits for tight and slack gauge should be as indicated in *chapter 4 (409 (2) (e) (v))*

(*) Suitability refers to good riding quality for passenger comfort and not from stability point of view.

(**) In above `few isolated locations' has been taken as not exceeding 10 per km.

(2) SD Values :

Values of SD specified by RDSO for new track, track requiring planned maintenance (also called priority-II values) and track requiring early maintenance (also called priority-I values) for 2 speed bands; i.e. for speed up to 110 Km/h and for speed greater than 110 but less than and equal to 130 Km/h are given in *Table 3.04.*

Table 3.04 – *SD Values for Priority I, Priority II and New Track (all SD values in mm)*

Parameter	Chord/ Base (M)	SD value for new track	Upto 110 KM/H		>110<=130 KM/H	
			SD-Priority II	SD-Priority I	SD-Priority II	SD-Priority I
Unevenness	3.6	1.20	2.5	3.3	2.3	3.0
	9.6	2.50	6.5	7.4	5.1	6.2
Twist	3.6	1.75	3.8	4.2	3.4	3.8
	4.8		4.2	5.0	3.8	4.5
Alignment	7.2	1.5	2.7	3.8	2.3	3.0
	9.6		5.0	6.3	3.3	4.0
Gauge	-	1.0	2.5	3.6	1.8	2.6

(3) Calculation of parameter wise Indices and TGI – Using the measured values of standard deviation and the SD values in *Table 3.04* above, the value of four indices viz. Unevenness Index (UNI), Alignment Index (ALI), Twist Index (TWI), Gauge Index (GI) and the Track Geometry Index (TGI) for each block

of 200 m is computed as explained below. For computing these four Indices for each block of 200 m of track following measured SD values are considered.

(a) SD values of unevenness for left and right rail on long chord of 9.6 m

(b) SD values of alignment for left and right rail on short chord of 7.2 m

(c) SD value of twist on short base 3.6 m

(d) SD value of gauge

$$Unevenness\ Index\ (UI) = 100 * e^{-\frac{(SDUm-SDUr)}{(SDUur\ -SDUr)}}$$

$$Twist\ Index\ (TWI) = 100 * e^{-\frac{(SDTm-SDTr)}{(SDTur\ -SDTr)}}$$

$$Gauge\ Index\ (GI) = 100 * e^{-\frac{(SDGm-SDGr)}{(SDGur\ -SDGr)}}$$

$$Alignment\ Index\ (ALI) = 100 * e^{-\frac{(SDAm-SDAr)}{(SDAur\ -SDAr)}}$$

$$Track\ Geometry\ Index\ (TGI) = \frac{(2UNI + TWI + GI + 6ALI)}{10}$$

SDUm = (SDU2L + SDU2R)/2

SDU2L & SDU2R = Measured SD value of Unevenness – left & right rail respectively on 9.6 m chord

SDTm = Measured SD value of twist on base of 3.6 m

SDGm = Measured SD value of gauge

SDAm = (SDA1L + SDA1R)/2

SDA1L & SDA1R = Measured SD value of alignment of left & right rail respectively on 7.2 m chord

SDUur = SD prescribed for unevenness – priority I values for 9.6 m chord in *Table 3.04*

SDUr = SD prescribed for new track for unevenness at 9.6 m chord in *Table 3.04*

SDTur = SD prescribed for twist – priority I values for 3.6 m base in *Table 3.04*

SDTr = SD prescribed for new track for twist for base of 3.6 m in *Table 3.04*

SDGur = SD prescribed for gauge – priority I values in *Table 3.04*

SDGr = SD prescribed for new track for gauge in *Table 3.04*

SDAur = SD prescribed for alignment – priority I values for 7.2 m chord in *Table 3.04*

SDAr = SD prescribed for new track for alignment on 7.2 m chord in *Table 3.04*

$$TGI\ for\ a\ KM = \frac{Sum\ of\ TGI\ for\ all\ blocks\ in\ a\ KM}{No.of\ Blocks\ in\ a\ KM}$$

TGI of a specified length of track can be calculated by taking arithmetical average of TGI values for each of the kilometers of specified length.

(4) Tolerances for good riding comfort – The stability of trains against derailment depend upon several factors such as track geometry, vehicle characteristics & state of their maintenance and speed of the particular vehicle at relevant point of time etc. Rail wheel interaction is thus, a complex phenomenon and therefore, safety tolerances for track alone cannot be prescribed in isolation. With this in view, safety tolerances for maintenance of track have not been prescribed on Indian Railways. Each derailment case, therefore, needs careful examination of all available evidence, in respect of track, rolling stock, speed and other factors considered relevant, to arrive at the cause. The provision and tolerances mentioned in *Para 308(1) (a) & (b) and 308(3)* above and elsewhere are with a view to maintain track geometry for good riding comfort.

309. Arrangements for Running Track Recording Car :

(1) The monthly program for running of TRCs on various zonal railways is issued by RDSO, 3 to 4 weeks in advance. On receipt of track recording car programme from the RDSO, the Zonal Railways should intimate all concerned including the operating department to arrange for suitable power and path for the TRC Special along with telecommunication arrangement between the track recording car and the locomotive. Engineering Branch of concerned Zonal railway will place requirement of suitable power and through path to ensure recording of longest possible length at maximum permissible speed of the section. Operating branch shall provide power and run through path in daylight hours. The Headquarters should also advise the Divisions concerned for making necessary arrangements to ensure that the Track Recording Car has an uninterrupted run.

(2) HSD Oil for the generators of these recording specials will be arranged by Engineering Department (Division) as per requirement given by RDSO in advance.

(3) The nominated Sr.DEN/DEN at the Divisional HQ shall ensure that there is proper liaison in the Control office to ensure power and path for the monitoring special.

310. Actual Running of Track Recording Car :

(1) Following officials should accompany the TRC run:

(a) HQ – officer nominated by CTE

(b) Division – Sectional Sr.DEN/ AEN and SSE/JE (P.Way)

(2) The maximum recording speed of contact sensor based TRC is 100 Km/h and of LASER contact less sensors based TRC is 160 Km/h. Measurement of Track recording is independent of speed above a minimum prescribed speed. Thus the Divisional/Headquarters Officers accompanying the special should ensure that the Track Recording Cars are run at the maximum speed of Section/TRC. The recording done below prescribed lower limit of speeds is taken as "Non-recorded". The TRC Special must run on through lines of all stations. Recording should be done during day light hours. Before start of any run it should be ensured that the calibration of the car has been done satisfactorily. TRC staff is required to provide the recording data in the soft format to the accompanying division/HQ officials. Divisional official shall upload the data in TMS. The printout of results should also be taken at the end of days recording for record.

311. Action to be taken on Track Recording Charts Results :

Spots (locations) requiring immediate attention, indicated by large peaks should be noted down by the ADEN, JE/SSE (P.Way) accompanying the car and immediate attention should be given to these kms without loss of time. Track Recording results and charts should be analyzed as detailed in Para 312 and track classified into various categories as detailed in Para 308. A comparison of the records of each section with the previous run should be made and details of locations needing attention is to be done by the divisions as well at HQ and use it in taking maintenance decisions including deployment of track machines. Special attention should be paid to analyse the root cause for the location(s) where irregularities are high and where the defects are reappearing in successive recording runs. Suitable action shall be taken to eliminate the cause(s).

312. Analysis of Results of TRC :

(1) Analysis of Track Recording results should be carried out within a weeks' time; in the track cell of Sr.DEN's office as well as Chief Engineer's Office using software like TMS or the offline software provided by the RDSO. Various reports can be seen in TMS, once the raw data file is loaded by the division. Though different kinds of reports are generated for the two types of TRCs, but the recording report gives following basic results

(a) SD based Results

(i) Standard deviation values for 200 m block for 4 parameters (Gauge, alignment, unevenness and twist) on two pre-decided chords

(ii) 50 m moving average gauge value for each block of 200 m

(iii) Indices for 4 parameters viz. unevenness, alignment, twist and gauge for each block of 200 m

(iv) Track geometry Index for 200 m block and each km

(v) Ride Index value – lateral and vertical for each 200 m block

(vi) Maintenance Instruction for blocks requiring priority and planned maintenance

(b) Peak based Results

(i) Number of peaks exceeding A, B, C and D limits for short chords and W, X Y and Z limits for long chords for four parameters viz. unevenness, alignment, twist and gauge in each km length

(ii) Categorization in alpha numeric form for each km length

(iii) Non-compliance of track for parameters specified in para 308 (1) (b) for four parameters for each km

(iv) Peak distribution – Peaks (defects) for 4 parameters for short chords as well as long chords exceeding pre-set limits with location (distance) of the defect

(v) Peak (defects) for vertical and lateral acceleration exceeding pre-set limits

(2) All the basic results listed in *para 312 (1) above*, peak based and SD based, are printed on one A4 size sheet for each Km; for the contact type TRC, the sample of which is attached in *Annexure – 3/1*. In addition summary reports, comparison of runs and exception reports can also be generated using offline software supplied by the manufacturer of the TRC.

(3) For the contact less TRC, following types of reports are generated using off line software

   (a) Various summary reports of track recording results;

   (b) Exception report of peaks for attending isolated defects and for blocks requiring planned or urgent maintenance;

   (c) Block and kilometer wise comparison of current recording with previous recording.

(4) The formats for the report are given in the operations manual of the TRC system. These are reproduced in *Annexure–3/2* for ready reference.

313. Monitoring of the Riding Quality of Track :

While the track recording cars can record the track geometry and thus track defects, the Oscillograph car and the portable accelerometers record vertical and lateral accelerations, which are the more direct measure of riding quality and comfort.

314. Oscillograph Car :

(1) Brief Description of the Car – The main equipment in this car is an accelerometer; Accelerometers being used are of MEMS based accelerometers. The acceleration is recorded in the form of digital data recording. Thus the vertical and lateral accelerometer measure accelerations on any part of the vehicle where the accelerometer is installed. In track monitoring runs the accelerations at the loco cab floor are recorded by keeping the accelerometer as close to the bogie pivot as possible.

(2) Details of recording – The following parameters are recorded in the oscillograph car runs-

   (a) Vertical acceleration of loco cab and coach floor near pivot.

   (b) Lateral acceleration of loco cab and coach floor near pivot.

(3) Frequency of Recording – On BG routes Oscillograph cars are used to monitor all "A" routes. These cars run once in six months to assess the riding quality of the track as distinct from actual track geometry recorded by the Track Recording Cars. Recording is done at the maximum sanctioned speed of the section.

315. Analysis of Data and Interpretation of Results :

(1) The data obtained from the oscillograph car are analyzed for the vertical and lateral acceleration.

(2) The analysis of records is done by counting the vertical and lateral accelerations above the threshold values separately. Threshold value of acceleration may be taken as follows.

(a) In Loco Cab floor –

(i) The threshold value of acceleration in vertical mode is taken as 0.20g for all locos (Diesel and Electric).

(ii) The threshold value of acceleration in lateral mode is taken as 0.20g for diesel and electric locos with double stage suspension (i.e. for WDP4, WDP4D, WDP4B, WAP1, WAP4 WAP7 and WAP5). In case of other locos, with single stage suspension the threshold value may be taken as 0.30g.

(b) On Passenger Coach Floor – The threshold value of acceleration for both vertical and lateral modes shall be taken as 0.15g.

(3) The analysis is done kilometer-wise and results are given under the following heads after counting the peaks above threshold value for the particular locomotive -

(a) KM wise indicating all the events like station yard, level crossing, curves, and hard spots like culvert, bridges etc.

(b) Speed grouping table is also prepared.

(c) Typical Statement prepared in connection with an Oscillograph run is given below (Statement 'A' & 'B') – *Table 3.05 and 3.06* respectively.

Table 3.05 *Oscillograph Results – Peaks above Threshold Values*

STATEMENT A

OSCILLOGRAPH RESULTS

Peaks above Threshold Value

Section	KM	Max Vertical Acceleration (g)	Max Lateral Acceleration (g)
Chennai - Vijayawada	32-33	0.383	-
	78-79	0.395	-
	86-87	0.401	-
	128-129	0.376	-
	139-140	0.38	-

***Table 3.06** Oscillograph Results – Active Continuous Stretches*

STATEMENT B

OSCILLOGRAPH RESULTS

Section: PWL-MTJ Instrumented Loco No.22569

Date of Run: 09-04-2010

Km	Km	SPEED KM/H	Loco No. WAP4-22569												Remarks
			Vertical Accelerations						Lateral Accelerations						
			0.15 <= 0.20	0.20 <= 0.25	0.25 <= 0.30	0.30 <= 0.35	> 0.35	Max "g"	0.15 <= 0.20	0.20 <= 0.25	0.25 <= 0.30	0.30 <= 0.35	> 0.35	Max "g"	
1479	1478	120	0	0	0	0	0	0.072	0	0	0	0	0	0.084	CT, CT
1478	1477	NR						NR						NR	
1477	1476	125	1	0	0	0	0	0.16	0	0	0	0	0	0.138	CT, XL
1476	1475	115	0	0	0	0	0	0.092	1	0	0	0	0	0.165	YY, CT

316. Use of Oscillograph Car Recordings :

(1) Threshold values of acceleration are given in *Para 315 (2) (b).* For ensuring good riding, track should be attended to at such locations where peaks above threshold values are noticed.

(2) Efforts should be made not only to check the extent of defect but also to find out whether it is occurring in an active patch; as such condition may lead to excessive oscillations.

317. Portable Accelerometers

(1) At present Indian Railways are using three types of OMS i.e. portable Oscillation monitoring system (OMS-2000), PC based OMS & Microcontroller based OMS to monitor the track condition and riding behavior of coaches.

(2) Accelerometer unit consists of two accelerometers for measurement of vertical & lateral accelerations and is kept in the cabin of locomotive or on the coach floor, as close to the bogie pivots as possible. It is preferable that same coach and the same vehicular position are used in successive runs. The measured accelerations are stored in the OMS memory and displayed on LCD display on real time basis. The stored data can be downloaded on TMS Computer for maintenance planning.

(3) This equipment measures the track performance by measurement of vehicles response in terms of vertical and lateral accelerations. The real time

output of the equipment is in the form of value of peaks exceeding the limiting value, their location and Ride index. These values are available for both vertical and lateral accelerations.

(4) Frequency of Recording :

(a) Broad Gauge

(i) For speeds above 100 Km/h – once every month

(ii) Others – once in two months

(b) Meter Gauge

(i) Speed above 75 Km/h – once every month

(ii) Others – once in two months

(5) The above schedule is only a guideline. Chief Engineers may vary it, depending upon the availability of instruments and its use. For the time being, A, B and C routes are to be covered once a month and other routes can be covered as per recording capacity and need.

(6) Recording and speed of run :

(a) Accelerometer recording should be done by putting the accelerometer over the rear pivot location of the nominated recording cum inspection coach for engineering department. This should be generally run with a separate locomotive or in exceptional circumstances attached with the fastest daytime train of the section. If it is not possible to do OMS run using a special coach, it can be placed on the pre-decided pivot (for the purpose of comparison) of the locomotive or rearmost vehicle of the fastest daytime train of the section

(b) Though accelerometer run is required to be done at the maximum permissible speed of the section, certain minimum recording speed is necessary to get meaningful results. Minimum recording speed for different routes is as below and recording done at the lower speed shall be treated as non-recorded:

(i) Broad Gauge

- “A” Routes Less than 75 Km/h
- “B” Routes Less than 65 Km/h
- Other Routes Less than 75% of maximum speed or 60 Km/h, whichever is less

(ii) Meter Gauge

- "Q" Routes Less than 60 Km/h
- Other Routes Less than 55 Km/h

(7) Recording of Defects – To assess the track quality, vertical and lateral acceleration peaks exceeding the values as below are to be considered.

(i) Broad Gauge

- High Speed Routes above 110 Km/h (on A & B routes) : Greater than 0.15 g
- Other routes up to 110 Km/h : Greater than 0.20 g

(ii) Metre Gauge

- All Routes : Greater than 0.20 g

(8) Classification of Track Quality – To Classify a continuous section's (SSE (P.Way) jurisdiction/sub division/division) track quality, the criteria used is average total number of peaks per km.

Speed Band	Very Good	Good	Average
High Speed	Less than 1.0	1-2	Greater than 2
Others	Less than 1.5	1.5-3.0	Greater than 3

The above criteria are for judging the quality of track. However, if the average number of peaks of vertical and lateral accelerations exceeding 0.30 g is more than 0.25 per km or more than one in any particular kilometer, the track will need attention. At locations where peaks of lateral and vertical accelerations exceed 0.35g, the track will have to be attended to urgently.

Annexure 3/1 (Para 312 (2))
TRC Result for One km

TRACK RECORDING RESULTS (CHORD MODE) ROUTE CODE : 1786 DATE 22/8/2008 RUN NO :c KM : 8 To 9

LOC	SHORT CHORD UN1L	UN1R	TW1	G	AL1L	AL1R	AVG-G	RIDE INDEX RIV	RIL	TRACK INDICES GP/TGI	SPD	MI	LONG CHORD UN2L	UN2R	AL2L	AL2R	TW2	PARAMETER WISE INDICES UNI	TWI	GI	ALI
Blk 1	2.4	2.2	3.2	1.0	3.6	3.4	1.8	2.17	2.15	55	33	**	4.5	4.0	5.4	5.1	3.5	70	55	100	42
Blk 2	2.2	2.6	4.3	1.1	2.0	1.9	2.0	2.77	2.49	73	47	***	5.2	5.6	2.8	2.7	4.6	55	35	96	82
Blk 3	1.8	2.2	3.4	1.0	1.9	2.0	2.0	3.74	2.64	78	58		3.9	4.7	2.7	2.9	3.7	69	51	100	82
Blk 4	1.9	1.8	3.2	1.9	3.0	1.9	0.5	2.74	2.99	68	63	**	3.2	3.9	3.8	2.6	3.4	81	55	71	66
Blk 5	3.0	2.8	4.4	2.0	2.5	2.6	2.5	3.18	3.01	57	66	***	6.5	6.1	3.6	3.8	4.8	46	34	68	63
1007											KM										

PEAK DISTRIBUTION

BAND	SHORT CHORD UN1L	UN1R	TW1	G	AL1L	AL1R	BAND	LONG CHORD UN2L	UN2R	AL2L	AL2R	TW2	BAND	IRPWM - 607 UN1L	UN1R	TW1	G	AL1L	AL1R
A	13	22	59	11	56	55	W	20	27	7	6	35	> LL <= HL	2	2	22	9	19	13
B	2	2	32	2	22	13	X	4	4	3	0	8	> HL	0	0	10	2	3	0
C	0	0	15	0	8	6	Y	1	0	0	0	2	Concrd			#	#	#	#
D	0	0	2	0	2	0	Z	0	0	0	0	0							

CATEGORY INFORMATION

B2 B2 D32 B2 C22 C13 TGI 66 Avg.Speed 53 KMPH

PEAK INFORMATION

UN1L	-10/655	-15/951	11/953															
UN1R	-12/280	10/282	-11/350	-10/828														
TW1																		
AL1L	-11/58	-14/669	13/673															
AL1R	8/38	8/58	-8/70	-9/123	-8/236	8/808												
G																		
UN2L	12/47	10/99	-10/104	-12/165	13/169	-13/174	-11/240	14/244	-17/296	14/301	13/386	10/413	10/442	-10/446	-10/484	-11/658	10/669	13/843
	11/900	-15/925	14/930	-17/934	18/939	15/946	-21/954	12/958	-12/963									
UN2R	10/94	-10/130	11/169	-12/221	16/226	-11/232	-11/240	12/244	-11/283	10/288	-18/296	-14/353	10/358	-10/420	-13/432	-11/446	-11/474	11/479
	-10/484	11/488	10/607	-14/659	13/663	10/789	-10/820	13/826	-17/831	-14/925	13/930	-12/934	18/939	-11/943	12/947	-13/952	-13/998	15/1004
TW2	19/221	18/1000																
AL2L																		
AL2R																		
VACC																		
LACC	-0.20/435	0.20/442	-0.20/448	0.20/455	-0.20/462													

Annexure 3/2 (Para 312 (4))

Summary, exception and comparison reports of contactless TRC
Report 1 and 2–index of track recording results
km wise summary & TGZ summary respectively

SUMMARY REPORT – INDEX OF TRACK RECORDING RESULTS – Printed on – 03-21-06 10:45:21

TRC No.	:	7968	Railway	:	CR
Run No.	:	140325b	Direction	:	UP
Section	:	NGP-ET		:	
Km	:	1042 to 1031	Run Date	:	03-25-2014

SN	KM		PARAMETER WISE INDEX				CTR	TGI	TQI	SPEED
	From	To	UI	TI	AI	GI				
1.	1042	1041	61	36	86	69	-28	74	139	87
2.	1041	1040	67	43	79	73	-21	72	143	84
Section Average			64.00	39.50	82.50	71.00	-24.50	73.00	141.00	

NR SUMMARY

TOTAL KMs	12
TOTAL NR KMs	2
TOTAL Recorded KMs	10

TGI SUMMARY

		No. of KMs	% of Recorded Kms
1	KMs with TGI (>=80)	1	10
2.	KMs with TGI (50 to 80)	9	90
3.	KMs with TGI (36 to 50)	0	0
4.	KMs with TGI (<36)	0	0

Report 3 and 4–Category of track recording results with summary and only summary respectively

SUMMARY REPORT – INDEX OF TRACK RECORDING RESULTS - Printed on – 03-21-06 10:45:21

TRC No.	:	7968	Railway	:	CR
Run No.	:	140325b	Direction	:	UP
Section	:	NGP-ET		:	
Km	:	1042 to 1031	Run Date	:	03-25-2014

SN	KM		PARA METER WISE CATEGORY OF TRACK						CTR	TGI	TQI	SPEED
	From	To	UNL	UNR	TW	G	ALL	ALR				
1.	1042	1041	A1	A3	C11	C26	C30	C23	-35	89	70	87
2.	1041	1040	A2	A0	B12	C28	C13	C18	-27	98	67	84
Section Average				`								

NR SUMMARY

TOTAL KMs	9
TOTAL NR KMs	1
TOTAL Recorded KMs	8

TGI SUMMARY

		UNEVENESS		TWIST		GAUGE		ALIGNMNET	
		No. of KMs	%age	No. of KMs	%age	No. of KMs	%age	No. of KMs	%age
1.	KMs in Category A	8	100	3	38	2	25	0	0
2.	KMs in Category B	0		4	50	5	63	4	50
3.	KMs in Category C	0		1	12	1	12	4	50
4.	KMs in Category D	0		0	0	0	0	0	0

Report 5 and 6 – Analysis with respect to para 308 (1) (b) with summary & only summary respectively

SUMMARY REPORT – INDEX OF TRACK RECORDING RESULTS
Printed on – 03-21-06 10:45:21

TRC No.	:	7968	Railway	:	CR
Run No.	:	140325b	Direction	:	UP
Section	:	NGP-ET		:	
Km	:	1042 to 1031	Run Date	:	03-25-2014

SN	KM		UNEVENNESS		TWIST		GAUGE		ALIGNMENT	
	From	To	> 10 <= 15mm	>15 mm	>7<=12 mm	>12mm	>3<=6 mm	>6mm	>5<=10 mm	>10mm
1.	1042	1041	# 12	# 1	5	0	0	0	10	# 2
2.	1041	1040	#15	0	7	# 1	0	0	#11	0

Section Summary

UN Peak > 10 mm <= 15 mm	=	5	(Km)
UN Peak > 15 mm	=	4	(Km)
TW Peak > 7.00 mm <= 12.00 mm	=	6	(Km)
TW Peak > 12.00 mm	=	4	(Km)
G Peak > 3 mm <= 6 mm	=	0	(Km)
G Peak > 15.00 mm	=	0	(Km)
AL Peak > 5.00 mm <= 10.00 mm	=	5	(Km)
AL Peak > 10.00 mm	=	4	(Km)

TOTAL KM RECORDED	=	10	
UN Peak	=	5	(50.00%)
TW Peak	=	6	(70.00%)
G Peak	=	0	(0.00%)
AL Peak	=	5	(100.00%)
TOTAL (AFTER ACOUNTING FOR COMMON KM)	=	7	(70.00%)

Report 7 – Exception Report of Peaks Exceeding the “A” Limits (Short Chord) for Attending Isolated Defects

EXCEPTION REPORT OF PEAKS EXCEEDING THE “A” LIMITS (SHORT CHORD) FOR ATTENDING ISOLATED DEFECTS
(PRINTED ON 2015/03/12 14:47)

TRC No.	:	7968	RAILWAY	:	CR
RUN NUMBER	:	140325b	DIRECTION	:	UP
SECTION	:	NGP-ET	Run Date	:	3/25/2014 8:45:07 AM
KM	:	1243 to 1241			

KM		Para-meter	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist
From	To																					
1243	1242	UNL	-10	576	-8	453	-7	768	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1243	1242	UNR	-12	456	-11	356	-9	777	-8	657	7	786	-6	678	6	555	-5	078	5	587	5	734
1243	1242	TW	-17	205	15	286	-13	048	12	786	12	987	-10	365	9	289	-9	567	7	328	6	105
1243	1242	ALL	-7	435	7	453	6	070	-6	456	6	675	6	790	-5	345	-5	657	5	876	4	254
1243	1242	ALR	8	342	8	564	-6	676	6	768	5	567	-5	678	5	802	5	987	5	1024	4	567
1243	1242	G	-6	956	-5	345	5	564	-4	567	4	678	4	865	-	-	-	-	-	-	-	-
1242	1241	UNL																				
1242	1241	UNR																				
1242	1241	TW																				
1242	1241	ALL																				
1242	1241	ALR																				
1242	1241	G																				

RESULTS GIVEN FOR NEXT 1 KM AND SO ON

Report 8 – Exception Report of Peaks Exceeding the “W” Limits (Long Chord) for Attending Isolated Defects

EXCEPTION REPORT OF PEAKS EXCEEDING THE “A” LIMITS (SHORT CHORD) FOR ATTENDING ISOLATED DEFECTS
(PRINTED ON 2015/03/12 14:47)

TRC No.	:	7968	RAILWAY	:	CR
RUN NUMBER	:	140325b	DIRECTION	:	UP
SECTION	:	NGP-ET	Run Date	:	3/25/2014 8:45:07 AM
KM	:	1243 to 1241			

KM		Parameter	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist	Peak	Dist
From	To																					
1243	1242	UNL	-16	576	-15	453	-14	768	13	487	-13	567	12	656	11	088	-11	234	11	678	11	865
1243	1242	UNR	-18	456	-17	356	-15	777	-16	657	15	786	-14	678	14	555	-13	078	13	587	12	734
1243	1242	TW	-25	205	23	286	-21	048	20	786	20	987	-18	365	17	289	-14	567	13	328	13	105
1243	1242	ALL	-12	435	12	453	11	070	-11	456	-10	786	10	879	8	345	-8	657	8	876	8	254
1243	1242	ALR	13	342	13	564	-12	676	12	768	11	567	-11	678	11	802	10	987	9	1024	7	567
1242	1241	UNL	RESULTS GIVEN FOR NEXT 1 KM AND SO ON																			
1242	1241	UNR																				
1242	1241	TW																				
1242	1241	ALL																				
1242	1241	ALR																				

(Para 312 (2))

Report 9 –Exception report for blocks requiring planned or urgent maintenance (Chord mode)

TRC No.	:	7968	RAILWAY	:	CR
RUN NUMBER	:	140325b	DIRECTION	:	UP
SECTION		NGP-ET			
KM	:	1042 to 1031	Run Date	:	3/25/2014 8:45:07 AM

KM		Block No.	SPEED	Adjusted value of SD												
				On short Chord						On Long Chord					Max Value	TGI
From	To			UL1	UR1	TW1	GA	AL1	AR1	UL2	UR2	AL2	AR2	TW2		
1042	1041	2	67	0.67	0.80	1.69	1.69	1.60	1.43	1.32	1.10	1.70	1.46	1.76	1.76	20
1042	1041	5	77	0.63	0.60	1.34	0.88	0.90	0.83	0.84	0.89	0.84	0.85	1.27	1.34	46

Report 10 – Block Wise Comparison of Current Recording with Previous Recordings

BLOCK WISE COMPARISON OF CURRENT RECORDING WITH PREVIOUS RECORDINGS																					
(PRINTED ON – 9/4/2014 12:46:33 PM)																					
TRC No.		:	7968																		
KM		BLK	Run No.: 140303e Section NGP-ET Date 2014/03/03							Run No.: 150303d Section NGP-ET Date 2015/03/03							PERCENTAGE IMPROEMENT OR DETERIORATION					
From	To		SPD	UI	TI	GI	AI	TGI	TQI	SPD	UI	TI	GI	AI	TGI	TQI	UI	TI	GI	AI	TGI	TQI
1340	1341	1	76	98	65	110	85	88	61	81	88	70	105	95	92	57	-10.20	7.69	4.55	11.76	4.55	6.56
1340	1341	2																				
1340	1341	3																				
1340	1341	4																				
1340	1341	5																				
1341	1342	1																				

Report 11 – Kilometer Wise Comparison of Current Recording with Previous Recording

KILOMETER WISE COMPARISON OF CURRENT RECORDING WITH PREVIOUS RECORDING						
(PRINTED ON – 9/4/2014 12:47:25 PM)						
TRC No.	: 7968					
KM		Run No.: 140303e Section NGP-ET Date 2014/03/03		Run No.: 150303d Section NGP-ET Date 2015/03/03		% IMPROVEMENT OR DETERIORATION OF TGI
From	To	SPEED	TGI	SPEED	TGI	
1390	1391	95	88	111	95	7.95

Report 12 – PWI/ADEN/DEN/SR.DEN or SECTION Wise Summary of TRC Results

PWI/ADEN/DEN/Sr.DEN WISE SUMMARY OF TRC RESULTS – PRINTED ON – 9/4/2014 12:32:31 PM													
TRC No.		7968						Generic Section			NGP-ET		
Section	Line	Date	From	To	UI	TI	AI	GI	TGI	TQI	CTR	% BUM	% BPM
NGP-ET	UP	9.04.2014	1041	1010	72	38	75	65	70	132	-64	59.65	31.58

- *Keep monitoring the health of P.WAY, for timely treatment of variation in vital parameters.*

Chapter 4

Regular Track Maintenance

401. Mechanised Track Maintenance:

For regular track maintenance of track consisting of concrete sleepers normally heavy on track machines should be deployed irrespective of being maintained under three tier system or otherwise.

402. Systematic Packing of Track by on Track Machines:

(1) General:

(a) Systematic regular maintenance tamping of track by heavy “on track machines”, requiring traffic blocks, should be planned for long continuous stretch based on periodicity stipulated as per *para (403)* below.

(b) An annual track machine deployment programme shall be drawn by zonal railway and circulated to the divisions before the beginning of the year. (During March, for next financial year beginning from April.)

(c) As far as possible a group of machines should be worked together in the same block section to make effective use of line block.

(2) Line Blocks and Engineering Time Allowance:

(a) The block time should be indicated in the master chart for time-tabled trains. This master chart should be updated/prepared with every change in time-table.

(b) It is desirable that these machines be given a single block of at least 4 hours per day or two separate blocks of 2½ hours each, for better output.

(c) On the double line section, temporary single line working may be introduced, for maximizing availability of block.

(d) Wherever required, for carrying out major works of maintenance/

rehabilitation of assets in double line sections, advance planning for provisions of mega blocks by conversion of double line into temporary single line with suitable modifications to signalling system for pre- decided number of days should be made by zonal railway.

(e) Diversion of some trains on alternative routes may also be resorted to, wherever possible. For this purpose it is desirable to frame annual machine deployment programme in consultation with the Operating Department.

` (f) The provision for necessary time allowance, for introduction of temporary single line working and/or diversion/regulation of trains should also be made in the working time table.

(g) Usage of traffic block should be maximized by planning other works (including bridge inspection and maintenance needing traffic blocks) in the shadow of same block in same and adjacent division/railway. The other infrastructure departments (S&T and Electrical department) may also be advised for planning and undertaking works during the same/shadow blocks.

(3) Pre-Requisites for Introduction of Tamping Machines:

(a) For undertaking regular through maintenance tamping of track including turnouts), advance planning and fulfilment of pre- requisite are necessary to ensure high quality work and increased retentivity of packing. For this purpose action, as mentioned below, shall be taken and a detailed project report prepared duly incorporating location specific needs, for undertaking time consuming and resource intensive structural improvement works.

(b) A field survey should be carried out to :

(i) Determine existing profile of track as per guidelines given in *Annexture 4/1* to calculate the extent of lifting required.

(ii) Availability of clean and total ballast cushion to access ballast requirement duly assessing lifting required.

(iii) Take census of hogged and battered joints, which may require large scale end cropping etc.

(iv) Take census of Broken and damaged sleeper on plain track as well as in turnouts needing large-scale replacement.

(v) To make assessment of large-scale cess repairs and major drainage improvement works. (including yard drainage)

(c) The proposed track profile should be designed as per the guidelines given in *Annexure 4/1,* and as per provisions of *Schedule of Dimensions-2004*

(d) A minimum clean ballast cushion of 150 mm below the bottom of the sleepers, at rail seat location, is recommended for quality output and retentivity of packing by the tamping machines. For new line, doubling, gauge conversion etc. the total (clean) cushion before undertaking tamping by machine should be at least 250 mm (on main line) and 150 mm on loop lines/siding.

(e) Availability of ballast should be, to ensured in shoulders and cribs, to allow required lift as per proposed track profile and to maintain stipulated ballast cross section after tamping work.

(f) Planning and execution of deep screening of ballast, training out of ballast, and cess repair, track drainage improvement works etc., as required, should be carried out well in advance.

(g) All Broken and damaged sleepers should be replaced including those in points and crossings.

(h) The beginning and end of curve/transition curves should be identified and marked in the form of permanent reference pillars. The permanent reference pillars should be installed at every 30 m alongside the length of track and documented for future reference for alignment as well as level. OHE mast in electrified sections can also be used for reference with suitable markings on them and its documentation along with intermediate reference pillars.

(i) In case of tamping on turnouts, sufficient length of approach track, taking into account the special track features on either side should also be planned. In case of the turnout leading to loop line, the turn in-curve shall also be tamped along with turnout.

403. Frequency of Tamping:

(1) The periodic attention to track and maintain of the track in good geometrical parameters with good packing condition for a good riding quality is essential for prolonged life of track components.

(2) The periodicity of regular maintenance tamping depends on many factors besides the GMT carried and type of sleepers. The nominal periodicity should be stipulated, duly approved by Chief Track Engineer of Zonal Railway, for each of the section separately for each road/line, keeping in view the general position of various factors. Some of the relevant factors to

be considered, while specifying periodicity of tamping, are mentioned hereunder

(a) Traffic Density, axle load and maximum permissible speed of trains

(b) Track Geometry (Gradients & Curvatures)

(c) Track Structure & condition of Track components

(d) Depth of ballast cushion, availability of clean cushion and arrears of deep screening, shoulder cleaning.

(e) Type of formation, i.e. embankment or cutting, type of soil, condition and stability of formation.

(f) Climate condition such as rainfall, snowfall etc.

(g) Local conditions such as adjoining built up area, trespassing, drainage problems, etc.

(h) Mode of tamping i.e. smoothening mode or design mode and dynamic track stabilisation after tamping.

(3) The nominal periodicity of regular maintenance tamping should be entered in Track Management System (TMS). The Nominal periodicity so fixed, as per *para 403 (2)* should be reviewed once in every 2 years (in the month of January) and relevant entries in TMS system updated accordingly.

(4) The program for planned deployment of Track machines for regular maintenance tamping should be generated from TMS based on frequency of tamping as per *para 403 (3)*

404. Pre-Tamping, During Tamping and Post-Tamping Attentions:

(1) Pre-tamping Works –The following preparatory works shall be completed during preceding week before undertaking tamping of track: -

(a) Another round of field survey should be carried out just before to deployment of Tamping machine to update the existing profile of track and rework proposed track profile as per guidelines detailed in *Annexure 4/1* and determine slew and lift values. The time gap between this field survey and actual Tamping machine working should be minimum.

(b) In case, the permanent reference pillars with marking for line and level have already been installed and documented, the slew and lift data can be determined directly.

(c) The measuring run facility of tamping machine, if available, should be used for surveying the existing track profile and determination of proposed track profile during the block itself, prior to tamping work.

(d) The beginning and the end of curve/transition curves should be marked conspicuously on sleepers *(see fig. 4.01)* along with the various parameters, mentioned hereunder on alternate/every third sleeper to act as guide for the operator for manual feeding.

(i) For straight track – Slew, lift values for designed longitudinal profile.

(ii) For horizontal curves – slew, versine correction (V_m/F) values (in 4 point lining system) or H values (in 3 point lining system), super-elevation, lift values (duly corrected i.e. "K" correction), for designed longitudinal profile.

(iii) For vertical curves : Lift values (duly corrected i.e. "X" correction).

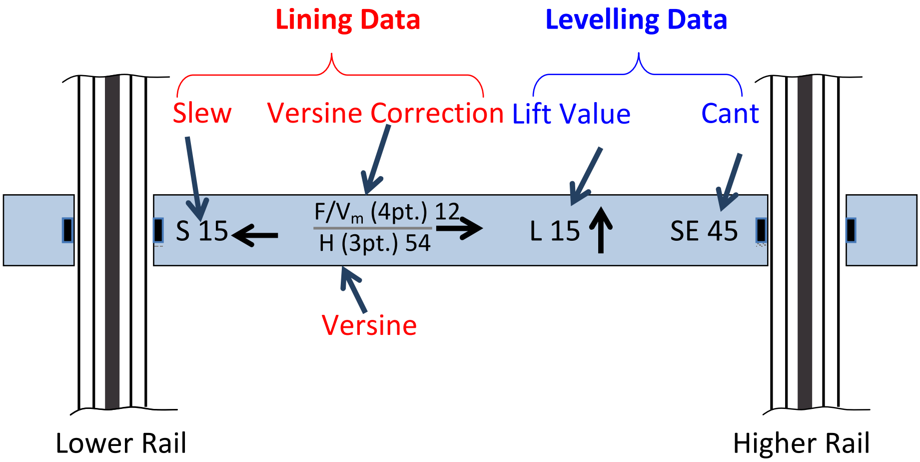


Fig. 4.01 *– Markings on sleeper for manual data feeding*

(e) Ballast should be heaped up in the tamping zone to ensure effective packing. However, sleeper top should be visible to the operator and the ballast must not obstruct the working of lifting rollers.

(f) Cleaning of pumping joints and by removing contaminated ballast and replacing it with clean, screened ballast supplemented with new ballast to make good deficiency.

(g) Necessary attention should be given to Hogged/battered joints

(h) All low joints, if any, should be attended.

(i) Deficient fittings and fastenings should be made good and all fittings and fastenings like fish bolts, keys, cotters, loose-jaws, elastic rail clips etc. should be properly tightened. Worn out fittings and rubber pads should also be replaced.

(j) Sleepers should be squared, uniformly spaced and gauge corrected.

(k) De-stressing of rails, adjustment of creep, expansion gaps in joints and SEJs etc., if necessary, shall be carried out.

(l) Guard rails at the approach of girder bridges and on ballasted deck bridges shall be removed temporarily.

(m) All obstructions such as rail lubricators, signal rods & bonds, cable pipes, axle counter etc., which may obstruct the tamping tools should be removed temporarily. In case it is not possible to remove, these obstructions should be clearly marked and made known to the operator before the start of the work.

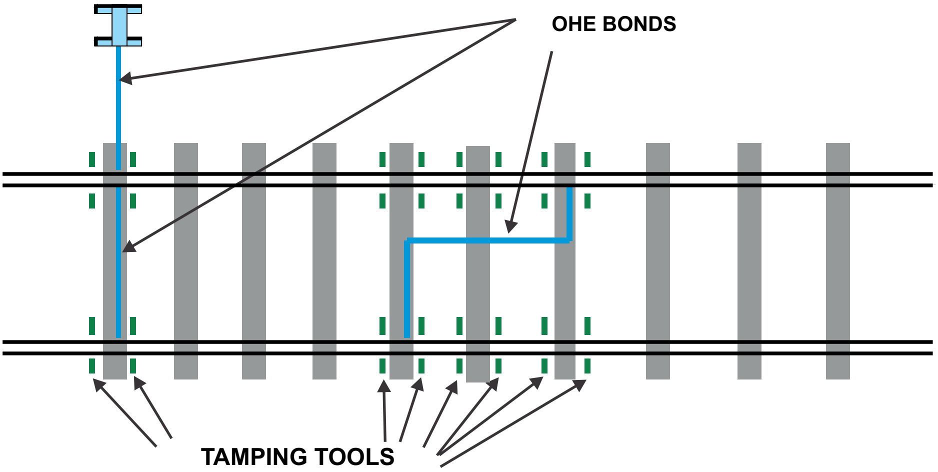


***Fig. 4.02** - Adjustment of OHE bond*

(n) Wooden distance blocks (pieces) on Platform lines, wooden blocks and joggled fish plates etc. shall be removed temporally ahead of tamping & J-clips therein shall be replaced with proper liners and ERCs.

(o) Suitable speed restriction as per the policy guidelines issued by Railway shall be imposed, if existing joggled fish plates are removed before packing. This speed restriction shall be relaxed after refixing them.

(p) Level Crossing shall be opened and check rail shall be removed temporarily ahead of tamping machine.

(q) In electrified sections, the Earth/Structure/cross bonds should either be removed temporarily or properly adjusted for unobstructed tamping.

(r) For turnouts:

(i) Complete Layout including spacing of sleepers as per relevant drawings shall be checked and corrected, if required.

(ii) The broken/battered or worn crossing should be either replaced or reconditioned, as necessary.

(iii) Ensure that all broken/damaged sleepers, if any, in crossing portion have been replaced.

(iv) High points on the turn out and approaches should be determined and general lift should be decided. General lift of minimum 10 mm must be given.

(v) In case of Unimat working on turnouts (being complex assembly), a joint inspection by SSE/TM and SSE/P.way shall also be carried out to ensure pre-requisites and preparatory works etc., to achieve high quality work by machine.

(s) Calculation of relevant values/corrections (which are machine specific). 'H' value in 3 point lining, V_m or F (in 4-point lining), K (lowering value for super-elevated horizontal curves), X (correction value for vertical curves) shall be done and verified. For this purpose, the ready reference tables available in the documentation of the track machine, provided by OEM, can be used.

(t) Co-ordination with other departments:

(i) Operating department: for planning and arrangement of sufficient line blocks to ensure optimum use of tamping machines.

(ii) Electrical department: for availability of OHE staff, as required.

(iii) S&T department: for availability of signal staff and making communication arrangements, as required.

(2) Operations During Tamping: The following points should be observed by the machine operator and the JE/SSE (P.Way):

(a) The tamping machine should work in design mode only, except for initial round of tamping at work site.

(b) The machine should have full compliments of tamping tools. The tamping tools should not be loose or worn out. The wear on the tool blade should not be more than 20% of its sectional area.

(c) The gap between top edge of the tamping blade and the bottom edge of the sleeper in closed position of the tamping tools should be adjusted depending upon the type of rail and sleepers. The gap for different types of sleepers should be as per type of sleeper as under:

  (i) Metal sleeper: 22-25 mm

  (ii) Flat bottom sleeper: 15-20 mm

(d) The tamping (Squeezing) pressure should be adjusted according to the type of sleeper as under:

  (i) CST-9 sleeper: 90 – 100 kg/cm^2

  (ii) ST or wooden sleeper: 100 – 110 kg/cm^2 (For turnouts: 110 - 115 kg/cm^2)

  (iii) PSC sleeper: 110 – 120 kg/cm^2 (For turnouts: 135 - 140 kg/cm^2)

(e) Care should be taken to ensure that tamping tools are inserted centrally between the sleepers into the ballast to avoid damage to sleepers. The number of insertions of the tamping tool per sleeper varies with the type of sleeper and the amount of track lift to be given. While tamping, Following guidelines should be adopted:

  (i) CST-9 sleepers and steel trough sleepers – double insertion before passing on to the next sleeper.

  (ii) Wooden sleepers – one insertion up to 20 mm lift and two insertions for lifts more than 20 mm.

  (iii) One additional insertion for joint sleepers.

  (iv) Concrete sleepers – one insertion up-to 30 mm lift. Two insertions for lift more than 30 mm.

  Note: Heavy slewing or lifting should be done in steps of not more than 50 mm in single pass. For LWR track, the relevant provisions of *Chapter - 7* shall also be adhered to.

(f) During tamping the recommended squeezing time shall be set between 1.0 second to 1.2 seconds. (lower squeezing time should be chosen for ballast in un-consolidated/partially consolidated conditions). However the squeezing time shall not be less than 0.8 second.

(g) A ramp of 1 in 1000 should be given before closing the day's work. The next day's work shall begin from the point of commencement of previous day's ramp.

(h) Correct feeding of relevant values i.e. V_m/F or H for lining, SE and lift values (duly corrected for horizontal/vertical curve corrections) for leveling should be ensured.

(i) If work is to be done during night, sufficient lighting at work site should be ensured.

(j) Where shoulder and crib compacting equipment is available with tie tamping machine, the same should invariably be used.

(k) While passing trains, on adjacent track(s) on double / multiple lines, it should be ensured that no part of the tamping machine is fouling with other track.

(l) While tamping, the parameters of tamped track should be checked immediately after tamping for cross-level and alignment and necessary corrective action should be taken.

(m) For turnouts:

(i) Ensure that sufficient length (at least 50 m) of approach track taking into account the special track features on either side are also tamped in continuation.

(ii) For turnouts in quick succession, without sufficient length in between, adequate line block shall be planned to tamp adjacent turnouts together.

(iii) S&T connections and stretcher bars shall be removed.

(iv) While moving the machine over the switch after tamping on main line portion, either leading or first following stretcher bar is connected for safe movement of machine over switch.

(v) For tamping of turnouts, main line portion is to be tamped first as shown in *fig. 4.03*

(vi) While tamping mainline portion, the additional lifting arrangement, provided in the machine, lifts the turnout side rail also. Therefore the lifted end of sleepers on turnout side should be adequately supported on wooden wedges, or using Non-infringing jacks under rails, till these sleepers are tamped by machine.

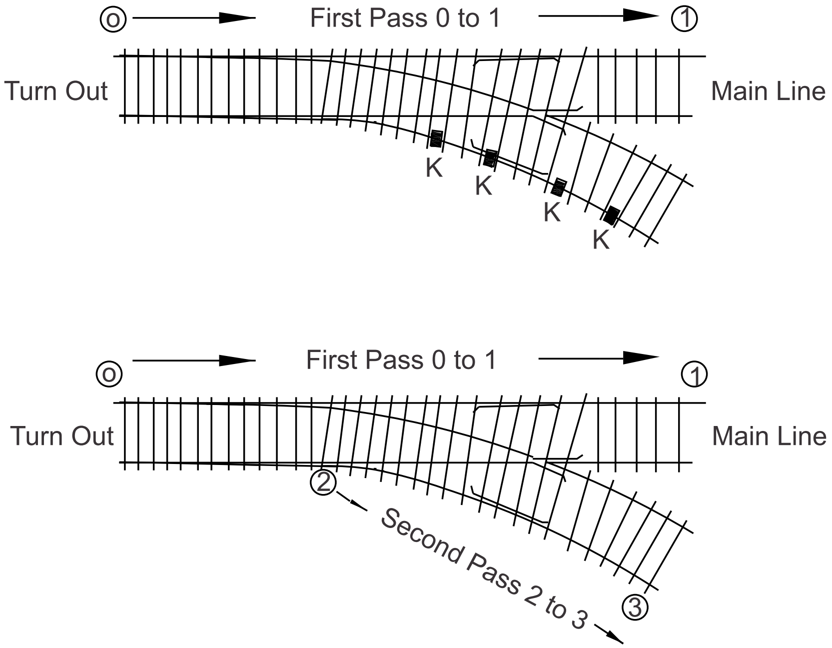


Fig. 4.03 *- Tamping sequence on turnout*

Note: wooden blocks to be placed at 'K' position shown above in case only main line track is tamped and turnout side is left while passing train

(vii) In case of the turnouts leading to loop line, the turn in-curve shall also be tamped in continuation.

(viii) In case of diamonds (with/without slips), direction of more traffic should be tamped first as shown in *fig. 4.04*

(ix) It should be ensured that S&T and electrical staff are associated during the work.

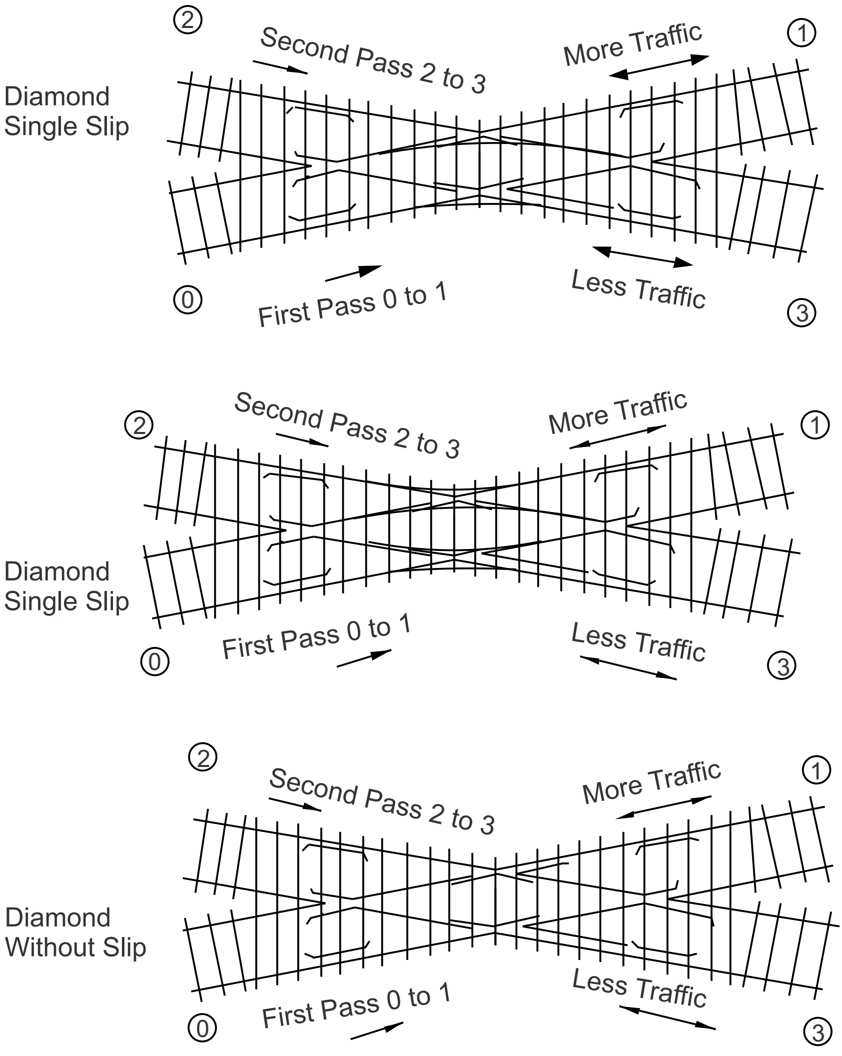


Fig. 4.04 Tamping sequence on Diamonds

(3) Post Tamping Operations: Immediately after tamping, the JE/SSE (P. Way) shall pay attention to the following items and ensure:

(a) Checking and tightening of all loose fittings.

(b) Replacement of broken fittings.

(c) Proper consolidation of ballast between the sleepers shall be one manually in case Tamping machine do not have shoulder and crib compacting equipment.

(d) The ballast should be dressed neatly to maintain profile.

(e) While working in LWR territory, the relevant provisions contained in *chapter 7* should also be followed.

(f) Any unusual occurrences shall invariably be reported to track machine control & Engg. Control along with loss of working time, if any.

(g) Final track parameters on straight track as well as main line on turnouts should be recorded with the help of recorders provided in the tamping machine or optional equipment like Data Recording Processor (DRP) etc. A copy of this record should be kept with the SSE (P. Way).

(h) If the recorder is not available, then gauge and cross level at every 5th sleepers of tamped track should be recorded. JE/SSE (P. Way) may also record alignment and unevenness at few locations and versines & super-elevation on curves to assess quality of corrected track geometry.

(i) Gauging shall be done, wherever necessary, after tamping.

(j) The fixtures like checkrails, guard rails etc. removed during pre-tamping operation should be restored.

(k) Distance blocks on platform lines, joggled fishplates, OHE bonds, signalling rods/bonds & cables pipes shall be put in place and all fittings should be tightened.

405. Dynamic Track Stabilization (DTS) :

The Dynamic Track Stabilizer helps to achieve a spatial force free consolidation while regaining the resistance to lateral displacement. This helps in relaxing the speed restrictions expeditiously and extension of maintenance cycle and thus constitutes an economically sound measure.

The machine should be used in maximum settlement mode at renewal or deep screening sites. On maintenance site, it should be used in controlled settlement mode. The DTS should be invariably deployed immediately behind the tamping machine.

The following extra precautions are necessary in the operation of this machine:

- Complete and tight fittings to hold rails with sleepers are essential.
- Adequate pre-depositing of ballast for achieving the required profile is necessary.

- The vertical pre-load is to be selected if the leveling system is used, in such a way that the determined maximum settlement is not exceeded.
- The selection of frequency (depending on track condition), working speed & vertical pre-load should be judicious according to the needs and with/without "Levelling" system in "ON" condition. The frequency is properly set when the machine appears to be in smooth behaviour i.e. the vibrations are transmitted to the track and not back to the machine.
- When stabilizing on bridges, with ballasted deck the frequency selected must not be within the natural frequency of the bridges so as to avoid resonance conditions. The natural frequency of girder bridges with a span of over 10 m lies below 30 Hz. The frequency of 40-45 Hz is selected when stabilizing the bridges.
- While working the machine in stretches adjacent to walls, trench walls, retaining walls, platform etc., no restrictions for the working of the machines are normally necessary. However when these structures are defective, extra care is necessary in the proximity of 20 m on either side, to avoid likely damages to the structure.

406. Intermediate Attention to Track :

(1) Between two systematic packing of track, by on track machines, need based attention may become necessary to ensure that the track is maintained in good riding condition.

(2) This intermediate attention should also be given by on-track machines as far as possible.

(3) The locations needing intermediate attention, both for planned as well as urgent maintenance, should be obtained from the exception reports generated from TMS. The order of priority for the intermediate attention should be based on normalized SD value of individual parameter, which exceeds limits prescribed for planned and/or urgent maintenance, (A sample of the exception report is shown below).

EXCEPTION REPORT FOR BLOCKS REQUIRING PLANNED OR URGENT MAINTENANCE (CHORD MODE)
(PRINTED ON - 03/05/2016)

SECTION :PA-DD KM :191 To 195 RUNNO :d TRC NO :7965 RUN DATE :22-APR-16

KM		BLOCK	SPEED	Normalised value of SD											MAX VALUE	TGI
				On short chord						On long chord						
FROM	TO			UL1	UR1	TW1	GA	AL1	AR1	UL2	UR2	AL2	AR2	TW2		
193	194	4	34	0.36	0.39	0.76	0.56	0.71	0.92	0.36	0.43	0.62	0.75	0.58	0.92	61
193	194	5	36	0.42	0.36	0.76	0.75	0.66	1	0.39	0.43	0.57	0.87	0.6	1	58
194	195	1	41	0.79	0.64	0.67	0.69	0.87	1.08	0.7	0.64	0.78	0.89	0.52	1.08	47
194	195	2	55	0.97	0.91	0.93	1.08	0.95	1.39	0.72	0.7	0.79	1.16	0.72	1.39	36
194	195	3	57	0.85	0.7	0.95	1.25	0.87	1.47	0.8	0.74	0.75	1.22	0.7	1.47	34
194	195	4	58	0.76	0.73	0.71	0.67	0.79	1.18	0.61	0.53	0.67	1.02	0.52	1.18	49
194	195	5	59	0.58	0.7	0.6	0.72	0.53	0.89	0.42	0.51	0.43	0.75	0.44	0.89	65

(4) For intermediate attention by means of on track machines, pre tamping, during tamping and post tamping attentions should also be given to track as detailed in para 404.

407. Systematic Overhauling of Track:

Periodical overhauling of track is necessary to best possible conditions continued with its maintainability of track. The overhauling should be completed before end of March every year.

(1) Sequence of operations- Overhauling shall consist of the following operations in sequence:-

(a) Shallow screening and making up of ballast.

(b) All items attended to, while doing through packing as detailed in Para

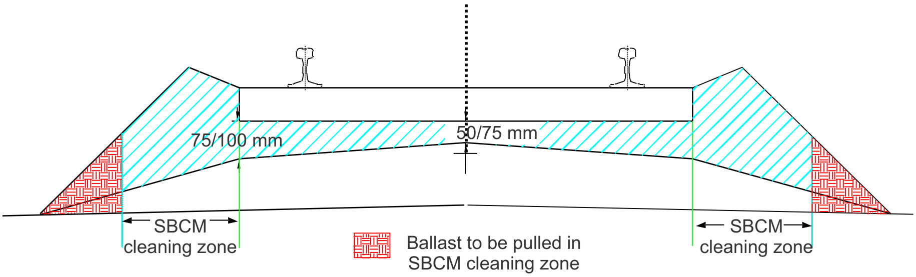
(c) Making up the cess.

(2) Shallow Screening/Shoulder cleaning and making up of Ballast

(a) For machine maintained section

(i) The crib ballast in the shoulders should be opened out to a depth of 75 to 100 mm, below the bottom of sleepers, sloping from the centre towards sleeper end. The ballast in the shoulders opposite to the crib as well as the sleepers is removed to the full depth. A slope is given at the bottom sloping away from the sleeper end. The ballast is then screened and put back. Care should be taken to see that the packing under the sleepers is not disturbed and the muck removed is not allowed to raise the cess above the correct level. *(Fig. 4.05)*

(ii) To undertake screening of shoulder ballast by machines, the crib ballast shall be opened as mentioned in *Para 407 (2) (a) (i)* above and moved in the screening zone (i. e. Front end of sleeper to toe of ballast section). The portion of ballast beyond screening chain of SBCM should also be pulled in screening zone to avoid formation of channel. *(Fig. 4.05)*



Manual - 50mm@ centre & 75mm @ end below sleeper as shown

Mechanised - 75mm @ centre & 100mm @ end of sleeper as shown

Fig. 4.05 *- Opening of ballast during overhauling of track*

(b) (i) For conventional system of maintenance, the crib ballast between sleepers is opened out to a depth of 50 to 75 mm, below the bottom of sleepers, sloping from the centre towards sleeper end. The ballast in the shoulders opposite to the crib as well as sleeper is removed to the full depth as shown in *fig. 4.05*.

A slope is given at the bottom sloping away from the sleeper end. The ballast is then screened and put back. Care shall be taken to see that the packing under the sleeper is not disturbed and the muck removed is not allowed to raise the cess above the correct level.

(ii) Two contiguous spaces between sleepers should not be worked at the same time.

(iii) Screening should be progressed in alternate panels of one rail length. In no circumstances should several rail lengths of track be stripped of ballast.

(c) Where drains across the track exist, they should be cleaned and filled with boulders or ballast to prevent packing from working out and forming slacks.

(d) After screening, full ballast section should be provided, extra ballast being run out previously for the purpose. Work should be commenced after making sure that the ballast will not be seriously deficient. Ballast deficiency, if any, should be shown in the central portion of sleeper and this also should be made up soon.

(e) Making up of Cess – Cess, when high, should be cut along with overhauling and when low should be made up. A template should be used for this purpose.

(f) In case of L.W.R. territory, the provisions contained in *chapter 7* should be followed.

408. Attention to Spots Giving Rough Riding:

(a) Based on field inspections (direct as well as indirect) exception reports generated by TMS and messages by Loco Pilots about rough running any specific location/spot needing attention shall be identified.

(b) The identified spot shall be thoroughly inspected track parameters measured and observations recorded, previous history, if any, and shall be analysed to arrive at practically workable solution to avoid recurrence.

(c) The structural improvement work required, if any, should be carried out expeditiously.

(d) For spot attention/slack picking, multi- purpose Tampers or Off-track Tampers shall be used as a regular measure on Concrete Sleeper Track for–

(i) Picking up slacks in isolated stretches.

(ii) Points and Crossing areas,

(iii) Approaches to bridges and level crossings,

(iv) Buffer rail joints/glued joints in LWR section,

(v) Block insulated joints/glued joints in track-circuited stretches.

(e) For off-track tampers, the working instructions, issued by Railway Board/RDSO as amended from time to time, should be followed.

(f) As an interim measure, where off-track tampers are not available, the packing may be done with the help of crowbar, duly taking care that the concrete sleepers are not damaged.

(g) Spot renewal of rails and sleepers shall be done as per requirement.

(h) For spot attention by on track tampers, Pre tamping, during tamping and post tamping attentions should be given to track as detail in *para 404.*

409. Through Packing (For other than concrete sleeper track)

(1) General: Through packing shall consist of the following operations in sequence. The length of track opened out on any one day shall not be more than that can be efficiently tackled before the end of the day:

(i) Opening of the road.

(ii) Examination of rails, sleepers and fastenings.

(iii) Squaring of sleepers.

(iv) Slewing of track to correct alignment.

(v) Gauging.

(vi) Packing of sleepers.

(vii) Repacking of joint sleepers.

(viii) Boxing of ballast section and tidying.

Through packing is best done continuously from one end of a gang length towards the other.

(2) Each of the above operations should be carried out as detailed

(a) Opening of Road: Ballast should be opened out on either side of the rail seats to the extent shown hereunder to a depth of 50 mm below the packing surface without disturbing the cores under the sleepers:

Broad Gauge: End of sleepers to 450 mm inside of the rail seat.

Metre Gauge: End of sleepers to 350 mm inside of the rail seat.

Narrow Gauge (762 mm): End of sleepers to 250 mm inside of the rail seat.

In case of cast iron plate or pot sleepers, the opening out should be to the extent of the plates or pots to enable packing being done conveniently.

The ballast should be drawn by rake iron ballast outwards and inwards i.e., that portion of the ballast on the outside of the rail should be drawn outwards, the portions between the rails being drawn towards the centre, care however, should be taken to see that the ridge between the rails does not project more than 50mm. above rail level.

(b) Examination of Rails, Sleepers and Fastenings:

(i) Rails should be examined, the underside for corrosion, the ends for cracks, the head for top and side wear, rail joints for wear on the fishing planes, fish bolts for tightness.

Rust and dust must be removed from the corroded rails by using wire brushes, kinks in rails should be removed by jim crowing.

(ii) Sleepers should be inspected for their condition and soundness particularly at the rail seats. In case of wooden sleepers, plate screws, spikes and fang-bolts should be examined for their firm grip. Sleepers should be checked for split and decay.

In case of cast iron sleepers, the condition and firmness of cotters and keys should be examined. Loose keys should be tightened by providing liners or replaced by appropriate oversized keys. In the case of wear in the rail seat of CST. 9 plates, suitable pad/saddle plates may be provided. Fastenings and fittings should be examined to ensure that they are in good order, appropriately tightened so that they firmly hold the rails. Broken fastenings should be replaced immediately.

(c) Squaring of sleepers:

Gauge variations and kinks inevitably result from sleepers getting out of square.

(i) The spacing of sleepers on the sighting rail should first be checked and correctly chalk- marked. Corresponding marks should then be made on the other rail using the square at every point. The core of sleepers that are out-of-square should then be picked with the pick ends of beaters, the fastenings loosened and the sleepers levered and squared to correct position.

(ii) Squaring should be done by planting the crow bars firmly against the sleeper and pushing it. Under no circumstances should sleepers be hammered. Sleepers that are squared should be re-gauged immediately, the fastenings tightened and repacked.

(d) Slewing of track to correct alignment:

(i) Heavy slewing will only be required during realignment of curves when it will be necessary to loosen the rail, joints and in case of steel sleepers and cast iron sleepers to loosen the fastenings, the packing cores being broken with the pick-ends of beaters. Slewing for normal maintenance will be of a small order and should be done after opening out the road, loosening the cores at ends and drawing out sufficient ballast at the ends of the sleepers.

(ii) Slewing of track shall be directed by the mate (Track Maintainer Gr. I) who on straights should sight the rail from a distance of 30 to 60 metres. On curves, he should sight the outer rail. Slewing is best done in the morning unless it is cloudy, as later on, sighting conditions become unfavorable.

When slewing, the crow bars should be planted well into the ballast at an angle not more than 30 degrees from the vertical; otherwise lifting of the track may occure.

(e) Gauging:

(i) Preservation of gauge is an important part of track maintenance especially through points and crossings. For good riding, the basic requirement is uniform gauge over a continuous stretch of track and such gauge should be allowed to continue so long as it is within the permissible limits of tightness or slackness.

(ii) Gauging should only be done after ensuring that sleepers are truly square. Standard keying hammers shall always be used. Beaters and heavier hammers should not be used, as this causes overdriving of keys and strained lugs on metal sleepers.

(iii) The track gauge should be held firm with one lug against the base rail, and the other end being swivelled over the opposite rails. The tightest position obtained determines the correct point to test the gauge. The gauge should not be forced as that causes considerable wear on the gauge lug.

(iv) The track gauge should be adjusted to correct gauge on the rail opposite to the base rail. The required slackness on sharp curves should be attained by using liners of the requisite thickness against the lug of the gauge as in the case of ordinary track iron gauge.

(v) While it is desirable to maintain correct gauge, it may not be possible to maintain correct gauge due to age and condition of sleeper. It is good practice to work within the following tolerances of gauge, provided generally uniform gauge can be maintained over long lengths:

Broad Gauge:

a) On straight	-6mm to +6mm
b) On curves with radius 440 m or more	-6mm to +15mm
c) On curves with radius less than 440 m	Upto +20 mm

Note : These tolerances are with respect to nominal gauge of 1676 mm.

Meter Gauge:

a) On straight	-3mm to +6mm
b) On curves with radius 290m or more	-3 mm to + 15mm
c) On curves with radius less than 290 m	Upto +20 mm

Note : These tolerances are with respect to nominal gauge of 1000mm.

Narrow Gauge:

a) On straight	-3mm to +6mm
b) On curves with radius of more than 175 m	-3mm to +15mm
c) On curves with radius less than 175 m	Upto +20 mm

Note : The above tolerance are with respect to nominal gauge of 762mm.

(f) Packing of sleepers:

(i) The aim of packing is to have each sleeper firmly and uniformly packed to ensure that the rails are at their correct relative levels i.e., level on the straight track and to the required cant on curves and that no sleeper has any void between it and its bed below.

(ii) Before packing is commenced, it is necessary to ensure that the chairs/bearing plates are firmly fixed to the sleepers and the rails are bearing on the chairs/ bearing plates. In case of rails resting directly on sleepers it should be ensured that there is no gap between the bottom of the rail and top of the sleeper.

(iii) The base rail shall be sighted by the Mate (Track Maintainer Gr. I) with eye along the lower edge of the head of rail and any dip or low joint lifted correctly. The adjacent sleepers should then be packed and the top checked. After two rail lengths have been attended to, the rail on the other side should be brought to the correct level by checking cross level with the straight edge and spirit level or gauge-cum level at every rail joint and at every fourth sleeper. The next two rail lengths should then be taken up and the process continued.

(iv) No joint or dip should be lifted higher than the proper level in the expectation that it will settle to the correct level. Instead it will settle more under traffic as a result of being high and cause rough running.

(v) Having aligned the track and adjusted the “top” the Track Maintainers (Trackmen) should be distributed in batches of two for packing all sleepers in a systematic manner, commencing from one end. Four men should deal with every sleeper successively, two at each rail seat. The ballast under the sleeper should be packed by the men standing back-to-back and working their beaters diagonally under the rail seat at the same time to ensure firm packing.

(vi) It is important that men should thoroughly “break” the cores with the pick-ends and then use the blunt-ends (head-ones), as otherwise, uniform packing will not be achieved and elasticity of the road- bed affected. After packing the rail seat the packing should be continued outwards and inwards to the requisite extent on each side of the rail seat i.e., end of the sleeper to 450 mm. inside on the B.G. and end of sleeper to 350 mm. inside on the M.G. and end of sleepers to 250 mm. inside on the N.G. (762 mm.). The beaters should not be lifted above the chest level, the strokes being kept as nearly horizontal as possible. Care must be taken to avoid forcing under the sleeper any stones so large as to cause uneven bearing and to avoid striking the edges of the sleepers and timbers. All men should aim to work the beater from the same height (chest level) so that the sleepers are uniformly packed. Higher or lower lifting of the beaters results in uneven compactness.

(vii) In case of steel trough and wooden sleepers, packing under the rail seat causes the ballast to work towards the center. Before final dressing is done, it should be ensured that no sleeper is centre-bound by working the pick-ends over the central range. Centre bound sleepers cause vehicles to roll from side to side.

(viii) In the case of CST-9 sleepers it should be ensured that the end pockets or bowls are filled with ballast and the main packing should be done at corners. The central flat portion of the plate should not be packed hard but only tamped lightly. On pot sleepers the ballast should be pushed through the holes provided at the top of the pot and rammed in with crow-bars.

(ix) Care must also be taken while packing to ensure that the work does not result in the sleepers adjoining those being packed, lifted off their bed, thus creating artificial voids under them.

(x) The packing on the inside and outside at every rail seat should, before boxing the track, be checked by the Mate (Track Maintainer Gr. I) by tapping with a wooden mallet or a canne-a-boule. A hollow sound would indicate defective packing, which should be attended to again.

(xi) As soon as the packing is completed, slight distortions in alignment and top should be checked and corrected by the Mate (Track Maintainer Gr. I), the sleeper disturbed for this purpose being finally repacked.

(g) Repacking of joint sleepers:

The joint and shoulder sleepers should be repacked, before boxing is done and the cross-levels at joints checked. The rail joint being the weakest portion, firmness of its support is essential.

(h) Boxing to ballast section and tidying:

(i) After completing the preceding operations in sequence, clean ballast should be worked in with ballast forks or rakes. The ballast section should be dressed to the specified dimensions, a template being used for the purpose. Hemp cords 6 mm dia. of sufficient length should be used for lining the top and bottom edges of the ballast section. Where the quantity of ballast is inadequate, full section of ballast should be provided near the rail seat, the deficiency being reflected along the centre of the track and not under the rails or in the shoulders.

(ii) The cess should then be dressed up. Where earth ridging exists at the edge of the bank, this should be removed. Cess should be maintained to the correct depth below rail level according to the ballast-section and formation profile. Too high a cess affects drainage; too low a cess results in ballast- spread and wastage.

Annexure 4/1
{Para 402 (3), 404 (1)(a)}

Guidelines for Operation of Tamping Machine in Design Mode

The tie tamping machines should be worked in design mode on top to eliminates long wave length irregularities of longitudinal level and alignment.

1.0 Datum Rail:

The guidelines for selection of datum rail for carrying out corrections to longitudinal/vertical profile and alignment are as under:

1.1. Longitudinal/vertical profile: Non-cess rail on straight track in double line section and inner rail in curves.

1.2. For Alignment: non-cess rail on straight track in double line section and outer rail on curves.

1.3. For single and middle line in multiple line sections, any of the two rails which is less disturbed may be selected as datum rail, both for alignment and longitudinal/vertical profile in straight track.

2.0 Survey for Longitudinal/Vertical Profile Correction:

2.1 The identified section should be divided by marking stations at 10 m interval. The starting point should be opposite a km post and the starting station should be marked “0". Station locations and station numbers should be painted in yellow paint on the web of the datum rail.

2.2 Bench marks:

Bench marks should be established at 200-1000 m interval, relating them to the GTS bench mark levels so that the plotted drawings are properly related to the existing index section. Fixing bench marks in relation to arbitrary levels shall be avoided. These bench marks can be established on the top of concrete foundation of OHE masts in electrified sections with conspicuous markings.

2.3 Recording of Actual Rail levels:

The JE/SSE (P.Way) should record the actual rail levels at all the stations of the datum rail, making use of the established bench marks. However, on the stretches where the datum rail is super-elevated, being on a horizontal curve, the rail levels should be taken on the other rail of the track, opposite the station locations. The stretch for which station levels are taken on "non-datum" rail, shall be noted in the level book.

2.4 Formation levels:

At every 5th station i.e. Station No. 0, 5, 10 etc., the JE/SSE(P.Way) should remove ballast below the rail seat where rail levels are recorded, up-to a level, below which it is not desirable to go, while carrying out deep screening work known as Formation Level and record the same. For example, in the redesigned vertical profile the rail level should be 700 mm and 680 mm above the formation level in case of 60 kg and 52 kg rail respectively on PSC sleepers with 300 mm ballast cushion, if sub-ballast is not provided.

2.5 Obligatory Points:

While carrying out the survey, the JE/SSE (P.Way) should record the location of obligatory points like level crossings, girder bridges, points and crossings, overhead structures etc., in reference to the station numbers as well as running Kilometre. The location of km posts and gradient posts should also be noted.

3.0 Plotting of Vertical Profile:

3.1 The existing vertical rail profile (of datum rail) and formation profile should be plotted on a graph sheet with the length of track as abscissa and elevation of rail top and formation as ordinate. The scale adopted should be:

Horizontal Scale: 1:1000 (1 cm = 10 m); and

Vertical Scale:1:10 (1 mm = 10 mm)

3.2 Having plotted the formation levels, the desired rail levels should be marked on the graph e.g. by adding 700 mm to the formation level in case of 60 kg rail on PSC sleepers (with 300 mm ballast cushion) and 680 mm in case of 52 kg rail on PSC sleepers (with 300 mm ballast cushion). The desired rail level so plotted should be taken into account, while marking the proposed vertical profile on the graph.

3.3 Proposed Rail Profile:

While deciding the final levels, the following considerations shall be taken into account:

(i) Sub-sections shall be selected keeping in view high points and obligatory points.

(ii) As far as possible, long stretches of uniform gradient shall be planned keeping in view the depth of construction to be provided, and relative implications of lifting or lowering of track. In no case the grade should exceed the ruling gradient of the section. While designing vertical curves, provisions of para 511 should be observed.

iii) The clearance to overhead structures (including OHE) shall be maintained within permissible limits.

iv) The redesigned profile should not normally involve lifting or lowering of obligatory points like girder bridges, Level crossing, and turnouts. For this purpose the SOD infringements, if any, shall also be considered.

v) The redesigned profile should aim at easing the sags and humps with manageable lift and lowering. It is not necessarily the intention that the original longitudinal section of the line should be restored.

vi) Generally, the redesigned profile should be so arrived at as to have lifting only, as machines have lifting facility only, and lowering shall be resorted to in exceptional circumstance only.

vii) Prescribed minimum ballast cushion as per Para 402 (3)(d) should be ensured. However, the requirement of ballast, over and above that for the prescribed cushion, can be optimised by designing suitable vertical curves.

viii) At locations where lifting or lowering is not possible, suitable ramping out preferably in the form of reverse curves in vertical plane should be provided on both approaches. In case lift is proposed at level crossings, the field staff should be prepared to simultaneously raise the road surface and re-grade the approaches.

ix) High points on the turn out and approaches should be determined and general lift of minimum 10 mm must be given at that point.

4.0 Requirement to be met, while redesigning the Profile:

4.1 For other than vertical curves-

The unevenness on 80 m chord should not exceed as under:

(i) on high speed routes with speed above 110 km/h – 40mm (corresponding to 20,000m vertical radius).

(ii) on other lines - 65 mm (corresponding to about 12,000 m vertical radius).

4.2 for vertical curves - The unevenness on 20 m chord should not exceed 10 mm (corresponding to 5,000 m vertical radius)

The profile designed should be analytically verified so that the above mentioned unevenness limits are not exceeded. The final levels at various points should be calculated, rather than scaling-out from the drawing, which mainly serves the purpose of visual appreciation.

4.3 The proposed levels should be approved by an officer not below the rank of DEN/XEN. The working plan so prepared should be distributed to the concerned field staff and AEN.

For designing of vertical profile, aid of a computer with software developed by IRICEN/Pune may be taken to speed up the design work.

5.0 Surfacing Operation

5.1 The finally proposed levels of rail top may be marked on the OHE masts/permanent reference pillars for executing the lifting operation. In case of non-electrified section, permanent level pegs should be provided at every 5th station.

5.2 Lifting of track may become necessary during regrading and for elimination of minor sags to keep a good top surface.

5.3 Heavy lifting should always be carried out under speed restriction and protection of engineering signals.

5.4 While lifting track under bridge and overhead switches and in tunnels it should be ensured that there is no infringement to SOD.

5.5 In case of curve, inner rail should be set to correct level and grade and to raise the outer rail to give required super elevation duly taking care that cant gradient is within permissible unit.

5.6 Lifting sequence :

(i) Lifting should commence from down hill and carried out in the direction of rising grade in case of single line.

(ii) In case of double line, the lifting should passed in the opposite direction to traffic.

5.7 Lifting should not exceed 75 mm at a time so as to allow, proper consolidation. The easement gradient for passage of trains should not be steeper than 25 mm in one rail length of 13 m. The operation should be repeated till required level is attained.

5.8 The track should be finally ballasted, packed, boxed and cess made to correct level.

5.9 The finished profile may not exactly conform to the redesigned profile, and the resurfaced levels may vary from the design profile. It is, therefore, necessary to check the finished levels in relation to the levels marked on the OHE masts/permanent reference pillars. The difference between the finished levels and designed levels should not exceed 10 mm, provided that the variation of unevenness from station to station is not more than 20 mm. To ensure this, JE/SSE (P.Way) will workout the unevenness at all stations in relation to the finished levels and the machine in-charge shall apply correction to levels, to bring the station to station variation of unevenness within the prescribed limit.

6.0 Survey for Alignment Correction:

6.1 All the weld and rail kinks should be rectified/eliminated by de-kinking or cutting and welding, before measurement for alignment defects are taken. Hydraulic jim-crows may be used for removing kinks.

6.2 In case some horizontal curves on the section to be surfaced warrant realignment, then the process of realignment should be carried out along with surfacing.

6.3 Alignment should be measured on a long chords (at least 80-100 m) chord on straight track and required slews, at alternate sleeper, should be worked by measuring the offsets at every 5 m interval and interpolating the offsets. The slews should be written on alternate sleeper.

6.4 On curved track, versines should be measured on 20 m chord at 10m intervals. The required slews at the stations are worked out taking note of the obligatory points and interpolated to give slews at every alternate sleeper. The slews are then written on alternate sleepers.

6.5 While working out slews, position of fixed structures should be noted and infringement to moving dimensions shall not be allowed.

6.6 Pre-tamping and Post-tamping operation and machine related track works as detailed in *para 404* shall be ensured by the SSE (P.Way).

■■■

- *P.WAY likes designer stuff. Design tamping is must have, at all costs.*

Chapter 5

Curved Track and Realignment of Curves

501. Definitions and Terminology :

(1) Curve – Curve is the arc of a circle facilitating gradual change in direction between two tangent tracks.

(2) Cant or Super-elevation - Cant or super-elevation (SE) is the amount by which one rail is raised above the other rail to counteract the centrifugal force when a vehicle moves on a curve track. It is positive when the outer rail on a curved track is raised above inner rail (see Fig. 5.01) and is negative when the inner rail on a curved track is raised above the outer rail.

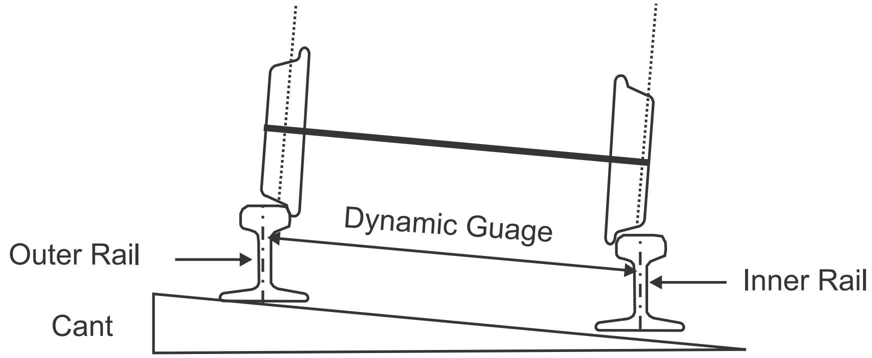


Fig. 5.01 *Canted track*

(3) Cant deficiency – Cant deficiency (C_d) is a virtual deficiency of cant experienced by the passenger when a train travels around a curve at a speed higher than the equilibrium speed. It is the difference between the theoretical cant required for such higher speed and actual cant provided.

(4) Cant excess –Cant excess (C_{ex}) occurs when a train travels around a curve at a speed lower than the equilibrium speed. It is the difference between the actual cant and the theoretical cant required for such lower speed.

(5) Cant gradient - Cant gradient (i_{ca}) indicates the amount by which cant is increased or reduced in a given length of transition e.g., 1 in 1000 means that cant of 1 mm is gained or lost in every 1000 mm of transition length. (i.e. 1 mm/m)

(6) Chord length (C) - For measuring versine of a curve, 20 meter overlapping chords with stations at 10 m interval, should normally be used. For checking the radii of turnout and turn-in curves overlapping chord of 6 m length with stations at 3 m interval, should be used.

(7) Direction of curve – The direction of curve is determined by change in direction with respect to tangent facing the curve in increasing kilometer, e.g. if change in direction is towards left hand side of the tangent then it is called LH curve.

(8) Deflection angle – Deflection angle is the external angle between the tangents, which are connected by a curve.

(9) Degree of curve -The degree (D) of the curve is the angle subtended at the center by a chord of 30.5 m length.

(10) Designation of curve – A curve can be designated by its radius in meter or by its degree. Curves are generally designated by their degree.

(11) Equilibrium speed - Equilibrium speed is the speed at which the centrifugal force developed during the movement of the vehicle on a curved track is exactly balanced by the restoring force generated by the component of the self weight of vehicle due to cant. Shown in *Fig. 5.02*

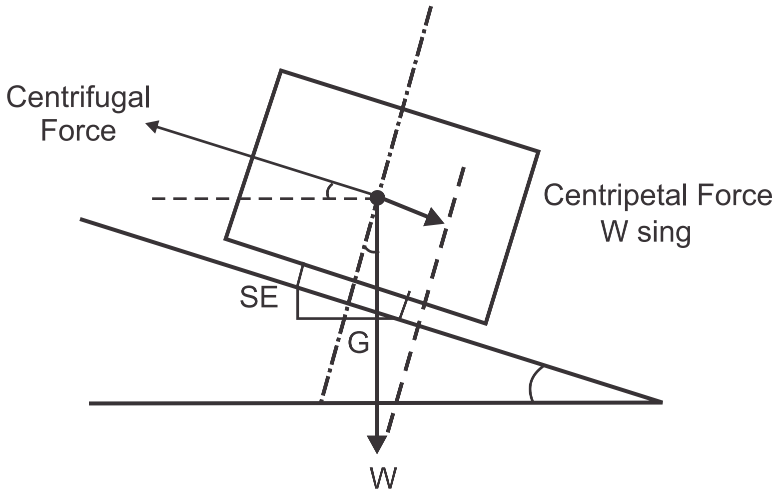


Fig. 5.02 *Balanced force on Railway vehicle*

(12) Grade compensation - It is the easement provided in gradient when both curve and gradient are present simultaneously so that the vehicle can negotiate the curve track at maximum permissible speed.

(13) Lean – *(l)* It is the lateral inward displacement of vehicle body due to leaning on a curve track provided with a cant. See *Fig. 5.03*

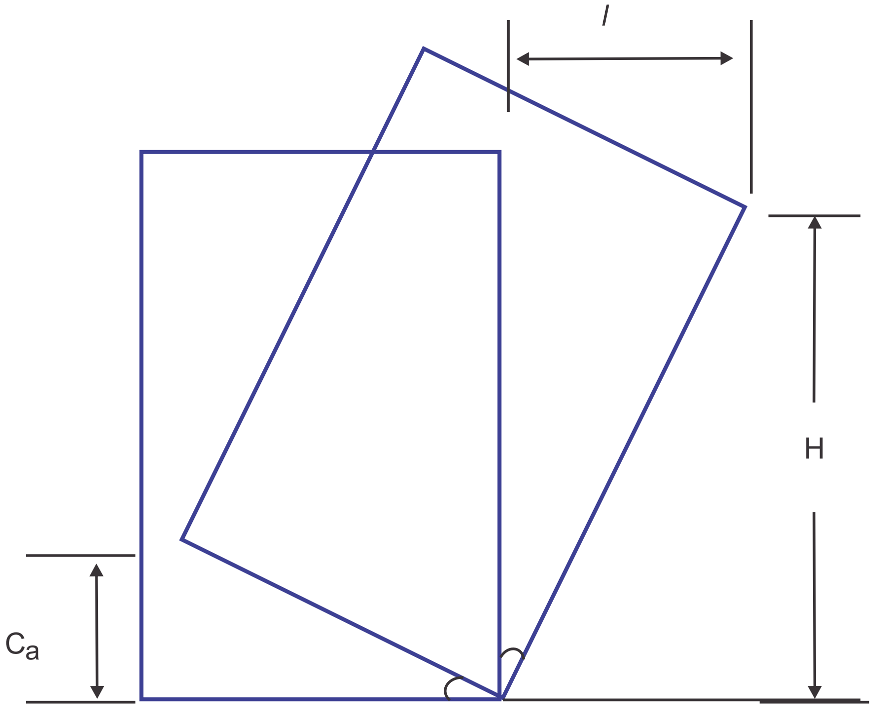


Fig. 5.03 *Lean due to vehicle on canted track*

(14) Maximum permissible speed of the curve (V_m) – It is the maximum speed (V_m) which may be permitted on a curve taking into consideration the radius of the curve, actual cant, cant deficiency, cant excess and the length of transition. When the maximum permissible speed on a curve is less than the maximum sectional speed of the section of a line, permanent speed restriction becomes necessary.

(15) Over throw (V_o) and End throw (V_e) –

Over throw (Mid throw) is inward lateral displacement of midpoint of vehicle body from the centre line of track for a vehicle moving on curve track.

End throw is out ward lateral displacement of ends of vehicle body, from the centre line of track for a vehicle moving on curve track. Refer following *Fig. 5.04*

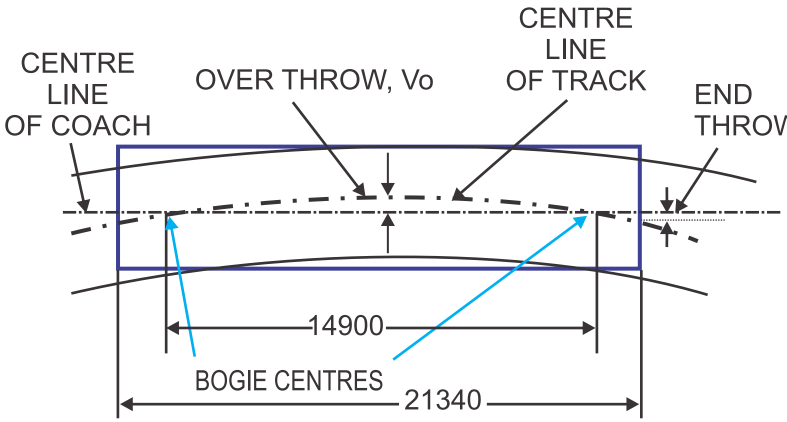


Fig. 5.04 *Plan showing vehicle on curved track.*

(16) Rate of change of cant (r_{ca}) and cant deficiency (r_{cd}) - Rate of change of cant (r_{ca}) or rate of change of cant deficiency (r_{cd}) is the rate at which cant or cant deficiency is increased or reduced per second, at the maximum permissible speed of the vehicle passing over the transition curve, e.g., 35 mm per second means that a vehicle when traveling at a maximum permitted speed will experience a change in cant or deficiency of cant of 35 mm in each second of travel over the transition.

(17) Radius of curve (R) - Radius of a curve is the radius of the arc of circle.

(18) Reference rail -The level of inner rail of any curve is taken as reference level. In case of reverse curves it depends upon the method of running out of transition and stipulations as laid down in *para 504 (4)* shall apply.

(19) Shift - Shift (S) is the amount by which the circular curve physically moves inwards due to introduction of transitions at the ends of the circular curve.

(20) Similar flexure and Contrary flexure – When a turnout takes off from a curve in similar direction it is called similar flexure. In this case cant permitted on turnout is same as main line. The curvature of the lead curve of turn out taking off from a curve becomes sharper as compared to the one taking off from tangent track.

When a turnout takes off from a curve in opposite direction it is called contrary flexure. In this case the cant on turnout will be negative. The curvature of the lead curve of turn out taking off from a curve becomes flatter as compared to the one taking off from tangent track.

(21) Station - Stations are painted on web of the inside face of outer rail with numbering, at predefined intervals for measurement of the versines. On curves stations are marked at 10 m interval. On the turnout and turn-in curves stations should be marked at every 3 m interval.

(22) Tangents – These are the two straight portions of track having fixed deflection angle, which are connected by a curve for affecting change in direction.

(23) Transition curve - Transition curve is an easement curve, in which the change of radius is gradual throughout its length and is usually provided in a shape of a cubic parabola at each end of the circular curve i.e. between tangent track and circular curve. It affords a gradual increase of curvature from zero at the tangent point to the specified curvature of circular curve; it also permits a gradual increase of super-elevation, so that the full super-elevation is attained simultaneously with the curvature of the circular curve.

(24) Versine (V) - The versine (v) is the offset between gauge face of the rail and the middle point of stretched fishing/nylon chord of standard length. Care should be taken that the chord or wire is applied to the side of the head of the rail at the gauge point.

(25) Virtual transition - When a vehicle moves on a non-transitioned track, the change in the direction of the vehicle from straight track to curved track takes place over the distance between the bogie centers. When both bogies are on straight track, the versine is zero. As leading bogie starts traversing the curve, versine gradually builds up attaining the maximum value when the trailing bogie reaches the curve track. Accordingly distance between the bogie centers of front and rear bogies of a coaching stock is taken as virtual transition, show in following *Fig 5.0*5. The virtual transition is commencing on the straight at half the distance before the tangent point and terminating on the curve at the same half distance beyond the tangent point.

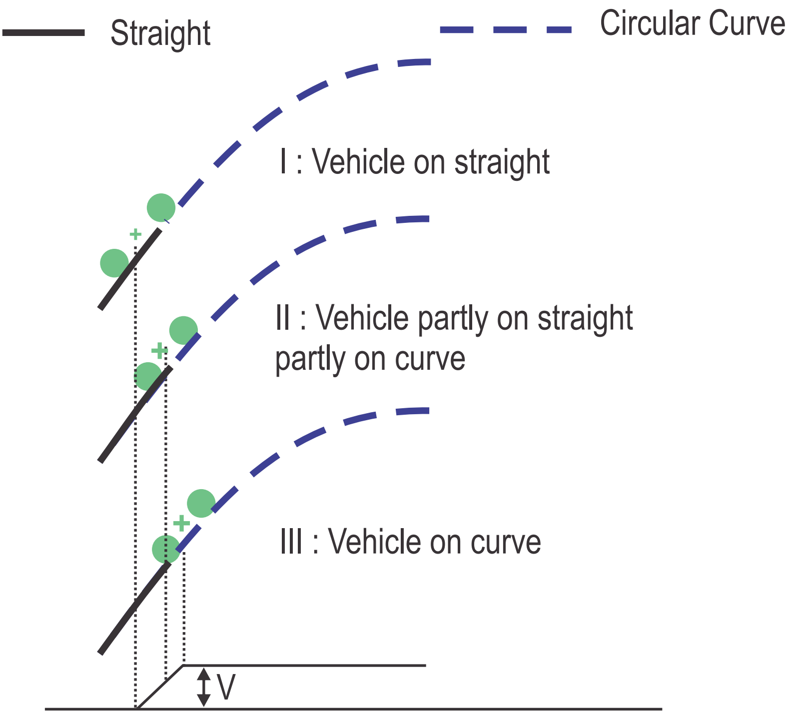


Fig. 5.05 *Virtual transition*

502. Gauge on Curves :

(1) On new lines and on lines where complete renewal or through sleeper renewal is carried out, the track should be laid to the following standards:

	Radius in meter	Variation in Gauge
(a)	Broad Gauge (1676 mm)	
	i) Straight including curves of radius up to 350 m and more	- 5 mm to + 3 mm
	ii) For curves of radius less than 350 m	Up to + 10 mm
(b)	Meter Gauge (1000 mm)	
	i) On straight including curves with radius 290 m and more	- 2 mm to + 3 mm
	ii) On curves with radius less than 290m	Up to +10 mm

(c)	Narrow Gauge (762 mm)	
	i) Straight including curve with radius up to 400 m	- 3 mm to +3 mm
	ii) For curves with radius less than 400 m and up to 100 m	Up to +10 mm
	iii) Curves with radius less than 100 m	Up to +15 mm

Note:

(a) These limits are not applicable to curves laid with different gauge widening by railways as trial measure in consultation with RDSO.

(b) For narrow Gauge sections for which special schedules have been prescribed by the Zonal Railways, provisions in those schedules should be observed.

(c) Extra widening of gauge has to be introduced gradually in the transition portion of the curve. The gauge shall be changed from normal to wider gauge in stages and sleepers are to be provided accordingly.

(2) Generally uniform gauge provided shall be maintained over long lengths. The maintenance tolerances of gauge are as below:

(a)	Broad Gauge (1676 mm)	Variation in Gauge
	i) On curves with radius 440 m or more	- 6 mm to +15 mm
	ii) On curves with radius less than 440 m	up to + 20 mm
(b)	Meter Gauge (1000 mm)	
	i) On curves with radius 290 m or more	- 3 mm to + 15 mm
	ii) On curves with radius less than 290 m	Up to + 20 mm
(c)	Narrow Gauge (762 mm)	
	i) On curves with radius of more than 175m	-3 mm to + 15 mm
	ii) On curves with radius less than 175 m	Up to + 20 mm

503. Radius and degree of curve :

(1) Determination of radius of curve – The radius (R) of a curve is determined by measuring the versine on a chord of known length, from the equation:

$$R = \frac{125\ C^2}{v}$$

Where, R is the radius of the curve in meters, C is the chord length in meters and v is the versine in millimeters. As per Schedule of Dimensions, 2004 minimum radius of curve is limited to 175 m on B.G., 109 m on M.G. and 44 m on N.G.

(2) Determination of degree of curve -The degree of a curve of radius R meter can be calculated from

$$D = \frac{360\ \times\ 30.5}{2\pi\ \times R} = \frac{1750}{R}$$

Thus radius of a 1° curve 1750 m. As per Schedule of Dimensions, 2004 maximum degree of curve is limited to 10° for B.G., 16° for M.G and 40° for N.G.

504. Super-Elevation/ Cant, Cant Deficiency and Cant Excess :

(1) Super-elevation/cant

(a) Equilibrium speed - The cant on a curve shall be provided for the equilibrium speed, which shall be decided by the Chief Engineer after taking into consideration of the followings, without appreciably affecting the speed of fast trains and their relative importance:

(i) The maximum speeds which can be actually attained by fast and slow trains,

(ii) proximity to permanent speed restriction in the route,

(iii) stopping places,

(iv) junction,

(v) gradients, which may reduce the speeds of goods trains.

For this purpose the entire section may be divided into a certain number of sub sections with a nominated equilibrium speed for each sub section, fixed on the basis of speeds which can be actually attained by fast or slow trains over the sub section, so that the need for imposing any speed restrictions for limiting the cant excess for slow trains and cant deficiency for fast trains is avoided.

Let us consider a section having the maximum permissible speed for passenger train is 120 Km/h and booked speed for goods train is 60 Km/h. The following cases may further elaborate criteria for equilibrium speed.

Case 1: If the section is carrying predominantly goods traffic then the preferable equilibrium speed shall be around 60 Km/h to minimize flattening of inner rail head.

Case 2 : If the section have predominating passenger traffic (say Rajdhani route), then the preferable equilibrium speed shall be around 120 Km/h to minimize the lateral wear of gauge face of outer rail.

Case 3 : Let us consider the section have a curve at the approach of a yard which is junction station having 30 km/h speed restriction on main line, also most of the passenger trains are stopping. The equilibrium speed for the curve shall be taken around 30 Km/h.

On sections where all trains run at about the same maximum permissible speeds, like suburban section, it will be preferable to provide cant for that speed.

(b) The amount of super-elevation to be provided for equilibrium speed 'V' is calculated from the formula

$$\mathrm{SE} = \frac{\mathrm{G\,V}^2}{127\ \mathrm{R}}$$

Where SE is super-elevation/ cant in mm, G is dynamic gauge (i.e. Gauge of track plus width of rail head) in mm, V is speed in km/h and R is radius of the circular curve in metre.

(c) Maximum permissible actual cant on curved track shall be as under –

(i) Broad Gauge– Group 'A', 'B' and 'C' routes - 165 mm.

Note: On Broad Gauge maximum cant of 185 mm may be assumed for the purpose of locating all permanent structures etc., by the side of the curves on new constructions and doubling on group 'A' routes having potential for increasing the speed in future. The transition length should also be provided on the basis of 185 mm cant for the purpose of planning and layout of the curve.

(ii) Broad gauge – Group 'D' and 'E' routes – 140 mm.

(iii) Meter Gauge – 90 mm (can be increased to 100 mm with special permission of Chief Engineer).

(iv) Narrow Gauge (762 mm) – 65 mm (can be increased to 75 mm with special permission of Chief Engineer).

Note: For Narrow gauge sections for which special schedules are prescribed by the Zonal Railways provisions in these schedules should be observed.

(d) Cant for each curve should be rounded off to the nearest 5 mm. In every case, the super-elevation to be provided should be specified when the line is originally laid and thereafter altered only with the prior approval of the Chief Engineer.

(2) Cant Deficiency – Maximum value of cant deficiency are as under:

(a)	On routes with track maintained to C&M-I, Vol-I standard for nominated rolling stocks with permission of the Chief Engineer.	100 mm
(b)	For Broad Gauge routes not covered by (a) above	75 mm
(c)	Meter Gauge	50 mm
(d)	Narrow Gauge (762 mm)	40 mm

Note: For Narrow gauge sections for which special schedules are prescribed by the Zonal Railways, provisions in these schedules should be observed.

(3) Cant Excess - The cant excess should be worked out taking into consideration the booked speed of goods trains on a particular section. In the case of a section carrying predominantly goods traffic, the cant excess should be preferably kept low to minimize wear on inner rail. The maximum values of cant excess is as under:

(a)	Broad Gauge	75 mm
(b)	Meter Gauge	65 mm

(4) Running out Super-elevation/ Cant

(a) On transitioned curves, cant should be run up or run out on the transition, not on the straight or on the circular curve, increasing or decreasing uniformly throughout its length.

(b) On non-transitioned curves, cant should be run up or run out over the *'virtual transition'* length. The concept of virtual transition is explained in *para 501(25).*

(c) Longitudinal profile of transition on the reverse curve may be in one of the following two alternatives:

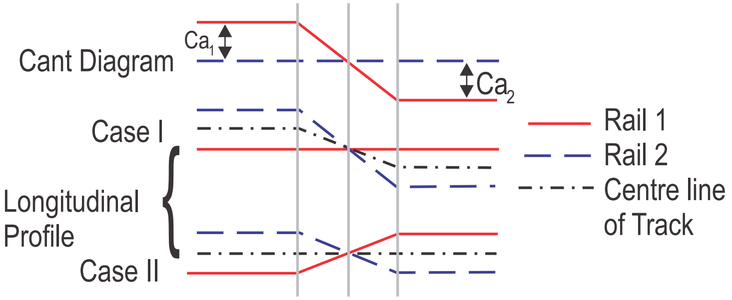


***Fig. 5.06** Running out/ in of Cant*

(i) In Case I, the level of one of the rails is maintained and the super-elevation is run out on the other rail by lowering it over half the transition length and raising it to the required amount of cant over the remaining half portion of the transition.

(ii) In Case II, the level of the centre line of the track is maintained the same throughout, and the cant is provided by raising one rail by half the amount of cant and lowering the other rail by the equal amount. Cant is run out or gained over the length of the transition by raising and lowering both the rails by equal amount symmetrically, with respect to the level of the centre line track.

In Case I, the level of the centre of the track gets disturbed whereas in Case II, it is maintained the same throughout.

(d) Special *cases of super-elevation run out may be approved by the Chief Track Engineer.*

505. Transition Curves :

(1) The desirable length of transition 'L' shall be maximum of the following three values:

(a) $L_1 = 0.008\, C_a V_m$

(b) $L_2 = 0.008\, C_d V_m$

(c) $L_3 = 0.72\, C_a$

Where L_1, L_2, L_3 is the length of transition in meter, V_m is the maximum permissible speed in km/h, C_a is the actual super-elevation on curve in millimeter and C_d is the cant deficiency in millimeter.

The formula (a) and (b) are based on rate of change of cant/ cant deficiency of 35 mm/s. The formula (c) is based on the maximum cant gradient of 1 in 720 or 1.4 mm/m.

(3) For the purpose of designing future layouts of curve, future higher speeds (such as 160 km/h for Group 'A' routes and 130 km/h for Group 'B' routes) may be taken into account for calculating the length of transitions.

(4) In exceptional cases where room is not available for providing sufficiently long transitions in accordance with the above, the length may be reduced up to 2/3 of the desirable length as worked by above formula (a) and (b) OR up to 1/2 of that calculated by above formula (c) whichever is greater. This is based on the assumption that a rate of change of cant/cant deficiency will not exceed 55 mm/s and the maximum cant gradient will be limited to 2.8 mm/m or 1 in 360. This relaxation shall apply to Broad Gauge only.

For Narrow Gauge and Meter Gauge sections, cant gradient should not be steeper than 1 in 720. For Meter Gauge the rate of change of cant/cant deficiency should not exceed 35 mm/s.

(5) At locations where length of transition curve is restricted, and therefore, may be inadequate to permit the same maximum speed as calculated for the circular curve, it will be necessary to select a lower cant and/or a lower cant deficiency which will reduce the maximum speed on the circular curve but will increase the maximum speed on the transition curve. In such cases, the cant should be so selected as to permit the highest speed on the curve as a whole.

(6) When realigning old curves, transition curves on approaches should invariably be provided. It should be ensured that there is no change of grade over the transition.

(7) Compound curves – A compound curve is formed when two or more circular curves of different radii curving in the same direction are having overlapping transition lengths. In this case common transition curve may be provided between the circular curves. Assuming that such compound curve is to be traversed at uniform speed, the length of the transition connecting the two circular curves shall be the larger of the following:

(i) $L_1 = 0.008\,(C_{a1} - C_{a2})V_m$

(ii) $L_2 = 0.008\,(C_{d1} - C_{d2})V_m$

Where C_{a1} and C_{d1} are actual cant and cant deficiency for curve No.1 in mm, C_{a2} and C_{d2} are actual cant and cant deficiency for curve No.2 in mm, L is length of transition in meter, V_m is the maximum permissible speed in km/h.

Cant gradient should be within the permissible limits as stated in *para 505(4).*

Common transition may be provided when the length of transition as worked out above is more than the length of virtual transition as specified in *para 506 (4) (a).*

(8) Reverse Curves

(a) A reverse curve is formed when two or more circular curves of different radii curving in the opposite directions are having overlapping transition lengths. In this case common transition curve may be provided between circular curves. The total length of common transition, i.e., from circular curve to circular curve shall be the greatest of the following:

(i) $L_1 = 0.008 (C_{a1} + C_{a2}) V_m$

(ii) $L_1 = 0.008 (C_{d1} + C_{d2}) V_m$

Whichever is greater, where C_{a1} and C_{d1} are actual cant and cant deficiency of curve No. 1 in mm, C_{a2} and C_{d2} are actual cant and cant deficiency of curve No. 2 in mm.

Cant gradient should be within the permissible limits as stated in *para 505 (4).*

(b) For high speeds, in group 'A' and 'B' routes, a straight with a minimum length of 50 m shall be kept between two transitions of reverse curves. In the case of M. G. high speed routes the distance to be kept will be 30 m.

On groups 'A' and 'B' routes on B. G., straights less than 50 m between reverse curves and on M. G. high speed routes, straights less than 30 m should be eliminated by suitably extending the transition lengths. In doing so, it should be ensured that the rate of change of cant and versine along the two transitions so extended is kept the same.

Whenever such straights between reverse curves can neither be eliminated nor the straight length increased to over 50 m in B. G. and 30 m in M. G. speed in excess of 130 km/h in B. G. and 100 km/h in M.G. should not be permitted.

506. Safe Speed on Curves :

(1) The *speed* on a curve shall not exceed the maximum permissible speed of the section.

(2) Curves laid with full transition length – The maximum permissible speed for transitioned curves should be determined from the following formulae:

(a)	Broad Gauge	$V = 0.27\sqrt{R(C_a + C_d)}$	G (dynamic gauge) is assumed to be 1750 mm
(b)	Meter Gauge	$V = 0.347\sqrt{R(C_a + C_d)}$	G is assumed to be 1057 mm
(d)	Narrow Gauge (762 mm)	$V = 3.65\sqrt{R - 6}$	Subject to maximum of **50 km/h**.

Where V is speed in km/h, R is radius in meter, C_a is actual cant in mm, C_d is permissible cant deficiency in mm.

(3) Curves laid with inadequate transition length – For curves laid with inadequate length of transition, the safe permissible speed should be worked out on the basis of actual cant/cant deficiency, which can be provided taking into consideration the limiting values of cant/cant deficiency gradient and the rate of change of cant and cant deficiency.

In this case, the maximum safe speed on the whole curve can be find out by equating the speed on transition curve to the speed on circular curve.

Select a lower cant and/or a lower cant deficiency, which will reduce the maximum speed on the circular curve but will increase the maximum speed on the transition curve of given length. In such cases cant should be so selected as to permit highest speed on the curve as a whole.

(a) For B.G. Route - Considering an exceptional situation the rate of change of cant/ cant deficiency will be taken as 55 mm/s. Also consider $C_a = C_d$ for equal transition length from the criteria the rate of change of cant/ cant deficiency. So, vide *para 505(1)* $L_1 = L_2$. From these two conditions the maximum possible speed on transition curve will be

$$V = \frac{55 \times 3.6 \times L}{C_a} = 198\frac{L}{C_a}$$

Equating this to safe speed on curve $V = 0.27\sqrt{R\,(C_a + C_d)}$ vide *para 506(2)* and substituting $C_d = C_a$

$$198\frac{L}{C_a} = 0.27\sqrt{R\,(C_a + C_a)}$$

Rearranging

$$C_a = 64.54\left(\frac{L^2}{R}\right)^{1/3}$$

Check for maximum permissible cant gradient and rate of change of actual cant/ cant deficiency on transition. However, value of C_d shall not be more than maximum permissible value so

$$V_m = 0.27\sqrt{R\,(C_a + C_d)}$$

(b) For M.G. Route - The rate of change of cant/ cant deficiency will be taken as 35 mm/s. Also consider $C_a = C_d$ for equal transition length from the criteria the rate of change of cant/ cant deficiency. So, vide para 505(1) $L_1 = L_2$. From these two conditions the maximum possible speed on transition curve will be

$$V = \frac{35 \times 3.6 \times L}{C_a} = 126\frac{L}{C_a}$$

Equating this to safe speed on curve $V = 0.347\sqrt{R\,(C_a + C_d)}$

vide para 506(2) and substituting $C_d = C_a$

$$126\frac{L}{C_a} = 0.347\sqrt{R\,(C_a + C_a)}$$

Rearranging

$$C_a = 40.4\left(\frac{L^2}{R}\right)^{1/3}$$

Check for maximum permissible cant gradient and rate of change of actual cant/ cant deficiency on transition. However, value of C_d shall not be more than maximum permissible value so

$$V_m = 0.347\sqrt{R\,(C_a + C_d)}$$

(4) Curves laid without transition curves

(a) With cant on virtual transition - The determination of the maximum permissible speed on curves without transition involves the concept of the virtual transition. The length of the virtual transition is equal to the distance between the bogies centers. Normally, the length of virtual transition is taken as 14.6 meter on B.G., 13.7 meter on M.G. and 10.3

meter on N.G. The cant or super-elevation is gained over the virtual transition length.

The cant gradient in any case should not be steeper than 1 in 360 (2.8 mm. per meter) on B.G. and 1 in 720 (1 .4 mm. per meter) on M.G. and N.G.

Note: This case is similar to the case of restricted transition length where transition length is equal to *virtual transition*.

(b) Without cant on virtual transition - In case of non-transitioned curves where no cant is provided, the safe speed over the curve can be worked out from the following procedure.

This case is also similar to the case of restricted transition but for actual cant C_a = 0, so rate of change of cant deficiency need special attention. Therefore, substituting C_a =0 and solving for C_d the equations arrived in *para 505(3)* will be revised as follows:

(i) For B.G $V = 198\frac{L}{C_d}$ and $C_d = 81.32\left(\frac{L^2}{R}\right)^{1/3}$

(ii) For M.G. $V = 126\frac{L}{C_d}$ and $C_d = 50.9\left(\frac{L^2}{R}\right)^{1/3}$

Where, L is virtual transition length. Check for maximum permissible rate of change of cant deficiency on transition. However, value of C_d shall not be more than maximum permissible value, now calculate V_m using above value of C_a and C_d as *per para 506 (2).*

(5) Design of Curve: Design of curve includes fixation of cant, maximum permissible speed and transition length.

(a) When equilibrium speed is known/ fixed - Radius of the curve (R) in m, is known based on alignment survey. The maximum sectional speed (V_{max}) in km/h, and booked speed of goods train (V_{goods}) in km/h and the equilibrium speed (V_{eq}) in km/h vide *para 504(1)(a)* are known.

Method statement:

Step-1: Calculate actual cant C_a for equilibrium speed V_{eq} by

$$C_a = 13.76\,\frac{V_{eq}^2}{R} \quad \text{For B.G.}$$

$$C_a = 8.32\,\frac{V_{eq}^2}{R} \quad \text{For M.G.}$$

Check: Actual cant should not be more than the maximum permissible value for the route vide *para 504(1)(c).*

Step-2: Calculate maximum permissible speed on the curve by

$$V_{prm} = 0.27 \sqrt{R\,(C_a + C_d)} \qquad \text{For B.G.}$$

$$V_{prm} = 0.347 \sqrt{R\,(C_a + C_d)} \qquad \text{For M.G.}$$

Where value of C_d shall be taken as per para504(2).

Step-3: Check for parameters

(iii) In case $V_{prm} < V_{max}$ then there would be *permanent speed restriction* because faster trains will be allowed with V_{prm} speed.

(iv) Check for cant excess:

$$C_{ex} = C_a - 13.76\,\frac{V_{goods}^2}{R} \quad \text{For B.G.}$$

$$C_{ex} = C_a - 8.32\,\frac{V_{goods}^2}{R} \quad \text{For M.G.}$$

In case C_{ex} exceeds the value given in para 504(3) limit C_{ex} and revised the actual cant by

$$C_a = C_{ex} + 13.76\,\frac{V_{goods}^2}{R} \quad \text{For B.G.}$$

$$C_a = C_{ex} + 8.32\,\frac{V_{goods}^2}{R} \quad \text{For M.G.}$$

Repeat Step-2 to obtain revise V_{prm} speed.

Check for C_d:

$$C_d = 13.76\,\frac{V_{goods}^2}{R} - C_a \quad \text{For B.G.}$$

$$C_d = 8.32\,\frac{V_{goods}^2}{R} - C_a \quad \text{For M.G.}$$

Step-4: Assessment of transition length (L) using formula given is *para 505.*

(i) In normal circumstances the transition length (L) shall be maximum of following L_1, L_2, L_3

$$L_1 = 0.008\ C_a V_m$$

$$L_2 = 0.008\ C_d V_m$$

$$L_3 = 0.72\ C_a$$

(ii) In exceptional circumstances when room is restricted to provide above transition length the transition length (L) shall be maximum of following L_1, L_2, L_3

$$L_1 = \frac{2}{3} 0.008\ C_a V_m$$

$$L_2 = \frac{2}{3} 0.008\ C_d V_m$$

$$L_3 = \frac{1}{2} 0.72\ C_a$$

Note: For B.G. both of the above (i) and (ii) are applicable whereas for M.G. only (i) of the above shall be used.

Step-5: Check rate of change of actual cant/ cant deficiency and cant gradient.

Time of travel on transition curve $t = 3.6\ L / V_{prm}$

where t in second, value 3.6 is introduced to convert speed from km/h into m/s.

rate of change of actual cant = C_a / t; mm/s

rate of change of cant deficiency = C_d / t; mm/s

Actual cant gradient = C_a / L; mm/m

The above values shall not be more than the specified values in *para 505;* otherwise revise L to suit the specified values

(b) *When equilibrium speed is not known* - Radius of the curve (R) in m, is known based on alignment survey. The maximum sectional speed (V_{max}) in km/h, and booked speed of goods train (V_{goods}) in km/h, are known. The equilibrium speed (V_{eq}) in km/h, for design of the curve is not fixed.

Method statement:

Step-1: Calculate actual cant C_a by

(i) For B.G.

$$C_{a1} = 13.76\ \frac{V_{max}^2}{R} - C_d$$

$$C_{a2} = 13.76\ \frac{V_{goods}^2}{R} + C_{ex}$$

(ii) For M.G.

$$C_{a1} = 8.32\ \frac{V_{max}^2}{R} - C_d$$

$$C_{a2} = 8.32\ \frac{V_{goods}^2}{R} + C_{ex}$$

Check: Actual cant should not be more than the maximum permissible value for the route vide *para 504(1)(c).*

Step-2: From this step onwards procedure is same as discussed in *para 506(6)(a).*

Example 5.01 - On a Broad Gauge Group 'C' route not maintained as per C&M-I Vol-I, a 600 meter radius curve is to be introduced. The maximum sectional speed is 110 km/h and the booked speed of goods train is 50 km/h. Equilibrium speed is fixed as 80 km/h. Design the curve.

Solution:

Given values - R= 600 m, V_{max} = 110 km/h, V_{goods} = 50 km/h, V_{eq} = 80 km/h.

Step-1: Calculate actual cant C_a for equilibrium speed V_{eq} by

$$C_a = 13.76\ \frac{V_{eq}^2}{R} = 13.76\frac{80^2}{600} = 146.98\text{mm}$$

say 145 mm < 165 mm O.K.

Step-2: Calculate maximum permissible speed on the curve for maximum permissible C_d and C_a calculated in Step-1.

$$V_{prm} = 0.27\sqrt{R\,(C_a + C_d)} = 0.27\sqrt{600\,(145 + 75)}$$

= 98.09 km/h say 95 km/h.

Step-3: Check for parameters

(i) In case $V_{prm} < V_{max}$ then there would be *permanent speed restriction* because faster trains will be allowed with V_{prm} speed.

(ii) Check for cant excess:

$$C_{ex} = C_a - 13.76\,\frac{V_{goods}^2}{R} = 165 - 13.76\,\frac{50^2}{600}$$

= 107.67 mm > 75 mm. Not O.K. So limit C_{ex} = 75 mm.

Calculate and revised the actual cant

$$C_a = C_{ex} + 13.76\,\frac{V_{goods}^2}{R} = 75 + 13.76\,\frac{50^2}{600} = 75 + 57.3$$

= 132.3 mm say 130 mm.

Repeat Step-2 to obtain revise V_{prm} speed.

$$V_{prm} = 0.27\sqrt{600\,(130 + 75)} = 94.69 \text{ km/h} \quad \text{say 90 km/h.}$$

Check for C_d:

$$C_d = 13.76\,\frac{V_{prm}^2}{R} - C_a = 13.76\,\frac{90^2}{600} - 130 = 185.76 - 130$$

= 55.75 mm < 100 mm O.K.

Step-4: Assessment of transition length (L) using formula given is *para 505.*

In normal circumstances the transition length (L) shall be maximum of following L_1, L_2, L_3

$$L_1 = 0.008\,C_a V_m = 0.008 \times 130 \times 90 = 93.6\text{m}$$

$$L_2 = 0.008\,C_d V_m = 0.008 \times 55.75 \times 90 = 40.14\text{m}$$

$$L_3 = 0.72\,C_a = 0.72 \times 130 = 93.6\text{m}$$

So the transition length is maximum of above is 93.6 m rounded off to next higher in multiple of 10 m i.e. L = 100 m.

Step-5: Check rate of change of actual cant/ cant deficiency and cant gradient.

Time of travel on transition curve $t = 3.6\,L / V_{prm} = 3.6x100/90 = 4$ s.

Rate of change of actual cant = $C_a / t = 130/4 = 32.5$ mm/s < 35 mm/s O.K.

Rate of change of cant deficiency = $C_d / t = 55.75/4 = 13.9$ mm/s < 35 mm/s O.K.

Actual cant gradient = $C_a / L = 130/100 = 1.3$ mm/m < 1.4 mm/m O.K.

Example 5.02 - On a Broad Gauge Group 'A' route maintained as per C&M-I Vol-I, a 1.5° curve is to be introduced. The maximum sectional speed is 130 km/h and the booked speed of goods train is 75 km/h. (a) Design the curve for exceptional circumstances. (b) Calculate the maximum permissible safe speed on the curve if the transition length is restricted to 40 m.

Solution:

Prerequisites -

$R = 1750/1.5 \approx 1167$ m, $V_{max} = 140$ km/h, $V_{goods} = 75$ km/h.

(a) Design of curve for exceptional circumstances

Step-1: Calculate actual cant C_a for equilibrium speed V_{eq} by

$$C_{a1} = 13.76\,\frac{V_{max}^2}{R} - C_d = 13.76\,\frac{140^2}{1167} - 100 = 131.1\text{mm say } 135 \text{ mm}$$

$$C_{a2} = 13.76\,\frac{V_{goods}^2}{R} + C_{ex} = 13.76\,\frac{75^2}{1167} + 75 = 141.2\text{mm say } 140 \text{ mm.}$$

Adopt lower of the above as actual cant $C_a = 135$ mm < 165 mm O.K.

Step-2: Calculate maximum permissible speed for maximum permitted C_d

$$V_{prm} = 0.27\sqrt{R\,(C_a + C_d)} = 0.27\sqrt{1167\,(135 + 100)}$$

$$= 141.4 \text{ km/h} > V_{max} \text{ O.K.}$$

Step-3: Check for parameters

$$C_{ex} = C_a - 13.76\,\frac{V_{goods}^2}{R} = 135 - 13.76\,\frac{75^2}{1167} = 68.68 \text{ mm} < 75 \text{ mm O.K.}$$

$$C_d = 13.76\,\frac{V_{prm}^2}{R} - Ca = 13.76\,\frac{140^2}{1167} - 135 = 96.10 \text{ mm} < 75 \text{ mm O.K.}$$

Step-4: Assessment of transition length (L) using formula given is para 505.

$$L_1 = \frac{2}{3} 0.008\, C_a V_m = \frac{2}{3} \times 0.008 \times 135 \times 140 = 100.8 \text{ m}$$

$$L_2 = \frac{2}{3} 0.008\, C_d V_m = \frac{2}{3} \times 0.008 \times 96.1 \times 140 = 71.75 \text{m}$$

$$L_3 = \frac{1}{2} 0.72\, C_a = \frac{1}{2} \times 0.72 \times 135 = 48.6 \text{m}$$

So the transition length is maximum of above is 100.8 m rounded off to next higher in multiple of 10 m i.e. L = 110 m.

Step-5: Check rate of change of actual cant/ cant deficiency and cant gradient.

Time of travel on transition curve t = 3.6 L / V_{prm} = 3.6x110/140 = 2.82 s.

Rate of change of actual cant = C_a/ t = 135/2.82

= 47.9 mm/s < 55 mm/s O.K.

Rate of change of cant deficiency= C_d/ t = 96.1/2.82

= 34.1 mm/s < 55 mm/s O.K.

Actual cant gradient = C_a/ L = 135/110 = 1.2 mm/m < 2.8 mm/m O.K.

(b) Calculate the maximum permissible safe speed on the curve if the transition length is restricted to 40 m.

Step-1: Calculate C_a from the consideration of restricted transition

$$C_a = 64.54 \left(\frac{L^2}{R}\right)^{1/3}$$

$$= 64.54 \left(\frac{40^2}{1167}\right)^{1/3} = 71.70 \text{mm. say 70 mm < 165 mm O.K.}$$

Step-2: Check cant gradient on transition = 70/40

$$V_{prm} = 0.27\sqrt{R\,(C_a + C_d)} = 0.27\sqrt{1167\,(70 + 70)}$$

= 1.75 mm/m < 2.8 mm/m O.K.

Step-3: Maximum permissible speed

= 109.13 km/h Say 105 km/h

Time of travel on transition curve t = 3.6 L / V_{prm} = 3.6x40/105 = 1.37 sec.

Rate of change of actual cant = C_a/ t = 70/1.37

= 51.1 mm/s < 55 mm/s O.K.

Example 5.03 - Calculate the maximum safe permissible speed on a 600 meter radius curve on Broad Gauge Group 'C' route not maintained as per C&M-I Vol-I (a) when it is not possible to provide transition curve, (b) recalculate maximum safe permissible speed when cant also cannot be provided.

Solution:

(a) Without transition curve but cant is provided-

Step1-

Calculate C_a from the consideration of virtual transition,

$$C_a = 64.54\left(\frac{L^2}{R}\right)^{1/3} = 64.54\left(\frac{14.6^2}{600}\right)^{1/3} = 45.71\text{mm Say 45 mm}$$

Step2-

Cant gradient on transition

$$= \frac{C_a}{L} = \frac{45}{14.6} = 3.08 \text{ mm/m OR 1 in 324} < \text{1 in 360 Not O.K.}$$

So revise maximum possible cant to

C_a = 14.6 x 2.8 = 40.88 mm, Say 40 mm < 165 mm O.K.

Step3-

But C_d still can be taken as 45 mm to find out maximum permissible speed.

Maximum permissible speed

$$v_{prm} = 0.27\sqrt{R\,(C_a + C_d)}$$

$$= 0.27\sqrt{600\,(40 + 45)} = 60.97 \text{ Say 60 km/h}$$

Time of travel on transition curve t = 3.6 L / V_{prm} = 3.6x14.6/60 = 0.88 sec.

Rate of change of actual cant = C_a/ t = 40/0.88

= 45.45 mm/s < 55 mm/s O.K.

Rate of change of cant deficiency= C_a/ t = 45/0.88

= 51.13 mm/s < 55 mm/s O.K.

(b) Without transition curve and without cant -

Step1-

Actual cant C_a = 0. So Cant gradient on transition is also = 0, O.K.

Calculate C_d from the consideration of virtual transition,

$$C_d = 81.32\left(\frac{L^2}{R}\right)^{1/3} = 81.32\left(\frac{14.6^2}{600}\right)^{1/3} = 57.59 \text{ mm} < 75 \text{ O.K.}$$

Step2-

Maximum permissible speed $V_{prm} = 0.27\sqrt{R\,C_d}$

$$= 0.27\sqrt{600 \times 57.59} = 50.19 \text{ Say 50 km/h}$$

Time of travel on transition curve t = 3.6 L / V_{prm} = 3.6x14.6/50 = 1.05 s.

Rate of change of cant deficiency= C_a/ t = 57.59/1.05

= 54.84 mm/s < 55 mm/s O.K.

507. Setting out Transitions :

(1) A transition curve is laid out as a cubic parabola and to accommodate this, the main circular arc is moved inwards by an amount called the "Shift".Calculate the shift for the given from the formula:

$$S = \frac{L^2}{24\,R}$$

Where S is shift, L is length of transition and R is radius of curve.

(2) Calculate the offset in meter from the tangent/ straight to any point on the transition curve is from the formula:

$$Y = \frac{X^3}{6\,L\,R}$$

Where Y is offset from the straight, X is distance from the commencement of the curve, L is length of transition and R is radius of curve.

(3) The arrangement of a transition curve is shown in the figure below:

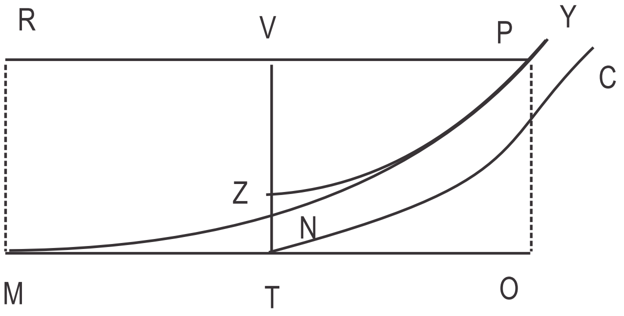


Fig. 5.07 *Arrangement of transition curve*

The original circular curve TC is tangential to the straight at T. The curve is shifted to ZY and TZ is the amount of shift. The transition curve MNP bisects the shift TZ at N. A typical example of working out maximum permissible speed on a curve, calculating the length of transition and detailed calculation of laying the transition are given in *Example 5.04.*

Example 5.04 – Calculate the offsets for setting out the transition for a 1.5° curve a Broad Gauge Group 'A' route maintained as per C&M-I Vol-I, the transition length is 160 m and the total angle of divergence between tangents is 70°.

Solution :

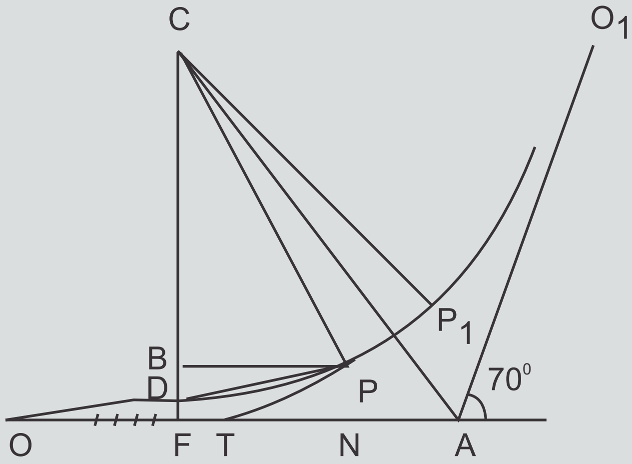


Fig. 5.08 *Tangent, transition and offset*

R = 1750/1.5 = 1167m

Calculate shift $S = \frac{L^2}{24\ R} = \frac{160^2}{24 \times 1167} = 0.9213$ m

CF = 1167 + 0.92 = 1167.92 m

FA = 1167.92 tan 35° = 817.79 m

OF = L/2 = 160/2 = 80 m

OA = 817.79 + 80 = 897.79 m

The point 'O' can be fixed by measuring this distance back from the apex.

The deviation angle for each transition is

$$= \tan^{-1}\frac{L}{2R} = \tan^{-1}\frac{160}{2x1167} = 3.9216°$$

The deviation angle for the circular curve

$$= 70° - 2 \text{ x } 3.9216° = 62.1568°$$

Length of circular arc

$$= \frac{1167x62.1568 \text{ x } \pi}{180} = 1266.00 \text{ m}$$

Offsets are required at every 20 m interval on the transition. Offset Y in meter can be calculated using $Y=\frac{X^3}{6\ LR}$ by substituting L, R and X (for X equal to 0, 20, 40 ... and so on).

The calculated values of the offset are as follows:

X (m)	0	20	40	60	80	100	120	140	160
Y (m)	0	0.007	0.057	0.193	0.458	0.894	1.545	2.454	3.663

508. Indicators/Boards Provided on Curves:

(1) Curve board – Each approach of a curve should be provided with a curve board at the tangent point fixed on the outside of the curve. This Board should indicate the radius of the curve, the length of the curve, length of transition in meter and the maximum cant and versine provided on the circular portion of curve in millimeter.

(2) Rail posts indicating beginning and end of transition curve – On the inside of the curve, rail posts should be erected on each approach of the curve, to indicate the positions of the beginning and end of transition curves. These rail posts may be painted in red and white colors respectively. In the case of non transitioned curve, similar rail post should be erected on the tangent track and on the circular curve over which the cant is run out/ run in, indicating the beginning and end of the virtual transition.

(3) Indication of cant on track – Cant and versine should be indicated by painting its value on the inside face of the web of the outer rail of the curve at every station, beginning with zero at the commencement of the transition curve. Following template may be followed *(Fig. 5.09)*

Additionally, on web of inner rail at every station a vertical mark indicating station is also painted.

Fig. 5.09 *Template showing station, versine and super elevation.*

(4) When curves are realigned, the repositioning of the curve boards and posts and repainting of values of cant and versine at every station should be done. Simultaneously details of the curve recorded in the *Track Management System* (TMS) shall also be updated.

509. Speed on Turnout on Curved Track:

(1) Provision in general rules - Relevant *para 4.10 of General Rules, 1976* Edition is reproduced below:

"(a) The speed of trains over non-interlocked facing points shall not exceed 15 kilometer per hour in any circumstances and the speed over turnouts and crossovers shall not exceed 15 kilometer per hour, unless otherwise prescribed by approved special instruction, which may permit a higher speed.

(b) *Subject to provision of sub-rules (a) a train may run over interlocked facing points at such speed as may be permitted by the standard of interlocking.”*

(2) Turnouts on running lines with passenger traffic –Turnouts in running lines over which passenger trains are received or dispatched should be laid with crossing, not sharper than 1 in 12 for straight switches. However, 1 in 8½ turnouts with curved switches may be laid in exceptional circumstances, where due to limitation of room, it is not possible to provide 1 in 12 turnouts. Sharper turnouts may also be used when the turnouts is taken off from outside of a curve, keeping the radius of lead curve within the following limits:

	Gauge	Minimum radius of lead curve
(a)	Broad Gauge	350 m
(b)	Meter Gauge	220 m
(c)	Narrow Gauge (762 mm)	165 m

Where it is not practicable to achieve the radius of curvature of turn in curves as specified above on account of existing track centers for the turnouts taking off from curves, the turn-in curves may be allowed up to a minimum radius of 220 m for B.G. and 120 m for M.G. subject to the following:

(a) Such turn-in curves should be provided either on PSC or steel trough sleepers only, with sleeper spacing same as for the main line.

(b) Full ballast profile should be provided as for track for main line

Emergency crossovers between double or multiple lines which are laid only in the trailing direction may be laid with 1 in 8½ crossings.

In the case of 1 in 8½ turnouts with straight switches laid on passenger running lines, the speed shall be restricted to 10 km/h. However, on 1 in 8½ turnouts on non passenger running lines, speed of 15 km/h may be permitted.

(3) Speed over interlocked turnouts - Speed in excess of 15 km/h may be permitted for straights of interlocked turnouts only under approved special instructions in terms of *G & SR 4.10.*

In the case of 1 in 8½, 1 in 12 and flatter turnouts provided with curved switches, higher speeds as permitted under approved special instructions may be allowed on the turnout side, provided the turn-in curve is of a standard suitable for such higher speeds. While permitting speed beyond 15 km/h, provisions of *para 509(4)* may be kept in view.

The permissible speed on turnouts taking off on the inside of the curve should be determined by taking into consideration the resultant radius of lead curve which will be sharper than the lead curve for turnouts taking off from the straight. 1 in 8½ turnouts should not be laid on inside of curves.

(4) Up gradation of speeds on Turnouts and Loops to 30 km/h -

(a) Length of Section - Up gradation of speeds on turnouts should cover a number of contiguous stations at a time so as to derive a perceptible advantage of the higher speed in train operation. The works described below, should cover all the running loops on the stretch of line taken up.

(i) Turnouts - Speed, in excess of 15 km/h, should be permitted on turnouts laid with ST or PRC sleepers only. All turnouts on the running loop shall be laid with curved switches, with minimum rail section being 52 Kg. All rail joints on these turnouts should also be welded to the extent possible.

For different type of curved switches permissible speed are as under:

Sl. No.	Type of Turnout (BG)	Permissible speed
(a)	1 In 8.5 curved switch	15 km/h
(b)	1 in 8.5 symmetrical sp lit with curved switches	30 km/h
(c)	1 in 12 curved switch	30 km/h

(ii) Track on running loops - Speed in excess of 15 km/h, should not be permitted on running loops laid with wooden sleepers. The minimum track structure on the running loops should be 90R rails laid as Short Welded Panels, M + 4 densities on PRC, ST, CST-9 sleepers and 250 mm ballast cushion. Out of 250 mm total cushion, clean cushion of 150 mm at least should be available. Proper drainage of the area should also be ensured.

(iii) Turn-in curves - Speed in excess of 15 km/h, should not be permitted on Turn-in curves laid with wooden sleepers. Turn-in curves should be laid with the same rail section as on the turnout with PRC, ST or CST-9 sleepers with sleeper spacing being 65 cm centre to center (maximum).

Turn-in curves should conform to *para 509 (2)* and especially so in respect of curvature of the lead curve.

Extra shoulder ballast of 150 mm should be provided on outside of the turn-in curves.

The frequency of inspection of turn-in curves should be same as that for main line turnouts.

(b) The following should be ensured, if CST-9 sleepers are used in running loops or turn-in curves:

(i) There is no crack or fracture at rail seat in two consecutive sleepers.

(ii) There is no excessive wear of lug and rail seat.

(iii) All the fittings, keys, cotters and tie bars are fitted properly. Rail is held firmly with sleepers.

(iv) Tie bars should not be broken or damaged by falling brake gear; wagon parts etc. and they should not have excessive corrosion or elongated holes. The corrosion of tie-bars inside the CST-9 plate should be especially checked as these results in their removal and adjustment becoming difficult.

(c) The following should be ensured, if ST sleepers are used in turnouts, turn-in curves or running loops:-

(i) There is no crack or fracture at rail seat in two consecutive sleepers.

(ii) There is no excessive wear of lug, MLJ and rail seat.

(iii) All the fittings are effective and rail is held with sleepers properly.

(iv) The sleepers and fittings do not have excessive corrosion, elongated holes etc.

(5) Permissible Speed over curved Main line at Turnouts – The permissible speed on the main line is determined from the allowable cant deficiency and maximum cant on the main line. The permissible speed on the main line will be worked out by the formula as given in *para 506 (2).* The speed so determined shall be subject to the permissible run through speed governed

by the standard of interlocking and the sectional speed.

Provision of super-elevation over turnouts **–** There should be no change of cant between points 20 meter on B. G., 15 meter on M. G., and 12 meter on N. G. outside the toe of the switch and the nose of the crossing respectively, except in cases where points and crossings have to be taken off from the transitioned portion of a curve.

Normally, turnouts should not be taken off the transitioned portion of a main line curve. However, in exceptional cases, when such a course is unavoidable a specific relaxation may be given by the Chief Engineer of the Railway. In such cases change of cant and/or curvature may be permitted at the rates specified in *para 505* or such lesser rates as may be prescribed.

Effective radius of turnout - In case the turnout is taking off from inside of the mainline curve as shown in following *Fig. 5.10*, then flexing direction of the effective curve on turnout is always same as that of the main line curve.

The effective radius can be found by $\frac{1}{R_e} = \frac{1}{R_m} + \frac{1}{R_t}$.

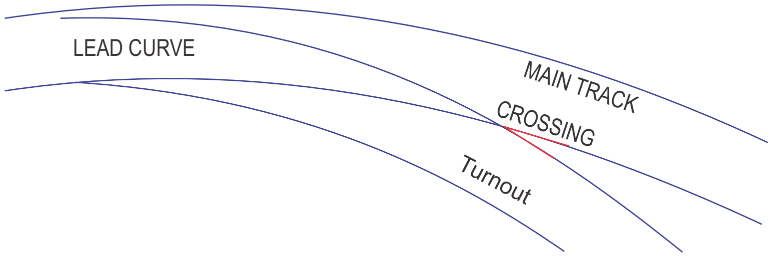


Fig. 5.10 *Turnout taking off from inside of main line curve.*

In case the turnout is taking off from outside of the mainline curve, then flexing direction of the effective curve on turnout will be in the direction of curve of sharper curvature as shown in following *Fig. 5.11.*

The effective radius can be found by $\frac{1}{R_e} = \frac{1}{R_m} - \frac{1}{R_t}$.

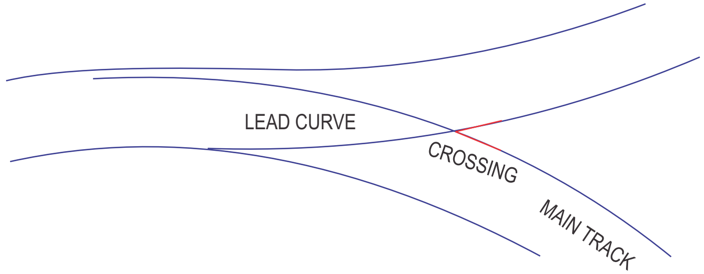


Fig. 5.11 *Turnout taking off from outside of main line curve.*

If the flexing of the effective curve is same as that of the main line then the turnout is called similar flexure otherwise contrary flexure. The flexing of turnout shall not be confused with the left/right hand (LH/RH) turnout.

For example, for right hand (RH) main line curves if turnouts flex in RH then it is similar flexure turn out. Further if turn out is taking off from the inner side of the main line curve then it is RH turnout, otherwise if turnout takes of from outside of main line curve then turn out is left hand (LH) turn out.

(a) *Speed on contrary flexure* – In the case of contrary flexure, the cant provided on mainline becomes negative cant for the turnout. The maximum cant on the main line is the difference between the maximum permissible cant deficiency and equilibrium cant for turnout determined vide *para 504(1).*

The permissible speed on the main line is then determined from the allowable cant deficiency and maximum cant on the main line.

Method statement *Speed on contrary flexure*:

Step-1: Find out effective radius of turnout,

$$\frac{1}{R_e} = \frac{1}{R_m} - \frac{1}{R_t}$$

Step-2: Find out equilibrium cant required for turn out track, where trains are permitted to run with speed V_t,

$$SE_t = \frac{G\ V_t^2}{127\ R_e}.$$

For B.G. $SE_t = 13.76\,\frac{V_t^2}{R_e}$ assuming G = 1750 mm and for

M . G . $SE_t = 8.32\,\frac{V_t^2}{R_e}$ assuming G = 1057 mm

Step - 3: Cant on main line shall be equal to $C_a = C_d - SE_t$ where C_d is is the maximum cant deficiency permitted on the turnout.

Step - 4: Maximum Permissible speed on main line can now be calculated as per *para 506(2).*

(b) *Curves of similar flexure* – In the case of similar flexure, cant on turnout is positive. The maximum cant on the main line is the sum of equilibrium cant for the turnout and maximum permissible cant excess.

The permissible cant on main line is restricted for the following situations:

(i) Turnout not followed by reverse curves - On a main line curve from which a curve of similar flexure takes off, not followed immediately by a reverse curve, the turnout curve shall have the same cant as the main line curve.

(ii) Turnout followed by reverse curves – A change of cant on the turnout may be permitted starting behind the crossing and being run out at a rate not steeper than 2.8 mm/m and subject to the maximum cant on the main line turnout being limited to 65 mm. on Broad Gauge, 35 mm on Meter Gauge and 25 mm on Narrow Gauge (762 mm)

The permissible speed on the main line is then determined from the allowable cant deficiency and maximum cant on the main line.

Method statement:

Step-1: Find out effective radius of turnout,

$$\frac{1}{R_e} = \frac{1}{R_m} - \frac{1}{R_t}$$

Step-2: Find out equilibrium cant required for turn out track, where trains are permitted to run with speed V_t

$$SE_t = \frac{G\ V_t^2}{127\ R_e}$$

For B.G. $SE_t = 13.76\,\frac{V_t^2}{R_e}$ assuming G = 1750 mm and

For M.G. $SE_t = 8.32\,\frac{V_t^2}{R_e}$ assuming G = 1057 mm.

Step-3: Cant on main line shall be equal to $C_a = C_{ex} + SE_1$

Step-4: Maximum Permissible speed on main line as per para 506(2).

Example 5.05 – Find out the maximum permissible speed on the main line curve, if permissible speed on 1 in 12 turnouts is 30 km/h. Turnout is taking off from outside of curve. If degree of main line curve is (a) 3° and (b) 5°

Solution:

For I in 12 turnout R_t = 441.36 m

(a) Degree of main line curve is 3°

$R_m = 1750/3 = 583.3$ m

Step-1: Find out effective radius of turnout,

$$\frac{1}{R_e} = \frac{1}{R_m} - \frac{1}{R_t} = \frac{1}{583.3} - \frac{1}{441.36}$$

$\Rightarrow R_e = -1813.4$ i.e. contrary flexure

Step-2: Find out equilibrium cant required for turn out track

$$SE_t = \frac{1750 \text{ x } 30^2}{127 \text{ x } 1813.4} = 6.84 \text{ say 7 mm,}$$ Note : *Negative cant*

Step 3 : Cant on main line shall be equal to

$$C_a = C_d - SE_t = 75 - 7 = 68 \text{mm say 65 mm.}$$

Step-4: Maximum Permissible speed on main line

$$V_{prm} = 0.27\sqrt{R_m(C_a + C_d)} = 0.27\sqrt{583.3\ (65 + 75)}$$

= 77.16 km/h Say 75 km/h

(b) Degree of main line curve is 5°

$R_m = 1750/5 = 350$ m

Step-1: Find out effective radius of turnout,

$$\frac{1}{R_e} = \frac{1}{R_m} - \frac{1}{R_t} = \frac{1}{350} - \frac{1}{441.36}$$

$\Rightarrow R_e = 1690.8$ m, i.e. similar flexure

Step-2: Find out equilibrium cant required for turn out track

$$SE_t = \frac{1750 \text{ x } 30^2}{127 \text{ x } 1690.8} = 7.33 \text{ say 7 mm.}$$

Step-3: Cant on main line shall be equal to

$$C_a = C_{ex} + SE_t = 75 + 7 = 82 \text{mm say 80 mm}$$

Step-4: Maximum Permissible speed on main line

$$V_{prm} = 0.27\sqrt{R_m(C_a + C_d)} = 0.27\sqrt{350\ (80 + 75)}$$

= 62.89 km/h Say 60 km/h.

Example 5.06 – A 1 in 12 turnout takes off from inside of a 4° curve; find out the maximum permissible speed on the main line if permissible speed on turnout is 30 km/h (a) Turnout not followed by reverse curves and (b) Turnout followed by reverse curves.

Solution:

$R_m = 1750/4 = 437.5$ m

$R_t = 441.36$ m

Step-1: Find out effective radius of turnout,

$$\frac{1}{R_e} = \frac{1}{R_m} + \frac{1}{R_t} = \frac{1}{437.5} + \frac{1}{441.36} \Rightarrow R_e \cong 220\text{m}, < 350 \text{ m}$$

may be permitted under exceptional circumstances.

Step-2: Find out equilibrium cant required for turn out track, where trains are permitted to run with speed say V_t,

$$SE_t = \frac{1750 \text{ x } 30^2}{127 \text{ x } 220} = 56.37\text{mm say 55 mm.}$$

(a) Turnout not followed by reverse curves

Step-3: Cant on main line shall be equal to

$$C_a = C_{ex} + SE_t = 75 + 55 = 130\text{mm}$$

Step-4: Maximum Permissible speed on main line

$$V_{prm} = 0.27\sqrt{R_m(C_a + C_d)} = 0.27\sqrt{437.5\ (130 + 75)}$$

= 80.86 km/h Say 80 km/h

(b) Turnout followed by reverse curves

Step-3: Cant on main line shall be equal to

$C_a = 131.37$ mm > 65 mm, Not O.K. $C_a = 65$ mm

Step-4: Maximum Permissible speed on main line

$$V_{prm} = 0.27\sqrt{R_m(C_a + C_d)} = 0.27\sqrt{437.5\ (65 + 75)}$$

= 66.82 km/h Say 65 km/h

(c) Curves with crossovers – On curves on double line connected by crossover road, the speed and the cant for both roads are governed by the inner road to which the cross over road is a curve of contrary flexure. On the outer road, it is a curve of similar flexure as shown in following *Fig. 5.12.* The permissible speed and the necessary cant on the inner road shall be calculated in accordance with *para 509(5)(a).* The same speed and the same cant shall be allowed on the outer road.

The outer track shall be raised so that both roads lie in the same inclined plane in order to avoid change in cross-level on the cross over road. Where this is not possible, both main line and the turnout should be laid without cant and suitable speed restriction imposed.

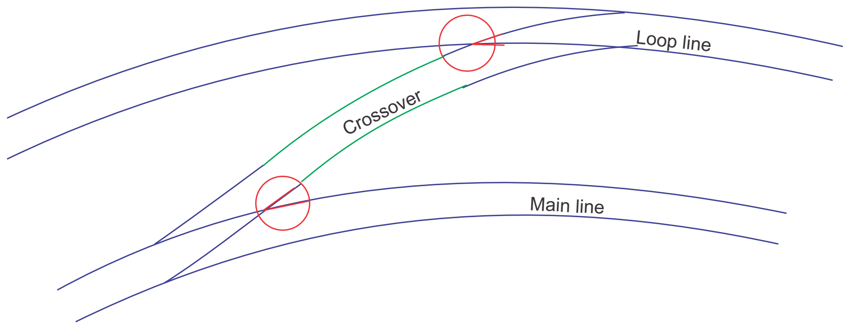


Fig. 5.12 *Crossover joining curved main line and loop line*

(d) *Curves with diamond crossing* – Normally straight diamond crossings should not be provided in curves as these produce kinks in the curve and uniform curvature cannot be obtained. However, where provision of such diamonds cannot be avoided or in case where such diamonds already exists in the track, the approach curves of these diamonds should be laid without cant for a distance of at least 20 m. on either side of the diamond crossings. Cant should be uniformly run out at the rate specified in *para 505* beyond 20 m. The speed restrictions on the approach curve shall be decided in each case by the Chief Engineer taking into consideration the curvature, cant deficiency and lack of transition but shall in no case be more than 65 km/h in the case of Broad Gauge, 50 km/h in the case of Metre Gauge and 40 km/h in the case of Narrow Gauge (762 mm). No speed restriction shall, however be imposed on the straight track on which the diamond is located. In the case of diamond crossings on a straight track located in the approach of a curve, a straight length of minimum 50 m. between the curve and the heel of acute crossing of diamond is necessary for permitting unrestricted speed over the diamond, subject to maximum permissible speed over the curve from considerations of cant deficiency, transition length etc.

510. Extra Clearances on Curves :

(1) Allowance to be made - The additional clearance to be given on the inside of a curve must include the effect of curvature, the lean due to super elevation, and an allowance for any additional sway of the vehicles over that already provided for in the clearance on straight tracks. The additional clearance to be given on the outside of a curve must allow for the effect of curvature. Additional sway or lurch due to curve can be considered as fully counteracted by the inward lean of the vehicle due to super elevation.

(a) *Allowance for curvature* - The allowance for curvature for a 21340 mm long vehicle having spacing between bogie centres 14900 mm shall be calculated as under:

(i) Over throw- At the centre of vehicle

$$V_o = \frac{14.900^2 \times 1000}{8 \times R} = \frac{27751}{R} \text{ mm}$$

(ii) End throw- At the end of vehicle

$$V_e = \frac{21.340^2 \times 1000}{8 \times R} - \frac{27751}{R} = \frac{29173}{R} \text{ mm}$$

Where R is the radius of the curve in metres

(b) *Allowance for super-elevation* - The lean *(l)* due to super elevation at any point at height 'h' above rail level is given by:

$$l = \frac{h \times SE}{G}$$

where SE is the super elevation G is the gauge of the track plus width of rail head.

(c) *Allowance for additionals way on curves* - The provision for additional lurch and sway on the inside of a curve is taken as one-fourth of the lean due to super elevation.

Accordingly additional clearance on curves under various situations shall be worked out as under

(2) Extra clearances on Platforms – It is undesirable to provide additional clearance for the platforms as this will create gap between the stationary coach and platform edge. For platforms the total additional clearance to be provided is:

On the inside of a curve: $v_0 + 1.25\,L - 51$ mm

On the outside of a curve: $v_e - 25$ mm

(3) Extra clearances required between adjacent tracks:

(a) *When no permanent structure in between track* - The worst case will be when the end of a bogie carriage on the inner track is opposite the centre of a similar carriage on the outer track. Nothing is allowed for super elevation, it being assumed that both tracks will be inclined the same amount. Though there are cases where a different super elevation is provided on each track = Extra clearance to be provided shall be = $v_e + v_0 + 2 * sway$

Extra clearance up to 5° curves have been accounted for the track spacing 5300 mm, vide Schedule of Dimensions, 2004.

(b) *When permanent structure located in between track* – The clearance for permanent structure shall be separately calculated for outer and inner curve. The total clearance will be sum of above clearances and width of the structure across the track. Extra clearance to be provided shall be

= $v_e + v_0 + 1.25\,l$ + width of structure.

Note: While locating any permanent structures by the side of the track in the case of trunk routes on main lines which have the potential for the increase of speed in future, the need for additional clearances for realignment of curves for higher speed operation should be kept in view.

The particulars of the extra clearances necessary on curves between structures and the adjacent track and between tracks when there are no structures are given in additional appendix of Schedule of dimension for extra clearances on curves for maximum speed of 200 km/h. The same should be followed when high speeds of the order of 160-200 km/h are contemplated.

511. Vertical Curve :

(1) A vertical curve shall be provided only at the junction of the grade when the algebraic difference between the grades is equal to or more than 4 mm/m or 0.4 per cent. Suppose 1 in 100 ascending gradient meets with 1 in 200 descending gradients, the algebraic difference of grade shall be

10 mm/m – (- 5 mm/m) = 15 mm/m

The minimum radius of the vertical curve shall be kept as under –

Broad Gauge		Metre Gauge	
Group	Minimum Radius	Group	Minimum Radius
A	4000 metres	All Routes	2500 metres
B	3000 metres		
C ,D & E	2500 metres		

512. Compensation for Curvature on Gradient :

(1) Compensation for curvature should be given in all cases where the existing gradient when added to the curve compensation exceeds the ruling gradient. The compensation to be allowed should ordinarily be:

Gauge	Grade compensation (In terms of Radius)	Grade compensation (In terms of curvature)
BG	70/ R	0.04% per degree
MG	52.5/ R	0.03% per degree
NG	35 /R	0.02% per degree

Thus for a ruling gradient of 0.5 per cent or 1 in 200, the actual gradient required to be constructed for 583 metre radius of curvature on Broad Gauge should be

$$= 0.5 - \frac{70}{583} = 0.38\ \%$$

OR

$= 0.5 - 3 \times 0.04 = 0.38\%$ (i.e. 1 in 264.)

513. Running on Curves :

(1) For smooth and satisfactory running on curves –

(i) There should be no abrupt alteration of curvature and/or super-elevation (cant), and

(ii) The super-elevation should be appropriate to the curvature, at each point.

(2) Each curve must be checked by SSE/P.Way (in-charge) and his assistants as well as by ADEN as per prescribed schedule. Such checks should also be carried out whenever the running over curves is found to be unsatisfactory.

The versines, super-elevation, and gauge should be recorded as per the pro forma given as *Annexure 5/1* in *Curve Register in TMS*. The decision to realign should be taken by the SSE/P.Way (in-charge) or ADEN. The realignment of curve should be carried out in dry season and not during rainy season except when this is unavoidable.

(3) Any addition / deletion/ alteration of curve and its parameter shall be reflected into *TMS*.

514. Criteria for Curve Realignment :

(1) When as a result of inspection by trolley or from the footplate of locomotive or by carriage or as a result of Track Recording carried out, the running on a curve is found to be unsatisfactory, the curve should be realigned.

(2) The running over a curve depends not only on the difference between the actual versine and the designed versine but also on the station-to-station variation of the actual versine values. This is because it is the station to station variation of versine, which determines the rate of change of lateral acceleration, on which depends the riding comfort.

(3) Service limits for station to station variation for 3 speed group viz., Below 140 km/h and up-to 110 km/h, Below 50 km/h should be considered as tabulated below:

Speed on curve	Service Limits of station to station Variation (mm)
Below 140 km/h and up to 110 km/h	10 mm (15 mm for speed 110 km/h) or 20% of the average versine on circular portion, whichever is more
Below 110 Km/h and upto 50 Km/h	20 mm or 20% of the average versine on circular portion, whichever is more.
Below 50 km/h	40 mm or 20% of the average versine on circular portion, whichever is more.

In case of exceeding of the above limit is observed during an inspection, local adjustments may be resorted to in cases where the variation of versions between adjacent stations is only at few isolated locations, at the earliest possible. If more than 20% of the stations are having versine variation above the limits prescribed, complete realignment of the curve should be planned within a month.

515. String Lining Method :

(1) General Principles -The method is based on following basic principles –

(a) The Sum total of versines between the two tangents remains the same, provided the chord length is identical. In other words, i.e. sum total of versines on existing curve = Sum total of versines on proposed curve.

(b) The slew applied at a station affects the versines at the adjacent stations by half the amount in the opposite direction provided the track is not disturbed at the adjacent stations.

(c) The second summation of versine difference represents half the slew at any station.

(d) At the first and at the last station, the slews should be zero.

(2) Stages of curve realignment - Curve realignment by string lining method consists of the following operations.

(i) Survey of curve by measurement of existing versines in the field.

(ii) Computation of slews and proposed versines on revised alignment including provision of correct super-elevation.

(iii) Stacking i.e. marking the centre line the proposed curves in the field.

(iv) Slewing the curve on revised alignment and providing correct cant.

(a) Survey of existing versines of curve

i) Chord length - Versine is measured on the gauge face of the outer rail of the curve at 10 m intervals, on 20 m chords.

ii) Equipment

- Nylon chord or piano wire of sufficient length (say 25 m)
- A measuring scale
- Wooden cubes or special gadgets - Cubes or special gadgets are used to measure negative versines, for flat curves and for transitions. They also help in applying the pull on the chord, which is otherwise difficult to apply.

(iii) Measurement of versines

- Outer rail is treated as the reference rail and measurements are taken on the gauge face, 14 mm below the rail top where the gauge is measured.
- To make sure that full curve is included in the survey, 3 stations before the apparent starting point of the curve are included in the survey.

  Similarly 3 stations after the apparent end point of curve are included in the survey.
- From the first station half chord lengths are marked on the rail, starting from one end to the other end, and numbered serially -3, -2, -1, 0, 1, 2, 3, 4…… These points are called “stations” and are marked using white paint on the gauge face of the rail.
- A piano wire or nylon chord is stretched between two stations 20 meters apart (say 0 & 2) and offset (versine) is measured at the mid station (Station 1).
- Similarly versines at all the stations are measured including those before start of the curve and after the end of the curve.
- Precaution should be taken to ensure the correctness of versines. String should be tightly stretched between the stations for measuring versines. If the string is loose, reading of versine will change on applying more force. Such a pull should be applied on the string that the versine reading does not change even after applying more pull.
- The existing super-elevation should also be measured and recorded against each “Station”.
- Features (obligatory points) such as girder bridges, level crossings, signal posts and OHE masts, columns of FOBs/ROBs etc, which restrict slewing of the track either inwards or outwards should be recorded, mentioning the maximum extent inwards and outwards to which slewing is possible:
  - in existing circumstances and
  - if a moderate expenditure is incurred in removing the “restriction”.

- Where there are two or more lines, track centers at regular intervals should be recorded. This is required to find out maximum possible slew outward & inward of line.
- The curve alignment shall not be disturbed until the realignment is commenced. The interval between the survey of the versines and realignment should be the least possible.
- In the case of reverse curves, the versine survey should be continuous, but transferred to the outer rail at points where the curvature changes sign. It is probable that the exact point will not be definite; it is therefore, desirable to keep the original rail face as the base until the change is certain to enable plus or minus versines to be read from the same rail. It is only necessary to hold the fishing chord or wire 20 mm clear of the rail edge at each end and subtracting 20 mm from the readings at the centre.
- The survey of curve would be in the following format:

Curve no: ------

Curve from km...............................to km...........……...........

Between station.............................and station........................

Date of survey..……....

Jurisdiction of Assistant Engineer/Permanent Way Engineer…….

Station at Half-chord intervals	Versine in (mm)	Cant existing	Remarks regarding restrictions to slewing
0	0	0	
1	2	5 mm	
2	4	10 mm	
3	4	20 mm	
4	10	25 mm	
5	11	..	1.6 meters.
6	23	..	Girder Bridge obligatory point
7 etc., etc.	30	..	Low or high bank, moorum or rock cutting etc.

(3) Determination of revised alignment and computation of slews -

(a) After recording the versines in mm, proposed versines are selected in such a way as to obtain uniform rate of change of versines over the transition curve and uniform versines over the circular portion of the curves. The transition length is calculated based on *para 505.*

(b) The difference between the proposed and the existing versines are worked out for each station, the positive sign being used, if the proposed versine is greater than the existing versine and negative sign if it is less *(Ref. Col. 4 -Table 5.01)* wherein a solution to a realignment of curve is worked out).

(c) First and second summations of the differences of proposed and existing versines are then worked out *(Ref. Cols. 5 & 6).*

(d) The first summation at any station gives the cumulative versine difference at each station. To begin with this value for station '0' is the same as the versine difference *(Col. 4)*. To obtain the corresponding value for station No. 1 the cumulative versine difference of station '0' *(Col. 5)* is added to the versine difference of station No. 1 *(Col. 4)* diagonally downward as shown by the arrow indication and the resultant value is written against Station No. 1 *(Col. 5)*. Similarly the cumulative versine difference is calculated at each station till the last station is reached. Since the sum total of the existing and the proposed versines is the same, the figure against the last station will be '0' *(Col. 5).*

(e) The second summation at any station gives the cumulative effect of the figures of first summation up to the previous station. This represents half the slew required at each station to obtain the proposed versine. To start with, this value for station '0' is taken as zero. To obtain the corresponding value of Station No. 1, the second summation value of the station '0' (i.e., the previous station) is added to the first summation value of the same station '0', as shown by horizontal arrow. This value is shown against Station No. 1 *(Col. 6)*. Similarly the second summation for Station No. 2 is the sum of the figures of the first summation and second summation of Station No. 1 *(Col. 5 and 6)*. The second summation is obtained against each station till the last station is reached. The slew at the last station should be zero. Otherwise the track beyond the last station will be affected by the slew at the last station. Normally this figure at the last station will not be zero. To bring this to zero correcting couples are applied.

(f) Method of applying correcting couples - For correcting the half-throws to zero the procedure shall be as follows:

When the final half-throw is negative, add to the versines having the lower station numbers and subtract an equal amount from the versines having the higher station numbers, selecting "station" in pairs such that the sum of the products of the difference of the "station" numbers taken in pairs and the amount added/ subtracted to the versines, equals the numerical amount of the negative half-throw to be cleared.

When the final half - throw is positive, subtract from the versines having the lower station numbers and add an equal amount to the versines having the higher station numbers, selecting the stations in pairs such that the sum of the product of differences of the station numbers in pairs and the amount subtracted/added from the versines, equals the numerical amount of the positive half throw to be cleared.

(g) Maximum slew - Maximum slew at any station is usually limited by practical considerations. The distance between tracks and adequate clearance to existing structures must be maintained and track must not be slewed too near the edge of the formation. At certain locations like bridges, it may not be possible to slew the curve at all

(h) In carrying out the calculations for the realignment of a long curve of more than 50 stations, it is best to write down values of about 10 proposed versines at a time and see that the sum is approximately the same as that of the corresponding existing versines and then workout the second summation to ensure that slews are minimum. A final adjustment to ensure that the sum of the existing and proposed versines is equal and that the slew at last station is zero can then be made.

(i) A numerical example is given in the *Table 5.01,* which illustrates the method of working out the solution for complete realignment of a curve and *Table 5.02* illustrates the method for local adjustments.

Alternatively proposed versines can be worked out using suitable software for alignment of curves. One such software developed by M.S. Ekbote, Rtd. AM/CE/Railway Board is available at www.iricen.gov.in.

(4) Slewing the Curve to Revised Alignment

(a) The revised alignment of the curve should be staked out with a steel tape by using the pegs cut from the tie bars (or wooden stakes with tack marks).

(b) The pegs should be fixed on the cess on the inner side of the curve square to the track and at such a distance according to the value of the slews, so that the final alignment of the track is at specified distance vide, from the face of the pegs to the outer edges of the inner rail.

(c) In narrow cuttings with sharp curves or in tunnels it may not be possible to measure versines on the pegs driven on the inner cess of the curve due to the face of the cutting fouling the fishing chord. In such cases, the pegs may be driven on the outer cess. Their correctness should be checked, by measuring the versines on these pegs, and verifying that they correspond with the final versines of the alignment.

(d) The curve should, then, be correctly slewed by taking reference of these pages.

(e) In no case permanent pegs are fixed on formation that is not firm or at locations where they are liable to get disturbed or tampered with.

(f) Where it is considered more expedient, the staking of the realigned curve may be done by driving tie-bar pegs of about 750 mm in length against each station down to rail level along the center line of the revised alignment and slewing the track to these pegs.

(g) It is important that the slewing is done to 2 mm accuracy and actual versines again taken to ensure that they accord with the calculated versines of the realigned curve.

(h) Along with slewing of the curve; correct station number, versine, and super-elevation should be repainted. Various indicators, vide para 508, shall be revised, and relocated as required. Simultaneously these values shall also be corrected in the curve register/ TMS.

Table 5.01 **-** *Realignment of curve by string lining method*

Station No.	Existing versines in mm on 20m chord	Proposed versine in mm.	Versine difference column 3-column 2	1st summation of versine difference	2nd summation of versine difference or half throw in mm in mm	Correcting Couple			Resultant half slew Col.9+Co.6 in mm.	Resultant full slew in mm	Resultant versine in mm col.3+col.7
						Correcting versine in mm	1st summation of correcting versine	2nd summation of correcting versine			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
0	2	2	0	0		-1	-1	0	-0	0	1
1	0	8	+8	+8	0	-1	-2	-1	-1	-2	7
2	14	16	+2	+10	+8	-1	-3	-3	+5	+10	15
3	28	24	-4	+6	+18	-1	-4	-6	+12	+24	23
4	30	32	+2	+8	+24	-1	-5	-10	+14	+28	31
5	36	32	-4	+4	+32	-1	-6	-15	+17	+34	31
6	36	32	-4	0	+36	-1	-7	-21	+15	+30	31

8	32	32	0	+8	+44		-8	-36	+8	+16	32
9	28	32	+4	+12	+52		-8	-44	+8	+16	32
10	36	32	-4	+8	+64		-8	-52	+12	+24	32
11	34	32	-2	+6	+72		-8	-60	+12	+24	32
12	32	32	0	+6	+78		-8	-68	+10	+20	32
13	34	32	-2	+4	+84	+1	-7	-76	+8	+16	33
14	36	32	-4	0	+88	+1	-6	-83	+5	+10	33
15	24	32	+8	+8	+88	+1	-5	-89	-1	-2	33
16	24	24	0	+8	+96	+1	-4	-94	+2	+4	25
17	28	16	-12	-4	+104	+1	-3	-98	+6	+12	17
18	0	8	+8	+4	+100	+1	-2	-101	-1	-2	9
19	6	2	-4	0	+104	+1	-1	-103	+1	+2	3
20	0	0	0	0	+104	+1	0	-104	0	0	1

+ ve Slew inside. – ve Slew outside

Illustration on local adjustment: The above example is worked out again to explain the local adjustment using string lining method. Stations from 5 to 10 are select to rectify the versine at stations 7 and 9. It can be seen from Table 5.02 that the amount of slew is very less in this case.

***Table 5.02** - Local adjustment of curve by string lining method*

Station No.	Existing versines in mm on 20m chord	Proposed versine in mm.	Versine difference column 3-column 2	1st summation of versine difference	2nd summation of versine difference or half throw in mm	Correcting Couple			Resultant half slew Col.9+Co.6 in mm.	Resultant full slew in mm	Resultant versine in mm col.3+col.7
						Correcting versine in mm	1st summation of correcting versine	2nd summation of correcting versine			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
5	36	32	-4	-4		+1	+1		0	0	33
6	36	32	-4	-8	-4	+1	+2	+1	-3	-6	33
7	24	32	+8	0	-12		+2	+3	-9	-18	32
8	32	32	0	0	-12		+2	+5	-7	-14	32
9	28	32	+4	+4	-12	-1	+1	+7	-5	-10	31
10	36	32	-4	0	-8	-1	0	+8	0	0	31

+ ve Slew inside. –ve Slew outside

516. Realignment of Curves through Machines :

Alternatively, the curve can be realigned with a track tamping machine. Realignment of curve using machine should be done in design mode only. The calculated slews should be written on (alternate) sleepers and fed in the potentiometer so as to slew the track to the desired amount.

517. Realigning Curves on Double or Multiple Lines :

(1) On double or multiple tracks each curve should be stringlined independently. No attempt should be made to realign any curve by slewing it to a uniform centre to centre distance from the realigned curve as –

(a) The existing track centers may not be uniform and relatively small throw on one may entail a much larger (even prohibitively large) throw on the adjacent track

(b) It is nearly impossible to measure the centre to centre distance of curved tracks along the true radial lines and a small error in angular direction of measurement would mean an appreciable error in true radial distance.

(c) The transitions at the entry and exit may be of different lengths, which make it impracticable to maintain uniform centers on them even though the degree of the circular curves may be nearly the same.

518. Cuttings of Rails on Curves :

(1) Joints on curves – Rails joints on curves normally be laid square. On the sharp curves less than 400 mon the Broad Gauge and 300 m on the Metre Gauge the rail joints may be staggered, where elbows and kinks are likely to develop if rail joints are laid square.

(2) Rails are usually laid with square joints on curve. On curved track the inner rail joints gradually lead over the outer rail joints. When the inner rail of the curve is ahead of the outer rail by an amount equal to half the pitch of bolt holes, cut rails should be provided to obtain square joints. Cut rail is a rail which is shorter than the standard length of rail by an amount equal to the pitch of the bolt holes. The excess length 'd' by which the inner rail gains over the outer rail is calculated by the formula

$d = L_c * G / R$

where'd' is the length in mm. by which the inner rail joint is ahead of the outer rail joint over the entire length of the curve, if cut rails are not provided.

L_c = length of the curve in meters,

R = radius of the curve in meters,

G = the gauge + width of the rail head in mm.

The number of cut rails for a particular curve is worked out by the formula –

N = d / P*itch of the bolt holes in mm*

Illustration - Suppose a 5° curve of 300 m length is to be laid with 60 kg/m rail rolled with 13 m standard length, then the value of 'd' i.e. the length in mm by which the inner rail joint is ahead of the outer rail joint over the entire length of the curve shall be

$= L_c * G / R = 300 * 1750\text{ mm} / (1750 / 5) = 1500\text{ mm}.$

The number of cut rails = 1500/166 = 9.03 say 9 nos.

It must be ensured that rail joints are square at beginning and at the end of the curve.

Note: Presently the rails rolled do not have holes, therefore the above concept of cutting the rail when inner rail is ahead by pitch length of bolt holes does not hold good.

Now the inner rail can be cut at suitable interval depending upon radius of curve i.e. with sharper curves the cutting of inner rail involved will be more frequent.

519. Check Rails on Curves :

(1) The check rail is generally provided as a measure against derailment proneness on sharp curves *(Fig. 5.13).*

(2) On B.G. routes check rails to be provided in curves where the radius is 218 meter or less i.e. curvature is 8° or more. On M.G. routes check rails to be provided in curves where the radius is 125 meter or less i.e. curvature is 14° or more. Check rails may also be necessary in the case of flatter curves, if high speed is contemplated.

Check rails should be provided on the inside of the inner rail of the curve as stipulated in the schedule of dimensions:

(a) As per SOD, 2004 for B.G. routes minimum clearance of check rails for a curve is 44 mm. This clearance must be increased by not less than half the amount of any difference between 1676 mm and the gauge to which the curve is actually laid.

(b) As per SOD, for B.G. routes minimum clearance of check rails for a curve is 41 mm.

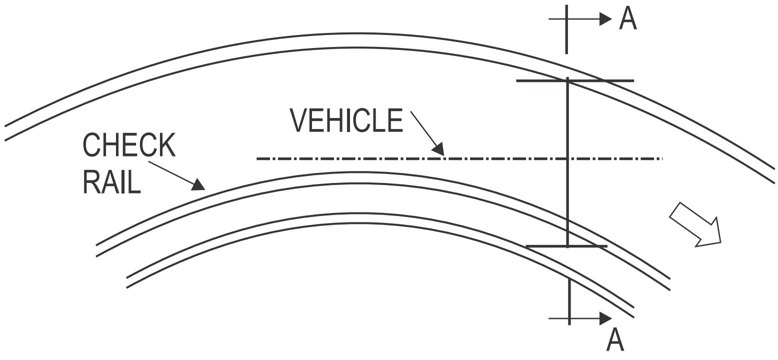


Fig. 5.13 *Curved track with check rail.*

(c) Location where check rails should be provided shall be decided by the Chief Engineer taking into consideration the negotiability of the rolling stock and the curve geometry.

(3) The check rail clearance shall actually depend upon the purpose for which it is provided on curve.

(a) Check rail clearance required to control wear on outer rail - The check rail clearance is worked out on the following basis (Fig. 5.14)

Check rail clearance = Track gauge * - (wheel gauge + flange thickness) + allowance for angularity of axle

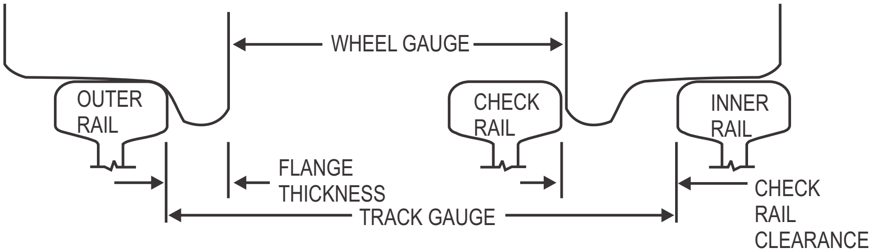


Fig. 5.14 *Check rail clearance.*

(*N.B.: This is the gauge actually provided i.e. including any gauge widening).

The flange thickness keeps on changing as the wheel wear out during service. The new BG wheel flange thickness is 28.5 mm & condemning limit for wheel is 16 mm, therefore, average flange thickness of 22 mm is considered for working out check rail clearance.

Taking track gauge as 1682 mm (considering 6 mm for gauge widening), wheel gauge as 1600 mm & 4 mm allowance for wheel angularity. The check rail clearance comes as 64 mm say 65 mm.

(b) Check rail clearance to safe guard against derailment - In case the check rail is intended only as a safeguard against derailment it need not be called upon to perform the guiding function. In that case check rail clearance can be increased to such a limit that only when the outer wheel mounts the rail should the check rail come into play and help in forcing the wheel back to the track. For this the only criterion is minimum bearing of inner wheel on the rail, which may be taken as 40 mm. Considering B.G. wheel having 127 mm width, the check rail clearance would work out 127 mm – 40 mm = 87 mm, say 85 mm.

520. Measurement of Rail Wear on Sharp Curves :

(1) The wear of rails of curves having radius of 600 m. or less on B. G. and 300 m. or less on M. G. shall be periodically recorded. Railways should prescribe the periodicity of measurement of wear on those sharp curves. The lateral, vertical and total loss of section should be recorded. Proper record of the measurements should also be maintained.

(2) Wear or outer rail of curves:-

(a) This can be reduced effectively:

(i) By lubricating the gauge face of outer rails on the curves.

(ii) By maintaining correct curve geometry and super elevation

(iii) Provision of suitable check rails

(b) Track mounted automatic Gauge Face Lubricators should be provided on curves of radius 875 m (2°) and sharper on Broad Gauge and of radius 300 m and less on Meter Gauge to reduce rail gauge face wear.

On routes where rail grinding is in practice, Track mounted automatic Gauge Face Lubricator should be provided on curves of radius 1400 m (1.25°) and sharper on B.G. While deciding the location of lubricators, following should be considered:

(i) It is located on tangent track at the beginning of transition curve where wheel flanging is just beginning to occur. On single lines, the lubricator shall be located in the direction of heaviest traffic.

(ii) Lubricator should be located away from switches, crossings and other areas where discontinuity in LWR track may exists.

521. Maintenance of Thermit Weld on Curves :

(1) Joggled fish plate with clamps or two far end bolts on good AT welds shall be provided on the curves of 3° or sharper.

ANNEXURE-5/1
{Ref. para 513 (2)}

PROFORMA OF CURVE REGISTER

ABSTRACT OF CURVES

--------Railway--------Section

Sl. No.	Curve No.	Between Stations	Line UP/DN/SL	Kilometers		RH/ LH	Gradient	Curve Type
				From	To			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Degree of curve	Radius of curve	Speed potential	S.E.	Length of curve			Whether joints are square or staggered	Whether reference pillars have been provided
				Transition	Circular	Total		
(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)

ANNEXURE-5/1 (contd.)
{Ref. para 513 (2)}

PROFORMA OF CURVE REGISTER DETAILS OF INSPECTION
--------- Railway Curve No. -------- From Km.-------- To Km. ---------

Initial Curve Geometry

Degree of curve	Radius of curve	Cant	Versine	Gauge	Length of curve			Speed potential	Maintenance Criteria
					Transition	Circul ar	Total		
D	R	C_a	V	g				v	
1	2	3	4	5	6	7	8	9	10

Details taken during Maintenance Inspection

Station No.	Date of measurement			
	Superelevation	Gauge	Versine	Station to station Versine variation
Action to be taken:				
-3				
-2				
-1				
0				
1				

Chapter 6

Maintenance of Turnout

601. General : Common terminology for parts and features of a turnout are shown in *Fig. 6.01*

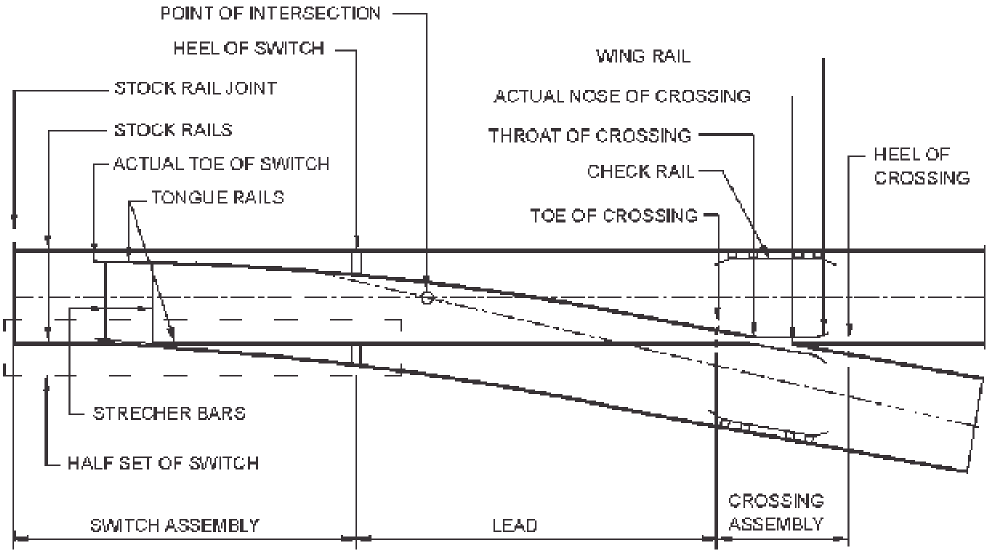


Fig. 6.01 *Components / Features of turnout.*

(1) For all the turnouts designed by RDSO, rails on turnout are to be laid vertical (without rail seat cant of 1 in 20). So the rails are required to be rotated to vertical on approach of turnout by special design of sleeper with varying rail seat slope. However in few turnouts which were imported, rails are laid at cant of 1 in 20.

(2) There should be no change of cross level within points and crossings as well as outside of toe of switch and nose of crossing upto a distance of 20 m on BG, 15 m on MG and 12 m on NG.

Normally in case of main line, turnouts should not be taken off from the transition portion of curve. However, in exceptional cases, when such a course is unavoidable a specific relaxation may be given by the Principle Chief Engineer of the Railway. In such cases, the rate of change of cant and/or curvature should not be steeper than the rate permitted for transition (for normal case; not for exceptional case). The correctness of cross level vis-a-vis radius and speed to be permitted on main line as well as turnout side should be checked at 2 places viz. SRJ and one m before ANC. The superelevation as limited by above calculations can only be provided at this location and speed restriction as calculated should be imposed.

(3) The points in yards which are negotiated by passenger trains cannot be inserted or removed unless the sanction of the Commissioner of Railway Safety is obtained.

602. Permitted Layout of Turnouts :

Normally, turnout of standard design issued by RDSO should only be laid over Indian Railways. In all future cases where special turnouts are to be used, specific approval of RDSO should be taken.

Following standard layouts of turnouts are approved by RDSO:

(1) Angle of crossing: 1 in 8½, 1 in 12, 1 in 16 and 1 in 20 turnouts are allowed to be used on PSC, ST and wooden sleepers. Turnout on ST and wooden sleepers should be replaced by PSC sleepers on planned basis.

(2) Type of Crossing: CMS crossing, Built Up Crossing, Heat Treated Welded crossing and Weldable CMS crossing.

(3) Type of Switch: Over Riding Switch (Straight and curved), Thick Web Switch (Non-Over riding). Straight Over Riding Switches should be replaced by curved switches/Thick web switches on planned basis.

(4) Following special layouts have also been standardized by RDSO:

(a) Diamond crossing: 1 in 8½ diamond crossings without/with single or double slip

(b) Scissor crossover of 1 in 8½ and 1 in 12

(c) Derailing switches

(d) Symmetrical splits

(e) 1 in 8½ and 1 in 10 movable switch diamond.

603. Speed Over Turnouts :

(1) Provision in general rules : Relevant Para 4.10 of General Rules *(G&SR)*, 2008 Edition is reproduced below -

(a) The speed of trains over non-interlocked facing points shall not exceed 15 km/h in any circumstances, and the speed over turn-outs and cross overs shall not exceed 15 km/h unless otherwise prescribed by approved special instruction which may permit higher speed.

(b) Subject to provision of sub-rules (a), a train may run over interlocked facing points at such speed as may be permitted by the standard of interlocking.

(2) Speed in excess of 15 km/h may be permitted for straights of interlocked turnouts only under approved special instructions in terms of *GR 4.10.*

(3) (a) Speed on turnout side should be normally restricted to 15 km/h. Speed over interlocked turnouts in case of 1 in 8 ½, 1 in 12 and flatter turnouts provided with curved switches may be permitted more than 15 km/h by approved special instructions, provided turn-in curves and loop lines are strengthened in terms of *para 604 (4) (a) & 604 (4) (b).*

(b) For permitting passenger traffic on running lines at a speed of 15 km/h, turnouts sharper than 1 in 12 shall not be provided. However, laying of 1 in 8½ curved switches can be permitted in exceptional circumstances due to limitation of room with the approval of PCE.

(4) Permissible cant and speed over turnout with contrary flexure: *(Fig. 6.02)*

In the case of branch line taking off from outside of a curved main line, cant to be provided on the main line shall be calculated as under:

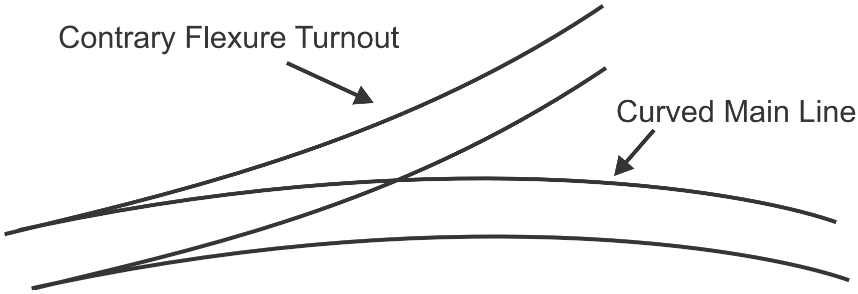


Fig. 6.02 - *Contrary Flexure Turnout*

Example 6.01

Suppose a 1 in 12 turnout is laid as contrary flexure on a curve of 2° (radius 875 m), following steps are followed

$$R_r = \frac{R_t - R_m}{R_t \times R_m}$$

(i) Resultant radius (R_r) of lead curve can be calculated as under:

Where R_m is the radius of main line curve i.e. 875 m and R_t, is the radius of lead curve of turnout when laid in straight i.e. 441 m. So by the above quoted formula,

R_r = (-) 889.11 m.

Here (–ve) sign indicates that the curvature is in opposite direction of the curvature of mainline curve.

(ii) Calculate the equilibrium cant (C_e) for turnout side :

$C_e = G*V^2/127\ R_r$

$=1750*15^2/127*(-889.11)$ (Speed on loop is assumed 15km/h)

= (-) 3.487mm say (-) 3 mm. [Negative sign indicate that eqillibrium cant for turnout side is opposite to main line cant requirement]

(iii) Calculate the cant to be provided on main line keeping cant deficiency to 75 mm:

The maximum super elevation which can be provided on main line is 75-3= 72mm.

(iv) Calculate the speed permitted on main line for this cant:

Speed potential for main line,

$V = (127* R_m *(Ca+Cd)/1750)^{½}$

$= (127*875*(72+75)/1750)^{½}$

= 96.61 km/h, say 95 km/h

(5) Permissible cant and speed over turnout with similar flexure: *(Fig. 6.03)*

In case of similar flexure, the maximum cant that can be provided on main line is the sum of equilibrium cant for turnout side and permissible cant excess. This limitation on the provision of cant is the reason for imposition of speed restriction on main line where turnouts is laid on curve as similar flexure.

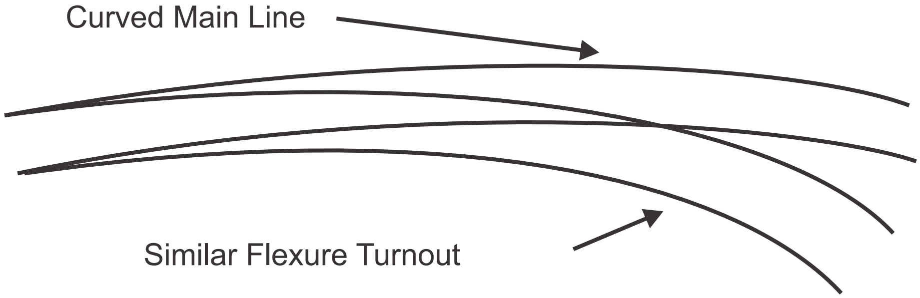


Fig. 6.03 *Similar Flexure Turnout*

Example 6.02

Suppose a 1 in 12 turnout is laid as similar flexure on a curve of 2^0 (radius 875 m).

(i) Resultant radius (R_r) of lead curve can be calculated as under:

$$R_r = \frac{R_t + R_m}{R_t \times R_m}$$

Where R_m is the radius of main line curve i.e. 875 m, and R_t is the radius of lead curve of turnout when laid in straight i.e. 441 m.

So by the above quoted formula, R_r = 293 m.

(ii) Calculate the equilibrium cant (C_e) for turnout side :

$C_e = G*V^2/127\ R_r$

$= 1750*15^2/127 * 293$ (Speed on loop is assumed 15km/h)

= 10.58 mm say 10 mm

(iii) Calculate the cant to be provided on main line keeping cant excess of 75 mm:

The maximum super elevation which can be provided on main line is 10 + 75= 85 mm.

(iv) Calculate the speed permitted on main line for this cant:

Speed potential for main line,

$V\ = (127 * R * (Ca + Cd) / 1750)^{½}$

$= (127*875*(85+75)/1750)^{½}$

= 100.79 km/h, say 100 km/h

(6) (a) In the above *example 6.02* speed of train on loop has been taken as 15 km/h; in case it is more than 15 km/h, the same should be used in calculation.

(b) Speeds so determined in (5) and (6) shall be subjected to speed limitation governed by standard of interlocking and the sectional speed.

(7) Provisions regarding permissible cant, speed on main line and turnout side on similar flexure: In the case of turnout taken off towards inside the curve of main line, speed and cant shall be calculated as under:

(a) Maximum cant on main line shall be limited to

(i) In case of turnout is not followed immediately by a reverse curve : On a main line curve from which a curve of similar flexure takes off not followed immediately by a reverse curve, the turn-out curve may have the same cant as the main line curve.

(ii) In case when turnout is followed immediately by a reverse curve: The maximum cant on main line shall be limited to 65 mm on B.G., 35 mm on M.G and 25 mm on N.G subject to running out of cant provided on the turnout at the rate of 2.8 mm/m; starting behind heel of crossing.

604. Upgradation of Speed on Turnouts and Loops to 30 km/h or More:

(1) Length of Section: Upgradation of speed on turnouts should cover a number of contiguous stations at a time so as to derive a perceptible advantage of the higher speed in train operations. The works described below should cover all the running loops on the stretch of line taken up.

(2) Turnouts: Speed in excess of 15 km/h should be permitted on turnouts laid with ST or PRC sleepers only. All turnouts on the running loops shall be laid with curved switches with minimum rail section being 52 Kg. All rail joints in the turnouts should also be welded to the extent possible as mentioned in drawing of turnout.

(3) Raising of speed on loop to 30 km/h: Following are the speed potential of turnouts presently in use on Indian Railway.

S.N.	Type of turnout (BG)	Speed Potential	
		PSC sleeper	Steel Sleeper
1	1 in 8½ straight switch	-	10/15 km/h*
2	1 in 8½ curved switch	15 km/h	15 km/h
3	1 in 8½ symmetrical split with curved switches 52/60kg including TWS on PSC sleepers	40 km/h	30 km/h
4	1 in 12 curved switch 52/60 kg including TWS on PSC sleepers	50 km/h	30 km/h
5	1 in 16 curved switch 60 kg including TWS on PSC sleepers	65 km/h	-
6	1 in 20 curved switch 60 kg including TWS on PSC sleepers	85 km/h	-

* For 1 in 8½ turnout laid on passenger running line speed of 10 km/h is permitted, however when laid on goods line speed of 15 km/h is permitted.

(4) However while dealing with such proposals, speed potential of all the turnouts laid on curve specially laid on inside of curve should be specifically checked and decision taken accordingly. Speed potential of all the turn in curves should also be checked. For raising of speed on loop to 30 km/h following instructions should be followed:

(a) Track on running loops: Speed in excess of 15 km/h should not be permitted on running loops laid with wooden sleepers. The minimum track structure on the running loops should be 90R rails laid as Short Welded Panels, M+4 density on PRC, ST, CST-9 sleepers and 150 mm ballast cushion. Out of 150 mm total cushion, clean cushion of at least 75 mm should be available. Proper drainage of the area should also be ensured.

(b) Turn-in/ connecting curves: Speed in excess of 15 km/h should not be permitted on Turn-in curves laid with wooden and CST-9 sleepers. Turn-in curves should be laid with the same rail section as on the turn-out with PRC or ST sleeper with sleeper spacing being 65 cm centre to centre (maximum).

Turn-in curve should conform to *para 607(2)*.

Extra shoulder ballast of 150 mm should be provided on out side of the turn-in curve. The frequency of inspection of turn-in curves should be same as that for main line turn-outs.

(c) The following should be ensured if ST sleepers are used in Turnouts, Turn-in curves or running loops:

(i) There is no crack or fracture at rail seat in two consecutive sleepers.

(ii) There is no excessive wear of lug, MLJ and rail seat.

(iii) All the fittings are effective and rail is held with sleepers properly.

(iv) The sleepers and fittings do not have excessive corrosion, elongated holes etc.

(5) It can be seen from *para (3)* above that most of the turnouts on PSC sleepers with curved switch permit speed of 40 km/h or more. Hence speed can be increased on loop beyond 30 km/h. However in case 1 in 8½ symmetrical split on PSC sleepers is being negotiated by passanger train on loop, speed can be raised up to only 40 km/h. In case all the 1 in 8½ symmetrical split turnouts on loop are replaced by 1 in 12 curved switch on PSC, speed up to 50 km/h can be achieved on loop line. However for increasing speed above 30 km/h, following additional instructions are required to be followed:

(a) Turnouts and turn in/connecting curves should be on PSC sleeper.

(b) If the passanger carrying train is negotiating any 1 in 12 turnout laid as similar flexure, speed more than 30 km/h should not be permitted.

(c) All other requirement in terms of track structure on loop and turn in curve specified for raising speed to 30 km/h on loop should be applicable for 40/50 km/h also.

(d) The speed potential of individual lead and turn in curve should be checked separately.

(e) Aspect of Home signal to be modified suitably so as to enable the driver to know whether he is passing through the loop line/main line or has to stop on the same so that he can control the train speed accordingly.

(f) LED signal should be provided for all signal aspects to realize the full potential of the arrangement through improved visibility of signals.

605. Cant and Speed on Curves on Double Line Connected by Crossover:

(1) The outer track shall be raised in the same inclined plane as that of inner track in order to avoid change in cross level on the crossover.

(2) The cant for both roads shall be governed by the inner curve because of crossover forming a curve of contrary flexure and accordingly the permissible cant and speed shall be calculated.

(3) The same speed and same cant shall be allowed on the outer road.

(4) In case it is not possible to have outer track and inner track on the same inclined plane then both mainlines and turnout shall be laid without cant and suitable speed restriction shall be imposed.

606. Speed on Diamond Crossing :

Normally a straight diamond crossing should not be provided in curves as it produce kinks in curve and uniform curvature cannot be obtained. There can be 3 situations for determination of speed on diamond crossing:

(1) Diamond crossing located on track with approaches straight: No restriction is contemplated.

(2) Diamond crossing located on curves: Whenever it is unavoidable to have diamond crossing on curved track, the approach curve of these diamond should be laid without cant for a distance of at least 20 m on either side of diamond crossing. Cant should be uniformly run out at the rate specified for transition curve beyond 20 m. The speed restriction on the approach curve shall be decided in each case by the Chief Engineer taking into consideration the curvature, cant deficiency and lack of transition but shall in no case be more than 65 km/h on B.G., 50 km/h on M.G and 40 km/h on N.G.

(3) Diamond crossing located having approach track in curve: A straight length of minimum 50 m between the curve and the heel of acute crossing of diamond is necessary for permitting unrestricted speed over the diamond subject to maximum permissible speed over the curve from considerations of cant deficiency, transition length etc.

607. Turn-outs on Running Lines with Passenger Traffic:

Turn-outs in running lines over which passenger trains are received or dispatched should be laid with crossing not sharper than 1 in 12 for straight switch. However, 1 in 8½ turnouts with curved switches may be laid in exceptional circumstances with the approval of PCE, where due to limitation of room it is not possible to provide 1 in 12 turnout. However 1 in 8½ turnout cannot be laid as similar flexure at all.

(1) When the turn-out is taken off from a curve, radius of lead curve should not be less than the following:

Gauge	Minimum radius of lead Curve
Broad Gauge	220 m (desirable 350m)
Meter Gauge	220 m
Narrow Gauge (762mm)	165 m

However for designing layout with lead curve of radius sharper than 350 m, specific approval of CTE should be taken.

(2) Design of radius of turn in curve/connecting curve:

(a) The radius of turn in curve should normally be designed as 441 m.

(b) In case it is not possible to achieve radius of 441 m due to constraint of space; for turnout laid on straight, the lead radius can be reduced to 350 m. However it should be noted that any reduction in radius from 441 m will reduce the speed potential of loop line. This factor may be kept in mind while designing the turn-in curve or while increasing speed on loop lines.

(c) Where it is not practicable to achieve the radius of curvature of turn in curves 350 m or more (as specified above) on account of existing track centers for the turnout laid on straight or taking off from curves, the turn-in curves may be allowed up to a minimum radius of 220 m for BG and 120 m for MG after obtaining specific permission of CTE subject to the following :

(i) Such turn-in curves should be provided either on PSC or steel trough sleepers only with sleeper spacing same as for the mainline.

(ii) Full ballast profile should be provided as for track for mainline.

(3) Emergency crossovers between double or multiple lines which are laid only in the trailing direction may be laid with 1 in 8½ crossings.

(4) In the case of 1 in 8½ turn-outs with straight switches laid on passenger running lines, the speed shall be restricted to 10 km/h. However, on 1 in 8½ turn-outs on non-passenger running lines, speed of 15 km/h may be permitted.

608. Track on Approaches of Points and Crossings:

(1) There should be no combination fish plates at stock rail joints or at the heel of crossings. At least one rail on either side of the points and crossings should have the same section as that of the points and crossings assembly. Similarly, there should not be any combination fish plate joint on turn in curve.

(2) The running out of 1 in 20 cant from approach track to uncanted turnout is done by laying four special sleepers in case of turn out on PSC sleepers and by suitably adzing and providing reverse canting on turnout laid on wooden sleepers.

(3) If gauge of track adjoining the points and crossings is maintained wider/tighter than the gauge on the points and crossings, the gauge on the adjoining track must be brought to same gauge as in the points and crossings and run out at the rate of 1mm in 3m to the requisite extent.

(4) LWR and SWR track laid in approaches of turnouts should be provided as per provisions contained in *chapter No. 7.*

(5) In non PSC layouts adequate creep anchors should be provided to arrest creep. Box anchoring of atleast one rail length ahead of stock rail is recommended. Creep posts should be erected at all interlocked facing points opposite the toe of the switch and creep should not be allowed to exceed permissible limits. In case of PSC sleeper layout with elastic fastening, creep anchors and creep posts need not be provided. In case excessive creep is observed at such layouts, the condition of elastic fastenings may be examined and suitable action be taken.

609. Inspection of Points & Crossings:

(1) Inspection of points and crossings will be carried out as per schedule prescribed in below. The readings taken during inspection should be recorded in "Point and Crossing" *proforma of TMS.*

(a) Inspection by ADEN: ADEN shall inspect once a year all points and crossing on passenger running lines and 10 percent of the points and crossings on other lines.

(b) Inspection by SSE (P.Way) in overall charge and his assistant: SSE (P.Way) in overall charge and his assistant should carry out the inspection of points and crossings in passenger running lines once in three months by rotation and on other lines and yards lines once in six months by rotation. However, for Points and Crossing laid on PSC sleepers, the detailed inspection as per *Annexure 6/1* should be done once in a year, all other in between inspections should be carried out as per proforma given in *Annexure 6/2. Annexures 6/3, 6/4 and 6/5* should be utilized for inspection of Diamond crossing, inspection of diamond crossing with single slip and inspection of diamond crossing with double slip respectively.

(c) Paint marking of locations where measurements are to be made: For the ease of inspecting officials, the locations on which measurement are to be taken to be marked by white or yellow paint on the gauge side web of the rail. Following location are to be paint marked to facilitate inspection:

(i) Locations where wear of crossing and wing rail are to be measured.

(ii) Locations where gauge, cross level, alignment (versine) or straightness are to be measured in the switch, lead and crossing.

(iii) Locations where clearances of check rails, wing rails are to be measured.

(d) In case of any accident involving turnouts, gauge and cross level measurements to be taken at the locations as specified in *Annexure 6/2.*

610. Maintenance of Point and Crossing:

(1) General

(a) Where large number of points and crossings are being maintained within a specific area such as marshalling yards, large layouts of sidings, terminal stations etc., regular cycle of maintenance covering all points and crossings should be organised. It is desirable to have a special gang by reorganising the existing gang strength for scheduled maintenance of points and crossings. Such a gang may work in close liason with S. & T. and Traction organization.

(b) (i) The major maintenance effort should be given through tamping machines. UNIMAT should be deployed every one year to one and half year frequency to attend all the turnouts from one end to other.

(ii) Shallow screening of crib and shoulder to be done before tamping by machine.

(iii) In between the tamping cycle, based on parameters recorded during point and crossing inspection, manual maintenance should be done.

(iv) As far as possible, the deep screening of turnouts should be done by BCM Machine so as to achieve better quality of screening and all necessary preparations such as removal of S. & T. fixtures should be done in advance. The discretion shall be with PCE for deciding the method of deep screening depending upon the local conditions.

(v) During machine tamping stretcher bars as well as other fixtures should be removed by S. & T. staff to ensure proper packing of all the sleepers for which S. & T. staff be given information in advance for opening of switch connections. This is particularly required on sleeper no. 3 and 4. In case S. & T. staff is not in position of opening such mountings,"off track tampers" should be used for the rail seats which could not be tamped by machine. However in case of any point failure on these points because of loose packing on such locations where S. & T. fixture were not removed the responsibility should lie on S. & T. department.

Signal rods and wires crossing track at other than toe of switch should preferably be encased in pipe so as to ensure proper packing of adjacent sleepers.

(c) Correct spacing of sleepers should be ensured according to the standard lay out drawings. Special care should be taken for sleeper no. 3 and 4, where spacing should be provided exactly as per drawings While laying turnout on curve spacing should be provided as per *RDSO circular (as per degree of main line curve)*. CT/PTX dated 17.08.2007 for laying 1 : 12 fan shaped turn out as similar flexure and CT/PTX dated 7.10.2007 for laying 1 in 12 turnout as contrary flexure.)

(d) The use of spherical washer is necessary where the shank of the bolt is not at right angles to the axis of the rail. Spherical washers are used on skew side at locations given as under:

(I) In switch portion, spherical washers are used on left hand side of switch on heel and distance blocks irrespective of LH/RH turnout.

(ii) In built up crossings, spherical washers are used on both sides of bolts. It should be used on end check blocks of flared check rails on inside of track. For machined check rail spherical washer is not required to be used.

(iii) on crossings spherical washer or taper washer of proper design should be used on both the sides of long bolts.

(e) Attempts should be made to provide 100% fittings on turnout. On wooden sleeper layout assembly, round spikes/ dog spikes should be replaced with plate screws/ rail screws.

(f) Cleaning and lubrication of points: At all interlocked and partially interlocked stations, the Signal Staff will be responsible for the periodical cleaning and lubrication of those slide chairs in which of signaling and interlocking gears are connected (generally upto third sleeper from toe of the switch) in all points interlocked with signals or provided with locks. Of the slide chair on such points will be cleaned and lubricated by Permanent Way staff. JE/SSE (P.Way) shall also be responsible for the cleaning and lubrication of slide chairs of all hand operated points on their section.

(g) In case of problem of frequent wear of tongue rail, a short check rail ahead of toe of switch as per design given by RDSO may be provided after taking approval of sectional DEN/Sr.DEN.

(h) The greasing of ERC should be done once in a year.

(i) Greasing of plate screws: Because of the corrosion of the plate screw it gets seized in the dowel of sleeper which leads to breakage of head of a screw at the time of opening. This makes sleeper unusable. So plate screw in the switch portion must be greased once in a year. Paint Marking of Year of Greasing should be done for easy identification of odd and even year and better planning.

Process:

(i) At one time only one plate screw should be removed with the help of spanner.

(ii) The screw should be cleaned with the help of wire brush; all the corroded material should be removed.

(iii) The dowel hole in the sleeper should be cleaned with the help of wire brush / vacuum cleaner.

(iv) The dowel hole should be filled by '"O" graphite grease.

(v) The screw alongwith the plain portion should be greased.

(vi) The screw should be refixed. The grease oozing out of dowel hole will fill the gap between screw cap and the dowel top.

(vii) In some cases where the plate screws are corroded, broken or seized, all four plate screws may have to removed at a time. S. & T. staff shall be required in such cases.

(j) Systematic recoupment of fitting: Fittings like rubber pad, GFN Liner, ERC, bolts etc. should be checked in every inspection. The recoupment of the fitting should be done after every inspection.

(k) Replacement of damaged sleeper: The sleepers which are damaged because of notching of sleeper, cracked, damage to dowel or any other defects making it unserviceable should be replaced. This exercise should be done once in a year. In case two or more consecutive sleepers are damaged then replacement should be done immediately after the damage has been pointed out.

(l) Thorough inspection of tongue rail on the non gauge face for crack near JOH : There have been cases of fracture of tongue rail because of crack starting from the foot of tongue rail on non gauge face side near JOH. So the tongue rail for 600 mm on either side of JOH should be cleaned with the help of kerosene and examined with the help of lens to find crack or damage to the foot of tongue rail on non gauge face of the tongue rail. This exercise should be done once in a year.

(m) Removal of burr from the switches and crossing: Removal of burr from the stock rail, tongue rail and the crossing should be undertaken once in a year. All the metal which is flown from its place should be removed with the help of portable grinder. In case the metal flow of stock rail is severe leading to disturbing the setting of tongue rail against the stock rail, grinding should be done to ensure proper setting of tongue rail.

(n) Greasing of fish plate in the turnout : 1 m fishplate with 06 bolts should be provided on all free (machine cut) joints in the turnouts especially ahead and behind the CMS Crossings. The fish plates in the turnouts should be greased once in a year to ensure free expansion/ contraction of the rail.

(o) Proper Size Crossing Blocks should be provided ahead and behind the CMS Crossing along with Standard Size Check rail Blocks at proper locations.

(p) Oiling and greasing of SSD: Proper cleaning and greasing of various pins in SSD should be done once in a year.

(q) Attention to Gauge, cross level and alignment: The track parameters are measured in every inspection. Attention to gauge, cross level and alignment should be done as per requirement.

(r) Since the dropping of night soil and garbage is much more in the yards than in the mid section, drainage in the yard needs to be given more attention. Regular attention to lower the height of cess to permit efficient drainage and adequate depth of ballast cushion should be provided.

(s) The service life of fabricated switches as well as crossings (all types) in terms of GMT (TSC item no. 1193)-

Rail section	Service life (In GMT)
60 KG	200
52 KG	150

(t) (i) Maintenance of gauge on turnouts:

Switch/ Lead of turnout	New Laying	Maintenance
Switch portion including Toe of Switch	-5 mm to +3 mm (1671 to 1679 mm)	-6 mm to + 6 mm (1670 to 1682 mm)
Lead portion	-5 mm to +3 mm (1671 to 1679mm)	-6 mm to + 6 mm (1670 to 1682 mm)

Above tolerances are for PSC as well as other than PSC turnouts.

(ii) The permissible gauge in crossing portion:

Crossing of Turnout	New Laying & Maintenance
PSC sleeper	1673 to 1677 mm
Other than PSC sleeper	1676 to 1680 mm

(iii) Range of clearance of wing rail opposite nose of crossing:

For Other than PSC sleeper	41 to 44 mm
For PSC sleepers	38 to 41 mm

(iv) Range of clearance of check rail opposite nose of crossing:

For Other than PSC sleeper	44 to 48 mm
For PSC sleepers	41 to 45 mm

(2) Maintenance of Switches:

(a) The track geometry at the turnout should not be inferior to the route.

(b) It is good practice to work within the tolerances of gauge as per *para 610 (1)(t).*

(c) The gauge just ahead of actual toe of switch shall be as follows (for design purposes):

(i) On BG turnout of 1 in 12, 60 kg with 10125 mm over riding curved switch (on wooden, steel or PSC sleepers), 1 in 12 BG 52 kg with 10125 mm over riding curved switch on PSC sleeper and all thick web switches (52 kg/ 62 kg) on wooden/PSC sleeper i.e. of turnout with switch having switch entry angle less than or equal to 0°20'0", gauge should be maintained as nominal gauge.

(ii) All other turnouts excluding those given above i.e. turnout with SEA more than 0°20'0"(including turnout on PSC sleeper) gauge should be maintained as nominal gauge + 6 mm. This can be achieved by giving required bend at TTS because of which gauge between TTS to ATS will vary. The amount of bend to be given at TTS has been given in *Annexure 6/6.* In case of 1 in 8½ symmetrical split, bend at TTS should be given on both the stock rails by half the amount.

(d) (i) The gap between underside of the stock rail and the top of the leading stretcher bar should be maintained between 1.5 mm to 3 mm.

(ii) Stretcher bars connected to the pull rod shall be maintained jointly by the Permanent Way Staff and the Signalling Staff. All other stretcher bars shall be maintained by the Permanent Way staff. Stretcher bars insulated for track circuit purposes shall not be interfered with unless Signal staff are present.

(iii) Total number of stretcher bars (including leading) to be provided in different types of B.G. layouts are as under:

1 in 8 ½ (Straight)	=	2
1 in 8 ½ (Fan shaped)	=	3
1 in 12 (Straight)	=	2
1 in 12 (Curved)	=	3
1 in 12 (Fan shaped)	=	4

(iv) All stretcher bars should be fixed by giving the 'Half Throw' to both the tongue rails so as to achieve good housing.

(e) (i) It should be ensured that thinner half headed stud bolts are only used over the planed length of tongue rail which butts against the stock rail.

(ii) It should be ensured that gauge tie plate is provided at the toe of switch and under crossing (only on wooden sleeper) to ensure proper gauge at these locations.

(f) The condition of stock and tongue rails should be carefully examined. Badly damaged stock and tongue rails should be replaced by serviceable ones. The tongue rail can, however, be reused after reconditioning of the broken/damaged tip by welding. Proper setting of the switch should be ensured over desirable length. A tongue rail may be classified as damaged when:

(i) It is chipped/cracked over small lengths aggregating to 200 mm within a distance of 1000 mm from its toe, chipped length will be the portion where tongue rail has worn out for a depth of more than 10 mm over a continuous length of 10 mm.

(ii) It is badly twisted or bent and does not house properly against the stock rail causing a gap of 5 mm or more at the toe; the limit described in the *I.R.S.E.M.*

(g) Stock rail having burr are likely to obstruct the lock bar should be replaced, if necessary and while doing so, the matching of tongue rail should be ensured.

(h) The gauge face of tongue rail should be lubricated once in fortnight at the locations where excessive wear is observed; otherwise it should be greased once in a month.

(i) Tongue rail should bear evenly on all the slide chairs to the extent possible. This will be ensured when all the sleepers are packed properly. Further, when the tongue rail is in closed position, it must bear evenly against distance/switch stops or blocks when spring setting devise has been used.

(j) It is desirable to weld stock and lead joints on the points and crossings assembly except joints at heel of switch, and toe and heel of crossing.

(k) To check the housing of the tongue rail and also the throw of the switch, all non-interlocked points should be operated by hand lever and other points from the signal frame/panel when traffic permits doing so. If the tongue rail is found to be not housing properly against the stock rail, the defect must be rectified by the Permanent Way Staff in case of non-interlocked points, and jointly with signal and telecommunication staff in case of interlocked points.

(l) Tongue rail shall be replaced / reconditioned when vertical/lateral wear exceeds the values laid down. The wear shall be measured at a point with 13 mm head width and at the point where tongue rail and stock rails are at same level. *(As given in Annexure 6/8)*

(m) Creep posts should be erected at all interlocked facing points opposite the toe of the switch and creep should not be allowed to exceed permissible limits. As far as possible toe of switch should be kept square for smooth and easy operation of points.

(n) Examination of integrity of slide chair lugs should be done in every inspection. In case breakages are found necessary welding of lugs or replacement of slide chair as per need should be done after every inspection

(o) To improve housing of switch, SSD may be provided and regular maintenance of SSD be done. Keyman should be given special tools and training for proper maintenance of the same on regular basis.

(3) Maintenance of Lead Portion:

(a) The outer rail of lead may wedge in liner to cause lifting of liner and widening of gauge. The same should be corrected.

(b) During maintenance, versines of curved stock rail should be checked at 3 m interval on 6 m chord length commencing from heel of switch for straight switches and from ATS for curved switches. For this purpose, stations at 3 m intervals should be marked on rail.

(c) The variation in versines on two consecutive stations in lead curve as well as turn in curve should not be more than 4 mm and versines at each station should also not be beyond $\pm$ 3 mm from its designed value. However the tolerance of variation in versine on two consecutive stations i.e. 4 mm is not applicable on every point on which curve is starting or ending.

(d) The gauge face of outer rail of lead portion should be greased once in a fortnight on locations where heavy wear is observed.

(4) Maintenance of Crossing Portion:

(a) Gauge: Gauge should be maintained to good standards in the crossing portion. On wooden sleepers layout, gauge can be maintained properly by the provision of a gauge tie plate under the nose of crossing. However, if any damage to the nose of crossing is noticed, its cause must be traced, which may be either due to tight gauge or due to excessive clearance of check rail. If wing rails or check rails are badly worn laterally, it could be due to wide gauge at the crossing.

(b) Wear of nose / wing rails:

(i) Maximum permissible vertical wear on wing rails or nose of crossing shall not be allowed to exceed 10 mm. However, on Rajdhani/Shatabdi routes as a good maintenance practice, crossing and the wing rails should be planned for reconditioning / resurfacing by welding on reaching following wear limit :

Built up / welded crossing-- 6 mm
CMS crossings -- 8 mm

Note : In case of CMS crossings, following dimensions should be deducted (to account for 1 in 20 cross slope in casting of wing rails) from the observed wear measurements to find out the actual wear:

For 52 kg section : 2.0 mm
For 60 kg section : 2.5 mm

Wear on nose of crossing and wing rail is measured at a distance 100 mm from ANC.

(ii) Clearances of check rails/ wing rails: Check rail clearance should be within limits as prescribed in schedule of dimensions. However, on B.G. track on PSC sleepers, check rail clearance should be maintained as per the range given in para 610(1)(t)(iii). In case the gap exceeds the limits, the excess check rail clearance should be corrected by removing one of the two special packing plates of 3 mm thickness provided for this purpose with the check block. In case, check rail clearance cannot be maintained within limit even after removal of both the packing plates, the worn out check rail should be replaced.

(iii) In case the steel trough sleepers are used under crossing, use of wooden blocks added to the contour of the underside of sleepers. strengthens the support and helps in better maintenance. However, for sleepers strengthened by providing steel ribs on their underside, use of wooden block is not required.

(c) Maintenance of CMS crossings:

(i) There is likelihood of the gauge faces of the wing rails developing sharp corners due to the wear and the inadequate flange way clearance. It will result in the wear of the wheels passing over them. In such cases, the gauge face should be ground to a radius of 10 mm.

(ii) Removal of burr: Removal of burr from the crossing should be undertaken whenever burr formation is noted during inspection. All the metal which is flown from its place should be removed with the help of portable grinder.

(iii) No holes should be made in the CMS crossing by the flame cutting or by any other means, as this will lead to cracking of the crossing.

(iv) Once a crack is observed in CMS crossing during inspection at any level, the crossing must be inspected on regular basis at the level of SSE(PWay) (section in-charge) and SSE/JE (P.Way) (sectional) at a frequency of one month by rotation and observations recorded in proforma given at *Annexure 6/10* which will be maintained only for CMS crossing having crack.

(v) Permissible length of cracks in CMS crossing (both 52 Kg and 60 Kg) at various locations provided that the cracks are kept under regular observation as described above are as under:

SN	Area/Location in various categories in CMS crossing	Allowable length of crack
1.	Category – (i) i.e. 300 mm of the top of nose, 300 mm of the wings on the either side of actual nose of crossing and edges of both top and bottom flanges (up to 25mm from edge).	50 mm
2.	Category – (ii) i.e. Running surface other than the area mentioned in Category-I	75 mm
3.	Category – (iii) i.e. Non running surface other than the area mentioned in category (iv) and top surface of ''vee'' not coming in contact with running wheels of rolling stock.	75 mm
4.	Category – (iv) i.e. Non vulnerable areas like bearing plates, walls of end sections (excluding head portion)	75 mm

(vi) The crossing needs to be replaced once the length of crack exceeds the permissible limit. In case of category – (i) locations, the crossing should be replaced if the distance between adjacent crack is less than 150 mm. Key sketch of crossing explaining different areas like category (i), (ii), (iii) and (iv) has been given in *Annexure 6/9.*

(vii) All the four joints at the heel and toe of the CMS crossing should be made gapless. There should be no gap between rail ends at a temperature higher than the installation temperature. In order to achieve Gapless Frozen Joints during renewal of Crossings, the Rail ahead and behind the CMS Crossing should be marked for 03 Bolt Holes after conjunction of Rail with CMS Crossing. This should be done outside the track and all bolt holes should be drilled and chamfered.

(viii) The condition of rubber pads should be checked and replaced whenever necessary. The Rubber pads under crossing tend to fall frequently, hence resetting of rubber pads under crossing should be done when noted in inspection.

(5) Special features of diamond crossing with or without slips:

(a) Diamond crossings with slips are special layouts where stock joint of switch is at the toe of the acute crossing.

(b) The schedule of dimension prohibits the use of diamond crossing flatter than 1 in 8½. However, 1 in 10 diamond can be permitted under approved special instructions.

(c) In diamond crossings, obtuse crossings should be laid square to each other with respect to the centre line of acute crossings.

(d) 25 mm thick flat is welded on top of wing rails of obtuse crossings on BG and MG which helps in guidance of wheels in unguided portion of throat. Further at obtuse crossing, the clearances at nose of obtuse crossing should preferably be maintained more carefully.

(e) Alignment over diamonds should be checked more frequently to eliminate kinks.

(f) A special gauge not interfering with the welded strip should be used for measurement of gauge at obtuse crossing.

611. Reconditioning of Switches and Crossings :

Reconditioning of worn out tongue rails and crossings shall be carried out following the detailed procedure and other instructions contained in *"Manual for Reconditioning of Medium Manganese (MM) steel Points& Crossings, Switch Expansion Joints (SEJs) and Cast Manganese Steel (CMS) crossings (1996)".*

To monitor the number of reconditioning for a particular component, each and every switch (every stock and tongue rails separately) and crossing should be given a unique number in every JE/SSE (P.Way) jurisdiction. Such unique number should be painted on the same component. The reconditioning register of JE/SSE (P.Way) should have one page for every individual switch (every stock and tongue rails separately) or crossing so as to monitor the number of reconditioning. After every reconditioning the same record should be updated. In case the component is inserted at different location in track after reconditioning the same should be entered in the register. The proforma for point and crossing reconditioning register has been given in *Annexure 6/7.*

For reconditioning of CMS crossing as far as possible of in-situ re-conditioning (by RDSO approved method) should be done.

- *Connections like relations are always complex. Handle with care to avoid surprises.*

Annexure - 6/1
(Para 609 (1)(b))

Proforma for inspection of Points and Crossings

Station:	Point no.:
Location:	Rail section:
Type of sleeper/assembly:	Angle of crossing:
Nominal gauge of turnout:	Left hand or right hand:
Laid on straight or curve (if curve radius):	If curve similar/contrary flexure:
Date of laying sleeper:	Type of crossing:

Date of deep screening	1^{st}	2^{nd}	3^{rd}	4^{th}
Date(MM/YY)				
Manual/Mechanised				
Date of laying new/reconditioned crossing	1^{st}	2^{nd}	3^{rd}	4^{th}
Date (MM/YY)				
Crossing Unique Number				
Manufacturer				
Date of laying new/reconditioned Switch	1^{st}	2^{nd}	3^{rd}	4^{th}
LH: Date (MM/YY)				
RH: Date (MM/YY)				

Particulars:	Details of inspection		Action with date & sign.	Details of inspection		Action with date & sign.
I. General 1. Condition of ballast and Drainage in turnout (Clean Cushion to be measured only Once in a year)						
II Switch assembly and lead :						
2. Condition of sleepers, side Chairs, plate screws , heel &Distance blocks, other fittings ofSwitch including tightness of bolts etc.						
3. Condition of tongue rails:	LH	RH		LH	RH	
a) Whether chipped or cracked Over 200 mm length within 1000 mm from ATS						
b) Whether twisted or bent (causing gap of 5 mm or more at toe)						
c) Remarks over condition of tongue rail, whether requires reconditioning or replacement						
4. Condition of Stock rail, burr formation to be mentioned specifically						
5. Creep and squareness of tongue rail at toe of switch.						
6. Straightness of straight stock rail if laid on straight (Measured on 7.5 m chord)						
7. Packing conditions under the switch assembly (preferably to be observed under traffic)						

	LH	RH			LH	RH		
8. Throw of switch:								
9. Housing of stock and tongue rails:								
10.Gap between top edge of leading stretcher bar and bottom of rail foot:								
11. Working of SSD (if provided)								
12. Gauge and cross level in switch and lead	G	XL			G	XL		
a) At 450 mm ahead of toe of switch								
b) At ATS between two stock rails								
c) Gauge and cross level for ML and turnout side. Versine of stock rail for turnout side upto end of lead curve.	G	XL	Ve		G	XL	Ve	
Station ATS/HEEL								
0								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

1) Station no. 0 to be marked at heel of switch for straight switch and at ATS for curved switches. Subsequent station shall be marked at every 3 m. Versines to be recorded on 6m chord length commencing from station no. 1.				
2) Versine reading shall be taken for turnout side except for symmetrical split turnout where it shall be taken on main line side.				
3) In case of gap between T/R and S/R, that should be added to gauge measurement.				
III. Crossing Assembly:				
13 Condition of crossing : a) Sign of propagation of crack (if any) in crossing assembly. b) Burr on top surface at nose. c) In case of Heat-treated welded crossing, Weld texture on top surface. If any flow or separation of weld portion: c) Tightness of bolts at CI/distance block at toe, heel and nose of crossing as applicable. d) Condition of gapless joints.				
14. Wear of crossing (to be measured with straight edge at 100 mm from ANC) a) LH wing rail b) Nose c) RH wing rail For CMS crossing. Actual wear for 52 kg. Section= measured wear – 2.0 mm & Actual wear for 60 kg. section = measured wear - 2.5 mm.				

15. Gauge and cross level at	Main		turnout			Main		turnout		
	G	XL	G	XL		G	XL	G	XL	
a) 1 m ahead of ANC b) 150 mm behind ANC c) 1 m. Behind ANC										
16. Condition of check rail fitting eg. Bearing plates, keys, blocks, bolts and elastic fastenings.										
17. Clearance of check rails a) Opposite ANC: b) At 1st block towards toe of crossing and 1st block towards heel of crossing. c) At the flared end towards heel and at the flared end towards toe.	LH		RH			LH		RH		
18. Clearance of wing rail (only for built up crossing										
IV. Turn in curve										
19. Turn in curve – Stations to be marked at 3 m interval, versines to be measured on 6 m chord. Station No. 0 to be marked at the centre of last long sleeper in case of PSC sleepers otherwise at heel of crossing.										
STATION NO.	Ve	G	XL			Ve	G	XL		
0										
1										
2										
3										
4										
5										
6										
7										
20. Availability of 150 mm, additional ballast shoulder width on outside of turn in curve.										
21. Any other special feature/defects.										
22. Signature of the inspecting official with date.										

Annexure - 6/2

(Para 609 (1)(b) & (d))

Proforma for intermediate inspections of points and crossings on PSC sleepers

<table>
<tr><td colspan="2">Station:</td><td colspan="3">Point no.:</td></tr>
<tr><td colspan="2">Location:</td><td colspan="3">Rail section:</td></tr>
<tr><td colspan="2">Type of sleeper/assembly:</td><td colspan="3">Angle of crossing:</td></tr>
<tr><td colspan="2">Nominal gauge of turnout:</td><td colspan="3">Left hand or right hand:</td></tr>
<tr><td colspan="2">Laid on straight or curve (if curve radius):</td><td colspan="3">If curve similar/contrary flexure:</td></tr>
<tr><td colspan="2">Date of laying sleeper:</td><td colspan="3">Type of crossing:</td></tr>
<tr><td rowspan="3">Date of deep screening
Date (MM/YY)
Manual/Mechanised</td><td>1st</td><td>2nd</td><td>3rd</td><td>4th</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Date of laying new /reconditioned crossing
Date (MM/YY)
Crossing Unique Number
Manufacturer</td><td>1st</td><td>2nd</td><td>3rd</td><td>4th</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Date of laying new/reconditioned Switch
LH: Date (MM/YY)
RH: Date (MM/YY)</td><td>1st</td><td>2nd</td><td>3rd</td><td>4th</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Particulars	Details of inspection		Action with date and sign		Details of inspection		Action taken with date and sign	
I. General 1. Condition of ballast, and drainage in turnout								
II. Switch assembly and lead portion:	LH	RH			LH	RH		
2. Condition of Tongue Rail a) Whether chipped or cracked over 200 mm length within 1000 mm from ATS								
b) Whether twisted or bent (causing gap of 5 mm or more at toe)								
c) Remarks over condition of tongue rail, whether requires reconditioning or replacement								
3. Condition of stock rail burr formation to be mentioned specifically								
4. Gauge and Cross level in switch portion and lead: a) At 450 mm ahead of toe of switch b) At ATS between two stock rail(only gauge) c) Gauge and cross level for ML and turnout side. Versine of stock rail for turnout side up to end of lead curve	G	XL			G	XL		
Station ATS/Heel	Ve	G	XL		Ve	G	XL	
0								
1								
2								
3								
4								
5								
6								
7								

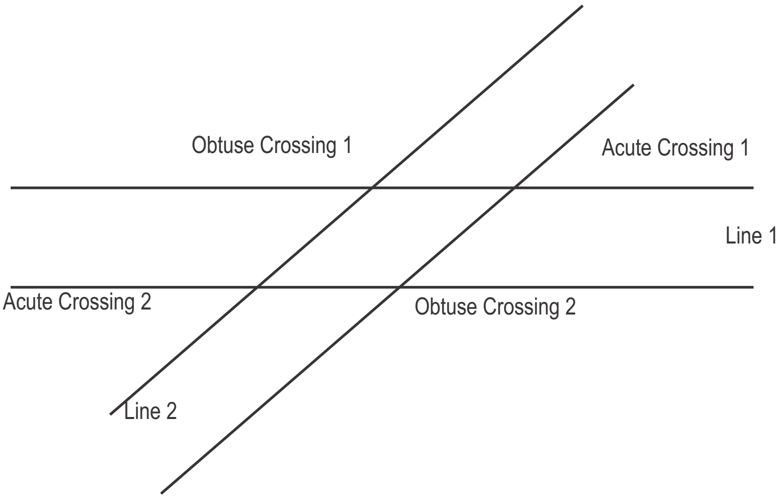
8								
9								
10								
11								
12								
13								
Note - 1. Station no. 0 to be marked at heel of switch for straight switch and at ATS for curved switches. Subsequent station shall be marked at every 3m. Versines to be recorded on 6m chord length commencing from station no. 1								
1. Versine reading shall be taken for turnout side except for symmetrical split turnout where it shall be taken on main line side.								
2. In case of gap between T/R and S/R, that should be added to gauge measurement.								

III. Crossing Assembly Condition of crossing a) Sign of propagation of crack (if any) in crossing assembly.								
3) Wear of CMS crossing: (wear to be measured with straight edge at 100 mm from ANC)	LH Wing	Nose	RH wing		LH wing	nose	RH wing	
Note- Actual wear for 60 kg section =measured wear -2.5 mm For 52 kg section= Measured wear-2.0 mm.								
4) Condition of check rail fitting bearing plate, blocks, bolts and elastic fastenings.								
8. Condition of welding of slide chairs and lugs.								
9. Condition of gapless joint in CMS Xing								
10. Any other special feature/defects								
11. Signature of Inspecting official with date.								

ANNEXURE – 6/3

(Para 609 (1)(b))

Key Sketch For Inspection of Diamond Crossing



Proforma For Inspection of Diamond Crossing

Station:____

Point No:____

Location:____

Type of Rail____

Date of laying :____

Date of laying reconditioned crossing: ______________________________

Angle of crossing: ____

Nominal gauge of turnout ____________________________________

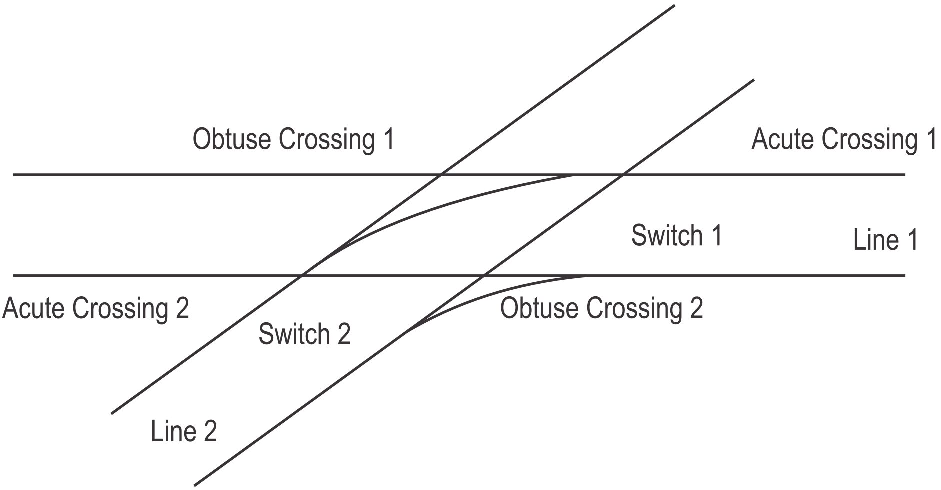
1	**Sleeper Details**									
1.1	Condition of sleeper									
1.2	Squaring									
1.3	Spacing									
2 2.1	**Ballast Details** Condition of ballast									
2.2	Condition of drainage									
2.3	Ballast in shoulders and cribs									
2.4	Clean ballast cushion(mm)									
3	**Gauge X – level between crossings**	Line 1			Line 2					
			Gauge	X-Level	Gauge	X-Level				
		Stn. 0								
		1								
		2								
	At 3 interval in lead portion	3								
		4								

4	**Condition of Crossing**	Acute Xing 1		Acute Xing 2		Obtuse Xing 1		Obtuse Xing 2	
4.1	Sign of Propogation of crack (if any)								
4.2	Burring of top surface at nose								
5	**Type of Crossing**								
6	**Wear of Crossing**	**Acute Xing 1**			**Acute Xing 2**				
		Left Wing Rail	On Nose	Right Wing Rail	Left Wing Rail	On Nose	Right Wing Rail		
		Obtuse Xing 1		Obtuse Xing 1		Obtuse Xing 2		Obtuse Xing 2	
		Nose 1		Nose 2		Nose 1		Nose 2	
		On Nose	Wing Rail	On Nose	Wing Rail	On Nose	Wing Rail	On Nose	Wing Rail
7	**Clearance of wing rail opposite nose of crossing and upto 450 mm towards heel end**	Acute Xing 1		Acute Xing 2		Obtuse Xing 1		Obtuse Xing 2	
		Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
8	Gauge and Cross Level	Acute Xing 1		Acute Xing 2		Obtuse Xing 1		Obtuse Xing 2	
		Line 1	Line 2	Line 1	Line 2	Line 1	Line 2	Line 1	Line 2
8.1	1 m ahead of ANC	Gauge							
		X- Level							

8.2	150 m ahead of ANC	Gauge							
		X- Level							
8.3	150mm behind ANC	Gauge							
		X- Level							
8.4	1m behind ANC	Gauge							
		X- Level							
9	**Condition of check rail and its fittings**	Acute Xing 1		Acute Xing 2		Obtuse Xing 1		Obtuse Xing 2	
9.1	Raised Check Rail								
9.2	Other bearing, plates, keys ,blocks, bolts and elastic fastening								
10.0	**Check Rail Clearance**	Acute Xing 1		Acute Xing 2		Obtuse Xing 1		Obtuse Xing 2	
		Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
10.1	Opposite ANC								
10.2	500 mm ahead towards toe of crossing								
10.3	500 mm behind heel of crossing								
10.4	All the flared end towards heels								
10.5	All the flared end towards toe								
11	**Remarks**								

Annexure - 6/4
(Para 609 (1)(b))

KEY SKETCH



Proforma for Inspection of Diamond Crossing With Single Slip

Station:________________________________

Point No:________________________________

Location:________________________________

Type of Rail________________________________

Date of laying reconditioned crossing : ____________________

Date of laying reconditioned switches : ____________________

Type of sleeper/assembly __________________________

Angle of crossing: ____________________________

Nominal gauge of turnout __________________________

1	**Sleeper Details**								
1.1	Condition of sleepers								
1.2	Squaring								
1.3	Spacing								
2	**Ballast Details**								
2.1	Condition of ballast								
2.2	Condition of drainage								
2.3	Ballast in shoulders and cribs								
2.4	Clean ballast cushion (mm)								
3	**Condition of Switch Assembly**		Switch 1	Switch 2					
3.1	Whether chipped or cracked over 200 mm length within 1000mm from ATS	Inner							
		Outer							
3.2	Whether twisted or bent (causing gap of 5 mm or more at toe)	Inner							
		Outer							
3.3	Whether knife edge	Inner							
		Outer							
3.4	Seating of tongue rails on slide chairs	Inner							
		Outer							
3.5	Housing of stock and tongue rails	Inner							
		Outer							
3.6	Condition of fitting of switches								
3.7	Packing condition under switch assembly								

4	**Creep at toe of switch**									
5	**Throw of Switch at ATS**		Inner							
			Outer							
6	**Divergence At Heel Block**		Inner							
			Outer							
7	**Straightness of Straight (Measured on 10m chord)**		Stock Hall							
			Tongue Rail							
8	**Wear in Tongue Rail and Stock Rail**			Switch 1		Switch 2				
				Inner	Outer	Inner	Outer			
8.1	Tongue Rail	At point with 13 mm head width (as per Annexure 26/8)	Vertical							
			Lateral							
8.2		At Point where tongue rail and stock rail level is same	Vertical							
			Lateral							
8.3	Wear in Stock Rail at point where tongue rail and stock rail level is same		Vertical							
			Lateral							
9	Distance between gauge faces of stock rails at JOH		Switch 1		Switch 2					
10	Distance between web to web of Tongue Rails									
10.1	Leading stretcher bar									
10.2	Ist following stretcher bar									
10.3	IInd following stretcher bar									

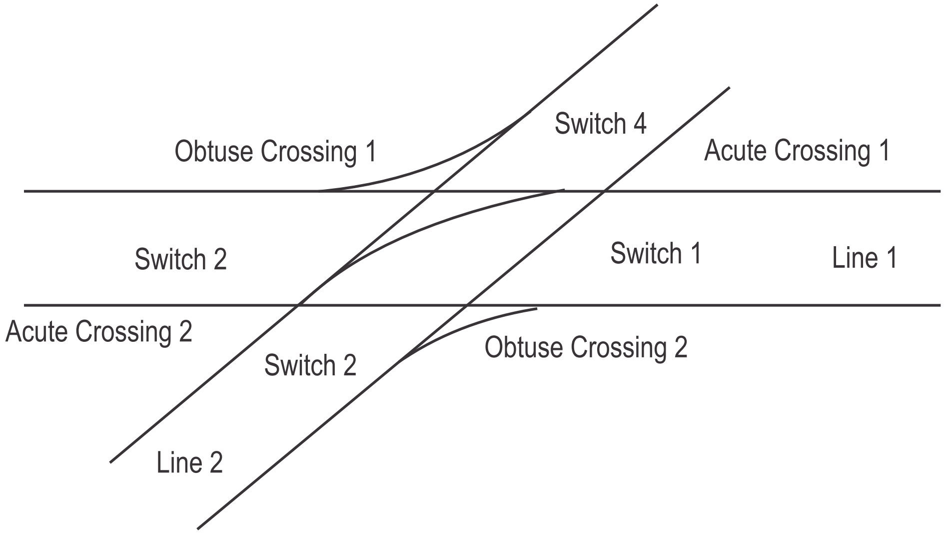
11	**Gap between top edge of stretcher bar and bottom of rail foot**									
11.1	Leading stretcher bar		Inner							
			Outer							
11.2	I[st] following stretcher bar		Inner							
			Outer							
11.3	II[nd] following stretcher bar		Inner							
			Outer							
12	**Clearance at JOH**									
12.1	On Open tongue rail side		Straight							
			Turnout							
12.2	On Closed tongue rail side		Straight							
			Turnout							
13	**Gauge and X-Level in Switch and Lead Portion**		Straight Side				Turnout side			
			Switch 1		Switch 2					
			Gauge	X-Level	Gauge	X-Level	Gauge	X-Level		
13.1	At 450 mm ahead of toe of switch									
13.2	At ATS between the two stock rails									
13.3	At 150 mm behind toe of switch									
13.4	At heel of switch									
13.5	At 3 m interval in lead potion	Station 0								
		1								
		2								
		3								

14	**Versine in Switch and Lead Portion**		**Switch 1 and Switch 2**						
			Inner	Outer					
		(Heel/ATS) 0							
		1							
		2							
		3							
		4							
		5							
15	**Condition of Crossing**		Acute Xing 1	Acute Xing 2	Obtuse Xing 1	Obtuse Xing 2			
15.1	Sign of Propogation of crack (if any)								
15.2	Burning on top surface at nose								
16	**Type of Crossing**								
17	**Wear of Crossing**	Acute Xing 1			Acute Xing 2				
		Left Wing Rail	On Nose	Right Wing Rail	Left Wing Rail	On Nose	Right Wing Rail		
		Obtuse Xing 1				Obtuse Xing 2			
		Nose 1		Nose 2		Nose 1		Nose 2	
		On Nose	Wing Rail	On Nose	Wing rail	On Nose	Wing rail	On Nose	Wing Rail

18	**Clearance of wing rail opposite Nose of crossing and upto 450 mm towards heel end**		Acute Xing 1		Acute Xing 1		Obtuse Xing 1		Obtuse Xing 2	
			Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
19	**Gauge and Cross Level**		Acute Xing 1		Acute Xing 1		Obtuse Xing 1		Obtuse Xing 2	
			Straight	Turnout	Straight	Turnout	Straight	Turnout	Straight	Turnout
19.1	1 m ahead of ANC	Gauge								
		X- Level								
19.2	150 mm ahead ANC	Gauge								
		X-Level								
19.3	150 mm behind ANC	Gauge								
		X-Level								
19.4	1 m behind ANC	Gauge								
		X-Level								
20	**Condition of check rail and its fittings**		Acute Xing 1		Acute Xing 1		Obtuse Xing 1		Obtuse Xing 2	
20.1	Raised check rails									
20.2	Other bearing, plates, keys , blocks and elastic fastening									
21	**Check Rail Clearance**		Acute Xing 1		Acute Xing 1		Obtuse Xing 1		Obtuse Xing 2	
			Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
21.1	Opposite ANC									
21.2	500 mm ahead towards toe of crossing									
21.3	500 mm behind heel of crossing									
21.4	All the flared end towards heel									
21.5	At the flared end towards toe									
22	**Remarks**									

Annexure - 6/5
(Para 609 (1)(b))

KEY SKETCH



Proforma for Inspection of Diamond Crossing With Double Slip

Station:____

Point No:____

Location:____

Type of Rail____

Date of laying : ____

Date of laying reconditioned crossing : ____________________________

Date of laying reconditioned switches : ____________________________

Type of sleeper/assembly ____________________________________

Angle of crossing: ______________________________________

Nominal gauge of turnout ____________________________________

1	**Sleeper Details**								
1.1	Condition of sleepers								
1.2	Squaring								
1.3	Spacing								
2	**Ballast Details**								
2.1	Condition of ballast								
2.2	Condition of drainage								
2.3	Ballast in shoulders and cribs								
2.4	Clean ballast cushion (mm)								
3	**Conditi on of Switch Assembly**		Switch 1	Switch 2					
3.1	Whether chipped or cracked over 200 mm l ength within 1000mm from ATS	Inner							
		Outer							
3.2	Whether twisted or bent (causing gap of 5 mm or more at toe)	Inner							
		Outer							
3.3	Whether knife edge	Inner							
		Outer							
3.4	Seating of tongue rails on slide chairs	Inner							
		Outer							
3.5	Housing of stock and tongue rails	Inner							
		Outer							
3.6	Condition of fitting of switches								
3.7	Packing condition under switch assembly								

4	**Creep at toe of switch**										
5	**Throw of Switch at ATS**			Inner							
				Outer							
6	**Divergence At Heel Block**			Inner							
				Outer							
7	**Straightness of Straight (Measured on 10m chord)**			Stock Hall							
				Tongue Rail							
8	**Wear in Tongue Rail and Stock Rail**			Switch 1		Switch 2		Switch 3		Switch 4	
				Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
8.1	Tongue Rail	At point with 13 mm head width (as per Annexure 6/8)	Vertical								
			Lateral								
8.2		At Point where tongue rail and stock rail level is same	Vertical								
			Lateral								
8.3	Wear in Stock Rail at point where tongue rail and stock rail level is same			Vertical							
				Lateral							
9	Distance between gauge faces of stoc k rails at JOH			Switch 1		Switch 2		Switch 3		Switch 4	
10	Distance between web to web of Tongue Rails										
10.1	Leading stretcher bar										
10.2	Ist following stretcher bar										
10.3	IInd following stretcher bar										

11	**Gap between top edge of stretcher b ar and bottom of rail foot**									
11.1	Leading stretcher bar	Inner								
		Outer								
11.2	I st following stretcher bar	Inner								
		Outer								
11.3	II nd following stretcher bar	Inner								
		Outer								
12	**Clearance at JOH**									
12.1	On Open tongue rail side	Straight								
		Turnout								
12.2	On Closed tongue rail side	Straight								
		Turnout								
13	**Gauge and X -Level in Switch and Lead Portion**		Straight Side				Turnout side			
			Switch 1 & Switch 2		Switch 3 & Swit ch 4		Switch 1 & Switch 2		Switch 3 & Switch 4	
			Gauge	X-Level	Gauge	X-Level	Gauge	X-Level	Gauge	X-Level
13.1	At 450 mm ahead of toe of switch									
13.2	At ATS between the two stock rails									
13.3	At 150 mm behind toe of switch									
13.4	At hee l of switch									
13.5	At 3 m interval in lead potion	Station 0								
		1								
		2								
		3								
		4								
		5								

14	**Versine in Switch and Lead Portion**	**Switch 1 and Switch 3**		**Switch 2 and Switch 4**					
		Inner	Outer	Inner	Outer				
	(Heel/ATS) 0								
	1								
	2								
	3								
	4								
	5								
15	**Condition of Crossing**	Acute Xing 1	Acute Xing 2	Obtuse Xing 1	Obtuse Xing 2				
15.1	Sign of Propagation of crack(if any)								
15.2	Burning on top surface at nose								
16	**Type of Crossing**								
17	**Wear of Crossing**	Acute Xing 1			Acute Xing 2				
		Left Wing Rail	On Nose	Right Wing Rail	Left Wing Rail	On Nose	Right Wing Rail		
		Obtuse Xing 1				Obtuse Xing 2			
		Nose 1		Nose 2		Nose 1		Nose 2	
		On Nose	Wing Rail	On Nose	Wing rail	On Nose	Wing rail	On Nose	Wing Rail
18	**Clearance of wing rail opposite Nose of crossing and upto 450 mm towards heel end**	Acute Xing 1		Acute Xing 1		Obtuse Xing 1		Obtuse Xing 2	
		Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer

19	**Gauge and Cross Level**		Acute Xing 1		Acute Xing 1		Obtuse Xing 1		Obtuse Xing 2	
			Straight	Turnout	Straight	Turnout	Straig ht	Turnou t	Straigh t	Turno ut
19.1	1 m ahead of ANC	Gauge								
		X- Level								
19.2	150 mm ahead ANC	Gauge								
		X-Level								
19.3	150 mm behind ANC	Gauge								
		X-Level								
19.4	1 m behind ANC	Gauge								
		X-Level								
20	**Condition of check rail and its fittings**		Acute Xing 1		Acute Xing 1		Obtuse Xing 1		Obtuse Xing 2	
20.1	Raised check rails									
20.2	Other bearing, plates, keys, blocks and elastic fastening									
21	**Check Rail Clearance**		Acute Xing 1		Acute Xing 1		Obtuse Xing 1		Obtuse Xing 2	
			Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
21.1	Opposite ANC									
21.2	500 mm ahead towards toe of crossing									
21.3	500 mm behind heel of crossing									
21.4	All the flared end towards heel									
21.5	At the flared end towards toe									
22	**Remarks**									

Annexure 6/6

(Para 610 (2)(c))

Bending of stock rail (B.G.)					
No. & Type of Switch	Switch Entry Angle	Crossing Angle	SRJ to ATS (mm)	TTS to ATS (mm)	Bend off set at SRJ (mm)
1 in 8½ IRS Straight	1°-34’-27”	6°-42’-35”	840	225	16.9
1 in 8½ Fan Shaped Curved on PSC	0°-46’-59”	6°-42’-35”	1500	439	14.5
1 in 12 IRS straight	1°-8’-0”	4°-45’-49”	1500	324	23.3
1 in 12 Fan Shaped Curved on PSC	0°-20’-0”	4°-45’-49”	1144	0	0

Bending of stock rail (M.G.)					
No. & Type of Switch	Switch Entry Angle	Crossing Angle	SRJ to ATS (mm)	TTS to ATS (mm)	Bend off set at SRJ (mm)
1 in 8½ IRS Straight	1°-35’-30”	6°-42’-35”	840	205	17.6
1 in 8½ IRS curved	0°-29’-14”	6°-42’-35”	1500	696	6.8
1 in 12 Curved (Partly Curved)	0°-24’-27”	4°-45’-49”	1500	844	4.7

Annexure 6/7
(Para 611)

Unique number:__________________ Whether Switch/Crossing:______________

If Switch component, stock rail or tongue rail and LH/RH____________________

____

If crossing, type of crossing (CMS/Built up) _______________________________

Year of purchase__________ Manufacturer _______________________________

Usage Details

Date of insertion in track	Date of removal from track	Location	Approx. GMT carried	Cum. GMT carried

Annexure 6/8
(Para 610 (2)(l))

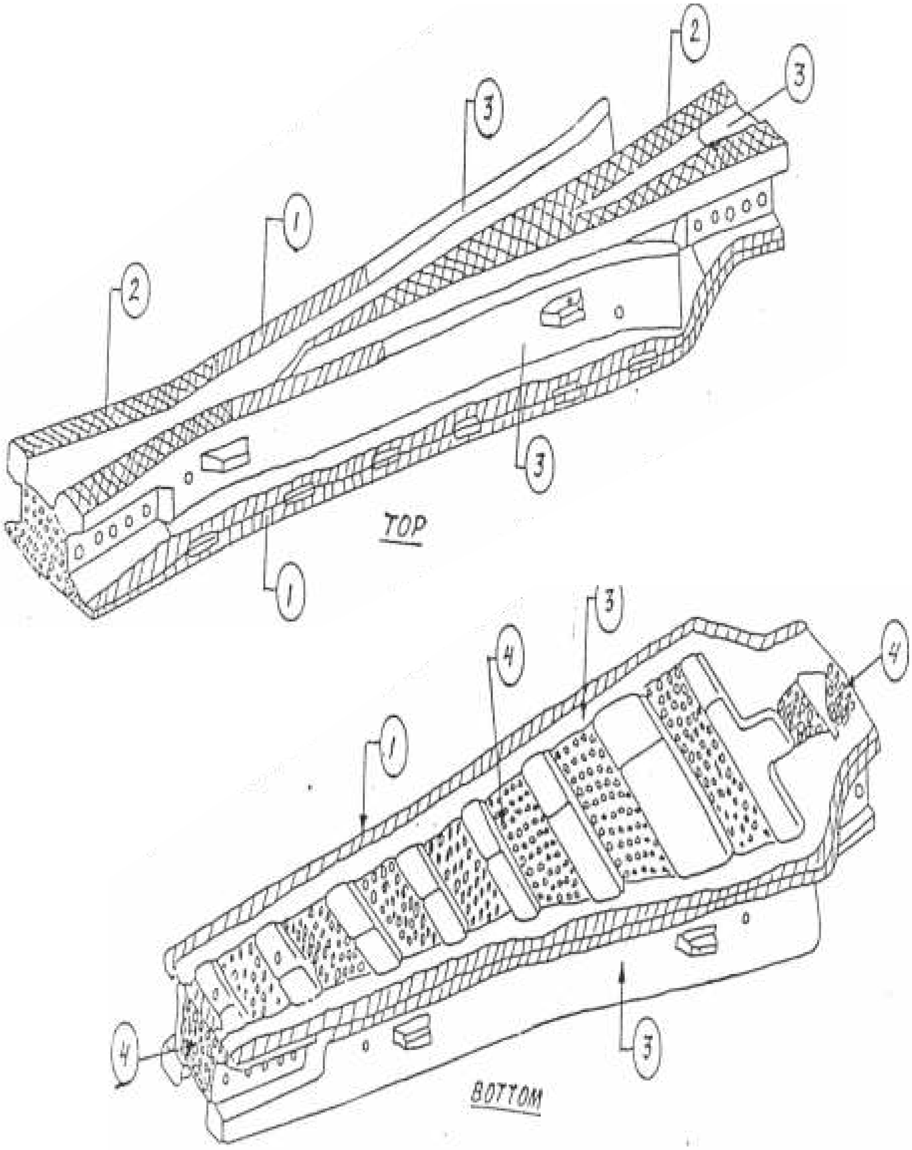
Particulars of Tonuge Rails Showing Location and Head Thickness at Level Point of Stock and Tongue Rail

SN	Description of switches	Drg. No. of tongue rails	Location of 13 mm head from ATS (mm)	Location of JOH from ATS (mm)	Location of level point of stock & tongue rail from ATS (mm)	Head thickness of tongue rail at level point (mm)
1	6400 mm C/S ON w/s BG 52 kg TA-20197	TA-20197/1	464	3005	1503	31.6
2	6400 mm C/S on s/s BG 52 kg TA-20836	TA-20197/1	464	3005	1503	31.6
3	6400 mm c/s on PSC BG 52 kg RT-4866	RT-4866/2	476.5	3023	1512	31.6
4	6400 mm c/s on PSC BG 60 kg RT-4966	RT-4966/1	476.5`	229	2348	48.25
5	7135 mm c/s on w/s BG 60 kg RT-3011	RT-3011/1	1046	3900	2836	50.54
6	7730 mm c/s on w/s BG 52 kg TA-20171	TA-20172/1	814	4669	2335	30.50
7	7730 mm c/s on s/s BG 52 kg TA-20832	TA-20832/1	814	4669	2335	30.50
8	10125 mm c/s on w/s BG 60 kg RT-2581	RT-2581/1	1682	5840	4247	43,40
9	10125 mm c/s on PSC BG 60 kg RT-4219	RT-4325/1	1682	4244	43.40	43.40
10	10125 mm c/s on PSC BG 52kg RT-4733	RT-4733/1	1682	5540	4029	40.34

Annexure-6/9

(Para 610 (4)(c)(vi))

Categorization of areas/locations in CMS crossing based on criticality from service considerations



CATEGORY- I

CATEGORY- II

CATEGORY- III

CATEGORY- IV

Annexure - 6/10
(Para 610 (4)(c)(iv))

Performa for recording details of cracks in CMS crossings

(To be maintained separately for each CMS crossing showing crack)

Point No.:	Station :
Location :	Type of sleeper/assembly :
Date of laying sleeper (mm/yyyy):	Left hand or right hand :
Rail section& Angle of crossing :	GMT on the point :
Detail of last deep screening (mm/yyyy) : Manual/Mechanized :	Date of laying of new crossing : (mm/yyyy) Date of reconditioning : 1st : 2nd: 3rd:
Manufacturer &Crossing unique number :	

Location of Cracks	**Length of crack**	**Date when observed first**
1.		
2.		
3.		

Date of Inspection	Location of Crack	Length of crack (mm) & orientation (vertical/ horizontal/ inclined)	Remarks, if any	Signature of JE/SSE (P.Way)

Chapter 7

Welded Rails - Laying and Maintenance

701. Types of Welding of Rails :

Welding of rails is carried out for joining the rails of various lengths. On Indian Railways, the welding of rails is generally done using two techniques namely-

(1) Flash Butt Welding

(2) Alumino Thermit Welding

The welding of rails is done in a depot by "Flash butt welding process" , and at site either by "Flash butt welding process" using mobile flash butt welding plant or by "Alumino Thermit Welding" process. The length to which the rails can be welded in a depot depends on the facilities available for transportation of these welded rails.

702. Flash Butt Welding of Rails :

(1) General:

Flash Butt Welding of Rails shall be carried out in accordance with the detailed procedure laid down in the "Manual for Flash Butt Welding of Rails" (Revised January 2012) updated from time to time.

(2) Principle:

The flash butt welding is a method of joining rails in which heat necessary to forge the joint is generated by resistance of rails being welded to the passage of electric current. The parent material is consumed during the welding process.

During welding of rails the voltage is stepped down to 4 to 12 Volts and the current varies from 30,000 to 80,000 Amp. Total length of 25 mm to 35 mm is consumed per weld . The recommended butting pressure is 5 kg/mm^2 for 72 UTS , 6 kg/mm^2 for 90 UTS and 7 kg/mm^2 for 110 UTS rails.

(3) Stages in Flash Butt Welding:

(a) Aligning

(b) Initial burn off

(c) Pre heating

(d) Flashing

(e) Forging (Upsetting)

(f) Stripping

(g) Post straightening

(h) Cooling

When Flash Butt Welding is done in situ using Mobile Flash Butt Welding machine, it gives continuous flashing instead of initial burn off, pre-heating and flashing cycles separately.

(4) Rail End Geometry:

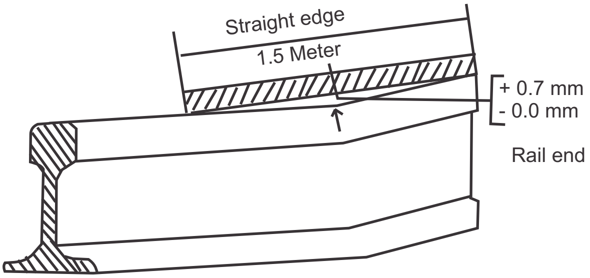
Rail ends to be welded shall meet following geometrical standards:

(a) End-bends in the vertical plane not greater than 0.7 mm on a 1.5 metre straight edge *(Fig7.01(a)).* Sagging ends not permitted

(b) End-bends in the horizontal plane not greater than + 0.7 mm on a 1.5 metre straight edge *(Figs. 7.01 (b) and (c))*

(c) Deviation of the end from the square not greater than +0.6 mm *(Fig.7.02)*

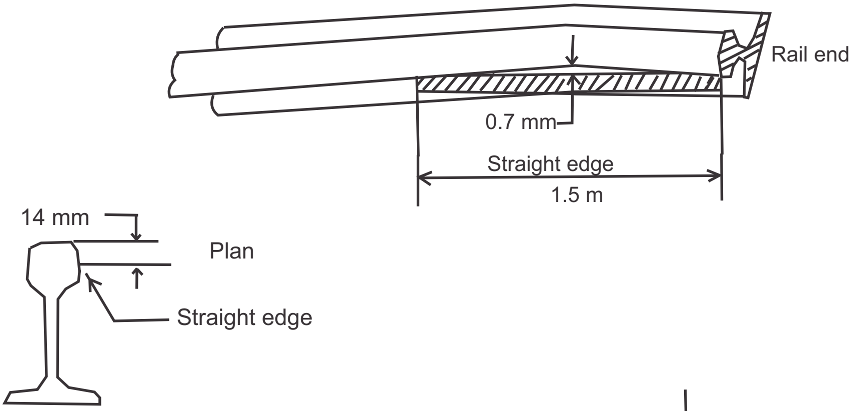
(a)



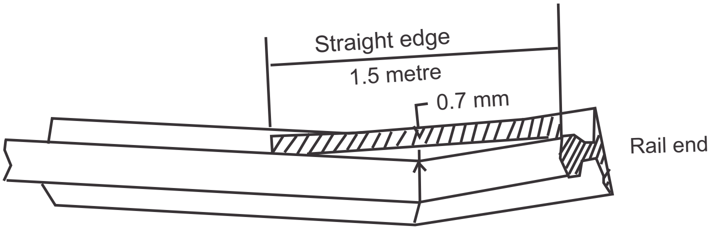
Elevation

Tolerance on the end bends in the vertical plane

(b)



(c)



Plan

Fig 7.01 (a),(b),(c) - *Tolerance on the end bends in the horizontal plane*

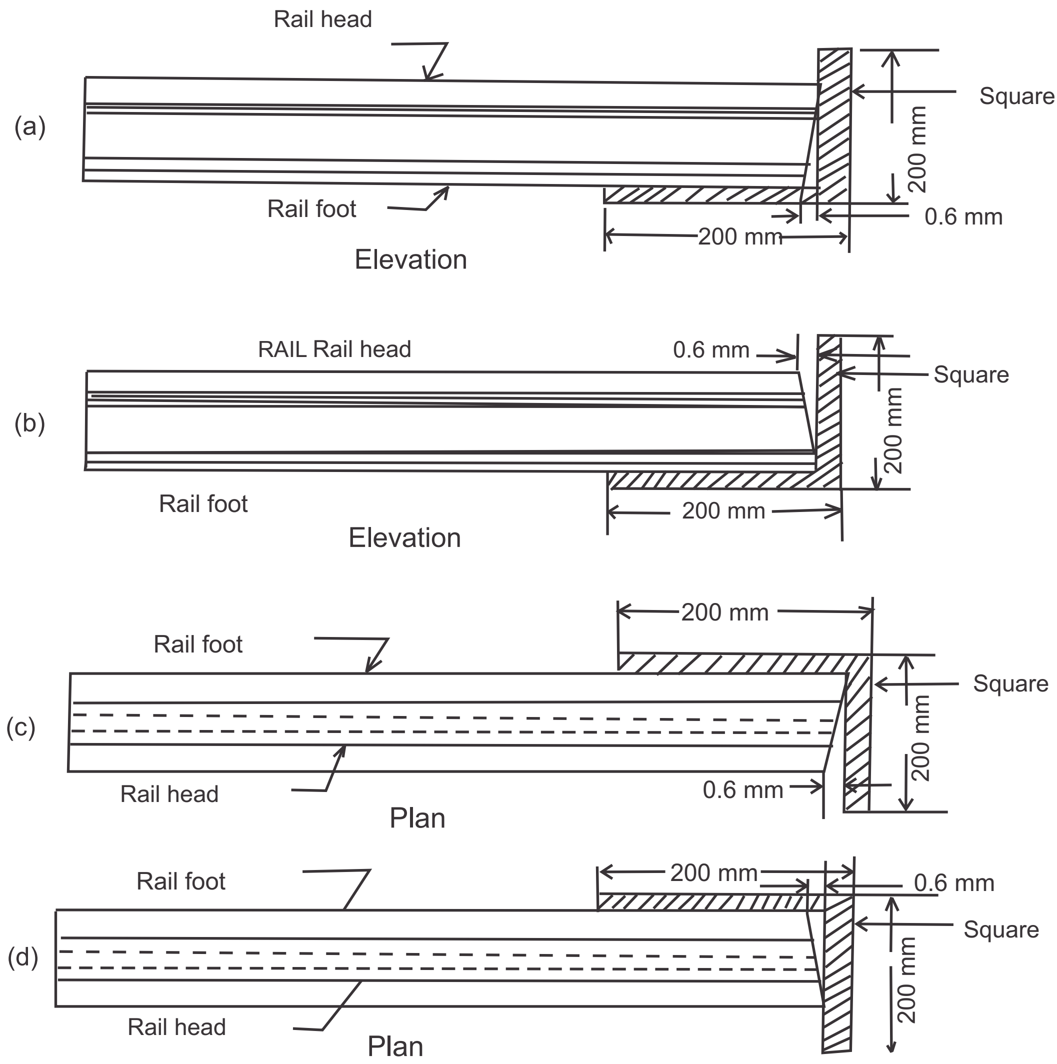


Fig. 7.02 (a), (b), (c), (d) *Deviation of the rail end from the square*

(5) Finishing of weld joint:

The top, side and bottom surfaces of the rail head shall be ground smooth so that the weld surface is absolutely flush with the parent rail surfaces. The finish grinding should not burn or notch the rail surfaces. After grinding, the top table and the sides of the rail head shall comply with the geometrical standards given under *in table 7.01.*

(a) Grinding shall be done preferably using a profile grinding trolley, in the absence of which manual grinding can be done using a cup grinder.

(b) In case of in-situ welding with mobile flash butt welding plant, profile grinding can be done in stages i.e. initial grinding and final grinding. Final grinding can be performed in track with rails fastened in position over a minimum length of three sleepers on either side of weld. Profile finishing of rail head shall be carried out and contained in shortest possible length but not greater than 400 mm on either side of weld. Profile finishing should not cause any thermal or mechanical damage to rail.

(c) Tolerances for finished weld joints are as under :

Table 7.01 *Tolerances for finished weld joint.*

S. No.	Description	Tolerances for New Rails	Tolerances for Old Rails
1.	Vertical misalignment At the centre of a 1 m straight edge.	+0.3 mm, -0.0 mm	±0.5 mm
2.	Lateral misalignment : At the centre of a 1m straight edge.	±0.3 mm	±0.5 mm
3.	Head finishing (in width): Side of rail head should be finished to :- On gauge side at the centre of 10 cm straight edge	± 0.25 mm	± 0.30 mm
4.	Finishing of top table surface: at the centre of 10cm straight edge	+ 0.2 mm, - 0.0 mm	± 0.2 mm
5.	Web zone (under side of head, web, top of base, both fillet each side):	+ 3.0 mm, - 0.0 mm of the parent contour	+ 3.0 mm, - 0.0 mm of the parent contour
6.	Upper sides, under surfaces and edges of rail foot shall be ground smooth. The edges of foot should be rounded and bottom of rail foot ground smooth without any minus tolerances to ensure proper seating on sleepers, unhindered movement of welded panels on end unloading rakes, avoid damage to elastic rail pads and eliminate stress riser.		

Note: The above tolerances are finished tolerances of welds inclusive of tolerances of rail.

The Schematic diagram depicting measurement of tolerances for vertical and lateral misalignment is shown below in *Fig 7.03.(a) and (b)*

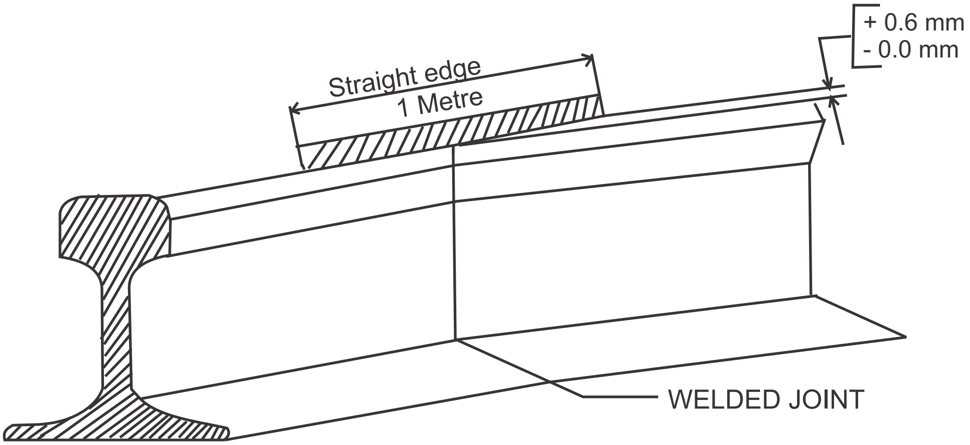


Fig. 7.03 (a) *Tolerances for vertical misalignment of welded joint with new rails*

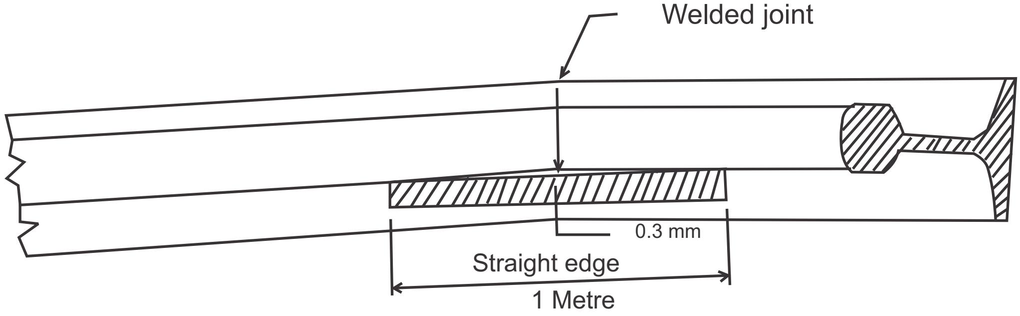


Fig 7.03 (b) *Tolerances for lateral misalignment of welded joint with new rails*

(6) Marking of Joints: Every joint shall have distinctive mark indicating the weld number, month and year of welding and the code of the plant *Fig. 7.06* The marking should be embossed on the gauge and non gauge face sides of the head of the rail and diagonally opposite to each other across the joint at 300 mm away from the centre line of weld by punching after finishing of the weld without causing any damage to rail, in letters/digits of 6 mm height.

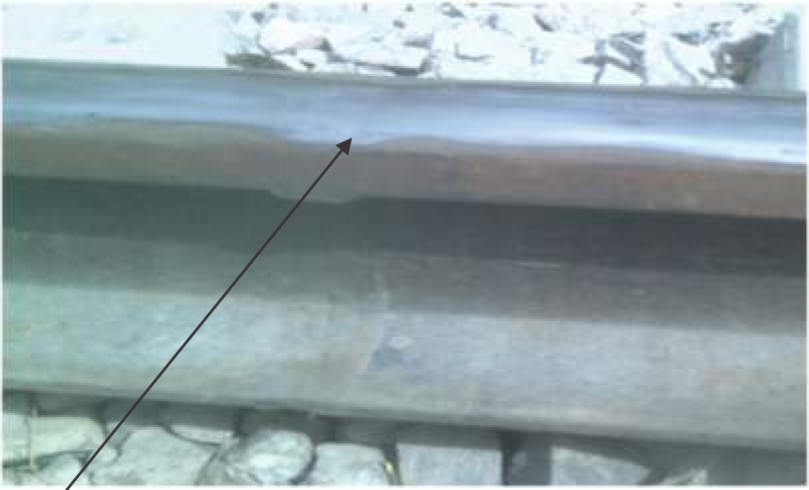


Fig. 7.04 - *Flash Butt Joint*

Fig. 7.05 *Mobile Flash Butt Welding Machine*

(7) Do's and Don'ts for Flash Butt Welding

(a) Do's

(i) Use only USFD tested rails, which are found good, and which satisfy the geometrical requirements as laid down in the *'Manual for Flash Butt Welding of Rails (Revised January 2012)'.*

(ii) Clean the rail end faces and the adjoining surface of the rail profile to a width of about 25 mm all around properly by portable grinders or brushing machine or shot blasting to remove loose scale, rust, scabs, dust, paint etc. before welding.

(iii) Remove oil and grease, if present, by Carbon Tetrachloride or Benzene before welding.

(iv) Ensure end square-ness of rail end faces before welding.

(v) Maintain preheating cycle and time, flashing and butting stroke as standardized during welding.

(vi) Ensure throughout uniform and smooth auto trimming of the squeezed out metal and complete grinding using profile grinder around the butt joint.

(vii) Ensure that notches, dents or chisel marks are not formed on the rail surface during stripping by chiseling and finishing by grinding of weld.

(viii) Clean loose oxide/metalfrom copper block by brushing after each weld operation to avoid copper intrusion in the weld joint.

(ix) Use suitably treated water for cooling system of machine and its electrodes.

(x) Butting stroke should be sufficient for complete coalescence (Not less than 12 mm).

(xi) Ensure minimum and nearly parallel heat affected zone of the joint by setting the appropriate weld parameters as approved by the RDSO.

(xii) Permit minimum 20 minutes time after trimming to pass train over the weld using proper packing and support below the joint, in case of in - situ welding.

(xiii) Weld together only same type of rails (section and metallurgy).

(xiv) Chamfer fishbolt holes if any before welding.

(xv) Provide joggle fish plate with two clamps and support weld Joint on wooden blocks till tested as good by USFD.

(xvi) Mark the joint as mentioned in the Manual for Flash Butt Welding of Rails as shown in *Fig. 7.06.*

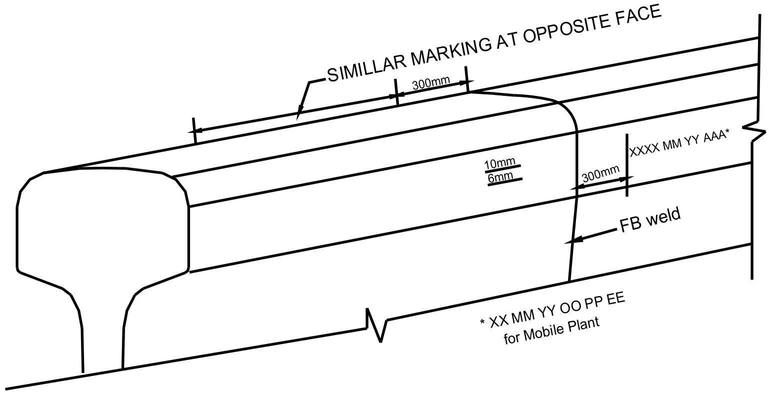


Fig. 7.06 *Location of marking of weld*

(b) Don'ts

(i) Allow welding if QAP of the Plant/Machine is not approved by competent authority and weld parameters are not standardized by RDSO.

(ii) Manipulate welding parameters standardized by RDSO.

(iii) Operate welding plant if the cooling system is non-functional.

(iv) Attempt welding of rails of different sections/ metallurgy.

(v) Weld rails with visible surface defects such as rolling/guide marks, chisel mark, dent of any type on bottom flange of the rail, wheel burns etc.

703. Alumino Thermit Welding of Rails:

(1) General: Alumino Thermit Welding of Rails shall be carried out in accordance with the detailed procedure laid down in the *"Manual for Fusion Welding of Rails by the Alumino-Thermic Process (Revised 2012)"* updated from time to time. A.T. welding is required for converting flash butt welded panels into further longer panels and for repair of fracture or defects. Normally new single rails shall not be welded by A.T. welding.

Conventional A.T. welding process utilising green sand mould has been banned on Indian Railways. Alumino-thermic welding techniques with short pre-heating process have been standardised for 75R, 90R and higher rail sections.

(2) Principle:

Alumino Thermic welding is a process that produces coalescence of metals by heating them with superheated molten metal from an Alumino thermic reaction between a metal oxide and aluminum.

(3) New Rails for Alumino Thermic Welding:

The dimensional tolerances of new rails for Alumino Thermic welding shall confirm to the limits prescribed in the *'Manual for Fusion Welding of Rails by Alumino-hermic Process (Revised 2012)'.*

(4) Second Hand Rails for Welding:

(a) The dimensional tolerances of second hand rails for Alumino Thermic welding shall confirm to the limits prescribed in the *'Manual for Fusion Welding of Rails by Alumino-Thermic Process (Revised 2012)'*

(b) Rails shall be free from corrosion or excessive wear. The height of rail and width of rail head shall not be less than the values as indicated in *Manual for Fusion Welding of Rails by Alumino-Thermic Process.*

(c) Rails shall be tested before welding, with ultrasonic flaw detector apart from visual inspection, so that rails having cracks and internal flaws are excluded from welding. Rails with excessive scabbing, wheel burns, corrugations and wear of rail seats shall not be used for welding. The rail flange bottom shall be visually inspected to ensure freedom from defects like dent, notch, corrosion, etc.

(d) The ends of second hand rails should be suitably cropped so as to eliminate fish bolt holes.

(e) The rail ends shall be cut by sawing or using abrasive disc cuter and not by flame cutting. Abrasive disc cutter should be used as far as possible as it gives perfectly vertical and square cut which is essential for good weld.

(f) Second hand rails shall be match-marked before releasing from track to enable matching of the rail ends at the time of welding. Kinks, if any, in the rails shall be removed before welding.

(g) The rolling marks on the web of rails shall be checked before welding to ensure that generally rails of different qualities are not welded together. However, in unavoidable circumstances, where rails of Grade 710 (72 UTS) rail chemistry and that of Grade 880 (90 UTS) chemistry are to be welded, the portion of Grade 880 (90 UTS) chemistry shall be utilised for welding.

(h) While using second hand rail panels for secondary renewal, released from LWR/CWR sections, the ends should be cropped to eliminate fish bolt holes. If rail ends do not have bolt holes, the ends may be cropped to a distance of minimum 150 mm for A.T. welds and 85 mm for flash butt welds from the center of welded joint to eliminate heat affected zone of welds. End cropping may be suitably increased so as to ensure that rail ends are within the tolerances as specified in the *'Manual for Fusion Welding of Rails by Alumino-Thermic Process (Revised 2012)'*

(i) In case of repair of fractured rail/defective weld with wide gap (75 mm gap) weld, the rail shall be cut from center of rail fracture/defective weld 37-38 mm each side for making suitable gap of 75mm, provided bolt holes do not fall within 40 mm from cut faces.

(5) Details of A.T. welding technique:

(a) The welding techniques approved provisionally or for regular adoption by Railway Board/RDSO should only be adopted for welding of rails. For details of approved welding techniques and vendors, *'Master list of approved vendors'* issued biannually by Quality Assurance (Civil) Dte. of RDSO may be referred.

(6) Recent Improvements in AT Welding Technique:

Presently on Indian Railways Alumino-Thermit welding of rails is being done with air-petrol fuel mixture/Oxy-LPG/ Compressed Air-petrol pre-heating, with pre-fabricated mould (zircon-washed) manually pressed using Single shot/ multiple use crucible fitted with Auto tapping/manually tapped thimble.

The major advancements in the AT welding technology adopted/under consideration on Indian Railways is as under:

(a) Improved Pre-heating techniques which provides Mechanical pressurization thereby reducing manual intervention, Lesser preheating time of 4-6 minutes as well as overall welding time, and narrower heat affected zone (HAZ).

(b) Three piece moulds *(Fig. 7.07)* are being employed to avoid formation of fin and 'Half moon defect' at the bottom.

Fig. 7.07 *Three piece Mould*

(c) Auto tapping thimble *(Fig. 7.08)* is used to automatically sense the completion of reaction and takes care of error involved in human judgment while tapping of molten metal from crucible.

Fig. 7.08 *Auto tapping thimble*

(d) Use of Single shot crucible *(Fig. 7.09)* fitted with Auto tapping thimble ensure that cleaner weld steel is produced free from impurities and pore. This also provides safety to welders. Moreover the time lost in cleaning the lining and repairing the same is also saved.

Fig. 7.09 *Single shot crucible*

(7) Portion for welding

(a) The portion used for welding shall conform to the technical requirements as mentioned in *IRS:T-19* with latest amendments. The suitability of the portion' for the welding process in respect of the type and section of rails to be welded shall be ensured before commencing welding. Only RDSO certified/passed portions should be used for welding.

(b) Shelf life of portion : No specific shelf life has been indicated for A.T. welding portions. A.T. portion is sensitive to moisture. Once the portion absorbs moisture, the same cannot be removed even by drying as the ingredients react chemically. All such portion should not be used for welding. For permitting use of portions beyond two years after the date of manufacturing, procedure given in the *'Manual for Fusion Welding of Rails by the Alumino-Thermic Process (Revised 2012)'* may be adopted.

(8) Preliminary work prior to welding

(a) In case of in-situ welding the rail fastenings for at least five sleepers on either side of the proposed weld shall be loosened. When the welding work is carried out on cess, full rail length shall be levelled by supporting on at least ten wooden blocks on either side.

(b) The rail end face and adjacent sides at foot (top and bottom), web and head up to 50 mm shall be thoroughly cleaned using kerosene oil and brushing with wire brush to remove all dirt, grease and rust before welding Any burrs at the rail ends shall be removed by chiselling or grinding.

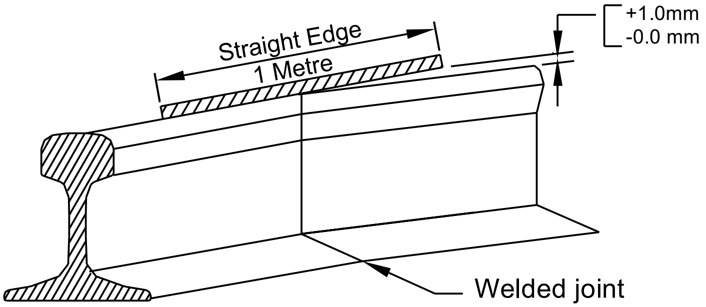
(c) Normally, no Alumino-Thermic welded joint shall be located closer than 4 m from any other welded or fish plated joint.

(9) Rail alignment

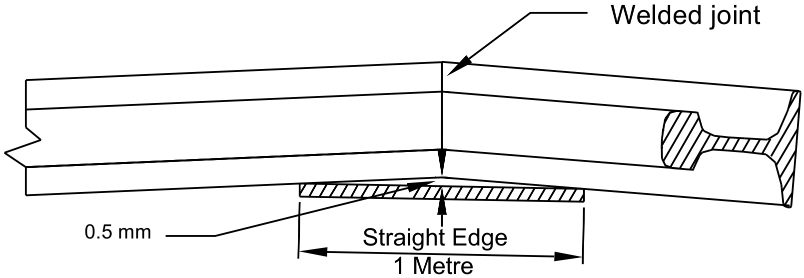
The rail ends to be welded shall be aligned in horizontal and vertical planes to the dimensional limits indicated below:

(a) Lateral alignment: The two rail ends, after alignment shall be within +0.5 mm when checked with a 1.0 m straight edge at rail ends. Any difference in the widths of rail heads shall always be fully kept on the non-gauge side, correctly aligning the rail ends on the gauge face.

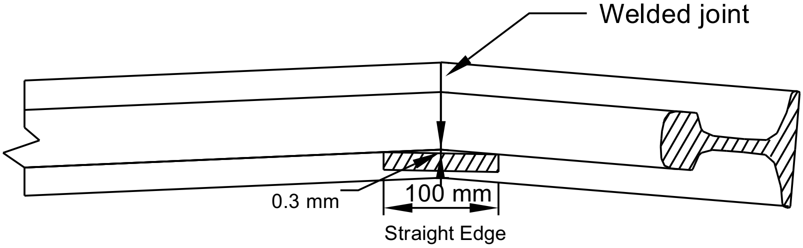
(b) Vertical alignment: The joint shall be kept higher by 3 to 4 mm for 72 UTS rails and 2 to 2.4 mm for higher UTS rails when measured at the end of 1.0 m straight edge, This shall be achieved by wedges applied on the rail supporting blocks on both sides of the joint.



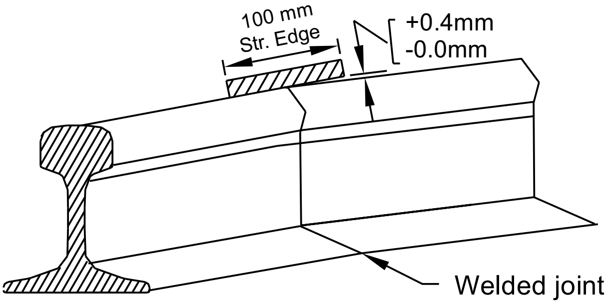
(a) Tolerance for vertical misalignment of welded joint



(b) Tolerance for lateral misalignment of welded joint



(c) Tolerance for finishing on sides of head of welded joint



(d) Tolerance for finishing top table surface of welded joint

Fig. 7.10 (a)(b)(c)(d) *Tolerances on the end bends in vertical / horizontals plane*

(10)Welding process:

The welding shall be done as per the process given in para 4.10 of the *Manual for Fusion Welding of Rails by the Alumino-Thermic Process (Revised 2012)'.* No welding shall be carried out if it is raining. In case, the rain starts while the joint is under execution, immediate arrangement to adequately cover the site shall be made.

(11) Acceptance Tests :

All the welded joints shall be subjected to visual inspection, dimensional check and Ultrasonic flaw detection tests. In addition to this, the test welds shall also be subjected to Mechanical and Metallurgical tests as given in *IRST-19* with latest amendments.

(a) Visual Inspection

All the welded joints shall be cleaned and examined carefully to detect any visible defect like cracks, blow holes, shrinkage, mismatch, surface finish (smooth surface finish required) etc. Any joint, which shows visible defect, shall be declared defective.

The bottom of the joint shall be checked by feeling with fingers as well as inspected with the help of a mirror for presence of 'fins' at the parting line of the mould. If fin is observed in any joint, the joint shall be declared defective.

(b) Dimensional Check *(Fig. 7.10)*

All the joints shall be checked for dimensional tolerances which should be within the limits prescribed in *table 7.02.*

Table 7.02 *- Tolerances of finished AT Weld*

Sr No	Description	Tolerance
1	Vertical alignment (measured at the end of one metre straight edge.)	+1.0 mm, -0.0 mm
2	Lateral alignment (5mm measured at centre of one metre straight edge.)	+0 -0
3	Finishing of top surface (measured at the end of 10 cm straight edge)	+0.4 mm -0.0 mm
4	Head finishing on sides(over gauge side of the rail head measured at the centre of 10cm straight edge)	+ 0.3 mm

Note: In specific cases, for rail joint geometry, in case of old rails, dispensations may be permitted by Chief Engineer.

(c) Ultrasonic flaw detection test:

All the fusion welded joints shall be ultrasonically tested as per the provisions of *'Manual for Ultrasonic testing of rails and welds'.* This testing shall be completed as early as possible but in any case before the welding team is shifted.

Thermit weld done in-situ shall be joggle fish plated with two clamps till tested as good by USFD. Subsequent USFD testing of A.T. welds shall be done as per the provisions given in *Manual for Ultrasonic Testing of Rails and welds, Revised-2012.*

(12) Weld Records:

JE/SSE (P.way) shall maintain 'Thermit Weld Register' as per proforma given in *Annexure-5* of *AT Welding Manual* The welded joints shall be serially numbered in a kilometer. Repair welds/additional welds done at a later date may be given continuing weld number in that kilometer. For example, the last thermit weld number in a particular kilometer was 88 and subsequently a thermit weld has been executed, it shall be numbered 89, irrespective of its location in that kilometer.

(13 Precautions:

While carrying out welding at site, the following precautions shall be observed:

(i) A minimum traffic block of 70-75 minute duration, depending upon the type of preheating technique adopted, should be obtained for complete operation of welding of first joint and to ensure good quality of A.T. weld.

(ii) No moist portion/ torn bag portion shall be used for welding.

(iii) Rail ends should be square. The two rail ends to be welded shall be held in position with a uniform and vertical gap as per gap specified for the particular welding technique.

(iv) The crucible lined with refractory material (magnesite / crushed alumina slag) and fitted with bottom stone and thimble shall be preheated before making the first weld of the day to ensure freedom from moisture.

(v) Slag shall be cleaned from the crucible after each reaction, if necessary. During cleaning, care shall be taken not to damage the refractory crucible lining.

(vi) Pressure in the tanks/cylinder should be properly maintained during pre-heating.

(vii) Stop watch should be provided to the welding supervisor at each welding site.

(viii) Correct gap between rail ends at head, web and foot shall be ensured.

(ix) Before mounting on the rail ends to be welded, each pair of moulds shall be examined for defects, dampness, cracks, blocked vents, etc. and defective moulds discarded. The prefabricated moulds shall be handled with care as they are fragile and liable to breakage.

(x) During fixing the moulds, it shall be ensured that the center line of the rail gap coincides with the center line of the mould to avoid cross joint. After fixing the moulds, the gap between mould and the rail shall be packed firmly ith luting sand to prevent leakage of liquid weld metal.

(xi) Excessive pressure may cause breakage of mould and dropping of sand inside the mould cavity. Care shall be taken during application of adequate pressure.

(xii) To protect the rail top table from metal splashes during reaction, the adjacent rail surface on either side of the moulds shall be covered with metal cover or smeared with luting sand up to 15 cm on either side.

(xiii) Correct preheating time for rail ends shall be ensured. The pre-heating shall be done from the top of the mould box for stipulated period for welding technique adopted, so as to achieve a temperature of around 600 ± 20° C.Preheating time would be about 10 to 12 minutes, 4.0 to 5.0 minutes and 2.0 to 2.5 minutes for Air-petrol, compressed Air-petrol and Oxy-LPG preheating techniques respectively. The actual preheating time would depend upon the rail section and welding technique adopted.

(xiv) Tightness of clips fitted with hose connections to compressor tank and burner shall be checked before commencing preheating.

(xv) Nozzles of burners shall be cleaned periodically to avoid back – fire.

(xvi) The compressor tank shall be kept at least 2 to 3 m away from burner to prevent fire hazard.

(xvii) The vertical distance between the tap hole and sand core/top of the pouring gate should be about 50 mm.

(xviii) The tapping shall be done within the time specified for that particular technique or automatically. For special type of welding i.e.75 mm gap, combination joint etc. the time of reaction and tapping shall be as stipulated by RDSO for that particular welding technique.

(xix) After the reaction subsides, about three seconds shall be allowed for the separation of slag from the metal, which may be judged by looking into the crucible through coloured glass when manual tapping of molten metal is employed.

(xx) If the reaction is found to be boiling, the metal shall be out-tapped. Vigorous reaction and loose closing of crucible may cause self-tapping. In this case also, the metal shall be out tapped. If, in any case, self-tapped metal enters the mould, the joint shall be rejected, cut and re-welded.

(xxi) The mould shoes shall be removed just prior to completion of mould waiting time. The mould waiting time is generally four to six minutes for 25 mm gap joints and 12 minutes for 75 mm gap joints.

(xxii) Arrangements for giving first aid shall be available at site.

(xxiii) Welders should be provided with gloves and coloured glasses.

(xxiv) In the eventuality of sudden failure of weld trimmer, manual chipping may be resorted to. In case of welding of old rails, if it is not possible to use weld trimmer due to flow of metal at rail head, manual chipping should be done.

(xxv) After the excess metal is trimmed off, the grinding of the remaining metal on the rail table and the sides of the rail head shall be carried out only with rail profile guided grinding trolley of approved design. Use of hand files should not be resorted to except in unavoidable circumstances.

(xxvi) The first train should be allowed to pass on the newly welded joint only after 30 minutes have elapsed since pouring of weld metal. Necessary speed restriction shall be observed until the grinding operation is over.

(xxvii) Each joint shall be provided with a distinctive mark for easy traceability as per the procedure given in *'Manual for Fusion Welding of Rails by Alumino-Thermic Process.'*

(xxviii) No hole should be made within heat affected zone of A.T. weld i.e. 75 mm from centre of AT weld in the new SKV welds of 25 mm gap.

(14) Do's and Don't of Alumino Thermic Welding

(a) Do's

(i) The welders and the supervisors carrying out AT welding should have a valid competency certificate issued by TPP/Lucknow, RDSO or Thermit Welding Centre/ Vijayawada. The bar coded I-card of the welder should be checked before the welding work is undertaken.

(ii) It should be ensured that the portion being used matches with type and chemistry of rail

(iii) AT Welding Portion should be properly packed and should be stored in dry, ventilated place.

(iv) Igniters should be stored in locked steel cupboard and away from portion.

(v) The Prefabricated Moulds should be properly packed and stacked in dry, ventilated place.

(vi) Complete T&P and consumables should be available at site before starting of the welding.

(vii) The moulds should be free from cracks.

(viii) The date of manufacture, rail section, type of gap and technique of portion should be checked before opening the bag.

(ix) Fitting of about five sleepers should be removed from joint so as to facilitate the desired gap and height at rail joint.

(x) Check the rail ends for gap, alignment, cleanliness etc. before starting the preheating.

(xi) The preheating time and mould waiting time is vendor specific for a particular technique and should be known before starting the preheating and should be adhered.

(xii) The air pressure, availability of petrol/LPG etc. should be checked before starting the preheating.

(xiii) The rail guard should be placed on the rail outside the mould area to avoid the sprinkles of molten metal to fall on the rail head.

(xiv) The grinding of rail table and the sides of the rail head shall be carried out only with rail profile guided grinding trolley of approved design

(xv) Necessary speed restriction should be observed until the grinding operation is over.

(xvi) The Identification code should be embossed on the non-gauge face side of A.T. weld by punching after finishing of the weld.

(xvii) Painting of weld collar should be done on all welds to protect them against corrosion immediately after the welding.

(xviii) In service painting of thermit welds should be carried out as per the following frequency:

Once in four years in areas not prone to corrosion.

Every year at locations prone to corrosion.

The frequency may be increased depending upon the site conditions.

(xix) All the welded joints shall be ultrasonically tested as per the provisions of *'Manual for Ultrasonic testing of rails and welds'.* This testing shall be completed as early as possible but in any case before the welding team is shifted.

(xx) A thermit weld done in-situ shall be joggled fish-plated with two clamps till tested as good by USFD.

(b) Don'ts

(i) The block time should not less than 70-75 mins.

(ii) The high moisture content luting sand should not be used.

(iii) No traffic should be passed over the weld for 30 minutes after the pouring of weld metal. Necessary speed restriction shall be observed until the grinding operation is over.

(iv) No chisel/hammer should be used to cut the extra metal.

(v) Use of hand files for grinding should not be resorted to except in unavoidable circumstances. In the case of in-situ joints, the grinding shall commence only after the sleeper fastenings are re fixed, after the removal of wedges.

(15) Training and Competency:

The training of welding supervisors and welders shall be done as per provisions of Annexure 1 of *Manual for Fusion Welding of Rails by Alumino thermic process (Revised 2012)'*. Thermit Portion Plant(TPP)/Lucknow shall impart initial and refresher training to Contractual welders and supervisors as well as departmental welders and supervisors. Thermit Welding Centre (TWC)/Vijayawada is authorised for training and certification of departmental welders and supervisors.

Category	Course	Syllabi	Periodicity	Duration	Agency
Welder	Initial Course	TW-1	-	2 weeks	TPP/ TWC
Welder	Refresher Course	TW-2	2 years	1 week	TPP/ TWC
JE, SE, SSE (P.Way)	Course for Welding Supervisor	TW-3	Based on performance	1 week	TPP / TWC

704. Short Welded Rails : Definitions :

(1) Short Welded Rail(SWR) is a welded rail which contracts and expands throughout its length.

Note – Normally the length of SWR is 3×13 m for B.G and 3×12 m for M.G

(2) Rail temperature is the temperature of the rail as recorded by an approved type of rail thermometer at site. This differs from the ambient temperature which is the temperature of air in shade at that place, as reported by the meteorological department.

The Indian Railways have been divided into four rail temperature zones. The map indicating 4 temperature zones & annual mean temperature at important places is placed *as Fig. 7.13.*

(3) Mean annual rail temperature (t_m) is the average of the maximum and minimum rail temperature recorded during the year. tm will be fixed locally wherever rail temperature records are available for a reasonable period of five years. Where rail temperature records are not available tm can be read from the rail temperature map as in *Fig. 7.13.*

(4) Installation temperature (t_i) is the average rail temperature during the process of fastening the rails to the sleepers at the time of installation of SWR.

705. Track Structure for SWR

(1) Formation – SWR shall be laid generally on stable and efficiently drained formation.

(2) Rails – The minimum section of rail shall be 90R for B.G and 60R for M.G. Only new rails and second hand rails conforming to the standards laid down in relevant clause of the Manual for Fusion Welding of Rails by Alumino Thermic Process and the Manual for Flash Butt Welding of Rails updated from time to time shall be welded into SWR.

(3) Sleepers – The sleepers approved for use with SWR shall be as under:

(a) Wooden sleepers with anti-creep or elastic fastenings.

(b) Cast iron sleepers and steel through sleepers with key type or elastic fastenings

Wooden sleepers with mild steel bearing plates and rail free fastenings may preferably be used at all fish plated joints when SWR is laid on metal sleepers. Concrete sleepers should be used in cases where SWR is likely to be converted to LWR immediately. In such cases the fish-plated joints shall have concrete sleepers at uniform spacing. In addition, 1 m long fishplates, be provided at fish plated joints.

(4) Minimum Sleeper density – Minimum sleeper density to be acheived during various works on BG & prescribed for MG routes is as under

Broad Gauge – The minimum sleeper density shall be as under:

Track works/ Projects	Sleeper density
All track renewals (complete track renewal and through sleeper renewal), Doubling, Gauge conversion, New line construction works for main lines	1660 nos. per km
Sidings with permissible speed more than 50 km/h	1660 nos per km.
Loop lines & sidings (permissible speed upto 50 km/h)	1540 nos. per km

Meter Gauge – In the case of MG track renewals, the sleeper densities as recommended for various MG routes are given below-

Route	Q	R_1	R_2	R_3	S
Sleeper Density	M + 7	M + 7	M + 7	M + 4	M + 3

Note for BG & MG :

(i) Higher sleeper density may be provided with the approval of the Principal Chief Engineer.

(ii) For existing LWR on main lines, loop lines and sidings, provisions of *C hapter 7* may be followed.

(iii) In case of SWR, the minimum sleeper density is fixed as 1340 nos. per km.

(5) Ballast:

Only stone ballast shall be used. The recommended depth of ballast below the bottom of sleepers is as indicated in *Para 263 (2)IRPWM,* the minimum in no case being less than 200 mm both for B.G and M.G

100 mm extra width of shoulder ballast over and above the standard ballast section on tangent track shall be provided on outside of curves up to 875 meters radius in B.G, 600 meters radius in M.G. In case curves are sharper than above limits, the extra width shall be 150 mm.

On existing SWR lengths, where this shoulder width is not available, this may be provided on a programmed basis.

In case of 60 kg Rails, LWR ballast profile shall be adopted.

706.Condition of Laying :

(1) Alignment: SWR shall not be laid on curves sharper that 500 meters radius in both Broad Gauge and Metre Gauge. However, on PSC Sleepers, SWR may be laid on curves with radius not less than 440 meters.

Existing SWR laid on sharper curves may, however, be allowed to continue if there is no difficulty experienced in maintaining these lengths. Chief Engineer's approval should be taken in such cases.

(2) Junction with Insulated Joints and Points & Crossings: SWR shall not butt against insulated joints, heel of crossing and stock rail joints. Two standard length rails (13 m /12 m) shall be interposed to isolate the SWR from such locations. These standard length rails shall be anchored effectively to arrest movement in either direction.

(3) Junction with Standard Length Rails on Wooden Sleepers: When SWR track butts against track laid with standard length rail (13 m for B.G and 12 m for M.G) on wooden sleepers, the latter shall be adequately anchored for at least six rail lengths to check the creep of rails. These six rail lengths shall have a sleeper density of M + 7. Additional shoulder ballast should also be provided.

(4) Laying of SWR in Level Crossings and Bridges:

(a) Track Structure in Level Crossings

(i) In level crossings U category sleepers (durable) should preferably be used.

(ii) All sleepers used in level crossings should be provided with suitable bearing plates.

(iii) Rail joints should be avoided in check rails and on the running rails, within the level crossings and three meters on either side.

(iv) In each rail seat, four spikes should be provided.

(v) In the case of S.W.R., the short welded panel may be continued through the level crossing, avoiding fish plated joint on the level crossing and within six meters from the end of level crossing.

(b) On bridges, 26 m long rolled rails may to be laid with 1.0 m long fish plate and 6 bolts. Joint gaps to be provided and maintained as per *para 707 and 709*.

707. Laying of Short Welded Rails (SWR)-

The gaps to be provided for SWR at the time of laying shall be in accordance with *Table 7.01* depending on the installation temperature (ti) and the Zone in which the rails are laid :

Table 7.01 : *Initial Laying Gaps for SWR for Various Installation Temperatures*

For Zones I and II

Rail temperature at the time of installation (in °C)	t_m-17.5 to t_m -12.6	t_m -12.5 to t_m -7.6	t_m -7.5 to t_m -2.6	t_m -2.5 to t_m +2.5	t_m +2.6 to t_m +7.5	t_m +7.6 to t_m+12.5
For 39 m panels	12 mm	10 mm	8 mm	6 mm	4 mm	2 mm
For 26 m rolled rail	10 mm	9 mm	7 mm	6 mm	5 mm	3 mm

For Zones III and IV

Rail temperature at the time of installation (t^i) in (°C)	t_m - 22.5 to t_m -17.6	t_m -17.5 to t_m -12.6	t_m -12.5 to tm - 7.6	t_m -7.5 to t_m - 2.5	t_m -2.4 to t_m + 2.5	t_m +2.6 to t_m + 7.5
For 39 m panels	12 mm	10 mm	8 mm	6 mm	4 mm	2 mm
For 26 m rolled rails	10 mm	9 mm	7 mm	6 mm	5 mm	3 mm

If the laying has to be done outside the temperature range given in table above, or wherever joint gaps could not be provided as per the table, are-adjustment of gap shall be carried out within two days of laying before the track consolidates. Along with the gap adjustment, any re-spacing of sleepers, if required, must be carried out.

708. Inspection and Maintenance of SWR

(1) Regular track maintenance including all operations involving packing, lifting, aligning, local adjustment of curves, screening of ballast other than deep screening, and scattered renewal of sleepers may be carried out without restriction when the rail temperature is below tm + 25°C in the case of zone I & II and tm + 20°C in the zone III and IV.

However on curves of less than 875 meters radius in B.G, and less than 600 meters radius in M.G or yielding formation, the above temperature limit shall be restricted to tm + 15°C in the case of Zone I and II and tm+ 10°C in the case of Zone III and IV.

(2) If the maintenance operations have to be undertaken at temperature higher than that mentioned above, not more than 30 sleeper spaces in one continuous stretch shall be opened, leaving at least 30 fully boxed sleeper spacer between adjacent lengths which are opened out. Before the end of the day's work it shall be ensured that the ballast is boxed up.

(3) As an additional precaution, during summer months, to be specified by the Chief Engineer, for attention to run down track, even if temperature is less the temperature specified in Para above, not more than 30 sleepers in one continuous stretch shall be opened, leaving at least 30 boxed sleeper spaces between adjacent lengths which are opened up.

Further, if joint gaps are not available at the time of opening of the track even when rail temperature are less than those specified in Para above. Not more than 30 sleepers in one continuous stretch should be opened leaving at least 30 boxed sleeper spaces between adjacent lengths which are opened up.

(4) Major lifting, major alignment of track, deep screening and renewal of sleepers in continuous length.

Each of these operations shall be done under suitable precautions and normally when the rail temperature is below tm + 15°C in the case of Zones and II, and tm + 10°C in the case of Zones III and IV.

If it becomes necessary to undertake such works at rail temperature exceeding the above values adequate speed restrictions shall be imposed.

(5) Adequate number of joggled fish-plates with special clamps shall be provided to the gangs for use in emergencies.

(6) In the case of any fracture in the weld or in the rail, the portion of rail with fracture is cut, and removed for a length of not less than 4 m to carry out the re-welding duly introducing a rail piece of equivalent length, also ensuring that no weld lies closer than 4 m from the fish-plated joint.

(7) Conversion of 10 rail/ 5 rail panels into shorter panels:

It will be desirable to convert the existing 10 rail panels and 5 rail panels into 2½ rail panels wherever maintenance problems cannot be solved otherwise. Wherever conditions permit, conversion of SWR into LWR may also be considered.

709. Gap Survey and Adjustment of Gap

(1) General:

Gap survey and rectification of gaps is to be carried out, in stretches where track develops excessive creep jammed joints, sun kinks, buckling, wide gaps, battered and hogged joints, fractures at joints and bending of bolts etc. In SWR the gap survey and adjustment should normally be done before the end of February once a year (i.e., before onset of summer)

(2) Gap Survey:

(a) The gap survey shall be conducted on a clear and sunny day in the cool hours of the day.

(b) The length over which gap survey is to be done should, wherever possible, be divided into suitable sub-sections, each bounded by fixed points such as level crossings, points and crossings etc. The survey should be completed during as short a time as possible, by employing adequate number of parties so that the rail temperature is not likely to var appreciably

(c) The joint gaps shall be measured by taper gauge in mm. (shown below) and the readings entered in the pro forma as shown in *Annexure 7/1.*

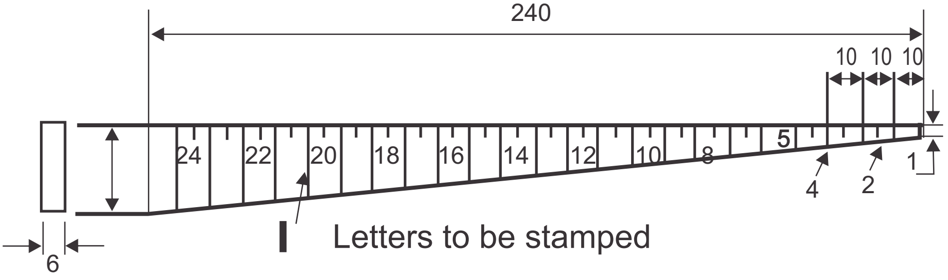


Fig 7.11 *Taper guage*

(3) Recommended range of value of gaps- The recommended range of value of gaps (in mm) during service for various range of rail temperature is indicated in table given below:-

Table 7.02 : *Permissible values of gaps for S.W.R during service under various ranges of rail temperatures (gaps in mm)*

For Zones 1 and II

Temperature during gap survey (in °C)	t_m -12.5 to t_m - 7.6	t_m -7.5 to t_m - 2.6	t_m -2.5 to t_m + 2.5	t_m +2.6 to t_m + 7.5	t_m +7.6 to t_m + 12.5	t_m + 12.6 to t_m + 17.5
For 39 m panels	11 to 14	9 to 13	7 to 11	5 to 9	3 to 7	1 to 5
For 26 m rolled rails	8 to 13	6 to 11	5 to 10	3 to 8	2 to 7	1 to 5

For Zones III and IV

Temperature during gap survey (in °C)	t_m -17.5 to t_m -12.6	t_m -12.5 to t_m -7.6	t_m -7.5 to t_m -2.5	t_m -2.4 to t_m +2.5	t_m +2.6 to t_m +7.5	t_m +7.6 to t_m +12.5
For 39 m panels	11 to 14	9 to 13	7 to 11	5 to 9	3 to 7	1 to 5
For 26 m panels	8 to 13	6 to 11	5 to 10	3 to 8	2 to 7	1 to 5

Note:

(a) The gaps given above are to be distinguished from the Values given in *Table -7.01*, which are intended to be provided at the time of initial laying of SWR.

(b) Gap survey should be carried out when rail temperature is in rising trend only.

(4) Calculations for adjustment:

The average of the measured gaps is worked out as shown in the proforma for gap survey *(Annexure 5/2).* A comparison of the results of the gap measurements recorded and the permissible values of gap (concerned range for gap) given above will lead to one of the following cases :

Case 1 – Average gap is within the recommended range, but some of the individual gaps fall outside the range.

Case 2 – Average gap falls outside the recommended range.

Case 3 – Average gap as well individual gaps fall within the range.

(5) Action to be taken:

The action to be taken is as follows:

Case 1 – Rectification work should be restricted to correcting the individual gaps, which falls outside the recommended range. Rectification should be done by pulling the minimum number of rails. Under no circumstances shall the adjustment be done by cutting a rail or introducing a longer rail.

Case 2 – The joint gaps shall be systematically adjusted from one end to the other end of the sub-section. The rails shall be unfastened over convenient lengths the gaps adjusted to the initial laying gaps as per *Para 707* and rails fastened. In this case introduction of a longer or shorter rail will be involved. Efforts should be made to see that only the minimum numbers of joint sleepers are disturbed.

Case 3 – No action is to be taken.

Note : As far as possible, the day chosen for rectification work should be a day on which the rail temperature is not likely to vary much during rectification period.

710. Long Welded Rails : Definitions

(1) Long Welded Rail (LWR) : is a welded rail, the central part of which does not undergo any longitudinal movement due to temperature variations. A length of greater than 250 meter on Broad Gauge and 500 m on Meter Gauge will normally function as LWR *(Fig. 7.12)*. The maximum length of LWR under Indian conditions shall normally be restricted to one block section.

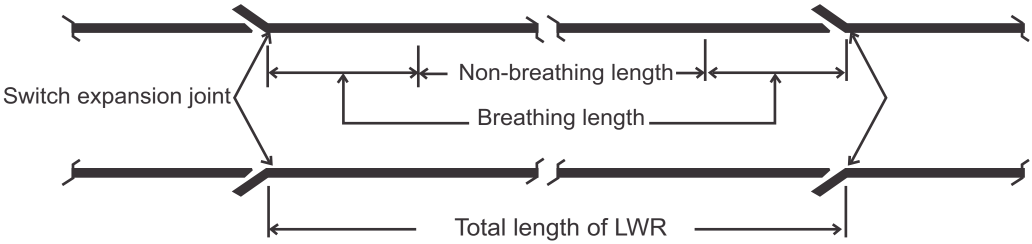


Fig. 7.12 *Long welded rails*

As the central portion of LWR/CWR does not expand/contract i.e. it does not under go any longitudinal movement, therefore, thermal forces builds up in the central portion due to temperature variations. The thermal force (P), calculated below is to be resisted by suitable track structure.

$$P = A E \alpha t,$$

Where, A = *Area of cross section of the rail (sq.cm)*

($A = 66.15\ cm^2$ for 52 kg rail & $A = 76.86\ cm^2$ for 60 kg rail)

E = *Modulus of elasticity of rail steel, (2.15×10^6 Kg/sq.cm)*

α = *Coefficient of linear expansion of steel, (1.152×10^{-5}/°C)*

t = *Variation of rail temperature from t_d / t_o (°C)*

The value of induced thermal force (P) works out 1.638 ton for 52 Kg & 1.903 ton for 60 Kg rail section for a temperature change of 1°C.

(2) Continuous Welded Rail (CWR) is a LWR which would continue through station yards including points and crossings.

(3) Short Welded Rail (SWR) is a welded rail, which contracts and expands throughout its length.

Note: *Normally the length of SWR is 3 x 13 meter for BG & 3 x 12 meter for MG. Provisions for laying and maintenance of SWR are contained in para 704 to 709*

(4) Breathing Length is that length at each end of LWR/CWR, which is subjected to expansion/ contraction on account of temperature variations. The usual breathing lengths for various track structure under four temperature zones (I to IV) is shown in *table 7.03*

Table 7.03 - *Breathing length for various track structures.*

Breathing length (in meters) on PRC sleeper track (BG)								
Sleeper density	1540 Nos. /Km				1660 Nos. /Km			
Rail section ↓ / Zone →	I	II	III	IV	I	II	III	IV
60 Kg (UIC) rails	60	69	77	82	58	66	74	79
52 Kg rails	52	59	66	71	50	57	64	68
90 R	38	44	51	55	37	43	49	53

Breathing length (in meters) on Steel sleeper track (BG)								
Sleeper density	1540 Nos. /Km				1660 Nos. /Km			
Rail section ↓ / Zone →	I	II	III	IV	I	II	III	IV
60 Kg (UIC) rails	77	88	98	105	73	84	94	100
52 Kg rails	66	75	85	90	63	72	81	86
90 R	49	57	65	70	46	54	62	67

Breathing length (in meters) on CST-9 sleeper track (BG)								
Sleeper density	1540 Nos. /Km				1660 Nos. /Km			
Rail section ↓ / Zone →	I	II	III	IV	I	II	III	IV
60 Kg (UIC) rails	--	--	--	--	--	--	--	--
52 Kg rails	89	101	114	122	86	98	110	118
90 R	66	76	87	94	63	74	84	91

Note: The Breathing lengths given above are indicative and are likely to vary as per based on site conditions, i.e. based on magnitude of longitudinal ballast resistance getting mobilized, which depends upon Type of sleepers, Sleeper density, Condition of packing, any track work under taken in the recent past, Ballast profile, Passage of traffic etc.

(5) Switch Expansion Joint (SEJ) is an expansion joint installed at each end of LWR/CWR to permit expansion/contraction of the adjoining breathing lengths due to temperature variations *(Refer Fig. 7.12).*

(6) Buffer Rails are, a set of rails provided in lieu of SEJ at the ends of LWR/CWR to allow expansion/contraction of adjoining breathing lengths due to temperature variations. These will be laid with prior approval of Chief Engineer at locations where provision of SEJ is not permitted. Buffer rails may also be temporarily laid to facilitate maintenance/renewal operations.

(7) Rail Temperature is the temperature of the rail at site as recorded by an approved type of rail thermometer as laid down in *Para 711 (2).* This is different from ambient temperature which is the temperature of air in shade at the same place.

Note: Tracks on Indian Railways have been divided into four rail temperature zones as shown in the "Map of India showing Rail Temperature Zones" at *Fig. 7.13*.

(8) Mean Rail Temperature (t_m) for a section is the average of the maximum and minimum rail temperatures recorded for the section.

(9) Destressing is the operation undertaken with or without rail tensor to secure stress free conditions in the LWR/CWR at the desired/specified rail temperature.

(10) Installation Temperature (t_i) is the average rail temperature during the

process of fastening the rails to the sleepers at the time of installation of the LWR/CWR.

(11)Destressing Temperature (t_d) is the average rail temperature during the period of fastening the rails to the sleepers after destressing LWR without the use of rail tensor. If rail tensor is used, t_d for all practical purposes is equal to t_o as defined in *Para 710 (13) below / sub para (13) below* (Stress-free Temperature). The Range of t_d or to shall be within the limits of rail temperature shown below

Zone	Rail section	Range for t_d or t_o
I, II & III	All Rail sections	t_m to t_m + 5°C
IV	(i) 52 Kg & heavier	t_m + 5°C to t_m + 10°C
	(ii) Other rail sections	t_m to t_m + 5°C

(12)Prevailing Rail Temperature (t_p) is the rail temperature prevailing at the time when any operation related to track maintenance on LWR track is carried out.

(13)Stress-free Temperature (t_o) is the rail temperature, at which the rail is free of thermal stress. When tensors are utilized for the destressing operation the work has to be carried out at t_P, which shall be lower than stress-free temperature. The extension to be applied by the tensor shall be calculated from the following formula:-

Extension $= L \quad (t_o - t_P)$

Where 'L' is the length of segment of the rail to which the extension is applied and 'α' is the coefficient of linear expansion of rail steel.

(14)Rail Tensor is a hydraulic or mechanical device used for stretching the rail physically.

(15)Anchor Length (l_a) is the length of track required to resist the pull exerted on rails by the rail tensor at temperature t_P, For practical purposes, this may be taken as equal to 2.5 meter per degree Celsius of (t_o – t_P) for BG and 4.5 meter per degree Celsius of (t_o– t_P) for MG track .

(16)Hot Weather Patrol is the patrol carried out when the rail temperature exceeds t_d + 25°C on PSC sleeper track with sleeper density 1540 Nos./km or more, in all other cases it shall be introduced when rail temperature exceeds t_d + 20° C.In addition, the period for regular hot weather patrolling during summer shall be laid down by the Chief Engineer for each section and patrol charts prepared where necessary.

(17)Cold Weather Patrol is the patrol carried out during cold months of the year in specified sections as per instructions of Chief Engineer. In addition the Cold weather patrolling shall also be introduced when the rail temperature is less than $t_d - 30°C$.

(18) Consolidation of Track is the process of building up ballast resistance against the tendency of movement of sleeper either initially before laying LWR or making up subsequent loss of resistance by anyone of the following:-

(a) Track consolidation by traffic passage:

(i) BG Concrete sleeper track: For the track structure consisting of BG concrete sleepers, passage of at least 50,000 gross tonnes of traffic or 2 days whichever is later. It can be reckoned / considered, in terms of days based on traffic density of line, as placed here under:

Traffic density Of the line	Consolidation period (in days)
10 GMT and above :	2 days
between 10 GMT- 5 GMT :	4 days
below 5 GMT :	7 days

Note: Route/ line having traffic density of 1 GMT will have train passage of 2700 tons daily. 10 GMT route will have train passage of more than 50,000 tons in 2 days i.e. 2 days x (10 GMT x 2700 ton per GMT per day) = 54,000 ton

(ii) Other than BG concrete sleeper track: For the track structure consisting of other than BG concrete sleepers, the period of consolidation will be as under:-

With compaction of ballast using → Type of track structure ↓	Hand operated compactors/ rammers	Mechanised shoulder & crib compactor
BG with other than concrete sleeper	3,00,000 gross tonnes of traffic	50,000 gross tonnes of traffic
MG with other than concrete sleeper	1,00,000 gross tonnes of traffic	20,000 gross tonnes of traffic
MG with concrete sleeper	20,000 gross tonnes of traffic	

(b) Track consolidation by DTS: Minimum one round of stabilisation by Dynamic Track Stabiliser (DTS).

(c) Track stabilisation by track tamping machines: For newly laid LWR/CWR, at least three rounds of packing, last two of which should be with on-track tamping machines.

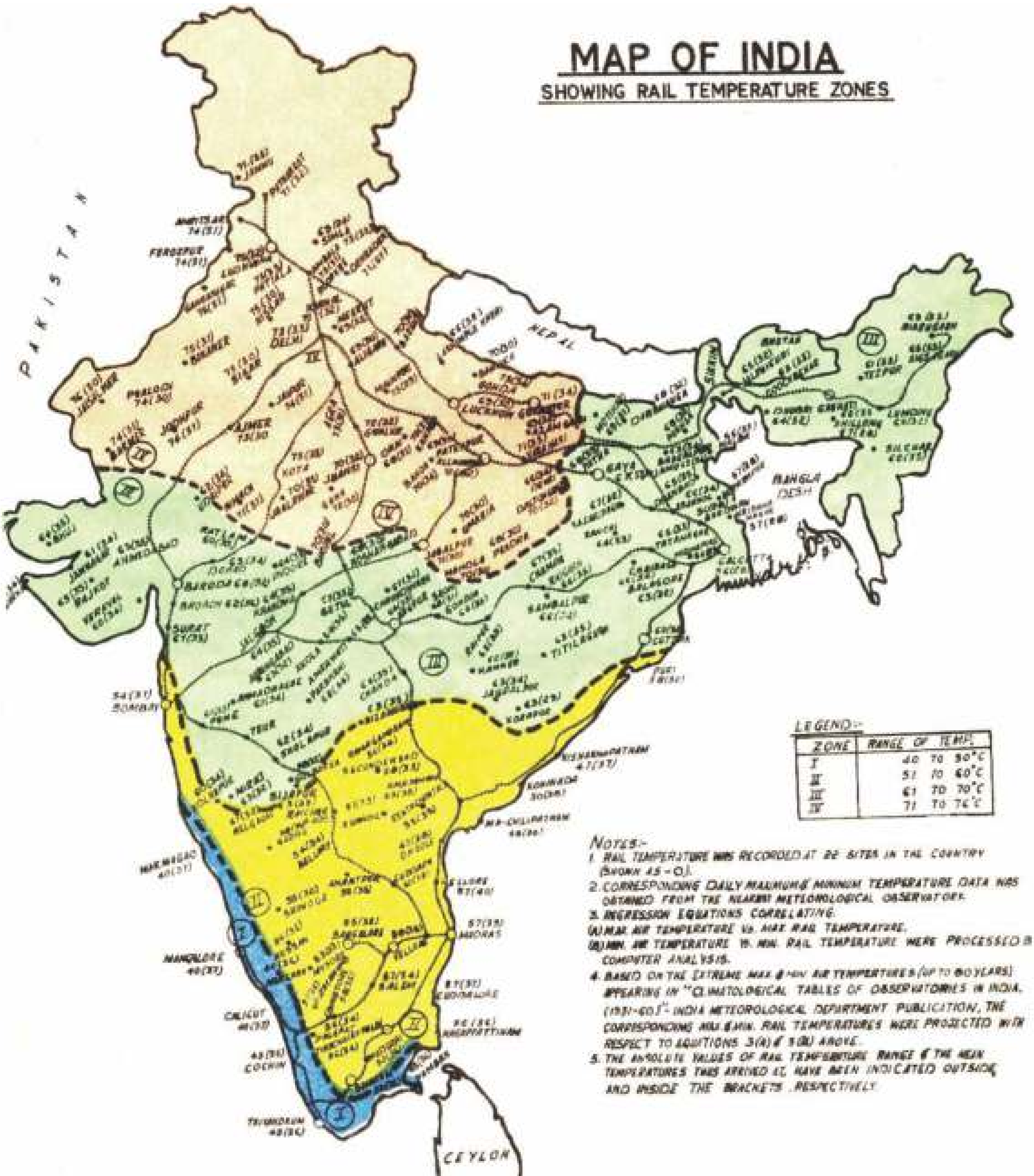


Fig. 7.13 : *Rail temperature zone*

(19) Longitudinal ballast resistance (R): The longitudinal ballast resistance (R) gets geared up whenever thermal change takes place in LWR track, causing rail sleeper assembly (fastened together by elastic fastenings) to move in the ballast mass, so there is relative motion of the sleepers with respect to the ballast in the longitudinal direction. Value of 'R' depends upon following factors:

(a) Type of sleepers

(b) Sleeper density

(c) Condition of packing

(d) Influence of any work on the track like through packing, machine tamping, deep screening etc.

(e) Ballast profile

(f) Passage of traffic

The value of 'R' is 13.28 Kg/cm/rail for sleeper density 1540 Nos. per Km & 13.74 Kg/cm/rail for sleeper density 1660 Nos. per Km.

(20) The term 'Chief Engineer' includes 'Chief Track Engineer' on Railways where latter post exists.

711. Measurement of Rail Temperature

(1) Thermometer

(a) The following are the types of approved thermometers for measuring rail temperature:-

(i) Embedded type - This is an ordinary thermometer inserted in a cavity formed in a piece of rail-head, the cavity filled with mercury and sealed. The rail piece is exposed to the same conditions as the rail inside the track. This type of thermometer takes 25 to 30 minutes for attaining temperature of the rail.

(ii) Dial type - This is a bi-metallic type thermometer, which is provided with magnet for attaching it to the rail. The thermometer is attached on the shady side of the web of the rail. A steady recording of the rail temperature is reached within 8 minutes.

(iii) Continuous recording type - It consists of a graduated chart mounted on a disc which gets rotated by a winding mechanism at a constant speed to complete one revolution in 24 hours or 7 days as applicable giving a continuous record of rail temperature. The sensing element is attached to the web of the rail and connected to the recording pen, through a capillary tube which is filled with mercury. Presently in the latest version of equipment the sensor is connected to main unit which display the temperature in digital form in place of graph

(iv) Any other type of thermometer approved by RDSO/Chief Engineer.

(b) Where a number of thermometers are used to measure the rail temperature at one place, as in case of laying of LWR, destressing etc., any of the thermometer showing erratic readings, appreciably different from the other adjoining thermometers, shall be considered as defective.

(2) Temperature Measurements

Zonal Railway should nominate 8 to 10 stations in their railway in a manner as to give the representative sample of the temperature variations on the Zonal Railway for the region allotted to each station. These stations shall be the existing SSE/P. Way's offices. On these stations rail temperature records shall be built up using preferably a well calibrated continuous recording type thermometer. The maximum and minimum rail temperature for a continuous period of at least 5 years shall be ascertained and the mean rail temperature (t_m) for the region arrived at.

Rail thermometer shall also be available with each Gang and sectional SSE/P. Ways to enable the Gangs to work within the prescribed temperature ranges

These temperature records shall be analysed to assess the probable availability of time periods during different seasons of the year for track maintenance, destressing operations and requirements of hot/cold weather patrolling etc.

The sample illustration for planning various track activities, based on the above Para is placed here under:

Illustrations: Planning of track activities w.r.t. temperature conditions in Pune area.

Pune temperatures: 61(34) based on *Fig. 7.13*

Range of temperature $t_{max} – t_{min} = 61$

Mean of temperature $(t_{max} + t_{min}) / 2 = 34$, $t_{max} + t_{min} = 68$

Therefore $t_{max} = 64.5$, $t_{min} = 3.5$

Pune lies in Zone-III, accordingly t_d shall be fixed as t_m to $t_m + 5°C$

t_m = 34°C so t_d will lie between 34 to 39°C say destressing is done at t_d = 36°C

Table 7.04 *Track activities in planning w.r.t. rail temperature*

Track activities	Specified temp. ranges	Rail temp for carrying out track activities (in ^oC)
Destressing	t_m to $t_m + 5$	34 to 39 say 36
Machine tamping	$(t_d +10)$ --- $(t_d – 30)$	46 to 6
Manual Packing	$(t_d +10)$ --- $(t_d – 30)$	46 to 6
Deep screening	$(t_d +10)$ --- $(t_d – 20)$	46 to 16
Hot weather patrolling	> t_d + 25 & months specified by PCE	More than 61
Cold weather patrolling	< t_d - 30 & months specified by PCE	Less than 6

The temperature records needs to be studied in detail to find out the rail temperature available during periods specified for integrated block working, and based on requirement of temperature ranges for various track maintenance activities as worked out above, the periods available during the year, for carrying out a specific maintenance activity is identified.

For example, suppose the integrated corridor block hrs. for Pune – Lonavala section is say 10.30 to 13.00 hrs., we have to say plan destressing blocks for this section, then we have to identify periods (from past temperature records) when the rail temperature is within 34 to 39 between 12.00 hrs. to 13.00 hrs. (Because during this time the track will be fastened back after destressing.) The destressing blocks will be planned during these identified periods/ months of the year.

712. Permitted Locations for LWR/CWR

(1) General Considerations for Laying LWR/CWR

(a) Complete Track renewals:

As a rule, complete track renewals (Primary) shall provide for LWR/CWR wherever permissible by the provisions of this Manual. Also existing rails on permitted locations may be converted into LWR/CWR, provided they meet the requirements laid down in the Manuals or Welding of Rail Joints by Alumino -Thermic (SKV Process)/Gas Pressure/Flash Butt Process, as the case may be.

(b) Construction Works:

New constructions/doublings/gauge conversions/retired alignment / permanent diversion shall be opened with LWR/CWR, wherever permissible by the provisions of this Manual.

(c) Goods Lines:

In goods running lines, goods yards, reception yards and classification yards, rail joints may be welded to form LWR if the condition of all the components of track is generally sound and without any deficiency, subject to such relaxation as may be approved by Chief Engineer, in each specific case.

(2) Alignment

(a) LWR/CWR shall not be laid on curves sharper than 440 meter radius (4° Curve). However, in temperature Zone - I, LWR/CWR may be laid on curves up to 360 meter radius (5° Curve) on BG with allowing additional precautions:

(i) Minimum track structure should be 52 kg rail on PSC sleeper, M+7 sleeper density with 300 mm clean ballast cushion.

(ii) Shoulder ballast for curves shaper than 440 m radius should be increased to 600 mm on outside of curve and should be provided for 100 m beyond the tangent point.

(iii) Reference marks should be provided at every 50 m interval to record creep, if any.

(iv) Each curve of length greater than 250 m should preferably be provided with SEJ on either side.

(v) SEJ should be located in straight track at 100m away from the tangent point.

(b) LWR/CWR may be continued through reverse curves not sharper than 875 meter radius (2° Curve). For reverse curves sharper than 1500 meter radius, shoulder ballast of 600 mm over a length of 100 meter on either side of the common point should be provided.

(3) Gradients

(a) The steepest permitted grade shall be 1:100.

(b) A vertical curve shall be provided at the junction of the grade when the algebraic difference between the grades is equal to or more than 4 mm per meter or 0.4 percent, as laid down in Para 419 of IRPWM.

Illustration: When 1 in 100 ascending gradient meets with 1 in 200 descending gradients, the algebraic difference of grade is 10 mm/m – (- 5 mm/m) = 15 mm/m.

The minimum radius of the vertical curve shall be kept as under:

Group/ Route	A	B	C, D, E & MG all routes
Minimum radius	4000 meter	3000 meter	2500 meter

(4) Approval of Principal Chief Engineer:

Installation of LWR/CWR or change in its constitution at a later stage shall have the approval of the Chief Track Engineer in each case, on a detailed plan prepared in accordance with *Para 715 (1) (c) Fig. 7.22.* However, for any deviation from the Provisions of LWR Manual, the approval of Principal Chief Engineer shall be obtained.

713. Track Structure for LWR/CWR

(1) FORMATION:

The LWR shall be laid on stable formation. The formation width shall be 7.85 m for single line track & 13.16 m for double line track. The formation width will be same for embankment & cutting.

(2) Ballast Cushion and Section:

The minimum clean stone ballast cushion (below the bottom of the sleeper) to be provided at the time of installation of LWR/CWR shall be as under:

Speeds up to 130 km/h - 250 mm

Speeds higher than 130 km/h on BG & 100 km/h on MG - 300 mm

The profile of ballast section shall be as shown below in *Fig.7.14 (a) & (b)*. The ballast section and cushion provided for LWR/CWR shall be continued over SEJ and up to 3 rails beyond it wherever it is followed by SWR/ fish plated track.

(a) Ballast Profile (BG Single line in embankment/cutting)

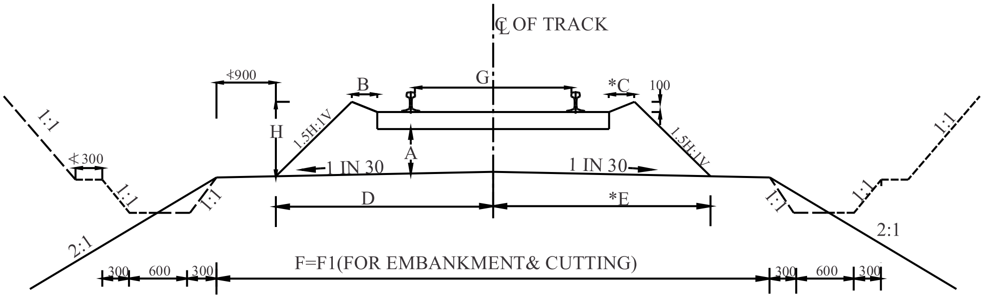


Fig. 7.14 (a) *Ballast Profile (BG single line in embankment / cutting)*

A	B	*C	D	E	F	H	Min. Cess in	
							Straight	Curve
250	350	500	2648	2804	7850	620	1277	1121
300	350	500	2723	2880	7850	670	1202	1045
350	350	500	2797	2954	7850	720	1128	971

Note:

(i) The minimum clean stone ballast cushion below the bottom of sleeper i.e. A= 250 mm

(ii) For routes where speeds are to be more than 130 km/h, A = 300 mm or 200 mm along with 150 mm of sub-ballast.

*(iii) * On outer side of curves only.*

(iv) Ballast side slope shall be 1.5 H : 1V.

(v) Cross-slope of 1 in 40 has been replaced with 1 in 30 for construction works. However, existing formation need not be disturbed.

(v) All dimensions are in mm.

(vii) Width of Formation in bank and cutting shall not be less than 7.85 meter for new works.

(b) Ballast Profile (BG Double line in embankment / cutting)

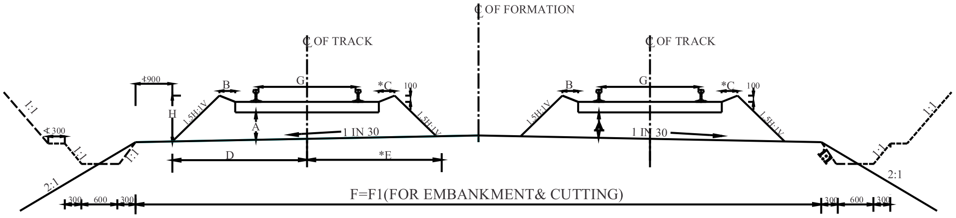


Fig. 7.14 (b) *Ballast Profile (BG double line in embankment / cutting)*

A	B	*C	D	E	F	H	J	Min. Cess in	
								St.	Curve
250	350	500	2689	2847	13160	648	5300	1241	1083
300	350	500	2764	2922	13160	698	5300	1166	1008
350	350	500	2839	2997	13160	748	5300	1091	933

Note :

(i) The minimum clean stone ballast cushion below the bottom of sleeper i.e. A = 250 mm.

(ii) For routes where speeds are to be more than 130 km/h, A = 300 mm or 200 mm along with 150 mm of sub-ballast.

*(iii) * On outer side of curves only.*

(iv) Ballast side slope shall be 1.5 H : 1V.

(v) Cross-slope of 1 in 40 has been replaced with 1 in 30 for construction works. However, existing formation need not be disturbed.

(vi) Cross-slope 1 in 30 for new construction/ All dimensions are in mm.

(vii) Width of Formation in bank and cutting shall not be less than 13.16 meter for new works.

(3) Sleepers & Fastenings

(a) On Broad Gauge:

(i) Concrete sleepers with elastic fastenings

(ii) Steel trough sleepers with elastic fastenings for speed not exceeding 130 km/h.

(b) On Meter Gauge:

(i) PRC sleeper & steel trough sleeper with elastic fastenings preferably for speeds above 75 km/h

(ii) Steel & CST-9 sleepers with keys for speeds not exceeding 75 km/h

(c) Sleeper Density:

The minimum sleeper density (number of sleepers/km) in LWR/CWR shall be as shown below.

Type of sleeper↓ / Zone	I & II	III & IV
PRC sleeper	1340	1540
Other than PRC sleeper	1540 in all temperature zones	

(4) Rails

(a) (i) On BG 90 R/ 52kg / 60kg Rails & on MG 75 R/ 90 R rails shall be welded into LWR/CWR. LWR/CWR already laid with 60 R rails on MG may be allowed to continue

(ii) In one LWR, two different rail sections are not permitted. In case of any change In the rail section of LWR arising out mostly due to TRR work, the LWR shall be bifurcated into two different LWR's, by providing SEJ.

(b) While converting existing fish plated/SWR track into LWR/CWR, following precautions shall be taken:-

(i) The rails shall be tested ultrasonically and all defective rails replaced before conversion into LWR/CWR.

(ii) Rail ends which are bent, hogged, battered, or having history of bolt -hole cracks shall be cropped before welding for conversion into LWR/CWR.

(iii) In case of LWRs laid on concrete sleepers having different rail section on either side of SEJs, instead of providing three normal rail lengths of each rail section between SEJs, two 3 rail panels, one of each rail section hall be provided with combination fish plated joint, between the two panels.

(c) New rails used in LWR/CWR shall, as far as possible be without fish-bolt holes. Joining of rail ends temporarily during installation of LWR/CWR shall be done by 1 meter long fishplates with special screw clamps/joggled fish-plates having slotted grooves & bolted clamps as shown in *Fig.7.18, 7.19 & 7.20* with speed restrictions of 30 km/h and 24 Hrs. watch. Fish-bolt holes if any, shall be chamfered.

714. Miscellaneous

(1) Continuity of track structure: Wherever LWR/CWR is followed by fish plated track/ SWR, the same track structure as that of LWR/CWR shall be continued for three rail lengths beyond SEJ.

(2) Level crossings: Level crossings situated in LWR / CWR territory shall not fall within the breathing lengths

(3) Points and Crossings: LWR shall not normally be taken through points and crossings. Three normal rail lengths shall be provided between stock rail joint (SRJ) and SEJ as well as between the heel of crossing and SEJ. These normal rail lengths shall be provided with elastic rail clips/anchors to arrest creep. However, where concrete sleeper turnouts are laid, instead of three normal rail lengths, one three rail panel shall be provided between SEJ and SRJ as well as between heel of crossing and SEJ.

LWR shall not normally be taken through points &crossings. For any exceptions in this regard i.e. in case CWR is to be constituted then the special arrangements as required shall have the prior approval of RDSO.

(4) Glued Joints: All insulations for track circuiting in LWR/CWR shall be done by providing glued joints G3 (L) type.

(5) Location of SEJ: The exact location of SEJ shall be fixed taking into account the location of various obligatory points such as level crossings, girder bridges, points and crossings, gradients, curves and insulated joints. The SEJ with straight tongue and stock shall not be located on curves sharper than 0.5 degree (3500 m radius) as far as possible. For curves 0.5° and up to 4°, the SEJ with curved tongue rail & stock rail shall be used.

Note: The SEJ shall not be located on transition of curves.

Fig. 7.15 *Conventional SEJ*

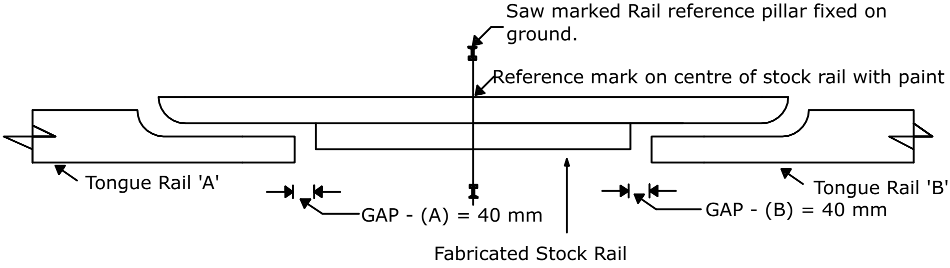


Fig. 7.16 *Two gap SEJ (65 mm gap)*

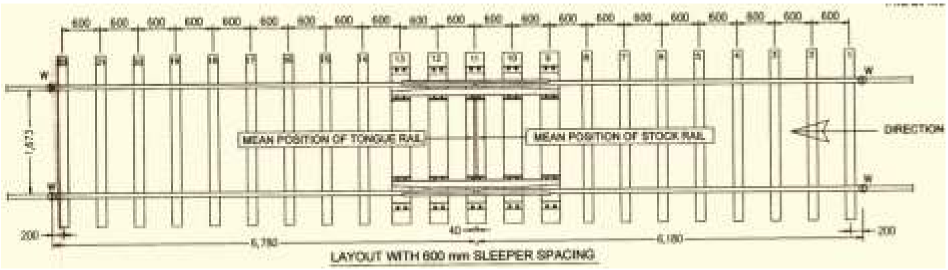


Fig. 7.17 *One gap SEJ with check rail (80 mm) gap)*

(6) Bridges with ballasted deck (without bearing):

LWR/CWR can be continued over bridges without bearings like slabs, box culverts and arches, without any restriction on maximum span length.

(7) Bridges with bearing (with/without ballasted deck) Concrete / steel girders

(a) General

(i) LWR/CWR shall not be continued over bridges with overall length as specified Under *sub para b to f* for BG and not more than 20 meter for MG

(ii) Bridges on which LWR/CWR is not permitted/provided shall be isolated by a Minimum length of 36 meter well anchored track on either sides.

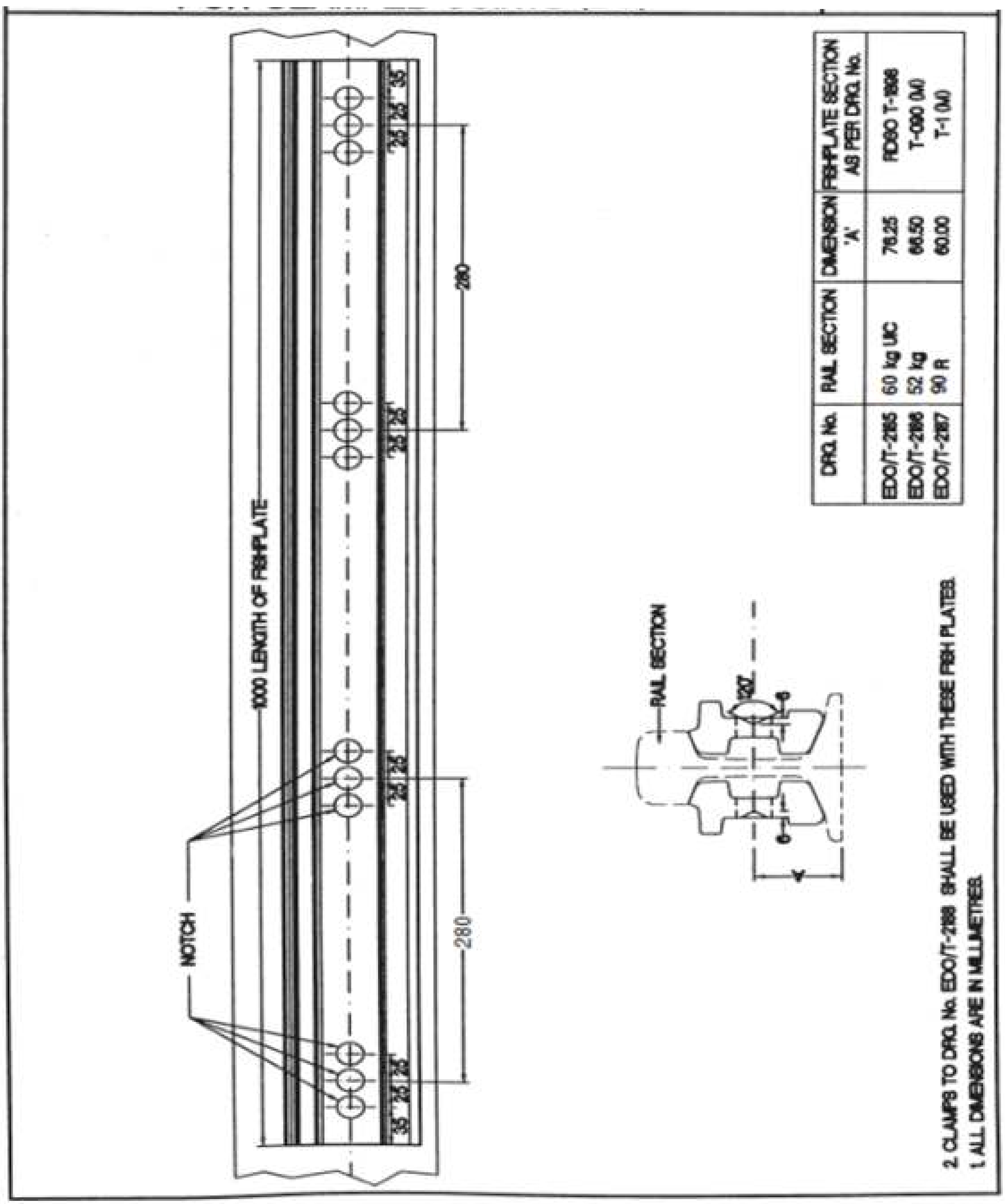


Fig. 7.18 : *1 m Long special fishplate for clamped joints (BG)*

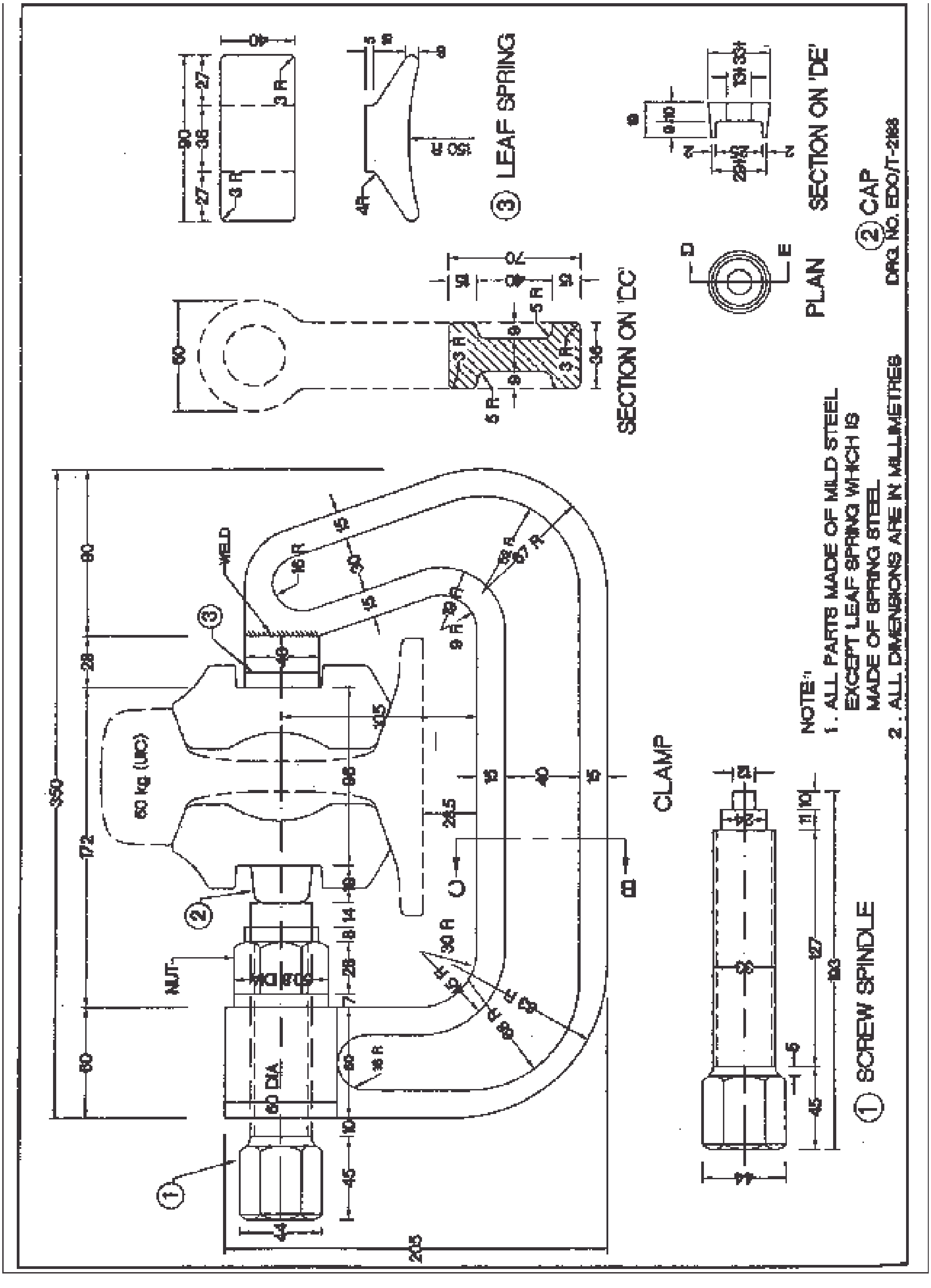


Fig. 7.19 *Screw clamp for fixing 1m long special fish plates*

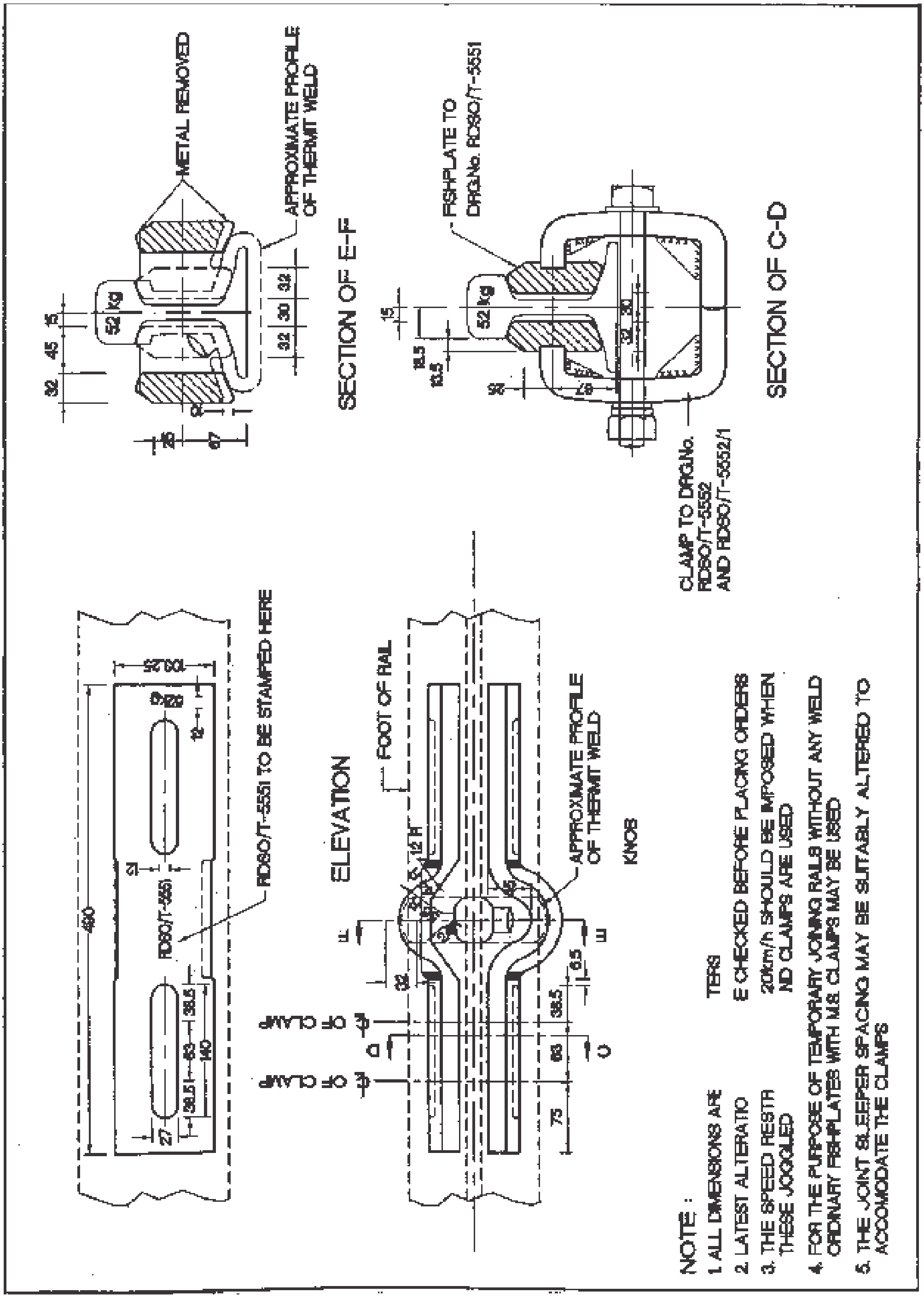


Fig. 7.20 *Detailed of Joggled fish plate and position of clamp.*

(b) Bridges provided with rail-free fastenings (single span not exceeding 30.5 meter and having sliding bearings on both ends)

Overall length of the bridge should not exceed the maximum as provided in Table below with following stipulations:-

(i) Rail-free fastenings shall be provided throughout the length of the bridge between abutments.

(ii) The approach track up to 50 m on both sides shall be well anchored by providing PRC sleepers with elastic rail clips with fair 'T' or similar type creep anchors.

(iii) The ballast section of approach track up to 50 meter shall be heaped up to the foot of the rail on the shoulders and kept in well compacted and consolidated condition during the months of extreme summer and winter.

Maximum Overall length of the bridge in meters				
Rail section / Zone	Zone I	Zone II	Zone-III	Zone IV
60 Kg	30	11	11	11
52 kg	45	27	27	27

(c) Bridges provided with rail-free fastenings and partly box-anchored (with single span not exceeding 30.5 meter and having sliding bearings at both ends)

Overall length of the bridge should not exceed the maximum as provided in Table given below with following stipulations:-

(i) On each span, 4 central sleepers shall be box-anchored with fair 'V' or similar type creep anchors and the remaining sleepers shall be provided with rail-free fastenings.

(ii) The track structure in the approaches shall be laid and maintained to the standards as stated in *sub para 8 (b) and (c)* above.

(iii) The girders shall be centralised with reference to the location strips on the bearing, before laying LWR/CWR.

(iv) The sliding bearings shall be inspected during the months of March and October each year and cleared of all foreign materials. Lubrication of the bearings shall be done once in two years.

Maximum Overall length of the bridge in meters				
Rail section / Zone	Zone I	Zone II	Zone-III	Zone IV
60 Kg	77	42	23	23
52 kg	90	58	43	43

(d) Welded rails may be provided from pier to pier with rail-free fastenings and with SEJ on each pier. The rail shall be box-anchored on four sleepers at the fixed end of the girder if the girder is supported on rollers on one side and rockers on other side. In case of girder supported on sliding bearings on both sides, the central portion of the welded rails over each span shall be box-anchored on four sleepers *(Fig.7.21 (a)).*

(e) LWR/CWR may also be continued over a bridge with the provision of SEJ at the far end approach of the bridge using rail-free fastenings over the girder ridge *(Fig.7.21 (b)).* The length of the bridge in his case, however, will be restricted by the capacity of the SEJ to absorb expansion, contraction and creep, if any, of the rails. The length of the bridges with the above arrangement that can be permitted in various rail temperature zones for LWR/CWR with SEJs having maximum movement of 120 mm and 190 mm are as follows:-

Rail Temp. Zone	Max. Movement of SEJ used (in mm)	Max. Length of bridge with SEJ (in meter)	Initial gap to be provided at t_d (in cm)	Note
I	120	50	4.0	SEJ is to be installed 10 meter away from the abutments.
	190	160	6.5	
II	120	20	4.0	
	190	110	6.5	
III	190	70	7.0	
IV	190	55	7.0	

(f) Welded rails may be provided over a single span bridge with rail free fastenings and SEJs at 30 meter away from both abutments. The rail shall be box anchored on four sleepers at the fixed end of the bridge if bridge is supported on roller on one side and rockers on other side. In case of bridge supported on sliding bearings on both sides, the central portion of the welded rails shall be box anchored on four sleepers. On both side of approaches fully creep anchored fastening shall be used. The length of single span bridge permitted temperature Zone–wise shall be as under:

Temperature Zone	Maximum length of single span girder bridge with SEJ (190mm gap) at 30m away from both abutments with full creep resistant fastenings at approaches ($t_d = t_m$)
I	146 m
II	110 m
III	87 m
IV	75 m

(8) Identification of track measures required for a particular span:

For a particular girder bridge planned in a project (lying in a particular temp zone) with given rail section, whether the LWR can continue or not, and in case it can continue then the track measures required on the bridge proper & approaches can be finalised looking into the summary table (which is summary of provisions *Sub. Para 7(b) to (f)* above.

Illustration: Suppose there is a girder bridge 3 x 18.3 m with overall length of 60 m on 52 kg rail section in a project which falls under Zone-III,

Then looking to summary table it can be easily found out that LWR can continue on this girder bridge as per *sub para 7(e) above* i.e. using rail free fastenings on girder bridge with SEJ (with 190 mm gap) at far end approach (to be installed 10 m away from the abutment).

In this case the max length of bridge permitted under *sub para 7(b) & 7(c)* is restricted to 27 m & 43 m respectively (for 52 kg rail section) so LWR cannot be provided under these Para / provisions.

Table No. 7.07

LWR Manual provision	Para details (in brief)	Rail sect.	Maximum overall length of bridges permitted on LWR / CWR on BG (in m)			
			1	II	III	IV
Single span not exceeding 30.5 m and having sliding bearing on both sides. Bridges provided with rail free fastenings.	Rail free fastenings throughout the length of bridge between abutments. The approach track up to 50 m on both sides well anchored by providing with fair T or similar type creep anchors & ballast section shall be heaped up to foot of rail & kept well compacted & consolidated condition.	60 kg	30	11	11	11
		52 kg	45	27	27	27
Single span not exceeding 30.5 m and having sliding bearing on both sides. Bridges provided with rail free fastenings & partly box anchored.	Track approaches to maintain as per Para above. On each span 4 central sleeper shall be box anchored With fair V or similar type creep anchors, remaining sleepers shall be provided with rail free fastenings. The bridge timbers shall not be provided with through notch but notch to accommodate individual rivet heads. The girders shall be centralized with reference to location strips on bearing. The sliding bearing shall be inspected during months of march & October and cleared of all foreign materials. Lubrication of bearings shall be done once in 2 years.	60 kg	77	42	23	23
		52 kg	90	58	43	43

Welded rails provided from pier to pier with rail free fastenings & with SEJ on each pier	Welded rails may be provided from pier to pier with rail free fastenings and with SEJ on each pier. The rail shall be box anchored on 4 sleepers at the fixed end of girder if girder is supported on rollers on one side & on rocker at other side. In case girder is supported on sliding bearings on both ends, the central portion over each span shall be box anchored on 4 sleepers.	60 kg	No Restriction on span length			
		52 kg	No Restriction on span length			
LWR over a bridge with provision of SEJ at the far end approach of bridge. Bridges rovided with pail free fastenings	LWR may continue over bridge with provision of SEJ at far end approach, using rail free fastenings over girder bridge. The SEJ is to be installed 10 meters away from the abutments	60 kg or 52 kg	160	110	70	55
Welded rails over a single span bridge with rail free fastenings & SEJ at 30 m away from both the abutments	Welded rail may be provided over a single span bridge with rail free fastenings & SEJ at 30 m away from both abutments. The rail shall be box anchored on 4 sleepers at the fixed end of girder if girder is supported on rollers on one side & on rocker at other side. In case girder is supported on sliding bearings on both ends, the central portion over each span shall be box anchored on 4 sleepers.	60 kg or 52 kg	146	110	87	75

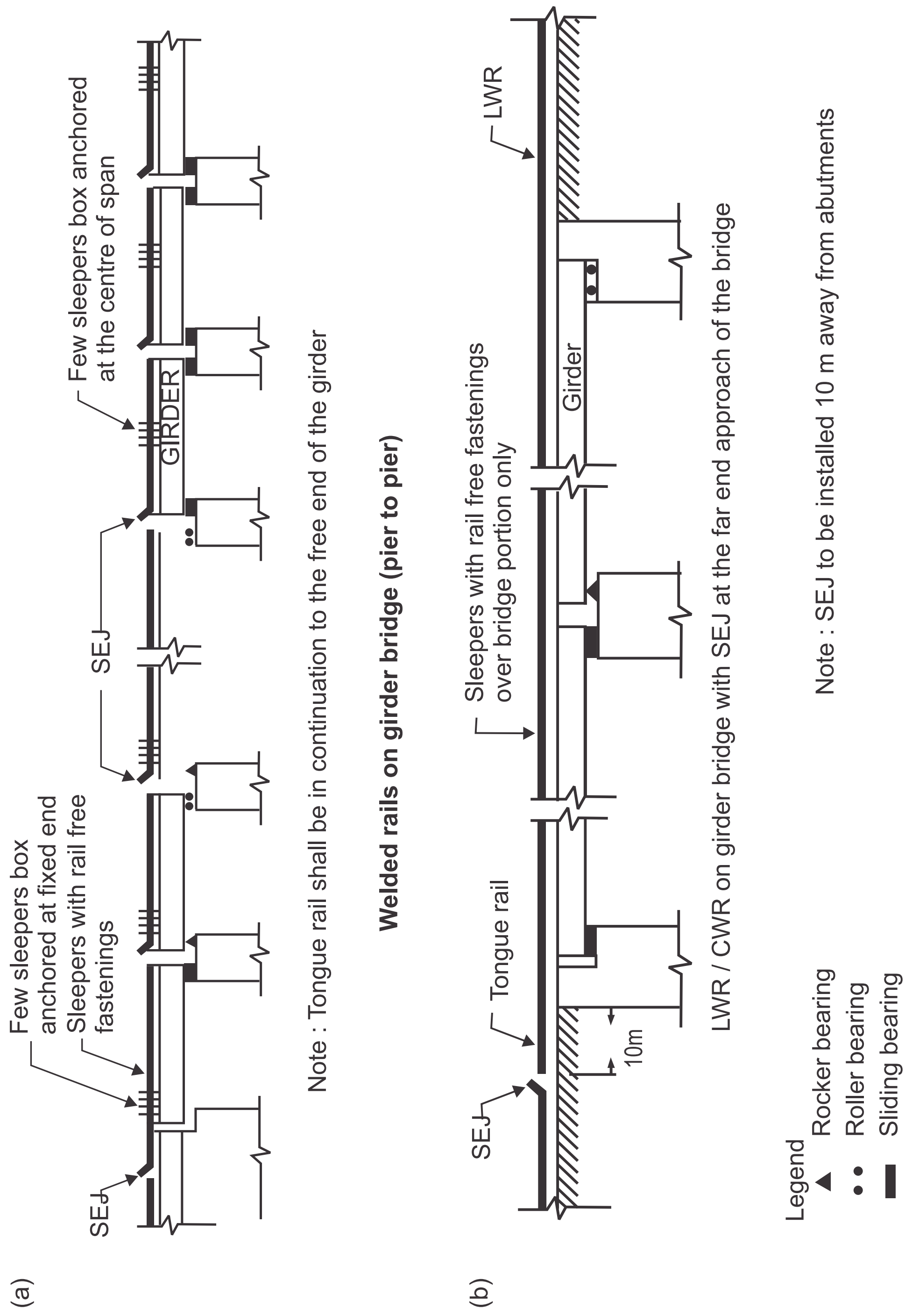


Fig. 7.21 *Welded rails on bridge.*

715. Laying of Long Welded Rails and Continuous Welded Rails

(1) Survey

A foot by foot survey of the sections where LWR/CWR is proposed to be laid shall be carried out in regard to the following:-

(a) Identification of location where LWR cannot be laid:

Locations over which LWR/CWR cannot be carried through on account of constraints such as bridges having substructure/superstructure in a distressed condition, curves, gradients, points and crossings, unstable formation etc. shall be identified. Such stretches of track shall be isolated from the remaining portion of LWR/CWR by provision of SEJs at either end.

(b) Identification of Preliminary works:

Locations where following preliminary works are required to be carried out shall be identified for completion before laying of LWR/CWR:-

(i) Replacement of insulated joints by glued joints

(ii) Realignment of curves

(iii) Lifting or lowering of track to eliminate sags and humps

(iv) Introduction and improvement of vertical curves

(v) Stabilisation of troublesome formation

(vi) Rehabilitation of weak bridges involving removal or lifting of rails or introduction of temporary arrangements.

(c) LWR Plan:

A detailed plan shall be made showing the exact locations of SEJs and of various other features mentioned in *Sub-Para a & b.* A sample of the detailed plan may be seen at *(Fig. 7.22).* The plans may be prepared to a horizontal scale of 1:5000.

(2) Temperature Records:

(a) The maximum daily variation of rail temperature and the mean rail temperature (t_m) for the section shall be ascertained from the temperature records available with the SSE/P.Way-In charge or as built up as per *Para 711(2)*. (Temperature Measurements).

(b) If rail temperature records of preceding five years are not available, the mean and range of rail temperatures shown in the 'Map of India showing Rail Temperature Zones *(Fig. 7.13)*, shall be adopted.

(3) Materials Required

Following materials are required for laying one LWR:-

(i) Four numbers of 6.5 meter or longer rail pieces of the same rail section as LWR.

(ii) Two sets of SEJs with sleepers and fastenings

(iii) Adequate numbers of 1 meter long fishplates with special screw clamps/ joggled fish plates with slotted grooves &bolted clamps as in *(Fig. 7.18, 7.19 & 7.20)*

Note: Slotted fishplates as in *(Fig. 7.23)* with fish-bolts may be used in exceptional cases.

(iv) Rail closures of suitable sizes.

(v) 1 meter and 10 cm straight edges.

(vi) Calipers and feeler gauges (2 mm to 0.1 mm)

(vii) Rail cutting equipment

(viii) Destressing equipment i.e. rollers, mechanical/hydraulic rail tensor, mallets and side rollers for curves, *(Fig.7.24 & 7.25)*

(ix) Alumino-Thermic /mobile gas pressure welding equipment and consumable materials.

(x) Equipment for protection of track.

(xi) Equipment for night working.

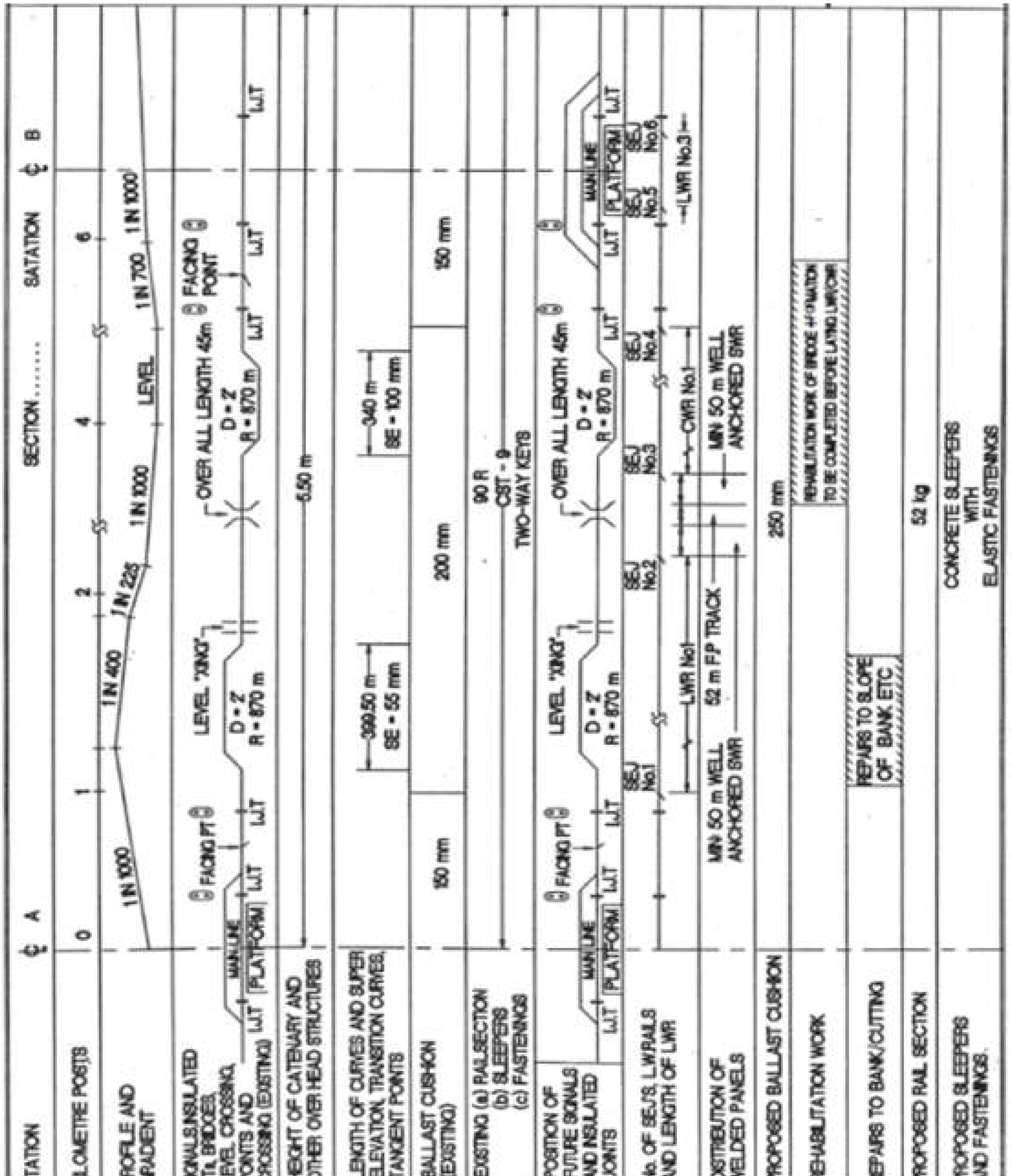


Fig. 7.22 *LWR (Plan)*

(4) Preliminary Works :

(a) Deep screening of ballast along with lifting or lowering of track, if required, should precede laying of LWR/CWR. Standard ballast section as stipulated in *Para 713(2)* (Ballast Cushion and Section) for LWR/CWR shall be provided. All other preliminary works identified in *sub para 1 (b) above* i.e. Replacement of insulated joints by glued joints, Realignment of curves, Lifting or lowering of track to eliminate sags and humps, Introduction and improvement of vertical curves, Stabilisation of troublesome formation, Rehabilitation of weak bridges involving removal or lifting of rails or introduction of temporary arrangements shall also be completed before laying of LWR/CWR.

(b) If any of the preliminary works cannot be completed before installation of LWR/ CWR, such stretches should be isolated by providing SEJs. On completion of these works, such stretches may be welded, destressed and joined with LWR/CWR in accordance with *Para 717* (Joining LWRs into CWR).

(5) Welding of Rails to form LWR :

(a) Welding of rails:

Rails shall normally be welded into sufficiently long panels of 10 to 20 rail lengths or more by flash butt welding/gas pressure welding, either in the welding depot or on Cess or in-situ. The joints in between only shall be welded by Alumino-thermic welding (SKV process).

(b) While unloading 880 grade (90 UTS) or higher grade rails, handling instructions laid down should be followed.

(c) Insertion of SEJ's at both ends:

Before laying long welded panels and/or before welding of rails, two complete sets of SEJs, one at either end of the proposed LWR/CWR shall be inserted at pre-determined locations with gaps in mean position as per *sub para 6* (Gaps at SEJ). Closure rails of 6.5 meter or longer length shall be provided at LWR side/sides of SEJs to facilitate adjustment of gaps during destressing operation.

(d) Unloading & laying of welded panels :

The laying of welded panels and/or welding of joints at site can be done at any time of the year. But after welding into sufficiently long panels of about 1 km or longer, destressing as per *Para 716* (Destressing of LWR) shall be undertaken as soon as possible.

Need for temporary destressing at higher temperature: Under unavoidable circumstances where destressing could not be done soon after and not likely to be done within a reasonable period, a strict vigil shall be maintained on the prevailing rail temperatures, and if the rail temperature rises more than 20° C above the rail temperature at which welding of rails/laying of welded panels was done, temporary destressing shall be undertaken at a rail temperature of 10° C below the maximum rail temperature likely to be attained until final destressing. If the rail temperature comes down appreciably, cold weather patrolling as per *Para 721 (2)* should be introduced. Final destressing shall be done after consolidation of track as per *Para 710 (18)* has been achieved

(e) Speed restriction:

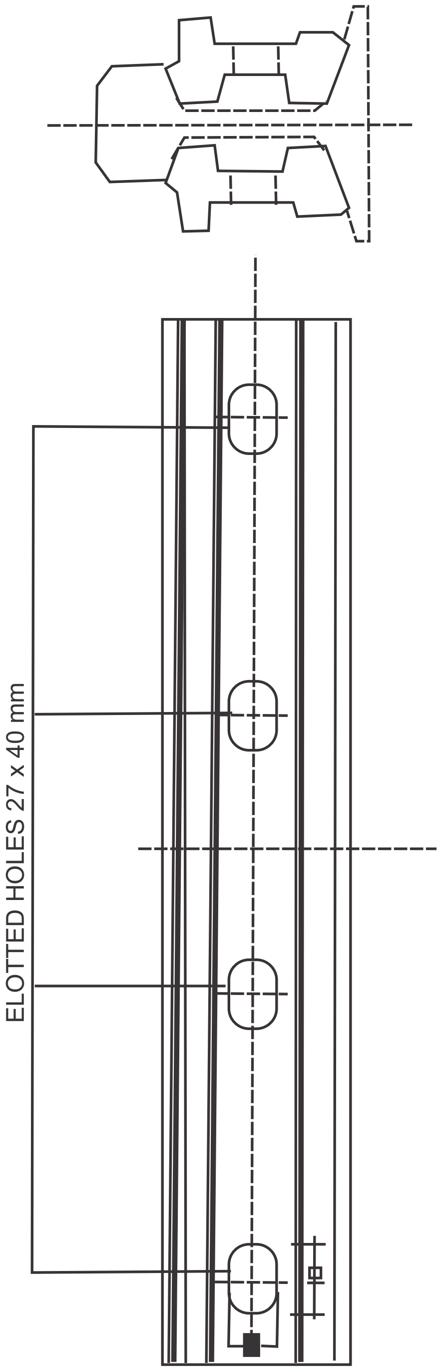
Temporary speed restriction of 30 km/h shall be imposed on the length of track (BG & MG both) where welded panels are joined by 1 m long fishplates with special screw clamps or joggled fish plates with slotted grooves &bolted clamps as in *Fig.7.18, 7.19 & 7.20* in all other cases permitted speed shall be 20 km/h (BG & MG both)

(6) Gaps at SEJ

(a) Gaps at SEJ shall be adjusted at the time of laying/subsequent destressing of LWR/CWR, as illustrated in *Fig. 7.26* The SEJ gap shall be kept 40 mm for 52 Kg/ 60 Kg rail section at t_d and for other rail section it shall be 60 mm.

(b) During service life / maintenance of LWR the measured gap between the reference mark and tongue rail tip/stock rail corner at various rail temperatures shall not differ by more than ± 10 mm from the theoretical range as shown in *sub para 7.*

(c) Where fish plated or SWP track is joined on one side of SEJ, the gap between the reference mark and tongue rail tip/stock rail corner on LWR/CWR side shall not differ by more than ± 10 mm from the theoretical range as shown in *sub para 7.*



Note :
Fishplate section and length is same as that of standard fishplate for the rail section

Fig. 7.23 *Slotted fish plate*

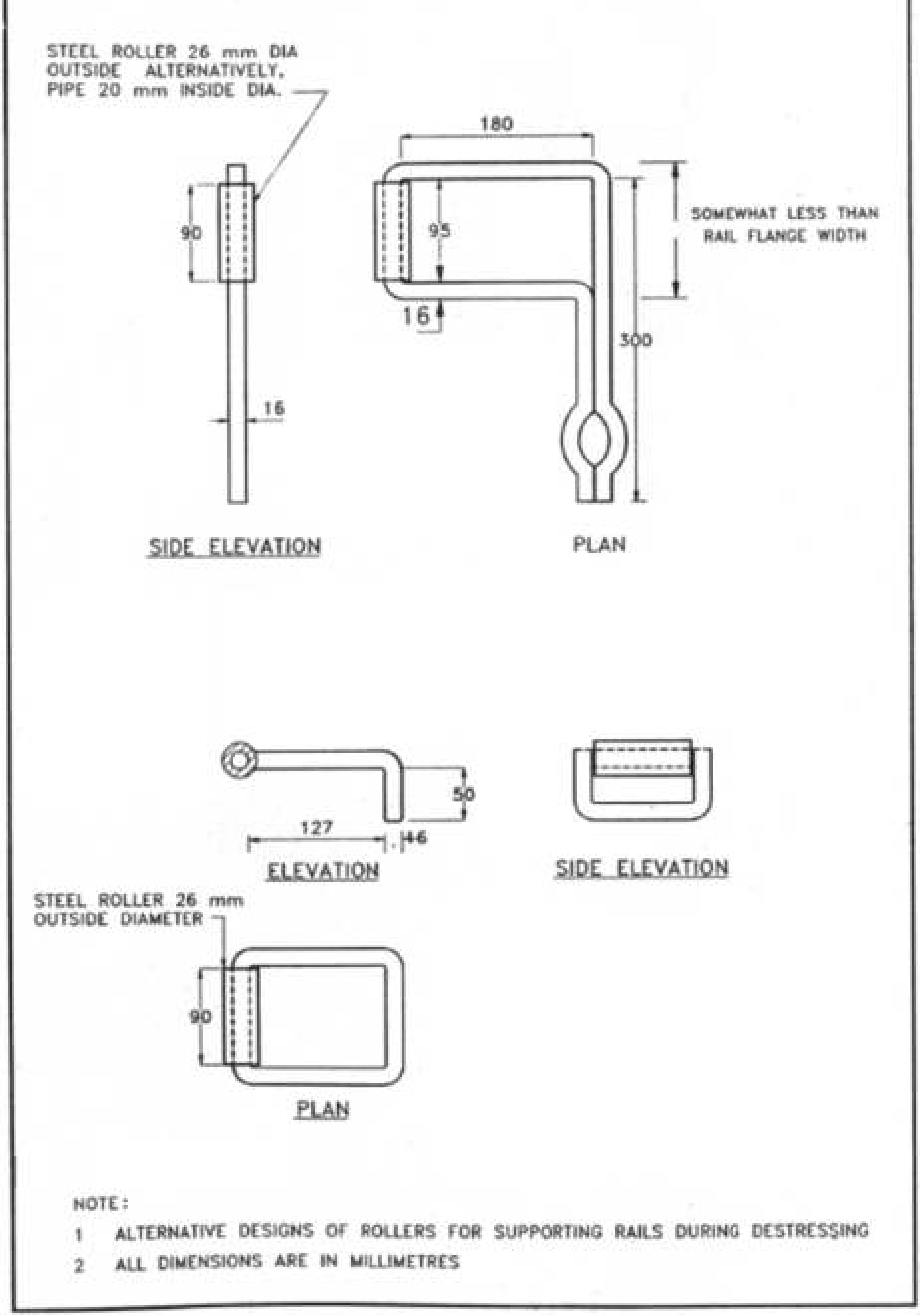


Fig. 7.24 *Rollers for BG*

Used for curved track to minimise friction and to give even extension to the rails and prevent rails from bow straininging out of the fastening position

For use on concrete sleepers or steel trough sleepers with modified loose jaw or for wooden sleepers fitted with pandrol bearing plates

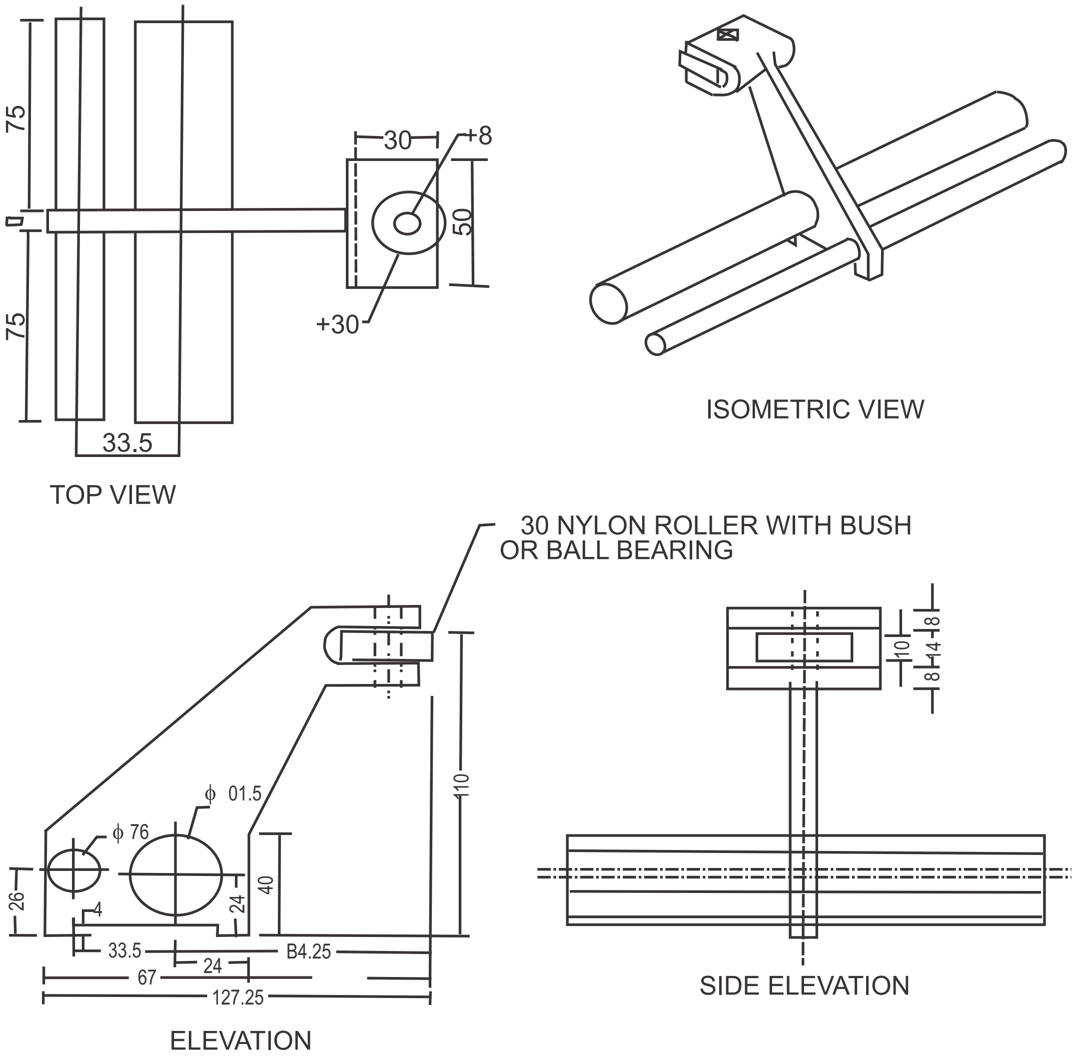


Fig. 7.25 *Side roller / support arm*

(7) Gaps between the reference mark and tongue rail tip/stock rail corner of SEJ.

(a) Gaps between the reference mark and tongue rail tip/stock rail corner of SEJ for various temperatures in mm. For BG, 60 kg, PRC sleeper, 1660 nos./km, value of R (ballast resistance) assumed = 13.74 kg/cm/rail and t_d as per para 710 (11) *Table 7.08*

Table 7.08

Temperature	Zone-I	Zone-II	Zone-III	Zone-IV
t_d + 28				14
t_d + 25			15	14 to 16
t_d + 20		17	15 to 18	14 to 18
t_d + 15	18	17 to 19	15 to 20	14 to 21
t_d + 10	18 to 20	17 to 21	16 to 23	15 to 23
t_d + 05	19 to 22	18 to 23	17 to 25	16 to 26
t_d	19 to 23	18 to 25	18 to 27	17 to 28
t_d - 05	20 to 25	19 to 26	19 to 28	18 to 29
t_d - 10	21 to 26	20 to 28	20 to 30	20 to 31
t_d - 15	22 to 27	22 to 29	21 to 31	21 to 32
t_d - 20	23 to 27	23 to 30	23 to 32	23 to 34
t_d - 25	25 to 28	25 to 30	25 to 33	25 to 35
t_d - 30	26 to 28	27 to 31	27 to 34	27 to 36
t_d - 35	28	29 to 31	29 to 34	29 to 36
t_d - 40		31	32 to 34	32 to 37
t_d - 45			35	35 to 37
t_d - 48				37

Note: The above values have been calculated with initial setting of gaps at SEJ as 40 mm.

(b) Gaps between the reference mark and tongue rail tip/stock rail corner of SEJ for various temperatures in mm. For BG, 60 kg, PRC sleeper, 1540 nos./km, value of R (ballast resistance) assumed = 13.28 kg/cm/rail and t_d as per *para 710 (11) Table 7.09*

Table 7.09

Temperature	Zone-I	Zone-II	Zone-III	Zone-IV
t_d+ 28				13
t_d + 25			15	13 to 14
t_d + 20		17	15 to 18	14 to 15
t_d + 15	18	17 to 19	15 to 20	14 to 18
t_d + 10	18 to 20	17 to 21	16 to 23	14 to 21
t_d + 05	19 to 22	18 to 23	16 to 25	16 to 26
t_d	19 to 23	18 to 25	17 to 27	17 to 28
t_d - 05	20 to 25	19 to 27	19 to 28	18 to 30
t_d - 10	21 to 26	20 to 28	20 to 30	20 to 31
t_d - 15	22 to 27	22 to 29	21 to 31	21 to 33
t_d - 20	23 to 28	23 to 30	23 to 32	23 to 34
t_d - 25	25 to 28	25 to 31	25 to 33	25 to 35
t_d - 30	27 to 28	27 to 31	27 to 34	27 to 36
t_d - 35	28	29 to 31	30 to 35	30 to 37
t_d - 40		32	32 to 35	33 to 37
t_d - 45			35	36 to 37
t_d - 48				37

(c) Gaps between the reference mark and tongue rail tip/stock rail corner of SEJ for various temperatures in mm. For BG, 52 kg, PRC sleeper, 1660 nos./km, value of R (ballast resistance) assumed = 13.74 kg/cm/rail and t_d as per *para 710 (11)*

Table 7.10

Temperature	Zone-I	Zone-II	Zone-III	Zone-IV
t_d+ 28				15
t_d + 25			16	15 to 16
t_d + 20		17	16 to 18	15 to 19
t_d + 15	18	17 to 19	16 to 20	15 to 21
t_d + 10	19 to 20	18 to 21	17 to 22	16 to 23
t_d + 05	19 to 22	18 to 23	17 to 24	16 to 25
t_d	19 to 23	19 to 24	18 to 26	17 to 27
t_d - 05	20 to 24	19 to 25	19 to 27	18 to 28
t_d - 10	21 to 25	20 to 27	20 to 28	20 to 30
t_d - 15	22 to 26	21 to 27	21 to 29	21 to 31
t_d - 20	23 to 26	23 to 28	23 to 30	23 to 32
t_d - 25	24 to 27	24 to 29	24 to 31	24 to 33
t_d - 30	25 to 27	26 to 29	26 to 32	26 to 33
t_d - 35	27	28 to 30	28 to 32	28 to 34
t_d - 40		30	30 to 32	31 to 34
t_d - 45			33	33 to 34
t_d - 48				34

Note: The above values have been calculated with initial setting of gaps at SEJ as 40 mm.

(d) Gaps between the reference mark and tongue rail tip/stock rail corner of SEJ for various temperatures in mm. For BG, 52 kg, PRC sleeper, 1540 nos./km, value of R (ballast resistance) assumed = 13.28 kg/cm/rail and t_d as per *para 710 (11) Table 7.11*

Table 7.11

Temperature	Zone-I	Zone-II	Zone-III	Zone-IV
t_d+ 28				14
t_d + 25			16	14 to 16
t_d + 20		17	16 to 18	15 to 19
t_d + 15	18	17 to 19	16 to 20	15 to 21
t_d + 10	18 to 20	18 to 21	16 to 22	16 to 23
t_d + 05	19 to 22	18 to 23	17 to 24	16 to 25
t_d	19 to 23	19 to 24	18 to 26	17 to 27
t_d - 05	20 to 24	19 to 26	19 to 27	18 to 28
t_d - 10	21 to 25	20 to 27	20 to 29	20 to 30
t_d - 15	22 to 26	22 to 28	21 to 30	21 to 31
t_d - 20	23 to 26	23 to 29	23 to 31	23 to 32
t_d - 25	24 to 27	24 to 29	24 to 32	24 to 33
t_d - 30	26 to 27	26 to 30	26 to 32	26 to 34
t_d - 35	27	28 to 30	28 to 33	29 to 34
t_d - 40		30	31 to 33	31 to 35
t_d - 45			33	33 to 35
t_d - 48				35

Note: The above values have been calculated with initial setting of gaps at SEJ as 40 mm.

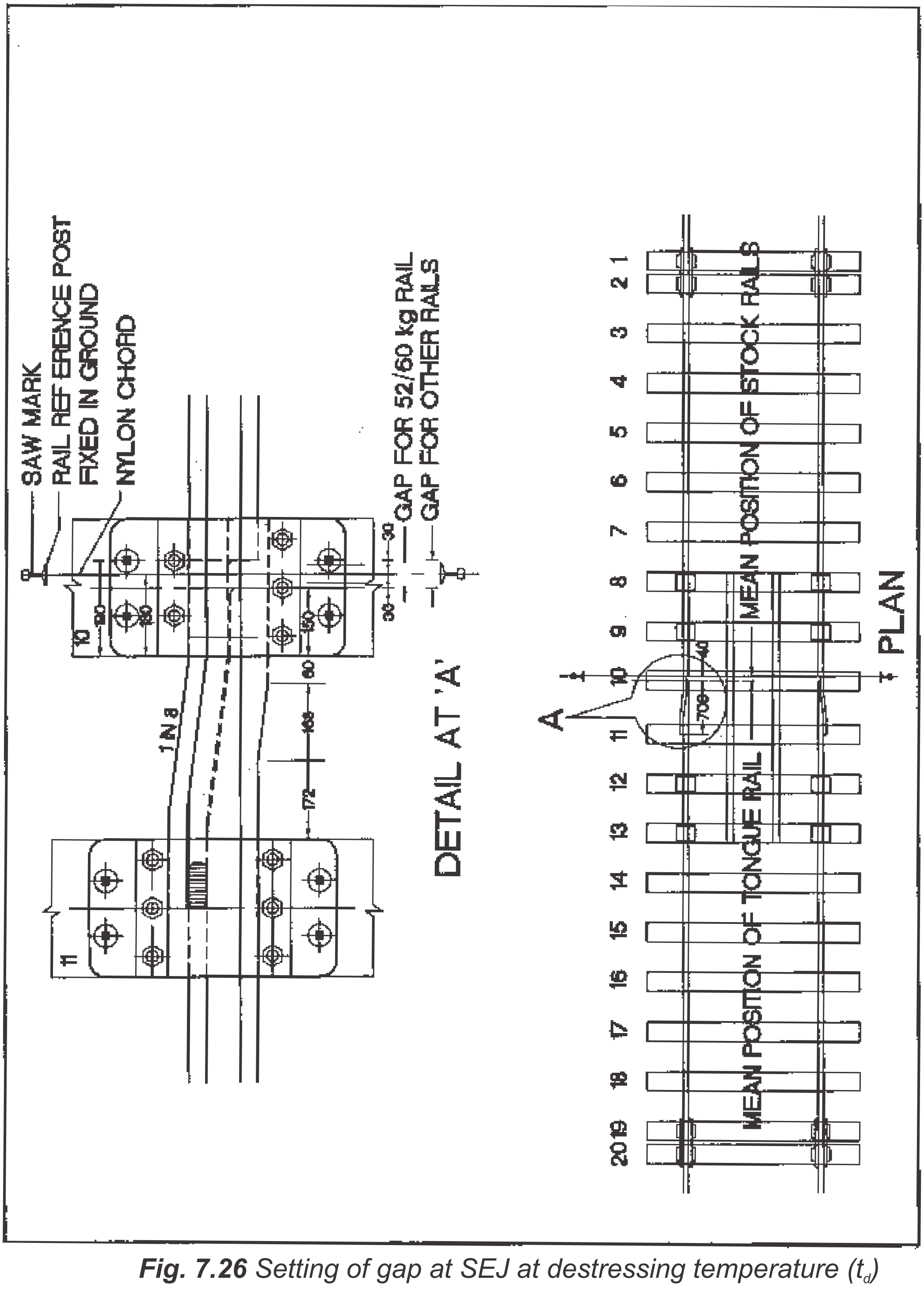


Fig. 7.26 *Setting of gap at SEJ at destressing temperature (t_d)*

Calculation for gap at SEJs for various rail temperatures and track structures based on hysteresis curve

(1) The movement of breathing length is (Lbα t / 2) or AE (α t)2/ (2 r), so the gap at SEJ depends on following factors:-

(a) Longitudinal Ballast Resistance of sleepers

(b) Area of rail section

(c) Modulus of Elasticity (E) for rail steel

(d) Coefficient of linear expansion (a) for rail steel

(e) Destressing temperature of the section where gap at SEJ is required.

(f) Initial gap at SEJ at destressing temperature

(2) Values of above variables for Indian conditions are tabulated below:-

Rail Section	Area (crn^2)	E (kq/crn^2)	α *(1°C)*
60kg (UIC)	76.86	2.15×10^6	1.152×10^{-5}
52kg	66.15		
90R	56.95		
75 R	47.37		

(3) Longitudinal Ballast Resistance (R in Kg/cm/rail) for various sleepers & S.D

Type of sleeper↓	BG		MG
Sleeper density→	1660 sleepers/km	1540 sleepers/km	1540 sleepers/km
PRC	13.74	13.28	---
Steel sleeper	12.68	12.14	3.86
CST-9	11.04	10.65	3.47

Note: The values given above are indicative and can vary as per site conditions.

Initial gap to be provided at destressing temperature (t_d)

Rail Section	Initial gap at t_d (mm)
60kg (UIC)/52kg	40 mm
Others	60 mm

Illustration:-

To find out the gap at SEJ at rail temperature of 58°C with the following data:

Rail Section	52 kg
Type of sleeper	PSC
Sleeper density	1540 sleepers/km
Temp. zone	IV
Destressing temp.	
Gap at SEJ at td	40mm

First of all hysteresis curve of movement of tongue/stock rail of SEJ will be drawn at different temperatures.

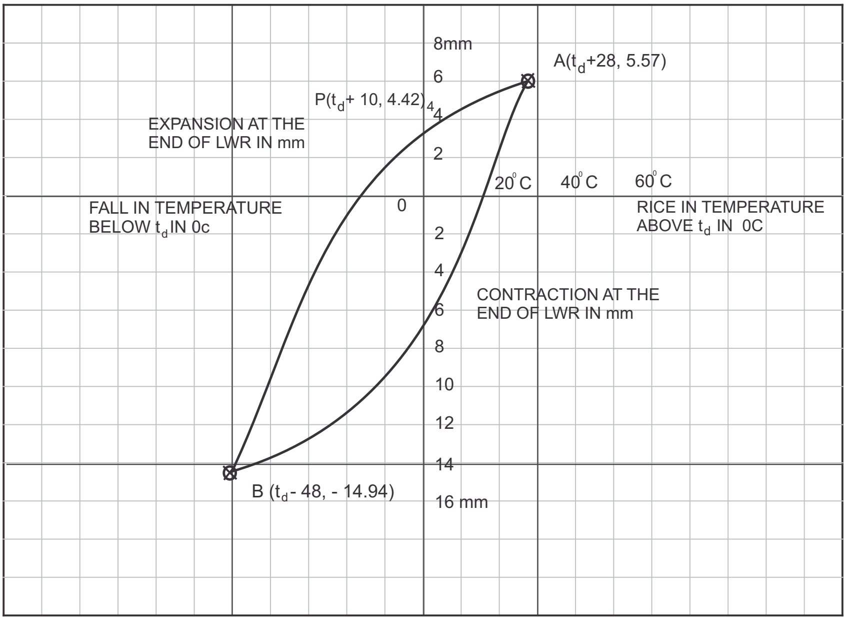


Fig.:7.27 *Hysteresis curve showing the movement of ends of tongue/stock rail of SEJ.*

(1) Movement of tongue/stock rail from the stage of destressing temperature (point '0') to the stage of maximum temperature (point A) for rising trend of temperature will be:-

= $AE(\alpha t)2/2R$

= $66.15 \times 2.15 \times 106 \times (1.152 \times 10\text{-}5)^2 \times (76\text{-}48)2 / 2 \times 13.28$

= 0.557cm

= 5.57 mm

Hence coordinate of maximum temperature (point 'A') will be (t_d + 28, + 5.57).

(2) Movement of tongue/stock rail from stage of maximum temperature (point 'A') to stage of minimum temperature (point 'B') for decreasing trend of temperature will be:-

= $AE(\alpha t)2/4R$

Note: At the reversal of temperature the ballast resistance has to get moblised in opposite direction, for this ballast core deformed in one particular direction has to come back to normal & then get moblised in reverse direction, summing up the ballast resistance + r which existed at the instance of reversal of temperature drops to zero and then develops to - r . Hence to decide the magnitude of ballast resistance opposing the reverse movement, its value is taken as r - (- r) = 2 r for mathematical purpose.

= $66.15 \times 2.15 \times 106 \times (1.152 \times 10\text{-}5)^2 \times (76)2 / 4 \times 13.28$

= 2.052 cm say 20.52 mm

Hence coordinate of minimum temperature (point 'B') will be (t_d + 28 - 76, 5.57- 20.52) or (t_d - 48, - 14.95)

(3) Movement of tongue/stock rail from stage of minimum temperature (point 'B') to stage of maximum temperature (point 'A') for increasing trend of temperature will be:-

= $66.15 \times 2.15 \times 106 \times (1.152 \times 10\text{-}5)^2 \times (76)2/4 \times 13.28$

= 2.052 cm

= 20.52 mm

Hence coordinate of maximum temperature (point 'A') will be

(t_d - 48 + 76, - 14.95 + 20.52) or (t_d + 28, + 5.57)

Temperature at which gap at SEJ is required is 58°C i.e. (t_d + 10)°C say point 'P'.

(4) Value of movement of tongue/stock rail at (t_d+ 10) °C point 'P' for falling trend of temperature will be

= 66.15 x 2.15 x 106 x (1.152 x 10-5)2 x (76 - 58)2 /4x 13.28

= 0.115 cm

= 1.15 mm

Hence coordinate at point 'P' for falling trend of temperature will be: (t_d+ 10, 5.57-1.15) or (t_d + 10, +4.42)

(5) In the same way, value of movement of tongue/stock at (t_d + 10) °C point 'P' for rising trend of temperature will be:-

= 66.15 x 2.15 x 106 x $(1.152 \times 10\text{-}5)^2$ X (58)2 /4x 13.28

= 1.195 cm

= 11.95mm

Hence coordinate at point 'P' for rising trend of temperature will be:- (t_d + 10, -14.95 + 11.95) or (t_d + 10, -3.0)

The calculations done above indicate that at temperature t_d + 10°C, i.e. at 58°C, movement of one side of tongue/stock rail for decreasing trend of temperature is +4.42 and for increasing trend temperature is -3.0 mm.

Hence the gap between the reference mark and tongue rail tip/stock rail corner of SEJ for decreasing trend of temperatures at 58°C shall be 20* 4.42 = 15.58 mm and for increasing trend of temperatures shall be 20* + 3.0

= 23 mm. Thus theoretical range will be 15.58 mm to 23 mm.

Note: * Value of 20 mm taken as standard gap to be provided between reference mark and tongue rail tip/stock rail corner at destressing temperature. If gap to be provided at destressing temperature is 30 mm, then these values will be (30 - 4.42) mm to (30 + 3.0) mm i.e. 25.58 mm to 33 mm respectively

Similarly values of gaps for various temperatures, tracks structures, temperature zones etc. can be calculated.

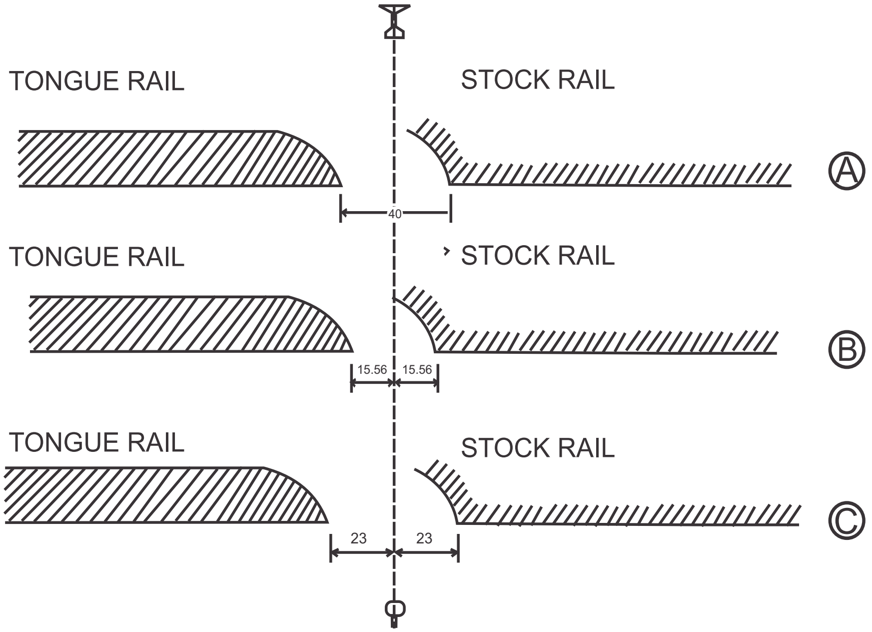


Fig. 7.28 *Gap at SEJ as per example given above*

(8) Laying of buffer rails

(a) Buffer Rails may be provided subject to conditions laid down in Para710 (6), i.e. these will be laid with prior approval of Chief Engineer at locations where provision of SEJ is not permitted. Buffer rails may also be temporarily laid to facilitate maintenance/renewal operations.

(b) In rail temperature zones I & II, 3 buffer rails, while in zones III & IV, 4 buffer rails shall be provided. Buffer rails would be 6.5 meter long for BG and 6.0 meter long for MG.

(c) Buffer rails may be laid with J-clips. Standard fishplates shall be used at the joints. However, for effective tightness of bolts, bolt to drawing No. T-11599 may be used in lieu of that of drawing No. RDSO/T 1899. The number, type and spacing of sleepers for buffer rail assembly shall be as indicated in *Fig. 7.29.*

(d) A gap of 7.5 mm shall be provided at each of fish plated joints of buffer rail assembly at the time of initial laying/destressing.

(e) The fish plated joints of buffer rails shall be accurately fabricated. In case pre-drilled rails and standard fishplates are used, the dimensions and square ness of rail ends shall conform to the tolerances stipulated in the specifications IRS T -12 for rails and IRS T-1 for fishplates. Holes drilled at site shall also conform to the above specifications. All holes in buffer rails shall be chamfered.

(f) In the case of buffer rails laid between conventional track and LWR, the former shall be box-anchored for 3 rail lengths.

(g) Special and prompt attention shall be paid to the alignment and levels of track in the buffer rail portions. Buffer rails shall be free of kinks and hogs.

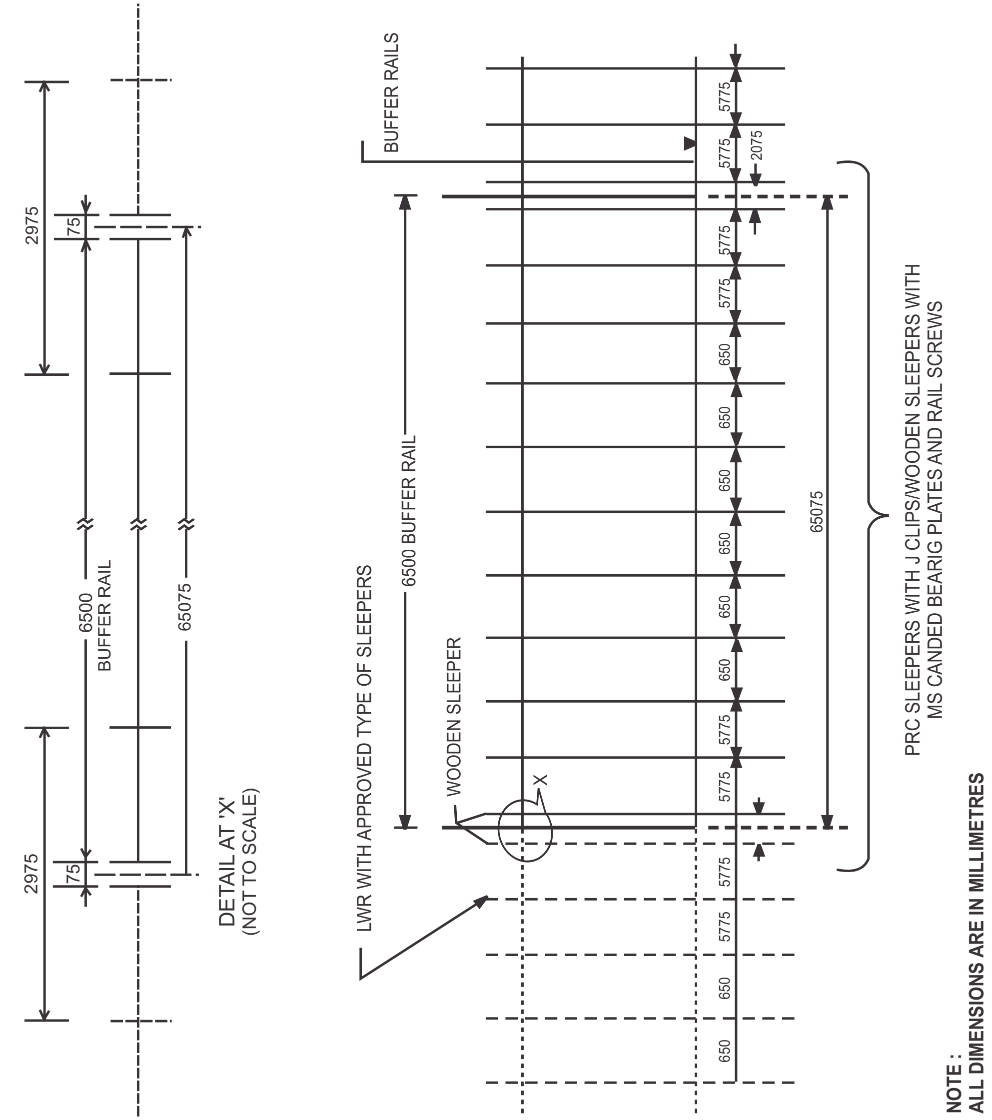


Fig. 7.29 *Sleeper spacing under 6.5 m buffer rails (BG)*

716. Destressing of LWR

(1) Need for destressing: The destressing is the operation undertaken with or without rail tensor to secure stress free conditions in the LWR/CWR at the desired/specified rail temperature. The destressing of LWR is to be carried out:

(a) On Initial laying of LWR

(b) During Maintenance of LWR track :

(i) When the gap observed at SEJ

(1) Differs beyond limits as specified under *para 715 (6) (b & c)* i.e. the gaps between the reference mark and tongue rail tip/stock rail corner at various rail temperatures differ by more than ± 10 mm from the theoretical range as specified in *para 715 (7).*

(2) Exceeds the maximum designed gap of SEJ

(3) When stock/tongue rail crosses the mean position.

(ii) After special track maintenance operations namely Through fitting renewal, Deep screening, Lowering/ lifting of track, Major realignment of curves, Through sleeper renewal, Rehabilitation of bridges and formation causing disturbance to track.

(iii) After restoration of track following an unusual occurrence namely Rail fractures, Damage of SEJ/ buffer rails, Buckling or tendency towards buckling, factors causing disturbance to LWR/CWR such as accidents, breaches

(iv) If number of locations where temporary repairs have been done exceed three per km.

(c) (i) In addition one round of temporary destressing is done, 10°C below the maximum rail temperature likely to be attained during the work related to special track maintenance works of long duration such as deep screening, through sleeper renewal, when the rail temperature during the track work is likely to fall outside t_d + 10°C & t_d - 20°C.

(ii) Similarly during laying of LWR, if the rail temperature rises more than 20°C above the rail temperature at which welding of rails/ laying of welded panels is done, the temporary destressing shall be undertaken at a rail temperature 10°C below the maximum rail temperature likely to be attained during the work.

(2) L.W.R Destressing Operation

(a) General

(i) The work of destressing shall be done under the personal supervision of a JE/SSE (P. Way), during a traffic block of adequate duration at appropriate rail temperature.

(ii) It is preferable to impose a speed restriction of 30 km/h before actually obtaining the traffic block to loosen rail fastenings on alternate sleepers to reduce total duration of the traffic block.

(iii) Remove impediments to free movement of rail such as rail anchors, guard rails, check rails etc. in advance

(iv) The destressing operation provides an opportunity to examine & replace Rubber pad, ERC & liner wherever necessary accordingly plan for replacement of bad Rubber pad, Liner, damaged ERC, recycling of greased ERC, shifting of liner bite rail zone wherever necessary, at the time of destressing.

(v) During destressing operation, the rail is required to be lifted and placed on rollers at every 15^{th} sleeper to permit the free movement of rails.

(vi) Side rollers shall also be used while undertaking destressing on curved track.

Side supports on the inside of curve should be spaced at every nth sleeper,

$$\text{Where, } n = \frac{\{\text{Radius of curve (R) x No. of sleepers per rail length}\}}{50 \times (t_O - t_P).}$$

for destressing with tensor.

In case of destressing without tensor the value of n can be taken as Radius of curve (R) / 50

Note : Outside supports shall be used in addition at the rate of one for every three inside supports.

(3) Destressing of LWRs/CWRs without use of Rail tensor

In case rail temperature at the time of destressing is within the range specified in *Para 710 (11)* (Destressing temperature), detailed procedure without using rail tensor, as given below, may be adopted.

(a) A traffic block of adequate duration should be arranged at such a time that the rail temperature will be within the temperature range specified for t_d in *Para 710 (11)* (Destressing temperature) during the fastening down operations.

Zone	Rail section	Range for t_d
I, II & III	All Rail sections	t_m to $t_m + 5°C$
IV	(i) 52 Kg & heavier	$t_m + 5°C$ to $t_m + 10°C$
	(ii) Other rail sections	t_m to $t_m + 5°C$

The entire work shall be done under personal supervision of the JE/SSE (P. Way).

(b) Before the block is actually taken, a speed restriction of 30 km/h should be imposed and fastenings on alternate sleepers loosened.

(c) When the block is taken, the closure rails shall be removed, the SEJs adjusted as per *Para 715 (6)(a)* (i.e. SEJ gap shall be kept 40 mm for 52 Kg/ 60 Kg rail section at t_d & SEJ fastened.)

(d) The remaining sleepers fastenings on both running rails shall be removed starting from the ends near the SEJs and proceeding towards the center of LWR. The rail shall be lifted and placed on rollers at every 15th sleeper to permit the rails to move freely. While destressing on curved track, provision of side rollers as per note of Para *716 (2)(vi) above* may be adopted. The rails shall be struck horizontally with heavy wooden mallets to assist in their longitudinal movement.

(e) The rollers shall then be removed, the rails lowered to correct alignment and fastenings tightened, starting from the middle of LWR and proceeding towards both ends simultaneously. The tightening of fastenings shall be completed within the temperature range for td as specified in *Para 716 (3)(a).* The actual range of temperature during the period of tightening shall be recorded by JE/SSE (P. Way) along with the time and date.

(f) Simultaneously with the tightening of fastening, arrangements for insertion of closure rails between the SEJ and LWR shall be started. The four gaps shall be measured individually and the rails of required length cut by saw keeping due allowance for AT welding. The closure rails shall then be placed in position fastened to the sleepers and welded at each end. Fastenings for 20 meter on each end of the LWR shall be removed before welding. Joints shall be clamped for 20 minutes after welding.

(4) Destressing of LWRs/CWRs with use of Rail tensor

For destressing of LWR with the use of rail tensor, the following procedure shall be adopted:-

(a) During the first traffic block, create a gap of 1 meter at location 'B' i.e. centre of LWR *(Fig. 7.31).* Introduce rail closure as required and fasten with 1 m long fish plates and special clamps. Allow traffic at restricted speed of 30 km/h with 24 Hrs. watch on the joint.

(b) Mark the anchor length A_1 A_2 and C_1 C_2 each equal to la at either end of the length A_2 C_2 to be destressed *(Fig. 7.31 (a))*

Note:The anchor length 'la' should be determined on the basis of the lowest value of t_P at which the destressing is likely to be carried out.

(c) Erect marker pillars W_0 W_1 etc., on each of the length A_2 Band C_2B. Transfer the marks W_0 onto the rail foot *(Fig: 7.31 (a)).*

Note: The distances W_0 W_1, W_1 W_2 etc. shall be marked at about 100 meter intervals, the distance from the previous pillars and the last pillar WB may be less than 100 meter.

(d) During the second traffic block, when tp, is less than the desired to *Fig. 7.31 (b)* destressing operation shall be carried out for the lengths A_2 Band C_2 B as described below:-

(i) Remove the closure rail from location 'B.' Unfasten and mount on rollers the portion from A_2 C_2. Measure the rail temperature t_P at this stage

(ii) Fix the rail tensor across the gap at 'B' and apply tension so as to obtain some movement at W_0 to remove any kinks or is alignment and to minimise the friction in the rollers etc. Release the tension and note the movement Y_0 at W_0.

(iii) Transfer marks W_1, W_2, ... onto the rail foot and note temperature t_P.

(iv) Calculate the required movement at W1 as under:-

Movement at W_1=Y_0 + elongation of length W_o W_1 (L) due to temperature difference $(t_o - t_p) = Y_0 + L\alpha\,(t_o - t_p)$

Calculate the required movement at W_2 as under:-

Movement W_2 = Movement at W_1 + elongation of length W_1W_2 (L) due to temperature difference $(t_O - t_P)$.

Similarly, calculate the required movements successively at each of the remaining points.

Mark the above calculated extensions with respect to the transferred marks referred at (c) above on the rail foot on the side away from the tensor.

Apply the tension by means of rail tensor till the mark of required extension comes opposite to the mark on the marker pillar W_1. Fasten down the segment W_0W_1.

Then check at W_2, bring the mark of required extension at this location opposite to the mark on the marker pillar W_2, by adjusting the tensor either by reducing or increasing tension and fasten down the segment W_1W_2. Similarly, check the remaining marks, adjust the tension as required and fasten down each segment before proceeding to the next.

Note: • Extension table given after *Para 718, i.e. table 7.11* gives the value of $L\alpha\,(t_o - t_p)$ for different values of L and $(t_o - t_p)$.

- Only one value of tp has to be taken at the time of marking W_1, W_2 etc. on the rail foot. The value of tp is not required to be taken thereafter. The variation of temperature, if any during the destressing operation shall automatically be taken care of by reducing or increasing the tensile force from the tensor, while coinciding the reference mark on rail with the corresponding mark on pillars.
- If for any reason, both the lengths A_2B and C_2B cannot be fastened down simultaneously, the final adjustment in pull and fastening down of the individual segments may be done in series, first from A_2 to B and then, from C_2 to B.

(v) After the fastening down of the last length A_2B and C_2B is completed, make a paint mark near free end of one rail at a distance of (6.5 meter + 2 x 25 mm -1 mm), measured from the end of the other rail across the gap spanned by the rail tensor.

(vi) Remove the tensor, close the 1 meter gap temporarily using 1 m long fish plate & special clamps and allow traffic at restricted speed of 30 km/h and 24 Hrs. watch on the joint *(Fig. 7.31 (c))*

(e) During third traffic block, cut the rail at the paint mark, insert a rail closure of length exactly equal to 6.5 meter and weld one end thereof *(Fig. 7.31).* If the gap at the other end is also 25 mm, it can be welded in the same block. Otherwise, fasten with 1 meter long fishplates with special screw clamps/ joggled fish-plates having slotted grooves & bolted clamps as in *Fig. 7.18, 7.19, & 7.20* with speed restrictions 30 Km/h and 24 Hrs.

Watch or 20 Kmph in case of other clamps are used. Fish-bolt holes if any, shall be chamfered. In the latter case, during a subsequent block, when t_P is not greater than to, release rail fastenings on either side to the required extent and pull the rails with rail tensor to get the desired gap of 25 mm *(Fig. 7.30);* re-fasten the rail and weld the joint. Release the tensor after a lapse of a minimum of 20 minutes after pouring of the weld metal.

(f) During fourth traffic block, when t_P is less than t_d, equalise the forces in the rail by releasing the fastenings over a length of 100 meter on either side of location 'B' and tapping with wooden mallets etc. *(Fig. 7.30).* Fasten down the rail and allow traffic.

(g) During fifth traffic block, when t_p is within the range of temperature specified for t_d in *Para 710 (11),* destress the end 100 meter from SEJ. Thereafter, weld the closure rail next to SEJ duly ensuring setting of the SEJ and i.e. SEJ gap shall be kept 40 mm for 52 Kg/ 60 Kg rail section at t_d and 60 mm for other rail section

Fig. 7.30 *Hydraulic tensor*

Alternatively the complete destressing work with rail tensor can be completed in 2 traffic blocks of adequate duration as detailed below:

In the first traffic block, when prevailing temperature t_p is less than td, rail to be cut at mid-point i.e. location B for 6.5 m length and destressing operation shall be carried out for the lengths A2 Band C2 B as described above under *(Sub para (4)(d) above.)*

In the second block when prevailing temperature t_p is within t_d, the operations mentioned under *sub para (4), (e), (f) & (g) above* may be carried using 2 teams one working in middle portion at location B for operations specified under *sub para (4) (e), (f) above* & other near SEJ's for operations specified under *sub para (4) (g)* above.

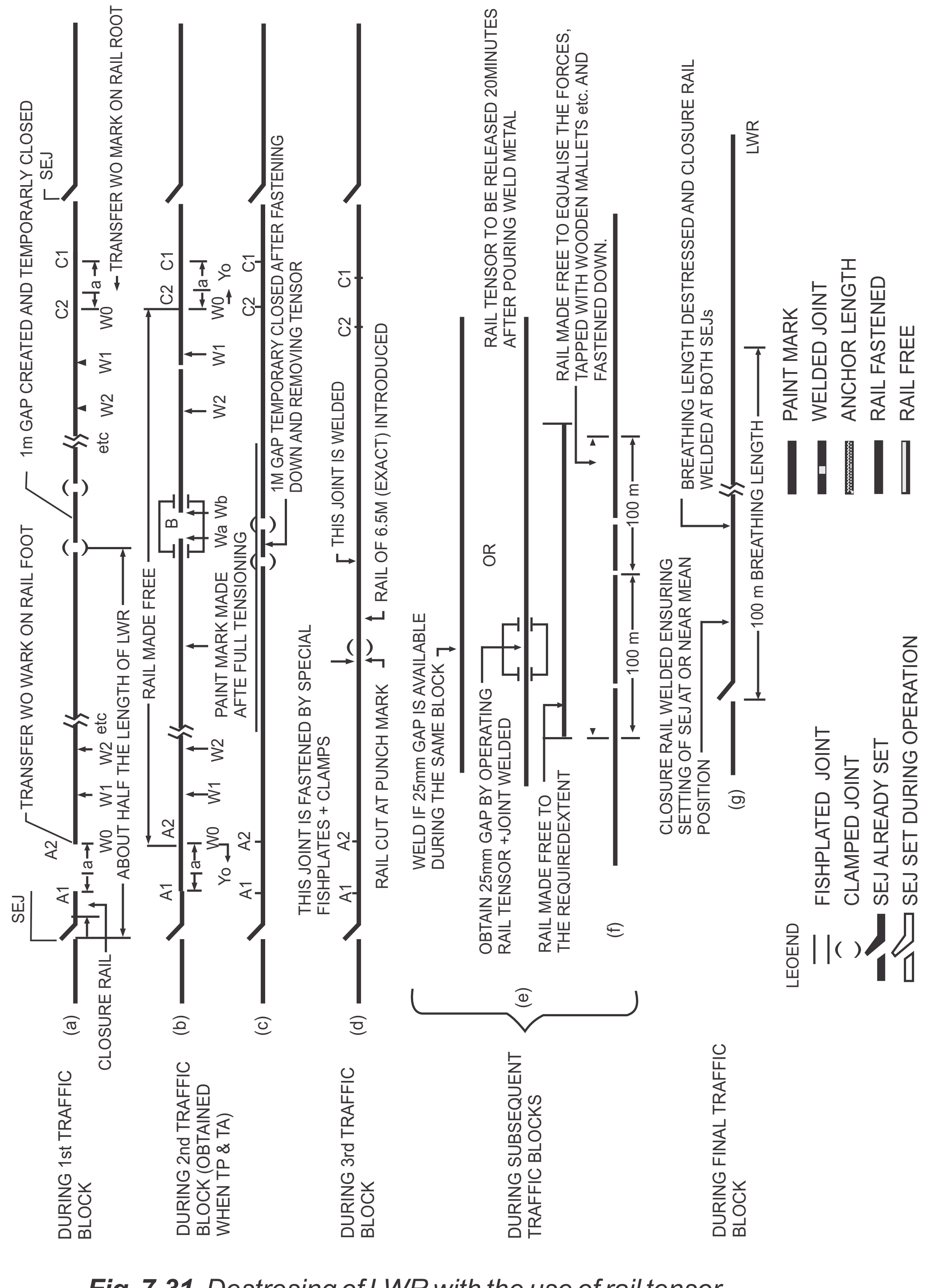


***Fig. 7.31** Destresing of LWR with the use of rail tensor.*

717. Joining LWRs into CWR

Detailed procedure for joining of LWRs into CWR is as given below *(Fig. 7.32 (a) to (f)):-*

(1) Replace the existing SEJs/buffer rails between the LWRs with ordinary rails, of which there should be two temporary rails about 6.5 metre long for each of left and right sides. Leaving the temporary rails fish-plated, weld the other rails.

Note: Where fluctuations of temperatures during the period of joining are likely to be small, only one temporary rail instead of two, may suffice.

(2) Provide W_o marker pillars for each of the LWRs at a distance of 100 metre from the center of temporary rails, to mark the ends of the breathing lengths.

(3) Keep ready two rails of standard length. Measure their lengths 'l' correct to the nearest millimeter.

(4) Transfer the marks W_o to the rail flange for both the LWRs. During the first traffic block when t_P is less than desired t_0, remove the fishplates and fish bolts connecting the temporary rails to the breathing lengths, release the fastenings of LWRs between the W_0 marks, mount the rails on rollers and note the movements Y_0 and Y'_0 at the marker pillars W_0, for LWRs 1 and 2 respectively.

Note: The movements of Y_o and Y'_o should be away from the ends of LWR, if the LWRs are in a state of correct destressing.

(5) Note: t_P and mark the anchor length on either side as shown *Fig.7.32 (b).*

(6) Make a paint mark near the end of either of the LWRs at a distance of 1+Lα (t_o- t_P) + Y_0+ Y'_0 + 2 x 25 -1 mm measured from the end of other LWR. Here L =200 metre, 25 mm is the allowance for each thermit weld and 1 mm is the allowance for a saw cut. The value of Lα (t_o-t_p) may be read from Extension Table given after *(Para 718),* i.e. for (t_o- t_p)=10°C, Lα (t_o- t_p) =23 mm.

(7) Remove the rollers, fasten down the length 'L', introducing closure pieces, if necessary, and allow traffic *(Fig.7.32 (c))*

(8) During the second block *(Fig. 7.32 (g)),* cut the rail at the paint mark, remove the temporary rails, insert the rail of length 'l' and weld one end of it. If the gap at the other end is 25 mm, it can also be welded during the same block. If the required 25 mm gap is not available, fasten the rails with fish plates and clamps and allow traffic at restricted speed.

(9) During the third block *(Fig. 7.32 (e)),* weld the other joint if the gap is 25 mm. If the gap is more than 25 mm, release the rail fastenings on either side to the

required extent and pull the rails with rail tensor to get the desired gap of 25 mm. Re-fasten and weld the rail. Release the tensor after the lapse of a minimum of 20 minutes after pouring of the weld metal.

(10)During the fourth and final block *(Fig.7.32 (f)),* equalise the forces in the railby releasing the fastenings over the portion marked 'L' and also over the anchor lengths on either side and tapping with wooden mallets, etc. Fasten down the rail and restore traffic.

718. Reference Marks

Reference marks shall be fixed at each SEJ and at the center of LWR/CWR, on the reference pillars erected for this purpose. While the reference marks on the reference pillars shall be saw marks, corresponding marks on the running rails shall be paint marks on the non-gauge face of the rail. In no case, a saw mark shall be made on the running rail. Reference marks are required to be fixed immediately after destressing of LWR/CWR and shall to be shifted or tampered with thereafter. Additional reference marks in fixed portion and breathing length may be provided to know the behavior of LWR/CWR.

Table 7.11 *Extension Table (Para ref. 716(4))*

Extensions in mm, based on formula e = Lα (t_o - t_p)														
(°C)	--------------------------------- L in meters -----------------------------------													
(t_o-t_p)	10	20	30	40	50	60	70	80	90	100	200	300	400	500
1	-	-	-	-	1	1	1	1	1	1	2	3	5	6
2	-	-	1	1	1	1	2	2	2	2	5	7	9	11
3	-	1	1	1	2	2	2	3	3	3	7	10	14	17
4	-	1	1	2	2	3	3	4	4	5	9	14	18	23
5	1	1	1	2	3	3	4	5	5	6	11	17	23	29
6	1	1	2	3	3	4	5	6	6	7	13	21	28	34
7	1	2	2	3	4	5	6	6	7	8	16	24	32	40
8	1	2	3	4	5	6	6	7	8	9	18	28	37	46
9	1	2	3	4	5	6	7	8	9	10	21	31	41	52
10	1	2	3	4	6	7	8	9	10	11	23	35	48	57

11	1	3	4	5	6	7	9	10	11	13	25	38	50	63
12	1	3	4	5	7	8	9	11	12	14	28	41	55	69
13	1	3	4	6	7	9	10	12	13	15	30	45	60	75
14	2	3	5	6	8	10	11	13	14	16	32	48	64	80
15	2	3	5	7	9	10	12	14	16	17	34	52	69	86
16	2	4	6	7	9	11	13	15	17	18	37	55	74	92
17	2	4	6	8	10	12	14	16	18	19	39	59	78	98
18	2	4	6	8	10	12	14	17	19	21	41	62	83	103
19	2	4	6	9	11	13	15	18	20	22	44	66	87	109
20	2	5	7	9	11	14	16	18	21	23	46	69	92	115
21	2	5	8	10	12	14	17	19	22	24	48	73	97	121
22	3	5	8	10	13	15	18	20	23	25	51	76	101	126
23	3	5	8	11	13	16	19	21	24	26	53	79	106	132
24	3	6	8	11	14	17	20	22	25	28	55	83	110	138
25	3	6	9	12	14	17	20	23	26	29	57	86	115	144
26	3	6	9	12	15	18	21	24	27	30	60	90	120	149
27	3	6	9	12	16	19	22	25	28	31	62	93	124	155
28	3	6	10	13	16	19	23	26	29	32	64	96	129	161
29	3	7	10	13	17	20	23	27	30	33	67	100	133	167
30	3	7	10	14	17	21	25	28	31	34	69	103	138	172

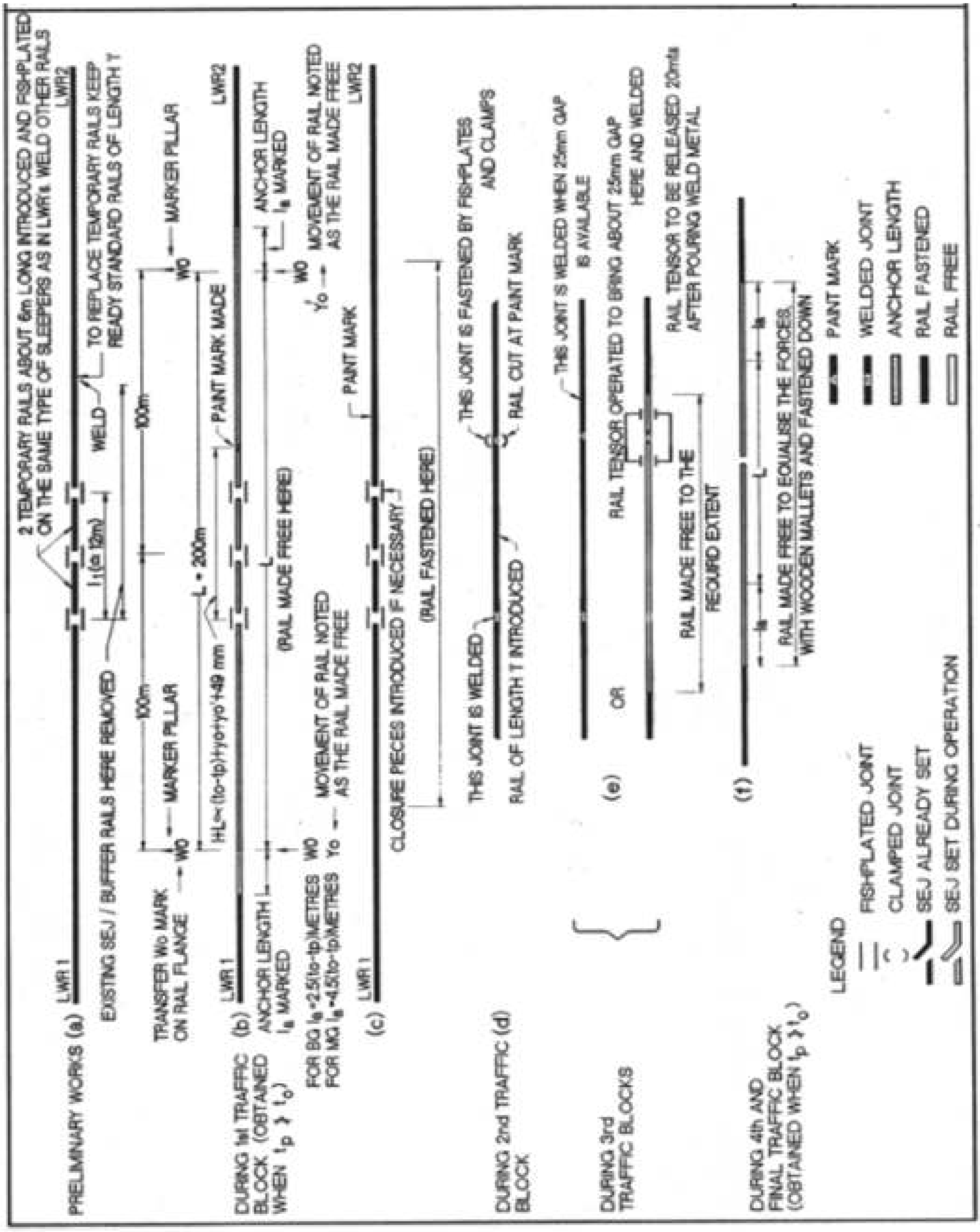


Fig. 7.32 *Joining LWR to form CWR*

719. Maintenance of LWR/CWR

(1) Pre-requisites of LWR:

An important prerequisite for proper functioning of LWR/CWR is its initial laying to a high standard and its subsequent maintenance by trained personnel possessing valid competency certificates and level of authorization not lower than what is laid down in the LWR manual.

The satisfactory behavior/ functioning of LWR largely depends upon

(i) The condition & performance of elastic fastenings,

(ii) availability of well consolidated & compacted ballast as per laid down ballast profile,

(iii) lifting / aligning /opening of track within permissible limits as laid down in the manual,

(iv) adhering to specified temperature limits while carrying out various track maintenance operations.

(v) maintaining metal equalibrium during maintenance operations such as fracture repairs.

(2) Regular Track Maintenance

Regular track maintenance in LWR/CWR includes operations namely

(a) Mechanised track maintenance involving

(i) Tamping/packing

(ii) Lifting of track.

(iii) Shoulder cleaning / shallow screening

(b) Manual maintenance

(c) Casual renewal of sleepers

(d) Renewal of fastenings

(e) Maintenance of buffer rails

(3) General (Temperature limits for working):

The regular track maintenance in LWR/CWR shall be confined to hours when the rail temperature is between t_d +10° C and t_d - 30°C and shall be completed well before onset of summer. After the maintenance operation if rail temperature exceeds t_d +20°C during the period of consolidation, then following action shall be taken

(a) BG Concrete sleeper track: on BG PRC sleeper track the speed restriction of 50 km/h shall be imposed, till the period of consolidation is over. The period of consolidation for BG PRC sleeper track is taken as passage of at least 50,000 gross tonnes of traffic or 2 days whichever later OR one round of DTS or 3 round of packing, last 2 of which are on track machine tamping.

(b) Other than BG concrete sleeper track: The speed restriction shall be imposed as under till the period of consolidation is over, in addition to posting a mobile watchman

Status of shoulder & crib compaction → Type of track structure ↓	When shoulder & crib compaction has been done	When shoulder & crib compaction has not been done
BG with other than concrete sleeper	50 Km/h	30 Km/h
MG with other than concrete sleeper	40 Km/h	20 Km/h
MG with concrete sleeper	40 Km/h, but no mobile watchman is required	

The period of consolidation for other than BG concrete sleeper track is already specified under *Para 710 (18).*

(4) Important precautions specific to particular operation:

In addition to *subpara 3* above, the important precautions which are required to observed during regular track maintenance operations are given here under, each activity wise:

(a) Mechanised Maintenance

(i) Maintenance tamping:

Tamping in LWR/CWR on concrete sleeper track shall be done with general lift not exceeding 50 mm including correction of alignment; In case of sleepers other than concrete sleepers the general lift shall be restricted to 25 mm.

(ii) Lifting of track:

Lifting on concrete sleeper track where needed, in excess of general lift of 50 mm & 25 mm in other sleepers, shall be carried out in stages with adequate time gap in between successive stages such that full consolidation of the previous stage as per Para 710 (18) is achieved prior to taking up the subsequent lift.

(iii) Cleaning of shoulder ballast:

Sufficient quantity of ballast should be made available for recoupment before taking up ballast screening work.

Authorised supervision level: SSE/JE (P. Way).

(b) Manual maintenance

(i) At any time, not more than 30 sleeper spaces in a continuous stretch shall be opened for manual maintenance or shallow screening with at least 30 fully boxed sleeper spaces left in between adjacent openings.

Maintenance of in between lengths shall not be undertaken till passage of traffic for at least 24 hours in case of BG carrying more than 10 GMT & 48 hours in case of other BG routes & MG routes.

(ii) For correction of alignment, the shoulder ballast shall be opened out to the minimum extent necessary and that too, just opposite the sleeper end. The ballast in shoulders shall then be put back before opening out crib ballast for packing.

(iii) In exceptional circumstances when more than 30 sleeper spaces have to be opened for any specific work, like through screening of ballast etc. during the period of the year when minimum daily rail temperature is not below t_d - 30°C or maximum does not go beyond t_d + 10°C, up to 100 sleeper spaces may be opened under the direct supervision of JE/SSE (P. Way). It should however, be ensured that rail to sleeper fastenings on the entire length of LWR are functioning satisfactorily and SEJs do not indicate any unusual behavior.

Authorised supervision level: Gang mate for manual maintenance involving up-to opening of 30 sleepers & JE/SSE (P. Way). for opening of more than 30 sleepers but up to 100 sleepers.

(c) Casual renewal of sleepers

Not more than one sleeper in 30 consecutive sleepers shall be replaced at a time. Should it be necessary to renew two or more consecutive sleepers in the same length, they may be renewed one at a time after packing the sleepers renewed earlier.

Authorised supervision level: Single isolated sleeper not requiring lifting or slewing of track - Gang mate (Track maintainer I).

Casual renewal of sleepers & fastenings over long stretches - JE/SSE (P.Way)

(d) Renewal of fastenings

Renewal of fastenings shall be done with following additional precautions

(i) Renewal of fastenings not requiring lifting:

Fastenings not requiring lifting of rails shall be renewed on not more than one sleeper at a time. In case fastenings of more than one sleeper is required to be renewed at a time, then at least 15 sleepers in between shall be kept intact.

Authorised supervision level: Key man.

(ii) Renewal of fastenings requiring lifting:

Fastenings requiring lifting of rails i.e. grooved rubber pads, etc. shall be renewed on not more than one sleeper at a time. In case fastenings of more than one sleeper is required to be renewed at a time, then at least 30 sleepers in between shall be kept intact

Authorised supervision level: Gang mate.

(e) Maintenance of SEJs/buffer rails

(i) Once in a fortnight SEJs shall be checked, packed and aligned if necessary. Oiling and greasing of tongue and stock rails of SEJ and tightening of fastenings shall be done simultaneously. Movement / Gap of SEJs shall be checked and action taken for destressing if necessary as per *Para 716.*

(ii) During his daily patrolling, Key man shall keep special watch on the SEJs falling in his beat.

(5) General precautions:

In addition to *subpara 3 & 4* above, the general precautions required to be taken, in the regular track maintenance operations are:

(a) Ballast section shall be properly maintained, especially on pedestrian & cattle crossings, curves and approaches to level crossings and bridges. Cess level should be correctly maintained. Dwarf walls may be provided on pedestrian and cattle crossings to prevent loss of ballast.

Replenishment of ballast shall be completed before onset of summer. Shortage of ballast in the shoulder at isolated places shall be made up by the Gang mate by taking out minimum quantity of ballast from the centre of the track between the two rails over a width not exceeding 600 mm and a depth not exceeding 100 mm on BG.

On MG the above dimensions are, width not exceeding 350 mm and depth not exceeding 75 mm.

(b) Sufficient quantity of ballast shall be collected to provide full ballast section before commencing any maintenance operation, specially lifting.

(c) When crow bars are used for slewing, care shall be taken to apply these in a manner so as to avoid lifting of track. The crow bar should be planted well into the ballast at an angle not more than 30° from the vertical.

(d) Special attention shall be paid to the L.W.R track at following locations

(i) SEJs/ Breathing lengths,

(ii) Approaches of level crossings, points &crossings and un ballasted deck bridges

(iii) Horizontal and vertical curves

(e) All fastenings shall be complete and well secured

(6) Renewal of Defective Rails/Welds

The procedure laid down in *Para 720 (2)* (Rectification of rail fractures) for repairs to track after rail fracture, shall be followed.

(7) Special Track Maintenance

(a) Through fittings renewal

Whenever it is decided to carry out through renewal of fittings so as to ensure proper functioning of LWR, the LWR shall be destressed along with the through fittings renewal. TFR is to be done under personal supervision of JE/SSE (P. Way).

(b) Deep screening/mechanised cleaning of ballast

(i) Provisions contained in chapter 10 will also apply to LWR/CWR (once the necessary changes have been made) with further provisions as mentioned hereunder in this Para.

(ii) Ballast Cleaning Machine (BCM), tamping machine and Dynamic Track Stabilizer (DTS) shall, as far as possible, be deployed in one consist.

(iii) Temperature records of the sections where deep screening is to be undertaken, shall be studied for the previous and the current year. The maximum and minimum rail temperature attainable during the period of deep screening and during the period of consolidation shall be estimated. Any of the following three options may be available for carrying out the work of deep screening/mechanised cleaning:-

Option 1 :- If range of rail temperature falls within t_d + 10°C to t_d - 20° C, deep screening may be done without cutting or temporary destressing.

Option 2 :- If range of rail temperature falls outside (t_d + 10°) to (t_d - 20° C) then above, temporary destressing shall be carried out 10°C below the maximum rail temperature likely to be attained during the period of work.

OR

Option 3 :- Wherever rail renewals are being carried out, LWR/CWR may be converted into three rail panels and deep screening done.

CWR shall be cut into LWRs of about 1 km length with two temporary buffer rails of 6.5 meter long, clamped with 1 meter long fishplates with special screw clamps/joggled fish plates having slotted grooves & bolted clamps as per arrangement shown in *Fig. 7.18,7.19 & 7.20* with speed restrictions of 30 Km/h and watch round the clock. When other clamps are used at a temporary rail joint, speed restriction of 20 Km/h shall be imposed Fish-bolt holes if any, shall be chamfered.

(iv) Constant monitoring of rail temperature shall be done during the progress of work. Should the temperature rise more than 10°C above temporary destressing temperature, adequate precautions shall be taken including another round of temporary destressing.

Note: Deep screening shall be undertaken within 15 days of temporary destressing failing which temporary destressing may become due again, if the rail temperature varies appreciably.

(v) During the period of deep screening, if there is any possibility of minimum temperature falling 30°C below t_d temporary destressing temperature, cold weather patrol as per *Para 721 (2)* should be introduced to detect & guard against rail fractures.

vi) Sequence of operation: -

a) Deep screening of LWR may be done from one end of LWR to other end.

b) After deep screening and consolidation as per *Para 710 (18),* destressing of LWR within normal td range shall be undertaken as per *para 716* (Destressing of LWR).

Note: The period of consolidation for BG concrete sleeper track is taken as passage of 50,000 tonnes of traffic or 2 days whichever later or one round of DTS or 3 round of packing, last two of which should be with on track tamping machines.

(8) Other special maintenance

(a) Other types of special track maintenance constitute jobs like lowering of track, major realignment of curves, renewal of large number of sleepers or rehabilitation of formation bridges causing disturbance to track. For carrying out such maintenance, the affected length of track may be isolated from LWR/CWR by introducing SEJs or buffer rails as needed.

(b) Temperature records of the section shall be studied and action taken in accordance with *sub para 719 (7) (b) (iii),* i.e. If range of rail temperature falls within t_d +10°C to t_d - 20° C, special track maintenance activity may be done without cutting LWR or temporary destressing and If range of rail temperature falls outside t_d +10°C to t_d - 20°C , temporary destressing shall be carried out 10°C below the maximum rail temperature likely to be attained during the period of work or by cutting LWR into 3 rail points.

(c) After completion of work, the affected length of track shall be destressed at the appropriate destressing temperature as per *Para 716* (Destressing of LWR) and joined with rest of the LWR/CWR in accordance with *Para 717* (Joining of LWRs into CWR).

(9) Special Equipment for Maintenance of LWR/CWR

Staff responsible for maintenance of LWR/CWR shall be trained in using and equipped with additional equipment detailed below:-

(a) Additional equipment with the Gangs

(i) A pair of joggled fishplates with bolted clamps *(Fig. 7.20)*

(ii) Rail thermometer with markings for temperature ranges for maintenance

(iii) Special 1 metre long fishplates with screw clamps *(Fig.7.18 & 7.19)*

(iv) Rail closure pieces.

(b) Additional Equipment with JE/SSE (P. Way).

Equipments listed under *Para715 (3)* (Materials required) should be available with JE/SSE (P. Way).

720. Unusual Occurrences

(1) List of Unusual Occurrences

Unusual occurrences in LWR / CWR comprise of the following:

(a) Rail fractures or replacement of defective rail/ glued joint

(b) Damage to SEJ/buffer rails

(c) Buckling or tendency towards buckling

(d) Accidents, breaches, insertion of temporary girders & diversion etc.

(2) Rectification of Rail Fractures

(a) Equipment required

(i) Special 1 metre long fishplates with screw clamps and joggled fishplates with bolted clamps (for fractures at welded joints) as per arrangement shown in *(Fig. 7.18,7.19 & 7.20)*

(ii) Steel tape capable of reading up to one mm

(iii) Alumino-Thermic welding and finishing equipment

(iv) Equipment for destressing

(v) 6.5 metre long sawn rail cut piece of the same section as LWR duly tested by USFD

(vi) Rail closures of suitable lengths

(vii) Equipment for protection of track

(viii) Equipment for night working

(b) Procedure for repairs *(please ref. fig. 7.33)*

If any fracture takes place on LWR/CWR, immediate action shall be taken by the official who detected the fracture to suspend the traffic and to protect the line. He shall report the fracture to the Gang mate / Keyman/ JE/SSE (P.Way), who shall arrange for making emergency repairs to pass the traffic immediately. Repairs shall be carried out in four stages as described below:-

(i) Emergency repairs

(ii) Temporary repairs

(iii) Permanent repairs

(iv) Destressing.

(c) Emergency repairs (to facilitate passage of traffic)

The fractured rails shall be joined by using the arrangements shown in *(Fig.7.18, 7.19 & 7.20)* i.e. 1 m long fishplate or joggled fishplate etc. If the gap at fracture does not exceed 30 mm, insertion of any closure rail piece is not necessary. The traffic may then be resumed at a speed of stop dead and 10 kmph for the first train and 20 kmph for subsequent trains.

The minimum authorized personnel to allow traffic after emergency repairs is Keyman /Gang man.

(d) Temporary repairs (Insertion of closure rail of min. 4 m length)

If a welding party is not readily available, the fracture shall be repaired by using a cut rail (not less than 4 metre long) and clamped/bolted as per arrangement shown in *(Fig.7.18, 7.19 & 7.20).*

(i) A traffic block shall be taken as soon as possible preferably when the rail temperature is within the range specified for td in *Para710 (11).*

(ii) Two points on either side of the fracture shall be marked on the rail such that the length of closure rail (not less than 4 meter) to be inserted is equal to the total length of the rail pieces removed from the track minus allowances for two welds and saw cut (normally 51 mm). See *Fig. 7.33.*

In this case the inserted length of closure satisfy material equilibrium of LWR i.e. Rail length removed from the track + 2 saw cut = Rail closure inserted in track + 2 weld length inserted in the track, accordingly

The length of inserted rail closure + 2 x welds – 2 saw cuts =Length of rail pieces removed from LWR

→ Length of inserted closure = length of rail pieces removed from track + 2 saw cuts – 2 x weld length

→Length of rail pieces removed from track - 51 mm.

In case closure rail length is inserted based on above, one of the joints may have to be provided with closure piece of adequate width and joined by one meter fish plate and clamps.

(iii) Alternately two points on either side of the fracture shall be marked on the rail at a distance equal to the length of the available closure rail. The length of closure rail should not become less than 4 meter at the time of permanent repairs. See *(Fig. 7.33.)*

In this case the length of inserted closure rail is more than required by an amount equal to gap caused by the fracture; this additional length is to be cut during permanent repairs.

(iv) The traffic will be allowed after temporary repairs at 30 km/h provided 1 m long fishplate with special clamps has been provided, using the arrangements shown in *Fig.7.18, 7.19 & 7.20* with 24 hours watch on the rail joint, in all other cases permitted speed shall be 20 kmph.

The minimum authorized personnel to allow traffic after temporary repairs is PWM / (JE/ P.Way)

(e) Permanent Repairs (welding of joints after pulling by tensor to ensure insertion of appropriate closure length)

(i) If the fracture is such that, wide gap AT welding can be adopted, then the total length of fractured ends to be cut shall be equal to the gap required for wide gap welding. Once the two ends are cut, a gap required for wide gap welding will be created by using rail tensors and joint welded by wide gap AT welding technique.

(ii) In case rail closure as per *sub para (d)(ii) above* has been provided for temporary repairs, one joint of the closure rail shall be welded without rail tensor after setting correct gap for welding. However, to ensure correct gap during welding of the other joint, tensor shall be used.

(iii) In case rail closure as per *sub para (d)(iii) above* has been provided at the time of temporary repairs, the rail closure shall be suitably cut such that the length of the rail to be finally inserted in track is equal to length of rail removed from track after fracture minus allowances for two welds i.e. 50 mm. Once the closure rail is cut, the closure rail will be welded as given in *(Para (ii))* above.

iv) After welding of joints, a length of track equal to breathing length or about 125 meters on either side be unfastened and tapped to ensure equalisation of stress and then refastened.

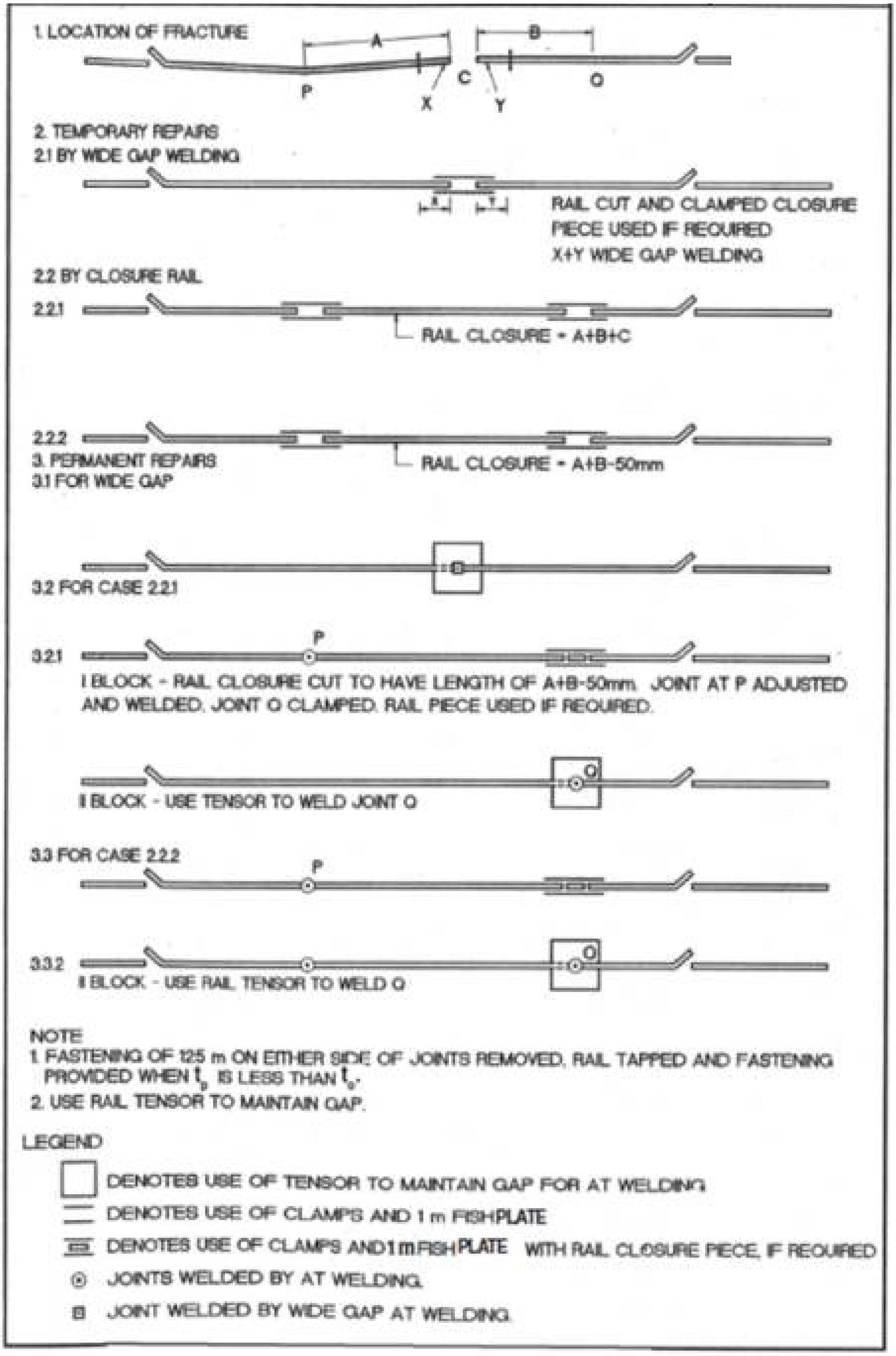


Fig.7.33 *Temporary and permanent repairs of rail fracture with the use of rail tensor.*

(3) Damage to Switch Expansion Joint

(a) The damaged/broken SEJ shall be replaced. The new SEJ shall be adjusted as per *(Para 715 (6) (a))* (Gaps at SEJ). Traffic may be allowed if necessary at a restricted speed and thereafter restriction relaxed progressively.

(b) If another SEJ is not available for replacement, both the damaged SEJ and the undamaged SEJ on the opposite rail at the same location, shall be replaced by a closure rail and connected to LWR/CWR by using the arrangements shown in *Fig. 7.18, 7.19 & 7.20 i* .e. 1 m long fish plate or joggled fish plate etc. with speed restrictions of 30 Km/h and 24 Hrs. Watch. When other clamps are used, speed restriction of 20 Km/h shall be imposed Fish-bolt holes if any, shall be chamfered. The restriction may be relaxed only after the new SEJ has been inserted in the correct position and the clamped joint has been replaced with in-situ weld.

(4) Buckling of Track

(a) General

Buckling or a tendency towards buckling may occur, among others, in the following circumstances:-

(i) Failure to adhere to the temperature ranges specified for operation on LWR/CWR

(ii) Inadequate resistance to longitudinal, lateral and vertical movement of track due to deficiencies in ballast section or/and inadequate ballast consolidation

(iii) Use of ineffective fastenings or missing fastenings resulting in loss of creep resistance and torsional resistance

(iv) Excessive settlement of formation

(v) Improper functioning of SEJ.

(b) Buckling & investigation

(i) Tendency towards buckling will usually manifest itself through kinks in track. Kinks may also arise from incorrect slewing or lifting operations. By tapping sleepers for hollowness, it may be possible to notice if there is any tendency towards vertical buckling.

(ii) As soon as the tendency for buckling is detected, the traffic shall be suspended and the track protected. The track shall then be stabilised by heaping ballast on the shoulders up to the top of the web of the rail obtaining the ballast from inter sleeper spaces between the rails. Thereafter full investigation shall be made to find out the cause of the tendency for buckling.

(iii) Each case or buckling shall be investigated by AEN soon after its occurrence and a detailed report submitted to DEN/Sr. DEN.

(c) Repairs to buckled track

(i) When the track actually buckles, the traffic shall be suspended and the cause of buckling ascertained. The position of tongue and stock rails of the SEJ shall be checked. The methods for rectification are explained below.

(ii) The rectification shall normally be carried out in the following stages under the supervision of JE/SSE (P. Way):-

- Emergency repairs
- Permanent repairs
- Destressing.

(d) Emergency repairs

The buckled rails shall preferably be gas cut adequately apart not less than 6.5 meter. The track shall then be slewed to the correct alignment and cut rails of the required lengths shall be inserted to close the gaps making due provision for welding of joints on both sides. The cut rails shall then be connected by use of special fish plates and screw clamps as shown in *(Fig.7.18, 7.19 & 7.20).* The traffic may then be resumed at a speed of stop dead and 10 kmph for the first train and 20 km/h for subsequent trains.

The minimum authorized personnel to allow traffic after emergency repairs is JE/SSE (P. Way)

(e) Permanent repairs

(i) As soon as possible the clamped joints shall be welded adopting the same procedure as followed for temporary repairs & permanent repairs in case of rail fracture. Additional pair of cut rails and rail cutting equipment shall also be required to adjust the gaps in case they have been disturbed in the intervening period.

The traffic will be allowed after temporary repairs at 30 km/h, provided 1 m long fishplate with special clamps has been provided, using the arrangements shown in *(Fig.7.18,7.19 & 7.20)* with 24 hrs watch on the rail joint. In all other cases permitted speed shall be 20 kmph. The minimum authorized personnel to allow traffic after emergency repairs is JE/SSE (P. Way).

The speed restriction shall be removed after welding, carried out by taking up permanent repairs as outlined under *sub para (2) (e) above.* The minimum authorized personnel to allow traffic at normal sectional speed after permanent repairs is JE/SSE (P. Way).

The entire panel shall be destressed as soon as possible as per *Para 716.*

(5) Accidents, Breaches, Insertion of Temporary Girders and Diversions

(a) The affected portion shall be isolated by insertion of SEJs preferably within the temperature range specified for td in Para *710 (ii)* The track thus isolated shall be replaced by fish plated track which shall be box anchored, if necessary.

(b) In the breached sections where the new banks are constructed, the formation shall be fully consolidated before laying LWR/CWR again.

(c) In case of diversions and insertion of temporary girders, SEJ shall be inserted to isolate the portion where such work is required to be done.

(d) LWR/CWR panels in the affected portion shall be destressed immediately after the LWR/CWR is restored.

721. Patrolling and Mobile Watchman

(1) Hot Weather Patrolling

(a) The period for hot weather patrolling shall be laid down by the Chief Engineer for each section and patrol charts prepared where necessary. Patrolling shall be organised by JE/SSE (P. Way) accordingly. In addition, the JE/SSE (P. Way) and the Gang mate shall be vigilant during summer and on hot days. The patrolling will also be introduced by Gang mate, when the rail temperature rises above t_d + 25°C for concrete sleeper track with sleeper density 1540 Nos. per km and above. In all other cases it shall be introduced when rail temperature exceeds t_d + 20°C.

(b) Hot weather patrolling will be carried out as follows:-

(i) On single line or where only one road in a double line section is having LWR/CWR - One patrolman for 2 km.

(ii) On double line section when LWR/CWR exist on both roads One patrolman for 1 km length of UP and DN road. The beats of each hot weather patrolman will thus be restricted to 2 km.

(c) The hot weather patrolman should always carry the following equipments:-

(i)	HS Flag/ Red	-	2 Nos.
(ii)	Staff for flags	-	1 No.
(iii)	Detonators	-	10 Nos.
(iv)	Canne-a- boule	-	1 No.

(d) Duties of hot weather patrolman are as follows:-

(i) He will walk over his beat slowly over one rail in one direction and on the other rail in the return direction. On double lines, he will repeat this procedure alternately on UP and DN tracks. He will be vigilant and look out for kinks in the rail especially during the hottest part of the days.

When a kink is observed, he shall immediately examine at least 100 sleepers ahead and in the rear of the kink for any floating condition of track. He should meticulously sound each and every sleeper, 100 sleepers on either side of the kink, to determine any floating condition. The sounding will be done by dropping a canne-a-boule on each end of the sleeper to determine the extent of void under the sleeper.

Should the sounding reveal a floating condition, under which a buckle may be anticipated or the patrolman has detected actual buckling of track, he will take immediate steps to protect the affected portion by display of hand signals as per rules in force. After protecting the track, the patrolman will arrange to advise the Gang-mate and JE/SSE (P. Way) of his apprehension of a buckle/actual buckle.

(ii) The Gang-mate on receipt of advice of a danger of buckle will proceed to the site quickly with all available men. On arrival at site, he will first ensure protection of affected portion. He should then inspect the condition of track 100 m on either side of this suspected zone and commence heaping of surplus ballast, if available, on the shoulders and up-to the rail head and keep on compacting the ballast with available tool. No attempt should be made to slew or align the track or disturb the existing ballast section. The mate should continue to remain at site till the arrival of JE/SSE (P. Way). The rail temperature will also be noted by one of these officials at the place of apprehended/ actual buckle. The rail facing the sun will be covered up to the level of rail head on the outside by ballast or leaves etc. to bring down the temperature of the rail.

(2) Cold Weather Patrolling

(a) The cold weather patrolling shall be introduced when rail temperature is less than td - 30°C. Period and section where cold weather patrolling is to be done shall be laid down by the Chief Engineer and patrol charts prepared where necessary. Patrolling shall be organised by SSE/JE/ P. Way accordingly. Following guidelines may be followed for issuing detailed guidelines by the Chief Engineer.

(b) Cold weather patrolling shall be carried out as follows:

(i) On single line or where only one road in a double section is having LWR/CWR - One patrolman for two kilometer.

(ii) On double line section when LWR/CWR rest on both road - One patrolman for one kilometer length of UP and DN road.

(iii) Changes in beat length and man power deployment as given above if found necessary, may be decided by the Chief Engineer depending on prevailing local conditions, frequency of train service, weather conditions etc.

(c) The cold weather patrolman should carry the following equipments: -

(i) 10 fog signals in a tin case

(ii) Two tri-colour hand signal lamps

(iii) One match box

(iv) Two red flags and one green flag

(v) One three-cell electric torch

(vi) One staff

(vii) Number plate

(d) Duties of cold weather patrolman are as follows:- He will walk over his beat slowly along one rail in one direction and on the other rail in the return direction. On double line, he will repeat this procedure alternately on UP and ON tracks. He will be vigilant and look out for rail/weld failure. He will also notice the gaps at SEJs if they fall in his beat. In case he notices a rail/weld failure or gap at SEJ becomes more than the designed maximum gap, he will take immediate action tosuspend the traffic and protect the line. After protecting the track the patrolman will arrange to report to Key man/ Gang mate JE/SSE (P. Way) who shall arrange for making emergency repairs to pass the traffic immediately.

(3) Mobile Watchman

(a) Mobile watchman shall be posted by Gang mate or higher official, on stretches where after maintenance operation, rail temperature has exceeded t_d +20°C during the period of consolidation as given in *Para 710 (18)* They would be withdrawn when the period of consolidation is over and the track behaves satisfactorily.

The period of consolidation for BG concrete sleeper track is taken as passage of 50,000 tons of traffic or 2 days whichever later OR one round of DTS OR 3 round of packing, last 2 of which are on track machine tamping.

(b) Number of Mobile watchman required to be posted would depend upon the length of track attended by manual or by tampers. Normally one Mobile watchman would be sufficient for one kilometer of track.

(c) Mobile watchman will be provided with all equipments depending upon the purpose of patrolling.

(d) Duties of Mobile watchman:-

(i) Mobile watchman posted on these sites would patrol the section, which has been freshly packed and for which period of consolidation is not over. He shall be vigilant and will look out for incipient buckles and kinks in the rails. He will also observe for rail/weld failures and gaps at SEJs.

(ii) When a kink is observed, he will take action as specified in *sub para (1) (d) above.*

(iii) If a rail/weld failure is observed or gaps at SEJs become more than the designed maximum gap of the SEJ, action as specified in *sub para (2) (d) above* will be taken.

Note: Hot and Cold Weather Patrolmen should be aware of their duties and should be drawn, as far as possible, from Gangs.

722. Inspection and Records

(1) Inspection:- While requiring less maintenance, LWR/CWR necessitate intensive inspection at supervisory and officer's level.

(a) The profile of the ballast section shall always be as shown in *Fig 7.14 (a) & (b)* This should be checked, especially at pedestrian/cattle crossings, curves, approaches of level crossings, points and crossings and bridges. Cess level should be correctly maintained. Replenishment of ballast shall be completed before the onset of summer.

(b) Inspection shall be more frequent in the afternoons during summer months. During inspections, look out shall be kept for kinks, incipient buckles and checks made on functioning of the patrols.

(c) Knowledge of staff in regard to prescribed maintenance practices shall be periodically checked and it shall be ensured that the work is done accordingly.

(d) Ultrasonic examination of rails should not be in arrears. Defective rails/welds should be replaced expeditiously.

(e) Inspections of gaps at SEJ and creep/movement at centre of LWR/CWR by Permanent Way officials would be done as per following schedule:-

(i) Once in fortnight during two coldest and two hottest months of the year at about minimum and maximum temperatures otherwise once in two months by rotation with SSE (P. Way).

SE (P. Way) - Once in fortnight during two coldest and two hottest months of the year at about minimum and maximum temperatures otherwise once in two months by rotation with JE (P.Way).

(ii) Assistant Engineer:- At least once in six months, preferably during coldest and hottest months

(2) Records

(a) Record of LWR/CWR, as per the proforma given in *Para 722 (2) (f)*, shall be maintained by the PWI in a permanent register called the Sectional LWR/CWR Register. The PWI shall be responsible for keeping this register up-to-date. .

(b) An indication plate similar to that suggested in *Chapter 1 (Para 104)* shall be fixed on the Cess at each SEJ showing the date of destressing, destressing temperature t_d /t_o and length of LWR/CWR.

(c) Observations of gaps at SEJ and creep/movement in fixed portion of

LWR/CWR shall be measured by the SSE or JE/P. Way/ADEN in proforma shown in A*nnexure 7/1 to 7/7* and feed into TMS.

(d) When creep in fixed portion of LWR/CWR exceeds 20 mm, full investigation shall be carried out and remedial measures undertaken.

(e) ADEN will analyse the observation of each LWR/CWR in his jurisdiction and give a certificate at the end of LWR/CWR register before onset of summer regarding satisfactory behavior of all LWR/CWRs. DEN/Sr.DEN will scrutinise observations of each LWR/CWR, initial each page and exception report to be submitted to Chief Track Engineer only when his orders are required.

(f) Proforma for various Records *(Para 722 (2) (a))*

(i) Sectional LWR/CWR Register

723. Duties, Responsibilities & Training of Staff

(1) Duties and Responsibilities: - The following are the special duties and responsibilities with reference to LWR/CWR:-

(a) SSE/SE/JE/P. Way (In charge of Section/Sub-section)

(i) They shall be in possession of Manual of Instructions on LWR/CWR posted up-to-date at all times. They shall have a thorough knowledge of important pre-requisites for proper functioning of LWR/CWR and the limitations and precautions laid down for work on LWR/CWR. They shall ensure that the maintenance instructions are strictly followed by all the staff under him dealing with maintenance of LWR/CWR.

(ii) They shall supervise all track maintenance work as shown below.

SN	Type of work	Work
1	Maintenance operation	Mechanised Tamping, Lifting (general Lift) Alignment, Minor alignment of curves, deep screening
		Lifting, aligning, packing etc., in case of emergencies at temperatures higher than those permitted
2	Rails sleepers and fastenings	Carrying out welding of rail joints at site
3	Ballast	Replenishment of ballast & checking ballast section before the onset of summer.
4	Curve realignment	Major realignment of curves under special instructions from ADEN
5	Hot weather work	Organising hot weather patrolling during summer months
		Inspection in summer months and checking on the working of hot weather patrols
6	Destressing	All operations regarding destressing
7	Rail fracture	Permanent repairs
8	Buckling	Emergency repairs
		Permanent repairs
9	Emergencies	Action in case of damage to track following derailments, breaches etc.
10	Inspection & checking	Inspection of SEJ

(iii) They shall be responsible:-

(1) For inspection of gaps at SEJ and creep/movement at centre of LWR/ CWR as per *Para 722 (2) (f)* and recording observations of each LWR/CWR register.

(2) For making arrangements for patrolling of track in hot and cold weather and post mobile watchmen as and when required. They will ensure that patrolmen and mobile watchmen are issued proper equipments for carrying out patrolling.

(3) For repairs and restoration of traffic in case of accident, derailment, buckling, breaches, rail fracture etc.

(4) For carrying out destressing, welding and other maintenance operation correctly and complete them within the block period for which block has been taken.

iv) They shall inspect LWR/CWR under their jurisdiction frequently, especially during the hottest part of afternoons in summer to look out for unusual features, tendency towards buckling and check patrolling.

(v) They shall ensure that all maintenance staff under them is fully aware of their duties and responsibilities at all time with regard to maintenance of LWR/CWR.

(vi) They shall always carry during their inspection a pair of joggled fishplates, clamps, rail thermometer, feeler gauges and one meter straight edge.

(vii) They shall record rail temperatures, destressing temperature, minimum &maximum rail temperatures and also periodically check the rail thermometers used for recording rail temperature with reference to standard thermometer.

(viii) They shall carry out all operations of maintenance under their personal supervision, in case Permanent Way Mistry/Gang mate possessing valid competency certificate is not present.

(ix) They shall impose necessary speed restriction, in case the temperature exceeds td +20°C after the maintenance work has been completed on LWRI CWR for the period of consolidation.

(x) They shall ensure proper maintenance of the ballast section of the track and shall arrange to complete replacement of ballast before the onset of summer.

(b) Senior Section Engineer/P. Way (In charge of Section)

SSE/P. Way Incharge of section will be responsible for following additional duties, apart from the duties as mentioned in *Para 723 (1) (a)*:

(i) He shall be responsible for the procurement of the permanent way materials and the equipment required for the maintenance of LWR/ CWR for all the staff working under him. He shall ensure that the materials are properly distributed and kept in good order and shall recoup the materials well in time.

(ii) He shall maintain a permanent record of each LWR/CWR as per the proforma laid down in *Para 722 (2) (f)* in a register.. He shall be responsible for keeping this register up-to-date and the same shall be handed over by him to his successor.

(c) SSE/SE/JE/P. Way (Special/Relaying)

When SSE/SE/JE/P. Way(Special/Relaying) is posted for carrying out special works etc. he shall be responsible for all the items indicated in *Para 723 (1) (a) & (b)* apart from other responsibilities assigned to him.

(d) Assistant Divisional Engineer

(i) He shall inspect all SEJs and movement at centre of LWR/CWR at every six months preferably during coldest and hottest months and record his observation in the LWR/CWR register.

ii) He will scrutinise/analyse LWR I CWR register to investigate the easons of unsatisfactory performance of LWR/CWR and shall give directions to his staff to take remedial action, if any.

(iii) He shall bring to the notice of the DEN/ Sr.DEN any work pertaining to LWR/CWR, which is beyond his capacity to deal with and any ther item which he considers necessary for safe functioning of LWR/CWR.

(iv) He shall ensure that the staff working under him is fully conversant with their respective responsibilities in regard to laying and maintenance of LWR/CWR.

(v) He shall ensure that all remedial action for LWR/CWR showing unsatisfactory behavior are taken in time.

(vi) He shall give certificate that all the LWR/CWR in his jurisdiction are behaving satisfactorily. He would arrange to send the LWR/CWR register for scrutiny of DEN/Sr.DEN once in a year before summer.

(e) Divisional Engineer/Senior Divisional Engineer

(i) He shall be responsible for ensuring that AENs and supervisors working under him are fully conversant and comply with provisions in this manual and such other supplementary instructions issued by Principal Chief Engineer from time to time.

(ii) He shall ensure that proper arrangements are made for training of staff working on LWR/CWR sections and posts for LWR/CWR sections are manned by qualified staff at all times.

(iii) He shall make arrangements for sufficient quantity of ballast required for LWR / CWR sections.

(iv) He shall scrutinise LWR/CWR registers of his jurisdiction every year in the month of February and record his certificate about satisfactory behavior of LWR/CWR in his jurisdiction. He shall refer the details of all LWR/CWR to Chief Track Engineer where he requires his orders/decision.

(v) He shall specify the coldest and hottest months in which fortnightly observations of gaps at SEJs and movement of LWR/CWR in fixed portion are done.

(2) Training

(a) Arrangements for training of all Permanent Way Staff working on LWR/CWR sections shall be made by Chief Engineer by holding special/regular courses in Zonal Training centers and by Sr. DEN/DEN in Divisional Training Centers.

(b) Keyman, Gang-mate, PWM, SSE/SE/JE/P. Way (Incharge of section/Sub- section)

Only staff trained in laying and maintenance of LWR/CWR shall be posted on LWR/CWR sections. In case of Keyman, Gang-mate & PWM only such staff who possess valid competency certificate issued by Zonal/Divisional training centre shall be posted on LWR/CWR section.

(c) The competency certificate shall be valid for three years from the date of issue.

(3) "DO's"AND "DON'T

For the guidance of Keyman, Gang-mate and PWM important do's and on'ts have been listed as under

(a) DO's of LWR for PWM, Gangmates & Keyman

(i) Check and carry LWR/CWR equipment daily. Each Gang-mate, JE/P. Way should keep two sets of joggled fishplates, 2 clamps, one rail thermometer, special 1 m long fishplates, rail closure pieces, one straight edge and one feeler-gauge. The thermometer should be regularly checked with that of standard thermometer kept in SSE/P. Way's office.

(ii) Know the td of your section/panels.

(iii) Keep the ballast section full and in compacted condition particularly in cribs and shoulders. Deficiency in ballast shall be brought to the notice of JE/P. Way.

(iv) Keep close watch on pedestrian and cattle crossings, where the ballast is always disturbed. Make up ballast deficiency promptly.

(v) Get your SEJs oiled and greased once in a fortnight.

(vi) Check the gaps of SEJ at extremes of temperatures.

(vii) Train men in detecting buckling, rail fractures etc. and protection of the trains in such cases.

(viii) Keep the patrolling equipments always handy and start patrolling of track as soon as temperature exceeds td + 20°C which is marked on the thermometer in red.

(ix) Commence patrolling as per laid down schedule for the prescribed periods.

(x) Keep sharp look out for severe alignment defects in summer. Protect the trains and report to supervisors.

(xi) Keep the anchors wherever provided always butting against the sleepers.

(xii) Renew fittings only on one sleeper at a time.

(xiii) Ensure that fittings are tightly fitted at proper places at all times.

(xiv) Pack loose sleepers without lifting or opening track in summer

(xv) Attend only one or two sleepers at a time for adjusting fittings while removing a kink.

(xvi) Confine essential maintenance to period when the temperature is below td + 10°C.

(xvii) Impose speed restriction if temperature exceeds td + 20°C during consolidation period.

(xviii) Pay special attention to SEJs, breathing lengths, curves, approaches to level crossings, un ballasted bridges, horizontal and vertical curves.

(xix) Keep the rail thermometer with proper markings with limiting temperature ranges thereon in proper working order. Learn the limits of temperature restrictions as marked on thermometers for various operations.

(xx) Check that reference posts at SEJ and at centre of LWR/CWR are correctly maintained.

(xxi) Learn the six items (i) missing and loose fastenings, (ii) shortage of ballast, (iii) misalignment, (iv) slewing, (v) lifting (vi) improper packing, about which you should be very careful to avoid buckling.

(xxii) Learn what to do when there is buckling or fracture in the track.

(xxiii) Ensure that all bridges and its approaches have all fittings at all times and are regularly tightened.

(b) DON'Ts of LWR for PWM, Gangmates & Keyman

(i) Do not touch the track unnecessarily unless specifically instructed by JE/P. Way.

(ii) Do not undertake through packing after the onset of summer months.

(iii) Do not open shoulder and crib ballast at one and the same time.

(iv) Do not try to lift the track while packing sleepers for replacement of fastenings and slewing with crow bars.

(v) Do not open the track for more than 30 sleepers in a stretch. Keep at least 30 fully boxed sleeper between adjacent lengths opened out.

(vi) Do not open the adjacent length till the passage of 20,000 tonnes of traffic or two days, whichever is later.

(vii) Do not renew more than one sleeper within 30 sleepers at a time.

(viii) Do not renew fastenings not requiring lifting on more than one sleeper within 15 sleepers at a time.

(ix) Do not renew fastenings requiring lifting on more than one sleeper within 30 sleepers at a time.

(x) Do not allow loose, missing or ineffective fastenings to remain in track.

(xi) Do not neglect checking and attending to the breathing lengths of LWR/CWR in a fortnight.

(xii) Do not lift track by more than 50 mm even if temperature is within td.

P.WAY doesn't like biting cold. (Introduce Cold weather patrolling, during cold months of the year in specified sections as per instructions of Chief Engineer when rail temperature drops below t_d-30°C).

Annexure 7/1

PROFORMA FOR GAP SURVEY AND RECTIFICATION OF GAPS

Between stations Nawabpalem and Nidadavole/Down Line.
Between Kms. 551/13 - 551/0.
Rails 52 kgs. on S.T. sleeper M + 7 density.
Mean annual rail temperature tm.
tm .= 38°C Zone II.

S urvey details
Date : 28th February 1981
Time : 12-00 hrs.

Average rail temperature 45°C (tm+7) during gap survey.

Rail temperature —
At start .. 44°C.
At close .. 46°C.

Recommended range of gap for 54 °C. noted at the time of survey as per Table II: 5 to 9 mm.

Adjustment details —
Date: 2nd March 1981. Time: 4-30 hrs. –

Rail temperature —
At start .. 40°C. At close .. 45°C.
Average temperature: 42.5°C.(tm.+4.5°C.)

To be adjusted to the gap as shown in Table I = 4 mm.

Location and description of immovable point	Serial No. of points	Gap in mm.		Action taken with P. W. I.'s initials and date	Adjusted gaps in mm.	
		Left	Right		Left	Right
Girder Bridge at km. 551/13 (first Fixed point).	1	51	11	Gaps systematically adjusted from one end to the other end and by providing a longer rail on 2nd March 1981 and gap adjusted to 4 mm.	4	4
	2	41	9		4	4
	3	17	41		4	4
	4	41	51		4	4
	5	01	51		4	4
	6	51	51		4	4
	7	17	41		4	4
	8	17	12		4	4
	9	51	01		4	4
	01	41	9		4	4
	11	11	6		4	4
	12	8	01		4	4
	13	11	12		4	4
	41	5	9		4	4
	51	13	12		4	4
	16	8	13		4	4
	17	51	51		4	4
	81	12	41		4	4
	91	41	41		4	4
	20	51	41		4	4
	21	13	16		4	4
	22	41	41		4	4
	23	51	17		4	4
Km. 551/0 Level crossing (Second fixed point).	24	81	20			
	25	91	01		4	4
	26	20	20		4	4
	Total ..	359	340		4	4
	Average	13.8	13.1		401	401
		This falls in case II.				

Annexure 7/2

Division :	Sub - division:
PWI :	LWR/CWR No.:

Details of structure of LWR/CWR as laid		
1.	General	
i)	Kilometer	From : to :
ii)	Between Stations	and
iii)	Up/Down/ Single Line	
iv)	Date of laying	
2.	Track structure	
2.1	Rails	
i)	Sectional weight :	
ii)	Rolling Mark :	:
iii)	Year of laying :	
iv)	Length of rails as rolled :	
v)	Plant where rails welded:	
vi)	Types of depot welding – Flash Butt/ Gas pressure	
vii)	Length welded into panels at depot	
viii)	Whether fish bolt holes provided :	Yes/No
ix)	Thermic welding done in-situ/on Cess by ordinary Alumino-thermic process/quick Alumino-thermic process/SKV/FB by Mobile plant.	
2.2	Sleepers	
i)	Type	
ii)	Density or No. per Km	
iii)	Type of fastenings	
iv)	Rail anchors if in use	
v)	Details of sleepers anchored	
vi)	Length of track box-anchored, location, reasons	

2.3	Ballast and Sub-Ballast	
i)	Size (mm)	
ii)	Depth of cushion (mm)	
iii)	Date of last deep screening of ballast	
2.4	SEJ	
i)	Location (km)	
ii)	Date of laying	
iii)	Maximum gap possible (mm)	
iv)	Drawing No.	
v)	Manufactured by	
vi)	Whether joined to LWR/CWR by machined, insulated or welded joint	
2.5	Girder Bridges	
i)	Location and No.	
ii)	Lengths and spans of bridges with LWR/CWR	
iii)	Type of fastenings used	
iv)	Any other remarks	
2.6	Level Crossings	
	Location and No.	
3.	Grades, alignment and formation	
i)	Steepest gradient	
ii)	Maximum degree of curvature	
iii)	Formation (indicate type of soil)	
iv)	Particulars of trouble with formation and treatment given, if any, at the time of laying (Sketch showing grades and curves with locations to be attached)	

Annexure 7/3

1.	Maintenance Details	
		Year/Year/Year/Year
i)	Method of packing at the time of laying, manual/by machines	
ii)	If by machine, type of machine/ tamper used	
iii)	Packing during maintenance - manual beater/by machines	
iv)	If by machines, type of machine/ tamper used	
v)	Whether directed maintenance/ systematic through packing is done and if the latter, the period when it is done	
vi)	Location requiring repeated maintenance, if any	
vii)	Quantity of ballast recouped	
2.	Climatic Details	
	(Measurements shall be taken on representative LWR only)	
i)	Maximum daily variation in temperature, vide Para 5.2	
ii)	Max. rail temperature °C	
iii)	Max. ambient temperature °C	
iv)	Minimum rail temperature °C	
v)	Minimum ambient temperature °C	
3.	Details of Installation, Destressing etc.	
	Items (i) to (iv) to be entered soon after LWR is laid and destressed for the first time.	
i)	Installation temperature	
ii)	Mean rail temperature for the locality	

iii)	Temperature at the time of destressing t_d	
iv)	Reasons for carrying out the destressing	
v)	Subsequent destressing done - temperature and date	
4.	Unusual Occurrences	
i)	Rail fractures	
ii)	Buckling (Location and reasons for buckling)	
iii)	Replacement of components in SEJ assembly	
	a) Fastenings	
	b) Bolts	
	c) Sleepers	
	d) Longitudinal ties	
	e) MS bracket	
	f) Chairs	
	g) Rubber pads	
	h) Tongue rails	
	i) Stock rails	
iv)	Derailments and accidents on the LWR/CWR portion (give km of the affected portion)	
v)	Replacement of sleepers (give km and the number of sleepers replaced and reasons)	
vi)	Replacement of rails (indicate length, km and reasons)	
5.	FORMATION	
	Any trouble subsequent to laying and the treatment given	

Annexure 7/4

Para 9.2.6.3 (i) - Measurements of Gaps at SEJs

CHART OF MOVEMENT OF LWR/CWR No.

SEJs at the ends of this LWR: SEJ No. ………… . at Km; SEJ No. ……. at km ………..

Date of measure-ment	Time of measure -ment	Rail Temp.	Right or left rail	Distance (mm) between tongue /stock rail & reference line at SEJ No. ….		Distance (mm) between tongue /stock rail & reference line at SEJ No. ….		C/C spacing (mm) between the two central sleepers		Measured by	Rectification carried out		Remarks
				Observed (a)	Permissible range	Observed (b)	Permissible range	At SEJ No. …	At SEJ No. …		On date	by	
1	2	3	4	5	6	7	8	9	10	11	12	13	14

Note:

1. (a) & (b) will almost always be positive except when tongue/ stock rail crosses mean position. In such a case, (-ve) sign will be prefixed.
2. Left and right rails on double lines are determined looking in the direction of traffic.
3. Left and right rails on single lines are determined, looking in the direction of increasing Kilometerage.
4. If spacing of two central sleepers of SEJ differs by more than 700 +/- 10 mm, immediate rectification will be made.

Annexure 7/5

Para 9.2.6.3 (i) - Measurements of Movements in LWR

CHART OF MOVEMENT IN CENTRAL PORTION OF LWR/CWR No. …………

Right or left rail	Distance (mm) between Ref. mark & mark on Rail at various Ref. Pillars in non-B.L. of LWR/CWR*					Measured by	Rectification carried out		Remarks
	Centre of LWR/CWR at Km …..	Km …..	Km …..	Km …..	Km …..		On date	By	
1	2	3	4	5	6	7	8	9	10

Note: *Movement of rail shall be positive in the direction of traffic on double lines and in the direction of heavier traffic on single lines which shall be specified.

Annexure 7/6

Measurement of Improved SEJ -65mm/80mm as Maximum .Gap.

(RDSO T-6922,T-6930 / T-6902,T-6914)

1	Type of SEJ (Max. Gap	65mm / 80mm
2	No. of SEJ	
3	No. of LWR	
4	Condition of (a) Stock Rail	
	(b)Tongue Rail	
	(c)Check Rail	
	(d)Gap avoiding Rail	
	(e) Fittings-Spl. Bearing Plate, Brackets Bolts & Nuts, Screws	
	(f) Tie angle	
5	Spacing of sleepers/Condition of sleepers & Packing.	

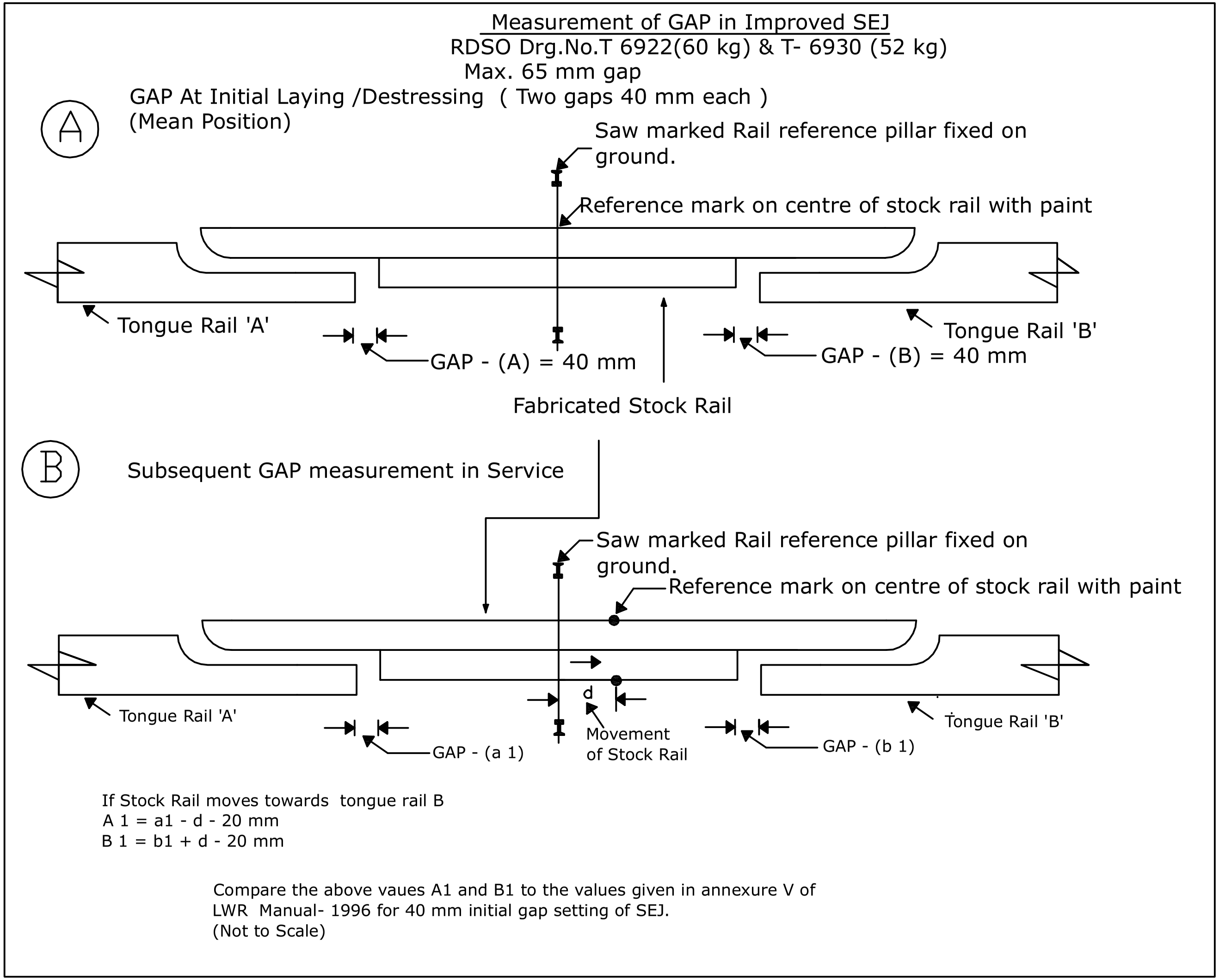
For 65 mm maximum gap (RDSO T6922/6930) (with two gaps) (Refer Annexure 7/7)

Date	Time	Temp.	Movement of Stock Rail w.r.f to ref.pillar (d) in mm	Total gap on one side (a1) in mm	Total gap on another side (b1) in mm	Calculated gaps as shown in sketch		Value as per Annexure V of LWR Manual (in mm)	Remarks
						A1 (in mm) (a1-d-20)	B1(in mm) (b1+d-20)		
			Right						
			Left						

For 80 mm maximum gap (Drg. No. RDSO T6902/6914) (with check rail) (Refer Annexure 7/8)

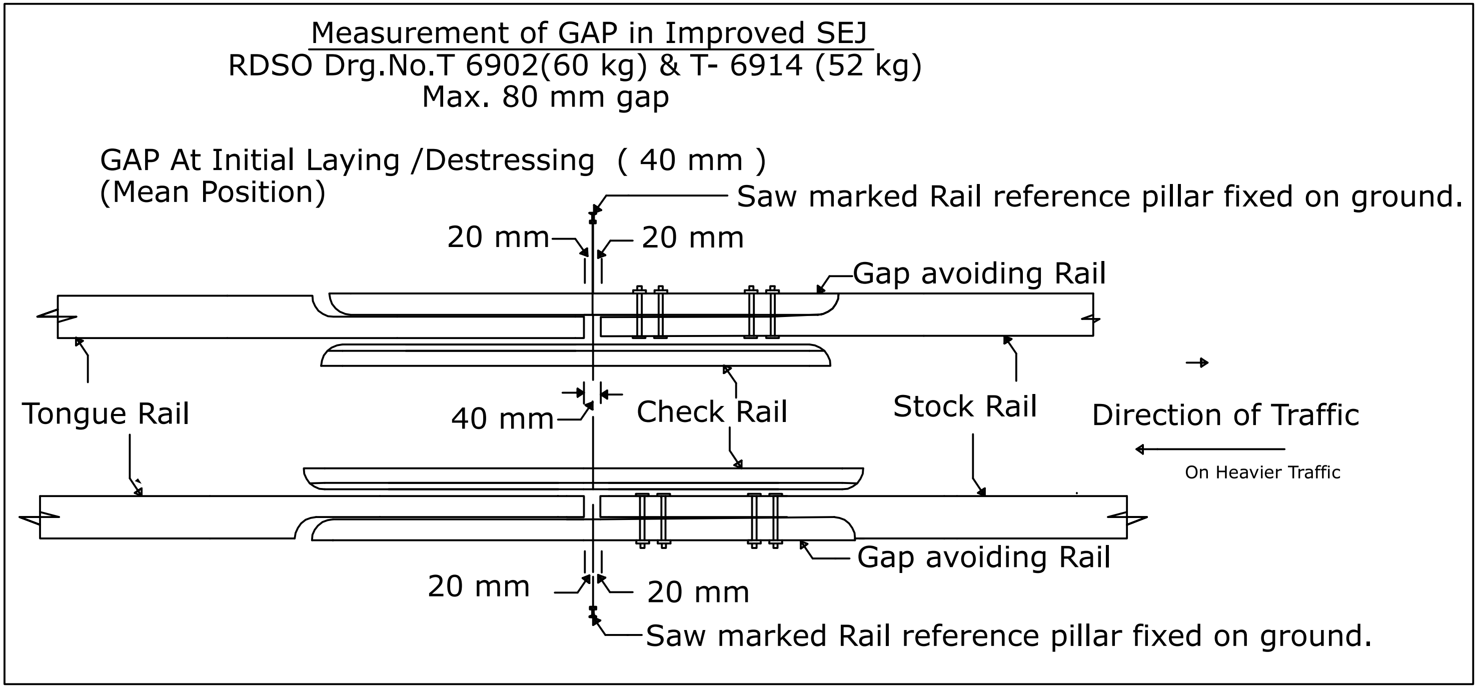
Date	Time	Temp.	Total gap (in mm)	Gap on LWR side (in mm)	Value as per Annexure V of LWR Manual. (in mm)	Check Rail Clearance (in mm)		Remarks
						At centre (41+3/-1)	At flare end (Varying 41-71)	
			R-					
			L-					

Annexure 7/7



Measurement of GAP in Improved SEJ
RDSO Drg.No.T 6922(60 kg) & T- 6930 (52 kg)
Max. 65 mm gap
A
GAP At Initial Laying /Destressing (Two gaps 40 mm each)
(Mean Position)
Saw marked Rail reference pillar fixed on ground.
Reference mark on centre of stock rail with paint
Tongue Rail 'A'
GAP - (A) = 40 mm
Tongue Rail 'B'
GAP - (B) = 40 mm
Fabricated Stock Rail
B
Subsequent GAP measurement in Service
Saw marked Rail reference pillar fixed on ground.
Reference mark on centre of stock rail with paint
d
Tongue Rail 'A'
GAP - (a 1)
Movement of Stock Rail
Tongue Rail 'B'
GAP - (b 1)
If Stock Rail moves towards tongue rail B
A 1 = a1 - d - 20 mm
B 1 = b1 + d - 20 mm
Compare the above vaues A1 and B1 to the values given in annexure V of LWR Manual- 1996 for 40 mm initial gap setting of SEJ.
(Not to Scale)

Annexure 7/8


Measurement of GAP in Improved SEJ
RDSO Drg.No.T 6902(60 kg) & T- 6914 (52 kg)
Max. 80 mm gap
GAP At Initial Laying /Destressing (40 mm)
(Mean Position)
Saw marked Rail reference pillar fixed on ground.
20 mm
20 mm
Gap avoiding Rail
Tongue Rail
40 mm
Check Rail
Stock Rail
Direction of Traffic
On Heavier Traffic
Gap avoiding Rail
20 mm
20 mm
Saw marked Rail reference pillar fixed on ground.

Chapter 8

Rail Defect Management

801. Rail Deterioration and Defects :

(1) Causes of Rail Deterioration : The principal factors causing rail deterioration are detailed below:

(a) Corrosion and rusting : Corrosion is caused not so much by the dampness as by acid gases dissolved in the film of moisture which frequently coats the rails. Corrosion is generally heavy in the following locations :

(i) Platform lines where trains make prolonged halts.

(ii) Sidings where saline or corrosive goods are dealt with.

(iii) Near water columns due to insufficient drainage.

(iv) Tunnels and damp cuttings.

(v) Areas near the sea coast.

(vi) Industrial belts.

Corrosion is generally noticed on the web and foot of the rail.

(b) Wear on Rail Table : Normally this is of a very small order. The amount of wear increases with heavy traffic density as in suburban section, though not proportionately.

(c) Flattening of Rail Table : This mostly occurs on the inner rail of a curve by high contact stresses combined with horizontal forces. The vertical pressure may be due to heavy axle load, large unsprung mass or vehicle running at lower speed than equilibrium speed on canted track. The horizontal forces are associated with slow running on canted track, which produces slipping of wheel sets. Spreading of rail table is an indication of overloading on one rail and such tendency can be reduced by providing appropriate cant.

(d) Wear on gauge face- The outer rail of a curve has to withstand heavy pressure from the wheels which results in the running edge becoming worn or 'side-cut'. Wear on gauge face is especially pronounced in case of suburban sections where multiple unit coaches are provided with laterally unsprung traction motors. *(Fig. 8.01 & Fig. 8.02)*

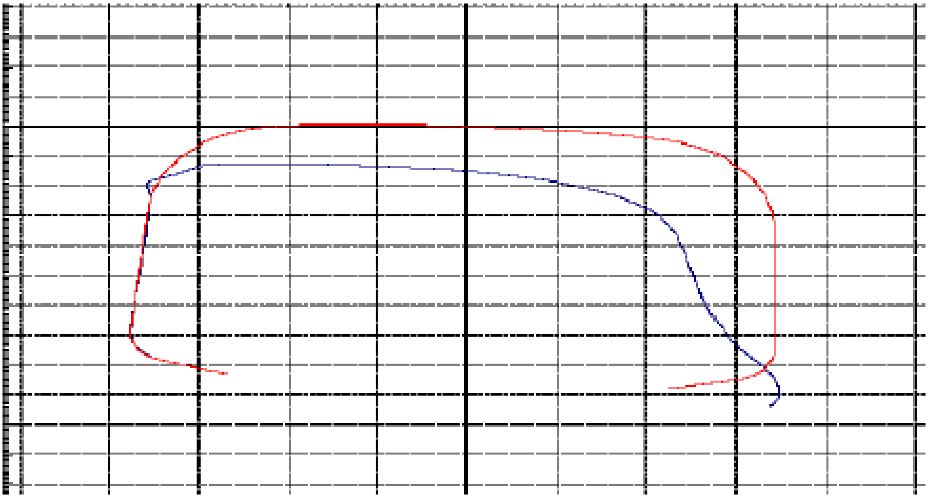


Fig. 8.01 *Wear on guage face*

Fig. 8.02 *Wear on guage face*

(e) Hogging of rail end : Rail with bent ends in vertical direction is termed as hogged rail. A hogged rail end in the track is ascertained by unfishing the joints, removing the fastenings and then measuring the extent of hog at the rail end by placing a 1 metre long straight edge over the rail table, centrally over the joint as shown in *Fig. 8.03.*

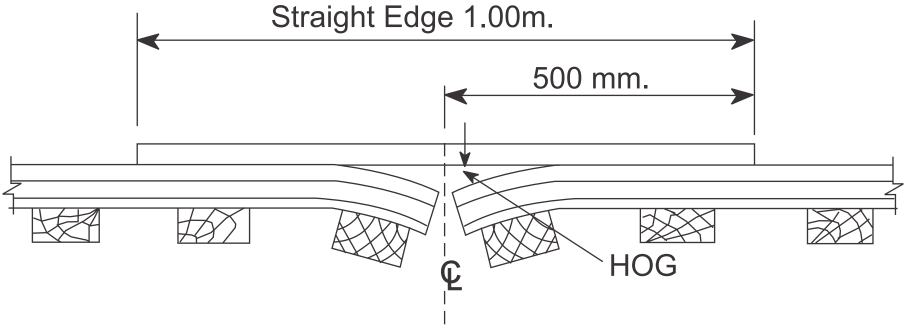


Fig. 8.03 *Method of measurement of hogging of rails.*

(f) Battering of rail ends : Rail end batter occurs where the joint gaps are excessive. It is caused by the impact of wheels on end of a rail particularly if the fish-plates do not fit snugly. Rail end batter is measured as the difference in heights of the rail at its end and at a point 30 cm. away from the rail end as shown in the *Fig. 8.04.*

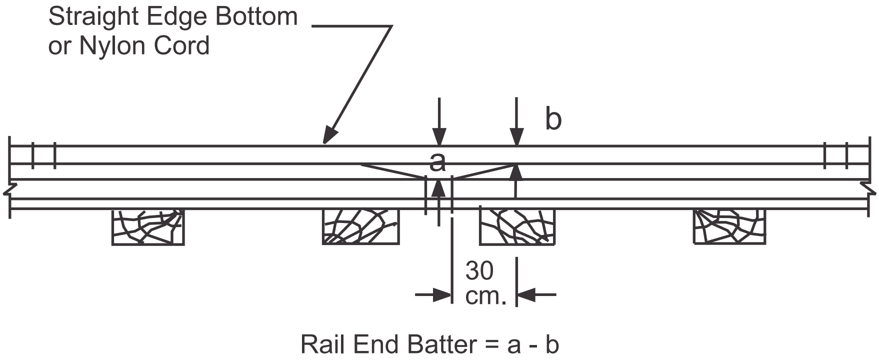


Fig. 8.04 *Method of measurement of battering of rail joints.*

802. Rail Defects :

1) Surface Defects : Surface defects can be seen on the surface of rails. Various types of surface defects are detailed below :

(a) Wheel burns : Wheel slipping occurs usually on adverse gradients or while starting on rising grades when considerable heat is generated and top of the rail is torn off in patches, causing depressions known as wheel burns, from which cracks may develop. Wheel burns cause the wheels to hammer the rails and lead to difficulties in keeping the sleepers packed firmly and fastenings tight. Such rail should be kept under observation and changed. The incidents of wheel burns is predominant where the mode of traction is electric or diesel-electric. (*Fig. 8.05).*

Fig. 8.05 *– Wheel Burns*

(b) Corrugation : In certain locations, rail table develops ridges and hollows called corrugation and when vehicles pass over these rails, a roaring sound ensues. Such rails are called “roaring rails”. In such locations, excessive vibrations are caused, due to which fastenings and packing tend to get loose, track needing frequent attention at these places. *(Fig. 8.06.)*

Fig. 8.06 – *Rail corrugation*

(c) Rail head checks : Rolling contact fatigue (RCF) of the rail surface leads to multiple hair line cracks known as rail head checks or gauge corner cracking. Surface initiated RCF defect are initiated by frictional loading of rail head. The cracks initially grow at shallow angle, as the cracks becoming larger, their growth becomes transverse. (*Fig. 8.07)*

Fig. 8.07 – *Gauge corner cracks*

(d) Shelling : Shelling is an internal defect that initiates at a depth of 2-8 mm below the gauge corner of generally the high rails in curved track. In the initial stages of development, shelling defects become noticeable in the gauge corner region of the rails as dark spots. Shelling defects do not form as regularly along the rail as gauge corner checking defects.

Shelling cracks develop on a horizontal or longitudinal plane consistent with the shape of the rail on the gauge corner. The cracks can continue to grow in a longitudinal direction on that plane for some distance at an angle of about 10° - 30° to the rail surface, and then either spall out into a shell or turn down and form transverse defects which can continue to grow on a transverse plane and eventually lead to rail failure, if not detected in time. (*Fig. 8.08, 8.09, and 8.10)*

However, sometimes transverse defects may also directly initiate from irregularities in the steel (inclusions) and grow in a transverse plane, without the need for a prior shelling defect.

Because of their internal nature, transverse defects cannot be visually detected, and hence must rely on regular ultrasonic rail inspection.

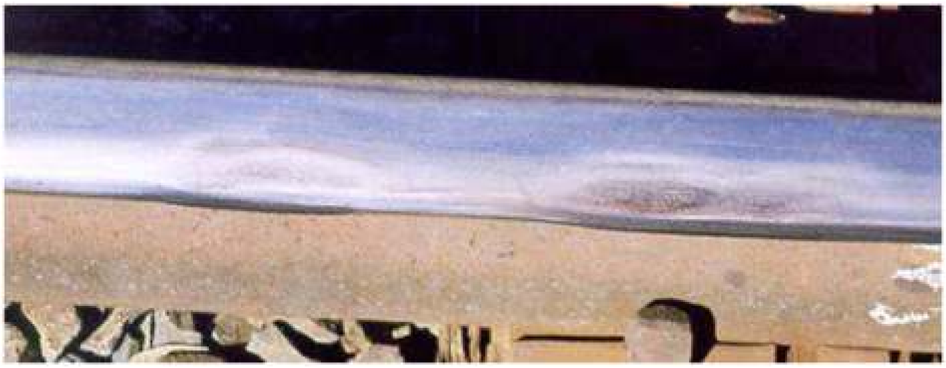


Fig. 8.08 - *Moderate shelling*

Fig. 8.09 - *Severe shelling*

Fig. 8.10 - *Very severe shelling*

(e) Squats : Squats are subsurface laminations which initiate as small cracks. These cracks extend diagonally downwards, at an angle of about 20°- 30° from the horizontal, until they reach approximately

4-6 mm below the surface, then spread laterally and longitudinally across and along the running surface. (*Fig. 8.11, 8.12 and 8.13)*

Squats are indicated by a darkened area in the contact band, which results from a depression in the rail surface and reduced polishing by train wheels.

Moderate to severe squats are often mistaken for wheelburn defects. The characterising differences are:

- Squats develop gradually over a period of months or years, whereas wheel burns occur instantly after a wheel slip incident.
- Squats often do not have a matching defect on the opposite rail. Squats tend to occur in tangent track and in curves of moderate radius (800 – 1600 m radius).
- In curved track they occur mostly on the high rail. They also occur in the transitions of sharp curves. Squats often occur on uncanted rails in turnouts.
- Squats occur on all types of rails and sleepers.

Fig. 8.11 - *Surface squat - small*

Fig. 8.12 - Surface squat - medium

Fig. 8.13 - Surface squat – large.

(f) Wheelslips : Wheelslip surface defects have been found to arise from wheelslip where the vehicle is continuing to move forward whilst at least one axle is slipping. The degree of initial damage to the rails will vary ranging from a visible discolouration to a severely mottled appearance. As the vehicle ceases to move forward the damage increases, leading to full wheelburns once the vehicle is stationary. (*Fig. 8.14)*

Wheelburns are nearly always evident on both rails, however the appearance of wheelslip can vary between rails. It can also be more evident depending on the position of contact of each wheel. Unusual contacts are common as the vehicle bogie may become skewed during wheelslip events.

The milder forms of wheelslip may cease to be visible after traffic has passed or rail grinding has taken place. If the damaged area has actually been removed before cracks have grown, no further problems may arise. Otherwise:

- On sharp curves the damage to the low rail can lead to continuous spalling along the rail surface. Typically the damage is less on the high rail and in any case normal wear on the high rail will removed damage before cracks grow. Damage to the low rail is often compounded by the additional impact from rail corrugations (which are also often associated with sharp curves).
- On the high rail of moderate curves and either rail on tangents the growth of rail squats is a very real possibility. The most severe semi-continuous squats have been associated with wheelslip events.

Fig. 8.14 - *Wheel slip*

(2) Internal Rail Defects: Rail is the most important and critical component of the permanent way. Most common cause of rail failure is the fatigue fracture, which is due to imperfections present in the material or due to crack formation during service.

(a) Causes of internal defects : The origin and development of such cracks is due to:

(i) Material defects originating during the manufacturing process such as clusters of non-metallic inclusions, hydrogen flakes, rolling marks, guide marks etc. which may be present in spite of successful non-destructive tests carried out on the rails during quality assurance examination.

(ii) Residual stresses induced during manufacture (cooling, rolling, gas pressing and straightening).

(iii) Defects due to incorrect handling e.g. plastic deformation, scoring, denting etc.

(iv) Defects associated with faulty welding i.e. gas pores, lack of fusion, inclusions, cracks etc.

(v) Dynamic stresses caused by vertical and lateral loads particularly by vehicles with wheel flats or when the vehicle runs over poorly maintained rail joints etc.

(vi) Excessive thermal stresses due to variation in rail temperature beyond specified limits.

(b) Defect location: In order to study the fractures in rail systematically, they may be divided into the following categories based on their location of occurrence in the rail length:

(i) Defects emanating from the rail end or reaching the end of the rail.

(ii) Defects observed within fish-plated zone.

(iii) Defects not covered in (i) and (ii).

(c) Nature of defects in rails :

(i) Horizontal crack in head : These cracks run usually parallel to the rail table at a depth of 10-20 mm and may finally split the material layer. Crushing of the railhead may also be observed in the vicinity of the crack. Clusters of non-metallic inclusions and abnormal vertical service stresses are the factors responsible for this defect. USFD can easily detect such flaws. (*Fig. 8.15 (a) and 8.15 (b)).*

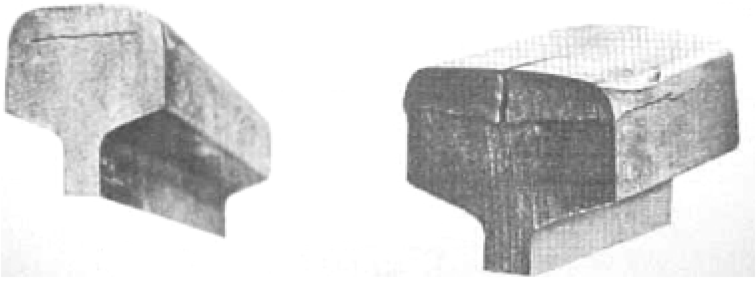


Fig. 8.15 *- (a) Horizontal crack in rail head.*

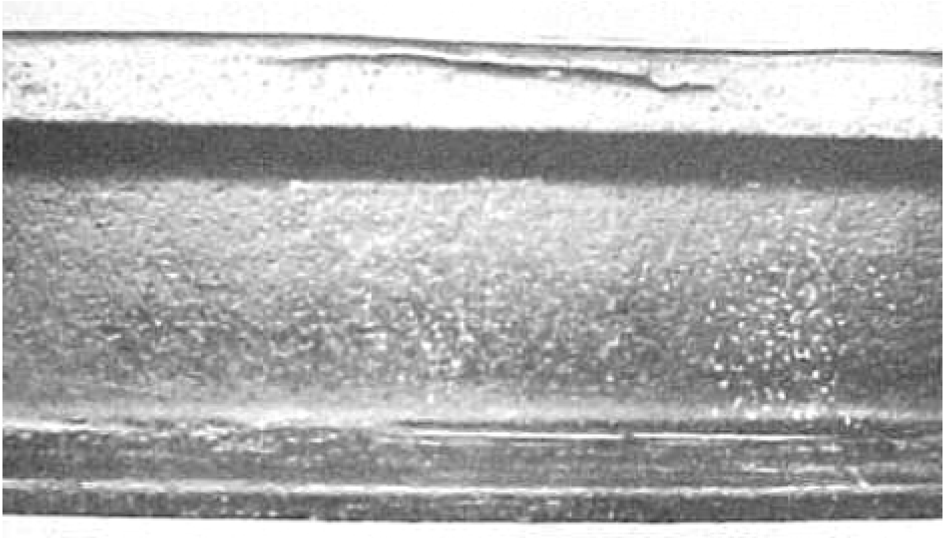


Fig. 8.15 *- (b) Horizontal crack in rail head.*

(ii) Vertical-longitudinal split in head : These cracks run parallel to the longitudinal axis of the rail and are caused by presence of non-metallic inclusions, poor maintenance of joints and high dynamic stresses. It cannot be easily detected in early stages by USFD due to their unfavourable orientation. (*Fig. 8.16 (a) and 8.16 (b)).*

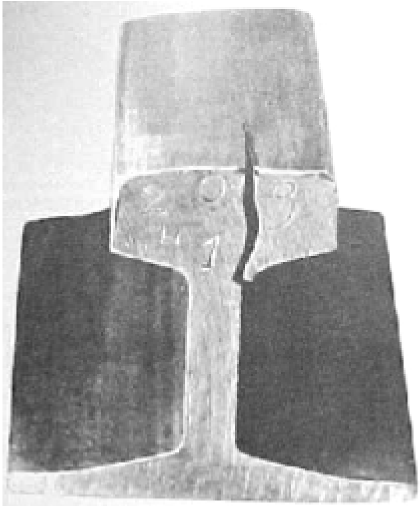


Fig. 8.16 (a) *Vertical longitudinal head split*

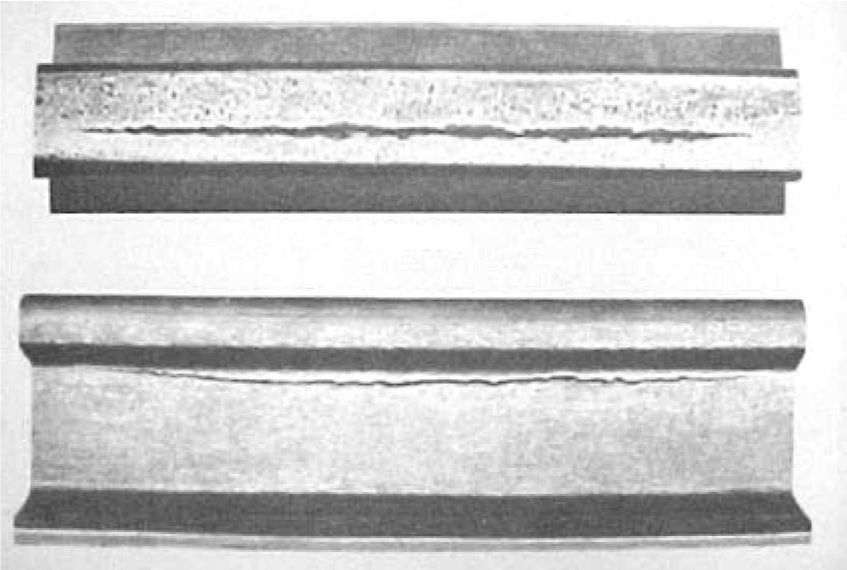


Fig. 8.16 (b) *Vertical longitudinal head split*

(iii) Horizontal crack at head web junction: Such flaws may lead to rail head separation. Contributory causes are wheel flats, bad fish-plated joint, inclusions and high residual stresses. USFD is sensitive to such defects and can easily detect them. (*Fig. 8.17 (a) and 8.17 (b)).*

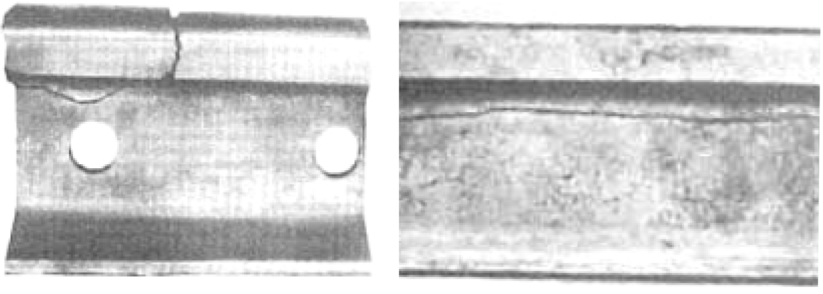


Fig. 8.17 (a) *Horizontal crack at head web junction.*

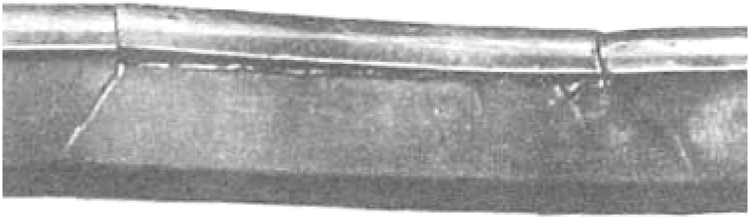


Fig. 8.17 (b) *Head web junction at top fillet radius.*

(iv) Horizontal crack at web-foot junction: Such cracks develop both towards head and foot. They are caused by high vertical and lateral dynamic loads, scoring and high residual stresses. USFD can easily detect these flaws. (*Fig. 8.18)*

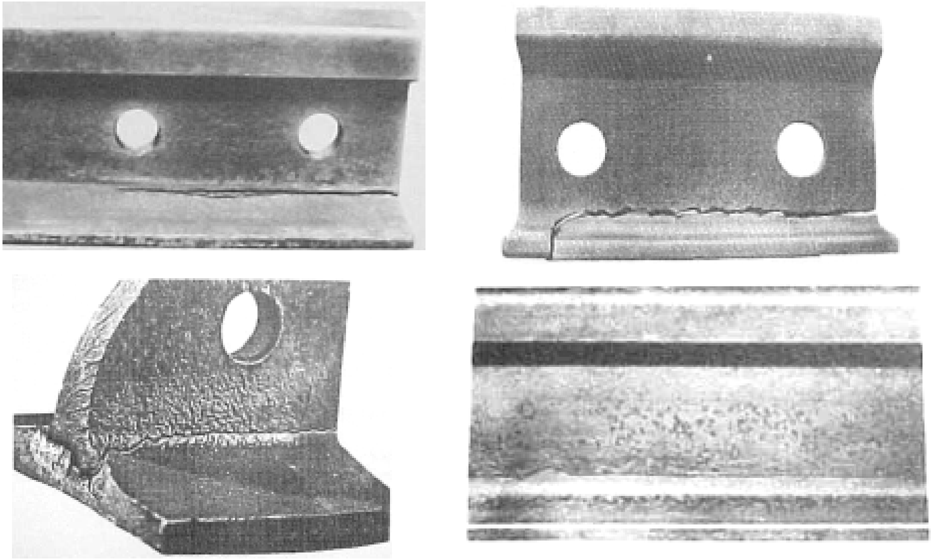
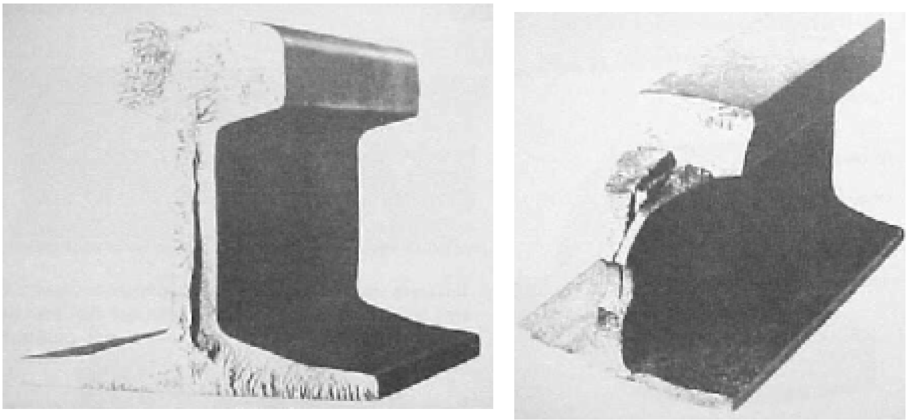


Fig. 8.18 *Web, foot junction crack at bottom fillet radius*

(v) Vertical longitudinal splitting of the web: It is primarily due to heavy accumulation of non-metallic inclusions and wheel flats. USFD conducted from rail top can detect it only if the defect is severe and in an advanced stage. Vertical longitudinal defects of minor nature are not amenable to USFD examination conducted from rail top. Probing from railhead sides can detect such defects for which hand probing may be essential. (*Fig. 8.19)*



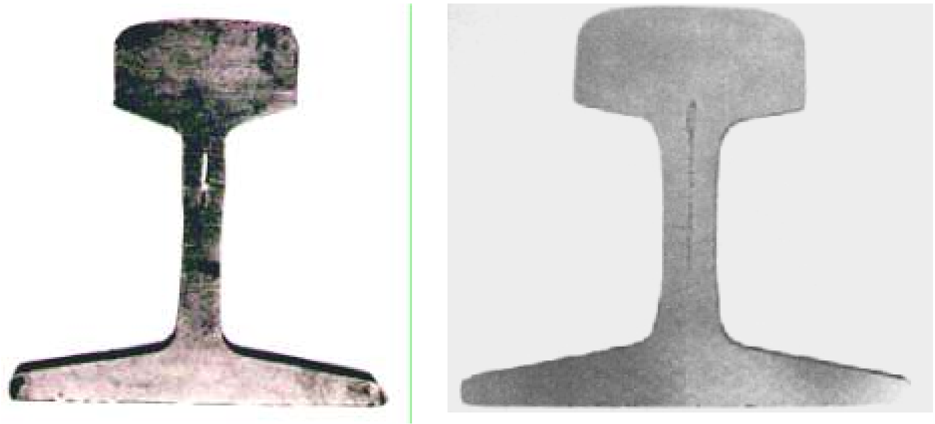


Fig. 8.19 *Web, Vertival longitudinal splitting (Piping)*

(vi) Bolt hole crack: Such cracks often run diagonally and may run towards head or the foot. They result from inadequately maintained joints and unchamfered fish bolt holes and stress concentration. USFD can easily detect these cracks. Normal probes provide indication as diminished back wall echo.(*Fig. 8.20)*

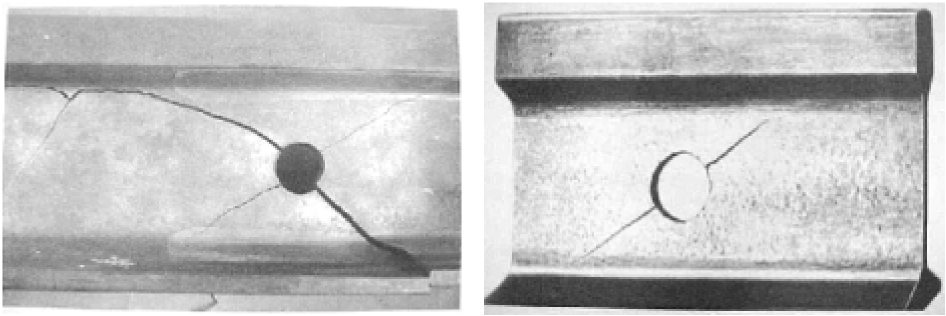


Fig. 8.20 *Bolt hole cracks at hole*

(vii) Transverse fracture without apparent origin: These fractures occur suddenly, especially during winter and may emanate from microscopic flaws (embedded or on surface) and are generally very difficult to detect by USFD. These minute flaws manifest suddenly under severe service conditions or when the fracture toughness values are comparatively low. (*Fig. 8.21)*

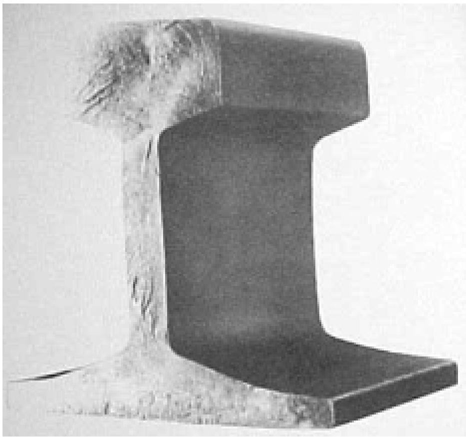


Fig. 8.21 *- Transverse breakage without apparent origin*

(viii) Transverse fatigue crack in head: They resemble a kidney in shape in the railhead and USFD is ideally suited for detecting them. They are generally inclined at the angle of 18°- 23° and originate at a depth of 15 - 20 mm below the running surface. Mainly hydrogen accumulation and non-metallic inclusions cause this defect. These cracks are easily detected by 70° probe. (*Fig. 8.22)*

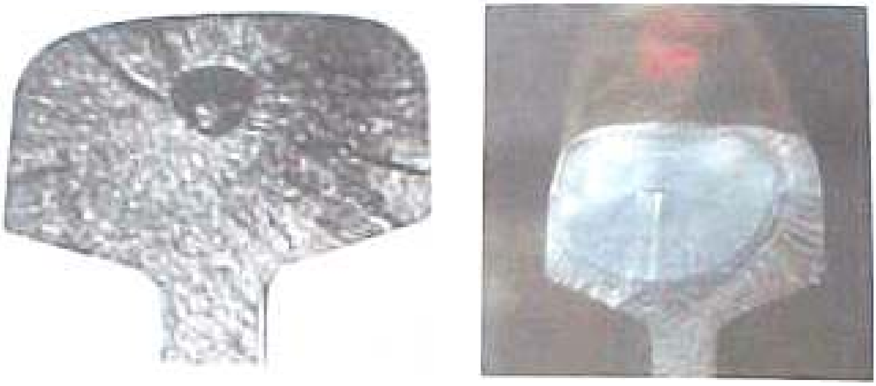


Fig. 8.22 - *Transverse fatigue crack in head*

When such defects are nearly vertical, they can be detected using additional gain of 10 db. Defects lying below scabs/wheel burns can be detected by 45° side probing of rail head.

(ix) Horizontal crack at top and bottom fillet radius: These cracks are caused by accumulation of non-metallic inclusions and high residual stresses introduced at the time of rail straightening. These are difficult to be detected by USFD. (*Fig. 8.23)*

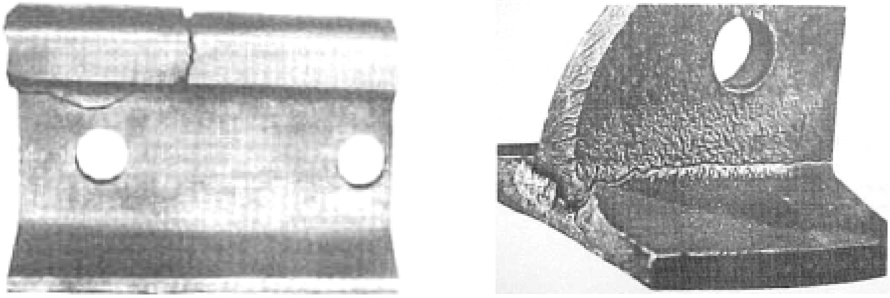


Fig. 8.23 *Horizontal crack at top and bottom fillet radius*

(x) Vertical – longitudinal crack in foot: Such cracks develop from sharp chamfers on the bottom surface of the rail foot. Cracks occurring in this way are the points of origin of transverse cracks in the foot. (*Fig. 8.24)*

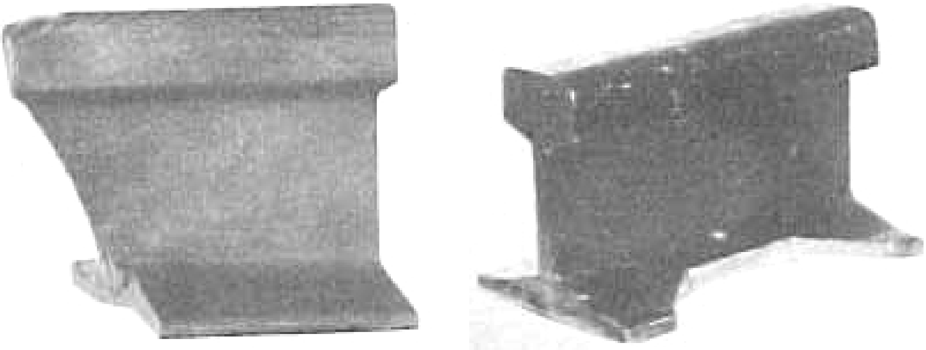


Fig. 8.24 *- Foot vertical longitudinal split (Half moon crack)*

(xi) Transverse cracks in rail foot: Due to localised overheating during FB welding, structural changes in the bottom surface of the rail material takes place which result in a minor crack. These cracks under the tensile loading give rise to brittle fracture. Such defects are not detectable by USFD. Transverse cracks originated from AT welds in the rail foot grow as half moon and are detectable by 45° probe.

803. Weld Defects:

Nature of defects in welds: Joining rails by improper welding may introduce a variety of defects on the joints as well as in the heat affected zone (HAZ) e.g. lack of fusion, cracks, porosity, slag inclusion, structural variation, etc. The quality of weld depends to a large extent on the careful execution of the welding operation. USFD testing done by manual rail tester suffers from following deficiencies:

(i) Full cross section of weld is not covered by normal USFD examination using manual tester thereby leaving areas in head and foot, which may have flaws.

(ii) Micro structural variations in the weldment cause attenuation of ultrasonic energy.

Therefore, a separate testing procedure for welds has been developed.

(1) Defects in Flash Butt Welds:

(a) Transverse cracks: The origin of these cracks is the imperfection in the weldment such as lack of fusion, inclusions, etc. Fracture usually occurs from these imperfections, which may be in railhead, web or foot. During the course of its propagation USFD testing is extremely effective. (*Fig. 8.25)*

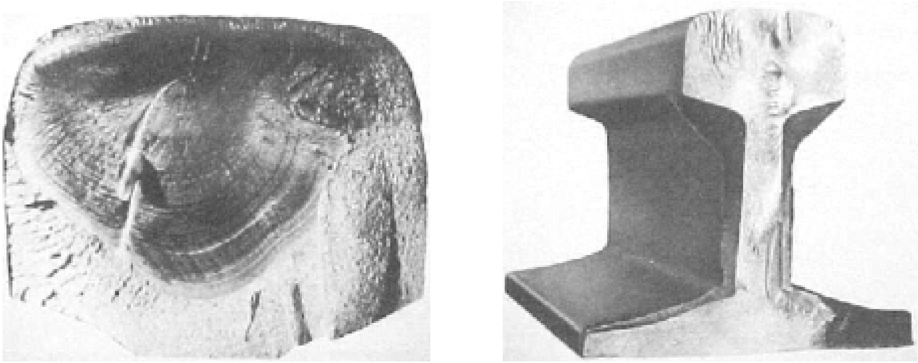


***Fig. 8.25** -Welding, flash butt joint, transverse crack*

(b) Horizontal cracks: These cracks develop in the web and propagate both in head and foot. The principal cause is large tensile residual stresses acting in the vertical direction. (*Fig. 8.26)*

***Fig. 8.26** - Welding, flash butt joint, horizontal crack*

(2) Defects in Alumino-Thermic (AT) Welds:

(a) Transverse crack in head and foot: It is caused by inclusions entrapped during welding, which leads to crack initiation on the foot and its growth in the web region causing fracture. Such cracks can be detected by USFD. (*Fig. 8.27)*

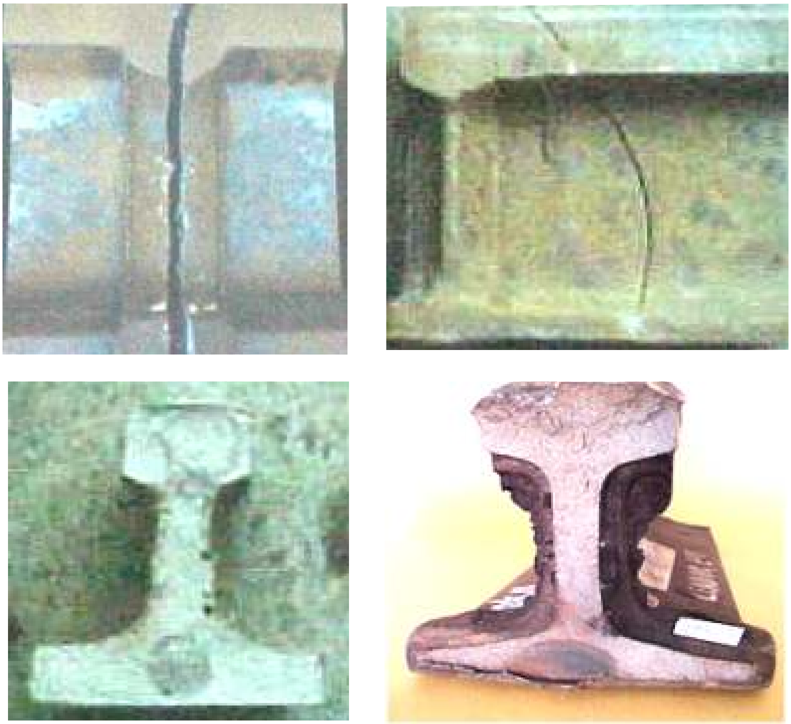


Fig. 8.27 - *Welding, thermit joint transverse crack*

(b) Horizontal cracks in web: These cracks occur in AT welds in which the ends having bolt holes have not been removed. The presence of holes result in unfavorable stress distribution caused due to non-uniform cooling. USFD can easily detect such flaws. (*Fig. 8.28)*

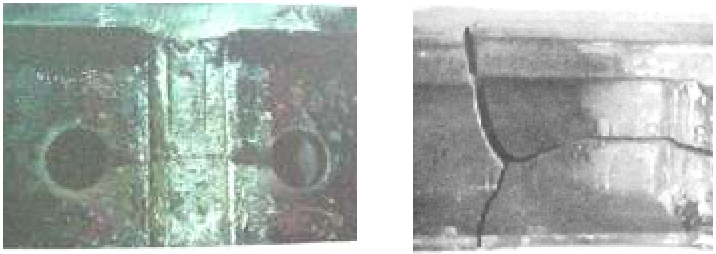


Fig. 8.28 - *Welding, thermit joint horizontal crack*

804. Rail Maintenance to Reduce Deterioration

Efficient maintenance of rails results in increased service life of rails. The following precautions/maintenance practices if observed will effectively reduce rail deterioration.

(1) Identification and Measurement of Corrosion :

(i) Areas prone to corrosion of rails shall be identified by the Principal Chief Engineer of the Railway on the basis of reports sent by Divisional Engineers.

(ii) In corrosion prone areas identified in accordance with above Para measurement of depth of corrosion pits both vertically and laterally (reduction in bottom flange width of rail), shall be done using straight edge and feeler gauge or any other suitable device at a fixed periodicity of once in a year on every 100 sleepers by removing elastic rail clips and liners and such measurements shall be recorded in a register to be maintained by each SSE (P.Way) as per *Annexure-8/1.*

(2) Classification of Sections Based on Corrosion Proneness:

The sections shall be classified in two group based on corrosion proneness as defined below

(a) Severe corrosion prone locations: The sections where rate of liner seat corrosion recorded is more than 3 mm in 3 years.

(b) Moderate corrosion prone locations : All sections where rate of liner seat corrosion recorded is between 1mm and 3 mm in 3 years.

(c) SSE (P.Way) incharge of the section shall carryout inspection of his section for corrosion in August & September. Extent of corrosion shall be measured once in a year on representative 100 sleepers in each block section & 50 sleepers in each yard by removing elastic rail clips and liners. Such measurement shall be recorded in a register to be maintained by each SSE (P.Way). ADEN should inspect all the locations having corrosion more than 1 mm and send exception report to DEN/Sr.DEN with his proposal for section to be taken. Sr.DEN/DEN shall also inspect such locations & record the instructions for action to be taken on the register. This exercise shall be completed by November every year.

(d) Locations with corrosion prone section shall be submitted to HQ office for approval of PCE giving full reasons. Sectional Sr.DEN shall record the action to be taken before sending the proposal to HQ. He shall also ensure the compliance. Only after approval of PCE, area should be considered as prone to corrosion.

(e) Classification of the sections based on the corrosion proneness as mentioned above shall be reviewed every year depending on the corrosion recorded. The locations classified under each group shall be recorded in the section register being maintained by each SSE/P.Way/Incharge.

(f) Method of measurement of corrosion : The accurate measurement of corrosion pit is very important. Generally, in field, corrosion pit depth is being measured with the help of either tapered gauge or feeler gauge. However, due to irregular depth of corrosion pit and due to rigid and flaky tapered gauge/feeler gauge, it will not be able to measure the depressions accurately. To measure the corrosion, only a pointer tip tool can be able to read accurately fixed in graduated scale. A drawing of instrument which may be used is given in *Fig. 8.29.*

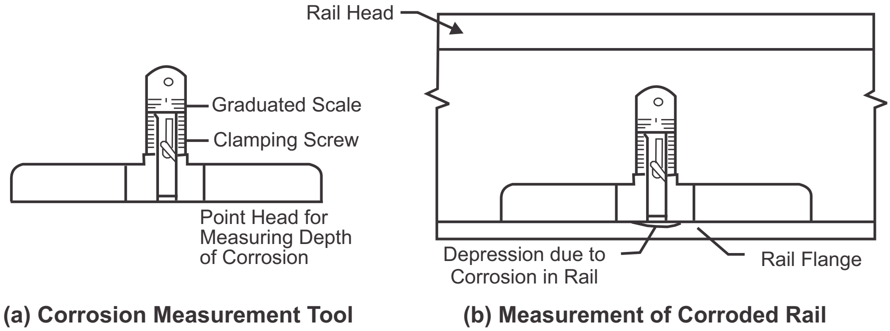


Fig. 8.29 - *Corrosion measurement tool*

For new line/gauge conversion projects, corrosion prone areas shall be identified by CAO(C)/ Chief Engineer(C) in consultation with Principal Chief Engineer.

(3) Preventive measures to reduce corrosion of rails

(a) General

(i) Ensure 100% complete and tight track fastening and earth bonds.

(ii) Ensure that corrosion of rail is controlled by various measures such as greasing of liner seats, sealing of liner seat, painting of liner sheets & weld collars, shifting of linear seats etc.

(iii) Ensure rail foot is away from stagnated water and ballast.

(iv) Ensure that drainage condition is good and anti-corrosive treatment is given to all parts of fastening of rail, prone to corrosion.

(v) Rail flanges/ web should be kept free of the muck particularly at stations.

(vi) Periodical cleaning of rubbish should be done in goods shed siding lines.

(vii) Train watering arrangements/water columns should be avoided on the run through main lines as far as possible. Proper drainage should be ensured in yard/ station lines including washing lines, washable aprons, train watering lines etc.

(b) Shifting of corroded liner seats :

By shifting the corroded liner seats from its original location, the locations affected by liner biting gets shifted away from the liner seat and a new location with normal thickness at rail foot comes under the liner seat. (*Fig. 8.30)*

***Fig. 8.30 -** Liner biting*

This can be done in following two ways.

(i) Longitudinal shifting of the rail:

In longitudinal shifting the corrosion affected portion is shifted between the sleepers. This shall preferably be done when reduction in thickness of rail at the bottom flange is less than or equal to 1.5 mm. This shifting of liner seats shall be done by 150 mm systematically along with distressing once in every 3 years in moderate corrosion prone locations and once every 2 years in severe corrosion prone locations and once every 2 years in severe corrosion prone locations or before corrosion pit depth at liner contact area reaches a limit of 1.5 mm, whichever is earlier.

In any case, efforts should be made to ensure that corrosion at liner contact area is not allowed to exceed a limit of 1.5 mm at any point of time.

(ii) Interchanging of rails :

Interchanging of rails may be done when shifting of liner seat from all sleepers is not practical i.e. where shifting of linear seat will not result in all liner seats to be way from the sleepers such as locations where sleeper density was increased locations and locations where liner seat got shifting non-uniformly during casual renewal, desressing, TWR etc.

(c) Destressing of LWR:

Distressing shall be done as per the following periodicity to avoid corrosion of rails at the liner seats:

(i) In severe corrosion prone areas, distressing shall be done once in 2 years or when corrosion reaches 1.5 mm at liner seat whichever is earlier.

(ii) In moderate corrosion prone areas, desterssing shall be done once in 3 years or when corrosion reaches 1.5 mm at liner seat whichever is earlier.

Destressing of LWR shall be done by cutting and removing the rails for length of 150 mm or in multiples of sleepers spacing +150 mm so as to ensure shifting of liner seat by 150 mm uniform at all locations during the process of distressing.

(d) Greasing and sealing of liner contact area :

In identified corrosion prone areas, bituminous painting of rails shall be done once in a year on inside of gauge face including web and foot and once in three years on non gauge face side of rail including web and foot. In other areas, wherever signs of corrosion are seen in isolated patches prompt action for anti corrosive painting shall be taken.

Greasing and sealing of liner contact area – In identified corrosion prone areas, the rail liner sheet should be greased using graphite grease to the RDSO specification after proper cleaning. The grease is also applied all around the liner on the rail foot on gauge face side to prevent the ingress of toilet droppings in the gap between the liner and the rail foot. Greasing and sealing of liners contact area shall be done once in a year for gauge face side and once in two years on non gauge face side of rail.

(i) Do not use untested grease. Grease must have oxidation stability and rust inhibitors.

(ii) Apply recommended cleaning agent and rust inhibitors before anticorrosive treatment.

(iii) Use preferably mechanised cleaning brush to scrap the rusted surface.

(iv) Greasing shall not be done in rainy condition and hot weather conditions.

(v) Greasing of plate screws at points & xings and at guard rails of bridges shall be done at the time of initial laying and also during maintenance once every one year and 2 year in severe and moderate corrosion prone locations respectively.

(e) Schedule of preventive measures to reduce corrosion of rails are summarised below:

SN	Measures	Severe (Corrosion more than 3mm in 3 years)	Moderate (Corrosion between 1 and 3 mm in 3 years)
1	Measurement of liner seat corrosion	Once in a year	Once in a year
2	Distressing & longitudinal shifting of liner seats.*	Once in 2 years	Once in 3 years
3	Painting of rails including SKV & Flash Butt Weld	Once in a year both inside & outside.	Once in a year inside only.
4	Greasing of ERCs, inserts, liner seats including sealing of liners.	Once in 6 months both inside & outside.	(1)Once in a year inside only. (2)Once in 3 years on outside along with destressing.
5	Greasing of plate screws at points and crossings and at guard rails of bridges.	Once in 6 months	Once in a year.
6	Painting of weld.	One in a year both sides.	Once in a year.

(4) Anticorrosive Painting :

(a) In case of the new rails to be laid during track renewal/doublings/ other construction projects in identified corrosion prone areas, anti corrosive bituminous coating as per procedure mentioned in (c) below should be provided before laying in track. This should preferably be done in flash butt welding plants.

For severe corrosion prone areas, wherever possible, zinc metallisation in lieu of bituminous painting in centralised plant /flash butt welding plant can also be done. The zinc metallisation shall be done as per specification of zinc metalisation is given in *Annexure 8.2.* Methodology and other details for zinc metalisation are enclosed as *Annexure 8.3.*

(b) In case of rails that are already laid in track in identified corrosion prone areas, anti corrosive bituminous coatings to rails should be given in the track itself as per procedure mentioned (c) below.

(c) Surface preparation of rails shall be done with the help of hand operated or power operated tools i.e. scrappers, wire brushes, sand papers, pumice stone etc. Wire brushing shall in variably be done at the end so as to obtain uniform rubbed surface. The surface prepared shall be checked visually for uniformity of surface. Special care should be taken in surface preparation at weld collars and liner contact areas. Surface preparation should not be done when ambient temperature is below 10°C or above 50°C, in rainy season, during night, in winter before 8 AM, in summer between 11 AM to 3 PM and in extremely windy /misty / dusty conditions. Chemicals should not be used for surface preparation. Painting should be done in two coats of thickness of 100 microns each by anti corrosive bituminous black paint confirms to IS: 9862 after an interval of 8 hrs. between two coats. All the liners and elastic rail clips shall also be painted with anti corrosive black bituminous paint after duly cleaning the surface.

(d) Zinc metalisation is required to be done only once in service life of rails. The need for periodical re-painting and the method to be followed will depend on the condition of the existing paint. In most cases complete removal of existing paint film may not be necessary.

(e) However, if the existing paint is found flaked or damaged, it should be removed completely by wire brushing without the use of scrapers or chipping tools. In case the original coat of zinc chromate primer is also damaged in patches, such patches should be painted with fresh zinc chromate primer before applying the finishing coat of aluminium.

(f) In the event of any localized damage to the metalised coating of aluminium, as evidences by traces of rust, the affected portion should be thoroughly cleaned of all rust before the priming and top coats of paints are applied. Rust streaks caused by droppings from the track should not be mistaken for corrosion.

(g) Painting of Alumino Thermit weld collars:

(i) AT weld collars shall also be painted along with all new welds immediately after welding on welded area and up to 10 cm on either side. Preferably Epoxy paint should be used in painting for AT weld collars.

(ii) Specification of paint:

Initial painting of weld collar can be done with bituminous black ready mix paint conforming to *IS:9862-1981* or Bituminous emulsion paint conforming to *IRS-P-30-1996* in corrosion prone areas and with high build Epoxy paint consisting of two pack as per *RDSO's specification No. M&C/PCN/III/88 (Annexure-8.4)* in Severe Corrosion prone areas. The methodology and other details are in *Annexure-8.5.*

(iii) Frequency of painting:

- Maintenance painting of AT weld collar will be done once in 4 years. Bituminous black ready mix paint or Bituminous emulsion paint will be utilised in Normal Corrosion Prone areas and Epoxy based paint in Severe Corrosion Prone areas.
- In case normal Bituminous paint is used in Severe Corrosion Prone areas, the frequency should be once every year.
- The specification and procedure of painting will be same as detailed in *Annexure – 8.6.*

(5) Reducing Side Wear on Rails - (Gauge Face of Outer Rails) :

(a) On sharp curves where the tendency to wear on the outer rail is noticeable, lubricators should be installed or hand lubrication of gauge face should be done, care being taken not to apply the lubricant on the top of the table.

(b) Track mounted automatic Gauge Face Lubricators should be provided on curves of radius 825 m (2°) and sharper on broad gauge and of radius 300 m and less on meter gauge to reduce rail gauge face wear.

On routes where rail grinding is in practice, Track mounted automatic Gauge Face Lubricators should be provided on curves of radius 1400m (1.25°) and sharper on Broad Gauge. While deciding the location of lubricators, following should be considered:

(i) It is located on tangent track at the beginning of transition curve where wheel flanging is just beginning to occur. On single lines, the lubricator shall be located in the direction of heaviest traffic.

(ii) Lubricators should be located away from switches, crossings and other areas where discontinuity in LWR track may exist.

(c) Increased life can be obtained by turning the rails when side wear reaches the permissible limit. At the time of turning, matching of rail ends on the gauge face should be ensured. Spot renewals should not be carried out with new rails particularly, if the heads of the existing rails are worn badly. These should be spot renewed with matching sections of serviceable rails.

(d) Besides lubrication, wear on outer rail of curves can also be reduced effectively by measures such as maintaining correct curve geometry & superelevation and by providing suitable check rail.

(6) Repairs to Wheel Burns : This could be carried out at site by in situ welding.

(7) Inspection of Rails in Service :

(a) General : Rails should be inspected for flaws specially, when the rails show signs of fatigue and the rail wear is excessive. The detection of rail flaws is done either by visual examination of the rail or by ultrasonic rail flaw detection.

(b) Visual examination of rails : Most of the rail flaws develop at the rail ends. Rail ends should be examined for cracks during the lubrication of rail joints by cleaning the surface of the rail by wire brushes and using a magnifying glass. A small mirror is of assistance in examining the underside of rails. Such an inspection on the important girder bridges and their approaches should be done twice a year.

(c) "Ultrasonic testing of rails is specialized activity and the inspectors carrying out the ultrasonic testing of rails shall be trained by RDSO, in the technique of USFD testing. Each zonal railway shall create adequate number of ex-cadre posts of inspectors to ensure that entire track length in their jurisdiction is ultrasonically tested at the laid down periodicity. Detailed instructions for ultrasonic testing of rails and welds are contained in the Manual for Ultrasonic Testing of Rails and Welds, which along with its correction slips may be referred to as Annexure to this Manual, It is very important that instructions contained therein are carefully studied by the Permanent Way Officials connected with the laying and maintenance of track".

(d) USFD testing of service rails: No rail untested by USFD shall be laid in the track whether for new lines or layouts or renewals or for repair works or even temporarily such as service rails for PQRS work. For repairs and casual renewals, a location-wise imprest of tested rails of various lengths (13 m, 9 m, 6 m) shall be prescribed for each JE/SSE (P.Way) by Sr.DEN/DEN.

805. Reporting of Rail/Weld Failures

(1) Rail Failures :

(a) Definition of a rail failure : A rail is said to have failed if it has fractured in track or it is considered necessary to remove it from track on account of defects other than those due to accidental damages due to buckling, kinking, derailments, abnormal wheel burns etc.

(b) Action to be taken in case of rail failures : When a rail fails in track, action as detailed in items (I(ii) and (iii) below is to be taken :

(i) Entry in the JE/SSE/(P.Way) section register as detailed in sub para (c) below.

(ii) Preparation of a detailed report of the failure in cases where applicable as laid down in *sub-para(d)* as mentioned below.

(iii) Detailed metallurgical investigation in cases, where applicable, as per *sub-paras (d) &(e)*

(c) Register of rail failures : All the cases of rail failures have to be entered in the section register by the JE/SSE (P.Way). For this purpose all failures whether in running lines, points and crossing rails etc. irrespective of type and age of the rails, have to be entered in the section register. This record is intended to serve as a basic record which should be available in the office of the JE/SSE (P.Way) and will serve to furnish data, if required subsequently for any statistical analysis or for framing out proposals for track renewal works. Care should therefore be taken by the JE/SSE(P.Way) for filling up all the details as per JE/SSE(P.Way) Section Register and entry into Track Management System (TMS). The ADEN concerned shall call for the SSE's (PWI's) register once every year and initial the same in token of his perusal.

(d) Reports of rail failures : In addition to the record maintained in the section register, as detailed above, a report has to be prepared in TMS *(Fig. 8.31)* in all cases of rail failures occurring in track with the exception of the cases noted below :

(i) Rail failures occurring in non running lines.

(ii) Non standard and obsolete rails.

(iii) Rails removed due to casual renewals on account of accidental damages to the rails such as wheel burns and scabbings, buckling, kinking, derailments, abnormal slipping of loco wheels, excessive wear, loss of section by corrosion, battering, elongation of holes.

(iv) Machined rails such as mitred joints, switch expansion joints, switches and crossings.

For this purpose, the JE/SSE(P.Way) will prepare a 'Rail failure' Report in TMS. In case of failures requiring metallurgical investigation, the report should be prepared in quadruplicate, the extra copy being sent to the Chemist and Metallurgist of the Zonal Railway along with the samples as detailed in the *sub-para (f)* below. Efforts should be made by DEN so that the report reaches the Director (M&C)/RDSO within a month of the rail failure. The Director (M&C) will arrange to carry out annual numerical analysis of rail failures from the reports received from the JE/SSE(P.Way) and the Chemist and Metallurgist and publish reports with suggestions for reducing failures.

Sketches illustrating the fractures will be prepared and submitted with the failure reports on each case, care being taken that the running face of the rail is indicated thereon.

In most cases, it is possible to determine the cause of the failure by visual examination/ultrasonic detection without the need for metallurgical investigation. However, in cases mentioned in *sub-para (e) below*, it is obligatory to take up full metallurgical examination by the Chemist and Metallurgist of the Railway concerned with a view to ascertaining the exact cause of failure. In such cases the rail failure report should be made out in the prescribed pro forma inserting the most probable code of failure and indicating whether the sample has been sent to the Chemist and Metallurgist for metallurgical investigation.

or the cases of rail failures detected visually, a short piece of rail approximately 2 m. long has to be sent to the Zonal Railway Chemist and Metallurgist by the JE/SSE(P.Way) direct, along with a copy of the rail failure report only for such cases which come under the category listed below. In other cases, i.e. those detected by ultrasonic flaw detectors, the rail pieces have to be sent for metallurgical test only from those rails which are removed from track based on the criteria for renewal of rails and falling in the category listed below. The test pieces for metallurgical examination are to be sent only for rail failures which occur within 10 years of primary renewals and for which detailed reports are to be prepared. To sum up, before sending the test pieces to the Chemist and Metallurgist, it should be ensured that :

(i) The rail failure is within 10 years of primary renewals;

(ii) The rails have been removed from track as a result of visual or ultrasonic detection;

(iii) The failures fall only in categories listed under para (e)below:

(iv) The rails where rail/weld failure is a prima facie cause of the train accident should be sent to RDSO.

In cases of failures of imported rails occurring within guarantee period, stipulation of *sub para (f)* to be followed.

__Fig. 8.31__ Weld fracture format in Track Management System

(e) Type of rail failures for which metallurgical investigation is required :

All the fractured rail/weld pieces of 150mm length on each side of fractured face, except those attributable to known extraneous causes such as fractures resulting from accidents, series of fractures resulting from passage of flat wheels, etc., shall be sent to Chemist and Metallurgist for detailed investigation in the following cases:

(i) Rail failure within 5 years of primary renewal/Spate of premature rail failures.

(ii) Weld failure within one year of execution.

(iii) Repetitive rail fractures of same rolling mark

(iv) The following type of rail failures:

- 100/200 - Transverse breakage with apparent origin (sudden breakage)
- 1212/2212 - Head, surface, shallow surface defect (line).
- 1321/2321 - Web horizontal crack at top fillet radius.
- 1322/2322 - Web horizontal crack at bottom fillet radius.
- 1323/2323 - Web horizontal crack not at fillet radius.
- 238 - Web diagonal cracks not at hole.

- 253 - Foot, vertical, longitudinal crack in foot half-moon break
- 1511/2511 - Foot transverse break at rail seat.
- 1512/2512 - Foot transverse break not at rail seat.
- 111/211 - Internal Flaw in head, transverse breakage
- 112/212 - Internal Flaw in head, horizontal crack
- 113/213 - Internal Flaw in head, vertical longitudinal split
- 133/233 - Web, vertical longitudinal splitting
- 139/239 - Web, lap
- 153/253 - Foot, vertical longitudinal split.

(f) Failure of imported rails within the Guarantee period: In all cases of failure of imported rails, occurring within the guarantee period, irrespective of the type of fracture/flaw a 2 m piece containing the fracture/ flaw detected visually or by ultrasonic flaw detector, should be sent to the Chemist and Metallurgist together with a rail failure report for metallurgical investigation.

(g) Procedure for sending samples for metallurgical investigation: In case of fractured rail, both the pieces containing fractured faces should be sent to the Chemist and Metallurgist for investigation. To avoid damage in transit, the fractured faces shall be protected with mineral jelly and suitably covered with hessian cloth. Cracked rails may also be suitably protected at the crack location to avoid damage in transit. Pieces having internal defects may be dispatched as such.

The Chemist and Metallurgist of the Railway will carry out metallurgical investigation, as required, and forward one copy of the report each to the Chief Engineer of the Railway and the Director (M&C)/ R.D.S.O.

In case of failures of imported rails within the guarantee period, attributable to manufacturing defects as revealed by metallurgical investigation, the Chief Engineer should immediately lodge a provisional claim with the manufacturer pending Director (M&C)'s confirmation of the findings submitted by the Chemist and Metallurgist of the Railway. The Director (M&C)/ R.D.S.O. will scrutinise the report submitted by the Chemist and Metallurgist and if he agrees with the findings as submitted, inform the Chief

Engineer accordingly. Where the Director (M&C)/ RDSO feels the need for carrying out further investigation before giving his verdict, he will call for the sample from the Chemist and Metallurgist of the Railway and carry out confirmatory tests, as necessary and intimate the findings to the Chief Engineer. On the basis of Director (M&C)'s advice, the Chief Engineer will then finalise the claim with the manufacturer.

In case of failures of rails other than imported, the Director(M&C)/RDSO will call for samples from the Chemist and Metallurgist, for confirmatory test, where necessary. Based on the trend indicated by the numerical analysis of the rail failures for the period under review, the Director (M&C) will bring to the notice of the indigenous manufacturers and D.G.S.&D. any predominance of failures attributable to manufacturing defects, to enable corrective action being taken.

All the failure reports and defects detected are required to be compiled. Each weld failure shall be analysed by sectional Sr. DEN/DEN, to ascertain whether the failure is sudden, due to impact or inherent defects such as lack of fusion, micro porosities, formation of fin etc. The data including causes, nature and frequency of defects shall be analysed and managerial decisions required for preventive/ corrective action shall be taken promptly.

806. USFD Testing of Rails / Welds :

(1) Ultrasonic testing of rails is specialized activity and the inspectors carrying out the ultrasonic testing of rails shall be trained by RDSO, in the technique of USFD testing. Each zonal railway shall create adequate number of ex-cadre posts of inspectors to ensure that entire track length in their jurisdiction is ultrasonically tested at the laid down periodicity.

Detailed instructions for ultrasonic testing of rails and welds are contained in the latest Manual for Ultrasonic Testing of Rails and Welds, which along with its correction slips may be referred to It is very important that instructions contained therein are carefully studied by the Permanent Way Officials connected with the laying and maintenance of track.

(2) USFD Testing of Service Rails: No rail untested by USFD shall be laid in the track whether for new lines or layouts or renewals or for repair works or even temporarily such as service rails for PQRS work. For repairs and casual renewals, location-wise imprest of tested rails of various lengths (13 m, 9 m, 6 m) shall be prescribed for each JE/SSE(P.Way) by Sr.DEN/DEN.

(3) On Indian Railways, flaw detection by ultrasonics is carried out with the help of two different types of equipments viz. single rail tester and double rail tester. The single rail tester has been utilised on Indian Railways for over 40 years and the double rail tester is of a relatively recent origin (developed ten years back)

(4) Due to frequent misalignment of probes on the fishplated joints and limitations of detection of bolt hole cracks having unfavourable orientation and size, it is desirable to use 'single rail tester' ultrasonic testing machine for testing of sections having free rail / 2 - 3 rail panels.

(5) Types of Probes:

Seven probes are provided in rail tester i.e. 0°, 70°Center Forward (C F), 70°Center Backward (C B), 70° Gauge Face Forward (G F), 70° Gauge Face Backward (G B), 70° Non-gauge face Forward (NGF) and 70° Non-gauge Face Backward (NGB).

Apart from that 45°, 2MHz probe, is also in use for testing of welds.

(6) Test rig for Wheel Burnt/Scabbed Rails:

For detection of transverse flaws in rail head when rail top surface is having wheel burns/scabs, a test rig with two 45° probes sending beam inward shall be used. The distance between probe index marks in the rig shall be adjustable and kept as 134 mm and 145 mm for 52 Kg and 60 Kg rails respectively while testing. For other rail sections this distance can be computed by multiplying rail head width at 20 mm from rail top by 2.

(7) Tandem Rig for AT Weld Testing :

For detection of vertically oriented defects in AT welds like lack of fusion, a tandem test rig with two 45° probes shall be used.

(8) Procedure for Ultrasonic Testing of Rails:

USFD operators must adhere to the following instructions:

(a) Before testing :

(i) Check the battery condition before start of work. Only fully charged battery is to be used during testing.

(ii) Check proper functioning of all controls of electronic unit i.e. depth range, gain, reject etc.

(iii) Check proper functioning of trolley and probes.

(iv) Check junction box, water outlet, probe cable contact and ensure smooth movement of trolley wheels.

(v) Maintain proper gap between probing face and probe shoe (0.2 mm). Check with the help of a feeler gauge.

(vi) Check probe alignment by keeping the rail tester on the rail.

(vii) Calibrate the instrument weekly and set it for proper sensitivity.

(b) During testing :

(i) Conduct test as per procedure mentioned in manual for ultrasonic testing for Rails and welds.

(ii) Maintain proper alignment of all probes during testing, otherwise false echoes may appear.

(iii) Ensure adequate supply of water for coupling.

(iv) Ensure proper functioning of 0° probes and 70° probes near bolt holes and rail ends at fish plated joints respectively.

(v) Look out for the back echo corresponding to normal probe throughout testing.

(vi) Lift the machine at crossings/change of rail table height at joints to protect the probes.

(vii) Mark the locations found defective as per classification

(9) Procedure for Ultrasonic Testing of Alumino-Thermic Welded Rail Joints:

(i) Testing of weld head/web, which gets covered during through periodic rail testing by SRT/DRT. As per this testing defects detected in weld heads are classified as 'IMRW' and 'OBSW'.

(ii) Periodic testing of complete weld by hand probing of weld head/web and bottom flange, using 0° 2 MHz, 70° 2 MHz, 45° 2 MHz probe (AT weld foot scanning for half-moon shaped defect) and 70° 2 MHz SL probes. As per this testing defects detected in welds are classified as 'DFWO/ DFWR'.

Besides this, welds are also tested after their execution using 0° 2 MHz, 70° 2 MHz, 45° 2 MHz probe (AT weld foot scanning for clustered defect/ micro porosities in web foot region) and 45° 2 MHz (Tandem probe scanning for lack of fusion). This test is termed as Initial Acceptance Test. As per this testing, defects detected in welds are classified as 'DFWO/ DFWR'.

(a) Testing of Weld: After execution of AT weld, welded zone shall be dressed properly to facilitate placement of probes and to avoid incidence of spurious signal on the screen. The top of rail head surface shall be dressed to obtain reasonably flat and smooth surface. The flange of the weld up to a distance of 200 mm. on either side of the weld collar shall be thoroughly cleaned with a wire brush to ensure freedom from dust, dirt, surface unevenness etc.

All the welded joints shall be cleaned and examined carefully to detect any visible defects like cracks, blow holes. Any joint which shows any visible defect shall be declared defective.

(b) The defective joints (DFWO or DFWR) shall not be allowed to remain in service for initial USFD testing of AT welds and subsequent testing within the guarantee period of contract and these joints shall be cropped, re-welded and tested again. The re-welded joints shall be scanned ultrasonically again with the same set of acceptance criteria to ensure freedom from any harmful defects.

(10) Frequency of Testing of Rails and Welds: In view of the revised criteria of the testing, a frequency of 8 GMT has been prescribed.

(a) Frequency of testing of rails:

(i) After the initial testing of rails in rail manufacturing plant, the first retesting need not normally be done until the rails have undergone 15% of the service life in GMT.

(ii) For rails rolled in April 1999 and later, the test free period shall be 25% instead of 15%.

(iii) Whenever, rails are not tested in rail manufacturing plant, the test free period shall not be applicable and the rail testing shall be done at the periodicity given below right from the day of its laying in field. However, the rails having sectional weight and grade equal to or higher than 52 Kg/90 UTS shall be ultrasonically tested covering gauge face and non-gauge face corner of rail head on passage of every 40 GMT traffic during test free period.

(iv) Frequency of testing for all BG (rail head center and gauge face /non-gauge face corner) and MG routes is given following para. For other sections Chief Engineer of the railway may adopt a frequency at his discretion.

(v) Digital double Rail Tester is to be used for testing of 'D' marked rails at reduced interval to be decided by Chief Track Engineer of zonal railway.

(vi) Frequency of rail testing : Frequency of rail testing shall be as under :

Route	Routes having GMT	Testing frequency once in
All MG routes	< 2.5	5 Years
	2.5 – 5.0	3 Years
	>5	2 Years
All BG routes (rail head center and gauge face corner/ non-gauge face corner testing)	<=5	2 Years
	>5 <=8	12 Months
	>8 <=12	9 Months
	>12 <=16	6 Months
	>16 <=24	4 Months
	>24 <=40	3 Months
	>40 <=60	2 Months
	>60 <=80	1.5 Months
	>80	1 Month

(b) Frequency of testing of welds :

The frequency of testing of AT welds shall be as under :

S No	Type of welds	Type of testing	Testing schedule	
2	SKV weld	Acceptance test	Immediately after welding	
3		First periodic test	1 year	
			Routes having GMT	Frequency
		Further tests based on route GMT	> 80	1 year
			> 60 ≤ 80	1½ years
4			> 45 ≤ 60	2 years
5			> 30 ≤ 45	3 years
6			> 15 < 30	4 years
7			0 - 15	5 years

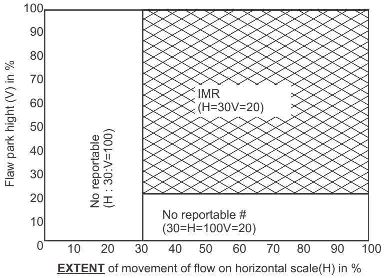
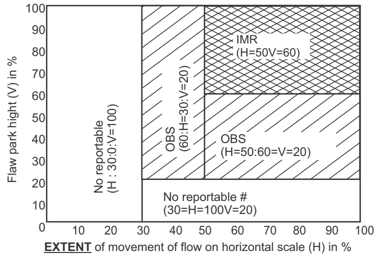
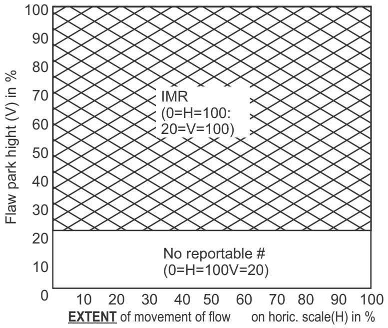
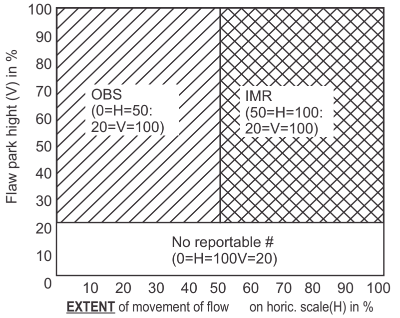
(11) Check list of Ultrasonic Testing of Rail/Welds is given in *Annexure 8/7.*

(12) Classification of Rail/Weld Defect USFD :

(a) The *Table 8.01* indicate the nature of defects, probe used to defect the defect in pattern shown on oscillograph and in classification. Defects occured in rail and welds are shown in *Table 8.01 and Table 8.02* respectively.

Table 8.01: *Classification of rail defects*

S.No.	Probe used	Nature of defect	Oscillogram pattern	Classification
1.	Normal probe 4 MHz (sensitivity set with respect to 100% back wall signal height from rail bottom)	A) Within fish plated area – (i) Any horizontal defect in head web or foot of length equal to distance between rail end and first bolt hole and connected with the rail head.	No back echo before or after appearance of bolt hole echo withFlaw echowith or without multiples OR Drop in back echo before or after appearance of bolt hole echo with flaw echo with or without multiple.	IMR
		(ii) Any horizontal defect connecting both bolt holes.	No back echo betweenbolt hole echo. Flaw echo with or without multiples.	IMR
		(iii) Any defect originating from bolt holes and progressing at an angle towards head-web junction or web-foot junction.	No back echo before or after appearance of bolt hole echo with or without flaw echo.	IMR
		B) Outside fish plated area- a) Any horizontal detect progressing at an angle in vertical plane in the rail at the following locations in the track. i) In tunnel & on tunnel approaches (100 m either side) ii) On major bridges & bridge approaches (100 m) either side the weld	No back echo with flaw echo (shifting/without shifting) for any horizontal length No back echo and no flaw echo. No back echo with flaw echo (shifting/without shifting) for horizontal length < 20 mm	IMR IMR
		b) Any horizontal defect progressing at an angle in vertical plane in the rail at track locations other than (a) above.	No back echo with or without shifting - flaw echo for horizontal length< 20 mm.	OBS
		c) Vertical longitudinal split (piping)	In case of partial/ complete loss of back echo, side probing shall be carried out with 0° probe, if any flaw echo with/ without multiples is observed (in any length)	IMR

2.	70°2 MHz Centre Probe (Sensitivity set with 12mm dia. Standard hole in rail head 25 mm from rail top) For non 'D' marked rails on double/ multiple Line sections	A) Any transverse defect in the rail head at the following locations in the track. i) In tunnel & on tunnel approaches (100 m either side). ii) On major bridge &bridge approaches (100 m) either side. iii) In the vicinity of holes near the weld (50 mm for old AT weld and 75 mm fornew AT weld from the centre of weld on either side of weld) A) Any transverse defect in the rail head at track locations other than 'A' above.	  Details to be forwarded to RDSO quarterly in farmat at para 5.1.3 to be as 'O' on web of rail.
3.	70º 2 MHZ (Centre) Probe (sensitiity set with 12 mm dia standardhole at railhead 25 mm from rail topand withadditional gain of 10 dB there on). For all single Line sections and 'D' marked rails on double/ multiple line sections.	A) Any transverse defect in the following locations in the track i) In tunnel & on tunnel approaches (100 m either side). ii) On major bridges & bridge approaches (100 m) (either side). iii) In the vicinity of holes near the weld (50 mm for old AT weld and 75 mm for new AT weld from the centre of weld on either side of weld) B) Any transverse defect in the rail head at track locations other than'A' above.	 

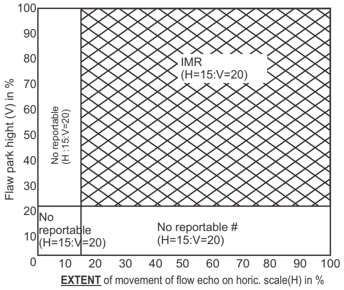
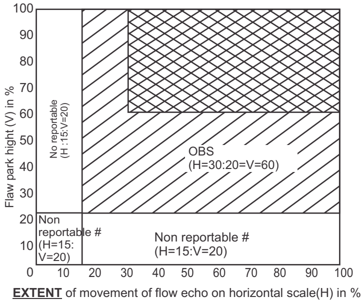
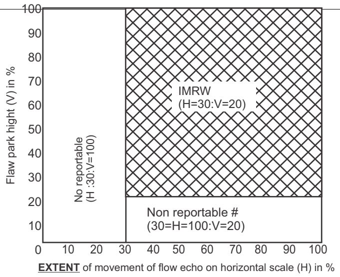
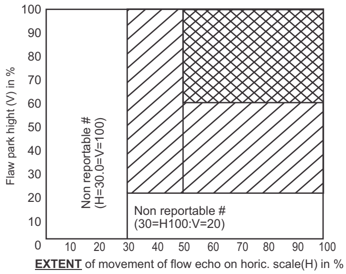
4.	70° probes Gauge Face & Non Gauge Face side (sensitivity set on 5 mm FBH)	A) Any transverse defect in the rail head on gauge face side/non-gauge Face at the following locations in the track. i) In tunnel & on tunnel approaches (100 m either side). ii) On major bridges & bridge approaches (100 m) either side. iii) In the vicinity of holes near the weld (50 mm for old AT weld and 75 mm for new AT weld from the centre of weld on either side of weld B) Any transverse defect in the rail head on gauge face/non-gauge Face side at track locations other than 'A' above.	  Details to be forwarded to RDSO quarterly in format at para 5.1.3 To be as 'O' on web of rail	
5.	45° probes mounted in test rig (sensitivity set to 100% with respect to reflection signal received from opposite face of rail head).	A) Any transverse defect in the rail, head with scabs/wheel burn on top surface, at the following locations in the track i) In tunnel & on tunnel approaches (100 m either side). ii) On major bridges & bridge approaches (100 m) either side. iii) In the vicinity of holes near the weld (50 mm for old AT weld and 75 mm for new AT weld from the centre of weld on either side of weld). Any transverse defect in the rail head with scabs/wheel burn on top surface at track locations other than 'A' above.	Loss of signal height equal to or more than 20% of full scale height. Loss of signal height equal to or more than 80% of full scale height. Loss of signal height equal to or more than 20% of full scale height.	IMR IMR OBS

Table 8.02 : *Classification of weld defects*

S. No	Probe Used	Nature of Defect	Oscillogram Pattern	Classification
1.	Normal probe 4 MHz (sensitivity set with respect to 100% back wall signal height from rail bottom).	A) Any horizontal defect progressing at an angle in vertical plane in the rail at the following location in the track i) In tunnel & on tunnel approaches 100 m (either side). ii) On major bridges & bridge approaches 100 m either side. iii) In the vicinity of holes near the weld (50 mm for old AT weld and 75 mm for new AT weld from thecentre of weld on either side of weld). B) Any horizontal defect progressing transversely in the rail at track locations other than 'A' above.	No back echo with flaw echo (shifting or without shifting) No back echo with flaw echo (shifting or without shifting).	IMRW OBSW
2.	70^0 2MHz (Centre) Probe (Sensitivity set with12mm dia standard hole at railhead 25mmfrom rail top).	A) Any transverse defect in the rail head at the following locations in the track i) In tunnel & on tunnel approaches (100 m either side). ii) On major bridges & bridge approaches (100 m) either side. iii) In the vicinity of holes near the weld (50 mm for old AT weld and 75 mm for new AT weld from the centre of weld on either side of weld) B) Any transverse defect in the rail head at track locations other than 'A' above.	  Details to be forwarded to RDSO quarterly in format at para 5.1.3 To be as 'O' on web of rail	

Note (i) Any defect at any location which is detected by two or more probes and are considered to be classified as OBS/OBSW based on peak pattern of individual probe, should be classified as IMR/IMRW and action shall be taken accordingly.)

(ii) In case two or more OBS/OBSW defects are located within a distance of 4.0 meter from each other, such OBS/OBSW defects shall be classified as IMR/IMRW and action shall be taken accordingly.

(b) USFD Testing using hand probes defect of following classification are grouped w.r.t. probe

(i) By 0°/ 2MHz Double crystal normal probe –

- For any flaw signal obtained by normal probe from the head region,
- Flaw signal 40% and above and up to 60% to be declared as DFWO.
- Flaw signal above 60% to be classified as DFWR.

(ii) For any flaw signal obtained by normal probe from web or foot location,

- Flaw signal of height more than 20% from the web or foot and up to 40% to be classified as DFWO.
- Flaw signal of height more than 40% from the web or foot or more to be classified as DFWR.

(b) By 70° / 2 MHz (Head scanning) –

- A welded joint showing moving signal of 40% or more and up to 60% of FSH shall be classified as DFWO.
- A welded joint showing moving signal of more than 60% of full screen height to be classified as DFWR.

  A bunch of moving signals more than 10% shall also be considered as defective weld & to be declared as DFWR.

(c) By 45°/ 2 MHz Probe (AT weld Foot Scanning) –

Any flaw signal obtained by this probe of 20% height or more shall be classified as defective AT welded joint (DFWR).

(d) Flange Testing by 70°/ 2 MHz Probe –

- A welded joint showing flaw echo of 40% vertical height or more and upto 60% is to be declared as DFWO.
- A welded joint showing flaw echo of more than 60% vertical height is to be declared as DFWR.

(e) By 45°/ 2 MHz Probe (Tandem Probe Scanning) –

Any flaw signal of 40% of full screen height or more shall be classified as DFWR.

(f) 70°/ 2 MHz SL (side looking) Probe - The defect signal of 20% full screen height or more is to be classified as DFWR.

(13)Record Keeping -

Proper record of testing, observations, echo pattern and echo amplitude of defects shall be maintained in the register in the following format. The details should be supplemented with A-scan recorded during testing.

Section .... Line…................................

Km from .... Km to…............................

Date of testing…..

S. No.	Location (Km)	Rolling mark	Rail/ weld No.& LH/ RH	Defect position (head/ web/ foot)	Defect indicated by ($0^0/70^0/45^0$ Probe)	Nature of echo (shift/ fixed)	Echo amplitude/ Travel		Classification		Remarks
							Previous	Present	Previous	Present	

(14) Action to be taken

Following action shall also be taken by JE/SSE(P.Way)/USFD in respect of defective rails & welds.

(a) Action to be taken in case of IMR, OBS, IMRW, OBSW

Table : 8.03 *Action to be taken after flow detection.*

S. No.	Classifi-cation	Painting on both faces of web	Action to be taken	Interim action
1.	IMR IMRW	Three cross with red paint	The flawed portion should be replaced by a sound tested rail piece of not less than 5.5m length (in case of fish plated track) & 4m (in case of welded track) within 3 days of detection.	JE/SSE(P.Way)/USFD shall impose speed restriction of 30 Kmph or stricter immediately and to be continued till flawed rail/weld is replaced. He should communicate to sectional JE/SSE (P.Way) about the flaw location who shall ensure that clamped joggled fish plate is provided within 24 hrs.
2.	OBS OBSW	One cross with red paint	Rail/weld to be provided with clamped joggled fish plate within 3 days. JE/SSE(P. Way)/ USFD to specifically record the observations of the location in his register in subsequent rounds of testing.	JE/SSE(P. Way)/USFD to advise sectional JE/SSE(P. Way) within 24 hrs about the flaw location. Keyman to watch during daily patrolling till it is joggled fish plated.

(b) Action to be taken in case of DFWO/DFWR is shown in *table 8.04.*

***Table 8.04 :** Action to be taken after defect identification.*

Classifi-cation	Painting on both faces of weld (In Head)	Action to be taken
Defective weld 'DFWO/DFWR' with 0^0/2MHZ, 70^0/2MHZ, 45^0/2MHZ or 70^0/2MHZ SL probe, 45^0/2MHZ Tandem Rig.	In case of DFWO, one circle with red paint. In case of DFWR,two cross with red paint.	(i) In case of DFWO weld, a) SSE / JE (P. Way)/ USFD shall impose speed restriction of 30kmph or stricter immediately and communicate to sectional SSE / JE about the flaw location, who shall ensure the following :- b) Protection of defective weld by joggled fish plates using minimum two tight clamps immediately with a speed restriction of 30 kmph. Speed restriction can be relaxed to normal after protection of DFWO weld by joggled fish plates with 2 far end tight bolts (one on each side) with champharing of holes, within 3 days. The joint is to be kept under observation. ii) In case of DFWR following action will be taken :- a) SSE / JE (P. Way)/ USFD shall impose speed restriction of 30 kmph or stricter immediately and communicate to sectional SSE/JE about the flaw location, who shall ensure the following :- b) Protection of DFWR weld by joggled fish plates using minimum two tight clamps immediately. SR of 30 kmph can be relaxed to normal after providing joggled fish plates with two far end tight bolts one on each side with champharing of holes. The DFWR weld shall be replaced within three months of detection. Adequate traffic block should be granted for removal of DFWR welds. In case of non removal within three months, a speed restriction of 75 kmph for loaded goods train and 100 kmph for passenger train should be imposed.

807. Rail Grinding

Rail Grinding is the process of periodic re-profiling of rails by removal of metal from the rail surface in a controlled manner using grinding wheels fixed on an on track grinding machine. During the process, it is ensured that there is no deformation of metal to avoid any change in the mechanical properties of the rail steel.

The target profile of the rail surface is selected to suit the rail wheel interaction. The target rail profile will differ from place to place as the rail wheel interaction will also be different and will depend upon the profiles of the rails, characteristics of the rolling stock, metallurgy of the rails, wear pattern and type of damage on the surface of the existing rails etc. For instance, on straight track, it is desirable to have contact of the wheel on the rail towards the center. For curve track, it is desirable to have rolling radius differential for better negotiability of the vehicle on the track since the distance to be traversed on outer rail is more as compared to inner rail. To achieve this, the contact should shift towards the gauge face on outer rail and towards the non-gauge face on inner rail. The contact on gauge face should not be severe to avoid high stresses. So the target profiles are designed to be conformal with the running wheel.

Rail grinding reduces the contact stresses in the contact patch between the rails and wheels, removes the damaged as well as fatigued steel from the rail top, removes surface defects on the rails, reduces wear of the rails and helps in reducing the propagation of the cracks deeper into the rail head.

Preventive rail grinding is preferred over corrective grinding due to its various advantages such as better productivity of the machine and retention of work hardened layer on rail top. However, to reach to the regime of preventive grinding, preventive gradual approach is to be adopted initially.

One of the very important factors in rail grinding is the frequency of grinding. The frequency of the grinding should be optimal as too frequent grinding will result in wasted efforts in the movement of the machine while the delayed grinding may leave the RCF damage on the rail. In preventive grinding mode, the frequency will be kept high initially till the target rail profile is achieved. Afterwards, the frequency will reduce so as to get a balance between metal removed and the extent of damage between two grind cycles. The frequency of rail grinding depends upon the characteristics of the traffic such as type of rolling stock, axle loads, GMT of the section and also on the track topology. It is important to adhere to the pre-decided frequency of grinding.

(1) Advantages of Rail Grinding

The various advantages of rail grinding are as below:

(a) Rail grinding can be used to reshape the rail head to engineered rail profiles so as to have a favourable rail–wheel interaction, thus reducing the contact stresses and maintain favourable steering of the wheels. This will result in reduction in damage to the rail and wheel surfaces.

(b) Rail grinding will shift the contact of majority of the wheels from the damaged area on the rail, thus avoiding further growth of defects in damaged region.

(c) Rail grinding will avoid the contact of tread of wheel on misaligned welds, thus resulting in reduction in hunting on straight track and avoiding consequent damage.

(d) Rail grinding will remove the cracks in the initial stages of their development, thus avoiding their growth deeper into the rail and reduction in rail/weld failures. The cracks will not be allowed to grow in high growth zone and will be ground in initial stages when their growth is slow.

(e) With the passage of traffic, the rail radius gets flattened and tends to go towards wheel radius. This results in large lateral slip of wheel causing hunting and damage on rail surface. Rail grinding will restore the rail crown radius, thus reducing lateral slip of wheel on the rail surface.

(f) Rail grinding will remove the white martensitic layer on rail top which is the cause for development of cracks due to its brittle nature.

(g) Due to difference in hardness of rail, weld and heat affected zone dip formation starts in the vicinity of the weld due to differential wear. This weld dip also promotes rolling contact fatigue in various forms. Thus dip formation will be avoided by regular rail grinding.

(h) Rail grinding will help in reduction of wear due to reduced contact stresses by adoption of engineered rail profiles.

(i) Wherever other surface defects such as wheel burns, scabs, low or high welds etc. exist on rail, grinding will help to taper down the defects after each grinding pass so as to reduce the damage due to these defects.

(j) The rail surface will become smooth resulting in better riding.

(k) The reliability of detection of internal defects by USFD will improve due to smooth rail surface.

(l) The fuel consumption and noise level will reduce due to reduced impact.

(m) The requirement of track tamping will reduce due to better retentivity of track parameters.

(n) There will be lesser pulverization of ballast and the requirement of deep screening of track will reduce.

(2) Works to be done before grinding:

Important works to be done as pre-requisite to grinding are listed below.

(a) Infrastructural facilities such as stabling rail grinding machine, arrangement for watering and fuelling of machine, arrangement of spares and consumables for the machines etc. are required to be made in the sections planned for grinding.

(b) Marking Obstructions in Grinding -Few locations in the track are to be left while grinding and the grinding motors need to be lifted on these locations to avoid damage to track structure as well as grinding equipments. These locations are turnouts, SEJs, level crossings, curves with check rails and axle counters. These locations are to be marked with paint (say red colour) prominently on the track for the guidance of grinding operator. The start and end of the curve should also be marked with a different colour paint (say yellow) on the sleepers prominently where a different pattern has to be selected.

(c) Collecting Track Details - The chainages of the start and end of the curves, turnouts on main line, SEJs, level crossings, axle counters and degree and direction of curves should be collected as these are required as input for the software of the machine. The direction of the curve should be seen in the direction of increasing kilometers and not in the direction of movement of traffic.The history of rail/weld failures, USFD defects in rail/welds, rail replaced for any other reasons, etc. should be compiled. The track stretches, which will be skipped during the grinding should be identified. These stretches may consist of the locations with rails due for renewal or where corrosion of the rails is very high. A typical track patch of about two kms should be identified in the section of every PWI where grinding will not be done so as to compare the condition of unground track with the adjacent ground track in long run. These selected stretched should be provided with boards for easy identification.

(d) Establishing Test Sites - Test site is a location, which is established in the track as a representative track location where intense monitoring and measurement will be done before and after grinding to monitor the quality of rail grinding and decision making for corrective action. The deterioration pattern and the defect generation at the selected test site should be representative of the rails in general. Location should be taken near the TP pole so that if paint goes away even then locations can be identified.

With the help of monitoring at these locations one should be able to decide the appropriateness of the metal being removed from the rail surface vis-à-vis growth of rolling contact fatigue cracks, the effectiveness of the grinding pattern to achieve the target rail profile and to control the grinding cycles to optimum frequency. The test sites are established to represent the track in a typical curvature and a typical rail type. It means there should be separate test sites for 52 kg and 60 kg rails, separate test sites for straight and curved track and in curves also separate test sites for mild and sharp curves should be established. Similarly, there will be separate test site for each rail on both UP and DOWN tracks opposite to each other.

Three locations should be marked in a straight track separated by about 100 meters or so from each other. If the curve is less than 1 km length, 3 locations should be marked; otherwise 6 locations may be marked. Once test site is developed, rail may be painted on non- gauge face for RGM test site. In all; three sleepers spacing are to be painted yellow and it should be clearly mentioned that one location each for surface photograph, dye penetration test, miniprof with particular location mark for miniprof.

The test sites can be representative of 10-20 or 50 kms of track depending upon the broad changes in the traffic pattern, age of rail and damage on rail surface. Typically we may have one test location in each SSE/(P.Way) section for straight track, mild curve and sharp curve each. The test site should have easy access by road so that one is not dependent on train/trolley to go or reach these locations. The rail should not be planned for replacement in the near future, say within the next 3-4 years so that the effect of rail grinding can be studied for a longer period. The test site should have typical traffic and speed potential and should be away from weld/ fish-plated joints, signal locations, Level crossings, yards, bridge approaches, etc. The history of defects, failures, rail surface damage etc should be established at test sites to the extent possible.

(3) Monitoring Rail Grinding:

It is to be ensured that the amount of the metal removal is optimum since any excess metal removed will shorten the rail life and inadequate metal removal will result in non-removal of the surface defects. So the quality of rail grinding is to be monitored closely by the field engineers to ensure its efficacy and optimum metal removal is necessary.

(a) Test Sites Measurements

A typical test site is represented in the *Fig. 8.32* below. It consists of 3 sleeper spacing - one for measuring rail profile by MINIPROF (Marked as MP), second for taking surface photographs and the third for doing Dye Penetration Test and taking photograph. In fact, we will have 3 such spots at the interval of 80 to 100 m apart to constitute one test site. Since we are going to take important decisions based on the measurements being at these locations, it is a prudent to monitor three spots instead of one for better reliability. Also in case the rail at one of the locations gets changed due to rail fracture etc, the other two spots will be available for further monitoring. The test site shall be established on both the rails of a track and on all the tracks in case of double/ multiple tracks. The measurements at the test sites are to be taken within 15 days before and after grinding. *(Fig. 8.32)*

Fig. 8.32- A Typical test site

A separate file should be made for each test site location and the data should be recorded chronologically for all the items discussed here so that it can be readily studied as to how the rail condition has been changing with the grinding.

(b) MINIPROF Measurement

The first spacing of the test site is marked as 'MP' and a arrow is painted here. This is the location where rail profile will be measured every time before and after grinding. A typical rail profile measured by Miniprof is given in *Fig. 8.33 & 8.34*.

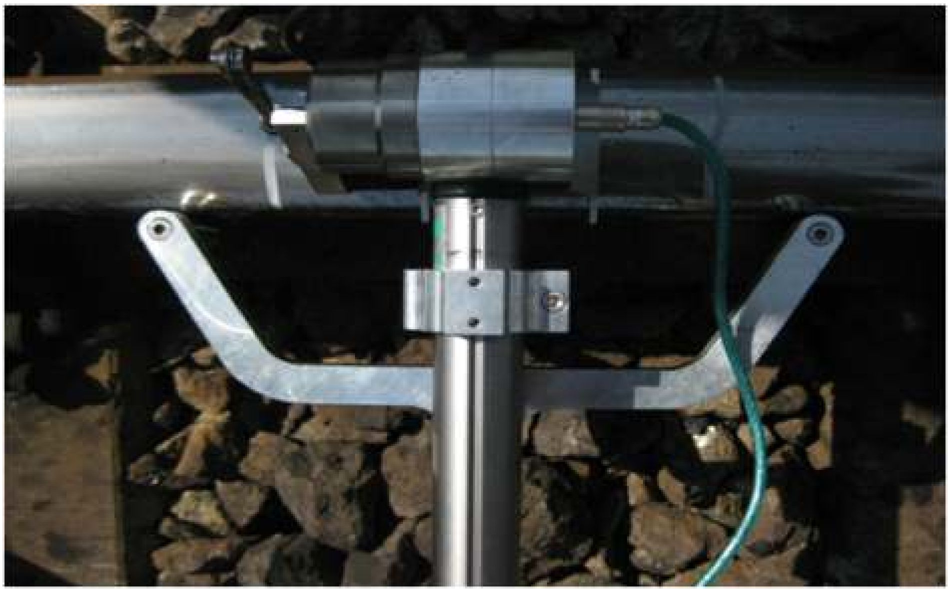


Fig. 8.33 *-Measurement by Miniprof*

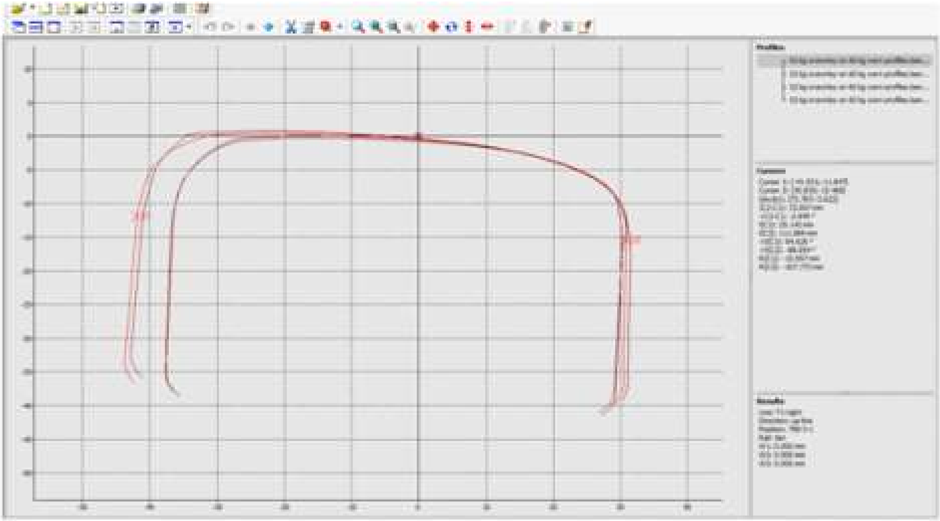


Fig. 8.34 *- Rail profiles measured by MINIPROF*

(c) Dye Penetration Test

At the second spacing of the test site, dye penetration test is done so that the damage on the rail surface including the cracks will become prominent. The dye penetration test uses 3 step process, viz. application of cleaner, application of dye penetrant and application of developer. After the test, details such as date, location, tangent or curved track (degree also), left/right rail or inner/outer rail, GMT carried, rolling year of rail, length of RCF cracks etc are written with a marker pen as shown in the figure and a photograph is taken with a digital camera . The gauge face side and direction of traffic is marked by arrows on the rail head as shown. Dye penetration test is carried out before and after grinding. After the grinding, the test should be done only when the rail surface has become smooth, i.e. 10-15 days after grinding. *(Fig. 8.35)*

Fig.8.35 - *Photograph taken after DPT*

(d) Surface Photograph

In the third sleeper spacing at the test site, the railhead is cleaned and the fixed details as given above in the dye penetration test process are written with the marker pen and a photograph taken with a digital camera before as well as after grinding. *(Fig. 8.36)*

Fig. 8.36 *- Surface photograph*

(4) Deviation from Target Rail Profile

The closer is the profile of the rail to the target after the grinding, the more will be the benefits accruing from it. So we need to monitor the deviation of the after grounded profile with the target profile. This will also help in decision making in choosing the pattern etc. for the future. A deviation of + 0.3 is generally considered as acceptable.

The deviation is measured with the help of the relevant template on the bar gauge and the gap is measured by a tapered or a feeler gauge. We have adopted preventive gradual mode of grinding, we will achieve the target rail profile will be archived after few cycles. *(Fig. 8.37 & 8.38)*

Fig. 8.37 *- Bar gauge having four templates*

Fig. 8.38 - *Measurement using bar guage*

(5) Monitoring Rail Crown Radius

The rail crown radius should be measured with the help of star gauge before and after the grinding. The crown radius will be more before grinding and should reduce after grinding. *(Fig. 8.39)*

Fig. 8.39 - *Star gauge*

(6) Monitoring Contact Band

Without grinding the wheels make contacts on the rail surface arbitrarily and the whole rail top is shining since different wheels are making a contact with the rail at different locations. The contact of the wheel on the rail should change after the grinding. Most of the wheels should make a contact on rail within a defined band. So a clear change in contact band should be visible. The contact band is to be monitored at isolated locations in curve and on straight track before and after grinding. It can be done by spraying the paint or chalk marks on rail surface and allow a freight train pass over it. The paint will vanish at the locations where wheels have made contact on rail top. Thus the contact band is visible. Write down the details of location, date, width of contact band, distance from gauge face etc. and take a photograph. *Fig. 8.40* shows a contact band photograph after passage of a goods train after the grinding.

***Fig. 8.40** - Photograph showing contact band details after grinding*

(7) Rail Surface Finish after Grinding

The condition of the rail top after grinding gives a lot of clues about the quality of grinding. A good finish should have regular grind marks of the wheels (these are known as facets) with silver finish. A bad finish will have irregular marks or skipped grinding at regular interval or blue colour on rails at certain location (known as blueing defect) or irregular facet width etc. The facet width (the width of the marks left by grinding wheels) should be about 10mm in the center of the rail and 4mm at the corners. *Fig. 8.41, 8.42 & 8.43* illustrate different rail surface finishes.

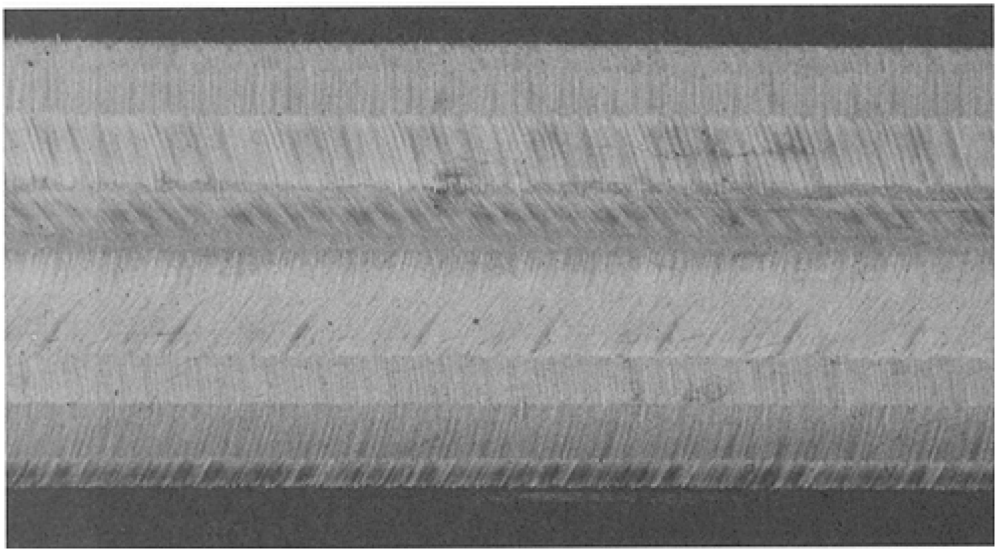


Fig. 8.41 *- A good surface finish after grinding*

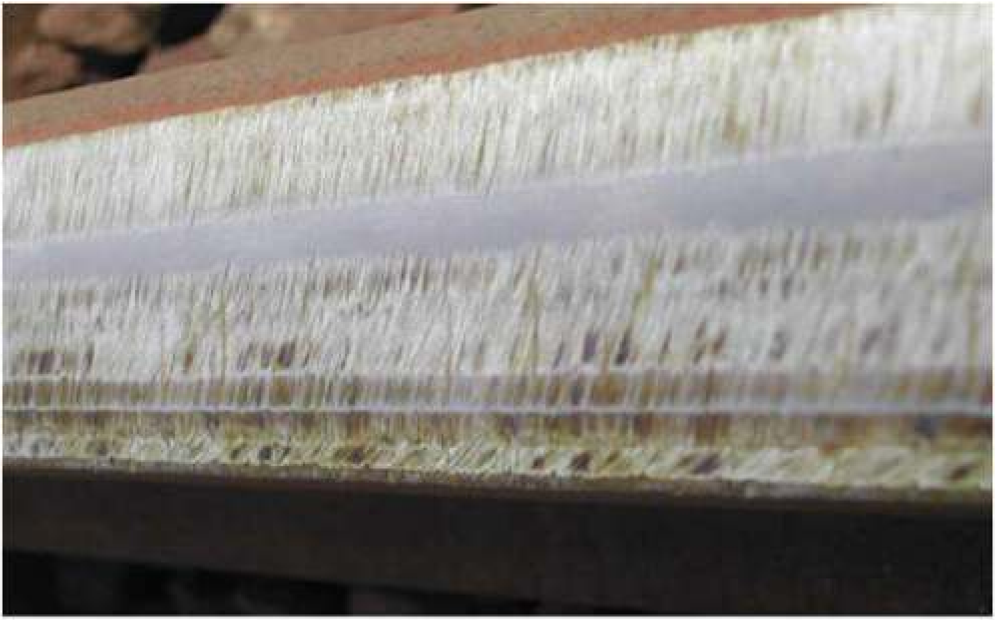


Fig. 8.42 *- Poor surface finish after grinding – skipped grinding*

***Fig. 8.43** - Skipped grinding & blueing of rail*

(8) Surface Roughness after Grinding

The rail surface should not become too rough after the grinding. NRC has prescribed that the surface roughness level should not go beyond 12 microns after grinding. So the surface roughness should be measured at isolated locations especially where the finish is poor.

(9) GQI before & after Grinding

Grind Quality Index (GQI) is a measure of the efficacy of the grinding process. GQI gives an indication as to how close or away ground rail profile is with respect to target rail profile. GQI value of 100 indicates that the target profile has been achieved within the specified tolerances. Lower the value, more is the deviation. The machine is equipped with profile measurement systems and a software to provide GQI continuously before and after grinding.

(10) Filling-up RDSO Proforma for Grinding

RDSO has issued a proforma *(copy attached as Annexure 8/9)* to be filled-up by the field units for monitoring of the Rail Grinding. The items given in the proforma are similar to those discussed above. The proforma needs to be filled every time before and after grinding and a copy (soft as well as hard) should be sent to RDSO for studying, decision making and issuing necessary guidelines to the field.

(11)Monitoring Fire Hazards

Due to lot of sparks generated during the grinding, cases of fire may take place in the section. This should be taken care of by proper watch and taking necessary action. As brought out earlier, there are adequate arrangements on the machine for quenching the fire. To reduce the cases of fire, tie spray and ditch spray systems on the front of machine should be ÓN' so as to make everything wet before grinding.

(12) Watch Grinding History

The grinding machine produces the history of the work done during the day giving the details of the track km, location, pattern used for each pass, speed of grinding and GQI before and after grinding for both the rails. This should be studied and see that the parameters selected were alright and GQI has improved after grinding in general. At isolated locations, GQI may reduce marginally, may be due to the error of measurement etc. A sample grind history sheet is attached as *Annexure 8.10.*

(13)Monitoring Rail Grinding

This will include the accurate measurement of rail profiles with the help of 'Miniprof' or a similar equipment, checking the profile of the rail using 'Bar gauge', monitoring the rail table radius using 'star gauge', measurement of roughness of rail top after grinding, monitoring grind quality index (GQI) during the run, watching fire in the section etc. The intense monitoring of the effect of grinding on the rail is done by establishing fixed representative locations in the track known as 'test sites'. In addition to miniprof measurements, dye penetration test and surface photographs are to be taken at test sites. A shift in the contact band indicating better rail wheel interaction should also be visible after grinding. The rail top should be observed for any visible defects like 'blueing of rail' etc.

(14)Permanent Test Sites

On last spacing of sleeper location, the existing profile of the rail shall be taken using MiniProf for the rail. Rail profiles at three locations each separated by at least two pole lengths, in the tangent or curve using the Miniprof is to be taken.

These locations are to be maintained as permanent test sites for future measurements. Besides taking data before and after grinding, observation and monitoring of test site is required to be done every three months.

(15) Records to be maintained for rail grinding machine

(a) The Performa for observation and monitoring of test sites has been given in *Annexures 8/9.*

(b) Clarification of some points is as below:

(c) The gauge face wear is measured at the gauge corner i.e 13 mm below the top table of rail.

(d) The condition of lubrication is recorded.

(e) Crown radius of the rail head top is measured using the star gauge.

(f)· The nearby welds are measured for their quality for dips and misalignments if any on 1meter long straight edge and measurements recorded.

(g) Corrugations on rail top table are inspected visually and if any corrugations are noticed, the same are measured for length & depth using straight edge .

(h) Hunting RCF is the RCF which is noticed in a cyclical manner on the rail top and its wavelength is to be measured manually using visual approximation.

- *Defective rail/weld is ticking time-bomb, get rid of it before it explodes.*

Annexure 8/1
{Ref. Para 804)

Proforma for measurement of liner bite/corrosion of rail

Division Section Between stations

Track structure (rail) Sleeper density Annual GMT

Whether corrosion prone area (Yes/No)

Date of recor ding	Loca tion (KM/ TP)	Slee per No.	Corrosion depth in mm								Remarks with signature
			Left Rail				Right Rail				
			Vertical		Lateral		Vertical		Lateral		
			GF	NGF	GF	NGF	GF	NGF	GF	NGF	
1	2	3	4	5	6	7	8	9	10	11	12

Annexure 8/2
{Para 804)

Zinc Metalisation for new rail followed by protective coating of Zinc Chromate & Aluminum paint.

1.0 In metalised protection, a sacrificial layer of metal e.g. zinc is provided on the surface of the parent metal. This layer is lost due to corrosive action, while the base metal (steel) remains unaffected Zinc in the form of wire is fed into an oxyfuel gasflame in a special tool and the molten metal is atomized in a stream of compressed air and sprayed on to the previously prepared surface.

2.0 Surface Preparation:

2.1 The adherence of flame sprayed coatings to the base depends upon mechanical interlocking of the first layer to the interstices of the roughened surface. For attaining a high degree of adhesion, careful attention should be paid to the surface preparation.

2.2 Cleaning Prior to Blasting – Grease, paint and other foreign matter should be removed from the area to be sprayed as well as the adjoining areas. If these are not removed from the surface prior to grit blasting, they may contaminate the grit. On re-circulation of the grit, the surface may be re-contaminated and this will prevent attainment of the required standard of surface cleanliness.

2.3 A chemical solvent, such as trichloroethylene or carbon tetrachloride, or heating or a combination of solvent cleaning and heating should be employed for cleaning the surface, prior to blasting.

2.4 Blasting with abrasive material shall be adopted for removing all existing corrosion and foreign material.

2.5 Abrasives for Blasting:-

2.5.1 Sand, special crushed slag, flint or garnet is used outdoors where the abrasive cannot be reclaimed and re-used. It should be hard, sharp and angular as might be produced by crushing. Round silica sand or similar materials should never be used.

2.5.2 Crushed steel grit is most commonly used where the abrasive may be reclaimed. Round steel shot or rounded grit should never be used. Aluminium oxide is also used where it may be reclaimed. All abrasives should be clean, dry and free from oil or other contamination.

2.5.3 Sizes:

a) Sharp coarse sand – The grain size of sand should be between 600 microns and 1.70 mm; a minimum of 40 per cent should be retained on a 850 micron IS Sieve.

b) Chilled iron grit – Grit Grade G-C 100 to G-C 42.

c) Aluminium oxide – The grain size should be between 300 microns and 850 microns; a minimum of 40 per cent should be retained on a 425 micron IS Sieve.

2.6 Blasting Method:

2.6.1 Common blasting methods in use for metal spraying are pressure blasting and centrifugal blasting (airless blasting). While pressure blasting is suitable for manual or mechanized operation, centrifugal blasting is used only as a mechanized system. The standard of cleanliness and surface roughness as prescribed in IS:5905 – 1970 should be maintained.

2.6.2 A fully mechanized blasting system either based on pressure blasting or centrifugal blasting shall be deployed.

2.7 The final surface roughness achieved shall be comparable to roughness with a reference surface produced in accordance with Appendix A of IS:5905 and shall provide an adequate key for subsequently sprayed metal.

3.0 Zinc Metalisation:

3.1 At least one layer of the coating must be applied within 4 hours of blasting and the surface must be finished to the specified thickness within 8 hours of blasting.

3.2 Uniform zinc spray with pure zinc wire of suitable dia to IS:209 –purity 99.9% is given with a spray gun. Zinc wire is fed into High Temperature zone of Oxy-Hydrogen flame just inside the nozzle of the spraying gun. Compressed air is admitted into the nozzle to atomize the metal and to force it against the surface to be coated. The advantage of coating metal by this method is that thickness of the sprayed film can be controlled. The nominal thickness of the coating shall be 140-150 microns. The minimum local thickness shall not be less than 115 microns i.e. 75% of the nominal thickness.

3.3 The operating conditions, such as wire speed, gas pressure and flame conditions recommended by the manufacturers of the pistol should be strictly adhered to. The practice of increasing spraying rates over those recommended, by increasing gas pressure, should be avoided as this may lead to poor results.

3.4 The specified thickness of coating shall be applied in multiple layers, not less than two. The surface after spraying shall be free from uncoated parts or lumps of loosely spattered metal.

4.0 Painting Over Metalised Rail:

After metalising, the rails are to be painted with 4 (four) coats of paint as follows:

4.1 Within 4 to 6 hours of zinc metalisation, Etch Primer to IS:5666 shall be applied preferably by spraying. The material is supplied as two separate components consisting of the base and accelerator to be mixed together before use, in specified proportions. The material is intended to improve adhesion of the next applied coat of paint. Though it possesses corrosion inhibiting properties, it does not work as a permanent protective coating by itself. Thickness of the coating shall be about 35 microns.

4.2 Etch primer shall be followed by a coat of zinc chrome primer to IS:104, applied with spray gun to ensure better quality. The zinc chrome used in manufacturing the primer should conform to type 2 of IS:51. The colour of this coat is yellow and thickness shall be about 45 microns.

4.3 The zinc chromate paint shall be followed by a coat of aluminum paint to IS:2339. It shall be applied with spray gun, to ensure better quality, to a thickness of 35 microns.

4.4 A finishing coat of aluminum paint to IS:2339 is applied with spray gun, to ensure better quality, to a thickness of 35 microns.

4.5 Second, third and fourth coats shall be applied after the hard drying of first, second and third coats respectively. The second coat shall, however, be applied as early as possible.

4.6 The total dry film thickness of all coats is about 300 microns. Metal liners may also be given a similar treatment as done for rails. The rails are treated on both sides of web, flange and bottom of the rail foot.

Annexure 8/3
{Para 804}

Specification for Zinc Metalisation for Rails.

1. Equipment Requirements:

The following equipment is recommended for spraying:

(i) Blasting equipment,

(ii) Set of air, oxygen and fuel-gas hoses,

(iii) Air filter,

(iv) Air regulator with gauge,

(v) Oxygen regulator with gauge,

(vi) Fuel-gas regulator with gauge,

(vii) Oxygen and fuel-gas flow meters,

(viii) Wire reel,

(ix) Necessary safety equipment, and

(x) Metal spraying pistol or gun.

2. Surface Preparation:

2.1 Grease paint and any other foreign matters should be removed from the area to be sprayed as well as adjoining area, for which petroleum hydrocarbon solvent to IS:1743:1978 shall be used.

2.2 Blasting:

2.2.1 Crushed steel grit shall be used as abrasive for blasting. It should be hard, be sharp and angular. Round steel shot or rounded grit should never be used. Chilled iron grit – Grit Grade G-C 100 to GC 42, as per IS:4683 shall be used.

2.2.2 Surface should be thoroughly cleaned and roughened by compressed air blasting or centrifugal blasting with grit as specified in clause 2.2.1. Immediately before spraying, it shall be ensured that the surface is free from grease, scale, rust moisture or any other foreign matter. After blasting it shall have a uniform metallic colour and correspond in appearance to prints designate SA 2 ½ in IS:9954 – 1981 i.e. near white metallic surface. It shall be compared in roughness with a reference surface produced in accordance with appendix 'A' of IS:5905 – 1970 and shall provide adequate key for the subsequent sprayed metal coating.

2.3 Blasting Method:

Blasting method shall be in accordance with IS:6586.

3. Spraying:

The metal spraying should be carried out without delay after the surface has been prepared by grit blasting, but in any case within aperiod that the metal is sprayed on to a surface which is till completelyclean and dry, without visible oxidation, if deterioration in the surface tobe coated is observed by comparison with a freshly prepared metalsurface of similar quality, which has undergone the same preparation,the preparation treatment shall be repeated on surface to be coated.

3.1 Purity of Zinc:

The chemical composition of zinc to be sprayed shall conform to grade 99.5% of IS:209.

3.2 Spraying Procedure:

Procedure followed should be strictly in accordance to as specified in IS:6586 – 1972. All the safety precautions shall be observed.

3.3 Appearance:

The surface of the sprayed coating should be of uniform texture and free from lumps, coarse area and loosely adhered particles.

3.4 Thickness of coating:

The nominal thickness of the coating shall be 140-150 microns. The minimum local thickness shall not be less than 75% of specified nominal thickness.

3.5 Adhesion:

The sprayed metal coating shall be subject to an adhesion test given in clause 4.2 below.

4. Inspection:

4.1 Determination of thickness:

Thickness shall be measured by the commercially available Elcometer. The method adopted shall be in accordance to IS:3203 – 1982.

4.2 Adhesion test:

The sprayed metal coating shall be subjected to adhesion test in the following manner as described in IS:5905 – 1970.

4.2.1 Method of adhesion test:

Using a straight edge and a hardened steel scriber which has been ground to a sharp 30_0 point, scribe two parallel lines at a distance apart, equal to approximately 10 times the average coating thickness. Inscribing the two lines, apply enough pressure on each occasion to cut through the coating to the base metal in single stroke. If any part of the coating between the lines breaks away from the base metal, it shall be deemed to have failed in the test.

5. Retreatment of Defective Areas:

Any defective area shall be cleaned of all sprayed metal by blasting and re-prepared to confirm the requirement of clause 2, surface preparation. Where the defect has been solely due to too thin coating, sprayed metal of same quantity may be added, provided that the surface has been kept dry and is free from visible contamination.

6. Safety Precautions:

6.1 The normal precautions against fumes and dust hazards, such as wearing of mask and proper ventilation should be observed.

6.2 Any warning painted on containers by the paint manufacturers should be observed and the user should consult him in all cases of doubt regarding health and fire hazards arising from the product.

6.3 Grit blasting, METALIZING and painting operation should be carried out in dry weather conditions, painting should not be done during damp and rainy weather without prior approval of Engineer in charge of work.

6.4 Spray coating should be applied without any undue delay and contamination of sprayed surfaces with oil, grease, dirt should be removed before application of first coat of paint i.e. primer.

6.5 The painting surface shall be free from flaking, peeling, cracking and blistering or any other forms of paint film failure.

6.6 Adequate precaution should be taken for operators safety, particularly during grit blasting and aluminum spraying.

6.7 The normal precautions against fumes and dust hazards, such as wearing of mask and proper ventilation should be observed. No special danger arises during the spraying of aluminum and zinc.

7. List of codes referred to:

Sl. No.	Code No.	Subject
1.	IS:5666	Specification for Etch (pre-treatment) primer
2.	IS:5905	Specification for cleanliness and surface roughness
3.	IS:460	Specification for test sieves
4.	IS:2451	Specification for chilled iron grit
5.	IS:5909	Specification for surface roughness grade
6.	IS:209	Specification for zinc
7.	IS:2339	Specification for aluminum paint
8.	IS:51	Specification for zinc chrome
9.	IS:104	Specification for zinc chromate primer
10.	IS:3203	Specification for measurement of paint film thickness.

Annexure 8/4
{Para 804}

R.D.S.O. SPECIFICATION NO. M & C / P C N -111/ 88

Specification for high build epoxy paint (two pack)

1. Scope

1.1 This standard prescribes the requirements and methods of testing two pack high build epoxy paint intended to be used at areas where grit blasting is not practicable. The material shall be suitable for application on a metal surface having surface finish equivalent to DST2 of IS:9954. It should be suitable for application by airless spray but by using suitable thinner it shall be suitable for brush application.

2. Terminology

2.1 For the purpose of these standard apart from the glossary of terms given in IS:1303-63 and terminology as per clause 2 of IS:9162-79 and IS:9954 and clause 2 of IS:101-64 the following shall also apply.

2.1.1 Pack - The term used to describe each of the two packs of the paint which when mixed together form High Build Epoxy Paint.

2.1.2 Paint - The mixture of the two packs ion the proportion recommended by the manufacturer.

3. Requirements

3.1 The mixing ratio of the pack A and pack B shall be in simple ratio by volume.

3.2 Composition : The paint shall consist essentially of two packs namely pack A and pack B.

3.2.1 Pack A: (Normally referred to as base) shall consist of epoxy resin with or without diluents.

3.2.1.1 In the formulation of paint, epoxy resin of the following grade shall be used.

Table -1 : Requirements for epoxy resin

Sl.No.	Characteristics	Requirement	Method of test
1.	Weight per epoxy Equivalent on		
2.	Non-volatile content basis.	180-260	Cl.4 of IS:9162-79

3.2.2 Pack B : (Normally referred to as Hardener) shall consist of any liquid hardener.

3.2.2 Liquid Hardener : This shall be liquid type such as an aliphatic amine, an aliphatic or aromatic amine adduct, a polyamide or amido polymine or any other suitable hardener. it shall react with epoxy resin at normal ambient temperature.

4. Properties:-

4.1 General :- The paint shall comply with the requirements specified in Table II of this specification.

4.2 Unless otherwise specified, the following testing conditions shall apply.

4.3 The preparation of metal panels shall be in accordance with CL. 5.2 to 5.2.1.1 of IS :101-87.

4.2.2 All the tests shall be conducted at room temperature (27±2°C) and a relative humidity at 65+5%, in a well ventilated chamber free from draughts and dust.

4.4 The two components i.e. base and hardener shall be mixed in the ratio recommended by the manufacturer before conducting the tests. Where the paint is required to be applied on panels, it shall be done so by using suitable airless spray/brush application.

4.5 For the preparation of painted panels for conducting different tests mentioned in Table II, the details given in Table III shall be followed:

Table II - Requirements for high build epoxy paint (two pack)

Sl. No.	Characteristics	Requirements	Test Method
1.	Drying time a) Hard Dry, max b) Recoating time, Max	8 Hours 6 Hours	IS: 101-86
2.	Consistency	Smooth and uniform, and suitable for air-less Spray/brush application.	IS: 101-89
3.	Finish	Smooth -matt/ semi-glossy, free from sagging &wrinkling	IS: 101-87
4.	Colour	Buff to Gery	IS: 101-89
5.	Dry Film Thickness percoat, min. a) By brush b) By airless spray	100-125 200	By Elcometer - do-
6.	Volume solids, % .min.	60%	See Appendix-1
7.	Scratch hardness (1.5Kg LOAD)	No such scratch so as to show base metal	IS: 101-88
8.	Flexibility & Adhesion	No visible damage or detachment of film	IS: 101-88
9.	Flash Point for both packs	Above 20°C	IS:101-87
10.	Resistance to salt spray	No sign of corrosion & no sign of deterioration up to2000 hrs	ASTM B-117
11.	Protection against corrosion under Condition of condensation	-do-	IS: 101-88
12.	Keeping properties for both the packs	Not less than 6 months	IS: 101-89
13.	Pot life at 27+2°C, min.	5 hours	See Appendix-II
14.	Mass in Kg / 10 litres,min.	12.0	IS: 101-87
15.	Spreading capacity,min.	3 m / litre	IS: 101-89

Table III - Details of preparing painted panels for Testing of high build epoxy paint (two pack)

S. No.	Test	Type of Metal Panel	Size in mm.	Painting details	D.F.T.	Method of Application	Duration on Air Drying Before Commencement of test	Special Instructions
1.	Dryingtime	M.S.	150x100 x1.25	One coat of H.B. Epoxypaint	125-150 microns	Brush /spray	-	-
2.	Finish	-do-	-Do-	-do-	-do-	-do-	48 hours	-
3.	Colour	-do-	-do-	-do-	-do-	-do-	24 hours	-
4.	Dry FilmThickness a) Bybrush b) Byairless	-do--do-	-do--do-	-do--do-	-do--do-	Brush Spray	-do--do-	-
5.	Flexibility & Adhesion	-do-	-do-	-do-	-do-	-do-	-do-	IS: 101/64
6.	Scratch Hardnees s	Tinned M.S.	150 x 150 x 315	-do-	-do-	Brush/ Spray	7 days	Apply a load 1.5 Kgs instead of 1 Kg as specified in Clause 15.1.2 of IS: 101-88
7.	Resistance to salt spray	M.S.	150x 100 x1.25	-do-	-do-	-do-	-do-	corroded panels to DST 2 of IS9954 to be used which will be wire brushed to remove rust.
8.	Protection against corrosion under conditions of condensation	-do-	-do-	-do-	-do-	-do-	-Do-	

Appendix I

Procedure for determining volume solids percentage in polyurethane paints

Scope:

This method is applicable to the determination of the volume nonvolatile matter of paint coatings.

Significance:

This method is intended to provide a measure of the volume of dry coating obtainable from a given volume of liquid coating. This volume is considered to be the most equitable means of comparing the coverage (square feet of surface covered at a specific film thickness per unit volume) and also for calculating the wet film thickness of the given paint.

Apparatus:

i. Analitical balance
ii. Steel disc – Preferably stainless steel, 60 mm. Dia and 0.70 mm. thickness with a small hole 2 to 3 mm. from the edge. A fine wire such as chromel is attached through the hole and made of the appropriate length for suspending the disc in a liquid.
iii. Weight box
iv. Breaker, 1 litre for weighing the disc in liquid.
v. Weight per litre cup for determining the specific gravity of the paint material and of the suspending liquid if not known.
vi. Oven

Procedure:

i. Dry the disc in an oven at 105ºC for 10 minutes and cool.
ii. Weight the disc in air. Let it be W1 grams.
iii. Suspend the disc in water and weigh again. Let it be W2 grams.
iv. Calculate the volume of the disc V as follows:

$$V = \frac{W1 - W2}{d}$$, where d is the density of the water at room temperature.

v) Determine the weight of nonvolatile content of the liquid coating material by drying a known amount of paint at 105°C for 3 hours. Let it be W grams.

vi) Determine the specific gravity of the paint to the nearest 0.001 g /ml by using weight per gallon cup. Let it be P.

vii) Dip the disc. in the paint sample for 10 minutes and take out the disc and allow the excess coating material to drain off. Blot the coating material off the bottom edge of the disc so that beads or drops do not dry on the bottom edge of the disc.

viii) Dry the disc in an oven for 3 hours at 105^{0} C and cool.

ix) Weigh the coated disc in air. Let it be W3 grams.

x) Suspend the coated disc in water and weigh again. Let it be W4 grams.

xi) Calculate the volume of the coated disc as follows:

$$V1 = \frac{W3 - W4}{d}$$, where d is the density of water at room temperature.

xii) Calculate the volume of the dried coating as follows:

Volume of dried coating (Vd) = V1- V

xiii) Calculate the volume of wet coating as follows:

$$Vw = \frac{W3 - W1}{W \times P}$$, where W = grams of nonvolatile water. P = specific gravity of the paint.

xiv) Calculate the percentage volume solids of the paints as follows:

$$\frac{V1 - V}{Vw} \times 100 \text{ or } \frac{Vd}{Vw} \times 100$$

The volume of non-volatile matter or the percentage volume solids of a paint is related to the covering capacity and thickness in the following manner:

(a) $$\text{Theoretical coverage (sq. m. / litre)} = \frac{\text{\% Volume Solids}}{\text{Dry film thickness (microns)}} \times 10$$

$$\text{(b) Wet film thickness (Microns)} = \frac{\text{Dry film thickness (microns)}}{\text{\% Volume solids}} \times 100$$

Appendix II

Procedure for determining the pot life

It is the duration where the mixed paint shall still be in usable condition, starting from the time of mixing.

Annexure 8/5
{Para 804}

Epoxy Painting For Weld Collars

1. Procedure of Painting:

1.1 Surface preparation:

a) Clean thoroughly with wire brush to remove loose dust and rust and wipe by dry waste cotton.

b) Grease and oil shall be freed from surface by use of solvent like carbon tetrachloride or equivalent to IS: 1745-1978.

1.2 Application of Normal paint

Apply by brush uniformly to a dry film thickness of 40 micron. Paint will not be applied by soaking in cotton waste.

1.3 Application of Epoxy paint

i) A homogeneous mix shall be prepared by mixing pack 'A' in simple proportion like 1:1, 1:2, 1:3 etc. as recommended by the manufacturer.

ii) The mix shall be applied on the prepared surface with airless spray or by hand brushing with suitable thinner to a dry film thickness (DFT) of 100-125 micron and allow to dry for 8 hrs.

Annexure 8/6
{Para 804}

Painting of In-service Rails with Anti Corrosive Bitumen black paint as per IS:9862 with grease around the liner

1. Surface Preparation:

   1.1 The surface preparation of rails is one of the most important prerequisite for the painting to serve the purpose. Surface preparation shall not be done unless the approved paints in sufficient quantities are available in stock at site. Sufficient care should be taken in preparing the surface and is, therefore, required to be done under proper supervision. The surface shall be made free from oil, grease and dust. The surface shall be rubbed with wire brush and sand paper etc. The tools used may be hand or power operated such as scrappers, wire brushes, sand paper; pumice stones, etc. Wire brushing should invariably be done at the end so as to obtain a uniform rubbed surface. The surface prepared may be checked by visual observation for uniformity of surface.

   1.2 Special care should be taken in preparing the surface at the weld collars; liner contact areas. Generally weld collars and liner contact areas are considered most corrosive areas.

2. Surface preparation/ painting shall not be done in the following conditions.

   i. When the ambient temperature is below 10_0 centigrade or above 50_0 centigrade.

   ii. In rainy season.

   iii. During night.

   iv. In winter before 8.00 A.M.

   v. In summer between 11.00 A.M. and 3.00 P.M. on areas that are likely to be exposed to direct sun light.

   vi. Extremely windy/misty/dust blowing conditions.

   vii. Chemicals should not be used for surface preparation.

3. Painting Scheme :

   (i) 1^{st} Coat: Anti corrosive bituminous black paint confirming to IS:9862 – 1981 to a thickness of 100 microns.

(ii) 2^{nd} Coat: Anti corrosive bituminous black paint confirming to IS:9862 – 1981 to a thickness of 100 microns.

4. Method of Painting:

A speed restriction of 30 kmph shall be imposed in a selected stretch and only alternate ERCs are removed either inside of the gauge face or outside of the gauge face. This work should be planned only when rail temperature is likely to be within the range t_d – 20° C to t_d +10° C. At no point of time both inside and outside ERCs even on alternate sleepers should be removed. The work shall be started at around 8.00 hrs. and ERCs shall be removed at alternate sleepers and on completion of surface preparation, bituminous black conforming to IS:9862-1981 shall be applied to a thickness of 100 microns and allowed to dry for 8 hours. Subsequently the second coat shall be applied to a thickness of 100 microns and allowed to dry for 8 hours. The liner and ERCs are fixed to the rails. All the liners shall also be painted with anti-corrosive black after duly cleaning the surface. Similarly, in the same caution order, alternative left over ERCs are removed and painting done as indicated above.

5. Treatment of Rail Surface Near Liner:

In corrosion prone areas, wherever considered necessary, at the time of initial provision as well as annual cleaning of central leg of elastic rail clips, Graphited grease grade ‘O’ to IS:408 shall be applied on the under side of liners as also the corresponding area of the rail foot. To avoid ingress of toilet droppings as well as moisture to the surface of liner and rail foot, grease shall also be applied along the boundary of liner so as to seal the liner boundary. The necessity and frequency of grease application under and around the liners may be decided based on experience.

Annexure 8/7
(Para 806 (11)

Check list for USFD testing

The work done by USFD Inspectors

Date of Inspection:

SECTION ….. DIVISION…………KM/TP…………….LINE……………

Machine used for testing: Single Rail Tester/ Double Rail Tester

Machine make and number:

Track Structure on test location:

Whether Stretch is having D-Marked Rails: Yes/No

SN	Item of Works	Observation/ Values Recorded	Remarks
A.	USFD Team		
1.0	Operator (s)		
1.1	Name		
1.2	Competency Certificate Details		
1.3	Competency Certificate valid	Yes/No	
2.	Adequate staff for handling/ lifting of machines	Yes/No	
B.	USFD Machines & condition		
1.	Machine used is RDSO approved	Yes/No	
2.	Availability of Requisite Tools & plants		
2.1	Sensitivity block	Yes/ No	
2.2	IIW block for calibration	Yes/ No	
2.3	Standard Rail test piece	Yes/No	
3.	Visual Condition of electronic unit	Proper/ Not proper	
4.	Visual condition of Trolley	Proper/ Not proper	
5.	Condition of Probes & shoes		
5.1	Right Hand Side		
(a)	0 degree	Proper/ Not proper	
(b)	70 degree(F)	Proper/ Not proper	
(c)	70 degree (B)	Proper/ Not proper	
5.2	Left Hand Side		
(a)	0 degree	Proper/ Not proper	
(b)	70 degree(F)	Proper/ Not proper	
(c)	70 degree (B)	Proper/ Not proper	
5.3	For Flange testing		
(a)	70 Degree 2 MHz	Proper/ Not proper	
(b)	70 Degree 2 MHz (8mmx8mm)	Proper/ Not proper	
(c)	45 degree 2 MHz	Proper/ Not proper	
5.4	Alignment of probes & Lifting System with respect to centre line	Central/ eccentric	

6.	Check on Characteristics of Machine		
(a)	Date of Check		
(b)	Whether due or not *(Monthly Check)*	Due/ Not Due	
7.	Condition of Battery	Charged/ Not Charged	
8.	Condition of Audio Alarm	Sounding/ not sounding	
9.	All controls of electronic unit i.e. depth range, gain, reject etc. properly functioning	Yes/No	
10	Whether Watering arrangement for probes is functional	Yes/No	
11.	Availability of spares		
11.1	0^0, 4 MHz Double crystal Probes: 8 No.	Yes/ No	
11.2	0^0, 2 MHz Double crystal Probes: 4 No	Yes/ No	
11.3	70^0 (F &B) probes, 2 MHz Single crystal: 8 No	Yes/ No	
11.4	45^0, 2 MHz Single crystal Probes: 2 No	Yes/ No	
11.5	70^0, 2 MHz Single crystal Probes: 6 No	Yes/ No	
11.6	70^0, 2 MHz Single crystal Probes (SLP): 2 No	Yes/ No	
11.7	0^0, 2/2.5 MHz Single crystal Probes: 2 No	Yes/ No	
11.8	Connecting Cable (Flaw detector with junction box): 6 No.	Yes/ No	
11.9	BNC Connector: 6 no.	Yes/ No	
11.10	IIW Block (as per IS:1408): 2	Yes/ No	
11.11	60x50x50 mm steel block (as per steel grade 45 C8 to IS: 1875-1992): 1 no.	Yes/ No	
11.12	Battery Charger: 1 no.	Yes/ No	
11.13	Fuse: 12 No.	Yes/ No	
11.14	Step gauge: 1 no.	Yes/ No	
C.	Check on Sensitivity settings and calibration		
1.	Calibration Check		
1.1	Calibration for 300/200 mm longitudinal wave using 0^0, Double crystal Probe	Proper/ Not proper	

2.3	Rail testing		
(a)	Whether all IMR defects confirmed	Yes/ No	
(b)	If No, number of additional defects		
	Over Reported		
	Under Reported		
(c)	Whether preventive action taken on all defects	Yes/ No	
(d)	Whether all OBS defects confirmed	Yes/ No	
(e)	If No, number of additional defects		
	Over Reported		
	Under Reported		
(f)	Whether preventive action taken on all defects	Yes/ No	
2.4	Weld testing		
(a)	Type of Welds		
(b)	Whether all defects confirmed		
(c)	If No, number of additional defects		
	Over Reported		
	Under Reported		
(d)	Whether preventive action taken on all defects	Yes/No	
2.5	Whether the A-scans of all defects preserved in machine	Yes/No	
3.	Check on day's work		
3.1	Type of Testing	Rail/ weld	
3.2	The A-scans of all defects being preserved.	Yes/No	
3.3	The defects details are properly logged in machine.	Yes/ No	
3.4	Defects are properly entered in Register	Yes/No	
(E)	Schedule of USFD testing and adherence		
1.	Date of last USFD Testing of Inspected Stretch		
1.1	Rail testing		
1.1	Weld testing		
2.	Stipulated frequency of section		
2.1	Rail testing		
2.2	Weld testing		
3.	Whether testing is done as per Schedule	Yes/No	
4.	Proper up keep of defects register has been done	Yes/No	

Annexure 8/8
{Ref. Para 807)

DOs for the Guidelines of Field Engineers

General

Arrange for proper stabling facilities for the machine at about 50 km distance.

Identify the RCDs and plan for timely supply of diesel to the machine.

Ensure that diesel does not spill onto the rubberized spark guards to avoid fire during grinding.

Make the arrangements for supply of water to the machine.

Plan for the adequate traffic blocks for the machine working.

Arrange for all the equipments for taking the required measurements.

Collect the track data for feeding in GDMS software installed in the machine. Note down chainages of the level crossings, SEJs, Points &Xings, Axle Counters, start and end of Curves. Curve direction should be taken in the direction of increasing km irrespective of direction of movement of traffic.

Find out history of the rail wear, surface damage on the rail, USFD defects, rail/weld failures etc in the section where grinding is being done and study the change in these parameters as the grinding is done.

Identify the stretches of the track which will be skipped during grinding like rails planned for renewal in next two years, rails having severe corrosion and liner bite corrosion etc.

Establish test sites.

Open a separate file for each test site in your section. Take measurements at the test sites as per RDSO proforma and keep in file.

Open a register on the machine where all the observations/ defects noticed by the P. Way supervisors and the officers will be recorded and the action taken with date should be mentioned by the machine maintenance supervisor.

Before the Block

Paint the sleeper prominently on either side of the SEJs and at the start and end of the curve.

Arrange for a pilot for the machine working.

Ensure effective communication between FCC, RCC and on the ground.

Counsel the staff and gatemen to keep everyone away from the machine during its working to avoid injury.

Counsel the staff to use safety gadgets such as helmet, goggles, reflective jackets, shoes etc on the track as well as on the machine during machine working.

Measure the rail profile with miniprof, carry out DPT and take surface photograph at each test site before grinding (say within 15 days). Keep these details in the file chronologically.

If the machine is to come back to the yard for the second pass as in case of a curve, co-ordinate with the station master for proper setting of the point to avoid accident.

During Block on Track

Go on a motor trolley behind the grinding machine and look for the fire in track or on cess, if any.

Check for the quality of surface finish visually for any irregular grinding, blueing of the rail, skipped grinding etc.

See the facet width is about 4mm at the corners and about 10mm at the centre of the rail.

Check the surface roughness at bad location and see that it is not exceeding 12 microns.

Check the profile at few places on straight and in curves after grinding with bar gauge and see how close or away we are from the target profile. See whether the profiles are within prescribed tolerances or not.

Check the rail crown radius with the star gauge and see that the radius after grinding is about 250mm.

Check the contact band in straight and curve track at one or two locations before and after grinding. Take a photograph and keep for record.

See that the dust collection system is working properly.

Inform any irregularity noticed to the machine operator and get it rectified.

See that a train with inflammable material is not passed by the controller on adjacent track.

During Block on Machine

Check whether the motor angles, calibration of tachometer and calibration of KLD has been done by the operator as per the schedule. Check yourself before the block once a while.

Check the proper functioning of the water pump and water cannons etc.

Check that all the motor are working properly. The indication comes on HMI panel.

Make a chart in advance for the pattern to be selected during the first pass of the grinding.

Synchronize the chainage of the track on the machine.

See whether the patterns being selected by the operator are correct.

See that the grinding speed is correct.

Check that the operator sequences the motors up and down correctly and promptly on the obstruction.

Check whether the direction of the curve in GDMS software is same as existing on the ground. Do not use GDMS suggested patterns for the second and the third pass of the curve in case the direction is wrong.

Make sure to get the GDMS data corrected if the direction of curve is found to be wrong so that the similar problem is not faced during the next cycle.

See that the patterns are changed promptly on entry and exit of the curves.

Check the GQI before and after grinding and see that generally, there is improvement in GQI after the grinding.

Learn the working of GDMS software including recommendation for the pattern and speed for the II and II pass on a curve.

Check the GQI before & after Grinding.

Check the active pattern selected in real time on the monitor.

Look for any alarm on HMI of the machine and see that corrective action is taken promptly by the operator.

After Grinding

Take rail profile after grinding within 15 days at the test sites.

Carry-out DPT test at test site 10-15 days after grinding and take a photograph. Keep in file.

Take a surface photo at test site 10-15 days after grinding and keep in file.

Preserve the soft copies of miniprof measurements and photographs.

Overlay and Analyseminiprof reading i.e. rail profile before grinding, after grinding and target profile. Calculate the metal cut and deviation from target profile.

Ensure safe disposal of the grind dust in a yard.

Clean the grind dust from the glued joints.

Check for the stone grind marks on the joggle fish plates.

Notice the change in contact band and analyse.

Fill-up RDSO proforma and send to track directorate.

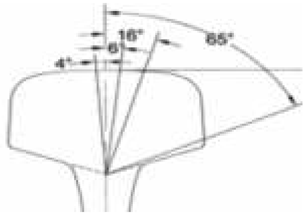
Ensure that the machine engines are not unnecessarily kept running by the machine staff.

Annexure 8.9
{Ref. Para 807)

RAIL GRINDING MONITORING PROFORMA
(Details of Test locations)

Rly…………………..	Divn……………… ……	Section……………………	Km/TP…………
Rail Section/ UTS…………	Type of sleeper…………..	Sleeper density…………..	Ballast cushion…
Tangent/Curved track………	Degree of curve………..	Line(UP/DN)………………	Axle Load………
Total GMT carried………..	GMT(Current)…………..	Date of Last Grinding……	Gauge(in mm)….

Engineered rail profile Template used ………….. Rolling mark of rails…………

S. No.	Item	Observations on Left Rail * *		Observations on Right Rail * *		Remarks
		Before Grinding	After Grinding	Before Grinding	After Grinding	
A	Visual Inspection (severity be indicated)*					
	1.Gauge corner chipping (Y/N)					
	2.Flow of rail top / Burring (Y/N)					
	3.Rolling Contact Fatigue (Visual inspection & Dye Penetration test)					For a) to c)  Field Gauge
	a) Gauge face (65 to 16 deg.) (Y/N)					
	b) Shoulder of Rail (16 to 6 deg.) (Y/N)					
	c) Crown of Rail (6 to -4 deg.) (Y/N)					
	d)Pitch of fatigue cracks (mm)(Range)					
	e)Max. length of fatigue crack(mm)					
	4.Wheel burns and Scabbing (Y/N)					
	5.Any other defect observed					
B	Corrugation (Y/N)					
C	Hunting (Cyclic Wear) (Y/N)					
D	Track Geometry (in mm)					
	1. Gauge					
	2. Cross level					
	3. Unevenness (7.2m chord length)					
	4. Alignment (9.6m chord length)					

* Hard & soft copies of Photographs of the test locations before and after grinding, after Dye penetration test indicating condition of rail (size of defect, location in Km, Line, indication of gauge face, direction of traffic) be sent.

** Indicate Low or High Rail in case of curve.

S. No.	Item	Observations on Left Rail		Observations on Right Rail		Remarks
		Before Grinding	After Grinding	Before Grinding	After Grinding	
E	Type of contact of wheel on Rail (One /Two/Multiple point contact)					
	1.One point contact					
	a) Contact Band Width (mm)					
	b) Distance from gauge face side (mm)					
	2.Two point contact					
	a) Contact Band Width (mm)					
	(i)					
	(ii)					
	b) Distance from gauge face side (mm)					
	(i)					
	(ii)					
	3. Multiple point contact					
	a) Contact Band Width (mm)					
	(i)					
	(ii)					
	(iii)					
	b) Distance from gauge face side (mm)					
	(i)					
	(ii)					
	(iii)					
F	Wear of rail (in mm)					To be measured by Mini Prof
	1. Gauge face					and hard & soft copies of rail
	2. Top table					profiles be sent.
G	Weld dip at nearby location(Same weld to be measure every time)					
H	Roughness (Microns)					To be taken with machine available at RGM, otherwise general observation to be recorded.

NOTE: Corrugation and Hunting should be observed in the block section containing the test sites (few kms on either side of test site)

Date:

(Signature of Inspecting official
with Name/Designation)

Annexure 8.10
{Ref. Para 807)

RAIL GRINDING MONITORING PROFORMA
(Route Specific details)

Railway…………………. Divn……………..Major Section………… From Km/TP………..To Km/TP………….. Line(UP/DN/ Single)…………
Rail section and UTS…………Type of sleeper………..Sleeper density…………….. Ballast cushion……………..Annual GMT………
Start Date of grinding cycle for major section……….. Date of last TRC run……… Axle Load…………..
Completion Date of Grinding cycle for major section………….

S. No.	Item	Tangent Track		Curved Track			Remarks
		Left Rail	Right Rail	Degree of curve	Outer rail	Inner rail	
A	Full details of locations before grinding -						Details be enclosed as per the format location wise (Line & Km details)
	1. Rolling Contact Fatigue (Head checks)						
	2. Corrugation						
	3. Hunting(cyclic wear)						
	4. Other defects (specify type)						
B	USFD Testing details of last grinding interval						
	1. No. of IMR defects in rail						
	2. No. of OBS defects in rail						
	3. No. of IMRW defects in weld						
	4. No. of OBSW defects in weld						
	5. Defect generation rate (DGR) of rails (Nos./km/ year)						
	6. Defect generation rate (DGR) of welds (Nos./km/ year)						
C	No. of fractures since last grinding interval						
	1. Rail						
	2. AT weld						
	3. FB weld						
D	Track Geometry/RI Value before grinding						
	1. Vertical RI						
	2. Lateral RI						
	3. Overall TGI						

Note : The above details be provided for the period between two successive grinding cycles.
Graphs for Rail Defects & Weld defects/km in last 2 years should be plotted for different cycles of USFD testing & attached.

Date:

(Signature of Inspecting official
with Name/Designation)

Chapter 9

Works Incidental to Regular Track Maintenance

901. General :

(1) Maintenance of track involves a number of important ancillary activities / works for effective maintenance system. These works incidental maintenance are required to be done on a systematic and programmed manner. These works enhance the general health of the track, improve maintainability and reliability of the track. The major activities / works incidental to regular track maintenance are as under:

(a) Side and catch water drains and waterway clearance.

(b) Drainage arrangement in station yard.

(c) Lubrication of Rail Joints.

(d) Greasing on sharp curves, ERC's, Screws and other track component needing lubrication.

(e) Counter action and adjustment of creep.

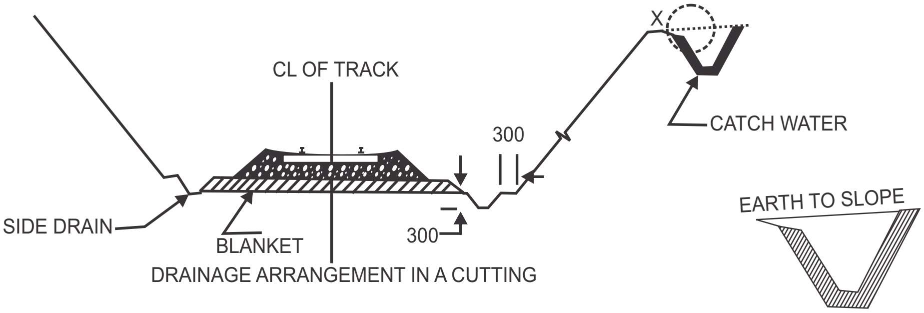
902. Side and Catch Water Drains and Waterways :

(1) For efficient drainage of cuttings, side and catch water drains of suitable type and size should be provided.

(2) (a) Side drains are to be provided in cutting, tunnel and level crossings to drain out the water from track. Normally, there is no need of side drains in case of embankment, however, when height of bank is such that the blanket layer goes below normal ground level, side drains may be required along the track at suitable distance so that the track alignment does not become the channel for flow of surface water. In case of cuttings, properly designed side drains of required water carrying capacity are to be provided. The bottom of side drains should be atleast 30 cm below the formation level. *(See Fig. 9.01)*

(b) Catch water drain is provided on top of the cutting to prevent surface water flowing from top of hill slope towards the track. Non-provision of catch water drain will result in erosion of slope and may also lead to slope failure. Moreover, in absence of catch water drains, side drains will have to be designed for carrying huge quantity of water, which is practically not feasible economically. Therefore, to intercept and divert the water coming from the hill slopes, catch water drains are provided, which runs almost parallel to the track upto a point where the water can be safely discharged off. *(See Fig. 9.01)*

In cutting of black cotton soil and similar soils, catch water drain should be provided sufficiently away from the top of the cutting to avoid any danger of a breach occurring between the drain and the cutting itself. The excavated spoil should be used to form a 'bund' between the drain and the top of the cutting.



Notes:

1. Catch water drains shall be provided on the natural ground level if formation in cutting is likely to get flooded from surface water flowing across the cutting or when depth of cutting is more than 4m.
2. All catch water drains shall be pucca. The expansion joint shall be sealed with Bituminous concrete.
3. All catch water drains shall have section enough to carry 50% more than the required discharge to cater for any blockage or silting.
4. Catch water drains shall have adequate slope to ensure development of self-cleaning velocity.
5. Catch water drains shall have well designed outfall with protection against tail-end erosion.
6. Catch water drains shall not have any weep hole.
7. Size of side drains of adequate capacity should be properly designed keeping its bottom level at 300mm below bottom of blanket layer.

Fig. 9.01 *Typical cross section of cutting showing side and catch water drains*

(c) Adequate provision of weep holes in all side drains should be made. No weep hole to be provided in catch water drains.

(3) Adequate openings to take the full flow of side drains should be provided across the road under level crossings where they exist in or at the end of the cuttings.

(4) Ballast walls, where provided in cuttings, should be regularly inspected. The efficient maintenance of ballast walls includes regular cleaning of weep holes, the provision of weep holes where none exist and repair/ rebuilding where necessary.

(5) The Permanent Way Staff shall carry out cleaning of side and catch water drains, clearing of obstructions from out falls and cleaning water-ways of bridges and culverts methodically and complete the work before the monsoon sets in. The spoil from cleaning drains or cuttings should not be deposited at a place from where it is likely to be washed back into the drains.

(6) In the Municipal areas, where the outfall of Railway drains is in the municipal drains, close co-ordination should be maintained with the municipal authorities to ensure free flow from Railway drains into the municipal drains.

(7) The invert of Railway drains should be well above the level of water/discharge of municipal drains so as to avoid reverse flow during intense rainfall when drains are subjected to full storm water load.

(8) Adjacent land owners or other parties shall not be allowed to divert water or sewerage from their property to Railway land.

903. Drainage in Station Yards:

(1) The network of cross and longitudinal drains in yards whether earthen or masonry , should be so planned that storm water is led away in the least possible time.

(a) There shall be a master plan for drainage for every major yard, showing the network of cross and longitudinal drains. Typical drainage arrangement is shown in *figure 9.02*.

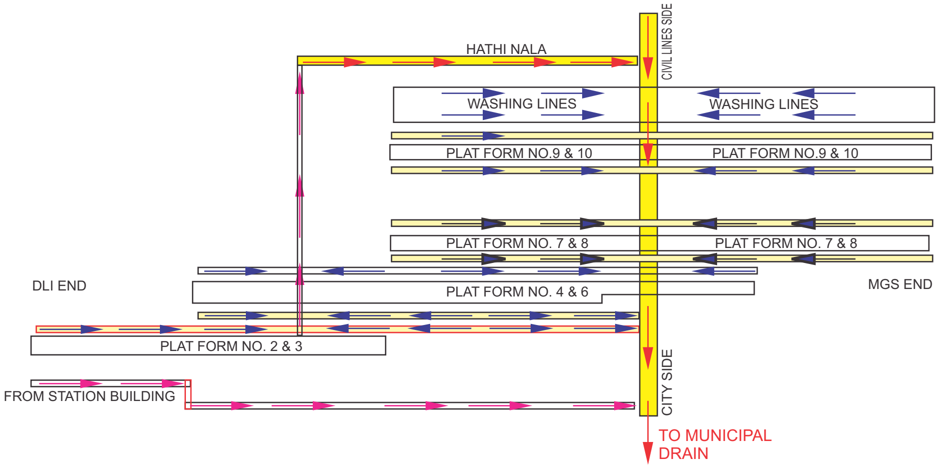


Fig. 9.02 *Typical drainage system in Allahabad yard*

(b) Gradient is an essential design parameter for drain. A gradient of 1 in 600 or steeper shall be provided as per site requirement, for easy flow. Section of the drain should be kept sufficient to accommodate the anticipated discharge.

(c) Normally, the drain top shall not be above the cess level for effective drainage of ballast bed. However, if a drain with higher top level has to be provided to retain ballast, weep-holes shall be provided at cess level. In any case, top of drain wall shall not be higher than bottom of the sleepers.

(d) The inlets to all manholes and covered drains should be protected through sealed gratings to prevent entry of plastic items, garbage, tree branches, dead animals etc. inside the manhole and covered drains, which can clog the drains.

(e) Once a year, prior to monsoon, all underground drains and manholes should be de-silted, cleaned and protected again with sealed gratings. Desilting of open drains should also be done regularly.

(f) Wherever out fall is available at either end of a yard, longitudinal drains shall be provided with slope in opposite direction from the middle of the yard so as to evenly distribute the drain water load.

(g) The yards must be kept clear of all loose materials, heaps of earth or cinder which may interfere with drainage.

The system of surface drains of water columns carriage-watering and carriage washing hydrants should be efficiently maintained.

(h) In the municipal areas where the outfall of railway drains is in the municipal drains, close co-ordination should be maintained with the municipal authorities to ensure free flow from railway drains. To ensure this, it is necessary to carryout pre-monsoon and post-monsoon inspections and carryout all necessary works before onset of monsoon.

(i) The invert of Railway drains should be kept well above the level of water/discharge of municipal drains so as to avoid reverse flow during intense rainfall when drains are subjected to full storm water load.

904. Lubrication of Rail Joints :

(1) The purpose of lubricating rail joints is not only to facilitate expansion of rails but also to retard wear on the fishing planes of the rail and the fish plate. Reduced wear on the fishing planes is one of the preventives of the low joints.

(2) The lubricant to be used should be specified by the Chief Track Engineer. A stiff paste of plumbago (Graphite) and kerosene oil, made in the proportion of 3 Kg of plumbago to 2 Kg of kerosene oil may be used. Black oil or reclaimed oil may be used for lubrication of fish bolts and nuts. Alternatives to the above may be used, with the specific approval of Chief Track Engineer.

(3) All rail joints should normally be lubricated once a year on a programmed basis during the cold weather months after the monsoon, from October to February. Lubrication should not be carried out in extremes of weather both hot and cold. In yards other than passenger running lines, this period may be extended to 2 years.

(4) Creep in excess of 150 mm should be adjusted before the work of lubrication of rail joints is undertaken.

(5) The lubrication of rail joints should normally be carried out by gangs working under the direct supervision of at least Mate (designated track maintainer Gr.I.) The work should be carried out under caution orders arranged to be issued daily by the JE/SSE(P.way) and under protection of engineering signals, as per *Chapter 11.*

The procedure to be followed for lubrication of rail joints will be as follows:

(a) The nuts are unscrewed and the fish bolts and fish-plates are removed.

(b) The fishing surfaces of the fish-plates and rail are then cleaned with a wire brush.

(c) The rail ends are inspected for cracks, and the fishing surfaces of rails and fish-plates are checked for wear. A magnifying glass and a mirror should be used for detecting cracks in rail ends and fish-plates including the bottom of foot of rail.

(d) The fishing surfaces of the rails and fish-plates are then lubricated.

(e) The fish bolts are then put back in reverse position than earlier and tightened using a standard fish bolt spanner, the inner two bolts being tightened first.

(f) While tightening overstraining of bolts shall be avoided.

(g) Spare fish-plates and bolts should be available for replacement of cracked ones.

(6) Alternatively, the work of lubrication may be carried out by the keyman (Track Maintainer) of the gang, assisted by one or more men on such sections as may be specified by the Divisional Engineer. In such cases the Keymen (Track Maintainer) shall exhibit a red signal flag at the site of the work and act as lookout man also. Normally not more than one joint should be opened at a time under this procedure.

In this case the lubrication of rail joints and reversing of fish bolts should be carried out as follows:

(a) The nuts are unscrewed and the fish-plate on the nut-side is then removed leaving the other fish plate and bolts in position.

(b) The fishing surfaces of the fish-plate and the rails are cleaned with a wire brush. The rails ends are examined for cracks and fishing planes of rails and fish-plates for wear, a mirror and a magnifying glass should be used to detect cracks including the bottom of foot of rail. Such conditions shall be brought to the notice of Mate (Track Maintainer Gr. I) JE (P.Way) for necessary action. The fishplates are lubricated and put back in position.

(c) The fish bolts are taken out one at a time, and then put back, after oiling.

(d) The other fish-plate and fishing surface of the rail is treated similarly.

(e) The nuts are replaced and tightened to the extent possible with the standard fish bolt spanner without overstraining the bolts.

(f) Two joints opposite each other or consecutive joints shall not be opened out at the same time. It should be particularly noted that at no time during the operation there is less than one fishplate and three fish bolts without nuts connecting the two rails. The men should sit facing the direction of train while doing the work.

(g) Both fish-plates should be fixed and at least one fish bolt and nut on either side of each joint should be tightened when a train is approaching the site of Work.

(h) Spare fish-plates and bolts should be carried for renewal of cracked ones.

(7) The Chief Track Engineer may issue subsidiary instructions as necessary.

(8) The lengths over which the rail joints are lubricated together with dates shall be recorded in the gang chart of the section and in the section register. In the month of April, SSE (P.Way) should submit to the ADEN certificates of lubrication of rail joints giving reasons for any exception to ADEN. Copies of these certificates should be forwarded with the ADEN's comments to the DEN for scrutiny and record.

(9) During all works such as relaying, rail renewals and renewals of turnouts, etc. rail joints should be lubricated. The importance of going over and re-tightening the bolts after the fish-plates have taken a bearing under traffic should be impressed on the staff.

(10) Insulated fish-plates should not be greased.

(11) All joggle fish plated joints should be lubricated once in a year before onset of winter.

905. Greasing on Sharp Curves, ERCs, Screws and Other Track Components Needing Lubrication :

For better maintenance practice and to prolong life of track components

(1) Outer rails on sharp curves shall be lubricated periodically to minimise wear and tear.

(2) ERC's on PRC Sleeper track shall be greased once a year in corrosion prone area and in other areas once in two years. Sealing of linear space by grease shall also be done to arrest corrosion at rail seat / liner bites.

(3) Rail screw on PRC turnout shall be lubricated at least once a year..

(4) SEJ lubrication shall be done once in 15 days.

(5) Greasing of switch portion, Lead curve and Nose of crossings on turnout shall be carried out.

906. Counteraction and Adjustment of Creep:

(1) General :

Rails have a tendency to move gradually in the direction of the dominant traffic. It is believed to be caused by the ‘ ironing out ’ of yielding track by the moving load, augmented by braking loads, and by the impact of the wheels on the running-on ends of the rails, particularly at times when they are in a state of expansion or contraction. Among the troubles caused by ‘creep’ are-

(a) Sleepers getting out of square.

(b) Distortion of gauge.

(c) Loosening of joints.

(d) Shearing and breaking of spikes, bolts and fish-plates.

(e) Buckling in extreme cases.

(2) Causes for Creep in Track :

The following are some of the avoidable causes to which creep is attributed :

(a) Inadequate toe loads of the rail to sleeper fastening and rails not secured properly to sleeper.

(b) Inadequate ballast resistance to the movement of sleepers due to poor or insufficient ballast or other causes.

(c) Inefficient or badly maintained rail joints.

(d) Rails too light for the traffic they carry.

(e) Improper expansion gaps.

(f) Decaying sleepers, uneven spacing of sleepers.

(g) Lack of proper drainage.

(h) Yielding formation resulting in uneven cross levels.

(i) Loose/uneven packing.

(j) steep gradient.

(k) Rail seat wear in metal sleeper road.

(3) Precautions to Reduce Creep :

(a) For reducing creep, it must be ensured that the rails are held firmly to the sleepers and adequate ballast resistance is available. All spikes, screws and keys should be driven home, the sleepers properly packed and crib and shoulder ballast should be compacted. Rail anchors should be provided wherever necessary.

(b) With steel trough and cast iron plate sleepers and in the case of sleepers where elastic fastenings and other fastenings with adequate toe load are used, no trouble is normally experienced. Careful watch should be kept for a series of jammed joints. Not more than six jammed joints continuously should be permitted in the case of single rails . In case of SWR not more than two consecutive jammed joints should be permitted at rail temperatures lower than "t_m" in the case of Zone I and II and "t_m-5" in the case of Zone III and IV. On girder bridges adjustment may be necessary at regular intervals. Anti-creep devices should be provided on the approaches of girder bridges for adequate length.

(c) The PSC sleepers with elastic fastenings are considered as creep resistant and therefore no other creep anchors are required. In case, excessive creep is observed on PSC sleeper road, the condition of elastic fastenings, sleepers and adequacy of ballast resistance should be examined. Action for replacement/renewal of fittings, sleepers and providing adequate ballast resistance etc. should be taken as necessary. Through renewal of fittings should be done in the direction of traffic in double and multiple lines to avoid chances of buckling due to locked up stresses.

(4) Creep Recording :

Creep shall be recorded in the TMS and entries shall be made accordingly, frequency of recording shall be specified by DEN taking into consideration the rate of creep. Sections which are prone to creep, ADEN shall carry out test check.

TMS Miscellaneous Creep Recording

(5) Creep Indication Posts :

Creep indication posts square to the track should be erected on either side of the track on the cess at intervals of about one km. These may be unserviceable rail posts with chisel mark square to the joints. The top of the post should be about 25 mm above the rail level and the amount of creep one way or the other measured with a fishing cord stretched over the chisel marks.

(6) Permissible Amount of Creep :

Creep in excess of 150 mm shall not be permitted.

(7) Adjustment of Creep :

Adjustments of creep should be carried out in the following manner :

(a) Careful measurement of expansion gaps, as existing, should be done and appropriate length which can be dealt with in one operation should be chosen. The total amount of gap in the length should be equal to the standard expansion gap required for the temperature at the time, multiplied by the number of joints in the length.

(b) Work should start at the running-on end of the length, commonly just beyond the points and crossings or level crossings. The work of creep adjustments should be carried out under the protection of Engineering signals by the Permanent Way Inspector as envisaged in *Chapter 11.* Before pulling back is commenced the keys are knocked out and fish-plates removed or eased. Correct expansion liners should be used and the rails should be pulled back with bars. If the fish-plates are removed, the bars can pull against a tommy bar thrust through a bolt hole. Next, the rail is keyed up, the bolts of joints correctly tightened up, and the expansion liner moved to the next joint, whereupon the process is repeated.

(c) It is a good practice to adjust creep before the beginning of summer. It is desirable to pull back the rails during the cool hours of the day. Mechanical and hydraulic devices are available for adjustment of creep.

(d) When the value of total gap exists is more than the standard expansion gap required for the temperature at the time of adjustment multiplied by the number of joints, it's necessary to provide closure rails and as speed restriction of 30 kmph shall be imposed till closure rail replaced from track.

(e) During adjustment of creep, the sleeper spacing should be adjusted, if necessary, special attention shall be given to the joint and shoulder sleeper spacing.

■ ■ ■

- *P.WAY likes clean surrounding. (Make sure that the ballast is not fouled and drainage is effective)*

Chapter 10

Deep Screening of Ballast

1001. General:

Ballast is one of the major constituents of track structure which ensures that the stresses coming from train wheels get dispersed at formation and the stresses remain less than the safe bearing capacity of the formation. The other functions of ballast are as under.

(1) Track maintenance involves number of activities which are incidental to routine or day to day maintenance. Deep screening of ballast is one of them, which is required to be done on a systematic and programmed basis at a predefined frequency. It enhances the general health of the track and improves maintainability, reliability of the track in following ways.

(a) Providing elastic and resistant medium to absorb shock from dynamic loading.

(b) Facilitate and maintain track geometry.

(c) Limiting sleeper movement by resisting vertical, transverse and longitudinal force from the trains.

(d) Facilitate drainage.

1002. Deep Screening of Ballast:

(1) General :

(a) Due to presence of bad formation, ballast attrition/abrasion, excessive rain fall and dropping of ashes/coal dust and ore, ballast gets choked up and track drainage is impaired. In such situations, it becomes necessary to screen the entire ballast right up to the formation level /sub-ballast level periodically as described in *para 1002 (2).* Such screening is called “Deep screening”, as distinguished from the shallow screening, which is done, during overhauling only for the top layer of ballast.

(b) Deep screening should be carried out in the following situations and full ballast cushion provided during the operations :

   (i) Prior to complete track renewal.

   (ii) Prior to through sleeper renewal.

   (iii) Where the caking of ballast has resulted in hard bed and causing unsatisfactory riding quality.

   (iv) Before converting existing track, fish plated or SWR into LWR; or before introduction of machine maintenance, unless the ballast was screened in recent past.

   (v) Generally the entire track should be deep screened once in ten years or after passage of 500 GMT traffic whichever is early. Deep screening shall also be carried out if the existing clean ballast cushion is less than 150 mm for effective machine tamping.

   The location where clean ballast cushion is adequate or formation rehabilitation work has been carried out with the help of geotextiles/ geogrid, deep screening frequency may be enhanced on condition basis.

   (vi) The frequency of deep screening in station yard areas can be increased on condition basis by Chief Track Engineer.

   (vii) The frequency of deep screening of Branch lines where traffic density is low can be reduced on condition basis by Chief Track Engineer.

(c) At the time of deep screening, standard ballast section should be provided invariably.

(d) In case of the bad formation, formation treatment should be carried out along with the deep screening

(e) The work of deep screening should be carried out continuously from one end of the section to the other.

(f) Deep screening should be done by ballast cleaning machines (BCMs). However in station areas, branch lines and other unavoidable locations manual deep screening can be permitted on case to case basis by Chief Track Engineer.

(g) Proper arrangements should be made to dispose off muck arriving from screening, particularly in station yard areas and in multiple line sections. Soil disposal units (SDU) may be attached with BCM as shown in *fig. 10.01* or arrangements similar to *fig. 10.02* may be made.

Fig. 10.01 - *Soil disposal unit for Ballast Cleaning Machine*

Fig. 10.02 - *Arrangement for soil disposal from Ballast Cleaning Machine.*

(h) Side drains and yard drains are to be cleared of the muck and to be repaired immediately after deep screening.

(2) Procedure for systematic Deep screening :

(a) Survey : Before deep screening of a section is undertaken, it is necessary to survey the section. This will consist of the following operations:

(i) A longitudinal section of the track should be taken indicating the rail levels at every 30 m on non electrified sections and as also at changes of grades, obligatory points like culverts, bridges, over line structures, tunnels, level crossings, Signal gantries, ash pits, and points and crossings etc.

(ii) In station yards, on run through lines, cross sections at every 50 meters should be taken and plotted including platform levels, rail levels and clearance to underside of overline structures and incidental Signaling, OHE installations or other adjacent structures.

(iii) On the basis of longitudinal and cross sections, the final levels of track after deep screening will be decided by the Divisional Engineer, keeping in view -

The depth of ballast cushion to be provided.

The relative implications of lifting or lowering of track.

The possibility of eliminating humps, sags, and unevenness in the existing longitudinal section.

It is not necessarily the intention that the original longitudinal section of the line should be restored.

(b) Preparation of project report and Estimates :

After carrying detailed survey as mentioned in *para 1002(2)(a)*, quantitative assessment of requirement is made. A detailed project report consisting of following items is to be prepared,

(i) Source/ base depot of ballast.

(ii) Cess repair execution scheme.

(iii) The obligatory locations where deep screening by BCM is not feasible, where manual screening will be required, such as

- Bridge approaches

- Tunnel/cutting- where SOD infringes
- Turnout territories and its approaches etc.

(iv) The period for which level crossing will remain closed for road user diversion scheme, if required.

(v) Block availability and duration of entire deep screening along with bar chart.

(vi) Engineering speed restriction and Engineering Time Allowance (ETA) requirement with speed restriction schedule.

(vii) Scheme of temporary distressing, if any etc.

Based on above and survey carried out as mentioned in *para 1002 (2) (a),* the estimate for the work of deep screening and full ballasting is prepared. Estimate should also include all incidental works related to signalling, OHE, cess repairs, bridge approaches, level crossing etc.

(c) Preliminary work :

(i) Additional ballast required, should be unloaded/spread out where it is required.

(ii) Pegs should be provided at intervals of 30 metres in non electrified territory to indicate the final rail levels. In electrified section, rail levels can be marked on OHE masts.

(iii) Slewing of curves should be done in advance.

(iv) Sleeper renewal and fitting renewals as necessary should be carried out in advance.

(v) All physical obstructions in working Zone of BCMs shall be cleared in advance.

(vi) Temporary destressing of LWR track, wherever applicable, should be done as per the provisions given in *Chapter 7.*

(d) Screening operations :

General :

(i) The work of deep screening by machine or manual shall be done under the supervision of an official not lower than the rank of JE/P.Way.

(ii) The daily output should be pre-determined, depending on the block time, availability of labour, extent of ballasting/screening to be done etc.

(iii) Taking the length to be deep screened daily, planning of speed restriction should be done and necessary notice should be issued to all concerned and temporary engineering indicator boards put up.

(iv) It will be desirable to proceed with the work of deep screening in the direction opposite to that of the traffic on double line.

(v) Deep screening work with BCM also involves deployment of large number of workforce as well as reduction in visibility due to dusty environment. A suitable speed restriction of 50 km/h with whistle freely and observing Engineering Hand signal at site should be imposed on adjacent track(s). Additional safety precautions such as hooter/ Alarm System should be provided to warn the workmen of approaching train on adjacent track(s).

(3) Deep Screening with BCM :

(a) Deep Screening with BCM (Ballast Cleaning Machine) followed by Tamping and Stabilisation of Track by Heavy on track machine for BG - The work is to be carried out in stages on various days after the start of the screening operations and the speed restriction recommended to be imposed are indicated in the schematic representation in *Table 10.03* below. According to the schedule, normal sectional speed can be resumed on the 8^{th} day.

Table 10.01

Schedule of speed restriction for deep screening by BCM followed by Tamping and Stabilisation by machines for BG

Details of Work	Days of Work	Speed Restriction
Deep screening of track by BCM, ballast equalisation followed by initial tamping and initial stabilization by Dynamic Track Stabiliser. (DTS)	1st day	40 Km/h
First round of tamping followed by stabilization of track by DTS.	2nd day (1st Tamping)	40 Km/h
Survey of track for design tamping mode (refer Chapter 4), boxing of ballast section and tidying	3rd day	40 Km/h
Second round of tamping in design mode followed by stabilization of track by DTS.	4th day (2nd Tamping)	40 Km/h
Survey of track for design tamping mode (refer Chapter 4), boxing of ballast section, and tidying	5th day	40 Km/h
Third round of tamping in design mode followed by third round of stabilization of track by DTS.	6th day (3rd Tamping)	75 Km/h
Inspection of track, boxing of ballast section and tiding.	8th day	Normal speed of the section.

Temporary destressing, if required, prior to BCM should be carried out.

(b) Precautions to be taken during deep screening of track by BCM followed by tamping by Tie Tamping Machines (TTM) and Stabilisation by DTS machines;

(i) All precautions laid down in chapter 7 shall be strictly followed, while working on LWR Section.

(ii) Hard Sal wood blocks of size 600 mm X 300 mm X 300 mm (six numbers) duly end bounded shall be arranged for supporting ends of three adjoining sleepers where cutter bar is left in the track and remains untamped.

(iii) Sleepers of cutter bar area shall be manually packed and ballast under cutter bar location sleepers shall be removed only half an hour before the expected traffic block. Adequate care shall be taken to ensure that wooden blocks are not dislodged before arrival of BCM at site.

(iv) Fish-plated joint shall not be located in cutter bar location.

(v) The cutterbar should be removed after the screening stops, sleeper spaced correctly, and ballast filled and tamped, before clearing the block.

(vi) The level of deep screened track and the old unscreened track should be provided with a suitable ramp. This Ramp shall not be located in locations like level crossing, girder bridge, transition portion of curve etc. It shall be kept minimum two rail length away.

(vii) In case of fracture or cut in CWR/LWR, a speed restriction of 20 Km/h shall be imposed till it is repaired *(Chapter 7)*

(viii) In case of malfunctioning of TTM and/ or DTS, deep screening shall be stopped and track which has not been tamped and stabilized shall be attended manually by ballast ramming and correction of track geometry to ensure safety of running trains. Speed restriction shall be imposed and relaxed in terms of *para 1002 (b)(i) or (ii)* as the case may be.

(ix) When Ballast regulating Machine (BRM) is not deployed, adequate track men shall be deputed to recoup ballast, particularly in shoulder and maintain ballast profile after machine working.

(x) Lifting of track shall be done after ensuring adequate availability of ballast for maintaining ballast profile for planned lifting.

(xi) Adequate arrangements for supply and training out of ballast prior to deep screening should be made. Special care shall be taken by deploying watchman on stretches overdue for rail renewal.

(xii) Deep screening work involves deployment of large number of workforce as well as reduction in visibility due to dust. A suitable speed restriction of with whistle freely and observe engineering hand signals should be imposed on adjacent track. Adequate safety precautions should be taken to warn the workmen of approaching train on adjacent lines.

(xiii) Deep screening of the full width possible upto OHE mast foundation or any fixed structure on cess should be done by Ballast cleaning machine by extending cutter bar wherever possible. In normal course of working of BCM, edge of shoulder ballast remains uncleaned, as shown in *Fig. 10.03* below, which causes drainage problem even after cleaning manually. An extended cutter bar with two additional links can be used to clean entire width.

Fig. 10.03 *Deep Screening of Ballast by BCM*

Alternatively before screening, the ballast at the edge of shoulder may be transferred into the middle of track and after BCM working cess making is to be done. Cess making work is to be carried out before the unloading of ballast.

(xiv) Cess should be brought up to correct level in relation to the final rail level after deep screening.

(4) Deep Screening of Ballast in Turnouts by BCM :

For better riding quality and reliability, it is desirable to carryout Deep screening of ballast in Turnout areas using BCMs.

Following procedures and precaution should be observed

(a) Joint survey of Yard -

(i) Joint survey of yard where Turnout deep screening by BCM is planned should be done by the Supervisors in charge of Engineering, S&T and TRD departments. Traffic Inspector / Station Superintendent to be involved to apprise about block duration and restriction on train movement during block.

(ii) The Joint Survey should list out activities and anticipated obstacles involved during the course of deep screening. All such obstacles should be removed before BCM work to allow efficient working during block. Hand held cable route locator / metal detector should be used to identify buried metal pieces / cables.

(iii) Proposed lifting of turnouts to improve drainage or to remove long chord unevenness defects is to be carefully planned and OHE modification may be done accordingly, if required.

(iv) The Joint survey should be signed by all supervisors concerned and a copy be sent to all officials concerned.

(b) Preliminary Works to be done by Engineering Deptt.

(i) Replace the damaged/cracked turnout sleepers by new sleepers.

(ii) Broken/damaged fitting should be recouped, loose lifting should be tighted.

(iii) Corroded chair plates and plate screws should be replaced.

(iv) A deep trench has to be made on the block day by adjusting sleeper for insertion of cutter bar.

(v) Clean ballast filled in gunny bags to be kept near the work site for filling up immediately after deep screening in packing zone under rail seat to facilitate quick setting of switch.

(vi) To keep one gas cutting equipment and concrete breaker to be used with machine for removal of obstructions.

(c) Preliminary works to be done by S&T Deptt.

(i) A thorough survey of all cable crossing the track and it's depth at the proposed portion of BCM working should be done in advance .

(ii) Cables at a depth less than 0.75 m from the rail level are to be identified. They are to be taken down to the extent possible or to be removed during block time to avoid possible damage.

(d) Activities During Block

(i) Adequate duration of traffic block shall be arranged. It is desirable to deep screen entire Turnout in a single traffic block.

(ii) Traffic Inspector / Station Superintendent to ensure timely clamping of points and passing of train as required.

(iii) TRD staff to Open traction bonds and cross bonds in the working area immediately after the block

(iv) The BCM machine has the facility of fixing extension of cutter bar on descending side of arm only.

(v) As the deep screening progresses from switch end to crossing portion cutter bar has to be extended at subsequent intervals. The number of extension pieces and the interval is tabulated as per *Table 10.02* below for 1 in 12 and in 1 in 8½.

Table 10.02

Deep screening upto sleeper number	No. of extension pieces
1 to 37	2
37 to 60	2 + 2
60 to 96	2 + 2 + 2

(vi) BCM should start from one rail length ahead of SRJ and should deep screen till one rail length behind crossing.

(vii) Once block is granted S&T installations should be remove immediately prior to BCM reaching the switch portion.

(viii) As the BCM progresses from switch towards crossing point motor after repositioning should be fix.

(ix) As the BCM advances keep recouping any deficient ballast from fresh ballast stored nearby in bags regularly.

(x) Extend cutter bar by using extension pieces at location mentioned in *Table 10.02.*

(xi) Deploy UNIMAT behind BCM for tamping of the turnout.

(xii) The S&T staff shall be allowed about 30 minutes for completing the work and giving reconnection after clearing of location by UNIMAT machine.

(xiii) In case of emergency cross-over with 1 in 8½ or 1 in 12 turnouts; Deep screening by BCM to be continued to the extent possible . Traffic block for both Up and Dn line will be required, once the cutter bar infringes the adjoining track. There will be some sleepers in cross-over for which deep screening by BCM may not be possible. Such portion of sleepers to be deep screened manually immediately after BCM work so that running over points and crossing can be smooth.

(xiv) In station areas to dispose of muck after deep screening, it is advisable to use wagon for collection of muck. All muck to be disposed off properly.

(e) Activities During Post Block Period

(i) As soon as machine clears a given area, the structural bonds, track bonds, cross bonds, longitudinal and rail bonds shall be reconnected by TRD staff.

(f) During BCM working, rail levels and implantations should be maintained as already planned and agreed by Engg & TRD.

(5) Detailed procedure for manual deep screening :

A day's length will be deep screened as per the procedure detailed below (please refer *Fig. 10.04* below)

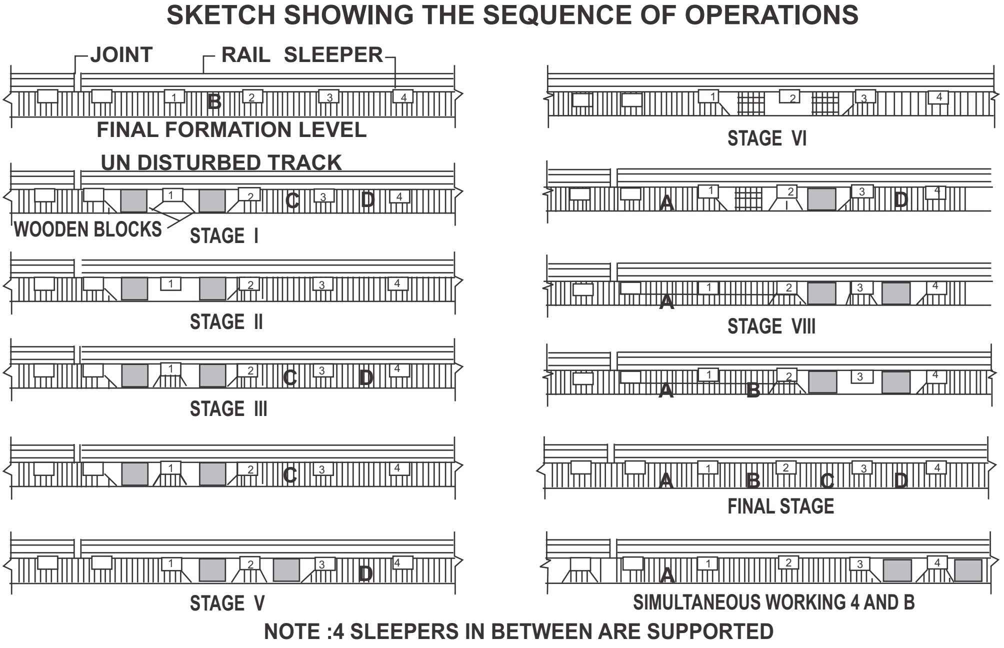


Fig. 10.04- *Sequence of operation for manual deep screening.*

Stage I — The ballast should be removed from space 'A' and 'B' on either side of the sleeper '1' down to final formation level and wooden blocks provided to support the rail for passing trains.

Stage II — The ballast is removed from under sleeper '1' down to final formation level/sub-ballast level.

Stage III — The ballast should then be screened and placed back under sleeper '1' which should then be packed.

Stage IV — The wooden blocks from space 'A' should then be removed.

Stage V — The ballast from space 'C' down to formation level should be removed and after screening, be placed in space 'A' upto bottom of sleeper. The balance may be taken outside the track and screened. The rail in space 'C' should be supported with wooden blocks.

Stage VI — The ballast should be removed from under sleeper '2' down to formation level.

Stage VII — Screened ballast should be provided under sleeper '2' and sleeper well packed.

Stage VIII — The ballast from space 'D' down to formation level should be removed and after screening, be placed in space 'B' upto bottom of sleeper; the balance may be taken outside the track and screened. The wooden blocks should be removed from space 'B' and placed to support the rail in space 'D'.

Stage IX — The ballast from under sleeper '3' should be removed and so on till the whole rail length is provided with screened ballast upto level of the bottom of sleepers

Final Stage — The track should be lifted to provide additional cushion where required. The track should be packed in the final position and then boxed. Sequence of the operations is shown in *Fig. 10.04.*

(a) The following points may be kept in view while doing the work –

(i) No unscreened length should be left between screened lengths of the track at the same time.

(ii) It should be ensured, that when ballast is being removed from any sleeper, invariably, there are at least four fully supported sleepers between it and the next sleeper worked upon.

(iii) Lifting should be limited to 50 mm. at a time.

(iv) It should be ensured that packing, cross levels and grade run off are satisfactory before closing the day's work.

(v) The work should be done under a speed restriction of 20 km/h.

(vi) The speed should be gradually raised as in para (b) below which will vary depending on the type of maintenance in the section.

(vii) The muck removed must be evenly spread to repair the cess. In no case the heaped muck should be left adjacent to track as it deteriorates the track drainage.

(viii) In station yards, where multiple lines are involved, any caked up portion between two adjacent lines should be deep screened so as to ensure proper drainage between the tracks.

(ix) Cess should be brought up to correct level in relation to the final rail level after deep screening.

(b) Schedule for working and speed restriction to be observed, in manual deep screening works :

(i) With Manual Packing – The details of the work to be carried out in stages on various days, after starting of the screening operation and the speed restriction recommended to be imposed are shown in *Table 10.03*. According to the above schedule normal Sectional speed can be restored on the 21st day.

(ii) With Machine Packing - The details of work to be carried out in stages on various days after the start of the screening operations and the speed restriction recommended to be imposed are indicated in the schematic representation in *Table 10.04*. According to this schedule, normal sectional speed can be resumed on the tenth day.

- *Fouled ballast is cancerous; clean it before the damage becomes irrepairable.*

Table - 10.03

Schedule for Deep Screening (Manual Packing)

Detail of Work	Day of Work	Speed restriction and their length	
		Broad Gauge	Metre Gauge
Deep screening and initial packing First through packing Second through packing	1 2 3	20 Km/h	20 Km/h
Picking up slacks as required Third through packing	4 5 6 7 8 9 10	45 Km/h	30 Km/h
Picking up slacks as required Fourth through packing	11 12 13 14 15 16 17 18 19 20	75 Km/h	60 km/h
	21 Onward	Normal sectional speed	Normal sectional speed

Table 10.04

Schedule for Deep Screening (Machine Packing in B.G.)

Details of work	Day of work	Speed restriction
Deep screening with initial packing	1	20 Km/h
First machine packing	2	
Picking up slacks as required	3	45 Km/h
	4	
	5	
Second machine packing	6	
Picking up slacks as required	7	
	8	
Third machine packing	9	75 Km/h
	10 days Onwards	Normal sectional speed

■ ■ ■

Chapter 11

Engineering Restrictions And Indicators

1101. Works involving Danger to Train or Traffic:

No work which will involve danger to trains or to traffic shall be commenced by P.Way gang without the previous permission of the JE/SSE (P.Way) or of some competent Railway servant appointed on this behalf by special instructions (as detailed in Annexure-6 of LWR manual and similar provisions in this regard given in this manual). The Railway servant who has given the permission should be himself present at the site to supervise the work. The responsibility of the Railway servant in-charge of the work who is present at the site of work is to ensure the protection of track and that Engineering signals are exhibited at the specified distance according to rules and flagmen are posted with necessary equipment to man them. Trains shall be permitted over the track under repair at such restricted speed as is specified, only after the track is rendered safe for the traffic. He should ensure that the provisions of *para 1105* are fulfilled before commencing the work.

1102. Traffic Blocks:

Traffic blocks are mandatorily required for such engineering works which obstruct the line for passage of train.

(1) Works requiring complete block protection: The following category of works will necessarily require complete block protection:

(a) Category of works where track is required to be occupied-

(i) Working of on-track machines.

(ii) Working of material trains or girder specials.

(iii) Working of dip-lorries.

(iv) Working of motor/moped trolleys.

(v) Working of push trolley in heavy graded sections.

(vi) Working of push trolley sections where visibility is obstructed.

(vii) Push trolley in long tunnels.

(b) Works where discontinuity in track is created or such conditions are created which may result in discontinuity or obstructions to running track-

(i) Through rail renewal

(ii) Casual replacement of rail

(iii) Replacement of SEJs or replacement of buffer rails with SEJs

(iv) Insertion or replacement of glued joints

(v) Temporary/Permanent repairs of rail fractures

(vi) Temporary/Permanent repairs of rail after buckling of track

(vii) Replacement of switch crossing or any part of turnouts

(viii) Destressing of LWRs

(ix) In-situ welding of rails

(x) End cropping and welding of rails in-situ

(xi) Through renewal of bridge sleepers

(xii) Replacement of girders with slabs

(xiii) Removal of rail from track for any purpose

(xiv) Renewal of sleeper on important and major bridges

(xv) Changing of guard rail on important and major bridges

Note:1. Some of the works listed above may also necessitate imposition of speed restrictions.

2. The list of works indicated above is indicative only and other works may also be required to be done under block protection based on site specific conditions as decided by P.Way officials.

(2) Essential Safety precautions before commencing works which would obstruct the line:

No person employed on the way, works or bridges shall change or turn a rail, disconnect points or signals or commence any other operation which would obstruct the line without obtaining the written permission of the Station Master who shall ensure that all necessary signals have been placed at ‘ON‘. In addition, the employee mentioned above shall also ensure that the necessary warning and stop signals like banner flags and detonators and hand signal flags have also been placed/exhibited at the prescribed locations as per *para 1105*. In emergent cases like Rail/Weld failure, Breaches etc, persons undertaking such operations shall first protect the track to bring the train to stop as stipulated in *para 1107* and advise the Loco Pilot of the train about the need to stop the train through a written memo as under:

Proforma for imposition of Caution in emergent cases by Track Maintainer from site

Date	Time	Line Up/Dn	Between Stations	Kilometer		Speed restriction	Signature of Loco Pilot with Train no.
				From	To		

Signature of Track Maintainer/

P.way official with designation

Note:1. One copy to be given to Loco Pilot and duplicate copy duly received by Loco Pilot should be kept by Track Maintainer.

2. Loco Pilot shall ensure action as per unified G&SR 6.07.

3. JE/SSE (P.Way) shall ensure to provide sufficient copies of the above blank proforma to the Track Maintainer (Gangmate, Keyman, Patrolman, Watchman).

Track Maintainer shall simultaneously communicate with the fastest available means to Mate (Track Maintaier Gr. I) / JE/SSE (P.Way) and in turn they shall arrange to send a message to the Station Master for the need to block the track as per para 1109 and obtain written confirmation of the same. The work which may lead to obstruction to the track shall however be done only during the traffic block, the written confirmation for which shall be obtained from the concerned Station Master. On completion of the work again the authorized railway servant shall advise the Loco Pilot through a written memo to proceed at the prescribed speed.

1103. Speed Restrictions:

Following works necessitate mandatory imposition of speed restrictions. The suggested initial speed restrictions are indicated below-

(1) TSR/CTR- 20 km/h

(2) TRR/TWR- 30 km/h

(3) BTR/Steel Channel Sleeper renewal-30 km/h

(4) Adjustment of creep / Lubrication of rail joints / Through Fitting Renewal- 30 km/h

(5) Deep Screening: Manual- 20 km/h, Mechanized- 40 km/h.

(6) Destressing/Welding- 30 km/h

(7) Rail/Weld Fracture- 1st train Stop dead 10 km/h and subsequent trains 20 km/h until temporary repair done.

(8) IMR Rail/Weld- 30 km/h

(9) Cut/Rail closure in LWR- 30 km/h

(10) Manned/Unmanned Level crossing without check rail- 30 km/h

Note: The list of works mentioned above is indicative only and other works may also be required to be done under speed restrictions based on site specific conditions as decided by P.Way officials.

1104. Categories of Engineering Works:

Engineering works can be broadly divided into three categories–

(1) Category (1) : Works of routine maintenance- Such works, which require no speed restriction, not necessitating exhibition of hand signals and involving no danger to trains or traffic. These include works of routine maintenance such as through packing, overhauling of track, picking up slacks, greasing of ERC, Cess repair, isolated renewals of a sleeper/fittings etc.

(2) Category (2) : Works of short duration-

(a) Such works, which are normally carried out under Speed Restriction of 30 km/h during day hours before sunset. These include works such as casual renewals of rails and sleepers, adjustment of creep and lubrication of rail joints and through fitting renewal which are completed by sunset of the day of commencement and no restriction of speed thereafter is required.

(b) Hand-signals, banner flags and fog-signals shall be used at specified distances as per *para 1105(1)(b)* to afford protection to trains.

(3) Category (3) : Works of long duration–

(a) Works such as relaying, deep screening, destressing, bridge construction, diversions which extend over a few days, or weeks during which period a continuous restriction of speed is to be in force, are termed as “works of long duration”.

(b) Temporary Engineering indicators shall be used at specified distances to afford protection to trains as per *para 1105(2)(b).* These works should be carried out to a programme in a planned manner, about which all concerned will be advised in advance.

1105. Methods of Execution of Works:

(1) Works of short duration– Protection in block section and procedure for passing of trains–Before commencing any work of such category the JE/SSE(P.Way) or an authorized Railway servant should issue a notice to the Station Master/Block hut in-charge at either end of the block section and obtain his acknowledgment. Depending as to whether the train is to be passed through the work site after stopping, or at a restricted speed, the line should be protected in the following manner:

(a) When the train is required to stop at the site of work (in Block section)–

(i) Post a flagman with hand signals and place a banner flag across the track at a distance of 30 m in rear of the place of obstruction, to show stop hand signals.

(ii) Post a flagman with hand signals and place a banner flag across the track at a distance of 600 m on BG, 400 m on MG and NG in rear of the work. The flag man will show stop hand signals.

(iii) Post a flagman with hand signals and detonators at a distance of 1200 m in the case of BG and 800 m in the case of MG and NG in rear of the work. The flagman shall fix three detonators on the line 10m apart and take stand at a place not less than 45 m from last detonator, from where he can obtain a clear view of the approaching train. He will show stop hand signals.

Note: In MG sections with trains running at a maximum speed of more than 75 km/h, the distances in (ii) and (iii) shall be as specified under approved special instructions.

(iv) After the train has come to a stop at the Banner flag and can be allowed to start, the man at the site of obstruction shall give proceed hand signal to indicate to the Loco Pilot, when he may resume normal speed after the train has been hand signaled past the obstruction *(Annexure11/1).*

(b) When the train can pass over the work spot at restricted speed in Block section-Keeping in view the provisions of *para 15.09 of GR*, the following protections should be adopted in the above cases:

(i) Post a flagman exhibiting caution hand signals at a distance of 30 m from the place of obstruction.

(ii) Post a flagman exhibiting caution hand signals at a distance of 1200 m for BG, 800 m for MG and NG from the place of obstruction.

(iii) Post a intermediate flagman with hand signals at a distance of 600 m for BG, 400 m for MG and NG from the place of obstruction. He will also place a banner flag across the track. The intermediate banner flag must be kept across the line until the speed of the train has been reduced, after which the banner flag shall be removed and the train hand signaled forward.

In MG sections with trains running at a maximum speed of more than 75 km/h, the distances in (ii) & (iii) shall be increased as specified under approved special instructions.

(iv) The railway servant at the site of work should give proceed hand signals to indicate to the Loco Pilot, that he may resume normal speed after the train has been signaled past the site of work *(Annexure 11/2).*

(c) The following points should be kept in view, while protecting the track in the cases mentioned in sub-para (a) and (b) above:

(i) On single line, the line must be so protected on both sides of the work.

(ii) At places where there are curves or falling gradients and at times of poor visibility the distances laid down in sub-para (a) and (b) above may be suitably increased wherever necessary and intermediate flagman posted to relay hand signals.

(iii) The location of the banner flag, detonators and hand signals should be so selected as to avoid stopping of trains, as far as possible, on continuous steep rising gradients.

(iv) If in an emergency, it becomes necessary to carry out such works at night, the provisions for protection of line as detailed in sub-para (a) and (b) must be complied with except that red light must be exhibited in the direction of approaching trains in place of red hand signaling flags and banner flags.

(v) In an emergency, when it is necessary on considerations of safety, JE/SSE (P.Way), or authorized railway servant may commence such work after protecting the line before issuing notice to the Signalman. If the work is likely to be prolonged he should notify the Signalman as soon as possible.

(d) Works to be carried out in station limits:

(i) No work should be commenced on running line at a station without the written permission of the Station Master and until the relevant signals have been placed at 'ON'.

(ii) Before commencing a work on a line which can be isolated from the other running lines, JE/SSE(P.Way) through Station Master should ensure that the line has been isolated. Where isolation is effected by the setting of points, they must be locked by means of clamps or bolts and cotters with pad lock, which should be ensured by Station Master as per *para 15.09(2) of GR.*

(iii) Before commencing work on a line which cannot be isolated from other running lines the JE/SSE(P.Way) should provide the prescribed hand signals, detonators and banner flags as per para (a) and (b) above.

(e) Works in Automatic Signalling Territory – In automatic Signalling territory, if the distance from the place of works/obstruction to the automatic signal controlling entry of a train into the signaling section is less than 1200 m on BG, 800 m on MG/NG and the automatic signal is secured at 'ON' the banner flag and three detonators may be provided at 90 m and 180 m respectively as per *para 15.09(3) of GR.*

(2) Works of long duration:

(a) Preliminary arrangements–

(i) For doing such works the Engineering Department will arrange with the Operating Department for the issue of the Circular notice as per extant instructions.

(ii) The concerned DEN will be responsible for obtaining the sanction of Commissioner of Railway Safety wherever necessary and sending Safety Certificate on completion of such works.

(iii) JE/SSE(P.Way) should obtain permission to commence work from DEN/ADEN and should arrange to block the line when work is proposed to be done under block with the permission of the

Controller/Chief Controller on the day of block and issue a notice to the Station Master on either side.

(iv) Caution orders will be issued by the Station Masters concerned or Caution Notice/Ordering station, as necessary.

(v) The necessary temporary Engineering indicators as prescribed should be provided.

(vi) In an emergency, when it is necessary on considerations of safety, JE/SSE(P.Way), or Authorized Railway servant may commence such work before issuing the notice, under the protection of hand signals and banner flags. As soon as possible, he should issue the notice and replace the hand signals and banner flags by temporary engineering indicators.

(b) Protection of line in block section-

(i) when restriction is to last for more than a day and in case where stop dead restriction is to be imposed, the following temporary Engineering indicators should be exhibited at the appropriate distance :–

- Caution indicator.
- Stop indicator.
- Termination indicators(T/P & T/G).

(ii) In case where the train is not required to stop (non-stop restriction) and the restriction is likely to last for more than a day the following temporary Engineering indicators should be exhibited at the appropriate distances :

- Caution indicator.
- Speed indicator.
- Termination indicators(T/P & T/G).

Note: (i) *Annexure 11/3 and 11/3A* indicate the distances at which these are to be fixed.

(ii) When during the course of the work, on consideration of safety it is not desirable to pass trains over the site of work for the time being, the track should be further protected by hand signals and banner flags, by the authorized Railway servant.

(c) Protection of line in station limits- Special instructions will be issued by the Divisional Operating Manager after consultations with DEN and

Divisional Signal and Telecommunication Engineer in regard to the use of temporary Engineering signals in conjunction with station fixed signals. In urgent cases, these will be issued by the Station Master at the request of JE/SSE(P.Way).

1106. Carrying out Work in Emergency:

In the case of an emergency, when the requirements of safety warrant the commencement of the work by the gang Mate (Track Maintainer Grade I), before the arrival of the competent railway servant, the gang Mate shall himself ensure that Engineering signals are exhibited at specified distances according to rules and flagmen are posted with necessary equipment to man them, before commencing the work.

1107. Temporary Signals in Emergency:

(1) Whenever in consequence of an obstruction of a line or for any other reason it is necessary for a railway servant to stop an approaching train he shall plant a danger signal at the spot and proceed with all haste in the direction of an approaching train with a danger signal (red flag by day and red light by night) to a point 600 m for BG, 400 m for MG and NG from the obstruction and place one detonator on the line after which he shall proceed further for not less than 1200 m for BG, 800 m for MG and NG from the obstruction and place three detonators on the line 10m apart. He should then take a stand at a place not less than 45m from the last detonator from where he can obtain a good view of an approaching train and continue to exhibit the danger signal, until recalled. If recalled, he shall leave on the line three detonators and on his way back pick up the intermediate detonator continuing to show the danger signal. In case of those MG sections where the maximum speed is more than 75 km/h these distances will be as per approved special instructions.

(2) On single line the line must be protected on each side of obstruction, with the priority given to the direction from which a train is first expected.

(3) Where there are adjacent lines and it is necessary to protect such lines, action should be taken on each such line in a similar manner.

(4) Warning Signals:

(i) Description-The signals to be used to warn the incoming train of an obstruction shall be a red flashing hand signal lamp at night or red flag during day as per *para 3.65 of GR.*

(ii) Use of Warning signals- When it becomes necessary to protect any obstruction in a Block section, a warning signal may be used, as prescribed under *para 3.66 of GR,* while the railway servant proceeds to place detonators. A warning signal is to be shown to give timely warning to a Loco Pilot of a train approaching any obstruction such as derailed train obstructing adjacent lines, breaches, wash away, floods, landslides etc., when the railway servant does not have adequate time to do the protection in the normal manner with the detonators as envisaged under rules. The knowledge and possession of warning signals should be as stipulated in *para 3.67 of G & SR.*

1108. Carrying out Planned work:

All long duration works should be carried out to a programme in a planned manner, about which all concerned have to be advised in advance.

(1) In all cases of engineering works which involve the breaking/obstruction of open line or observance of any other restrictions in normal working the Engineering department will arrange with the DOM for the issuing of Green notice with standing instructions.

(2) DEN will be responsible for obtaining sanction of CRS, wherever necessary and sending to him the Safety certificates on completion of the works in accordance with extant instructions.

(3) Temporary working instructions for each phase of work shall be prepared and issued jointly by DEN and DOM and other Associated Divisional Officers.

1109. Procedure for Blocking Line for Engineering Works:

(1) Arrangements for block–

(a) Except in very urgent cases, normally the arrangements for blocking the lines between stations shall be made by the DEN in consultation with the Divisional Operating Manager, before the block is imposed.

(b) The Divisional Operating Manager will issue instructions to the Station Masters on either side of the section to be blocked and Station Masters/Yard Masters of train ordering stations concerned about the last train to pass over the section before the block is imposed, the trains to be cancelled because of the block and any other particulars and will conclude by stating which official of the Engineering Department will impose and remove the block. The instructions will be acknowledged by those to whom issued.

(c) In an emergency when there is no time to refer to Divisional Operating Manager or where block will not interfere appreciably with the traffic, the

Station Master after consulting control will arrange directly with the Engineering Official requiring the block.

(2) Imposition of Engineering Block:

(a) The JE/SSE(P.Way) or authorized railway servant who blocks the line should transmit a message to the Station Master on either side of the block section to be blocked, copy to the DEN, Divisional Operating Manager, ADEN and Controller advising them of the time from which the block is to be imposed and the kilometrage and asking for acknowledgement from the concerned Station Masters.

(b) The Station Master receiving the message for transmission will sign for it, noting the time of receipt and shall transmit the message to the Station Master on the other side of the block section, which is to be blocked, and to the Controller. The Station Master on the other side will acknowledge receipt by a message addressed to JE/SSE (P.Way) or authorized railway servant and the Station Master of the transmitting station.

(c) On receipt of this message the Station Master of the station from which the message was transmitted will block the line in the manner prescribed and hand over a signed copy to the JE/SSE(P.Way).

(d) Portable Field telephone/Walkie-talkie/Mobile phone on MTRC section should be used for liaison with the Control and Station Master for the operation of block. However, for imposition, extension and cancellation of block by using them, private numbers shall be exchanged between JE/SSE (P.Way) and Station Master. Alternatively, JE/SSE (P.Way) may depute P.Way staff at the Station Master's office with a Walkie-talkie/Mobile phone and standard blank formats for imposition/ extension/cancellation of block, who on receiving orders from JE/SSE (P.Way) will fill up the format and give written memo to Station Master, accordingly.

(3) Removal of Engineering Block:

(a) When removing a block the JE/SSE (P.Way) or authorized railway servant responsible will transmit a message to the Station Master on either side of the block section blocked, copy to the DEN, ADEN, Controller, Divisional Operating Manager etc., advising them that the block has been removed and asking for acknowledgement from Station Masters. Particulars of kilometrage, restriction of speed and position of Engineering Indicators should be given in the message.

(b) The Station Master who receives the message for transmission will sign for it, noting the time of receipt and transmit the message to the Station Master of the other station. The message must be acknowledged by the latter, addressed to the JE/SSE(P.Way) and Station Master of the transmitting station.

(c) On receipt of this acknowledgement the Station Master who originally imposed the block, will remove it in the manner prescribed. The Control or the Divisional Operating Manager will advise the Station Masters on the train ordering stations when a block is finally removed.

(4) Issue of Caution Orders to Loco Pilots – Caution order to Loco Pilots of all trains will be issued by the Station Masters for temporary engineering restrictions. Caution order will indicate the exact kilometrage, speed restrictions, stops, as the case may be, but will not include permanent restrictions that are notified in the working time-table.

1110. Engineering Fixed Signals:

(1) Temporary speed restriction indicators- Location and details:

(a) These consists of-

(i) Caution indicator.

(ii) Speed indicator.

(iii) Stop indicator.

(iv) Termination indicators (T/P & T/G).

(b) (i) Single Speed Restriction: In case of existence of only one speed restriction, the details and position of fixing each indicator are detailed in *Annexure 11/3 and 11/4.*

(ii) Multi Speed Restriction (i.e. existence of two or more speed restrictions in continuation). When work of deep screening or sleeper renewal etc. is in progress, there is situation of having two or more speed restrictions in continuation. In such situation, placement of speed boards for following speed restriction shall be as under:

- In case of following speed restriction being more restrictive, a minimum of 200 m track should be under earlier speed restriction zone. If not, then only one speed restriction board should be provided, considering that the previous speed restriction is at par with the following speed restriction, which is more restrictive.

- In case of following speed restriction being less restrictive, corresponding speed indicator board for following speed restriction shall be placed at a distance equal to the length of the longest goods train operating on the section after termination point of previous speed restriction zone.
- The details and position of fixing such indicators/boards are detailed in *Annexure 11/3A and 11/4.*

(c) All temporary Engineering Indicators shall be only retro-reflective type and need not be lit after sunset.

(d) For intermediate tracks on triple or multiple lines, engineering indicators should be fixed between tracks so that the centre line of Board is within 300 mm from rail-level, to avoid infringements of standard dimensions. However, for single line and double lines, the edge of Indicator/Board shall be minimum 2.5 m from track centres, in block sections.

(e) All indicators should be placed on the left hand side as seen by the Loco Pilots.

(f) Each JE/SSE(P.Way) should have in his possession at least one complete set of signals consisting of 2 caution indicators, 2 speed indicators, 2 stop indicators and two sets of termination indicators (2 Nos.T/P &T/G indicators).

(g) One termination indicator board bearing letters T/ G should be located at a distance equal to the length of the longest goods trains operating on the section from the end of the restricted length. Another Termination indicator bearing the letters T/P should be located at a distance equal to the length of the longest passenger train operating on the section from the end of the restricted length which will help the passenger trains to pick up speed after reaching T/P indicator, without losing time. The Guard of a passenger train shorter than the longest passenger train will exhibit an all-clear signal to his Loco Pilot when the rearmost vehicle has cleared the restricted length and the Loco Pilot will resume normal speed. In the case of light-engines or single unit rail cars, the Loco Pilots will resume normal speed after clearing the restricted length.

(2) Permanent speed restriction indicators:

(a) Permanent speed restriction boards–

(i) Permanent speed restrictions in force are notified in working time-tables. The speed indicators for the permanent speed restrictions are erected to indicate to the Loco Pilots the speed restrictions to be observed e.g., between stations, and at stations due to weaker/non standard track/ bridges, restrictions on curves, grades and points and crossings etc.

(ii) The indicators to be used are similar to those used for temporary restrictions, namely, caution indicator, speed/stop indicators and termination indicators (T/P&T/G). The details of the indicators and the distance at which they are to be fixed are the same in both the cases *Annexure 11/3 & 11/4*). These should also be of retro-reflectivetype.

(iii) The permanent indicators need not be lit at night.

(b) Siding Boards- When a speed restriction has been imposed on account of facing points of an outlying siding an ‘S‘ marker board (a circular board of 1m dia. painted yellow, with 300 mm. letter ‘S‘ painted in black on it) should be fixed at the points in addition to the speed and caution boards fixed in rear of the points. Where however, the sanctioned speed of the section does not exceed 50 km/h the speed indicator and the ‘S‘ board need not be provided except where the speed over the points is less than sanctioned speed of the section. ‘S‘ marker should be so fixed that the center of the board is 2 m above the rail level and the edge of ‘S’ marker shall be minimum 2.5 m from track centre.

(c) Board indicating speed over points - Where the speed over the points at a station is less than the speed sanctioned at other stations on the same section, a permanent speed indicator should be fixed on the first approach signal before the point at the station.

(d) The posts of Permanent speed indicator Board should be painted with 300 mm high bands in white and black.

(e) Where a permanent speed restriction is in force on any intermediate track on triple or multiple lines, the engineering indicators should be fixed between tracks so that the centre line of board is within 300 mm from rail-level to avoid infringement of standard dimensions.

1111. Procedure for Passing Trains at Stop dead Restrictions:

The flagman at the Stop indicators shall present his Restriction book to the Loco Pilot who should stop in the rear of the stop indicator to sign this book. The “Restriction book” should be in the following form:

Engineering indicator at km…………

S.N.	Date	Train	Time	Signature of Loco Pilot

After the flagman has obtained the signature of the Loco Pilot at the indicator, he should exhibit proceed with caution signal to the Loco Pilot. The Loco Pilot will then be authorized to pass the Stop indicator and continue at this speed until his train has cleared the restricted length, after which he will resume normal speed.

1112. Works at Times of Poor Visibility :

In thick foggy or tempestuous weather impairing visibility, no rail shall be displaced and no other work which is likely to cause obstruction to the passage of trains shall be performed except in case of an emergency. When such work has to be undertaken and the site is protected by temporary engineering fixed signals, 2 detonators on the line 10 m apart should be fixed not less than 270 m in rear of the caution indicator and a caution hand signal exhibited to approaching trains.

1113. Periodical notice of Engineering Restrictions :

For works involving restriction of speeds of trains the DEN will arrange periodic circulation of notice, furnishing following details :–

(1) The names of the block stations on either side of the site where the engineering work will be undertaken in order that caution orders may be issued.

(2) Kilometrage of site of work.

(3) Restricted speed and stop dead restriction to be observed by the Loco Pilot.

(4) Nature of work being undertaken or reasons for restriction.

(5) Probable duration.

1114. Detonating Signals :

Detonating signals otherwise known as detonators or fog signals are appliances which are fixed on the rails, and when an Engine (or vehicle) passes over them, they explode with a loud sound so as to attract the attention of the Loco Pilot.

1115. Use of Detonating Signals:

(1) General-

(a) The staff in possession of detonators shall not make any improper use of them. Engineers are responsible to ensure that the staff working under them know how and when to use detonators.

(b) A detonator when required to be used shall be placed on the rail with the label or brand facing upwards and shall be fixed to the rail by bending the clasps around the head of the rail.

(c) In the case of a mixed gauge, detonators shall be placed on the common rail or on the rail of each gauge.

(2) Testing-

(a) Once a year, one detonator shall be taken by JE/SSE (P.Way) from his own stock and from the stock of Track Maintainer (gang Mate, Keyman, Gateman, Patrolman and Watchman) for testing, one also from each of the lots in the personal custody of DEN, JE/SSE (Bridge), ADEN, works and relieving JE/SSE(P.Way) where the headquarters of these officials falls within the SSE(P.Way)'s jurisdiction. The oldest detonators should be selected for the test.

(b) The testing of detonators should be done under an empty BG/MG/NG wagon propelled by an engine and moving at walking speed up to 10 km/h under the direct supervision of the JE/SSE (P.Way), who shall ensure safety range during testing. Results of tests should be entered in a register.

(c) JE/SSE (P.Way) shall submit, by the end of the year (31st December), a certificate in duplicate to the ADEN to the effect. *'I certify that I have tested the detonators from stocks mentioned below in accordance with standing orders for the year ending ….. and append a list of those that failed to explode.'* The ADEN shall countersign and forward one copy of the certificate to the DEN with remarks, if any. Orders regarding the return or destruction of those lots, the samples from which failed to explode, shall be issued by the DEN.

(3) Life of detonators-The normal shelf life of detonators manufactured during 2010 and thereafter shall be 5 years reckoned from the year of its manufacture. It can, however, be extended further for a maximum of 3 more years provided that detonators which are more than 5 years old are effective. For this purpose two detonators of each batch/lot should be tested at the end of 5 years and if the result of these tests are satisfactory, life of the detonators

of that batch should be extended by one more year on expiry of which similar tests should be conducted annually to extend the life of the detonator of that particular batch/lot up to a maximum of 8 years from the year of manufactures. Such time extended detonators can be used on all sections after satisfactory testing. In case the results are not satisfactory, they should be destroyed as envisaged in *Sub-para (4) below.* For detonators, which are manufactured before 2010, the life of detonators will betaken as 7 years from the month of manufacture. In any case, no detonator should be kept in use after eight years.

(4) Disposal of time-barred Detonators - No detonator that bears any sign of rust and is time- barred shall be held in stock. Such detonators shall be destroyed by one of the following methods

(a) By soaking them in light mineral oil for 48 hours and then throwing them one by one into fire with due precautions.

(b) By burning them in incinerator.

(c) By detonating them under wagon during shunting operations.

(d) By throwing them in deep sea.

The destruction of time-barred detonators should be done in the presence of a JE/SSE (P.Way) who should ensure that every care is taken to see that splinters of detonators do not cause any injury to life and property. They should not be buried or thrown in places from where they could be recovered.

(5) Safety Range-When detonators are being tested, no person should be allowed within a radius of 45 m from the detonators to be exploded; the engine crew shall remain well within the cab. In practice, splinters from detonators when exploded seldom fly in a direction to the rear of the wheel which detonates them. Staff should therefore, when observing the safety radius, place themselves, as far as possible on the rear side.

1116. Care and Precautions in use of Detonating Signals:

(1) Care and Custody-

(a) Detonators should be protected against dampness. They should be stored in plastic/tin cases with papers wrapped over them; a layer of waste cotton must be kept at bottom and top of the tin cases to avoid contact with the metal.

(b) In one case not more than ten detonators should be kept.

(c) The cases should be stored in wooden boxes which should be kept in dry places and not left in contact with the brick walls, damp wood, chloride of lime or other disinfectants; these should not be exposed to steam or other vapours.

(d) Unexploded detonators should not be, as far as possible, sent from place to place by consignment; they should be conveyed personally or by a messenger.

(2) Stock with Engineering staff-

(a) Each JE/SSE (P.Way, Works and Bridge) shall have a stock of detonators sufficient to recoup the number annually tested and any which may be exploded for works and emergency. JE/SSE (P.Way) shall ensure that all track maintenance teams, Track Maintainers (Gatemen, Keyman, Patrolmen and Watchmen) are equipped with the specified number of detonators.

(b) Every ADEN, Track Maintainer (gang Mate, Keyman, Gateman, Patrolman and Watchman), whose duties include protection of track shall carry the specified stock of detonators with him on duty, for use during an emergency.

(c) The month and year of manufacture are shown on the label outside each case and also stamped on each detonator. Detonators should be used in the order of the dates stamped on them, the oldest being used first. To facilitate ready withdrawal in this sequence, they should be stored also accordingly.

1117. Protection at Worksites:

Any work in the proximity of running track shall be started by contractor only in the presence of competent railway supervisors or his representative and the contractor’s supervisor at site along with other procedures and rules to ensure safety. The work site must have fencing between the track and site to forewarn the road vehicle Loco Pilots working in vicinity of railway track. The authorized level of supervision by railway officials has been provided in *Chapter 7.* DEN/ADEN shall inspect work site in his section as much as possible and staff working at site need to be sensitized not to adopt any short cut methods leading to unsafe condition. Railway watchman must be posted when work is not being executed to avoid any unusual due to negligence of contractor’s labour in absence of the competent supervisors. The protection of work site by providing fencing/barricading shall be as per *Annexure 11/6*.

1118. Safe Working of Contractors on or Near Track:

A large number of men and machinery are deployed by the contractors for track renewals, gauge conversions, doublings, bridge rebuilding etc. It is therefore essential that adequate safety measures are taken for safety of the trains as well as the work force. The following measures should invariably be adopted:

(1) The contractor shall not start any work without the presence of the competent railway supervisor or his representative and contractors supervisor at site.

(2) Wherever the road vehicles and/or machinery are required to work in the close vicinity of railway line, the work shall be so carried out that there is no infringement to the railway's schedule of dimensions. For this purpose the area where road vehicles and/or machinery are required to ply, shall be demarcated and acknowledged by the contractor. Special care shall be taken for turning/reversal of road vehicles/machinery without infringing the running track. Barricading shall be provided as per *Annexure-11/6* wherever justified and feasible as per site conditions.

(3) The *"Look out and Whistle"* caution orders shall be issued to the trains and speed restrictions imposed where considered necessary. Suitable flagmen/detonators shall be provided where necessary for protection of trains.

(4) The supervisor/workmen of the contractors should be counseled about safety measures. A competency certificate to the contractor's supervisor as per proforma at *Annexure 11/5* shall be issued by ADEN which will be valid only for the work for which it has been issued.

(5) The unloaded ballast/rails/sleepers/other P.Way materials after unloading along tracks should be kept clear off moving dimensions and stacked as per the specified heights and distance from the running track.

(6) Supplementary site specific instructions, wherever considered necessary, shall be issued by the SSE (P.Way).

(7) The Engineer in-charge shall approve the methodology proposed to be adopted by the contractor, with a view to ensure safety of trains, passengers and workers and he shall also ensure that the methods and arrangements are actually available at site before start of the work and the contractor's supervisors and the workers have clearly understood the safety aspects and requirements to be adopted/ followed while executing the work.

(8) There shall be an assurance register kept at each site, which will have to be signed by both, i.e. Railway supervisor or his representative as well as the

contractor‘s supervisor as a token of their having understood the safety precautions to be observed at site.

(9) Contractor shall ply road vehicles only between Sunrise and Sunset. In case of an emergency where it is necessary to work during might hours, sufficient lighting shall be ensured in the complete work area for the safety of public and passengers. Also additional competent Railway staff shall be posted as necessary for night working. Permission for Night plying of road vehicle is to be taken from ADEN in advance.

(10) If any vehicle / machinery has to be left at site, it should be adequately away (not less than 3.5 m) from the track and should be fully secured, chained and pad locked so that it may not roll down or otherwise move.

(11) In case, work is planned to be done within 3.5 m from centre line of running track, it shall be ensured that the work is done under block protection only and necessary safety precautions for protection to track as per *para 1105* are taken.

1119. Personal Safety Measures at Work Sites:

The following should be ensured at work-sites for personal safety of P.Way staff to avoid incidences of run-over/grievous injury during working on tack.

(1) Use of personal protection equipments like luminous/florescent jacket, helmet, shoes, hand gloves etc.

(2) Keeping general alertness for personal safety as well as safety of co-workers.

(3) Avoid use of mobile phone during working.

(4) Always move in direction opposite to that of approaching train. While tightening bolts/fitting, Greasing of ERCs, Keyman must do work in the facing direction of approaching trains.

(5) On track work sites in double/multiple lines, move towards the cess on seeing approaching train on the track at which they are working. In yard lines, stand on platform while passing a train while working on track.

(6) Ensure at least 3 days training/ counseling sessions of newly recruited track men regarding track safety and their personal safety before engaging them in the track work. Newly recruited trackmen should not be sent alone for patrolling and other similar work.

(7) Hooter should be provided to Gang Unit with a separate dedicated hooter man, to alert the worker about the approaching trains.

(8) Gang mate should also be provided with thunder whistle to warn the workers about the approaching trains.

(9) Before giving signal to start a material train, it should be ensured that all the workers are on train and sitting down to avoid falling from the train.

(10) Some track machine working produce dusty atmospheres and/ or heavy noise pollution. It should be ensured that all the trains passing on the adjoining track are issued a caution order of 50 km/h or stricter to"Observe Hand Signal, Whistle freely and Stop, if required".

1120. Whistle Indicators:

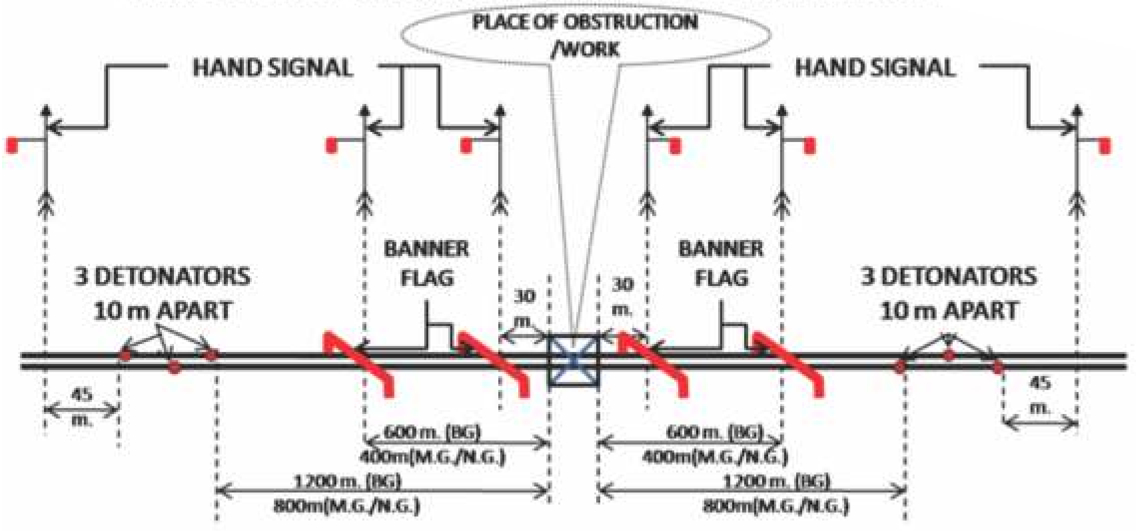
(1) Whistle boards for curves, cuttings and tunnels- Whistle boards as per *Annexure-11/7* with the letter 'W' of size 0.3 m high shall be provided 600 m in rear of all places where the view of the Loco Pilots is obstructed by cuttings or tunnels or curves and where it is necessary to give audible warnings of the approach of a train to those working on the track.

(2) Whistle boards for level crossings- Whistle boards are also provided on the approach of all unmanned level crossings and in case of manned level crossings, where a clear view is not obtained. These bear the letters W/L. The details of these whistle boards are described in *Annexure - 11/8.*

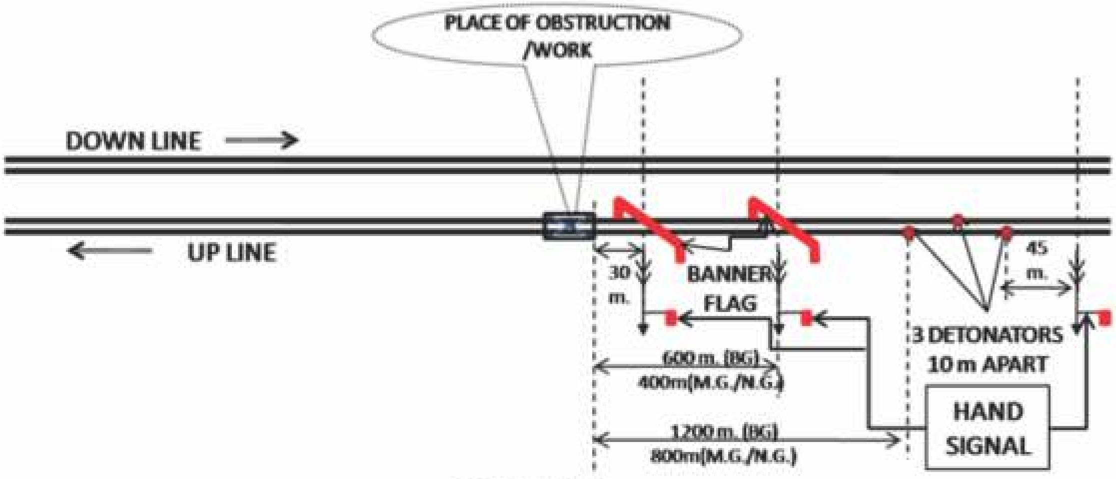
- *P.WAY is shy, do not repair without adequate protection. (Always protect the track before undertaking any maintenance activity)*

Annexure 11/1
{para 1105(a) (iv)}

WORKS OF SHORT DURATION – PROTECTION OF LINE IN CASE OF STOP DEAD RESTRICTION



SINGLE LINE



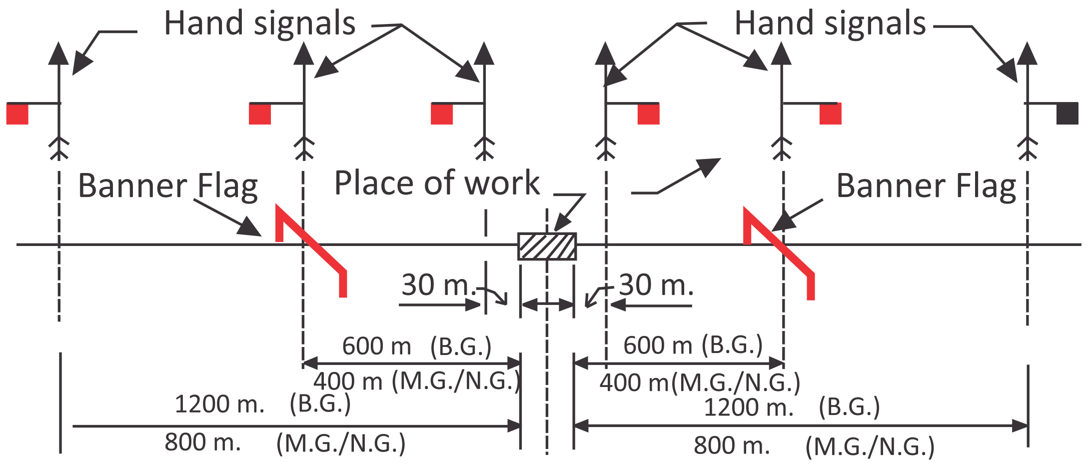
DOUBLE LINE

NOTE:

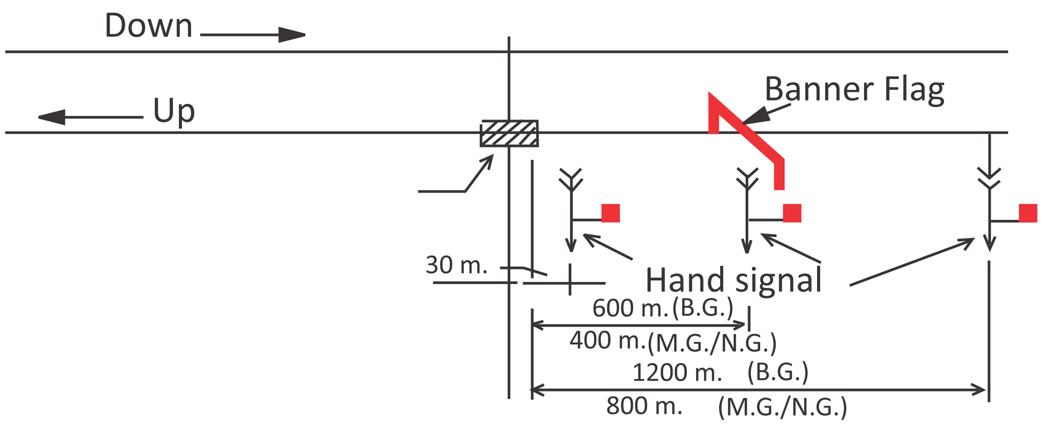
IN THE CASE OF M.G. SECTIONS WHERE THE TRAINS RUN AT A SPEED MORE THAN 75 KMPH THE DISTANCE OF HAND SIGNALS AND DETONATORS SHALL BE INCREASED SUITABLY AS PER APPROVED SPECIAL INSTRUCTIONS.

Annexure- 11/2
{para 1105(b)(iv)}

Works of short duration - protection of line in case of reduced speed



Single Line



Double Line

Note :

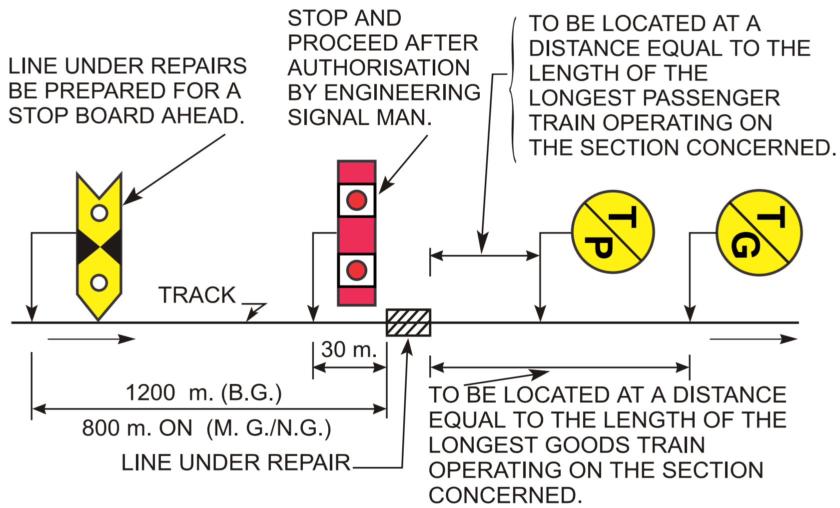
(1) Intermediate flagman will keep banner flag until the speed of the train has been reduced, after which the banner flag will be removed and train hand - signalled forward.

(2) In case of M.G. sections where the trains run at a speed more than 75 Km. P.H. The distance of hand signals and detonators shall be increased suitably as per approved special instructions.

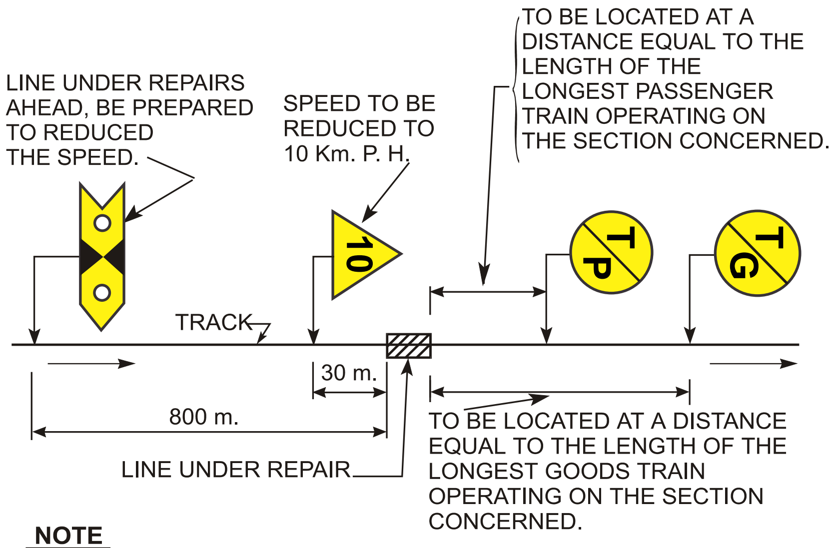
Annexure- 11/3
{para 1105(2)(b)}

FIXTURE OF ENGINEERING INDICATORS FOR DEAD STOP & NON STOP RESTRICTIONS OUTSIDE STATION LIMITS

FOR STOP - DEAD RESTRICTIONS



FOR REDUCED SPEED



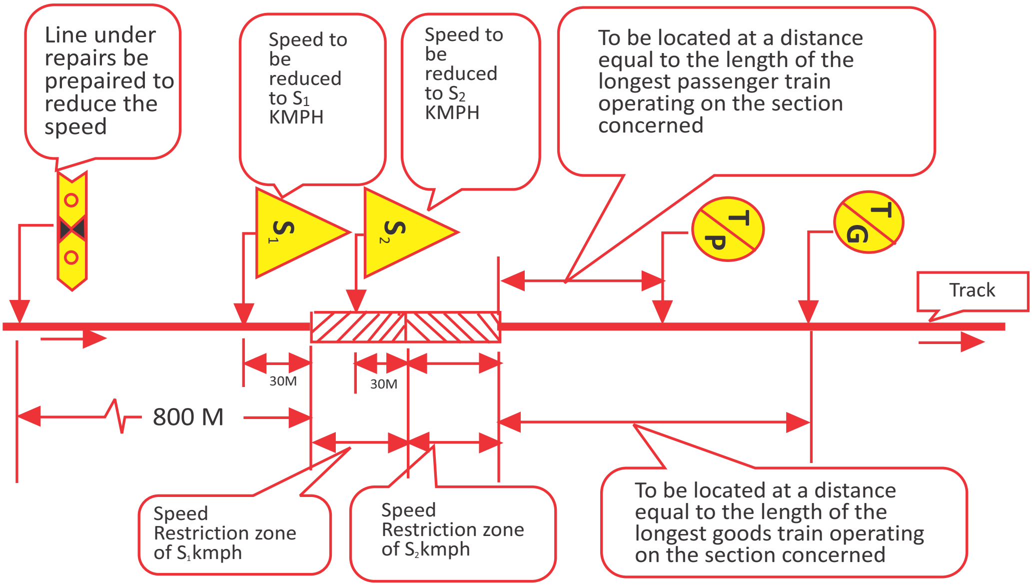
NOTE

In the case of M.G. Sections where the trains run at a speed more than 75 km. p. h. The distance of hand-signals & detonators shall be increased suitably as per approved special instructions.

Annexure- 11/3-A
{para 1105(2)(b)}

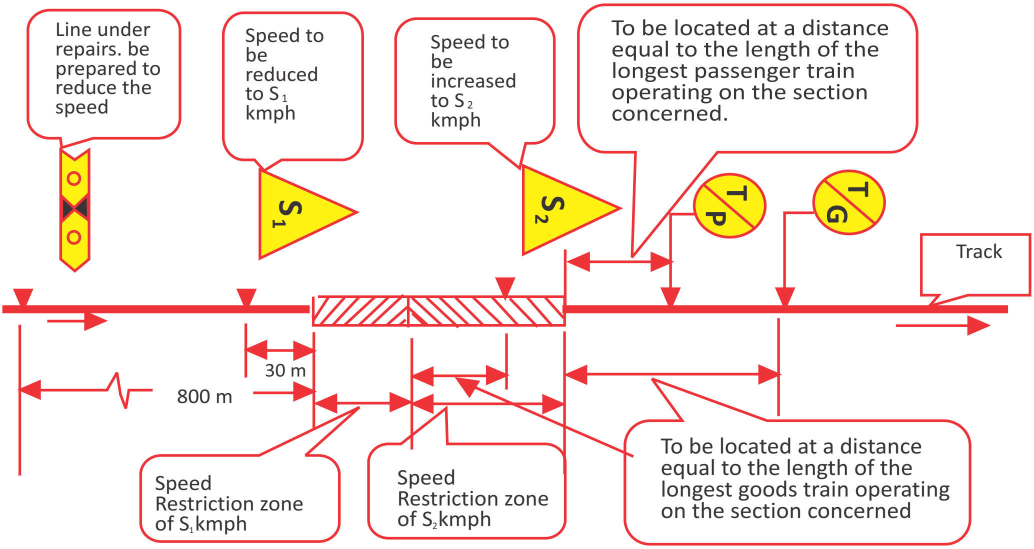
Position of Engineering Indicators in case of multi speed restrictions

CASE - I : $S_2 > S_1$



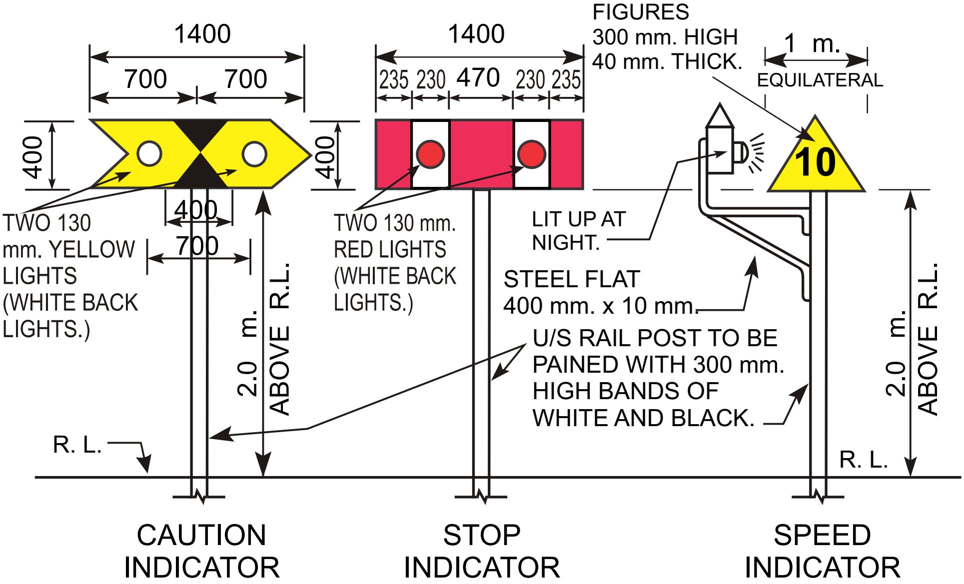
NOTE : Min length of speed restriction zone of S_1 kmph should be 200 m. otherwise speed indicator board S_2 shall be provided at the place of S_1

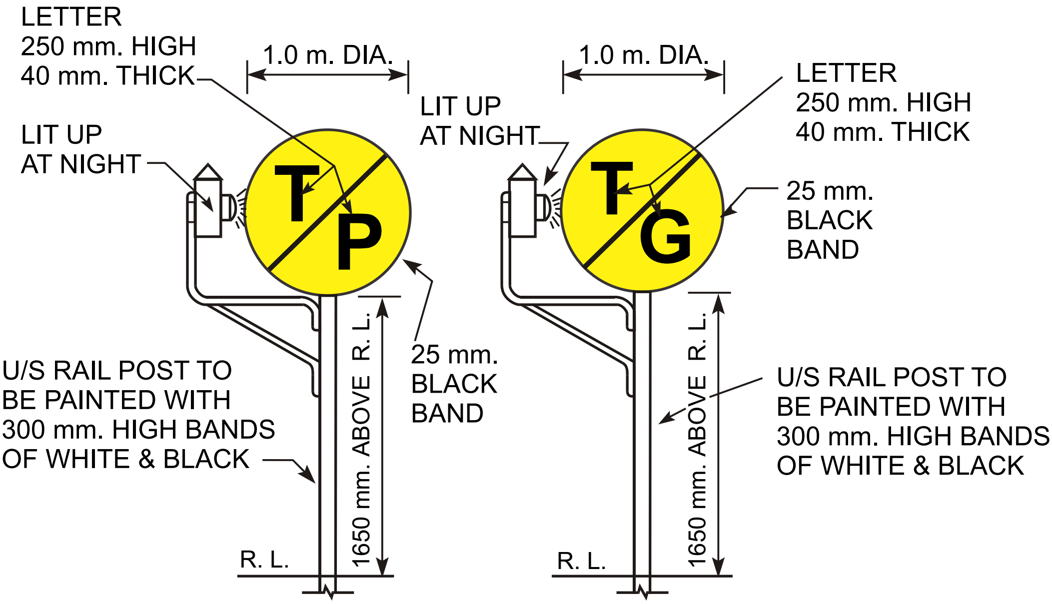
CASE - II : $S_2 > S_1$



Annexure- 11/4
{para 1110}

ENGINEERING INDICATORS FOR TEMPORARY RESTRICTIONS





TERMINATION INDICATOR FOR PASSENGER TRAINS

TERMINATION INDICATOR FOR GOODS TRAINS

Annexure 11/5
{para 1118 (4)}

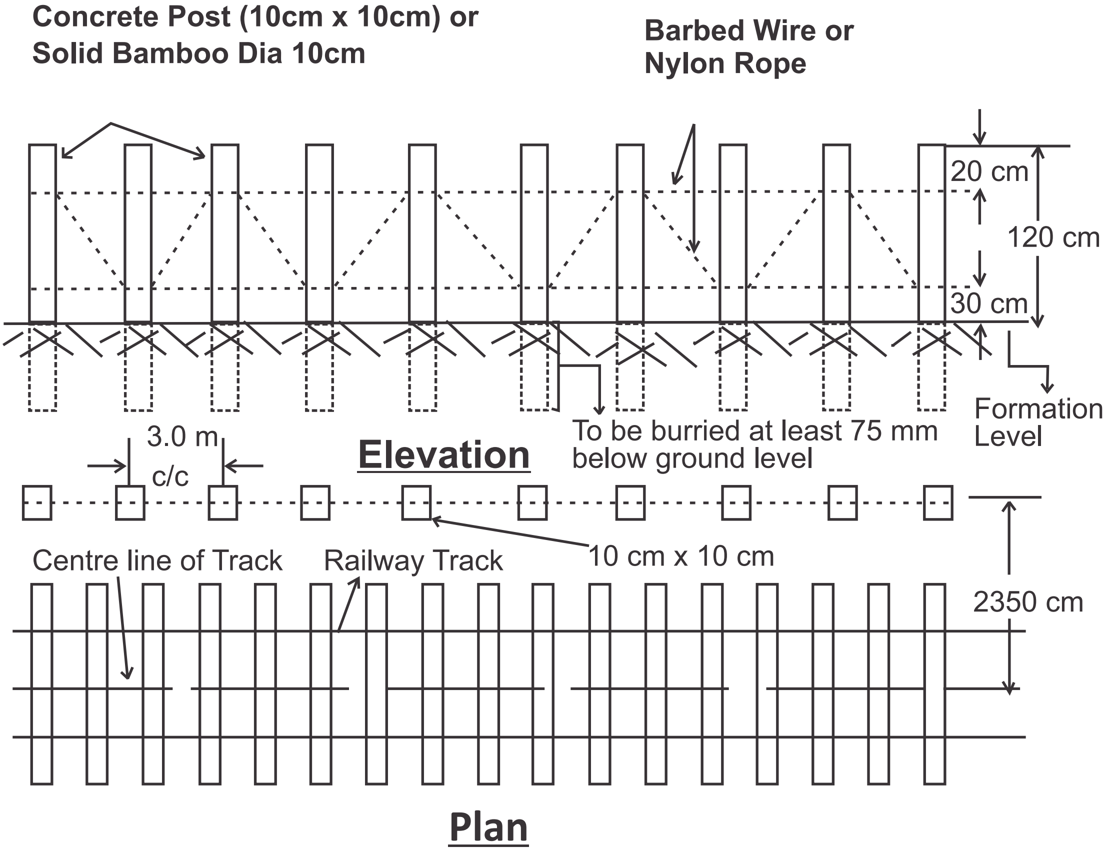
COMPETENCY CERTIFICATE

Certified that Shri...
P.Way supervisor of M/s. ....
has been examined regarding P.Way working on/ Other Engg. Works ....
work. His knowledge has been found satisfactory and he is capable of supervising the work safely.

ADEN

(Sub. Div.)
(Division)

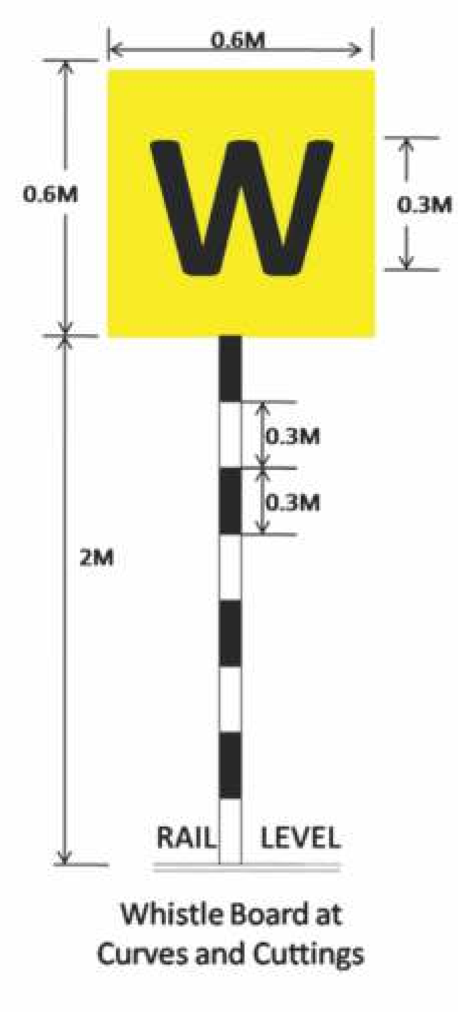
Annexure 11/6
{para -1117 & 1118 (2)}



Note : Barricading at work sites should be provided as far from centre line of track as possible but not less then 3.5 m from centre line of track. when the barricading is provided parellel to track at more than 3.5 m from centre line, barricading perpendicular to the track also need to be provided at terminating ends up to 3.5 m from centre line of track to avoid any movementof road vehicle between barricading and the track.

Annexure 11/7
{para 1120(1)}

Whistle Indicator



NOTE:

1. All letters 40mm thick
2. Whistle board shall be of retro reflective type.

Chapter 12

Working of Material Trains and Track Machines

1201. Working of Material Train :

(1) Departmental Material Train (DMT) :

A departmental train intended mainly for carriage of railway material for execution of works, either between stations or within station limits.

(2) Types of Material Train:

Building Material DMT :- BCHNL wagons used for transportation of boulders, moorum, sand.

Ballast DMT :- BOBYN wagons used to train out ballast on track. Sleepers

DMT:- MBOX wagons used for transportation of sleepers.

Rail DMT :-

(a) End unloading rake (EUR) used to load, unload and transport 10 rail and 20 rail panels.

(b) BFR/BRN - wagon used for transportation of free rail & 26 m / 39 m long rail panels.

(3) Rules for Working of Material Train:

The rules for the working of material trains are outlined in *Appendix IX of the Indian Railway Code for the Engineering Department, and Para 4.62 to 4.65 of General Rules for Indian Railways (1976) and Subsidiary Rules of Railways.*

(4) Formation of Material Train and Economical Working :

(a) Material Train shall consist of

(i) Power (Engine)

(ii) Loaded wagons

(iii) A covered wagon for shelter to labour and their equipments.

(iv) At least one brake-van in rear of train.

The ADEN should arrange to form a train of maximum capacity consistent with the haulage capacity of the engine and tonnage approved for the section. In consultation with the Operating Department, the running of goods trains should be suitably regulated so as to provide as long a working time for material train as possible. Delays in working should be traced to their source and remedies applied as circumstances demand.

(b) Register of Engineering Vehicles:

(i) The DEN and ADEN should maintain subdivision-wise a complete inventory in the form of a register of all closed wagons, open wagons, hoppers, etc., on the division. The register should contain :

Vehicle numbers;

Type of vehicle;

Capacity;

Condition of vehicle;

BPC Revalidation Date;

Intensive Due Date;

(ii) Locations and particulars of periodical overhaul, when carried out and due. The register should be kept current to facilitate issue of instructions when ordering a material train.

(iii) A monthly return of engineering vehicles on the sub-division should be submitted by the ADEN to the DEN. It should be the ADEN's responsibility to keep track of all Engineering vehicles allotted to his sub-division.

(5) Ordering of Material Train :

Operating Department is the authority for ordering material train. The details consist of:

(a) The composition of train.

(b) The loading kilometrages.

(c) The sections over which the train will work.

(d) The date of commencement of work.

(e) The station at which the rake will be stabled.

(f) The engineering official who will be deputed to be in-charge of the train.

The notice to be given by the Engineering department should not normally be less than a week.

(6) Train Examination and "Fit- to-Run" Certificate :

(a) Before a material train is allowed to work, the complete rake should be examined by the carriage and wagon staff and a "fit-to-run" certificate issued to the Guard.

(b) Other repairs in rake which may cause problem during movement are to be attended by SSE/C&W before dispatch.

(c) Round trip BPC will be ensured.

(d) Examination after every

(i) 15 days for air brake stock

(ii) 10 days for vacuum brake stock.

(e) Arrival and departure examination by C&W staff should be ensured at loading point.

(f) Check for hopper valves working.

(g) Check for EUR Rake at loading point:

(i) That welded rail panels are loaded centrally and uniformly at plant.

(ii) Loading of rails panels can be four tiers/five tiers.

(iii) End supports should be provided to prevent longitudinal movement of panels while in transit.

The Guard of the material train should at once bring to the notice of the Train Examiner under advice to the ADEN, any deficiency or damage which may have escaped the attention of the train examining staff. The Guard will also keep a record of all damages caused to the vehicles during the work and report to the ADEN the circumstances in which they occurred.

(7) Equipment :

Every material train Guard must have following equipments with him while on duty:

(a) A copy of General and Subsidiary Rules.

(b) Working Time Table with correction slips and appendices, of the

Railway over which the material train is to be worked.

(c) A Watch.

(d) Hand signal lamps. (LED type)

(e) Two red flags and a green flag .

(f) A whistle.

(g) Not less than 10 detonators in a tin case.

(h) A carriage key.

(i) Padlocks as prescribed by special instructions.

(j) A set of clamp for point locking and/or other locking devices.

(k) A spare pair of glasses if he is required to wear glasses.

(l) First aid box.

(m) Sprags and Chains.

(n) A tail lamp/L.V. Board.

(o) Portable telephone (on controlled sections), and any other equipment and stores prescribed by special instructions.

(p) Megaphone.

(8) Working in Block Section :

(a) Before entering in Block Section the Engineering Supervisor in-charge of the material train must ensure scheduled train examination.

(b) A material train shall be worked with the permission of the Station Master on either side and in accordance with the provisions and system of working in force on the section. Before a Material Train enters a block section for work, the Station Master should advise the Driver and the Guard in writing of the time by which the train must clear the block and whether it is to proceed to the block station in advance or return to the same station.

(c) A " Working Trip " is a trip when one or more wagons are to be unloaded between two stations. A "Running Trip" is a trip from one station to the other when no wagons have to be unloaded on the way. Before departing on a 'Working Trip' the JE/SSE (P.Way) shall supply the Material Train Guard/Official-in-charge with a memo furnishing the kilometre at which the wagons shall be unloaded and the quantity to be unloaded.

(d) While unloading on double/multiple lines, adjacent lines shall be protected in the direction of traffic in accordance with the instructions in G&SR. Caution Order of Observing Engineering Hand Signals and whistle freely should be issued for adjoining line.

(e) Loose shunting and sudden application of brakes shall not be permitted and clear instructions shall be given to Loco Pilot and Guard in this regard.

(f) The Driver of a material train should stop the train short of all catch, loop or spring points which are facing for his train and which are not protected by signals. The Guard should ensure that these are correctly set and locked and then hand signal the Driver past the points.

(g) The Guard/Engineering official-in charge shall ensure efficient and proper working and adhere to sanctioned time and occupation of block section.

(h) When a material train enters a block section to work under instructions of other than under the normal system of working, the Guard and the Driver of the train shall ensure that the train is protected from the direction a train is approaching on double line and in both directions on a single line in accordance with General Rules.

(i) On stopping a material train on a grade, the Driver should give a long blast of the whistle to call the attention of the Guard and thereafter three sharp blasts, the signal for application of hand brakes. The brakes must not be released until the driver has signalled for this by giving two sharp blasts.

(j) Before entering a section, on which a material train is required to stand on a grade of 1 in 50 or steeper, the engine should be so attached that when the train is standing the engine is at the down-hill end of the train.

(k) The P.Way Engineer, not below JE (P.Way) /Guard/BTC, shall always be alert especially while working on gradients.

(l) In case parting is observed, all out efforts should be made to apply the hand brakes and place the wooden wedges below the wheels in such a manner so as to arrest the movement of the parted portion. The Station Masters on either side of the block section where the material train is working on line, shall be vigilant.

(m) The train Guard/Engineering official-in-charge shall be responsible for working the train to the instructions issued by the ADEN. The JE/SSE

(P.Way) shall arrange for the inspection and clearing of track behind the train.

(n) A caution order shall also be given to Loco Pilot of all trains running on adjacent lines on a section gauge stating, "Men at work, whistle frequently and observe hand signals at site".

(o) To despatch material train as block back message from a block station intimating to the block station immediately in rear on a double line, or to the next block station on either side on a single line, that the block section is obstructed or is to be obstructed.

(p) To despatch material train as block forward message from a block station on a double line intimating to the block station immediately in advance the fact that the block section in advance is obstructed or is to be obstructed.

(q) When a material train is working between stations, the Guard will in consultation with the engineering official in-charge of the material train, depute adequate number of permanent competent engineering staff to protect the train at site by red banner flag and 2 detonators 10 metre apart near the banner flag as follows:

(i) On Broad gauge:

At a distance not less than 600 m in direction opposite to traffic movement from material train on double line and in both directions on single line.

(ii) On Metre gauge and narrow gauge:

At a distance not less than 400 m in direction opposite to traffic movement from material train on double line and in both directions on single line.

Banner flag and the detonators must shift accordingly with material train movement.

(r) A material train should not be split outside station limits except in an emergency. Before the train is split the Guard should put the handbrake in the brake-van hard on. Vehicles should not be detached from a material train on a grade of 1 in 100 and steeper. The engine itself maybe detached with the Guard’s permission after he has ensured that hand brakes on each vehicle are properly applied and the wheels spragged against any movement.

(s) Warning to workers on Material Trains:

(i) The Guard of a material train shall before giving the signal to start, see that all the workers are on the train, and warn them to sit down.

(ii) Before moving his trains, the Driver must sound the whistle, according to the prescribed code, as a warning to the labourers that the train is about to move.

(iii) Before commencing any shunting with his train, the Guard must ensure personally that all labourers have been de-trained.

(iv) In the event of it being necessary to part a material train, the Guard must ensure personally that all labourers have been detrained before doing so.

(t) Precautions to be taken while pushing back:

On down gradient steeper than 1 in 100, pushing is not permitted. On gradient easier than 1 in 100 ascending or descending pushing may be permitted at a speed not exceeding 25 kmph provided the brake-van occupied by Guard is the leading vehicle. The speed will be restricted to 10 km/h, if the brake van is not leading.

Following points should be kept in mind while pushing back :

(i) No train must be allowed to push back without a written authority from the Station Master of the station from which it entered the section.

(ii) The Station Master of a station where the train starts from and pushes back to, must advise the station in advance and also the Controller on controlled sections that the train will push back to the station. He will then obtain the acceptance of the "is line clear for a train stopping in the section" signal from the station in advance and then give the "train entering section" signal.

(iii) On the return of the train, the Guard will intimate that the whole of the train has returned to the station complete, from the section and sign in the trains register book to the effect and return the "authority to push back" to the Station Master which must be cancelled by the latter.

(iv) When it has been arranged for a train to push back from the section, it must always do so and not go through to the station in advance.

(v) Before starting, a green flag must be tied to a convenient fixture in front of the engine and also at the back of the rear brake-van to indicate to men working on the line that the train will push back.

(vi) On the double line/single line , when the train is required to be pushed back into a station, the train must come to a stand outside the advance starting signal and the Driver shall whistle, when, if a line is clear for its reception, it must be piloted into the station. If there is no advance starting signal, than the train be stopped at outer signal and piloted into the station.

(vii) Except in an emergency, material trains may push back during day-light only. If push back during the night, it must do so at a walking pace and the Guard or a competent railway servant must walk at least 600 m on B.G. and 400 m on M.G. and N. G. in advance, exhibiting a danger signal until the train comes to a stand .

(u) Speed and Gradient running of Material Trains:

(i) When running between block stations with the engine leading, the speed of material train shall not exceed that prescribed for a goods train with a similar load.

(ii) When the engine is pushing the train and when as in the case of emergencies the brake-van is not leading –

(a) The speed must not exceed 10 km/h.

(b) The speed must not exceed 25 km/h (if brake-van is leading).

(c) The Guard must travel on the leading vehicle and exhibit hand signals to the Driver.

(iii) Speed while negotiating turnouts should be restricted to 15 km/h and for turnouts having speed potential less than 15 km/h shall be negotiated at specified speed.

(iv) Loco Pilots should observe all permanent and temporary speed restrictions imposed in the section during its run.

(v) In case of partial unloading of one layer of EUR rake if rake is taken to station from block section, the speed shall not be more than 15 km/h.

(v) Restrictions on Running Material Trains :

(i) Except with the permission of the ADEN or DEN, a Material Train should not be permitted to work during periods of poor visibility due to fog, storm or any other cause.

(ii) Except in an emergency, working of material trains carrying labour should not be permitted between sunset and sunrise. If it is necessary to work Material Trains during night, permission to do so should be obtained from the DRM.

(w) Running on Ghat Section and Descending Grade :

(i) On Ghat sections, it may be necessary to attach an engine to bank the load.

(ii) When a material train is descending a long and continuous steep grade, the brake levers of as many wagons as may be necessary to assist in controlling the speed, should be notched down by the Guard under arrangements with the Driver.

(x) Stabling of a Material Trains :

(i) Material train shall not be stabled on running lines at a station, except in unavoidable circumstances.

(ii) When a material train is stabled at a station it shall be protected in the following manner and Station Master shall ensure that –

(a) The vehicles of the material train have been properly secured and are not fouling any points and crossings.

(b) All necessary points have been set against the line on which the material train is stabled and such points have been secured with clamps or bolts and cotters and padlocks, and

(c) The keys of such padlocks are kept in his personal custody until the material train is ready to leave the siding or line.

(iii) The Guard shall not relinquish charge until he has satisfied himself that the material train has been protected as prescribed in this rule.

(iv) When the train is ready to leave, the Guard must advise the Station Master in writing. The Station Master must then arrange for correct setting of the points.

(v) When a material train is stabled in an outlying siding, the Guard must ensure that it is inside the trap, clear of fouling marks and clear of running line. He must pin down sufficient number of brakes and if necessary, lock by means of safety chains or sprag the wheels.

1202. Official-In-Charge of Material Train :

Whenever a material train is worked it shall be accompanied by a Guard. As the Guard is not qualified to carry out such duties as working of hoppers, distribution of ballast/materials, supervising loading and unloading, maintaining muster rolls and daily reports of labour and preparation of daily reports on material train working, a qualified engineering official should be deputed on the train to ensure working of material train to the programme specified by ADEN.

1203. Care in Unloading of Ballast Hopper:

(1) Loading at Ballast Depots : The staff at the ballast depots are responsible to ensure that the wagons are loaded to the correct level.

(2) Working Trip :

(a) The train Guard or Engineering official-in-charge shall be responsible for working the train to the instructions issued by the ADEN. The JE/SSE (P.Way) shall arrange for the inspection and clearing of track behind the train.

(b) A " Working Trip " is a trip when one or more wagons are to be unloaded between two stations. A "Running Trip" is a trip from one station to the other when no wagons have to be unloaded on the way. Before departing on a 'Working Trip' the JE/SSE (P.Way) shall supply the Material Train Guard/Official-in-charge with a memo furnishing the kilometrage at which the wagons shall be unloaded and the quantity to be unloaded.

(3) Operation of Hoppers :

The hopper valves shall be operated under the direct supervision of the train guard or official-in-charge. As far as possible one hopper may be unloaded at a time moving at walking speed. The official-in-charge should walk on the side and instruct the labour as to when to open or close the hopper valves. The train should not be stopped, while ballast is being discharged ; labour should not be moved from the platform without first stopping the train.

1204. Care in Unloading of End Unloading Rakes (EUR) :

(1) For EUR Guard/Engineering officials should have these additional equipments-

(i) Spare hooks and slings, crow bars, manila rope

(ii) Rail cutting facilities for cutting rail in emergency i.e. gas cutter etc.

(iii) Wooden Wedges/skids of standard design.

(2) Precautions to be kept in mind for EUR Rakes :

(a) During unloading, neither person shall be allowed to stand between bulkhead doors, nor staff should climb over the rail panels.

(b) The protective rail and flap door of bulk head shall be opened during block "ONLY" and once all the rails of one layer unloaded, next layer door shall be opened and shall be unloaded.

(c) In case of partial unloading of one layer if rake is taken to station from block section the speed shall not be more than 15 km/h.

(d) No staff will be allowed on ramper and threader during movement from one station to other station where rake is moving for non block activity. Staff shall sit on front portion of brake van. Guard of the train will allow only those workers (Railway or Contractor) who have identity card issued by competent authority not less than SSE/ ADEN.

(e) The Sectional P.Way Engineer, not below SSE (P.Way) shall be responsible for:

  (i) Placement of unloaded rail panels in safe position, so that panel does not infringe the Standard Dimensions.

  (ii) Only tested slings shall be used for unloading of welded panels. Slings to be tested every 6 months.

  (iii) Un-loading of panels should be arranged in such a way that turnout & crossovers and girder bridges are avoided.

  (iv) Proper anchorage shall be done to keep the rails secured to the ground. Pulling of first two panels into chute wagons should be done only at the spot where unloading is planned. Panels should not be pulled out in advance in to chute wagons in the yard or en-route.

(f) Bulk head doors should be properly fixed/closed and rail stoppers are to be positioned when the formation is in motion. During unloading process, the bulk head doors and rail stoppers of the unloading layer only are to be in open condition.

(g) If any rail panel extends beyond bulk head doors and do not permit the closure of bulk head doors, all the panels in that layer shall be properly secured with the help of wire ropes to stanchions and then only formation should be moved with a speed restriction of 10 km/h or less.

(h) While unloading, panels shall be unloaded by the side of running rails duly clearing the ballast up to the sleeper ends clear of any infringement to the running trains.

(i) The wedges/skids shall be placed in the rear most vehicle in such a way to prevent the rolling back of the formation.

(j) A continuous proceed hand signal shall be shown by the Guard/Ballast

Train Checker (BTC) throughout the movement of the train during unloading.

(k) A megaphone shall be available at the site of unloading for the use of sectional P. Way Engineer to direct staff and keep them alert to avoid any accident

1205. Training Out Material and Daily Reports of Working:

(1) Training out of material and ballast should be done to a programme sanctioned by the DEN or ADEN.

(2) The Guard/Engineering official-in-charge should adhere to the sanctioned programme and submit daily report on prescribed form shown below *(Fig. 12.01)* (Material Train Journal) to the Assistant Engineer. Where the contractual labour is employed, the daily report should show the correct number of labourers of each class employed and the nature and approximate quantity of work done. For Departmental labour, Muster rolls should be maintained by the Guard or Engineering Official-in-charge and checked and initialed frequently by the officials concerned .

DAILY REPORT OF MATERIAL TRAIN WORKING

Material Train Report of .... train, ordered *vide* Divisional Engineer's/Assistant Engineer's No. .... working from kilometre .... to kilometre .... Engine No. .... Class .... composition of train .... labour .... Mistries/Mates .... Men …..... Women ……….….... Name of the Contractor ....

Station		Time		Hours occupied	Trip No.	Work done	Trains crossed	Allocation	
From	To	From	To					Name of the work	Head of Account

At		Trip No.	Contents			At		Trip No.	Contents		
Kilometre	T.P.		Wagon	Description of material	Quantity	Kilometre	T.P.		Wagon	Description of material	Quantity

Contractor or his authorised agent	Inspector No. .... Section	Material Train Guard/ Official.	Assistant Engineer. Sub-Division	Divisional Engineer. Division ....

Note – On reverse of this form the class, capacity and number of each wagon should be shown; also, particulars of detentions to train other than for Engineering Work.

Fig. 12.01 *- Material train journal*

(3) In cases where the material is not loaded in bulk *e.g.,* rail girders and bricks, the actual weight and number loaded should be given in the daily report.

(4) Sufficient number of copies of daily reports should be prepared by the Guard/Engineering official in-charge and submitted to the concerned officers *e.g.,* Engineering, Operating, Mechanical etc.

(5) The number of wagons on the train with their capacity and painted numbers should be indicated on the form of daily report. Particulars of detention to the train other than for Engineering work should also be indicated.

(6) The ADEN should scrutinise the daily reports and take such action as considered necessary to avoid or minimise detentions in the working of the material train, before forwarding the same to the DEN for allocation, initials and record.

1206. Charges for Material Train Working:

For purposes of debiting the charges "Material Train Return" on the form given in *Para 1466-E* will be prepared by Operating Department and sent to the DEN for completion and submission to the Accounts Department.

1207. Working of Track Maintenance Vehicles :

(1) General information:

(a) Heavy Self-propelled machines used for track maintenance and renewals are known as Track machine.

(b) Various types:

(i) Track Maintenance machines.

Machines for Plain Track Maintenance.	High Output Tampers:- CSM and Tamping Express (TEX) (For Plain Track Tamping)
	Work Site Tampers:- (For Tamping of Plain Track after track renewal/deep screening) Ballast Regulating Machine
	Dynamic Track Stabiliser (DTS)
Machines for Turnout maintenance	Unimat Machine (for Tamping of Points and Crossings)
Machines for Turnout and plain track maintenance.	Multi-Purpose Tamper (MPT) :- (For both Points and Crossings and Plain Track tamping.)

Machines for Ballast Cleaning	Ballast Cleaning Machines(BCM)
	Shoulder Ballast Cleaning Machine (SBCM)
Machines for Loading/Unloading and transportation of Track Material	Utility Vehicle (UTV) (for Loading/Unloading and Transportation of Track Material.)

(ii) Track Relaying Machine.

Machines for Track Renewals	Turnout Laying Machine (T-28)
	Track Relaying Train (TRT)
	Plasser Quick Relaying System (PQRS)

(iii) Rail Grinding Machine (RGM)

(c) Competency for Track Machine Operator:

Machine In-charge or Operator of Machine should be of rank not below JE and must have

(i) Attended & satisfactorily completed safety courses at ZTC.

(ii) attended & satisfactorily completed - Machine operational training at IRTMTC - Allahabad.

(iii) Attended & satisfactorily completed Road learning of section where he has to work. Compliancy certificate to this effect will be issued by Sr. DSO/DSO of division & valid for one year.

(iv) Valid Medical category Certificate i.e. A3

(v) Valid Competency Certificate issued by Dy. CE/Track Machine, after prescribed test.

NB : Whosoever Senior most Operator handling the Machine, will be designated as Machine Incharge.

(d) Equipments:

(i) The operator shall ensure that the following equipment is available in working condition before the machine is put on running line.

- Two red and one green hand signal flags.
- Two tri-colour hand signal lamps. (LED type)
- Two chains with padlocks.
- Two Clamps with padlocks.
- 10 Fog signals (detonators) in a tin case.
- A copy of the working timetable of the section where the machine is working.
- G&SR book with upto date amendment slips.
- One 4 cells flasher light.
- One portable field telephone.
- Two banner flags.
- One First Aid box.
- Two Skids.
- Petromax/LPG lamp
- Safety helmets for all machine staff
- Protective clothing, safety shoes and Safety gloves.
- Track Machine Manual
- Accident Manual

(ii) Machine Operator shall check and ensure proper functioning of Head and Tail Lights, Marker lights and Flasher lights, LV board.

(iii) Equipment to be available to meet exigencies during block working:

- Fire extinguisher: One
- Hooter (manual): Two
- Jack 50 t. Two with Traverser Facility
- Wooden blocks Four
- Crow bars Four
- Hydraulic hand pump One
- Emergency pneumatic/hydraulic hose off sizes suiting to

different machines (Complete with end fitting)

- Wire rope with close loops at both ends 2 m and 9 m for BCM.

(2) (a) General instruction for safe working of machine

(i) Track machines shall be worked as a train, as defined in *G & SR 1.02* for Train Working.

(ii) Duties of guard shall devolve on the in-charge of machine /machines.

(iii) Movement of machines in convoy :

(1) Under block working :

(a) During day when visibility is adequate, required no. of Track Machines may be allowed under one authority to proceed for working within the block section. During Night, adequate visibility to be ensured.

(b) All 'On Track' Track Machines must leave and enter the station, one after another.

(2) Under shifting from one station to another station:

Only one 'On Track' Track machine may be allowed under one authority to proceed, at a time.

(3) The tail lamp/board should be fixed only on the last machine in the direction of movement.

(iv) OHE block should be ensured while working of track renewal track machines to ensure safety of working staff.

(v) The JE/SSE (P.Way) is responsible for protection of the site of work and adjoining track(s) in case of infringement.

(vi) He shall be conversant with the infringing conditions of the various machines. He shall also be responsible for safe condition of track before clearing the block after machine working.

(vii) Minimum distance between two machines should be:

$\geq$ 50 m when working.

$\geq$ 120 m while driving.

Or as per *G & SR* of railway.

(viii) Types of authority required for movement of track machine.

- Shunting authority used to bring track machines from siding to running line.
- Track Maintenance Machine Permit: Signed by all machine operator and Permits to work under block section.
- Authority for passing last stop signal at danger.
- Pilot-in and Pilot out Memo : A written authority by SM to Pilot out and Pilot in machines by Points-man from Station to block section and Block section to Station respectively after ensuring padlocking of all the facing points.

(ix) Protection of track machines at work site:

- When working in block section:

  JE/SSE (P.Way) (official in-charge of machines), in consultation with JE/SSE (Track machine) depute adequate number of permanent competent staff to protect machines at site by red banner flag and 2 detonators 10 m apart near the banner flag as follows:

  On Broad gauge:

  At a distance not less than 600 m in direction opposite to traffic movement from last track machine on double line and in both directions on single line.

  On Metre gauge and narrow gauge:

  At a distance not less than 400 m in direction opposite to traffic movement from last track machine on double line and in both directions on single line.

  Banner flag and the detonators must shift accordingly with track machine movement.

- In station yards banner flags must be placed at either end of the track machine standing on a line unprotected by signals.
- Protection of affected line during accident should be done as prescribed in *G&SR.*

  Note: In emergency red hand signal can be used in place of banner flags.

(x) Caution Orders to be imposed on adjacent line for block duration only:

- for BCM, FRM, TRT, T-28, PQRS, Material trains.

  suitable speed restriction as per local site condition + whistle freely + observing engineering hand signals + STOP, if required.

- All other machines

  Whistle freely and observing engineering hand signals

(xi) Failure of track machines in mid-section:

- In the event of break-down, the track machines shall be protected as per *G & SR 6.03* thereto by the machine staff, as directed by machine in-charge.
- Failures in block sections of the track machines will be treated as accident under class 'J', if overdue by one hour. Accidents involving track machines shall be treated as train accidents under the appropriate class and action shall be taken as per the rules in force.
- In case of failure of track machine in block section, the JE/SSE (P. Way) may decide to push the disabled unit to the nearest station provided the brake power is in good condition. Otherwise, intimation shall be sent to the nearest Station Master through a messenger and to the Control through portable telephone asking for a light engine to tow the unit. In case, machine in-charge feels clearance of section is going to take long time, the assistance of Accident Relief Train shall be asked for immediately. Meanwhile the machine in-charge shall take necessary action to rectify the defect(s).

1208. Rules of Movement of Machine :

(1) working procedure for one block station to another block station:

When the track machine is required to move from one block station to another block station, the operator shall run the machine with the proper authority to proceed as defined in *G & SR 1.02 (6)*.

(2) All the operators (in-charge) shall acknowledge the block authority by signing on it.

(3) Movement from siding/stabling line: Machine/machines shall not be bought on running line without shunting authority.

4) Procedure for working of machines between block stations during working:

(a) Double line section-Work and proceed:

(i) *Via Right Direction*

- Machines working permit shall be signed by all machines operators
- If machines are in group (not coupled) all facing point shall be clamped and pad locked even if last stop signal is off. The authority this regards shall be given by SM on duty.
- While clearing block on next station all the Facing points shall be clamped and pad locked and the machine/machines shall be piloted by points-man.
- JE/SSE (P.Way) in-charge shall travel on the last machine

(ii) *Via Wrong Direction:*

- Issue of PLC and block working permit, which shall be signed by all operators.
- The machines shall be piloted out on written authority issued by SM after locking all facing points.
- While clearing block on other end the machines shall be piloted in by points-man.
- JE/SSE (P.Way) in-charge shall travel on the last machine

(b) Double line section-Work and return:

(i) *Via Right Direction*

- Block permit dully signed by all operators plus authority for passing last stop signal at danger.
- If machines are in group (not coupled) all facing point shall be clamped and pad locked even if last stop signal is off. The authority this regards shall be given by SM on duty.
- While clearing the block the points-man shall piloted the machine/machines after pad locking the facing points on written authority(Pilot-in Memo) of SM.
- JE/SSE (P.Way) in-charge shall travel on the first machine

(ii) *Via Wrong Direction*

- Block authority shall be signed by all operators
- The points-man shall pilot out the machines on proper authority of SM after locking all facing points.
- Similarly while clearing the block machine/ machines shall be piloted in after pad locking the points.
- JE/SSE (P.Way) in-charge shall travel on the first machine.

(5) Role of JE/SSE (Track Machine / P.Way):

(a) JE/SSE (Track Machine) shall be official in-charge of track machines and ensure that all operator acknowledge and sign the authority for the block.

(b) JE/SSE (P.Way) should demand the block for machines only in the prescribed format.

(c) JE/SSE (Track Machine) will ensure in all condition that all the facing points are pad locked before movement of more than one machine.

(d) JE/SSE (P.Way) should know that he has to travel in the last machine while block operated "work and proceed" and in the first machine while "work and return"

(e) JE/SSE (P.Way) will ensure Protection of Site while working in block as per *G&SR.*

(f) JE/SSE (P.Way) will ensure Protection of adjacent track if required and ensuring caution order for safety of staff.

(g) JE/SSE (Track Machine) will ensure that *G&SR* is being followed by SM for movement of machines.

■ ■ ■

- *Observe safety rules, these are your best tools.*

Chapter 13

The Working of Trollies, Motor Trollies and Lorries

1301. Definitions:

(1) Push Trolley : A vehicle which can be lifted bodily off the track by four men.

(a) Used for Permanent Way inspection.

(b) A vehicle which can be lifted manually off the track.

(c) Manned by minimum four competent track maintainers.

(d) To operate under HS flag protection between sunrise to sunset.

(e) Push Trolley may be used during night under block protection.

(2) Motor Trolley : Any trolley which is self propelled, by means of a motor, is a motor trolley.

(a) Used for fast Permanent Way inspection.

(b) Any trolley which is self-propelled, by any means other than manually.

(c) Manned by adequate competent track maintainer and one driver.

(d) Operation requires traffic block.

(3) Lorry : Any vehicle similar to trolley but heavier (which includes dip lorry) is deemed to be a lorry.

(a) Used for transportation of Permanent Way Material.

(b) Includes dip-lorry.

(c) Manned by minimum Eight competent track maintainer, under supervision not below Mate (Track maintainer Gr. 1)

(d) Normally operates under traffic block, unless otherwise exempted by approved instructions.

(4) Rail Dolly :

(a) Rail Dolly is a device with two or more wheels.

(b) In balanced condition it can be moved manually on one rail of track.

(c) Manned by minimum three track maintainers under supervision not below mate (Track maintainer Gr. 1).

(d) To operate under HS Flag protection between sunrise to sunset.

(e) When more than two dolly/monorail cum road trolley *(Para 1301 (5))* are operated, minimum level of supervision shall not below JE/P.Way.

(5) Mono Rail Cum Road Trolley :

(a) Used to transport small track machines and track fittings on road as well as on rail.

(b) Light weight small platform trolley.

(c) Manned by minimum two track maintainers under supervision not below keyman (Track maintainer Grade II) .

(d) To operate under HS Flag protection between sunrise to sunset.

6. Rail Borne Motor Vehicle (RBMV) :

(a) Used to transport staff or material.

(b) Can be used for inspection sparingly, if required.

(c) Operates under traffic block.

1302. General Instructions :

(1) The Rules for working trolleys, motor trolleys and lorries are contained in *Para's 15 (18) to 15 (27) of Chapter XV-B of General Rules 1976,* supplemented by the subsidiary rules issued by individual railways. The instructions contained in this chapter are in amplification of these rules and shall not supersede the general and subsidiary rules of Railways.

(2) Conveyance of Trolleys/ Motor Trolleys/ Lorries by Trains – (1) No trolley, motor trolley/ lorry should be loaded in a train without the consent of the Guard in-charge of the train, who will direct where it is to be placed.

(3) When loading a motor trolley with petrol in the tank , the following rule extracted from *Para 1106 of the I.R.C.A. Coaching Tariff No. 21, Part I / 1972* as applicable to carriages, motor-cars, boats etc., should be adhered to – *"……………….. a quantity of petrol not exceeding 9.00 litres may be left in the tank provided that,*

(a) The flow of petrol in the carburettor has been cut off;

(b) Any pressure has been released from the tanks;

(c) The tank is in sound condition and closed by a well fitting cap;

(d) The engine has been run by the official-in- charge until the carburettor has become exhausted and the engine stops automatically."

(4) Trolleys, Motor Trolleys and Lorries Not in Use :

(a) A trolley, motor trolley or lorry, when not in use shall be placed clear of the line, and wheels thereof secured with a chain and padlock.

(b) When a trolley / motor trolley is placed on a platform to be loaded into a train, it should be under the charge of a Trolleyman (Track maintainer) and placed where it will not be in the way of passengers or working staff.

(c) Whenever possible, motor trolleys should be placed in a shed, the key of which shall be in the possession of the official-in-charge.

(5) Trolley Refuges and Observation Posts :

(a) Trolley Refuges : Trolley refuges over long Bridges should be provided at such intervals, as prescribed in the Schedule of Dimensions. In cuttings and high banks trolley refuges should be provided at suitable intervals. A square platform generally of size 3.1x3.1meter sloping away from track shall be used for placing Trolley/lorry clear of track in block section with regular interval as prescribed below.

(i) On straight track	-	less than 1000 m.
(ii) Cuttings	-	200 m in straight & 100 m in curve.
(iii) High banks (Ht. $\geq$ 5 m.)	-	$\leq$ 200 m.
(iv) On bridges with		
main span < 100 m	-	100 metre
main span $\geq$ 100 m	-	Trolley Refuse over each pier.
(v) Tunnels	-	< 100 metres.

For easy identification of the location of trolley refuges in Tunnels, Deep cuttings and on Bridges a distinguishing mark such as a rail post, painted with luminous paint with a mark 'R' may be erected by the side of the trolley refuge.

(b) Observation Posts : Where, owing to curves in cuttings or due to other reasons view of the line is restricted, "observation posts" should be established at such sites as to command the best view in both directions for the use of Flagmen, thus enabling hand signals being conveyed to the trolley on line.

Poor visibility : locations where clear view is less than 1200 m due to curves in Cuttings, Jungles, Tunnels, Long Bridges, Foggy Weather, or Stormy Weather etc. *(see fig. 13.01)*

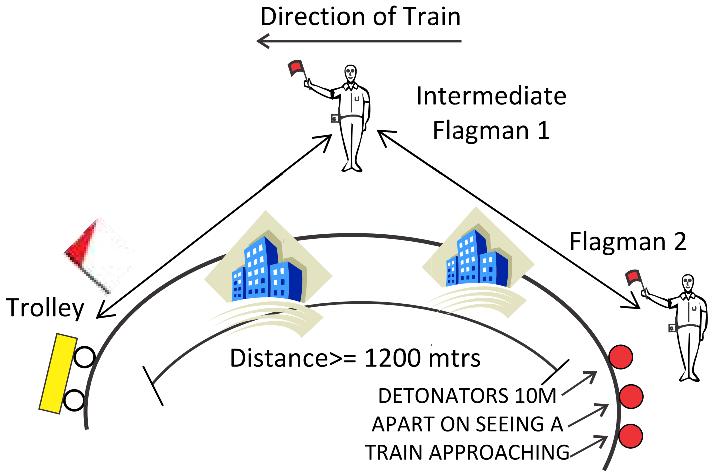


***Fig. 13.01** - Protection diagram for trolly when clear visibility is less than 1200 metres*

(6) Signals for Trolley/ Lorry/Dolly :

(a) Day Signal : Every trolley/Lorry should be equipped with Red flag fixed to 180cm high staff visible in both directions.

(b) Night Signal :

(i) On a double line, red light in the direction from which trains are expected and white light in the other direction. On a single line, red light in both directions. When on double line, single line working is introduced; the night signal should be as per single line.

(ii) When working within the station limits, the light displayed at night shall be red in both directions.

(iii) Signals within long tunnels/Bad weather :

The night signals must be displayed in tunnels during the day in addition to the red flag. In case of thick foggy or tempestuous weather impairing visibility, light signals must be displayed in addition to the red flag.

(iv) As soon as a Trolley/ Motor trolley/ Lorry is removed and placed clear of track, the red flag or light signal shall be removed; care should be taken for not taking off signal before the lines have been cleared of all the obstructions.

(7) All trolley/motor trolley/lorry/dolly should be coded with:-

e.g. (123/ENGG/SSE/BINA)

(a) number, (123)

(b) initials of the department, (ENGG)

(c) the designation (SSE)

(d) headquarters of the official-in-charge of trolley (BINA)

(8) All trolley/lorry/dolly should be insulated for working in track circuited area.

(9) Official in-charge working or operating the Push/Motor trolley/Lorry/Rail Dolly/Monorail-cum-road trolley shall be responsible for its safe working.

(10) A non-railway official can use trolley on non-passenger private siding by executing bond with railway on Form (ANNEXURE 13/1) and after obtaining Trolley permit from competent railway authority.

Railway shall not be responsible for Trolley working in Ordinance depot by Military officers.

(11) Trolley-Permits for Private Sidings : A non-railway official is permitted to use a trolley on private sidings when he is in possession of a permit signed by the competent authority. Such permits are granted for use of the trolley on sidings where there is no passenger traffic. The party shall execute a bond (Annexure 13/2) indemnifying the Railways against all liabilities and risks. The issue of trolley permits will be subjected to such rules as may be prescribed. In such cases, the Head trolley man shall hold a certificate of competency issued by the authorized Railway Official.

(12) Attachment to Trains Prohibited : No trolley / motor trolley/ lorry shall be attached to a train.

(13) Responsibility for Safe Working :

(a) The official-in-charge of trolley/ motor trolley/ lorry is responsible at all times for its safe working. When more than one person holding competency certificate travels in a trolley, the official working the trolley is responsible for its safe working.

(b) It shall be clearly understood by officers and staff that they are to take every possible precaution and protection against accidents. While entering a tunnel or cutting or proceeding over a long bridge or curve, the official-in-charge will make sure that no train is likely to be met. While approaching a level crossing the official-in-charge, should look out for road traffic and ensure safe passage of his vehicle over the level crossing.

(c) In the case of an accident/emergency, trolleys/ motor trolleys may be carried by Mail /Express trains on which there are restrictions normally for loading of trolley/ motor trolley.

(14) Efficient Brakes : No lorry, trolley or motor trolley shall be placed on the line unless, it is fitted with efficient brakes. The brakes should be tested before the commencement of each journey. It is desirable that trolleys and lorries working on ghat section are fitted with screw down brakes in addition to ordinary hand/foot brakes. It will be the responsibility of the official-in-charge to ensure the adequacy of braking.

(15) Additional instruction for Working of Cycle Trolleys and Moped Trolleys:–

(a) Cycle Trolleys : Cycle trolleys are those trolleys which are propelled, by pedalling instead of pushing. It may be pushed when necessary but not pulled. A cycle trolley shall be manned by at least four men, including the persons pedalling or driving. They may be worked as per rules pertaining to a “Push-Trolley”.

(b) Moped Trolleys : These are light motor trolleys with lower speeds, which can be lifted manually. These may be worked as per the rules pertaining to a Push-Trolley, and for which the Railway Administration may issue additional special instructions, if required.

1303. Certificate of Competency :

(1) Essential Requirement to Issue Competency :

(a) Staff, in whose favour it is to be issued, should be literate, have knowledge of Rajbhasa and other local languages of area.

(b) have passed the prescribed Medical test i.e A-3 category medical certificate.

(c) should be conversant with the safety rules for working of trollies, motor trollies and lorries, as the case may be.

(d) Should be conversant with all related Equipment of Trollies, Lorries, Dollies as the case may be.

(2) Validity of Competency :

Validity of competency certificate will be for a period of one year and it can be renewed periodically.

(3) Competent Officers to issue Certificate:

(a) Sr. DEN/DEN for all type of Trolley/Lorry.

(b) ADEN/SSE (P.Way) In-charge for Rail Dolley.

1304. Officials Permitted to Use Trolley/Lorry/Dolley :

(1) Push Trolley/Motor Trolley/lorry:-

(a) All officers, SSE (P.Way) /JE (P.Way) of Engineering Department.

(b) Track maintainer, motor trolley driver as may be authorised.

(c) In special cases, Magistrates, Police, Civil, Telegraph, Military, Medical and Forest Department Personnel or a person requiring medical aid, Contractors and their Agents may be conveyed by trolley by order of the competent authority (The ADEN), after a signed bond on form as per ANNEXURE 13/1.

(2) Rail Dolley / Mono-Rail-Cum-Road Trolley :

Not lower than Keyman (Track Maintainer Gr. II) as may be authorised.

1305. Equipment for Trolley :

1.	Push Trolley/ Lorry/ Rail dolley.	i. Four red hand signal flags. ii. Two green hand signals flags. iii. 3 LED tri-colour (white/red/green) hand signal lamps. iv. 10 Detonators live/active. v. Walkie-Talkie. vi. Updated working time table copy. (not for rail dolley) vii. Two banner flags. viii. Whistle thunder. ix. A chain and pad lock (to secure).
2.	Motor Trolley	In addition to equipment for Push-trolley i. A motor horn ii. Search light.

1306. Working of Trolleys :

(1) Manning of trolleys : Trolleys in all cases shall be manned by four men.

(2) Mode of working of trolley : Trolleys in all cases should be pushed and not pulled.

(3) Working under Block protection :

(a) Trolley may be worked under Block protection wherever it is possible to do so without interference to train service.

(b) Trolleys should be worked under Block protection in the night.

(c) During day time in foggy weather and during dust storm, when the visibility is poor, a Trolley should be worked under Block protection.

(d) Sections with restricted visibility due to curves, cuttings or due to other local conditions specified by Railway Administration, wherever practicable, should be traversed under Block protection.

(e) When working under Block protection, trolleys will be worked in the same manner as trains.

(4) Working without Block protection :

(a) During day time in sections with normal visibility, the official-in-charge shall before leaving a station/ Block post, ascertain the whereabouts of the trains likely to be met and remove the trolley off the track.

(b) In sections with restricted visibility [specified sections, Ref-Para 1306 (3) (d)] when the official- in-charge, is not able to block the section and work under Block protection, he will follow the following procedure :

(i) The Station Master/ Signalman will on receipt of advice from official-in-charge (in triplicate on Form *Annexure 13/3*) giving his trolley program ascertain and fill in particulars of trains running on the section, retain one copy and return the other two to the official-in-charge of the trolley.

(ii) As a reminder that the block section is occupied by the trolley and caution orders must be issued, a small placard with words “Trolley on line” will be hung in front of the block instrument, until advice of the removal of the trolley is received.

(iii) If telephone communications are interrupted and the Station Master/ Signalman is unable to communicate with the station at the other end of the block section, the official-in-charge of the trolley will be advised of this fact and form *Annexure 13/3* endorsed accordingly. When communication between the two stations is restored, the messages referred to above will be exchanged, if the trolley has not cleared the section or removal report has not been received.

(iv) From the time of exchange of the messages, until intimation has been received that the trolley has cleared the block section, the Station Master/ Signalman at both ends of the block section shall issue caution orders to Drivers of all trains entering the block section. On the double line, caution order should be issued for both up and down trains.

(v) The issue of caution orders in no way relieves the official-in-charge of the duty of complying strictly with the rules for protecting the trolley.

(vi) On arrival of the trolley at the other end of the block section, the person-in-charge of the trolley shall fill in the removal report and send it to the Station Master/Signalman who will return the third copy signed. The Station Master/Signalman will then advise the Station Master/Signal man at the other end of the block section of the trolley having cleared the section.

(vii) If the trolley is removed from the track at the station not provided with telephone instruments or in the block section and if it is not intended to place it on the track again, the official-in- charge of the trolley shall fill in the removal report and send it to the Station Master / Signalman at the nearest block station. In the former case, the Station Master will send written advice by the first train in either direction to the next block station. The Station Master / Signalman at the latter station should then advise the Station Master / Signalman at the other end of the removal of the trolley.

(viii) Station Masters/Signalmen at the both ends, of the block section will enter remarks in the train registers pertaining to the block section concerned showing the times at which the trolley entered and cleared the block section and the number of the trolley.

(5) Protection in Block Section :

(a) When a trolley is worked other than under the rules for working of trains i.e., without block protection and when a clear view is not obtainable for an adequate distance of 1200 m on BG and 800 m on MG/ NG, the following precautions should be taken (*Annexure 13/4)* :

(i) On a double line, he must depute a Flagman with detonators to precede or follow the trolley, and to exhibit a hand danger signal at a distance of not less than 1200m on BG and 800m on MG / NG in the direction from which trains may approach.

(ii) On single line, depute a Flagman with detonators to proceed and another to follow the trolley and to exhibit hand danger signals at a distance of not less than 1200 m on BG and 800 m on MG and NG.

(iii) Where necessary, intermediate Flagman should be posted to relay signals.

(b) The distance at which the signals are to be exhibited may be suitably increased in the case of MG High speed routes where the speeds are more than 75 km/h under special instructions by the Railway Administration.

(c) The flagman should only be withdrawn when a clear view of at least 1200 m on BG and 800 m on MG/ NG can be obtained in the direction from which trains may approach.

(d) When a train is sighted, the Flagman should wave the red flag vigorously to warn the official-in- charge of the trolley of the approach of the train, and at the same time place three detonators 10 m apart on the line to protect the trolley. The detonators should be removed only on receipts of hand signals from the official-in-charge by waving of a green flag to withdraw the danger signal indicating that the trolley has been removed. When conditions are such that the Flagman cannot be seen by the official-in-charge of trolley, the latter must arrange before entering the section to take with him sufficient men with hand signals who will be placed in suitable positions between the trolley and the Flagman so that the signals from the Flagman can be repeated to the person-in-charge of the trolley and vice versa.

(e) On sighting an approaching train or the Flagman's signal, the trolley must be removed clear of the line and kept in such a manner that it cannot roll towards the line.

(6) Trolleys travelling together : When two or more trolleys are running together in the same direction in the same line, care should be taken to ensure that they are kept at least 100 m apart to safeguard the trolley in rear from colliding with the front one, in case the front trolley has to be stopped suddenly for any reason.

1307. Working of Motor Trolleys :

(1) A motor trolley shall only be run in accordance with special instructions.

(2) A motor trolley shall be worked only under block protection.

A motor trolley should be run only under block protection.

(i) during night; (ii) during day time, when the visibility is poor due to fog or dust storm.

Sections of restricted visibility should invariably be traversed under block protection. A list of “sections of restricted visibility” may be specified for the guidance of all concerned, either in the subsidiary rules or in the working time table.

When a motor trolley that is worked under block protection breaks down in the block section, the official-in-charge should remove it clear of the line and send a written advice to the nearest Station Master / Block Hut -in-charge returning the line clear ticket or token or in case of a motor trolley when the token has been clamped for a preceding train the key of the padlock. He should not replace the motor trolley on the line without the written permission of either Station Master / Block Hut-in-charge at the end of the block section concerned. On arrival at the other end, the official in-charge will deliver the authority to the Station Master after the trolley has arrived complete.

(3) Following a Train / Motor trolley : Motor trolley may follow a fully vacuum brake train or another motor trolley in the same block section during day light hours and in clear weather under special instructions issued by the Railway Administration. Normally distance between train and following motor trolley should not be less than 500 m when following a train.

1308. Working of Lorries :

(1) Mode of working of lorry : Lorries in all cases should be pushed and never pulled. Riding of persons on the same is prohibited.

(2) Manning of Lorries : When running under block, a lorry must be accompanied on foot by not less than four men in addition to the number of men required for expeditiously loading and unloading materials being conveyed on the lorry. When running without block protection a lorry should be accompanied on foot by an adequate number of men required to remove the lorry and its contents readily off the line in addition to Flagman for its protection. The Duties of Flagman should invariably be entrusted to trained person experienced in the working of lorries and who has passed the prescribed medical test.

(3) Working under Block Protection :

(a) whenever it is possible to block the line without interference to trains, the lorry shall be worked under block protection, after blocking the line.

(b) A lorry shall be worked only under block protection when

(i) It is necessary during an emergency to run it at night.

(ii) The visibility is restricted due to sharp curves/cuttings etc., as on certain specified sections.

(iii) It is loaded with rails, girders or especially heavy materials which will cause delay in unloading.

(c) Actual Working of Lorry :

(i) Before obtaining line clear, the official-in-charge of a lorry should advise the Station Master / Block Hut-in-charge, whether it is his intention to return to that station, to run to the other end of block section, or to remove the lorry in mid-section.

(ii) The official-in-charge, after getting the authority to proceed in the form of line clear ticket / token, double line certificate or shunting key, as the case may be, should work his lorry.

(iii) He should, after completion of his work, hand over the authority to proceed to the concerned Station Master / Block Hut-in-charge and remove his lorry.

(iv) In case the lorry is off loaded in the mid section, the authority to proceed should be returned by a special messenger to the nearest station after ensuring that the lorry is kept clear off the line.

(v) On the double line the official-in-charge should run the lorry on the proper road. The lorry should be taken along the line in the direction in which the trains will run; except when returning to the original starting station/ Block Hut.

(4) Working without Block Protection :

(a) A lorry shall ordinarily be run only by day and when the weather is sufficiently clear for a signal to be distinctly seen from an adequate distance, which shall never be less than 1200m on BG and 800 m on MG/ NG. Distance may be specified by administration in MG high speed routes where the maximum speed is more than 75 kmph. In such cases the lorry can be worked without block protection when it is not possible to block the line without interference to train service.

(b) Procedure for Working :

(i) When a lorry is to enter a block section without line clear, Form Annexure 13/3 should be prepared by the official- in-charge in triplicate and necessary particulars filled in by the Station Master / Signalman who will retain one copy and return the other two to the official-in- charge.

(ii) Until the "lorry removed from section" signal has been dispatched and received, both Station Masters / Signalman shall issue caution orders to the Drivers of all trains entering the section on which the lorry is working. All trains booked to run through and extra, special and other out of schedule trains should be stopped at the station in order that this advice may be given.

(iii) Lorries should be removed clear of the main line or if within station limits, of the line on which a train is to run, at least 15 minutes before the train is due.

(iv) On completion of work, the lorry removal report in Form Annexure 13/3 should be completed and handed over to the Station Master / Signalman concerned and his acknowledgement obtained.

(c) Protection of lorry in Block Section – When the line has not been blocked and a lorry whether loaded or empty is placed on the line without block protection the lorry shall be protected as detailed in sub-Para below *(Annexure 13/5)*

(i) On double line, by one or two men as required at a distance of 600 m on the BG and 400 m on the MG and NG, carrying a Banner Flag across the track and another man plainly showing a stop hand signal at a distance of not less than 1200 m on BG and 800 m on MG / NG from the lorry in the direction from which trains may approach, or

(ii) On single line, by one or two men as required, following and preceding the lorry at a distance of 600 m on BG and 400 m on MG/ NG carrying a banner flag across the track and another man plainly showing stop hand signal at a distance of not less than 1200 m on BG and 800 m on MG/ NG from the lorry on either side.

(iii) Each man so following or preceding the lorry at a distance of 1200 m on BG and 800 m on MG / NG shall be provided with detonators and place three on the line 10 m apart, immediately the lorry comes to a stand for the purpose of either loading or unloading and continue to display the Stop hand signal.

(iv) The man or men carrying the banner flag shall immediately fix the banner flag across the track immediately as the lorry comes to a halt or a train is seen approaching, and continue to display the Stop hand signal.

(v) In all cases, where the Flagman in advance or in rear cannot be kept in view from the lorry, additional intermediate signalman as required should be posted to relay the signals.

(vi) The Stop Signals and detonators shall not be removed until the Flagman, receives the orders to withdraw them from the official-in-charge of lorry.

Note: In MG section High speed routes where the maximum speed is more than 75 km/h the distances should be specified by the administration.

(5) Working in Station Limits :

(a) When a lorry is required to work within Station limits, the permission of the Station Master shall be obtained in writing before working the lorry and the lorry should be worked as per the approved special instructions.

(b) Protection in Station limits : When a lorry works in a station yard the Flagman must exhibit danger signals at such a distance on both sides as will ensure safety. When the lorry is required to remain stationary for more than 15 minutes, it must be protected by banner flags placed at an adequate distance supplemented by three detonators on both sides.

(c) When a lorry has to work on a section with a steep down gradient (gradients steeper than 1 in 100), the same should not only be controlled by hand brakes, but by a rope tied in the rear and held in tension by men following a lorry.

1309. Working of Rail Dollies :

(1) The railway servant in-charge of rail dolly(s) must inspect the section in advance particularly in reference to heaping of ballast, girder bridges and any other special features which make it difficult to drop the material and remove the rail dolly in the event of an approaching train. He shall get the ballast heaps cleared and work the dolly(s) only when the visibility is clear for at least 1200 m on BG and 800 m on MG/NG and the rails/ sleepers can be dropped off safely without affecting the safety of trains and workers both.

(2) Rail dolly shall not be worked on sections having gradients steeper than 1 in 200.

(3) Not more than 6 rail dollys should be worked in a group in any one block section.

(4) Normally, not longer than 3 rail welded panels should be carried by rail dolly. The rail dollys must not be worked after sunset and before sunrise and in bad weather when the visibility is poor. Rail dolly should not be worked in deep cuttings, steep grades, sharp curves and heavily built up areas where the visibility is not clear for 1200 m on BG and 800 m on MG/NG. In such locations, the rail dolly's should be worked under block protection.

(5) In case, a rail dolly is to carry rails longer than 3 rail panel or it is required to move over x- over in yard crossing more than one line in deep cuttings and curves then it should work under block protection.

(6) No traffic block or caution order is normally necessary for working of rail dolly except as indicated in Para 1*309(4) and (5)* above.

(7) Every rail dolly/group of rail dolly when on line shall exhibit a red flag.

(8) The rail dolly shall be protected by a flagman at a distance of 1200 m on BG and 800 m on MG/NG from the rail dolly, on a double line in the direction from which trains may approach, and by two flagmen one on either direction on single line. The flagmen shall also carry three detonators for use in any emergency.

(9) Where necessary intermediate Flagman should be posted to relay signals.

(10) When a train is sighted, the Flagman should wave the red flag vigorously to warn the official- in charge of the dolly of the train and at the same time place three detonators 10 m apart on the line to protect the rail dolly(s). The detonators should be removed only on receipt of hand signals from the official-in-charge by waving of a green signal to withdraw the danger signals from indicating that rail dolly(s) have been removed.

(11) The official-in-charge of the rail dolly shall keep a look out for approaching trains and will get the rail dolly(s) and materials cleared off the track as soon as an approaching train is sighted.

(12) While approaching level crossings, the official in-charge shall look out for road vehicles and ensure safe passage of rail dollies.

(13) The official in-charge shall be fully responsible for the safe working of rail dollies.

Annexure-13/1

{Ref. Para 1302(10)/1304 (1)(c)}

Indemnity Bond in Connection with the Permission Granted to Travel on a Railway

.........................Trolley/Motor trolley

In consideration of my being granted permission to travel between .... and ....on .... Railway ....Trolley/Motor Trolley I .... hereby undertake and agree that the Railway shall be free from all responsibility or liability for any delay or detention or for any injury or loss to me or to any property of whatsoever kind accompanying me occasioned during the journey for which the permission is granted or whilst I am or the said property is within Railway limits.

I further undertake that I shall not interfere with or obstruct .... on his duties and shall obey all reasonable directions he shall give me to be subject to the bye-laws and other general regulations of the Railway.

I further undertake to indemnify and keep indemnified and save harmless the Railway Administration for and against any loss or damage done to the property of the Railway through any act or omission on my part or on the part of my agent or servants while so travelling on the Trolley/Motor Trolley.

Dated .... Name ....

Witness – Designation ....

1. ....

Address ....

....

....

2. ....

Address ....

....

....

.... (To be executed on stamp paper)

Annexure-13/2

{Ref. Para 1302 (11)}

THIS INDENTURE made the .... day of .... between .... of the one part and the President of India as owner of and administering the ....Railway (hereinafter called "the Administration") of the other part WHEREAS by an Agreement dated the .... day of ....and made between the Administration of the one part and the said ....of the other part, the President of India agreed to allow the said .... to use and work a private trolley on the railway line of the said .... Railway between .... and whereas prior to the execution of the agreement the said .... agreed to execute these presented.

NOW THIS INDENTURE WITNESSETH AS follows :

The said .... shall henceforth at all times perform and observe the stipulations, provisions and conditions on his part to be performed and observed and contained in the aforesaid agreement.

The said .... shall observe and perform the bye- laws, rules and regulations of the .... Railways for the time-being in force.

The said .... shall not in any way interfere with or hamper the working of the .... Railway.

The said .... shall from time-to-time and at all times hereafter indemnify and keep indemnified the Administration from and against all actions, claims, demands, costs, losses, damages and expenses including claims by 3rd parties Workmen's Compensation and Employees' liability which may be brought against or made upon the Administration or which the Administration may, pay, incur, sustain or be put to by reason of any loss of life or injury or damage to any person or property caused by or arising out of or from the user and for working of a private trolley by the said .... on the said railway line and the user of permanent way in pursuance of the said agreement.

IN WITNESS where of the said .... has hereunto set his hand and seal the .... day and ....year first herein/above written.

Signed, Sealed and Delivered

by the said ----------------------------

In the presence of :

Annexure-13/3

{Ref. Para 1306 (4)(b) /1308 (4c)}

Trolley/Motor Trolley/Lorry Notice

(Working without line clear)

Notice No. .... Station ....
Dated ....

To

The Station Master/Signalman .... Station. Trolley / Motor Trolley / lorry No... is required to work between .... and .... It will leave .... station at .... hours Kilometer .... at .... hours this day for...Station. Kilometer .... Official - in - charge

To

The Official-in-charge Daily and extra trains due to arrive at or pass this station up to .... hours have actually done so except. No .... minutes late .... The following extra trains, special trains and light engines will enter .... section as shown. .... I have exchanged advice with .... station/block post and shall issue caution orders to all Drivers until I receive advice of removal of the trolley/motor trolley/lorry. .... Station Master/Signalman

Removal Report Reference trolley/motor trolley/lorry Notice No. .... dated .... trolley/motor trolley/lorry No. ....arrived at .... at .... hours.

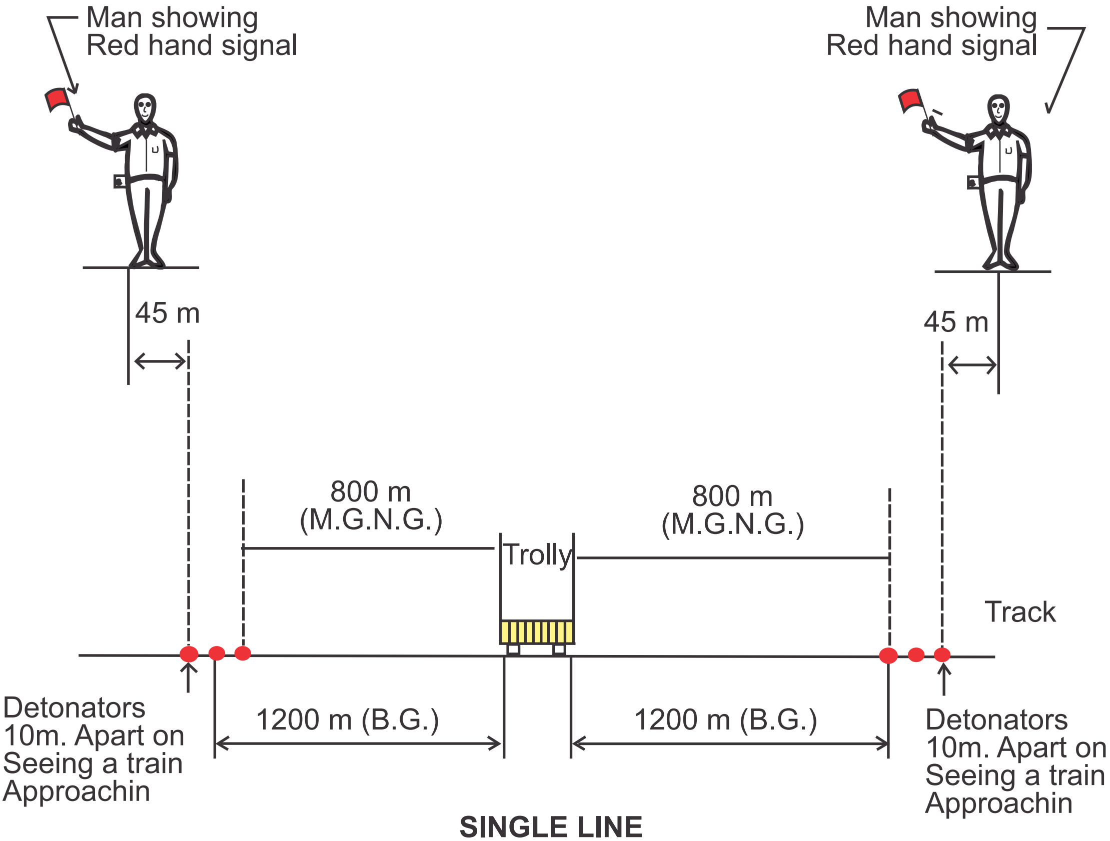
was removed from the track at kilometer. Removal report received at .... hours. Station Master/Signalman, ... Station.

Official - in - charge.

Annexure-13/4

{Ref. Para 1306 (5)}

PROTECTION OF TROLLY ON LINE



SINGLE LINE

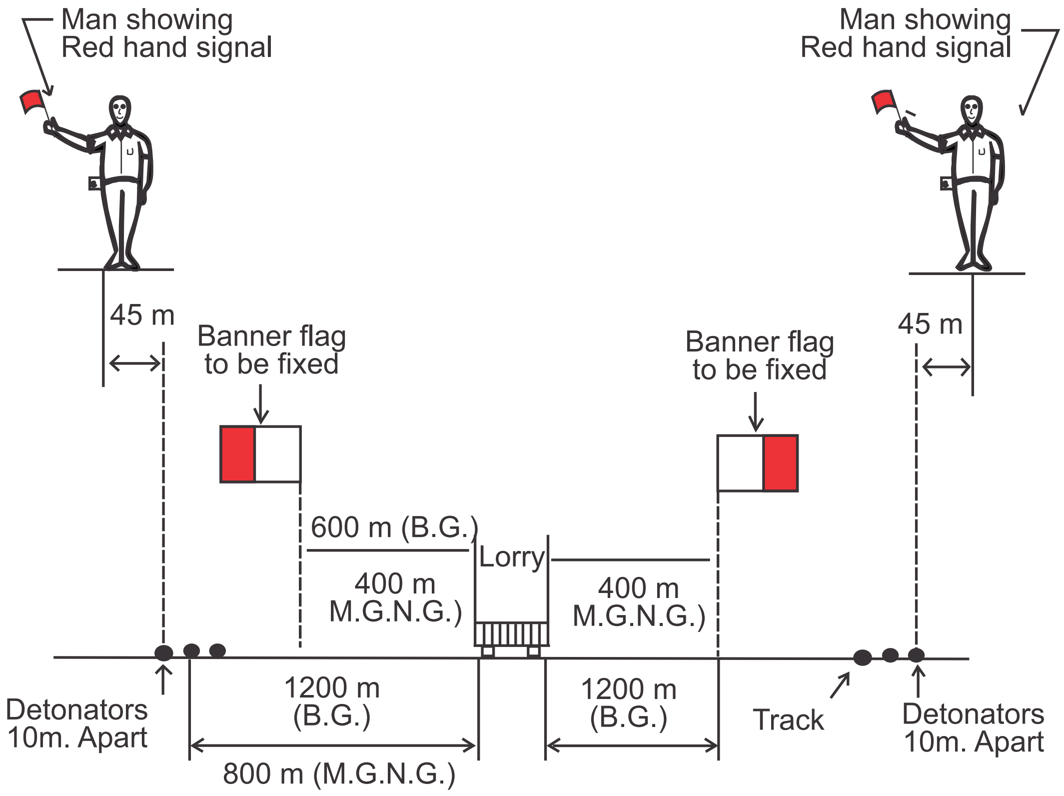
Note :

1. In metre gauge section, where sanctioned speed is more then 75 km/h. the distance of protection will be increased as specified by the administration.
2. In case of double line, the flag-man is to be deputed either to follow or to proceed the trolley, as the case may be.

Annexure-13/5

{Ref. Para 1308 (b)}

PROTECTION OF LORRY ON LINE



SINGLE LINE

Note :

1. In metre gauge section, where maximum speed is more then 75 km.p.h. the distance of protection will be increased as specified by the administration.
2. In double line, protection is to be done in direction of approaching train.
3. Detonators should be placed on the line when the lorry comes to a stop.

Chapter 14

Maintenance in Electrified Areas, Territory

1401. General :

(1) Requirement of Bonding and Earthing in Non-Track Circuited Sections

(a) To ensure a reliable electrical circuit continuity and also to ensure proper earthing in case of leakage of current, various types of traction bonds as described below are provided at suitable places and maintained by the Electrical Traction Department.

(b) In the case of 25 kV, A.C., 50 Hz single phase traction system, the traction current is drawn from the overhead equipment (OHE) by the electric rolling stock, operating in a section and passes through the traction rail. The return current flows mostly through the earth leaving the traction rail, except in a zone extending over a few hundred meters on both sides of the electric rolling stock in operation in the section or in the vicinity of a feeding station and returns to the traction substation. Bonding of all rails is, therefore not absolutely essential unlike in the case of D.C. traction, where practically the whole traction return current flows through the rail and hence bonding of rails is essential.

(c) However bonding of rail facilitates passage of the traction return current from the earth and vice versa and is, therefore, provided in the vicinity of traction sub station/feeding posts, where the traction return current has to flow back from the earth to the traction rails which are connected to the earthed leg of the traction transformer at the substation, through a buried rail opposite the feeding post. Bonding of rails also ensures the spread of flow of return current into the earth and, therefore, reduces the voltage between rail and earth. So bonding of rails is done wherever it is essential to keep the rail voltage low to ensure safety of personnel.

(2) Definitions :

The following terms wherever appearing in this Handbook shall, unless excluded by or repugnant to the context, have the meaning attributed there to and applies as follows:

(a) “Bond” means an electrical connection between two or more conductors or non-current carrying metallic parts of traction masts or structures or supports and rails.

(b) “Cross-bond” means a bond between two rails of a track or two rails of adjacent tracks. It is also called a 'transverse bond'.

(c) “Earth wire” means a conductor on traction masts or structures or supports and bonded to their metallic parts/supports and connected to earth.

(d) “Impedance-bond” is a bond, installed by the Signal and Telecommunication Department, which provides a low impedance path for the traction return current and a relatively high impedance path for track circuit current.

(e) “Rail-bond” means an electrical connection across a rail joint between consecutive lengths of rails. It is also called a 'Longitudinal bond'.

(f) “Rail length” means a continuous length of rail with or without welded joints but with no fish plate joints.

(g) “Structure bond” means bond connecting the non current carrying metallic parts of a traction mast or structure or support to the traction rail.

(h) “Signal bond” means an electrical connection across a rail joint, provided by the Signalling & Telecommunication Department, to facilitate over track circuit current.

(i) “Short direct connection” means a connection for electrical continuity, which shall be of the shortest possible length with minimum bends.

(j) “Traction rail” means a non-track-circuited rail of a wired track, not required for signalling purpose and which may be earthed. In non-track circuited sections, both the rails of wired track are traction rails and in single rail-track-circuited sections, the traction rails is the non-track circuited rail.

(k) "Welded bond" means a bond which is made of standard copper conductors with Mild Steel. ferrules at the either end, pressed on the conductors and bent to shape.

(l) "Wired track" means a track provided with 25 kV, A.C., 50 Hz single phase overhead equipment (OHE).

(m) "Neutral Section"- The catenary has breaks or gaps in its electrical continuity every once in a while at points where successive sections are connected to different substations. A neutral section of catenary is usually provided between the two live sections of different phases or connected to different substations. Speed Restriction at such locations should be Imposed only after concurrence from TRD and Operating Departments. (Warning boards at 500 m and 250 m before the neutral section are provided for this purpose).

(3) Requirement of Bonding and Earthing in Track Circuited Sections:

In sections, equipped with single rail-track circuits, the traction rail shall be bonded to ensure that:

(a) The A.C. voltage drop along its length is reduced so as to minimize the risk of A.C. voltage being applied to the track relays.

(b) A resistance path as low as possible is provided both for traction return as well as signaling currents as fish plate joints can not be relied upon for low resistance.

(c) In sections with double rail-track-circuits, both rails are longitudinally bonded to ensure a low resistance path for traction return and signaling current; and also to distribute the return current more evenly in both the rails. Impedance bonds are installed at insulated joints to provide a continuous path to the traction return current. All track-circuited-rails are, in addition, provided with signal bonds.

(4) Types of Bond :

All types of bond i.e. rail bond, cross - bond and structure bond shall be of mild steel of not less than 200 mm^2 cross sectional area.

(a) Structure-bond : Rigidly connected by means of galvanized steel fasteners to the traction rail and the metallic part of traction mast or structure or support.

Fig 14.01 *Structure Bond*

(b) Rail-bond: Rigidly connected by means of galvanized steel fasteners longitudinally across the fish plate joint of the traction rail and the track circuited rail in a track circuited section except at the insulated joint of the track circuited rail.

Fig 14.02 *Rail Bond*

(c) Cross-bond : Rigidly connected by means of galvanized steel fasteners between two traction rails of a track or non track circuited rails of an adjacent track. Where it is not possible to provide a rail bond a welded bond shall be used. The bond shall be connected to the rails by electric or gas welding.

Fig 14.03 *Cross Bond*

The bond for connecting return conductor to the traction rail through the buried rail shall normally be made with Galvanized Iron nuts and bolts with spring washer and check nuts.

1402. Proper Fixation of Bonds and other TRD Installations on Track :

(1) All bonds which are being provided should be fixed at the centre of the Neutral Axis of the rail in the presence of P.Way staff.

(2) All bonds should be provided on the non-gauge face of the running track.

(3) The bonds should not be above 25mm from the top of the sleeper in any case.

(4) The bonds should be hanging loose or not riveted with Martensite Free Rivet provided for the same.

(5) The bonds should not cause any interference to the moving vehicles.

(6) Only Martensite Free Rivets / Pins should be used for bonding.

(7) The rail surface should be cleaned thoroughly to remove rust, scale before any bond wire is provided.

(8) The area of the rail to be bonded should be lightly ground to a bright finish with no scratch marks.

(9) All bonds provided by Electrical Department shall be of detachable type and the bonds should be parallel to sleeper over it not above 25 mm from top of sleeper so as to avoid any infringement and de-bonding issues during Mechanised Track Maintenance and Renewal.

(10) After fixing a bond Dye Penetration Test (DPT)/ Magnetic Particle Test

(MPT) should be done to ensure no surface cracks and tightening of bolts for bonds should be ensured on regular basis by TRD Department.

1403. General Instructions to Engineering Staff :

(For work to be carried under the presence of Traction Distribution (TRD) staff in Electrified Territory/ Areas)

(1) Every engineering official working in electrical traction area shall be in possession of a copy of rules framed for the purpose of the operation of the Traction Power Distribution system pertaining to Engineering Department and ensure that staff working under him is also acquainted with the rules. He will ensure that rules pertaining to carrying out engineering works are strictly observed.

(2) All electrical equipment, every power line or cable shall be regarded as being 'live' at all times. No work shall be commenced adjacent to any electrical equipment except on authority issued in writing by a competent official of the Electrical Department to the effect that the equipment has been made dead and earthed.

(3) Permanent Way tools (insulated and uninsulated) with gloves shall be used in such a manner so as not to cause build up potential or charge in them by keeping in proximity to live conductors. Tools should not be shorted in between the two rails in Track/ Non-Track circuited Areas.

(4) No part of the tree shall be nearer than 4 m from the nearest live conductor. Any tree or branches likely to fall on the live conductor should be cut or trimmed periodically to maintain the safety clearances. The decision whether to cut or trim a tree, shall be taken through a joint inspection of Engineering and Electrical officials. The responsibility for wholesale cutting of the trees, i.e. cutting of tree trunks, will rest with the Engineering Department. In the electrified territories, however, the cutting of the trees shall be done by the Engineering Department in the presence of authorized TRD staff to ensure safety and satisfactory completion of the work. Trimming of the tree branches, wherever required, to maintain the 4 m safety clearances from OHE shall be done by the authorized TRD staff and Supervisors. The modalities to be adopted for cutting / trimming of the trees i.e. contractually or departmentally, may be decided by the respective departments based on local conditions. Accountal and disposal of trees cut will be done by the Engineering Department. While the disposal of the 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.

(5) Visible break-downs in the overhead equipment including any type of bonds noticed by the Engineering staff shall be reported immediately to the Traction Power Controller through Engineering Control or through SSE/OHE when defects in the overhead equipment that are likely to cause damage to pantographs or trains, are noticed and it is not possible to convey information to Station Masters or signalmen to enable them to issue caution orders, the line shall be protected by the staff noticing such defects according to *General Rule 3.62.*

(6) 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 Gatekeeper shall immediately make arrangements to stop all road traffic.

1404. Precautions While Working of Engineering Staff In Traction Area :

(1) Need For Precautions:

(a) Proximity of a Live Conductor – The risk of direct contact with live OHE is ever present while working in electrified sections such as for painting of steel work of through spans of bridges and platform cover.

(b) Build-up of potential due to return current in rails. - The return current in the rails may cause a potential at following locations

(i) Between rail and the surrounding mass of earth.

(ii) Between two ends of a fractured rail.

(iii) Between the two rails at an insulated joint.

(iv) Between earth and any other metallic mass.

(2) Precautions :

(a) No work shall be done within a distance of two meters from the live parts (Contact Wire, Catenary Wire, Insulating Discs/Rods, Droppers, Frame) of the OHE without a *'permit-to-work'. (PTW)*

(b) For work adjacent to overhead equipment, the JE/SSE (P.way) shall inform SSE (OHE)/ Traction Power Control (TPC) well in advance for arranging sanction of power block required.

(c) The Traction Power Controller through Senior Section Engineer (Traction Distribution) will arrange to isolate and earth the section concerned on the date and at the time specified in consultation with the Traffic Controller. He will then issue *'Permit-to-Work' (PTW)* to JE/SSE (P.way).

(d) On completion of the work the 'Permit-to-Work' should be cancelled and Traction Power Controller will be advised accordingly, who will then arrange to remove the earth and restore power supply.

(e) Steel tapes or metallic tapes with woven metal reinforcement should not be used in electrified tracks. Linen tapes are safer and, therefore, should be used.

(f) In case of Material Trains, 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 JE/(P.Way), who shall personally ensure that no tool or any part of body of the workers comes within the '*danger zone'* i.e., within 2m range of OHE.

(g) During working of On-Track Machines, No staff should be allowed to climb on top of machines and the JE/(P.Way), shall personally ensure that no tool or any part of body of the staff comes within 2 m of OHE.

(h) Staff working on station roofs and signal gantries and similar structures adjacent to live OHE shall not use any measuring tapes, tools and materials when there is a possibility of their being dropped or come in contact due to flowing wind on to the live overhead equipment.

(i) No crane shall be worked except on the authorised *'Permit-to-Work'.* In every case of working a crane, arrangement should be made for the presence of authorised overhead equipment staff to ensure that all safety precautions are taken.

(j) For inspection of roofs and sides of a tunnel, the overhead equipment shall be rendered 'dead'. Special insulated apparatus should be used if sounding the unlined portions to locate loose rock in the roof and sides, is required to be carried out, when the overhead equipment is 'live'.

(k) The top foundation blocks in electrified structures should be kept clear of all materials.

(l) Dangerous voltages may be induced in metallic masses such as fencing posts in the vicinity of traction conductors due to induction in metallic bodies close to OHE. To avoid possibility of shock due to such voltages, the metallic structures are bonded together and earthed.

(m) When unloading of rails along the tracks, care shall be taken to ensure that rails do not touch each other to form a continuous metallic mass of length greater than 600 m.

(n) In track circuited area, insulated joints shall not be bridged with bare hands or any metallic articles.

(o) 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 range of live equipment.

1405. Check by TRD and Engineering Staff :

(1) TRD Department shall provide approved plan of all their existing cables and electrical fixtures on rails to the concerned Engineering Supervisor. No new TRD Installation on the rail shall be done without approved plan.

(2) All bonding should be provided a certification of chamfering by TRD Staff to Engineering Staff. A sample check of 5 % should be done per kilometre.

(3) For all OHE masts, implantation distance and rail level should be checked jointly by both departments atleast once in a year.

(4) During working of tamping machine, BCM, PQRS/TRT etc. special precautions must be taken and implantation should be monitored.

(5) Prior information shall be given by the Engineering Department for proposed lifting of track.

(6) For better alignment of track or for any technical reason, if slewing/ lifting/ lowering of track is essential then TRD will arrange necessary slewing/lifting/ lowering of wire accordingly.

(7) OHE height should be checked at all special locations such as girder bridges, tunnels and turn-outs jointly. Stagger should also be measured. TRD department to jointly frame a programme once a year for the same.

(8) The TRD official shall see that all insulating sleeves on traction bonds passing under positive rail track circuits are intact and take prompt action to replace the missing/ damaged ones.

1406. Working of Engineering Staff During Track Works :

(1) All Bonds are to be removed by the staff of the Electrical Department during Track renewal and Track Maintenance by On-Track/ Off-Track Machines. The same shall be replaced by the staff of the Electrical Department.

(2) 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 *(Fig. 14.04)*. The necessary jumper will be provided by the Electrical Department on requisition.

(3) In case of rail fracture, the two ends of the fractured rail shall be first temporarily connected by a temporary metallic jumper of approved design. In all cases of discontinuity of rails, the two parts of the rail shall not be touched with bare hands; Gloves of approved quality shall be used.

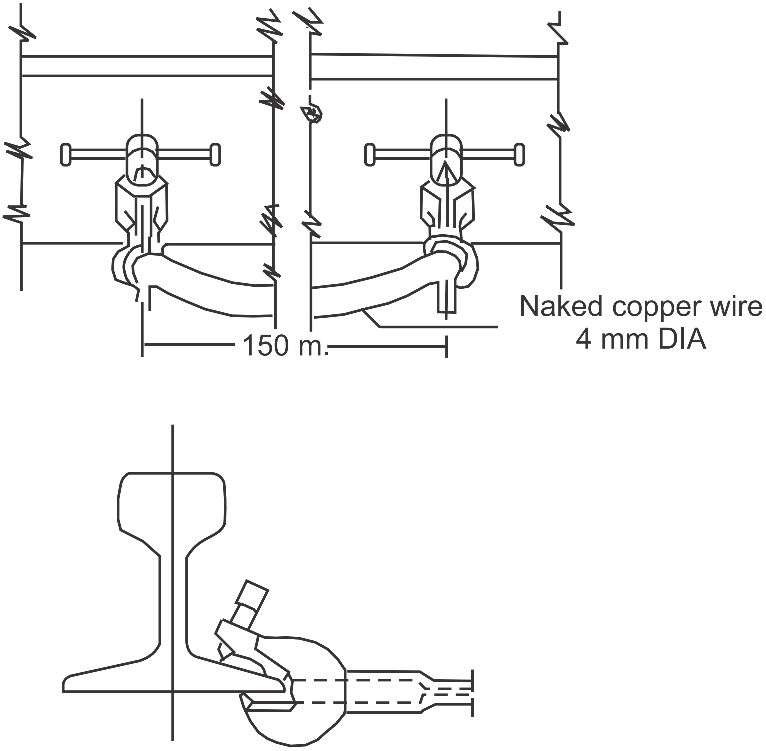


Fig. 14.04 - Temporary jumpering of rails in case of rail fracture

(4) In the case of track renewals, defective or broken rail bond and before fish plates are loosened or removed, temporary connection shall be made as shown in *fig. 14.05*. This has to be done by Engineering Staff in presence of TRD Staff.

(5) Since relaying by (PQRS/TRT/T-28) involves removal of existing rails along with all the different types of traction bonds, provide temporary jumpers for passage of return current till such time the permanent bonds are fixed to the new rails.

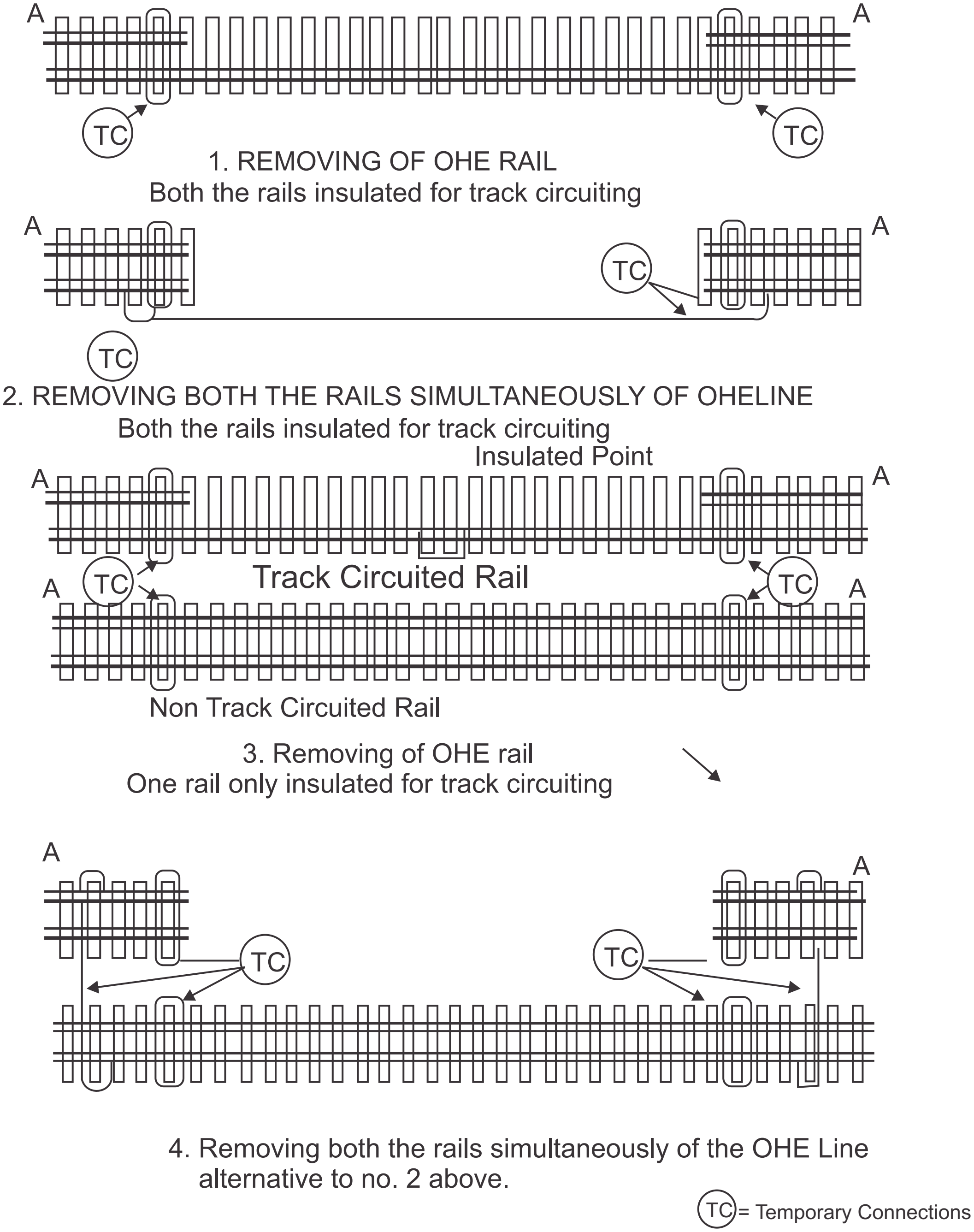


Fig. 14.05 - *Temporary connection during track removal*

(6) Alteration to Track during Machine Tamping/Track Renewal

(a) Before any alteration to alignment or level of electrified track is commenced, prior notice of 48 hrs. in advance shall be given to those responsible for the OHE so that OHE may be adjusted to conform to the new condition (at PQRS/TRT site, work will be done under the joint supervision of SSE/(P.Way), TRD, and S&T Departments). Do not raise the rail level under FOBs, ROBs and other over line structures or slew track / realign without the knowledge of traction staff.

(b) The relative alignments of the centre line of the track with respect to the alignment of the contact wire must be maintained within the specified tolerances. This applies to both horizontal and vertical clearances. Slewing or lifting of track must not be done outside the agreed maintenance limits, unless the position of the contact wire is altered at the same time. Adjustment of cant has a magnified effect of the horizontal displacement of the centre line of the track with respect to the alignment of the contact wire.

(c) Horizontal clearances to structures within the limits laid down in the Schedule of Dimensions must be maintained. For Slewing or alterations to track involving adjustment of contact wire (outside the agreed maintenance limits) sufficient notice should be given to the traction staff so that they arrange to adjust the overhead equipment.

(7) Earth Work – For excavation work adjacent to tracks, the following action is taken :–

(a) In DC traction areas, intimation should be given in writing sufficiently well in advance to the concerned Traction Distribution Officer to enable him to depute the Traction staff to be present in order to prevent possible damage to the traction underground feeder cables which are always located near the running lines.

(b) In AC traction areas, intimation should be given to the concerned officers of the Electrical General services and Signal and Telecom Department as well, since all the S&T and Electrical lines are cabled on account of Electrical Induction.

(c) In all AC and DC traction areas, Cable markers showing location of cables are provided by the Traction Department. In addition, the cables are protected by tiles and bricks, and during excavation if workmen come across such tiles or bricks in an arranged manner, they should at once report the matter to the higher officials. Any further excavation should be carried out only in the presence of the authorised staff of Electrical Traction and/or S & T Department as the case may be.

(d) While excavating, the foundations of OHE not be exposed and there should be no risk of sinking of the foundations.

1407. Working of Engineering Staff during Emergencies :

The Permanent Way Officials noticing a fire likely to result in loss of life or cause damage to property shall take all possible steps to prevent it from spreading and to extinguish it. In case the fire is on adjacent to any electrified equipment, the Permanent Way Official shall make no attempt to extinguish the fire but shall report the occurrence of fire to the nearest Station Master by most expeditious means.

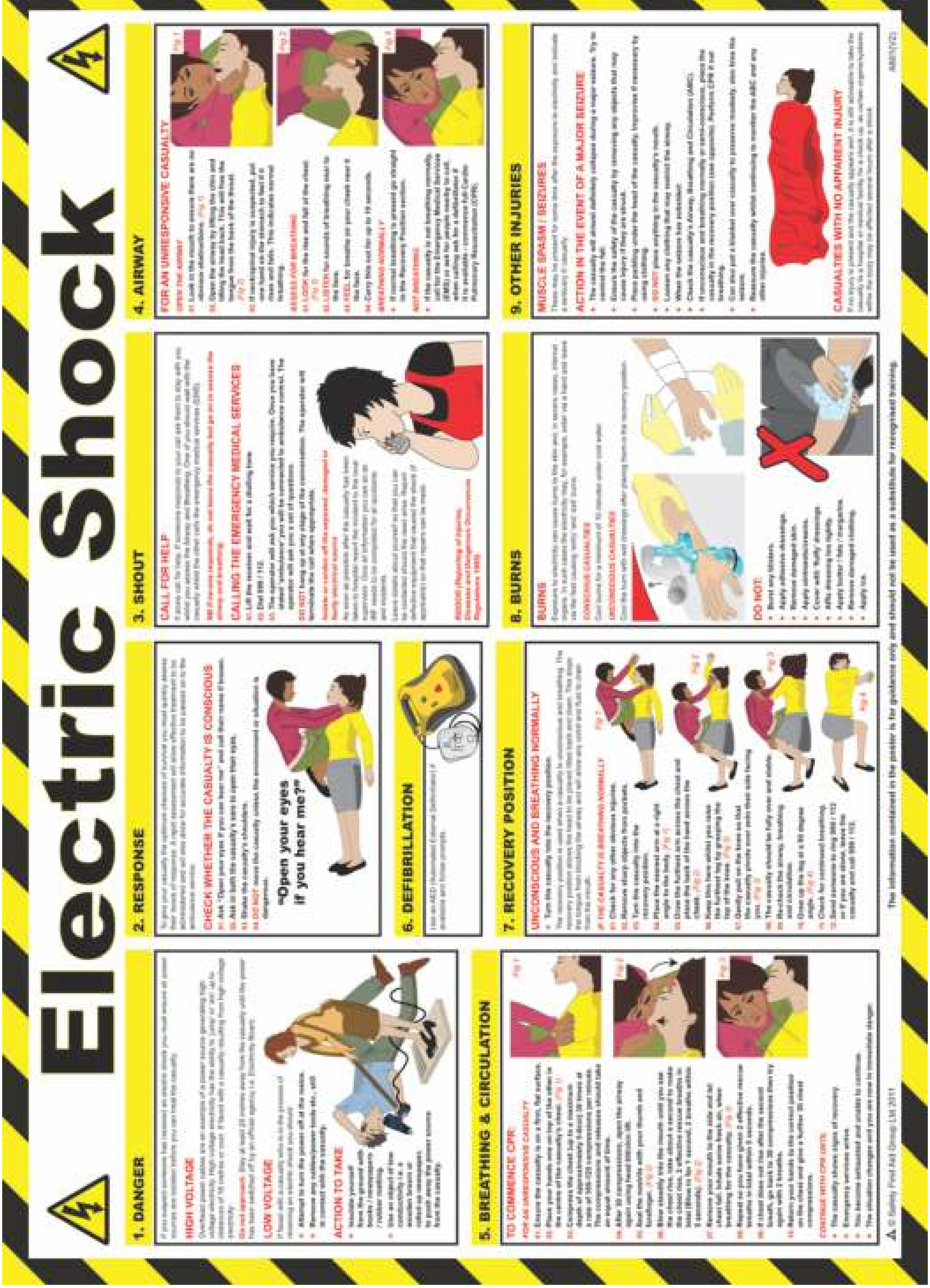
(1) Treatment of persons suffering from Electric shock :

When persons receive electric shock, practically in every case they can be revived with prompt application of First-Aid.

(a) Method of Resuscitation.- The method of resuscitation resorted to should be that known as artificial respiration.

Continuity of Treatment – The efforts to restore breathing must be continued regularly and with perseverance, and must not be discontinued until a Doctor has taken charge of the case.

- *Discontinuity in rail may give shock of your life, always use jumpers in electrified sections.*



Electric Shock
1. DANGER
2. RESPONSE
3. SHOUT
4. AIRWAY
5. BREATHING & CIRCULATION
6. DEFIBRILLATION
"Open your eyes if you hear me?"
7. RECOVERY POSITION
8. BURNS
9. OTHER INJURIES

Chapter 15

Maintenance of Track in Track Circuited Area

1501. General Information :

To detect the presence of a vehicle of a set portion of track is known as train detection. Basically there are two means to detect the presence of a train over a track, i.e.

(1) Track Circuit (DC, AC & Audio Frequency)

(2) Axle Counters.

1502. Understanding Track Circuits and Related Terminology :

(1) Track Circuit is a low powered electrical circuit in which running rails are used as a part. With the help of track circuit, one can easily identify whether the particular section is clear or occupied by a train/vehicles or Track Circuit is in failed condition. A track circuit has mainly two ends i.e. feed end and relay end. A track circuit gives two indications.

- Yellow/White/No light indication - When track circuit portion is clear i.e. when line is unoccupied.
- Red indication - When track circuit portion is occupied by a vehicle or track circuit is in fail condition.

According to the nature of supply source, the track circuits are categorised as: DC Track Circuits, Audio frequency track circuits, and A.C. Track circuits

(a) D.C. Track Circuits –

(i) Open DC Track circuit - now obsolete.

(ii) Closed DC Track circuit

(b) Audio Frequency Track Circuits (also known as Electronic Track Circuits) -

(i) Non-Coded

(ii) Coded

(c) A.C. Track Circuits – 83 Hz and 50 Hz was used in Mumbai (Western, Central & SE Rly), but now obsolete.

(2) Types of Track Circuits :

A closed type track circuit shall be provided to prove the clearance of rail track.

(a) Double rail track circuit :

Double rail track circuit is to be provided on non-electrified (RE) areas, as far as practicable.

In double rail track circuit both the running rails are insulated from adjoining sections by insertion of block joints.

(b) Single rail track circuit :

(i) In RE area, generally single rail track circuit is used where one of the rails is reserved for the traction return current. This rail is referred to as the un-insulated rails.

(ii) Any connection from the OHE mast or other structure shall be made only to the un-insulated rails.

(iii) Similarly, connections for the return current at feeding points as well as from booster transformers and return conductors shall be made only to the un-insulated rail.

(iv) Other rail carries positive polarity of DC track circuit. This positive polarity rail is insulated from either side.

(v) As far as practicable, the rail adjacent to the OHE mast shall be utilised as the insulated rail. However, this may not always be possible, particularly in yards where there are a large number of points and crossings or where the OHE masts.

(vi) In single rail track circuits, in the event of a break in the un-insulated rails, very heavy current will flow through the track relay as well as the equipment at the feed point. To avoid this the un-insulated rails of the adjacent tracks shall be cross-bonded at intervals of not more then 100 m. In case the track circuit is less then 100 m, The cross bonding shall be provided on the un-insulated rail at either end of the track circuit.

(vii) In case of adjacent track circuits, the return rail shall be staggered as shown in *fig. 15.01.*

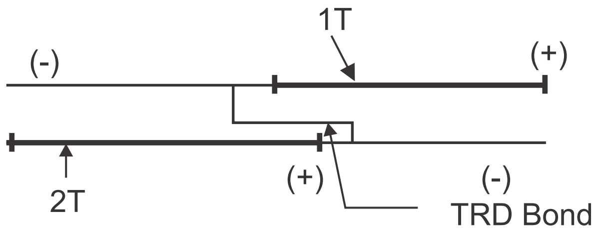


Fig. 15.01 - *Adjacent track circuit.*

(3) Bond Wires :

A straight track portion of welded rails does not need any props to enhance its conductivity. But if smaller panels or individual rails are to be included, the ordinary fish plated and bolted joints themselves cannot give good electrical continuity. In such cases, the rails are to be connected with continuity rail bonds.

(a) Bond wires shall be of an approved type or 8 SWG (Standard Wire Guage) GI (Galvanized Iron) bond wires may be used for rail bonds.

(b) These bond wires are fitted with channel bond pins, which have grooves to hold the wires.

(c) It is desirable to used bond wire clips to secure the bond wired.

(4) Insulation Rail Joint :

Two types of insulated joints are presently in use.

(a) Nylon insulated rail joints [supplied by S&T dept.]

(b) Glued joints [supplied by Engineering Dept.]

For one Nylon insulated joint, following insulation components are required:

(i)	Bushes	08 Nos.
(ii)	End post	01 Nos.
(iii)	Channel side plate LH	02 Nos.
(iv)	Channel side plate RH	02 Nos.
(v)	Nylon Insulating Plate	04 Nos.
(vi)	Steel backing plate	04 Nos.

Maintainer shall select suitable insulation components with care, as these are available in various sizes to suit Rail sections of 90 R, 52 Kg, 60 Kg etc.

(5) Track Lead Junction Box :

Track Circuit is provided with two track lead junction boxes, one at feed end insulation joint and another at relay end insulation joint. Jumpers are used for connecting track feed to rails from feed end junction box. Similarly jumpers are used for connecting rails to relay end junction box.

Cable from power source and feed end jumpers are terminated in feed end junction box. Similarly cable from track relay and relay end jumpers are terminated in relay end junction box. The above installations and their connection should be made in such a way that no hindrance is caused for mechanized maintenance of track.

(6) Ballast Resistance :

This is the total resistance of various leakage paths across the track circuit rails offered by ballast and sleepers.

Sl. No.	AREA	Minimum BALLAST Resistance
1	Block Section	4 Ohm/km
2	Station Section	2 Ohm/km
3	Double Rail track circuit with concrete sleeper	1 Ohm/km
4	Single Rail track circuit with concrete sleeper	0.6 Ohm/km

The ballast resistance of the track circuit should be as high as possible. Its value also changes for track circuit situated in different areas as below :

(7) Train Shunt Resistance :

This is the maximum value of resistance, when applied across the track, drops the track relay. The min. permissible value is 0.5 Ohm for track circuit.

Maximum permitted voltage at relay terminal under maximum ballast resistance condition shall not be more than 250% of relay pickup value for shelf type relays and 300% for plug in type relays.

For lengthy track circuit of length between 450 m - 750 m. The maximum permissible relay voltage will be 235% of relay pick up voltage.

The permitted voltage under minimum ballast condition shall be 125% of Relay Pick up value.

The maximum permitted relay terminal voltage with 0.5 Ohm TSR (Train Shunt Resistance) shall be less than 85% of drop away value of relay.

Due to safety consideration the pick-up voltage if increased shall be reduced in normal conditions so that there is precaution against boosting of Track Circuits and pick up Relay only takes place when it is required and pertinent.

(8) Rail Resistance :

The resistance of rail and bonding per 1000 m of track should not exceed 0.5 Ohm for track circuits longer than 700 m.

A rail and bond resistance up to 1.5 Ohm per 1000 m of track may be allowed for length of track circuit less than 700 m.

(9) Axle Counter :

The Single Section Digital Axle Counter system consists of at least two detection points, one at each end (entry & exit) of the track section which are to be monitored.

The Axle Counter should be fixed on Non-Cess Rail so that operations of Rail Dolleys and Single Rail Trolley are not affected and in turn the Track Circuit is not affected.

The Holes which are being drilled in the rail should be in the presence of JE (P.Way) and shall be chamfered by S & T Staff who shall confirm this by issuing a certificate.

1503. Permanent Way Requirements for Track Circuited Areas

(1) Glued joints or insulation joints of approved type are to be provided for defining boundary of track circuit. In all future works of track circuiting, G3L type glued insulated joints are to be preferably used as they are ideally suited for LWR and SWR territory where there are high compressive tensile forces.

(2) Insulated Joints wherever provided is to be maintained as square joints. Where staggering cannot be avoided the distance between staggered joints shall not exceed the minimum wheel base of the vehicles.

(3) Rail ends of insulated joints shall be square and true. All rough edges and burrs shall be removed from bolts holes. Battered ends shall be put right and the gap between the rails is to be equal to the thickness of the end post.

(4) Proper drainage should be ensured so as to avoid flooding of tracks during rains, particularly in the yards where watering of coaches is done and in the water columns and ash pits. It would be desirable to provide washable concrete aprons on platform lines at originating stations, in track circuited areas.

(5) Ballast must be kept clean throughout the track circuited section and care should be taken to see that minimum ballast resistance per kilometre of track should not be less than 2 ohms per km in station yard and 4 Ohm/km in the block section

(6) To overcome crushing of end posts of insulated rail joints due to creep at least one rail length in either side of insulated joint should be provided with anti creep devices.

Rail screws should preferably be used in place of dog spikes at insulated joints.

(7) Wooden sleepers concrete sleepers or any other approved type insulated sleepers shall be provided for track circuiting. Concrete sleepers where used shall have a minimum resistance of 500 ohms between insert-to-insert.

(8) Where short welded rail panels are used, SWR shall not butt against insulated joints. Two rails lengths of 13 m /12 m shall be interposed to isolate short welded rail from insulated joint or Glued joints to be used on such places.

(9) In case of turnouts and crossings, insulated stretchers, insulated gauge ties plates and insulated crossings plates shall be provided as per approved drawings. GFN liners shall be provided in the track-circuited area using concrete sleepers. No more than 3% of liners should be missing.

1504. Precautions to be taken while Working in Track Circuited Areas and Yards

(1) Approved cable route plans for all old laid cables should be available with S&T supervisors, so that S&T supervisors can advice about the locations of cable in case any Engg work which can damage cables is to be taken in hand.

(2) No cable laying work should be started without approved plan and thereafter permit from Engg. supervisors.

(3) The Permanent Way Staff should instruct the staff not place across or touching two rails in the track, any tool or metal object which may cause short circuiting.

(4) All gauges, levels, trolleys and lorries used on the track circuited length should be insulated. S&T Staff should jointly check the Insulation of all equipment used by P.Way Staff once in 6 Months and should attend the deficiencies, if any found in the insulation of the equipment.

(5) Steel or C.I. pipes used for carrying water/ gas under the track should be run sufficiently below the rails to prevent any short circuiting to be avoided as far as possible.

(6) While carrying out track maintenance, care should be taken to see that no damage of track circuit fittings like rail bonding wires, lead wires to rails, boot leg, jumper wires etc., takes place. However the above installations and their connection should be made in such a way that no hindrance is caused for mechanized maintenance of track.

(7) Use of steel tapes should be avoided in track circuited section.

(8) Pulling back of rails should be done in track circuited areas in the presence of S&T staff, where signaling connections are involved. Staff should be provided on priority S&T deptt. to avoid delay in work.

(9) Proper drainage should be ensured so as to avoid water logging of track, during rains, particularly in yards, where watering of coaches is done and in water columns and ash pits.

(10) Commercial department should ensure that sweeping of platforms and muck from the drains should not be thrown or deposited on track.

(11) S&T Supervisors should check the bond wire connections to avoid high resistance, which are causes of voltage drop.

(12) S&T Supervisors should apply glue/epoxy on the rail and fish plate of those joints, which are shorting due to iron filings and iron powder.

(13) S&T Supervisors should at the time of replacing the insulation joint apply quick drier paint on the rail and fish plate.

(14) P.Way Staff should try to replace the insulation joint when the temp. is between 20° - 35° C. At insulation joint pandrol clip should be opposite in direction so that pandrol clip's small portion should be towards fishplate or use 'J' Pandrol clip to avoid touching of pandrol clip with the fish plates.

1505. Proper Installation of Track Circuiting Components :

(1) Insulation Block Joints :

Track circuited sections are 'insulated' electrically from the track on either side by insulated joints. The standard insulated joint in normal use, is made out of ordinary fish-plates duly planed on the fishing planes for accommodating channel type insulation between rails and fish-plates with ferrules/ bushes over the fish bolts and end posts between the rail ends.

(a) Select the correct insulation components as per rail section i.e. 90 R, 52 Kg & 60 Kg etc.

(b) Check that track circuit rail section is welded or not, if not then provide rail joint bonding. These bonding are provided by drilling 7.2 mm holes in the rail webs closer to the fish plate joints on either ends and on rail joints. The bond wires are inserted into the holes along with channel pins which are having grooves to hold the wires. These holes to be chamfered by S&T staff under confirmation to P.Way staff.

(c) Insulation joint must be located according to the approved interlocking plan.

(d) The ends of rails, where insulation joint are fitted, must be square and smooth. There should not be any burr or rough edge which can damage the insulation material.

(e) The gap between the rails where the end post is provided must be maintained properly.

(f) Holes must be proper in accordance with fish plate hole i.e. oblong holes crush the bushes.

(g) Jumper connections must be so made that the whole of track circuit is in series.

(h) The insulated rail joint shall be installed at least one rail length in advance of the signal.

(i) In case of turnouts and crossings, insulated stretchers shall be provided.

(j) The distance between the track circuit termination and fouling mark shall not be less than 3 m.

(k) Insulated rail joints shall be as for as possible not be provided on the outer rail in curves.

(l) Steel backing plate of 4mm thickness with bends shall be used at ends to prevent damage to insulating plate.

(m) In case, the top edge of the Nylon end post protrudes above, the top of the rail surface, it shall be made in level with the rail surface by cutting off the extra portion of the end post.

(n) Where track circuit are adjacent, the polarity on adjacent the rail should be opposite.

(2) Glued Joint :

Before installation insulation of glued joint must be tested by S&T deptt. Glued joint should be kept in dry condition wooden sleepers.

(a) Insulation test in dry condition

The value of resistance shall not be less than 25 Mega Ohms when a meggering voltage of 100 V DC is applied across the joint and resistance is calculated by dividing the voltage by current.

1506. Maintenance of Various Components

(1) General Instructions :

(a) Every joint must be tested by maintainer to ensure high resistance. If the value of I.R. is below 5 Mega ohm, such joint should be marked and insulation must be replaced on priority as it may fail intermittently.

(b) Sleepers edge from insulation joint must be 125 mm so that dog spikes/pandrol clip may not short the insulation.

(c) S&T staff shall remove accumulation of brake-dust, dirt, other foreign matter and formation of burrs from insulated joints.

(d) Fish bolts at the joints must be kept tight and the sleepers well packed in the vicinity of the joints.

(e) Ensure provision of anti-creep devices on either side of the insulated joint, specially which are in block section and near by long welded rail (LWR).

(f) Keep atleast two-rail length of 13 m/12 m to isolate SWR from insulated joint.

(g) S&T deptt to ensure that rail ends shall be kept free from brake-dust, sand, rust, other foreign materials etc. all rough edges and burrs at rail ends must be removed.

(h) Ensure tightness of fish plate bolts and proper packing of ballast in the vicinity of the joint.

(i) Ensure proper drainage to prevent joint being water logged with rainwater.

(j) Ensure sound condition of stretcher bar insulation, D type insulation and rodding insulation.

(k) Ensure no leakage of current on account of muddy portion between feed end and relay end. If leakage is more, then advise to PWI for deep/shallow screening of ballast.

(l) For glued joints on wooden sleepers, ensure provision of dog spikes. The spikes should not protude below the sleeper.

2. Insulated Block Joint (IBJ):

(a) Before opening an insulated rail joint, the components required for replacement, confirming to the rail section, shall be kept ready by the side of the track.

(b) For replacement of an end post when there is no gap at the insulated rail joint, loosen the rail fastening and pull back the rail and insert end post between the rail ends.

(c) It is imperative that when an insulated rail joint is provided at least three sleepers on either side of the insulated rail joint shall be packed properly. To ensure this the all S&T connections which may cause TTM tamping should be removed by S&T department at the time of machine working.

(d) Fish bolts shall be kept tight. Nuts shall be tightened several times during the first two weeks after installation/replacement, until all components of an insulated rail joint are firmly set.

(e) A metal flow is seen often at the rail table at the joints. Such metal flow of metal forms a lip and creates sharp burrs at the rail ends. Projections formed at the rail ends shall be chiseled by S&T department without damaging the end post so that these do not bridge the rail expansion gap and cause a short circuit.

(f) Brake block dust, which may accumulate on the head and sides of the end post and top surfaces of the fish plate, shall be brushed off frequently by S&T department so that the possibility of electrical conductivity being established between the rail ends is eliminated.

(g) Special type pandrol clips ('J' types) shall be provided at nylon insulated joints/ glued joint to avoid touching of pandrol clip with the fish plate.

(h) Periodic coating by insulating varnish/epoxy over the nylon insulated joint/glued joint to avoid shorting due to brake dust shall be done by S&T department.

(i) A faulty insulated joint may be detected by taking the voltage readings across the track by S&T department.

Relay terminals and noting if this reading changes when the adjacent track circuit feed is shunted or disconnected. Any change in the voltage reading will indicate a faulty insulated joint.

1507. Joint Inspection of Track by JE/SSE (S&T and P. Way):

The track-circuited portion of the track shall be jointly inspected by SSE/Signal and SSE/P.Way *at least once in three months.* This is in addition to routine inspections to be carried out by each branch.

The following items should be checked:

(1) The condition of rail and insulation at the rail joints.

(2) Condition of ballast and sleepers.

(3) Abnormal collection of brake dust, rusting of the rail and drainage of the yard.

(4) It shall be ensured that percentage of missing liners for track circuit length not to exceed 3%.

(5) Condition of bonding wires and insulation pieces of block joints.

(6) Bond wires should not be rusted and double bonding should be provided. (bond lugs must be firmly fixed into the web of the rail).

(7) Jumper wire insulation should be in proper condition.

(8) Necessary casing pipes and insulation arrangement should be provided for the wires/cables running across the track and placed in such a way that will not get damaged during TTM tamping.

(9) Bottom of junction box connecting to track circuit should be kept above rail level.

(10) Data logger's 6 monthly reports and failures on Engg. account should be shared by S&T supervisors with P-way supervisors.

(11) Track feed and relay end voltage.

(12) Adjustment of track circuit to be done to ensure pickup voltage +25% with minimum ballast resistance.

(13) Ballast resistance

(14) Resistance of glued joints

(15) Condition of coils in axle counter.

■ ■ ■

- *Team-up with sister departments to ensure safety.*

Chapter - 16

Permanent Way Renewals

1601. Classification of Renewals –

(1) The track renewal works can be classified generally into one of the following categories:

(a)	Complete Track Renewal (Primary):	CTR(P)
(b)	Complete Track Renewal (Secondary):	CTR(S)
(c)	Through Rail Renewal (Primary):	TRR(P)
(d)	Through Rail Renewal(Secondary):	TRR(S)
(e)	Through Sleeper Renewal(Primary):	TSR (P)
(f)	Through Sleeper Renewal(Secondary:	TSR (S)
(g)	Through Rail Renewal on P&C	
(h)	Through Turn-out Renewal	TTR
(i)	Through Fitting Renewal	TFR
(j)	Through Fitting Renewal on P&C	
(k)	Through Weld Renewal	TWR
(l)	Through Ballast Renewal	TBR
(m)	Through Bridge Timber Renewal	TBTR
(n)	Through Bridge Sleeper Renewal	TBSR
(o)	Through SEJ Renewal	TSEJR
(p)	Through GJ Renewal	TGJR
(q)	Scattered Renewal	
(r)	Casual Renewals	

(2) Complete and through renewals are those in which the renewal is done for long continuous stretches of track and of the complete components respectively. These can be done either using new material or serviceable released material. Primary or through renewals are those in which only new materials are used and secondary renewals are those in which released serviceable materials are used.

(3) Scattered Renewal- In this case, unserviceable rails, sleepers and fastenings are replaced by identical sections of serviceable track components. Effort should be made to use material of same vintage. These are carried out in isolated locations and not more than around 10 rails and /or 250 sleepers in a gang beat in a year. Such renewals are a part of normal maintenance operations.

(4) Casual Renewal- In this case, unserviceable rails, sleepers and fastenings are replaced by identical sections of serviceable and nearly the same vintage or new track components. These are carried out in isolated locations of continuous but small stretches. Such renewals are not a part of normal maintenance operations and cannot be covered under scattered renewals. Casual renewal is normally done for continuous track length up to 500 m.

1602. Factors Governing Permanent Way Renewal :

(1) Criteria for Primary Rail Renewal - The following are to be considered in connection with the criteria of primary rail renewals :-

(i) Incidence of rail fractures/failures.

(ii) Wear on rails.

(iii) Difficulty in Maintainability of track to prescribed standards.

(iv) Expected service life in terms of Gross milliontonnes carried.

(v) Plan based renewals.

Details of above is as below:

(a) Incidence of Rail Fractures/Failures - A spate of rail fractures on a particular sections having 5 withdrawals of rails per 10 km. in a year due to fracture and/or rail flaws detected ultrasonically falling in the category of IMR & REM will have priority while deciding rail renewals. In case the rail failures at fish- plated/welded joints are pre-dominant, end cropping with or without welding could be considered. Through Rail Renewal is also allowed in locations of track where more than 30 defective welds per track km are existing. Through Rail renewal may also be allowed in locations where the rails do not have adequate balance service life of 50% of stipulated GMT to carry out through weld renewal.

(b) Wear on Rails –

(i) Limiting Loss of Section – The limiting loss in rail section as a criterion for recommending rail renewals shall be as under:

Gauge	Rail Section	Loss in section in percentage
B.G	60/52 kg	6
	90 R	5
M.G.	75 R	4.2
	60 R	3.25

Note: Rail wear may be determined by actual weighment, (or) taking rail profiles.

(ii) Wear due to corrosion - Corrosion beyond 1.5 mm in the web/foot and foot may be taken as the criterion for wear due to corrosion. Existence of the localized corrosion such as corrosion pits, specially on the underside of the foot and liner biting etc. on rail foot, act as stress raisers for the origin of fatigue cracks and would necessitate renewals.

However, before proposing for rail renewal, other options such as shifting of rail seat, interchanging of rails etc have to be explored based on the condition of corrosion in the rail foot. In general, longitudinal shifting of liner seat shall preferably be done when the rail is relatively new and reduction at the bottom flange is less than 2 mm. Interchanging of rails may be done when the rail is relatively old and shifting of liner seat from all sleepers is not practical i.e. where shifting of liner seat will not result in all liner seats to be away from the sleepers such as increasing sleeper density locations and locations where liner seat got shifted non-uniformly during casual renewal, destressing, TWR etc.

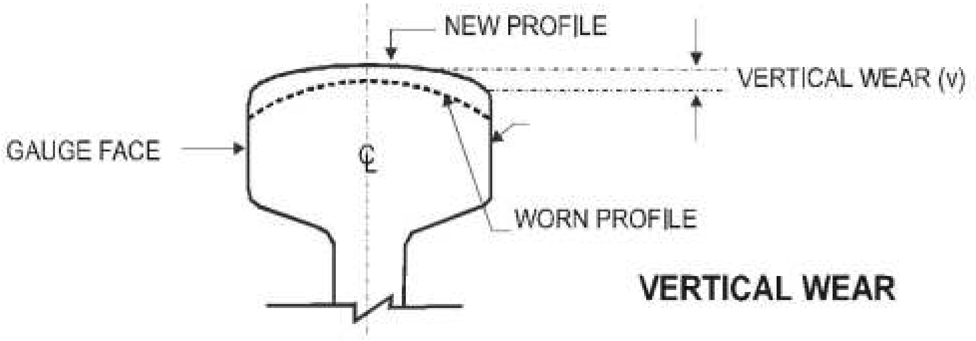
Interchanging of rail shall not preferably be done if reduction in bottom flange thickness is more than 4 mm either at present liner seat or shifted liner seat locations. However, interchanging may be done if reduction in bottom flange thickness is between 2 mm and 4 mm to avoid further corrosion till TRR is done provided the liner seats are not shifted from the sleepers which can be done only if special care is taken by conducting detailed survey before doing the work to ensure the same. In curved track while interchanging rails, the location of liner seating cannot be maintained at any desired location, hence, interchanging shall not be resorted to if reduction in bottom flange thickness is more than 4 mm on curves.

(iii) Vertical Wear – When the reduction of the depth of the rail head reaches a point beyond which there is a risk of wheel flanges grazing the fish-plates, such rails should be renewed. The limits of vertical wear at which renewals are to be planned are given as below.

Limit of Vertical wear for planned rail renewals

Gauge	Rail Section	VerticalWear
B. G.	60 Kg./metre	13.00 mm
	52 Kg./metre	8.00 mm
	90 R	5.00 mm
M. G	75 R	4.50 mm
	60 R	3.00 mm

A typical profile showing the measurement of vertical wear of the rail is given below

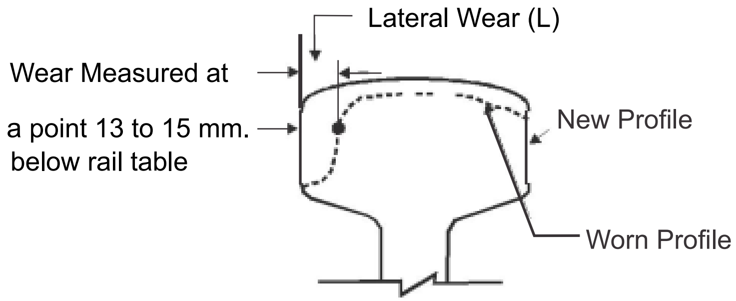


Vertical wear is to be measured at the centre of the rail either by measuring the height of the worn out rail by callipers or by plotting the profile. In the first case, the wear is the difference between the height of the new rail and the height of the worn out rails.

(iv) *Lateral Wear* – Limits of lateral wear from relaying considerations are as under : :

Section	Gauge	Category of track	Lateral wear
Curves	B.G.	Group 'A' & 'B' Routes	8 mm
		Group 'C' & 'D' Routes	10 mm.
	M.G.	Group 'Q' & 'R' Routes	9 mm.
Straight	B.G.	Group 'A' & 'B' Routes..	6 mm
		Group 'C' & 'D' Routes	8 mm.
	M.G.	'Q' Routes	6 mm.
		'R' Routes	8 mm.

A typical profile of the worn rail showing the measurement of lateral wear is shown as below.



Lateral Wear

Lateral wear is to be measured at 13 to 15 mm below the standard rail top table. Worn rail profile should be recorded and superimposed over new rail profile to find out the lateral wear.

(c) Maintainability of track to prescribed standards –

There may be cases, where renewals may be necessary on the following considerations viz.,

(i) Poor running quality of track in spite of extra maintenance labour engaged for maintaining the same,

(ii) Disproportionate cost of maintaining the portion of track in safe condition.

(iii) The condition of rails with regard to hogging/battering, scabbing and wheel burns and other conditions such as excessive corrugation of rail as can be ascertained by visual inspections, which affect the running quality of track, and make the track maintenance difficult and uneconomical, should be taken into account while proposing renewals.

(iv) Renewals of rail due to hogged and battered rails ends should be considered only if other remedies have not been found to be effective.

(d) Renewals on consideration of service life in terms of total G.M.T. of traffic carried – The rail shall be planned for through renewal after it has carried the minimum total traffic as shown below –

Gauge	Rail Section	Total G.M.T. carried for T.12 Med. Manganese rails	Total GMT carried for90 UTS rails
B.G.	60 Kg./metre	550	800
	52 Kg./metre	350	525
	90 R	250	375
M.G.	75 R	150	-
	60 R	125	-

The service life in terms of total GMT of traffic carried for considering through rail renewal on the bridge proper and in approaches (upto 100 m on either side) for all the important brides and such of the major bridges where height of bank is in excess of 4.0 m, all tunnels and their approaches (upto 100 m on either side) shall be half of the GMT specified in *para 1602(1) (d)* above.

(e) Plan based Renewals – Renewals to pre-determined plan with the objective of modernising the track structure on selected routes in the quickest possible time may be planned even if it involves premature renewals

(2) Secondary Rail Renewals :

(a) Secondary Rail Renewals may be necessitated due to following reasons:

(i) To eliminate obsolete/old/worn out rails in loop lines, yards, unimportant branch lines etc.

(ii) When the existing rails in loop lines, yards, unimportant branch lines have vertical/lateral wear in excess of limitations specified in *para 1602 (1) (b) (ii).*

(iii) For upgrading the loop lines/unimportant branch lines in phased manner for increasing speed or as a policy etc.

(iv) When it is considered unsafe to continue the existing rails based on condition such as excessive corrosion etc.

(b) In the case of Secondary Renewals, if the condition of rail is satisfactory, it is a good practice to crop the rail ends and weld them into ten rail panels with flash butt welding and use them in lesser important lines. The rails should be ultrasonically tested before use.

(c) Building up of chipped rail ends by welding will also improve the service life.

(d) If the condition of rails released from primary renewals is satisfactory for use in secondary renewals, the same shall be used in loop lines, yards, other unimportant branch lines after converting them into 10 rail panels with flash butt welding

(e) The rails released from primary relaying and not fit for use in secondary relayings should be used in sidings.

(f) Before using the released rails, they shall be tested with USFD and shall be defect free.

(3) Criteria for Renewal of Sleepers :

(a) The sleepers which cannot hold gauge, provide satisfactory rail seat, does not permit rail fastenings being maintained in tight condition and not able to retain the packing underneath are required to be renewed.

(b) Broken/cracked sleepers, sleepers with broken / cracked / elongated /

ineffective inserts are required to be renewed.

(c) Obsolete/non standard sleepers in continuous stretches require through sleeper renewal.

(d) Locations where 30% or more sleepers qualify in any of the above criteria in continuous stretches shall be planned for Through sleeper Renewal, other wise scattered renewal to be resorted to.

(e) On girder bridges, when 30% or more sleepers are defective and qualify for renewal, then, renewal should be carried out for the full span, the released serviceable sleepers may be used for casual renewals on other spans.

(4) Criteria for renewal of other track components :

(a) Renewal of ERC

Proposal for Renewal of ERCs shall be initiated as per the procedure elaborated :

(i) Sample size:

Toe load of all elastic rail clip of a sleeper should be measured on 1 out of 100 sleepers selected randomly.

(ii) Testing frequency: Initial testing of ERCs is to be done after four years or passage of 200 GMT of traffic, whichever is earlier. In corrosion prone area, the initial testing of ERC is to be done after two years or passage of100 GMT, whichever is earlier.

(iii) Subsequent testing will be done every four years or 200 GMT in normal areas and two years or 100 GMT in corrosion prone areas, whichever is earlier. However, if 20% or more of sample size records toe load below 600 Kg. both frequency of inspection and sample size are to be doubled.

(iv) If 20% or more of sample size records toe load below 400 Kg which is to be confirmed by 5% sample size, proposal of ERC renewal should be initiated.

(v) While measuring the toe load, the effectiveness of other fittings such as GRP, liner to be considered.

(vi) It is desirable to carryout renewal of ERC along with major track renewal works such as TRR/CTR/TSR/TFR, provided the above conditions are satisfied.

(vii) If such renewals are not planned, ERC should be planned for renewal, once in 5-10 years as per the codal life, according to route of the section.

Route	A & B	C (Sub)	D	E
Average life of ERC	5- 8 years		8 - 10 years	

(b) Grooved Rubber Pad (GRP) renewal

(i) It must be ensured that the rubber pads are in correct position. The rubber pads are considered to be unserviceable when the same are crushed or when the grooves of rubber pads are flattened. Loss of toe load can also be due to ineffective/missing rubber pads. In addition, ineffective/missing rubber pads facilitate creep, especially in sections with steep gradients.

(ii) GRP shall be renewed along with major track renewal works such as CTR/TRR/TSR/TFR.

(iii) If such renewals are not planned, Through rubber pad renewal shall be carried out once in 2 to 6 years, as per the codal life according to route of the section.

Route	A & B	C(Sub)	D	E
Average life of GRP	2 - 4 years		4 years	4 - 6 years

(c) Renewal of Liners

(i) Nylon/composite insulating liners used with pandrol clip shall be examined periodically for sign of cracking and breakage. All cracked/ineffective insulating liners should be replaced with fresh ones.

(ii) Metal liners shall be examined for dents/corrosion and other deterioration effects. Unserviceable liners shall be renewed with new/serviceable liners.

(iii) Preferably, Liners shall be renewed along with ERC renewal and along with major track renewal works mentioned above.

(iv) If such renewals are not planned, liners shall be renewed at a frequency similar to codal life of GRP.

(d) Through rail renewal of P&C: The life of fan shaped layout (PSC turnout sleepers) is much more compared to the life of other track components, such as rails, switches, crossings and fittings. Hence these track components require planned renewals, throughout the life of PSC layout.

(i) Service life of fabricated switches -

Rail section	Service life (In GMT)
60 Kg	200
52 Kg	150

Codal life of switches –

Route	A & B	C (Sub)	D
Average life of switch	4 years	2-3 years	5 years

(ii) Switches shall be planned for renewal, before they cross the above service life. Renewals may also be planned based on the codal life specified according to the route of the section.

(iii) Renewals shall be planned on condition basis such as wear / corrosion or as a result of joint inspection notes or on account of maintainability condition.

(iv) The provisions contained in other relevant chapters of the manual also should be followed before deciding the renewal of switches.

(v) All fan shaped switches should be replaced with thick web switches in phased manner considering the priority and GMT of the section. Priority should be given to A & B routes followed by C, D and E routes.

(vi) Before carrying out renewals, the option of reconditioning of switches with approved means should be explored to extend the life of switches. Considering the condition of switch, reconditioning should be carried out not more than three times.

(vii) CMS crossings shall be planned for renewal, before they cross the service life. Renewals may also be planned based on the codal life specified according to route of the section.

Service life of CMS crossing in GMT

Rail section	Service life (In GMT)
60 Kg	200
52Kg	150

Codal life of crossings

Route	A & B	C (Sub)	D	E
Average life of crossing	5 years	4-5 years	8 years	

(viii) Before carrying out renewals, the option of reconditioning of CMS with approved means such as translamatic robotic welding/latest approved welding should be explored to extend the life of crossings.

The robotic welding should be carried out by the RDSO approved firms as per the procedure laid down, not more than three times.

(e) Renewal of Switch Expansion Joints:

SEJs shall be planned for renewal as per the service life specified below. All renewals of SEJs shall be carried out with improved SEJs only. Conventional SEJs shall be eliminated in phased manner.

Service life of SEJ in GMT

Item	Service life (In GMT)	
	60 Kg	52 Kg
Ordinary SEJ	200	150
Improved SEJ	400	300

(f) Renewal of Glued joints:

Glued joints shall be planned for renewal on the basis of service life mentioned below or on condition basis which warrants renewal of Glued joint such as insulation failure or crack in the GJ etc.

Service life of glued joint in GMT

Rail section	Service life (In GMT)
60 Kg	200
52Kg	150

(g) Through fitting renewal: Through fitting renewal shall be planned when the elastic fastenings become ineffective or as per codal life of the elastic fastenings. The criteria specified in *para 1602(4)(a), (b) and (c)* shall be followed while proposing through fitting renewal. It is a good practice to replace ERC, GRP and liner while carrying out TFR, unless otherwise any of these fittings are effective in performing their function.

(h) Through Weld renewal:

(i) Through Weld Renewal should be planned before the welds reach 50% of the stipulated GMT of adjacent rails. The sections where there are series of cupped welds in continuous stretches also shall be considered for TWR. Among the various sections, due for Through Weld Renewal (TWR) as per this criteria, Chief Track Engineer will decide inter-se priority based on incidences of defect detection and weld failures.

(ii) It has to be ensured that the rails proposed for TWR are fit for welding and have adequate residual life. If rails are not fit for welding or do not have adequate service life, then the stretches shall be planned for TRR instead of TWR.

(iii) Through weld renewal shall be carried out with flash butt welding except where it is unavoidable to use SKV welds. In such cases, TWR with SKV process to be executed with approval of PCE.

1603. Track Renewal Programme :

(1) Planning of Renewals – Renewals may be planned in as long and continuous lengths as practicable, within the available resources with priorities to meet the projected traffic. Short isolated stretches of 10 kms and less, not due for renewal on condition basis may be programmed along with the adjoining lengths, if these stretches do not confirm to the required standards. Priority in planning renewals should be given to busy and important lines.

Track renewal programmes shall be framed by the Chief Engineer of each Railway taking into consideration the proposals submitted by the Divisional Engineers.

(2) Initiation of Proposals –

(a) Track renewal proposals are to be initiated by ADEN and submitted to the DEN. The proposals should be based on specified criteria or on condition basis and also on the basis of various inspections carried out during the year. The DEN/Sr.DEN shall personally check the details submitted by the ADEN and after verification, Sr.DEN/Co shall compile the track renewal programme indicating the priorities. The justification for track works shall be prepared on the basis of factually correct data and submitted in proforma given at *Annexure 16/1.*

(b) The track renewal proposal should be prepared on IRPSM website duly following the guide lines issued from time to time. Details of locations including cost, track structure details and details of all other annexure to be entered. All the details given in the formats must be indicated accurately. In addition, any special features which help establish the justification for renewal should be brought out, separately and attached with the proposal.

(c) Documentary evidence like photographs, km wise list of Rail/weld failures, details of wear, rail profiles and measurement of corrosion/liner bites etc. for the proposed locations (as applicable) should be attached along with each proposal for better appreciation. The proposals along with justification should be submitted to Chief Track Engineers office by the end of July every year online through *IRPSM* portal.

(3) Verification of proposals by the Track Cell in the Chief Engineer's Office – Important items relating to complete track renewal, through sleeper renewal or through rail renewal shall be test checked by the nominated administrative officer of the Headquarters who will –

(a) Study the proposals received from the divisions;

(b) Frame programmes for renewal taking into account the sections planned for renewal;

(c) Decide priority for the works considering the total funds available;

(d) Satisfy himself that the renewal is unavoidable in the case of track renewal proposals which are justified primarily on condition basis but are premature as far as quantum of traffic carried (GMT) is concerned and;

(e) Track renewal programme are sent by Principal Chief Engineer to Railway Board vetted by FA&CAO and approved by General Manager of the zonal Railway by the end of August.

On receipt of Sanction of proposals by Zonal Railway, Railways shall take following actions:

(a) Sanction of detailed estimate

(b) Preparation of project report

(c) Procurement of track materials

(d) Creation of posts chargeable to work. (if required)

(e) Finalization of agency for the work.

(f) Planning and Deployment of track machines.

- *P.WAY is getting old, start process for its reincarnation in time for graceful exit of aging track. (Never delay initiation of proposals for track renewal as per prescribed criteria)*

Annexure 16.1
{Para 1603 (2)(a)}

PROFORMA FOR SITE SURVEY DATA FOR TRR/TBR/CTR Proposals

All the relevant details to be filled in by the division
Site Survey Data for every 200 M (From to Locations to be given as KM. Chain-ages and not as Km/TP)

Proposal No. Division Major Section Code
Description work :

Location		Rail fracture Nos. (for the past one year only)				Weld Fracture Nos. (for the past One year only)				Rails replaced due to IMR in USFD in past year	Wear in Rail				% unserviceable Sleepers	Ballast cushion in mm		Remarks	Details of speed drestrictions (if any)
From	To	FP Zone	Dates of occurrence	Mid rail	Dates of Occurrence	AT Weld	Dates of Occurrence	FBW	Dates of Occurrence		Limiting loss of section (in %)	Corrosion (in mm)	Vertical (in mm)	Lateral (in mm)		Clean	Caked		

Chapter 17

Planning and Execution of Renewal Works

1701. Project Report for Renewal Works :

(1) Systematic and meticulous planning for various items of execution of track works is essential for achieving quality, economy and timely completion of works. For every sanctioned track work e.g. CTR, TSR, TRR, deep screening, bridge timber renewal, etc. a detailed project report should be prepared. The report should inter alia, cover the following aspects:

(a) Details of Work - Pink book detail, scope of work, locational details, cost and estimate particulars etc.

(b) Existing track structure - Inventory of existing track structure including rails, sleepers, fittings, ballast quantity/deficiency in track, type, width of formation and other details should be taken as prescribed in P.Way diagram, details of level crossings, bridges, electrical fittings, curves, height of bank/cuttings, yards, sidings, etc.

(c) Classification of track materials - During inventory of the existing track structure by foot by foot survey, identification, classification and colour making of existing track materials as second hand and scrap should be done as provided in *Para 1709*. The classification should be approved by the competent authority. Action plan for stacking/ storage and disposal of the released materials should be clearly indicated. Inventory of existing track materials would normally be prepared jointly by the SSE (P. Way) of the section and the SSE (P. Way) (Spl) for the renewal.

(d) Proposed track structure - The proposed P. Way diagram of the proposed length should be prepared in the same format as done for the existing track structure and incorporated in the project report.

(e) Existing/proposed gradient profile - The levels of existing track should be taken at every 20 metres and a gradient diagram prepared. Introduction of vertical curves should be critically examined and the proposed profile of track shown in red line indicating the proposed grades. Lowering of track should be avoided. Precise lift of track at girder bridges should be worked out and a separate scheme developed for lifting of girders on each of the affected bridges. Similarly, the magnitude of lifting at level crossing should be worked out and indicated in the report. Care should be exercised to keep the road surface at same level on level crossings spanning across multiple tracks. This may require regrading of adjacent lines too.

(f) Realignment of curves - All curves should be measured afresh and slews worked out for realignment wherever necessary, keeping the obligatory points in view.

(g) Method of execution - The work should be executed “bottom upwards” i.e. sequence of execution of works will be in the following order -

Formation ⟶ Ballast ⟶ Sleepers ⟶ Rails

(h) Formation:

(i) Repair and widening of cess : The project report should indicate the requirement of and plan for widening of formation in both banks and cuttings wherever necessary. Provision of proper drains in cuttings should also be planned.

(ii) Formation treatment: Areas needing formation rehabilitation should be identified and a study for possible solutions and method of execution of the rehabilitation scheme should form part of the project report.

(i) Ballast - The requirement indicating bifurcation of cess supply and depot supply and the source and means of each should be spelt out clearly. Mode of providing ballast cushion i.e. deep screening or raising should be identified along with sketches of cross sections present and proposed. Sleeper renewal would normally not be started unless adequate arrangements for supply of ballast have been made.

(j) Transportation of P. Way materials - The mode of transportation for various track components and unloading of rails and sleepers in particular, at the work sites should be indicated in the project report.

(k) Welding - Complete details of welding requirements, and arrangements need to be made for its execution whether departmentally or through contract should be clearly indicated in the report.

(l) Renewal of turnouts, bridge timbers, etc -

The project report should cover the complete details of turnouts, bridge timbers, level crossings, etc. where renewal is to be carried out. Whether turnouts are to be laid manually or by mechanized means, should be clearly brought out indicating the arrangements made. The report should also include the mode and agency for overhauling and relaying and making up of road surface at the level crossings.

(m) Use of machines - The requirement of machines for renewal (if machanised renewal is planned) deep screening (if mechanized deep screening is planned) and tamping/stabilizing and the duration for which the machines are required should be indicated. The machines that would be deployed should be identified and staff nominated. Planning for repair of machines at the works site, supply of fuel and other consumables should be planned. Requirement of additional lines (if any) in the existing yards for making base depot and arrangements made for the same should be indicated in the report.

(n) Contracts - The contracts that are required to be entered into for various activities of works and the activities, which are to be done departmentally, should be spelt out. The planning for deployment of staff/supervisors for execution at various activities should be indicated.

(o) Material Planning - The material requirement should indicate the materials to be arranged by the headquarters and by the Divisions. Against each material, proper nomenclature and drawing number should be indicated. Rails nos. and sizes (including lead rails, check rails etc.), sleepers (including specials), rails and sleeper fastenings, switches and crossings, level crossing and bridge sleepers and fittings, etc. should be fully covered. Consignee particulars and the destination, mode of transport should also be indicated.

(p) Manpower Planning - The requirement of manpower including the officers, supervisors, artisan and other staff should be worked out with minute details. The arrangements made for camping of these officials and mobilization should be reflected in the report.

(q) LWR plans - For welding of rails into LWR, the “LWR plan” should be got approved by the competent authority in advance. Such plan should form part of the project reports.

(r) Requirement of speed restrictions, traffic blocks and other material train - Planning for execution of track renewal works should be such that the time loss on account of speed restriction is minimal and is within the permissible limits. The report should indicate requirement of speed restrictions and traffic blocks together with duration. The corridor for blocks is required to be planned in consultation with the Operating Department and accordingly reflected in the report after obtaining the approval of DRM. Arrangements made for various types of wagons for transportation of ballast, sleepers, etc. together with requirement of locomotives should be indicated in the report in consultation with Sr. DOM and with the approval of DRM.

(s) Monitoring mechanism - The list of all activities involved and the time estimation for each activity should be worked out. These activities should be sequenced and co-related in logical manner and network diagram prepared using CPM method. The critical activities should thus be identified. These should form part of the project report.

(t) Preparation and submission of report - The detailed project report covering the various points as mentioned above should be prepared as soon as the approval of Board to include the works in FWP is conveyed to the Railways. These reports should be submitted to headquarters for scrutiny and approval.

(2) Preliminary Works –

(a) Ballast required for making good possible deficiency in cushion due to deep screening should be arranged and unloaded from hopper wagons before start of deep screening. Where complete track renewal or through sleeper renewal is planned, deep screening of ballast should also be planned and executed. Progress of deep screening should match with the progress of renewals and should precede complete track renewal or through sleeper renewal by a couple of days. In the case of LWR track, the additional requirement of ballast for the extra profile should also be ensured.

(b) Treatment of bad formation should be carried out in advance of the relaying.

(c) Centre line and level pegs made out of scrap tie bars as also the pegs for realignment of curves should be fixed before hand. Where necessary, curves should be realigned and transitioned. Longer transitions should be provided to cater for future increase in speed wherever possible. In case heavy slewing is necessary for providing longer transitions, centre line pegs indicating revised alignments should be fixed and new track laid accordingly. The formation should be suitably widened. The constraints of OHE should, however, be kept in view.

(d) On sections where creep is noticeable, joints should be squared and gaps rectified for short length at the point of commencement.

(e) As a preliminary measure the SSE (P.Way) should actually mark out the position of the new rail joints with a tape. The lengths marked out should be the length of the new rail together with one expansion space. On a curve the rail lengths should be set out along each rail, starting from a point on the straight where the sites of the two joints have been set out opposite one another by means of square. Square should be used at each joint on the curve to determine the amount by which the inner rails gaining over the outer rail. As soon as the lead of the inner rail is equal to half the distance between fish bolt holes, a length shall be sawn off the end of the rail equal to the full distance and a new fish bolt hole drilled. The length of cut rails varies according to the degree of each curve, and should be determined before hand; a cut rail will be required after every two or three or four full length rails depending on the curvature. On LWR section, where 10/20 rail panels are used, similar action of cutting of inner rail shall be taken to ensure the joints are square.

(f) Sufficient track gauges, gauge-cum-levels, spanners, keying and spiking hammers, augurs, crow bars, tommy bars, claw bars, grip gauges, beaters, ballast rakes, wire claws, forks, wire brushes, ballast screens, mortar pans screening baskets, shovels, powrahs, rail thermometers, expansion liners, slotted fish-plates, rail closures, combination fish-plates, wooden blocks and wedges and all tools and equipment necessary for efficient execution of work including small track machines for rail cutting, rail drilling, tensors, SKV welding and mechanical tampers where used, should be arranged by the SSE (P.Way), in advance. Before starting and during the course of work, the track gauges and the gauge-cum-levels should be checked periodically for their accuracy.

(g) Labour should be properly organized and suitably distributed to ensure maximum efficiency.

(h) Before carrying out track renewal work in electrified areas sufficient notice should be given to the Electrical Traction Distribution Department so that they can arrange for adjustment of overhead wires to conform to the new alignment and level. They will also arrange for bonding the new track. In track circuited sections and in yards where change in yard layout is contemplated notice should be given to the Signalling Department for getting assistance in executing joint works. Advance Notice as laid down by the respective railway should be given to the

Operating Department of the actual commencement of work by the SSE (P.Way), for sending advice to all concerned. The safety of traffic is of paramount consideration.

1702. Planning for P.Way Materials :

(1) It should be ensured that materials are unloaded fairly opposite to the position where they are to be laid. Care should be taken to avoid unloading of materials in excess of the actual requirement, so as to avoid double handling.

(2) Utmost care should be exercised in unloading of rails. Ramps made of unserviceable rails should be used for unloading single hails. Short welded panels as well as rail panels for laying welded rails may be unloaded by *"end unloading"* method,

(3) The unloaded panels should be carefully stacked on a level base, care being taken to prevent formation of kinks. Flat footed rails, as a rule should rest on the flat foot. Any carelessness in unloading and stacking is liable to cause irreparable damage, resulting in bad running. While carrying rails they should be supported at several places by rail tongs or rail slings. Carrying of rails and heavy articles on the head or shoulder should be avoided. Kinked rails must be jim-crowed and straightened. Punch marks on rails or marking by chisel should be prohibited as these cause incipient failures.

(4) Sleepers are to be laid by track machines – TRT or PQRS as far as possible.

(5) Rails of 880 grade are to be handled during unloading as per the provisions contained *RDSO L.No. CT/3S, 'Guidelines for Handling and stacking of Rails.'*

(6) Material new or old, lying along side the track is always a potential source of danger and efforts should be made to keep the quantity as low as possible and should be under watch by posting a watchman.

1703. Planning for Posting of Staff :

(1) Special SSE (P.Way) with clerical staff at the executive and office levels as provided in the estimates shall be posted before start of work. Provision of gazetted staff may be made in the estimate the case of large scale permanent way renewals according to the yard sticks laid down.

(2) The SSE (P.Way) in-charge of track renewal will take over the maintenance of suitable lengths of the section to be relaid a few days in advance of the actual commencement of the work. He will be responsible for its maintenance till the section is handed over to the maintenance SSE (P.Way)

after completion of the work. Requisite staff for maintenance shall also be given to special SSE.

(3) Experienced labour shall be deployed by the agency for relaying works

(4) The Special SSE (P.Way). shall make all arrangements for the training out of materials, A fully equipped First Aid Box should be always kept at work site. Labour camp should be so located that men are not required to walk a long distance to reach the site of work.

1704. Planning for Allied Facilities :

(1) In the case of big relaying works, additional sidings as necessary should be provided at the depots for receipt and dispatch of materials preparation of panels etc.

(2) Arrangements for special rakes for movement of rails and sleepers should be made by the DEN in consultation with the Operating Department. Where necessary, separate power and crew should be arranged. Provision of Engineering time allowance (ETA) in the working time table should be arranged with the Traffic Department.

(3) Traffic blocks may be necessary depending on the method of relaying adopted. In such cases the DEN must give adequate notice to the Operating Department before framing of the time table for the period during which the track renewal work will be carried out. Such information is useful to the Operating Department in framing the time table and making the required time available by regulating certain trains, as necessary. In case of any difficulty, the DEN should refer the matter to the PCE, who will arrange for the required blocks in consultation with the Chief Operations Manager. A minimum block of 2 to 3 hours duration is necessary where renewal works are carried out manually. In the case of mechanical relaying, a minimum block of 4 hours is desirable.

(4) When work is being carried out between trains in a location from where the SSE (P.Way)-in-charge cannot readily communicate with the Station Master at either side of the block section, a field telephone, on controlled sections may be installed, in order to permit utilisation of every suitable interval between trains being utilised.

(5) The DENs, in consultation with the Operating Department Officers, should manage to carry out permanent way renewals with the minimum obstruction and detention to traffic.

Whenever possible, the following arrangements should be made in consultation with the Operating Department :

(a) On double line, the traffic of both lines may be worked over the unaffected line under the *"Single line-working"* regulations.

(b) If there are triple or more lines, two lines may be worked as the up line and the down line respectively, subject to compliance with single line working regulations in respect of the line over which trains run in a direction contrary to the normal usage of that line.

(6) Arrangements should be made for –

(a) Notification by the Operating Department, authorising Engineering Department to undertake the work.

(b) Imposition of blocks and protection by temporary Engineering fixed signals.

(c) Issue of caution orders to Drivers by Station Masters on daily advice of actual kilometrages received from the Inspector-in-charge of the work.

(7) Speed Restrictions – The speed restrictions to be imposed during various sequences of work are given in Table 17.01 and 17.02

Table 17.01

Broad and Metre Gauge - Manual Packing

Day	Sequence of events	Recommended Speed restriction in Km/h. B.G.	M.G.
1^{st}	Opening, relaying and initial packing	20	20
2^{nd}	1^{st} through packing	20	20
3^{rd}	2^{nd} through packing	20	20
4^{th} to 9^{th}	Picking up of slacks as required	45 (after second through packing)	30 (after second through packing)
10^{th}	3^{rd} through packing	45	30
11^{th} to 19^{th}	Picking up of slacks as required	75 (after third through packing)	60 (after third through packing)
20^{th}	4^{th} and final through packing	75	60
21^{st}	.....	Normal sectional speed.	Normal sectional speed.

Table I7.02

Broad Gauge - Machine Packing

Day	Sequence of events	Speed in Km/h.
1st..	Opening, relaying and packing	20
2nd..	1st tamping	20
3rd to 5th	Attention to track as required	45 (after completion of 1st tamping)
6th..	2nd tamping	45
7th to 8th	Attention to track as required	75 (after completion of 2nd tamping)
9th	3rd tamping	.....
10th		Normal sectional speed.

Note : The work of Track renewals on double line should normally proceed in the direction opposite to Traffic.

1705. Methods for Carrying Out Renewals :

Complete track renewal is carried out by any one of the following methods:–

(1) With mechanical equipment.

(2) Complete dismantling of old track and relaying with new track(manual).

(3) Piecemeal method in which sleeper and rail renewal are carried out separately.

Detailed instructions shall be issued by the Assistant Divisional Engineer regarding the method of relaying which depends on the site conditions.

1706. Renewal by Machines :

Due to modernsation of track structure, track renewal works have to be carried out with suitable machines namely track relaying train (TRT), Track laying equipment (TLE) for CTR/TSR, Points and Crossing Changing Machine (PCCM) for TTR and Mobile Flash Butt welding Plant for TWR.

The preliminary (preparatory) work prior to relaying at site, the actual relaying process at site and the post relaying operations are described in detail in other relevant chapters of this Handbook.

1707. Piecemeal Renewal :

(1) General–In this method Through Sleeper Renewals (T.S.R.) is carried out first. Through Rail Renewal (T.R.R.) is carried out after the track gets consolidated by three rounds of through packing and also on account of passage of trains.

1708. Track Laying Standards :

(1) Utmost care should be taken during linking to ensure good quality of work, which on no account should be allowed to suffer.

(2) As a good practice, the following standards of track geometry measured in floating condition during primary renewals for Broad Gauge and Metre Gauge should be achieved (Track laid with new materials). The track geometry will be recorded three months after the speed is raised to normal.

1	Gauge *(Ref para 502))*	a) Broad Gauge (1676 mm) i) Straight including curves of radius upto 350m and more ii) For curves of radius less than 350m.	-5 mm to +3 mm upto +10 mm
		b) Meter Gauge (1000 mm) i) Straight including curves of radius upto 290 m and more ii) For curves of radius less than 290 m	-2 mm to +3 mm upto +10 mm
		c) Sleeper to Sleeper variation	2 mm
2	Expansion gap	Over average gap worked out by recording 20 successive gaps	± 2 mm
3	Joints	i) Low joints not permitted ii) High joints not more than iii) Squareness of joints on straight	± 2 mm ± 10 mm
4	Spacing of sleepers	With respect to theoretical spacing	± 20 mm
5	Cross level	To be recorded on every 4th sleeper	± 3 mm

6	Alignment	On straight on 10 m. Chord	$\pm$ 2 mm
		On curves of Radius more than 600 m. On 20 m. Chord. Variation over theoretical versines	5 mm
		On curves of Radius less than 600 M. On 20 m. Chord. Variation over theoretical versines	10 mm
7	Longitudinal level	Variation in longitudinal level with reference to approved longitudinal sections	50 mm

1709. Markings and Identification of Permanent Way Material :

All Permanent Way material should be distinguished as follows or as otherwise directed:

(a) Class I - No marks.

(b) (i) For rails-

(i) Class II (a) Second hand rail fit to be relaid in running lines - Ends to be painted with a daub of white.

(ii) Class II (b) Second hand rail fit for use in non-running lines - Ends to be painted with a daub of yellow.

(iii) Unserviceable rails not fit for use - Ends to be painted with a daub of red.

(ii) For other track materials like sleepers etc.–

(i) Class II i.e., Second hand fit for use in track works to be painted with a daub of white.

(ii) Unserviceable material not fit for use - Ends to be painted with a daub of red.

It should be ensured by the ADEN and SSE (P.Way) that the materials of each class including fittings, are separately stacked for convenience of accounting and despatch and indication signage thereof.

(2) Identification of different qualities of rails in the Field –

(a) ‘Prime Quality’ Rails – Indian Railway Specification IRS-T-12/2009 provides the detailed specification of flat bottom rails 68 kg/m, 60 kg/m, ZU-1-60 & 52 kg/m of grade 880 MPa, 1080MPa CR and 1080 MPa HH. These rails shall be classified as Class ‘A’ and Class ‘B’ rails based on tolerance in End straightness. This specification also specifies the requirements of special class of rail steel such as Niobium (NB), Vanadium (VN), Corrosion Resistant rail steel Copper Molybdenum (CM), Nickel Chromium Copper (NC). The rolling mark on rails shall indicate rail section, the grade of steel, identification marks of the manufacturer, process of steel making and direction of rolling of rails.

(b) 'Industrial Use' Rails (IU rails) – In addition to above 'Industrial Use' rails are arising at steel plants, particularly during the inspection of rails as per IRS-T-12/2009 while producing *'Prime Quality'* rails. There is no deviation in chemical composition or mechanical properties in 'Industrial Use' rails form that of 'Prime Quality' rails. The deviations exist only in tolerances for parameters as mentioned in *IRS-T-12/2009.* These rails can be used in industrial sidings with speed restriction of 50 km/h. IU rails shall be identified by blue paint on both sides end face of flange on either side for distance of 500 mm from each end. The letter 'IU' (Industrial Use Grade) shall be stamped in 15 mm size on both end faces of rails in addition to colour marking.

(c) Colour codification for identification of new rails as per *IRS-T-12/2009 is as per Annexure 17/1.*

1710. Post Renewal Activities :

Works to be attended after completion of relaying –

(1) Classification and loading of released materials – Materials as and when removed during the progress of relaying should be collected and classified and despatched to the destination. No released material should be left lying about at the site of the renewals. A relaying work shall not be considered complete until all released materials are removed from site and necessary credit afforded.

(2) Description Boards –

Boards displaying information in regard to track materials laid for special or experimental purposes should be erected at each end of the length over which the trial is being conducted & maintained only for so long as the materials remain under trial.

(3) Revision of Permanent Way Diagrams –

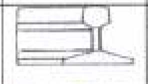
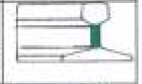
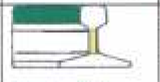
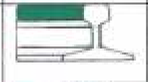
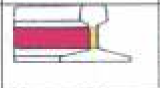
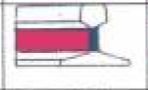
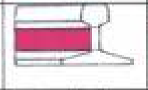
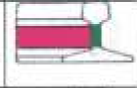
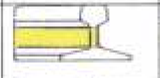
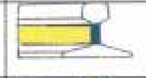
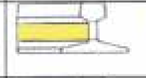
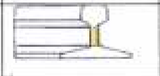
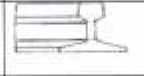
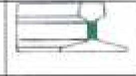
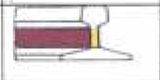
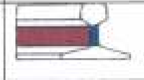
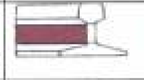
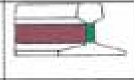
As soon as the rail and / or sleeper renewal work is completed, the Permanent Way diagrams & the station yard diagrams and the index section that embody the detailed particulars of the track in regard to the year of laying, section of rail, type of sleepers, fish plates & fittings should be amended up-to-date in the Track Management System and the headquarters advised. Other track works carried out should be also be amended up-to-date in the Track Management System and the head-quarters advised.

(4) Closing of the Accounts – The account for relaying works should be closed within 3 months of completion of the work & completion report submitted.

- *Plan for healthy birth of New P.WAY. (Detailed planning and systematic execution would go a long way in ensuring longer life of new assets)*

Annexure 17/1
(Para 1709 (2))

COLOUR CODE FOR RAILS

S. No.	Grade	Colour Code	13m, 26m, 130m, 260m	12m, 25m, 129m, 259m	11m, 24m	10m
1	GR. 880	Only common length wise colour code and no paint on web surface				
2	GR.1080 H.H.	In addition to common length wise colour code, **Blue** paint on both sides of web surface for a distance of 500 mm from each end.				
3	Gr 1080 Cr	In addition to common length wise colour code, **Green** paint on both sides of web surface for a distance of 500 mm from each end.				
4	CLASS'A' RAIL	In addition to common length wise colour code, grade code as 1, 2 & 3 and **Green** paint on gauge/non gauge face for a distance of 500 mm from each end.				
5	NIOBIUM 880 NB	In addition to common length wise colour code, **Purple** paint on both sides of web surface for a distance of 500 mm from each end.				
6	VANADIUM 880 VN	In addition to common length wise colour code, **Yellow** paint on both sides of web surface for a distance of 500 mm from each end.				
7	Copper-Molybdenum 880 CM	In addition to common length wise colour code, **White** paint on both sides of web surface for a distance of 500 mm from each end.				
8	Nickel Chromium Copper 880 NC	In addition to common length wise colour code, **Brown** paint on both sides of web surface for a distance of 500 mm from each end.				
9	IU	In addition to common length wise colour code, **Blue** paint on end face of flange and both sides of flange for a distance of 500mm from each end.				

Common lengthwise colour code

1. No paint on gauge/non-gauge face indicates class 'B' rails.
2. Yellow paint on each end face on web region indicates **13m, 26m, 130m, and 260m** length.
3. Blue paint on each end face on web region indicates **12m, 25m, 129m, and 259m** length.
4. White paint on each end face on web region indicates **11m, 24m** length.
5. Green paint on each end face on web region indicates **10m** length.

Note: - This colour code is for new rails, for second hand rails Para 321 of IRPWM-1986 may be referred to.

Chapter 18

Laying of Track

1801. General :

Laying of track is a significant operation involving huge investment and it must be ensured that terms of reference as stipulated are fully met while executing these works.

A well laid track reduces maintenance problems during life time of asset. Various occasions for laying of track include construction of new line, gauge conversion, doubling, yard remodeling etc.

For good laying of track, following aspects need to be looked into:-

(1) Design/Planning aspects e.g. standard of track structure, alignment, ruling gradient, selection of proper terrain, drainage scheme etc.

(2) Execution aspects like choice of proper material embankment and blanketing, ensuring proper leveling and compaction in different stages, ensuring proper laying of sleepers with respect to their sequences and spacing, correct laying of turnouts, proper welding etc. It also covers, ensuring necessary work site safety precautions.

1802. Sequences of Laying of Track:

The work of track laying shall be done in following sequence

(1) Project development process including finalization of terms of reference.

(2) Detailed engineering work including detailed drawings and estimate.

(3) Formation and related works.

(4) Ballast spreading and linking of track.

(5) Post linking works to achieve installation tolerance.

1803. Project Development Process Including Finalization of Terms of Reference :

Laying of new track shall be done in accordance with Terms of reference (TOR) as stipulated and approved by competent authority. The important parameters to be part of TOR shall normally include

(1) Category of line- group A, B, C, D, DSpl, E.

(2) Gauge- Broad Gauge/Meter Gauge/Narrow gauge

(3) Traction- Electrical/Diesel

(4) Maximum degree of curvatures

(5) Speed potential of the section

(6) Obligatory points - to include existing station or towns

(7) Width of formation and side slope

(8) Ruling gradient in section and yards

(9) Length of loop lines

(10) Track Centres

(11) Level Crossings

(12) Track structures with specific mention of new/second hand material including type of rails, sleepers, ballast cushion, welding and points and crossings.

(13) Loading standard of bridges

(14) Drainage should be given prime importance with planning of longitudinal drains and its connection to final outfall.

(15) There should be minimum number of level crossing and no road should be diverted into the existing bridges which are meant to cater to Railways requirement of drainage system.

(16) The boundary walls should be provided in the inhabited areas where there are chances of encroachments.

(17) Proper sidings shall be required for stabling track machines for meeting the requirement of relaying and track maintenance.

(18) Alteration/ Modification/ shifting of infringing OHE/signaling installations in station yard should be planned.

(19) To study the requirement of rooms/ service buildings for supervisor & staff and for keeping the stores/ M&P items.

1804. Detailed Engineering Work :

The project shall be thoroughly surveyed in terms of stipulations of engineering code as detailed in provisions related to final location survey. The detailed engineering work shall include:

(1) Topographic/ foot by foot survey of the proposed Railway Corridor, verification of existing yard plans, establishment of horizontal and vertical controls as well as fixing control pillars all along the alignment.

(2) Identification and verification of Railway boundary, updating of land boundary plans.

(3) Detailed study of existing bridges, road culverts and road crossings that are expected to be encountered during laying of new track.

(4) Finalization of design parameter of the project and develop conceptual plans indicating modification of existing layouts and various proposals to suit requirement of the project.

(5) Development of project sheets which would indicate LWR diagrams, details of curves , bridges, LCs and junction arrangements.

(6) Develop engineering scale plans of yards on 1:500 scale to suit requirement of new proposals, modifications to yard layouts.

(7) Computation of additional land width required and preparation of plans for land acquisition. Identification of encroachments coming on alignment and preparation of encroachment plans.

(8) Prepare longitudinal section, cross sections on standard scale and firming most suitable alignment by total station. The geometrical design will be done preferably using Rail design software.

(9) Conduct geotechnical investigation for major bridges and other locations which may include minor bridges, FOBs / ROBs / Flyover and other structures, earth work in banks as per RDSO guide lines.

(10) Based on approved yard plans, prepare General Arrangement drawings of extension / rebuilding of minor bridges, major bridges, FOBs, platforms, ROBs (to be rebuilt / raised).

(11) Based on approved GAD's of minor bridges, major bridges and FOBs,ROBs, preparation of detailed design and working drawings including phase work where necessary.

(12) Prepare design and drawings of service buildings and any other buildings or structures, drainage/ water supply arrangements either affected or

additionally required and prepare plans for diversion of utilities.

(13) Survey of existing infringements, firming most suitable alignment by total station and modification of structures, (if any) to remove the existing infringement.

(14) Prepare detailed Civil Engineering estimate based on approved plans and detailed design.

(15) Prepare Bill of quality (BOQ) for different bid packages supported with quantity take-off sheets, rate analysis based on latest market survey and budgetary quotations/vouchers and technical specifications.

(16) Survey to be done by total station and alignment to be fixed by Rail design software only.

(17) While making the final location survey, Geotechnical investigations and detailed Engineering study for proposed new line, the future planning of any new additional line may also be kept in mind (if any).

1805. Formation and Related Works :

Formation is one of the most important component of track laying work and this work shall be done in accordance with RDSO guidelines. To achieve the objective of constructing a railway formation which would give trouble free service, the design and construction procedures should be such that it should be able to sustain the track geometry under anticipated traffic densities and axle loads during service under most adverse conditions of weather and maintenance of track structure, which are likely to be encountered. This necessitates that:

(1) Sub-grade in bank or cutting should be structurally sound so as not to fail in shear strength under its own loads and live loads.

(2) Any settlement due to compaction and consolidation in sub grade and sub-soil should be within the permissible limits.

(3) Top width of formation should be adequate to accommodate track laid with concrete sleepers with standard ballast section, and still leave a minimum 900mm cess on either side. It should be regulated in accordance with extant instructions as detailed in IRPWM

(4) Adequate drainage must be ensured for the worst service conditions. The top of formation should have cross slope of 1 in 30 from centre of track towards both sides for single line and from one end towards cess/drain side (single slope) in multiple lines.

(5) Suitable and cost-effective erosion control system considering soil matrix, topography and hydrological conditions to protect the side slopes of bank should be provided.

(6) It will be necessary to keep borrow pits sufficiently away from the toe of the embankments to prevent base failures due to lateral escapement of soil. The minimum distance to be provided between borrow pits and railway bank will be decided by the Engineer, in each case, on its merits. Existing borrows pits, close to toe of bank may be filled under the specific instructions of the Engineer.

(7) Provision of ballast wall wherever necessary.

(8) Special precaution with compaction at bridge approaches.

(9) Provision of trolley refuges and man refuges.

(10) Provision of catch water drain in cuttings.

(11) Adequate precaution against rock falling in cutting.

(12) Adequate ballasting of prescribed cushion conforming to specifications shall be ensured.

(13) Provision of ballast profile in accordance with the manual of instructions of LWR shall be followed.

1806. Good Practices for Formation Earthwork :

The work shall be executed in conformity to RDSO *'Guidelines for Earthwork in Railway Projects'-2003* (with latest amendments), which shall form a part of the contract documents.

The work of execution of earth work in embankment shall be carried out and completed by the contractor as per approved drawings and specifications.

Execution of earth work has to be carried out in systematic manner so as to construct formations of satisfactory quality which would give trouble free service. The activities and adoption of good practices involved in execution of earthwork are covered as under -

(1) Preliminary works such as preparation of ground- site clearances, setting out of construction limits and selection of borrow pits and fill material.

(2) General aspects to be kept in mind while execution.

(3) Compaction of earth work.

(4) Placement of Back-Fills on Bridge Approaches and Similar Locations.

(5) Drainage Arrangement in Bank/Cutting.

(6) Erosion control of slopes on banks & cuttings.

1807.Preliminary Works for Formation of Railway Track :

Preparation of ground surface may be carried out as follows:

(1) Site clearances: Full formation width at ground level plus additional extra width of 1 m on both sides should be cleared of all obstructions viz. vegetation, trees, bushes, building, fences, abandoned structures etc. and thereafter it should be dressed and leveled. Depressions if any, should be filled with suitable soil duly compacted. Finally, leveled surface should be properly compacted by mechanical means to get a level and uniform ground surface.

(2) When bank is constructed on ground having steep slope then the ground surface should be suitably benched so that new material of bank gets well bonded with the existing ground surface.

(3) Setting out of construction limits :

Centerline of the alignment (@ 200 m c/c or so) and full construction width should be demarcated with reference pegs and dog belling about 90 cm away from proposed toe of the bank. Care should be taken not to disturb the pegs during construction. Pegs should be preferably painted for identification.

(4) Selection of borrow area :

(a) Borrow area should be selected sufficiently away from the alignment, as far as possible but normally not less than 3 m plus height of the embankment to prevent base failure due to lateral escapement of the soil

(b) Borrow area should be selected for soil suitable to be used in construction,

(5) Selection of Fill Material :

(a) Except for unsuitable soils, any type of locally available soil can be used as a construction material. Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of the selected fill material should be tested in the laboratory as per laid down frequency.

(b) Use of material should be planned in such a way that soil with higher percentage of coarse-grained particle is placed on the upper layers of the embankment.

1808. General Aspects while Constructing Formation :

(1) A field trial for compaction on a test section shall be conducted on fill material to assess the optimum thickness of layer and optimum number of passes for the type of roller planned to be used to arrive at desired density. Procedure for field compaction trials as given in RDSO *Guidelines for Earthwork in Railway Projects'* shall be followed for guidance.

(2) If the soil has less than required moisture content, necessary amount of water shall be added to it either in borrow pits or after the soil has been spread loosely on the embankment. Addition of water may be done through flooding or irrigating the borrow areas or sprinkling the water on the embankment through a truck mounted water bowser. Use of hose pipe for water need to be avoided.

(3) If the soil is too wet, it shall be allowed to dry till the moisture content reaches to acceptable level required for the compaction.

(4) Placement moisture content of soil should be decided based on the field trial and site conditions. The objective should be to compact near OMC to achieve uniform compaction with specified density in most efficient manner.

(5) Clods or hard lumps of soil of borrow area shall be broken to 75 mm or lesser size before placing on embankment.

(6) Each layer should be compacted with recommended type of roller upto required level of compaction, commencing from the sides. Minimum overlap of rolled surface should be kept as 200 mm, before putting next upper layer.

1809. Compaction of Earth Work :

Performance of the embankment would depend to large extent on the quality of compaction done during execution. To ensure proper compaction, precautions/guidelines given in *Para 6.3 of 'RDSO Guidelines for Earthwork in Railway Projects - 2003'* should invariably be followed.

1810. Placement of back-fills on Bridge Approaches and similar locations :

The back fills resting on natural ground may settle in spite of heavy compaction and may cause differential settlements, vis-a-vis, abutments, which rest on comparatively much stiffer base. To avoid such differential settlements, while on one hand it is essential to compact the back fill in the properly laid layers of soil, on the other hand, the back fill should be designed carefully to keep;

(1) Settlements within tolerable limits.

(2) Coefficient of sub grade reaction should have gradual change from approach to the bridge,

Back-fills on bridge approaches shall be placed in accordance to para 605 of Indian Railways Bridge Manual 1998.

Fill material being granular and sandy type soil, therefore need to be placed in l50 mm or lesser thick layers and compacted with vibratory plate compactors.

While placing backfill material, benching should be made in approach embankment to provide proper bonding.

1811.Drainage Arrangement in Banks :

Drainage is the most important factor in the stability of bank/cutting in railway construction. Effective drainage of the rainwater in the monsoon season is very important to safe guard bank/cutting from failure. Railway formation is designed for fully saturated condition of soil. However, flow of water should not be allowed along the track as it not only contaminates ballast but also erodes formation. Stagnation of water for long time on formation is not desirable. Therefore, drainage system should be efficient enough to prevent stagnation and allow quick flow of water.

1812. Erosion Control of Slopes on Banks and Cuttings :

Exposed sloping surface of bank/cutting experiences surface erosion caused due to the action of exogenous wind and water resulting into loss of soil, leading to development of cuts, ruts/gullies adversely affecting the cess width, soil matrix, steepening of slopes etc which depends on type of soil, climatic conditions, topography of area, length of slope etc. Bio-Technical solution, a most commonly method may be adopted.

In this system, vegetation is provided on exposed slopes. It is suited for soil with some clay fraction. Method consists of preparing slope area by grading it for sowing seeds or planting root strips of locally available creeping grass. Its root goes upto 50 to 75mm deep into the slopes serving as a soil anchor and offering added resistance to erosion. Some typical species of grass which develop good network of roots and considered suitable are listed below:

(1) Doobgrass

(2) Chlorisgyne

(3) Iponeagomeas (Bacharum Booti)

(4) Casuariva and goat foot creepers etc

(5) Vetiver grass (vetiveriazizanioides)

1813. Execution Methodology of Earthwork in Railway Formation :

(1) Spreading of material in layers of desired thickness over the entire width of embankment should be done by mechanical means and finished by a motor grader. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the slope and grade.

(2) Thickness of layer is decided based on field compaction trials. However, as a good practice thickness of layer should be generally kept as 300 mm for fill material and 250 mm for blanket material in loose state before compaction.

(3) Fill material shall be placed and compacted in layers of specified thickness. The rate of progress should be, as far as possible, uniform so that the work is completed to final level almost at the same time.

(4) The rolling for compaction of fill material should commence from edges towards center with minimum overlap of 200 mm between each run of the roller. In final pass, roller should simply move over the surface without vibration so that top surface is properly finished.

(5) Extra bank width of 500 mm on either side shall be rolled to ensure proper compaction at the edges. The extra soil should be cut and dressed to avoid any loose earth at the slopes. This should preferably be done with help of grade cutter.

(6) At the end of the working day, fill material should not be left uncompacted. Care should be taken during rolling to provide suitable slope on top of the bank to facilitate quick dispersal of water and avoid ponding on formation.

(7) During construction of formation, there may be rainfall to the extent that rain cuts may develop on the surface of formation due to erosion of soil. Care should be taken that these rain cuts are not allowed to develop wide and deep otherwise these locations will remain weak spots. The contractor must ensure at its own cost, to attend/ repair such rain cuts, as a regular measure to the satisfaction of the Engineer.

(8) Top of the formation should be finished to a cross slope of 1 in 30 from one end to other towards cess/drain in multiple lines and from center of formation to both sides in single line.

(9) Once the top surface of the formation has been finished to proper slope and level, movement of either empty or loaded Road vehicle for transportation of ballast, sleepers etc. should be avoided, as these movements will cause development of unevenness, ruts on the surface

which will accumulate water and weaken the formation. The methodology of transportation of P.Way materials needs to be planned properly avoiding movement on finished formation.

(10) In gauge conversion/doubling projects, suitable benching of existing slope shall be done before new earthwork is taken up to provide proper bonding with material left on the benched slope. Care needs to be taken to avoid entry of rainwater into the formation from this weak junction, otherwise this would result in development of weak formation, slope failure, maintenance problem due to uneven settlement etc.

(11) At locations where the water table is high and the fill soil is fine-grained, it may be desirable to provide a granular layer of about 30 cm thickness at the base, above subsoil across the full width of formation. The contractor shall take this factor into account while designing the formation.

(12) At places where embankment materials are not conducive to plant growth, top soil obtained from site clearance as well as top layer of borrow pit which is rich in organic content and suitable for plant growth, may be stored for covering slopes of embankment & cutting after construction, or other disturbed areas, where re- vegetation is required, as far as practicable.

1814. Linking of Track :

(1) Track laying with new material

(2) Track laying with second hand material

1815. Track Laying with new Material :

Track structure with new material shall conform to relevant provisions *contained in chapter 16.* The material to be used for linking shall be inspected for suitability as per prescribed provisions. It is a good practice to lay the initial track with second hand Rails and then renew with First Class Panels so as to avoid defects generated during welding of rails at site.

1816. Track Laying with Second Hand Material :

(1) The rail should be within the permissible limit of wear in accordance with provisions *contained in Chapter 16.*

(2) The rail should be tested ultrasonically before use.

(3) The second hand rails used should normally be end cropped. All AT welds should be ultrasonically tested and defective welded joint should be removed.

(4) SH metal sleepers and fastening should not be used in main line.

1817. Scheme of New Track Laying :

A detailed scheme of track laying shall be prepared in advance to facilitate achieving correct geometry of finished track. The track laying shall be preceded by:

(1) Approval of scheme of track laying including approval of project sheets, LWR diagrams, Yard plans.

(2) Approval for laying of turn out and speed potentials

(3) Setting up of track depot which would be required to store materials and equipments.

1818. Specific Approval of PCE/CTE shall be Obtained for :

(1) Deviation of track standards as stipulated in TOR

(2) Laying of any turn out in curves or laying of any diamond crossing (Single Slip / Double Slip)

(3) Introduction of reverse curves due to presence of bridge cuts, embankments.

1819. Sequence of Track Laying Activities :

The sequence of Permanent Way works to be executed can broadly be grouped as under:

(1) Setting out the line and level of track for the proposed line and establishing working, bench marks and alignment references, taking the details from bench marks and alignment references established by the Employer / by the same or other Contractor earlier in main lines, and in station yards including for loops, turnouts, cross over roads, derailing switches, sand humps etc.

(2) Supply of ballast along the track in mid section and in yards and running out about 30% of ballast to the top of formation and compaction of ballast with mechanical means.

(3) Supply of rails, sleepers and fastenings required for the work and for installation of track in main lines and yards.

(4) Supply of 1 in 12 & 1 in 8 ½ Turnouts with CMS crossings including lead rails, derailing switches, Switch Expansion Joints, Glued joints etc.

(5) All transportation, handling, stacking materials, watching, protection of the above listed material from the manufacturer's works to the sites of use, including rails.

(6) Assembling and laying of new track, turnouts, switch expansion joints, glued joints, derailing switches etc., on newly made up formation with/without traffic blocks.

(7) Dismantling / Replacing existing turnouts where necessary with plain track on running lines at stations under block.

(8) Insertion of new turnouts on main line and running lines where necessary under block.

(9) Slewing and lifting / lowering of track as required with / without blocks.

(10) Packing of PSC sleepers including lifting and lining of track, turnouts, etc., as required.

(11) Welding of rail joints by Flash Butt/ SKV process for Conversion of free rails to SWR/LWR.

(12) De-stressing of LWRs gap adjustments for SWRs and Free Rails.

(13) Fabrication of check rails for Level Crossings, shifting of gate leaves, W& W/L boards etc.

(14) Installation of P.Way components for all level crossings including shifting of existing gate posts, fencing etc for the new line.

(15) nstallation of P.Way components for shifting of level crossing in yards for both the lines including provision of gate posts, fencing etc.,

(16) Laying of guard rail on bridges including at bridge approaches.

(17) Erection of all type of Boards / Indicators.

1820.Method of Laying :

(1) Marking of Center Line :

In case of construction of new line, after the correct formation profile is achieved and consolidation made, temporary center line pegs should be provided at every 30m intervals on straights and 10m intervals on curves. However, concreting of center line pegs at following locations should be done

(a) The beginning and end of transitions

(b) Every 50 m on curves

(c) Approach of bridges and level crossing and

(d) Every half km on straights

Besides the above, concreted level pegs for future reference should be provided at the beginning, end and at every 10m interval for vertical curves and 30 m on either side of bridge approach. ADEN/XEN incharge of work should carry out test check as prescribed of the centre line and level pegs at the time of initial layouts.

(2) Spreading of Ballast on prepared formation :

(a) About 30 % of total requirement of ballast shall be taken as cess ballast for spreading directly on the prepared formation using methods that avoid road traffic over the support structure and also avoiding damage to the cable ducts/trenches already provided for signalling and electrical cables on the sides of embankment. The formation would have been properly dressed and well compacted to true profile and levels before running ballast on to the formation. The ballast shall then be laid in layers of loose ballast layers of maximum of 100 mm each, each layer being compacted by a minimum of 4 passes of a smooth vibrating roller, with a minimum static load of 4 kN per 100 mm of width or similar as approved by Engineer.

(b) The ballast shall be laid to a maximum level of 200 mm (+0, - 20 mm) above the formation.

(c) On completion of the initial spreading of ballast, a survey shall be undertaken to demonstrate the acceptability of the ballast bed for track laying. The survey shall include graphical plotting of cross-sections and computing quantities of ballast.

(d) The ballast bed survey shall be undertaken on a longitudinal grid of 30 meters along the line of the ends of the sleepers and at the extremities of the specified profile.

(e) On completion and acceptance of the ballast bed for track laying, no vehicle of any type shall be permitted to run over the accepted ballast bed.

(f) The use of vehicles on the completed ballast bed will result in the rejection in that particular length where the vehicle has been used. In such a length, all contaminated ballast should be removed and replaced with new ballast. Re-grading and rolling of such line should be done to the satisfaction of the Engineer. No further track laying operation shall be done until the ballast bed has been re-inspected and approved by the Engineer.

(3) Track laying over the ballast :

The track laying over the laid and compacted ballast shall be done using following stipulations

(a) Flash butt welding shall not be undertaken until the track has sufficient ballast to hold it to alignment both before and after welding.

(b) All Sleepers required for a linking of a portion of track should be stacked in layers near to the edge of formation along with the Rails being laid as a boundary of the ballast profile. This shall enable the ballast to be confined in an area and spread evenly without any loss/rolling along the formation. Thereafter sleepers may be brought on top of 6-8” of Ballast from where the Rails can be linked and then track can be lifted as a whole to form the new track.

(c) In this way laying of sleepers can be ensured on a compacted ballast bed at the specified spacing. The sleepers shall be correctly aligned and squared.

(d) Alternatively, pre-assembled panels may be laid directly onto the prepared bottom ballast for installation of track by utilisation of PQRS or by any other mechanized method, which should have prior approval of the Engineer.

(e) Sleeper shoulder then shall be adequately ballasted and compacted to obtain enough lateral resistance of track.

(f) The spreading of rails over the sleepers should be done for one rail only, termed as base rail, ensuring correct expansion gaps at joints wherever required and duly aligned according to centre line. However, in case of curve, outer rail should be taken as the base rail. The rails should be fastened with the sleeper and the joints should be fish plated as per specified track structure.

(g) Correct spacing should be marked on the base rail and sleepers adjusted accordingly.

(h) The other side rail should then be placed and linked with correct expansion gap. The squaring of sleepers along with gauging, thereafter, should be taken into hand.

(i) Welding of rail joints should be done at desired location

(j) The ballast section and cess should be neatly dressed up.

(k) It must be ensured that the gauge face is greased properly.

(l) After a suitable length of track has been laid, but before any movement of rail mounted Construction Plant or equipment on that track, the laid sleepers shall be leveled and tamped by mechanical means using off-track tampers to ensure the final lines and levels of the resulting track are within acceptable tolerances.

(4) Top Ballasting, Tamping & Lining :

(a) Prior to the placing of top ballast the track shall be marked in preparation for tamping and lining operations with the following information:

(i) All horizontal and vertical tangent points

(ii) Transition curve details

(iii) Circular curve details

(iv) Cant details

(v) Vertical curve details

(vi) Chainages

(b) The tamping parameters such as the rate of tamping, number of passes, number of insertions per sleeper, depth of insertion, length of tamping and optimum frequency of vibration for the tamping, squeezing pressure and tamping cycle shall be decided.

(c) Once the top ballast is adequately regulated the track shall be lifted, levelled and aligned as required, using mechanized means. The top ballasting, regulating, tamping and lining shall be repeated in stages of a lift of upto 50 mm at a time, until the track is at the designed horizontal and vertical alignment.

1821.Mechanised Laying :

Mechanised laying is done with the help of TRT /PQRS or T28 for which P.Way official must make themselves conversant with various operations and working of the machines to be used.

Normally track laying with machine requires base depot which should be planned with great care having adequate provisions for stacking of sleepers, stabling lines for machines and other coaches etc. Before laying center line and the level pegs , ballast spreading and compaction shall be done as in case of manual laying elaborated in terms of *para 1820 (2) (a) & (b).* The track should be laid with the help of machines and packed ensuring the tolerance prescribed in various sub paras of *para 1824 (4).*

1822. Post linking Work for Relaxation of Speed :

The standard of initial laying and the immediate post-laying maintenance determines to a large extent the quality of track for several years. Therefore after linking, ballasting and bringing the track to final line and level, the following precautions are necessary even for running of material trains, or opening of traffic at restricted speed, till the speed is relaxed to normal.

(1) Alignment on curves and transitions to be checked and minor adjustment made as needed.

(2) Alignment kinks or gauge kinks should be rectified to avoid permanent set.

(3) Attend track during working of departmental materials trains to avoid permanent set, though it may not be considered necessary otherwise.

(4) Special attention to expansion gaps after full ballasting to ensure gaps within acceptance range as specified.

(5) Excessive expansion gaps if allowed will cause significant battering of rail ends even during movement of departmental material trains.

(6) As the new rails put in track would have rusted due to storage, lubrication of gauge faces is desirable before opening for traffic to avoid excessive frictional forces.

(7) The Track Machines deployment and USFD testing shall be done by Open Line.

1823.Track Laying Register :

It shall be ensured that all track laying conforms to the prescribed standards. A track laying register shall be maintained at site. In this register, concurrent recording of relevant data including the approved longitudinal section, programme of work, requirement and availability of materials, position and performance of tools, equipment, track machines, daily labour position and output, position and the condition of the finished track both structural as well as geometrical shall be maintained.

After the completion of track laying, sleeper by sleeper inspection shall be done and following details recorded ;

(1) All structural differences with respect to the prescribed standards.

(2) Track geometry achieved as compared to the standards recommended for track laying. The deficiencies should be made up and the final condition again recorded in the register.

1824. Deployment of Track Machines :

Heavy duty on Track Machines are required to be deployed on Construction projects for plain track as well as turn out tamping. There is normally a requirement of minimum 2 rounds of tamping with Track Machines before section is offered for inspection by CRS.

In order to get the improved quality of tamping and also productivity, following procedure is proposed to be implemented:

(1) The requirement of machine should be projected by Construction organisation to Open Line at the beginning of the year to incorporate the same in the annual deployment programme.

(2) A quarterly review of requirement and annual deployment shall be undertaken at the level of Dy.CE/TMC and one of the Dy.CE of Construction orgnisation to be nominated by CAO/C.

(3) CSM/DUO and UNI machines are basically maintenance tampers and required to be utilized for tamping of a reasonably GOOD track. The new track should be attended manually to made it fit for 30km/h speed prior to deployment of tampers.

(4) The track structure and geometry standards to be ensured before deployment of track machine to Construction projects are :-

(a) Track laying standards in respect of gauge, joints, expansion gaps and spacing of sleepers for the new track as specified in chapter 17 should be followed.

(b) The pre-tamping and post tamping operations should be followed *as detailed in para 404.*

(c) A minimum cushion of 150 mm of clean ballast along with adequate ballast on shoulders and cribs should be ensured before deploying the tamping machines.

(d) The track geometry prior to deployment of track machines for new works of new line, doubling, gauge conversion etc. should be as under:

Peak value of Unevenness	15 mm on 3.6 m chord
Peak value of Twist	15 mm on 3.6 m chord
Peak value of Alignment	15 mm on 7.2 m chord

The above track geometry standards are not safety/slow down tolerances but are only a prerequisite for deployment of tamping machines for better machine productivity and their optimum utilization.

(e) For achieving the track geometry parameters as above, suitable small track machines such as off-track tampers etc. may be used

(f) Dy.CE(C)/XEN (C) should certify the track geometry as mentioned above before deploying the track machines.

(g) Deployment of Dynamic Track Stabiliser along with tamping machines is desirable.

(h) Before deployment of Track Machine on the track linked, the same should be certified at officer level of both Track Machine and Executing Agency that the track is fit for deployment of Track Machines.

(5) The actual requirement of the tamping machine based on the deployment programme shall be intimated by concerned CE/C to CE/TMC atleast 15 days prior to actual commencement of work.

(6) Entire length to be attended by machine must be pre-surveyed and desired profiling plotted. Lifts and slews required to be given by machine should be transferred appropriately at site. A copy of the survey date should be sent in advance to concerned XEN/AEN-(TMC) of respective division.

(7) Adequate arrangements of consumables such as HSD oil etc. and transportation of other spare parts of machine by road should be arranged by Construction organization. If the machine is working in remote area without any train connectivity suitable transportation arrangements for staff may also be done.

(8) Track parameters before and after tamping must be recorded in a register which should be test checked by XEN/AEN (C) and XEN/AEN/(TMC).

■ ■ ■

- *Careful execution of new track works, right from formation till the finished line and level of P.WAY would make it lovable lifeline yet again.*

Abbreviations

AC	Alternating Current
ACS	Advance Correction Slip
ADEN	Assistant Divisional Engineer
ALI	Alignment Index
AM	Latin: Ante Meridiem (English : before noon)
ANC	Actual Nose of Crossing
ART	Accident Relief Train
AT	Alumino Thermic (weld)
ATS	Actual Throw of Switch
BCM	Ballast Cleaning Machine
BG	Broad Gauge (1676 mm)
BOBYN	Ballast Wagon with side discharge facility
BPC	Brake Power Certificate
BRM	Ballast Regulating Machine
BTC	Ballast Train Controller/Ballast Train Checker
BTR	Bridge Timber Renewal
C&M	Civil and Mechanical
C&W	Carriage and Wagon
CAO(C)	Chief Administrative Officer (Construction)
CMS	Cast Manganese Steel
CRS	Commissioner of Railway Safety
CSM	Continuous Squeezing Machine (A type of tamping machine)
CST-9	Cast Steel T-9 sleeper
CTE	Chief Track Engineer
DC	Direct Current
DEN	Divisional Engineer
DFWO	A classification of weld in USFD testing signifying 'Defective weld to be kept under observation'
DFWR	A classification of weld in USFD testing signifying 'Defective weld to be removed'

DGS&D	Directorate General of Supply and Disposal (A central purchase and quality assurance organisation of Government of India)
DMT	Departmental Material Train
DMTR	Daily Material Transaction Record
DN	Down
DOM	Divisional Operations Manager
DPT	Dye Penetration Test
DRP	Data Recording Processor
DTS	Dynamic Track Stabilization/Stabilizer
DUO	Duomatic tamping Machine
Dy. CE	Deputy Chief Engineer
ENGG	Engineering
ERC	Elastic Rail Clip
ESP	Engineering Scale Plan
ETA	Engineering Time Allowance
EUR	End Unloading Rake
FA&CAO	Financial Advisor and Chief Administrative Officer
FB	Flash Butt (weld)
FOB	Foot Over Bridge
FWP	Final Works Program
G&SR	General and Subsidiary Rules
GCC	Gauge Corner Cracks
GDMS	Grind Data Management System
GE	Geotechnical Engineering
GFN	Glass Filled Nylon (Liner)
GI	Gauge Index
GI	Galvanized Iron
GJ	Glued Insulated Rail Joint
GMT	Gross Million Time
GPS	Global Positioning System
GQI	Grind Quality Index
GR pads	Grooved Rubber Pads

HAZ	Heat Affected Zone
HMI	Human Machine Interface
HQ	Head Quarter
HS	Hand Signal
HSD	High Speed Diesel (oil)
IBJ	Insulated Block Joint
ICF	Integral Coach Factory
IMR	A classification of rail defect signifying 'Immediate Removal'
IMRW	A classification of weld defect signifying 'Immediate Removal of Weld'
IR	Indian Railways
IRICEN	Indian Railways Institute of Civil Engineering
IRPSM	Indian Railway Project Sanction and Management
IRPWM	Indian Railway Permanent Way Manual
IRS	Indian Railway Standard
IRSEM	Indian Railways Signal Engineering Manual
IRTMTC	Indian Railway Track machine Training Centre at Allahabad.
J2EE	Java 2 Platform Enterprise Edition
JE	Junior Engineer
JOH	Junction of Heads
KLD	Laser profile detection system
KM	Kilometre
KV	Kilo Volts
LC	Level Crossing
LCD	Liquid Crystal Display
LED	Light Emitting Diodes
LH	Left Hand
LPG	Liquid Petroleum Gas
LV	Last Vehicle
LWR	Long Welded Rails
M.S.	Mild Steel
MBOX	Modified Box Wagons
MEMS	Micro-electro Mechanical System

MG	Meter Gauge (1000 mm)
MHz	Mega Hertz
ML J	Modified Loose Jaw
MM	Medium Manganese
MMU	Mobile Maintenance Units
MDD	Maximum Dry Density
MPT	Multipurpose Tamper
MT	Metric Tonne
NG	Narrow Gauge (762 mm)
NGF	Non Gauge Face
OBS	A classification of rail defect signifying 'keep under observation'.
OBSW	A classification of Weld defect signifying 'Keep weld under observation'.
OHE	Overhead Electrical Equipment
OMC	Optimum Moisture Content
OMS	Oscillograph Measuring Systems
OMU	On Track Machines Unit
P.Way	Permanent Way
PCE	Principal Chief Engineer
PLC	Paper Line Clear
PM	Latin : Post Meridiem (English: after noon)
PME	Periodic Medical Examination
PQRS	Plasser Quick Relaying System
PSC/PRC	Prestressed Concrete Sleeper
PTW	Permit to Work
RBMV	Rail Borne Maintenance Vehicle
RCC	Reinforced Cement Concrete
RCF	Rolling Contact Fatigue
RDPS	Route Data File Preparation System
RDSO	Research Design and Standards Organisation
RGM	Rail Grinding Machine
RH	Right Hand

ROB	Road Over Bridges
S&T	Signalling and Telecom
SBCM	Shoulder ballast cleaning machine
SD	Standard Deviation
SDU	Soil disposal unit of BCM
SE	Super Elevation
SEA	Switch Entry Angle
SEJ	Switch Expansion Joint
SIP	Signal Interlocking Plan
SKV	Short Preheating AT Welding
SM	Station Master
SOD	Schedule of Dimension
Sr DSO	Senior Divisional Safety Officer
Sr DEN	Senior Divisional Engineer
Sr DOM	Senior Divisional Operations Manager
SRJ	Stock Rail Joint
SSD	Spring Setting Device
SSE	Senior Section Engineer
ST Sleeper	Steel Trough Sleeper
SWG	Standard Wire Gauge
SWR	Short Welded Rail
T/G	Termination of speed restriction for Goods Train
T/P	Termination of speed restriction for passenger trains
T-28	Turnout Laying Machine
TEX	Tamping Express
TFR	Through Fitting Renewal
TGI	Track Geometry Index
TMS	Track Management System
TOR	Terms of Reference
TPP	Thermit Portion Plant
TRC	Track Recording Car
TRD	Traction Distribution

TRR	Through Rail Renewal
TRT	Track Relaying Train
TSC	Track Standards Committee
TSR	Through Sleeper Renewal
TTM	Tie Tamping Machine
TTS	Theoretical Toe of Switch
TWI	Twist Index
TWR	Through Weld Renewal
UIC	International Union of Railways
UNI	Unevenness Index
UNIMAT	Universal Machine for Tamping
USFD	Ultrasonic Flaw Detection
UTS	Ultimate Tensile Strength
UTV	Utility Vehicle
W Board	Whistle Board
W/L	Whistle Board for Level Crossing
WAP	Broad Gauge AC traction Passenger Loco
WDP	Broad Gauge Diesel Passenger Loco
XEN	Executive Engineer
ZTC	Zonal Training Centre

Keywords

Notes

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ज्ञान ज्योति से मार्गदर्शन

To Beam As A Beacon of Knowledge

Annual Maintenance Programme

	Post Monsoon Attention					
	Month	Month	Month	Month	Month	Month
Day	1	2	3	4	5	6
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Annual Maintenance Programme

Pre-Monsoon Attention		Attention during Monsoon				
Month	Month	Month	Month	Month	Month	
1	2	1	2	3	4	Day
						1
						2
						3
						4
						5
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ज्ञान ज्योति से मार्गदर्शन

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