

NOTES ON

PERMANENT WAY



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COURSE MODULE-INDUCTION COURSE – INITIAL SSE/JE

Course No. CE 26

Module No. 26.5

SUB: P.WAY, ESTABLISHMENT, ACCOUNTS, STORES & RAJBHASHA

Duration: 74 Sessions = 148 Periods

Sub-discipline	Lesson	Contents	Period	Total Period
Track Technology	Introduction to Railway Organization	History of Railways, Zonal Railways Divisions and Production units.	2	4
		TT Organization on Indian railways, Organization at headquarters Divisional levels, CPOH and Bridge Workshop.	2	
	Railway Track	Constituents of Railway Track. Requirements of Good Railway Track, Classification of Routes. Different Gauges.	2	2
	Formation	Formations in Embankment and Cutting. Sub-Grade materials and Track Drainage	2	2
	Rails	Functions, Types & Standard Rail Section. Standard length, Rolling marks & UTS.	2	2
	Sleepers	Functions, Types & Sleeper Density, Requirements of PRC sleepers-their advantages and disadvantages.	2	2
	Fastenings	Rail to Rail fastenings and Rail to Sleeper fastenings.	2	2
	Ballast	Functions & Specifications and Ballast profile	2	2
	Points & Crossings	Functions & Important terminology ,Constituents of Turnout	2	12
		Types of switches and crossing and Switch Angle Flange way clearance Heel divergence and Throw of switch	4	
		Types of Crossings, Crossing number & Main constituents of Built-up Crossing ,Standard Turnouts & permissible speed ,Position of Sleepers at Points & Xing	4 13	
		Yard Visit	2	
	Welding of Rails and LWR	Welding Terminology , Evil effects of Rail joints	2	10
		Different types of welding		
		Development of Welded rails and Theory of Welded rails	2	
		Thermal forces in LWR and Permitted locations of LWR/CWR	2	
		Different Temperature Zones and De-stressing	2	
		Yard visit	2	
	Track Renewal	Classification of Track Renewals Factors governing rail renewal	2 (20)	2

	Maintenance of Track	General Instructions as contained in IRPWM, Provisions on Regular Track Maintenance as contained in IRPWM	2	6
		Provisions on Works incidental to Regular Track Maintenance with thrust on Deep Screening Provisions on Maintenance of Track in Track Circuited areas as contained in IRPWM	2	
		Provisions on Maintenance of Track in Electrified Areas as contained in IRPWM Precautions during Machine working	2	
	Engineering Restrictions & Indicators	Categories of Engineering Works Engineering Fixed Signals/Indicators: Temporary and Permanent	2	4
		Emergency Protection of track: Single Line & Double Line, Detonators & Flare Signals.	2	
	Curves	Necessity of curves , Types of curves	2	10
		TTP, CTP & Transition lengths, Radius, Degree, Versine & field measurement	2	
		Super-elevation: Cant deficiency, Cant excess Cant gradient, Equilibrium cant and Negative Super-elevation	3	
		Gauge widening and Safe Speed on Curves	2	
		Field visit	1 (30)	
	Track Tolerances	Different Track Parameters and Service tolerances	2	8
		Different Schedules and Standard Dimensions	2	
		Loading Gauge and Over Dimensioned Consignment (ODC)	2	
		Classification of ODCs and Introduction to various track machines	2	
		Total	68	68

Sub-discipline	Lesson	Session wise Contents	Periods	Total periods
Establishment	Leave Rules	Various types of Leaves, Eligibility etc.	2	2
	Pass Rules	Various types of passes, Eligibility etc.	2	2
	P.L. Bonus & GIS	Terms of Payments PLB, GIS Monthly subscription, Payment at retirement.	2	2
	Allowances & Overtime	Various Types of Allowances & Eligibility	2	2
	P.F.	Meaning, Rate Withdrawal.	2	2
	Pension Rules	Pension Rules	2	2
	DCRG	Amount of DCRG, Emoluments.	2	2
	D&A Rules	Minor Penalties.	2	2
		Major Penalties.	2	2
	Service Conduct Rules	Explanation and understanding of different Conduct rules.	2	4
		Manpower Planning & Training Welfare Measures in Railways, PNM, JCM & PREM.	2	
	Objectives and understanding of Various Acts	Minimum Wages Act, Factory Act, Industrial Dispute Act,.	1	2
		Contractor Labour Act & Workmen Compensation Act	1	
	HOER	Classification and Duty roster	2	2
	Awards	Different Awards.	2	2
Accounts	Estimates	Definition & Necessity of Estimates.	2	2
		Kinds of Estimates & their Vetting.	2	2
	Tenders	Different types of tenders.	2	2
		Power for Invitation of tenders & NIT.	2	2
	Railway Budget	Parliamentary Control over Railway Finance	1	2
		Public Accountability, Canons of financial Propriety.	1	
		Railway Budget, Budgetary Terms, Budgetary Cycle	1	2
		Demand of Grants, Expenditure classification , Works Programme	1	
Store	Introduction to Engg. Stores & Inventory Control	Stock heads of Accounts, Disposal of released and surplus materials.	2	2
		Indenting procedure, Issue note and Write-off statement.	2	2
		Stock verification and Inventory Control Technique.	2	2
Medical Awareness Programme	Medical Awareness Programme	Family Welfare, AIDS, Family Management & First Aid.	2	2
		Stress Management & Disaster Management.	2	2
Rajbhasha	Rajbhasha	Constitutional Provisions, Official Language Act 1963, Official Language Rules 1976.	2	2
		Policy Guidelines & Instructions.	2	2
		Total	54	54

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Introduction to Railway Organization

History of Railways and General Features

History of Railways:

The history of railways is closely linked with the growth of civilization of mankind. In 15th century stone slabs or wooden baulks were laid flush with the road surface for carriage of heavy goods loaded on carts and drawn by animal. These were called “Tram ways”. These Tram ways were extensively used in 16th century in mines in central Europe for carriage of coal and other minerals.

The timber bulks were replaced by iron plates to reduce wear and these were called “Plate ways”. These iron plates were also substituted in course of time by angle irons to give lateral support or better safety. The present railway track is a gradual evolution from these “Plate ways.”

The first public railway in the world was opened to traffic on 27th September, 1825, when the first train made its maiden journey between Stockton and Darlington in U.K.

The maiden trip on Indian Soil of the first train consisting of one steam engine and 4 coaches was made on 16th April 1853, when it traversed a 21 mile stretch between Bombay and Thana in 1.25 hours time. Starting from this humble beginning, the Indian railways system has grown up today into a giant network consisting of about 63000 route Kms.

The Indian Railways run about 11,000 trains every day, serving about 7300 railway stations and carry about 5112 million passengers and about 581 million tonnes of goods traffic in a year. For moving this traffic, the Indian Railways deploy about 15, 40,000 (15.4 lakh) employees and maintain 7566 locomotives.

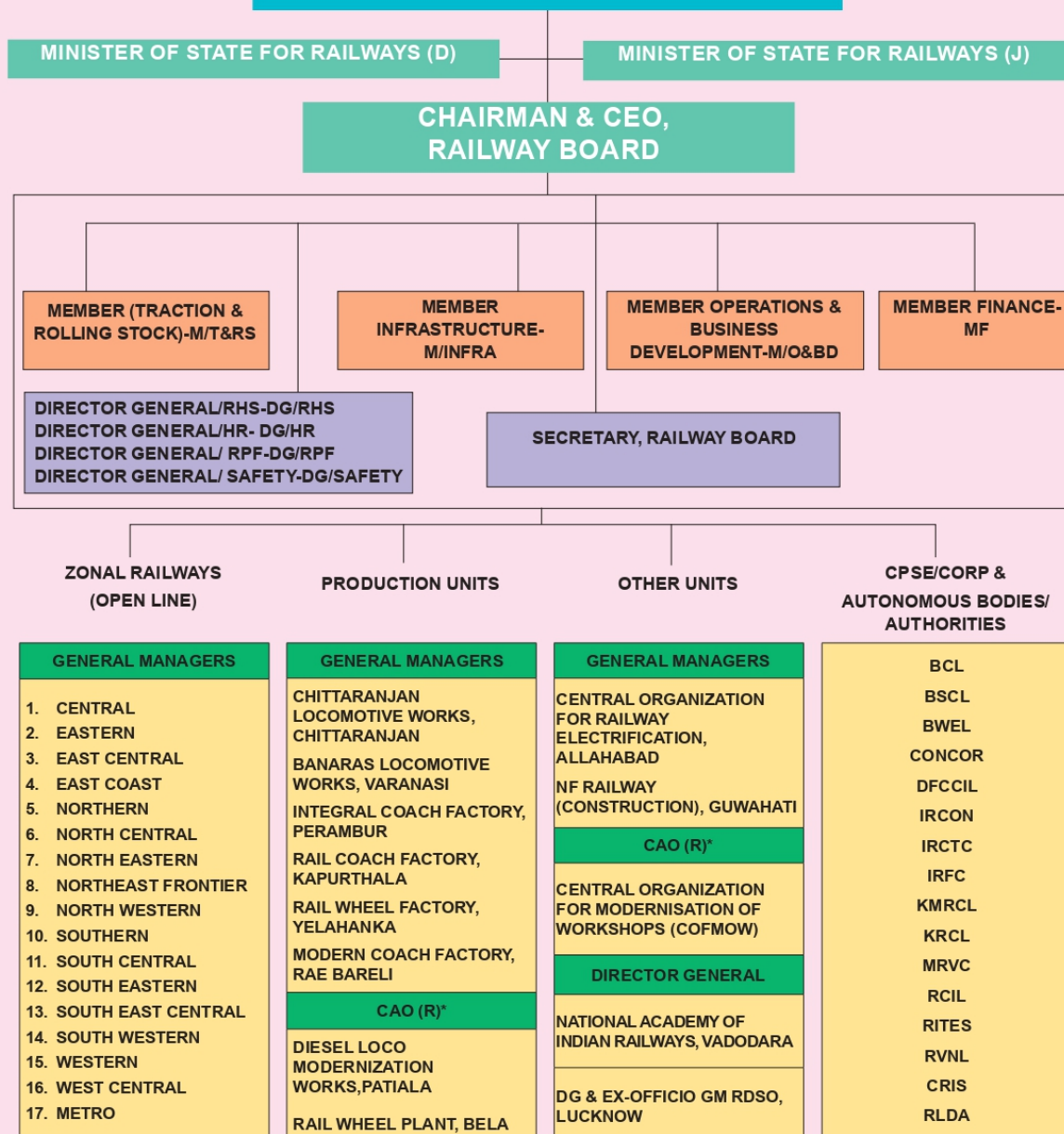
Railway Board:

The responsibility of the administration and management of the Indian Railways rests with the Railway Board under the overall supervision of the minister for railways. The Railway Board consists of Chairman and four functional members.

The organization chart is as below:

ORGANIZATION STRUCTURE OF INDIAN RAILWAYS

MINISTER OF RAILWAYS



*CHIEF ADMINISTRATIVE OFFICER (RAILWAYS)

INDIAN RAILWAYS ANNUAL REPORT AND ACCOUNTS 2020-21

Zonal Railways details & Divisions:

The entire railway system has been divided into 17 zones. Zonal Railways work on divisional system. Each division has around 800 to 1500 kms of track. There are 68 divisions on Indian railways. Each division works under the overall Control of Divisional Railway Manager (DRM) who is assisted by ADRM. In Engineering the division is headed by Sr. Divisional Engineer(C) and he is assisted by Sr.DEN/DENs. Each Sr. DEN/DEN is incharge of around 1100 ITKM & has 2-3 ADENS to assist him in maintenance of P. Way & Works. The details of zones and zone-wise break up of divisions over Indian Railways are listed as below:

Sl. No	Name	Abbreviation	Date Established	Headquarters	Divisions
1.	Central	CR	5 November 1951	Mumbai	Mumbai, Bhusawal, Pune, Solapur, Nagpur
2.	East Central	ECR	1 October 2002	Hajipur	Danapur, Dhanbad, Mughalsarai, Samastipur, Sonpur
3.	East Coast	ECoR	1 April 2003	Bhubaneswar	Khurda Road, Sambalpur and Waltair (Visakhapatnam)
4.	Eastern	ER	April 1952	Kolkata (Fairlie Place)	Howrah, Sealdah, Asansol, Malda
5.	North Central	NCR	1 April 2003	Allahabad	Allahabad, Agra, Jhansi
6.	North Eastern	NER	1952	Gorakhpur	Izzatnagar, Lucknow, Varanasi
7.	North Western	NWR	1 October 2002	Jaipur	Jaipur, Ajmer, Bikaner, Jodhpur
8.	Northeast Frontier	NFR	15 January 1958	Guwahati	Alipurduar, Katihar, Rangia, Lumding, Tinsukia

9.	Northern	NR	14 April 1952	Delhi	Delhi, Ambala, Firozpur, Lucknow, Moradabad
10.	South Central	SCR	2 October 1966	Secunderabad	Vijayawada, Hyderabad, Guntakal, Guntur, Nanded, Secunderabad
11.	South East Central	SECR	1 April 2003	Bilaspur	Bilaspur, Raipur, Nagpur
12.	South Eastern	SER	1955	Kolkata(Garden Reach)	Adra, Chakradharpur, Kharagpur, Ranchi
13.	South Western	SWR	1 April 2003	Hubli	Hubli, Bangalore, Mysore
14.	Southern	SR	14 April 1951	Chennai	Chennai, Trichy, Madurai, Salem, Palakkad, Thiruvananthapuram
15.	West Central	WCR	1 April 2003	Jabalpur	Jabalpur, Bhopal, Kota
16.	Western	WR	5 November 1951	Mumbai	Mumbai Central, Ratlam, Ahmedabad, Rajkot, Bhavnagar, Vadodara
17.	Kolkata Metro Railway	KMR	29 December 2010	Chitpur(Kolkata)	Kolkata metropolitan area, South 24 Parganas, North 24 Parganas

Production Units:

Apart from Zonal Railways there are seven production units as given below:

S. No.	Name of Unit	Headquarters	Establishment Year	Functions
1.	Chitranjan Locomotive Works (CLW)	Chitranjan	1947	Manufacture of Electric Locomotives
2.	Diesel Locomotive Works (DLW)	Varanasi	1961	Manufacture of Diesel Locomotives.
3.	Integral Coach Factory (ICF)	Parambur	1952	Manufacture of Coaches
4	Diesel Component Works (DCW)	Patiala	1981	Manufacture of Diesel components
5	Rail Coach Factory (RCF)	Kapurthala	1986	Manufacture of Coaches
6.	Wheel& Axle Plant (W&AP)	Bangalore	1984	Manufacture of Wheel & Axles
7.	Rail Coach Factory(RCF)	Rae-Bareli	2012	Manufacture of Coaches
8.	Rail Wheel Plant	Bela	2014	Manufacture of Wheel

Summary:

History of Railways:

Railway history is closely linked with the growth of civilization of mankind.

Growth of Railways:

- ☞ In 15th century stone slabs or wooden baulks were laid flush with the road surface for carriage
- ☞ Of heavy goods loaded on carts and drawn by animal. These were called “Tram ways”.
- ☞ These Tram ways were extensively used in 16th century in mines in central Europe for carriage of coal and other minerals.
- ☞ The timber bulks were replaced by iron plates to reduce wear and these were called ‘Plate ways’. These iron plates were also substituted in course of time by angle irons to give lateral support or better safety.
- ☞ The present railway track is a gradual evolution from these ‘Plate ways.’

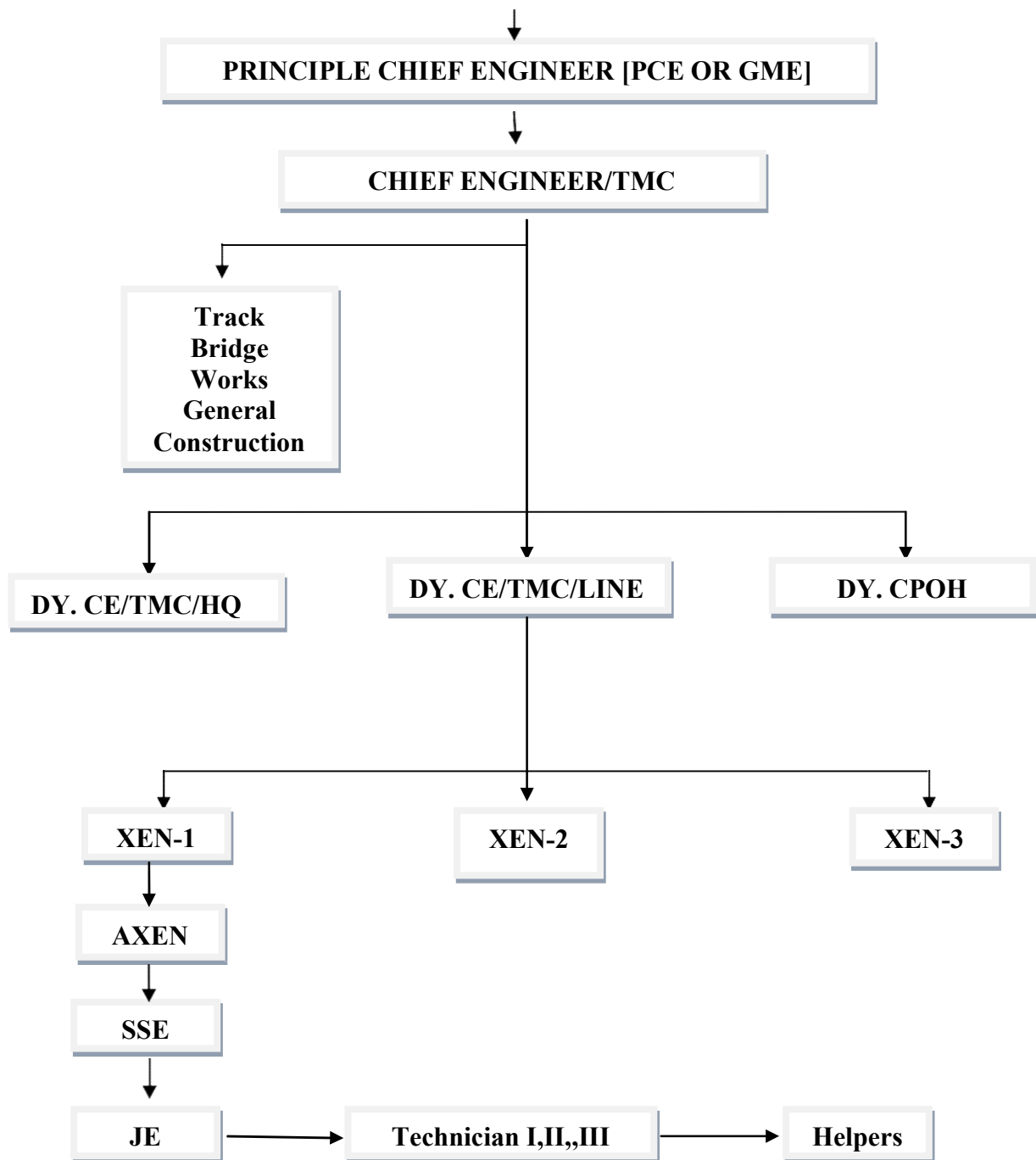
Public Railway Service

- ☞ The first public railway in the world was opened to traffic on **27th September, 1825**, when the first train made its maiden journey between **Stockton and Darlington in U.K.**

First Rail Trip in India

- ☞ The first train consisting of one steam engine and 4 coaches made its debut run on **16th April 1853**, for a Stretch of **21 miles (33.796 Kms)** between **Bombay and Thana** in **1.25 hours time**.

Zonal Railway Organization Chart for Track Machine Department:



TT Organization on Indian Railways

The organization shall be under the overall charge of Chief Track Engineer (Machines) of the Railway who shall be reporting to the Chief Engineer through Chief Track Engineer. The organization shall be responsible for the following functions:

- i. Field operation of track machines,
- ii. Repair and maintenance of machines,
- iii. Supervision and technical services including training, and
- iv. Planning and deployment of machines.

To carry out each of the above functions, chief Track Engineer (Machine) shall be assisted by one or more Deputy CE (Machine). It is already shown in the previous organizational chart.

DUTIES OF AEN:

GENERAL:

The Assistant Engineer is responsible for maintenance and efficient working of all the track machines in his charge.

IMPORTANT DUTIES:

- Inspection and maintenance of all machines.
- Ensure adherence to stipulated maintenance schedules.
- Ensure availability of necessary staff for operation.
- Ensure achievement of stipulated target.
- Ensure adequate availability of consumables and spares.
- Initiate proposals and plans for major schedule of work.
- Ensure co-ordination with other units of engineering department.
- Verification of store.
- Ensure maintenance of various records.
- Ensure availability of tools.

TRAINING OF PROBATIONERS

STAFF MATTERS

- All the section engineers and other staff working under him receive proper training in maintenance practice.
- Witnessing payments to staffs.
- Knowledge of rule & regulation.
- Inspection by higher officers.
- Service and leave records.

INSPECTION OF MACHINE BY ASSISTANT ENGINEER

- Inspection of machines by the Assistant Engineer shall be carried out in detail covering necessarily the following aspects and keep in view the Check List Maintenance Schedule issued by RDSO.

- Health of engine.
- Condition of hydraulic, pneumatic, electrical and electronic systems.
- Condition of transmission/brake system.
- Performance of the machine.
- Staff accommodation.
- Availability of the spares with the machine.

EXECUTION OF WORKS

DUTIES OF (SENIOR) SECTION ENGINEER/TMC:

One of the SSE/JE/TM on the machine, shall be nominated as the machine-in-charge i.e. SSE/JE/TM/I. In addition to his normal work as detailed in Para 106 above, he shall be responsible for the following functions in which he will be assisted by all the staff posted on the machine:

- (1) Carrying out the prescribed schedule of maintenance and keeping proper records of the same.
- (2) Safe custody, accountal and replacement of the spares, Tools & Plants and consumables issued for the machine and returning of released spares to zonal depot for reclamation/condemnation.
- (3) Keeping systems of the machine in working condition and ensuring the target output, duly maintaining quality.
- (4) Maintaining log books and other records, sending daily and other periodical reports/statements using appropriate fastest mode of communication.
- (5) Liaison with the divisional officials and Engineering control for efficient working of his machine, co-ordination with the permanent way staff and planning daily programme of machine work and interacting with the permanent way staff for working e.g. working in design mode for slewing and lifting of track etc.
- (6) Actively associating during visit of firm's Service Engineer, furnishing of such information as may be needed for proper examination of the machine and taking necessary follow up action.
- (7) Furnishing necessary reports to and keeping SSE/TM/SDI or SD informed as the case may be, about all the relevant aspects of the machines as also other records and details as asked by him and carry out necessary actions as directed for proper operation and maintenance of his machine.
- (8) In the event of breakdown of the machine, he will be responsible for setting right the defect in shortest possible time with the help of machine and other staff. In case the machine cannot be repaired in the block, he shall be responsible for winding up using all resources including back-up systems and clear the block section as early as possible. He shall be assisted by SSE/JE/P.Way and demand the engine/breakdown train through SSE/JE/P.Way, if required, without undue delay.

DUTIES OF SSE/JE/TM working on machines :

Each machine shall be worked under the direct charge of SSE/JE/TM during the movement and working of track machine. He shall be in possession of the valid competency certificate, road learning and medical fitness certificate for working the machine. He shall perform the following duties:

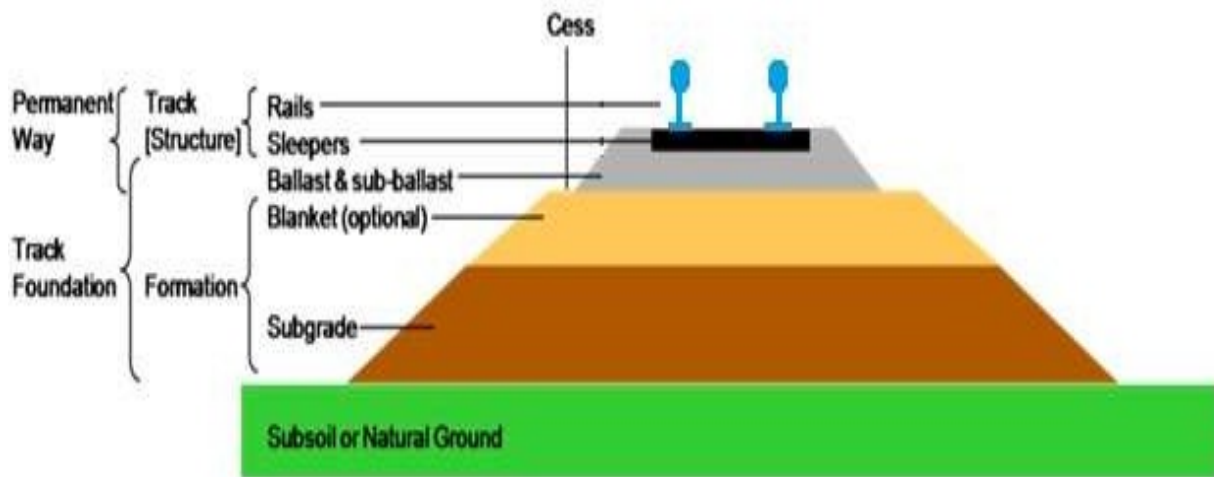
- (1) Operate the machine following the instructions issued by RDSO/OEM including calculation and input of data as required.
- (2) Carrying out pre-block maintenance daily as per schedule, other maintenance schedules, and making the machine fit for working and give machine ready memo to SSE/JE/P.way or station master.
- (3) Ensure proper functioning of all the systems and components and keeping a watch on the controls/indicators/gauges.
- (4) Initial setting out for the block working and closing the work of the machine.
- (5) Taking precautions for Design Mode operations such as slewing, lifting etc. in case of tamping machines.
- (6) Deploying of MCMs, TMMs and Machine Assistants at respective places around the machine for monitoring the work of various systems, maintenance activities during block and also to attract attention of the SSE/JE/TM working in operating cabin and assist him in the event of malfunctioning of the machine or obstructions in track.
- (7) He shall ensure safety of staff working around the machine.
- (8) Participate in IOH and POH activities of the machine as required.
- (9) Assist SSE/JE/TM (in-charge) on the machine in all aspects of machine working and maintenance within his competency.

DUTIES OF Master Crafts Man (MCM) and Track Machine Maintainers (TMM):

MCMs and TMMs attached with the machine(s) shall assist the SSE/JE/TM in operation and maintenance of track machines. Their main functions are:

- (1) To attend to the daily and weekly maintenance schedules of machine and record the compliance in log book. To attend and assist service checks by the service engineers.
- (2) To attend to breakdown and repairs of machines in block with due urgency.
- (3) To keep in his custody the various tools, plants and equipment necessary to attend repairs and ensure their working condition.
- (4) To attend to the repairs and maintenance of machines including during IOH and POH.
- (5) To guide and supervise the machine assistants and other staff in attending to the maintenance/repairs.
- (6) To remain vigilant during movement and working of machine and to inform the concerned SSE/JE/TM of any abnormalities.
- (7) To ensure safety of the machine and staff working at machine site.
- (8) Accompany the machines during shifting as directed, especially T-28 machine and PQRS portals.
- (9) Any other work assigned to him by the SSE/JE/TM.
- (10) MCMs and TMMs posted in depots and work areas other than machines will perform duties assigned by their controlling officials.

1. RAILWAY TRACK:

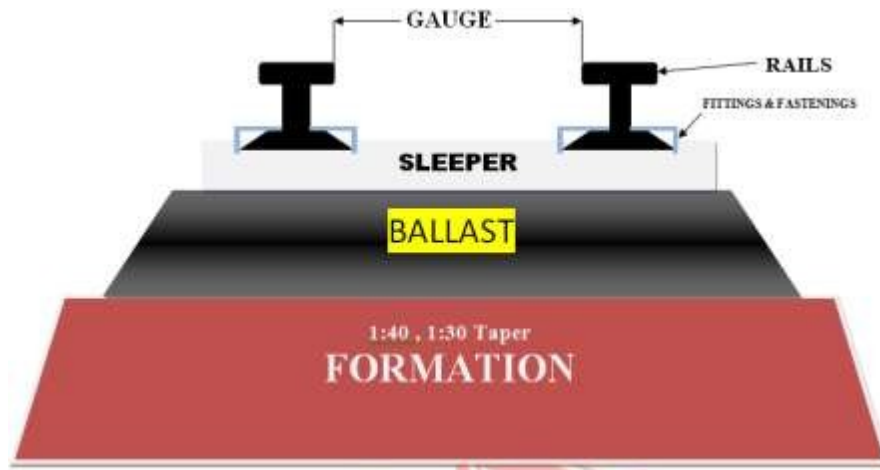


It is a rail road on which the train runs.

It is also called permanent way. It basically consists of two parallel rails having specified distance in between them and fastened to sleepers which are embedded in the layer of ballast, which is spread over formation.

Rail are joined to each other longitudinally by fish plates by end to end and fastened to sleeper by various fittings. Sleepers are placed at a specified distance and are held in position by embedding in the ballast.

Track Gauge:



The perpendicular distance between inner faces of rail is called gauge. It is measured 13mm below from rail top. The Indian Railways operate in three different gauges mainly Broad Gauge (1676mm), Meter Gauge (1000mm), and Narrow Gauge (762mm & 610mm) wide. The broad gauge accounts for nearly 94.6% followed by meter gauge 3.1% of the total route length. The gauge of track in India is measured as the minimum horizontal distance between the running or gauge faces of two rails 14mm below from top of rail. The standard gauge is 1435mm

DIFFERENT GAUGES ON INDIAN RAILWAY:

(i) B.G. (broad gauges)	:-	1676 mm
(ii) M.G.(Meter gauges)	:-	1000 mm
(iii) N.G. (Narrow gauges)	:-	762 mm
(iv) Special Narrow Gauge	:-	610 mm
(v) Standard Gauge	:-	1435 mm (Foreign Railways)

2. COMPONENTS OF TRACK:

Following are the main components of the track:-

- (1) Rails
- (2) Sleepers
- (3) Fitting & Fastenings
- (4) Ballast
- (5) Formation

3. REQUIREMENT OF GOOD TRACK:

A permanent way or track should give comfortable & safe ride at maximum permissible speed with minimum cost. For achieving the above objectives a good permanent way should have the following characteristics:-

- (i) The gauge should be correct and uniform.
- (ii) The rail should have uniform and perfect cross-level.
On curve outer rail should have proper super – elevation to take an account of the centrifugal force.
- (iii) The alignment should be straight and free of kinks. In case of curve proper transitioning should be provided between straight and curve to give smooth ride.
- (iv) The gradient should be uniform and as gentle as possible.
The change of gradient should be followed by proper vertical curve.
- (v) The track should be resilient and elastic in order to absorb shocks and vibrations of running trains.
- (vi) The track should have good drainage so that the stability of the track is not affected due to water logging.
- (vii) The track should have good lateral strength, so that it can maintain its stability due to variation of temperature and other factors.
- (viii) There should be provision for easy replacement and renewals of various track components.
- (ix) The laying & Maintenance cost of track should be low.
- (x) It should be antitheft type & shall be free from sabotage.

CLASSIFICATION OF ROUTES:

Broad Gauge Routes:

All the B.G. routes of Indian Railways have been classified based on speed criteria as given below:

(A) Group ‘A’ Lines:

These are meant for a sanctioned speed of >130 & up to 160 KMPH. In this category, the following lines fall:

1. New Delhi – Howrah – by Rajdhani Exp. Route.
2. New Delhi – Bombay – By Frontier Main or Rajdhani Route.
3. New Delhi – Chennai Central – By Grant Trunk Route.
4. Howrah – Mumbai VT - via Nagpur.

(B) Group ‘B’ Lines:

These are meant for a sanctioned speed >110 & up to 130 KMPH.

(C) Group ‘C’ Lines:

These include suburban section of Mumbai, Delhi, Chennai and Kolkata

(D) Group ‘D’ Lines:

These are meant for a sanctioned speed up to 110 KMPH

Classifications of M.G. Routes

Depending upon the importance of route, traffic carried and maximum permissible speed M.G. routes are classified in three categories as Q.R. and S. routes.

(1) ‘Q’ Routes:

These routes consist of routes where the max^m permissible speed will be more than 75 Kmph. And the traffic density will be more than 2.5 GMT. Max^m speed do not exceeds 100 Kpmh.. As Bangalore - Miraz route.

(2) ‘R’ Routes:

These routes will have a speed potential of 75 Kmph. and the traffic density will be more than 1.5 GMT. Routes have further been sub-divided into 3 categories depending upon the volume of traffic as follows:

- (a) R₁: Where the traffic density will be more than 5 GMT.
- (b) R₂: In between 2.5 GMT to 5 GMT
- (c) R₃: 1.5 GMT – 2.5 GMT

(3) ‘S’ Routes:

These routes will be the routes where speed potential will be less than 75 Kmph. and where the traffic density is less than 1.5 GMT. These will consists of other routes which are not covered in „Q“, „R₁“, „R₂“ and „R₃“ routes. S“ Routes have been further subdivided into 3 routes as S₁, S₂ and S₃ etc.

RAILS

It is a special type rolled steel bar which is placed end to end two parallel line at a fixed distance on sleeper to provide continuous, leveled and smooth surface for train to move.

Or

Rails are similar to steel girder placed end to end at gauge distance to provide continuous, leveled and smooth surface for giving path to running wheel.



FUNCTIONS OF RAILS:

Following are the main functions:-

- (i) Rails provide a continuous and leveled smooth surface for running wheels of trains.
- (ii) It provides a path way which is smooth and has very less friction like $1/6^{\text{th}}$ of road.
- (iii) The rails serve as a lateral guide for running of wheels.
- (iv) The rail wears various types of mechanical stresses such as vertical load, braking forces, and thermal stresses due to temperature etc.
- (v) Rails carry out the functions of transmitting load to a large surface area of formation through sleeper and ballast.

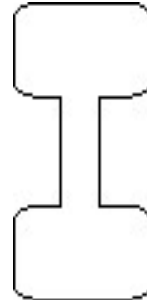
TYPES OF RAIL:

Various types of rails are:-

1. Double Headed rail (D.H. Rail)
2. Bull Headed Rail (B.H. Rail)
3. Flat Footed Rail (F.F. Rail)

(1) Double Headed Rail (D.H. Rails):

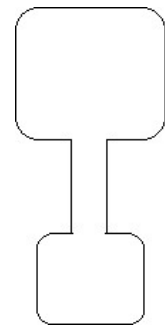
It is “I” section or “dumb-bell” section type rail having identical heads on both sides. Idea was that these rails were re-used after wear, by reversing it.



(2) Bull Headed Rail (B.H. Rails):

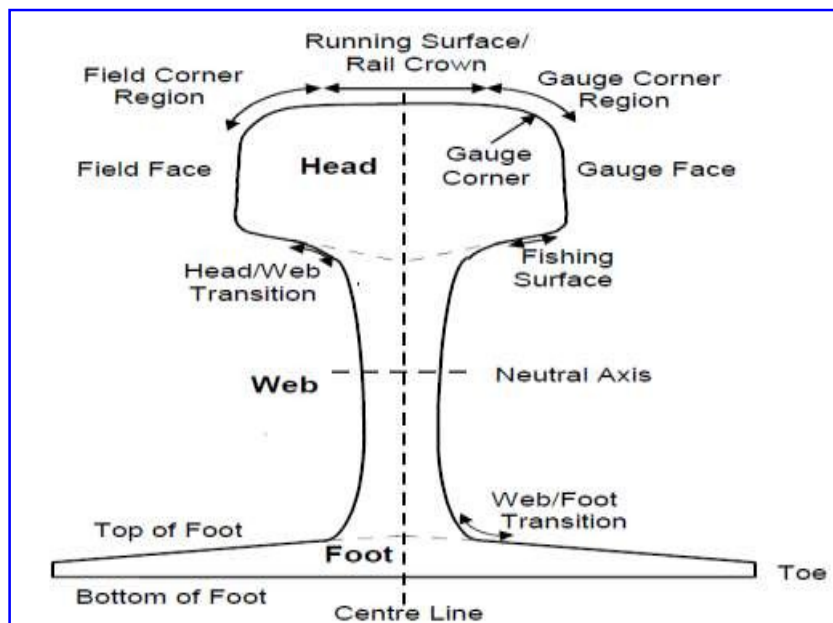
The shape of these rails is similar to D.H.R. and only difference is that its head has more metal to allow wear& tear, so that it may run for long life.

The idea was that these rails will have long life but due to unbalanced head and problem in gauge maintenance, these rails were not successful rails.



(3) Flat Footed Rails (F.F. Rails):

These rails are having inverted “T” cross-section and can be directly fixed to the sleeper with the help of spikes. These rails have been standardized for use in Indian Railways. These rails have more economical design giving greater strength & Lateral stability.



STANDARD LENGTH OF RAIL:

The Longer rails are not only economical and gives smoother and comfortable riding of trains. The length of rails is however, restricted due to the following factors.

- Lack of facilities for transport of longer rails particularly on curves.
- Difficulties in handling of long rails.
- Uneconomical in manufacturing of very long rail.
- Difficulties in having a bigger expansion joint for long rails.
- Heavy internal thermal stresses in long rails.

However standard rail length of B.G. track is 13 meters.

Standard Gap at Fish Plate Joint

- a. Standard gap for B.G. Fish Plate joint is **6 mm**.
- b. Maximum gap can be accumulated at the rail joint in normal condition is **15mm**.

Standard Rail Section

The rails are designated with its weight per unit length. In India, initially we opted British/Revised British system in FPS system (Foot Pound Second), the rail section was designated in lbs. per yard.

For Example: 90 R lbs. rail section means weight of rail section is 90 lbs per one yard length by Revised British System.

Presently in Indian Railway Standard [I.R.S] MKS (meter /Kilogram sec] system is in co-operation in which we designate the rail system weight in kilogram / meter.

For Example: 52 kg rail section means the weight of one meter rail is 52 Kgs.

Nowadays we are manufacturing only the following two rails

- (i) 60 Kg
- (ii) 52 Kg

Note: Nowadays for laying new rails/ Gauge conversion etc only 60 Kg rail is considered as standard.

Rolling mark on rails:

Every rail rolled has a brand on its web, which is repeated at certain intervals is called rolling mark:

Details are as follows

Indian Railway Standard Rolling Mark

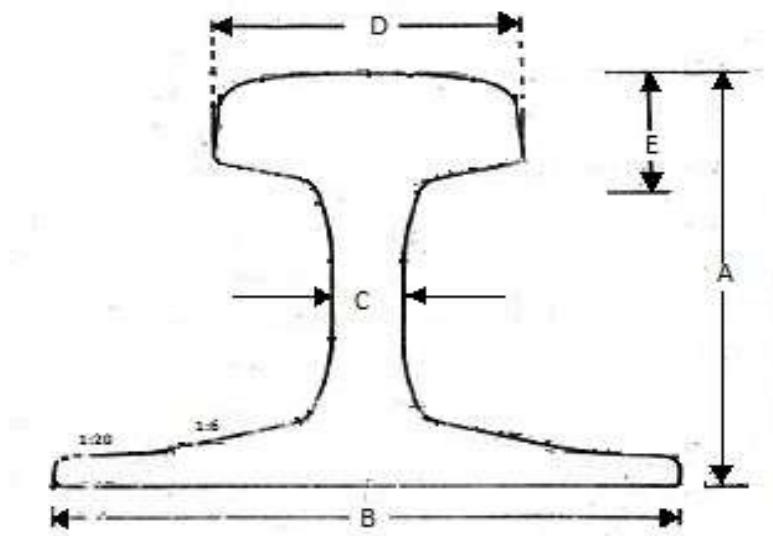
IRS-52kg-710-TISCO/SAIL-II 1997 —————> OH

The explanation for various new abbreviations is as given below:

- IRS : Indian Railway Standard
- 52 Kg : Weight of rail section; 52 kg / meter
- 710: Grade of the rail material
- > : Direction of Rolling
- TISCO/SAIL : Manufacturing Company Tata iron and Steel Company/Steel Authority Of India Ltd
- II/ 1997 : Month and year of manufacture; February 1997
- OH: Manufacturing Process Open Hearth Process

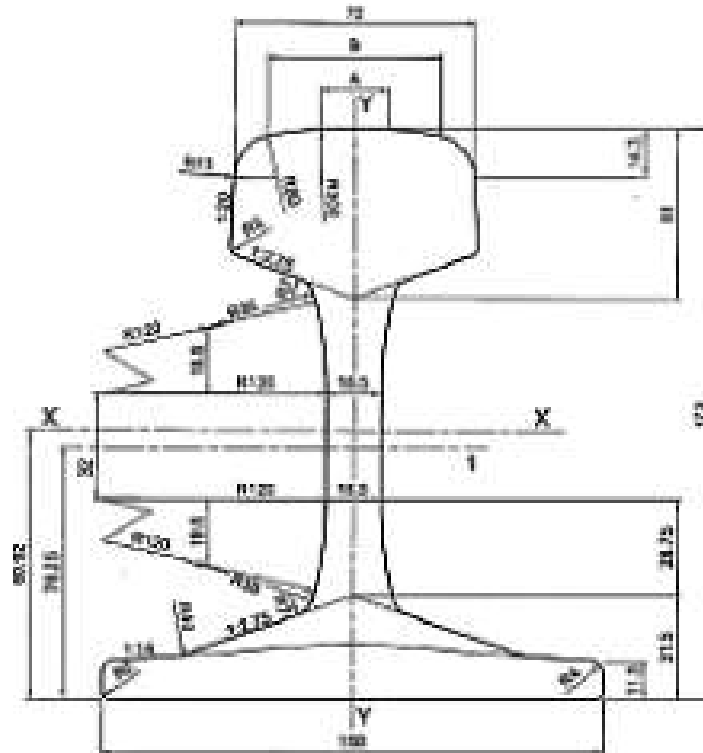
Standard Dimension of the Flat Footed Rail:

Rail Section	Height (A) in mm	Flange Width (B) in mm	Web Thickness (C) in mm	Top Width (D) in mm	Top Height (E) in mm	Actual Weight in Kg
60 Kg	172	150	16.5	74.3	51	60.34
52 Kg	156	136	15.5	67	51	52



For 60 Kg/m rail, the UIC 60 profile has been changed to 60 E1 profile, which is accurately dimensioned profile developed from the previous less accurately dimensioned profile of UIC 60. In this profile, there is a minor variation in the profile of rail head top as compared to the UIC 60 profile. There is no difference in the dimensions of Rail flange and web including the fishing planes.

60 Kg/m rail (60 E1)



Cross-Sectional Area - 76.70 cm²,
Indicative dimensions: A = 20.456mm,

Mass per metre - 60.21 Kg/m
B = 52.053mm

Relationship between Grade, Ultimate Tensile Stress (UTS) and Service Life of Rails

Grade	Ultimate Tensile Stress(UTS)	Type of Rail	Stipulated Service Life
710	72	52 Kg	350 GMT
		60 Kg	550 GMT
880	90	60 Kg	800 GMT
		52 Kg	525 GMT
1080	110	60 Kg	Under Trial

Handling Of 90 UTS Rail

While Handling a 90 UTS rail special care should be taken following are the important points to be taken into account

- ☞ Protection of straightness
- ☞ Protection of rail surface
- ☞ Protection of Metallurgical Surface
- ☞ Protection from contact of other products
- ☞ Slings Arrangement
- ☞ Personnel Safety

Slings Arrangement:

SL. No	Rail Length in (m)	Lifting Point	Distance Between Lifting Point in (m)	Over Hanging in (m)
1	13	2	6.5	3.25
2	26	4	6.5	3.25
3	39	6	6.5	3.25
4	130	20	6.5	3.25
5	260	40	6.5	3.25

HANDLING INSTRUCTIONS FOR 90 UTS AND HEAD HARDENED RAILS

1. Protection of straightness

Barely visible straightness deviations, for example, a deflection of 0.75 mm over 1.5 meters span, render a rail unacceptable and require careful handling and stacking. Therefore,

AVOID

- Heavy static loading
- Sudden impact or dynamic loading
- Localized point or line contact loading in stacking
- Excessive end drop and flange overlaps while lifting/moving
- Criss-cross stacking of rails of alternative layers at right angles as far as possible.

DO

- Keep rails horizontal and straight while lifting/moving

- Stack rails of same length on firm level base of well drained platform preferably of concrete
- Stack subsequent layers on uniformly placed spacers in vertical alignment with base supports
- Keep rail ends in vertical alignment
- Place rails of shorter length in upper layers.

2. Protection of rail surface

Surface notches of even less than 0.75 mm in depth are liable to cause rail fracture in service. Therefore,

AVOID

- Impact abrasion of rails against separators in wagons
- Round link chain slings for securing the rails.

DO

- Use conventional slings for lifting rails made of flat link chains
- Lifting of rails preferably with magnet lifting device.

3. Prevention of metallurgical damage

These rails are thermally very sensitive and are likely to develop metallurgical defects if exposed to localized heating, which produces very hard, brittle and cracked metallurgical structures which may lead to sudden failures. Therefore,

AVOID

- Heating, flame cutting, on or adjacent to rails
- Contact with electric arcs and molten metal splashes, i.e. from loose cables or adjacent welding operations.

DO

- Flame cutting when found essential, after preheating minimum of 10 cm of rail length on either side of the cut to about 250-350°C by uniform movement of heating torch.

4. Protection from contact with injurious substances

These rails can withstand normal degree of rusting but localized corrosion pitting may cause

subsequent rail fractures. Therefore,

AVOID

- Contact with injurious substances which produce high corrosion of steel, i.e. acids, alkalis, salts, etc.

DO

- Stack rails on well drained platform preferably on concrete as per drawing No. RDSO/T-4962.

5. Slings principles

The single point slinging increases risk of bending and surface damage to the rails. The overhang beyond the outer lifting point should not be greater than one half the distances between lifting points. Therefore,

AVOID

- Single point slinging.

DO

- Use two points slinging for rail length up to 13m
- Recommended locations of lifting points for various rail lengths are tabulated below:

Rail length (meters)	No. of lifting points	Distance between lifting points (m)	Max. rail overhang(m)
12-13	2	6-6.5	3-3.25
26	4	6.5	3.25
39	6	6.5	3.25
130	20	6.5	3.25
260	40	6.5	3.25

Use of lifting beams fitted with slings is desirable.

6. Safety of Personnel

AVOID

- Standing under suspended loads.

DO

- Use protective gloves and clothing to minimize the risk of skin abrasion
- Wear distinctive colored helmet and clothing for easy identification by crane and machinery drivers to avoid accidents.

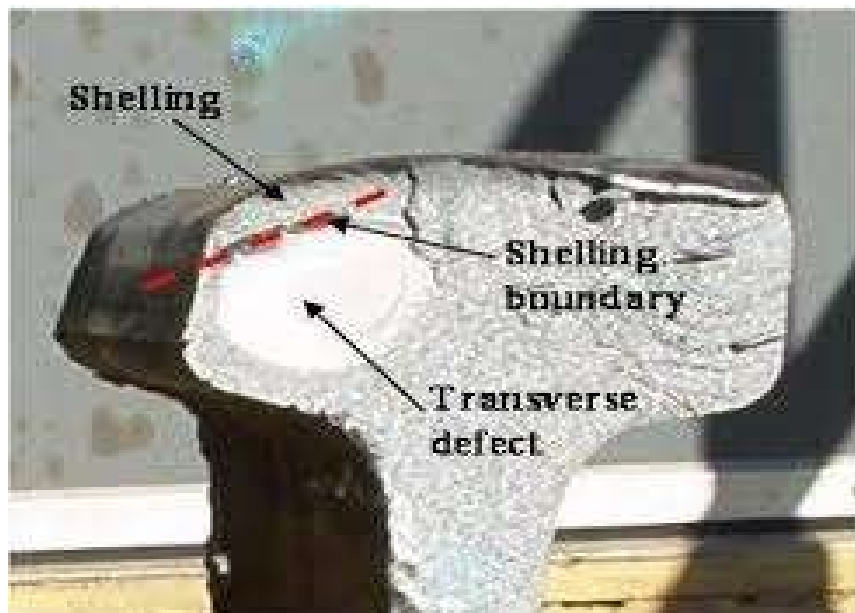
Ultra Sonic Flaw Detector (USFD) Testing of Rail

Brief Idea:

There are two types of testing which are carried out in tracks

- Rail testing (70° of probe is used)
- Joint testing (0° and 70° of probe is used) Rail flange testing by 0° probe





Rail Testing (Frequency)

1. Initial Testing : in the rolling mill (or) in manufacturing plant
2. First Retesting : After passing of the 15% of stipulated GMT
3. Subsequent Testing

Service GMT/Annum	Frequency of Rail Test in Months	Testing frequency only for cc+8+2t routes with 52kg (90 UTS) in Zone III & IV
≤ 5 GMT	2 years	18 Months
$> 5 \text{ \& } \leq 8$ GMT	12 Months	09 Months
$> 8 \text{ \& } \leq 12$ GMT	9 Months	6.5 Months
$> 12 \text{ \& } \leq 16$ GMT	6 Months	4.5 Months
$> 16 \text{ \& } \leq 24$ GMT	4 Months	3 Months
$> 24 \text{ \& } \leq 40$ GMT	3 Months	2.5 Months
$> 40 \text{ \& } \leq 60$ GMT	2 Months	1.5 Months
$> 60 \text{ \& } \leq 80$ GMT	1.5 Months	1 Month
Above 40 GMT	1 Months	20 days

Weld Testing Frequency:

Conventional AT Welding	
Type of Testing	Testing Schedule
Periodic Test	Every 20 GMT or 5 years whichever is earlier

SKV AT Welding			
Acceptance Test	Main Line	Immediately after welding	
	Loop Line		
First Periodic Test	Main Line	20 GMT or 1 year whichever is earlier	
	Loop Line	After 1 year	
Further Tests		Routes having GMT	Frequency
	Based on Route GMT in Main Lines	>80	1 year
		>60 ≤80	1.5 years
		>45 ≤60	2 years
		>30 ≤45	3 years
		>15 ≤30	4 years
		0-15	5 years
	Loop Lines	Once in 5 years for Passenger Running Loop Lines	
		Not to be carried out for Non-Passenger Running Loop Lines	

Marking of USFD and Action taken:

S.No	Defects	Mark	Action Taken
1	IMR [Rail]	XXX (3 red X markson both faces of rail)	<ol style="list-style-type: none"> 1. Remove immediately within 30 days 2. Impose 30 Kmph caution Immediately 3. Fish Plate the particular location immediately withthe help of clamp or Fish plate 4. Depute one watchman for round the clock tillremoval 5. Replace by 6m USFD tested rail
2	IMR [Weld]	XXX(3 red X mark on Both Sides of weld)	<ol style="list-style-type: none"> 1. Impose 30 Kmph Caution Immediately 2. Provide Joggle fish plate within 24 Hours 3. After the Provision of joggle fishplate speed canbe increased up to 70 Kmph 4. Rest of action will be taken as per IMR (Rail)
3	OBS [Rail]	X (one Red mark on both side of the rail)	<ol style="list-style-type: none"> 1. Provide Joggle fish plate within 3 days 2. Key man should keep for watch everyday 3. Remove within 30 days

4	OBS[Weld]	X (one Red mark on both side of theWeld)	<ol style="list-style-type: none"> 1. Provide Joggle fish plate with 4 bolts within 3 days 2. Key man should keep for watch everyday
5	Defective Flange [Weld]		<ol style="list-style-type: none"> 1. If renewal(CTR) sanctioned then provide joggle fishplate and watch. 2. If renewal(CTR) is not sanctioned then defective weld will be joggled and 30 Kmph caution will be imposed till its removal within 15 days

IMR : Immediate removal , OBS: Observation

SLEEPERS

Sleepers are the components of track on which rails are fixed with the help of fittings and fastenings in correct gauge and alignment.

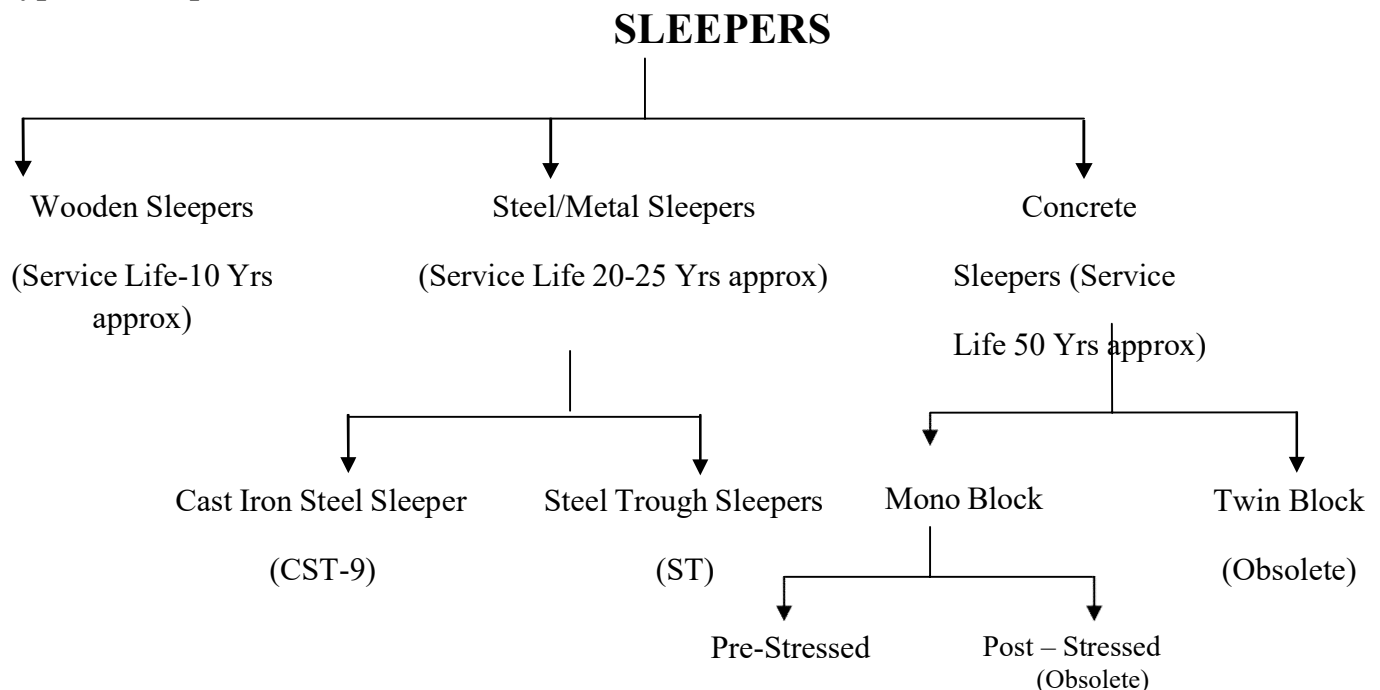
The sleepers in the initial stages were planted in the longitudinal direction of rails. These were known as Longitudinal Sleepers. These types of sleepers were not economical so they changed to transverse sleepers.

Functions of sleepers

The main functions of the sleepers are as follows

1. It should hold the rail in correct gauge and alignment.
2. It should give a firm and even supports to rails.
3. It should transfer the load evenly and efficiently from rails to the wider area of ballast section.
4. Act as an elastic medium between rail and ballast to absorb shocks and vibrations of moving loads.
5. It provides longitudinal and lateral stability to permanent way (Track).

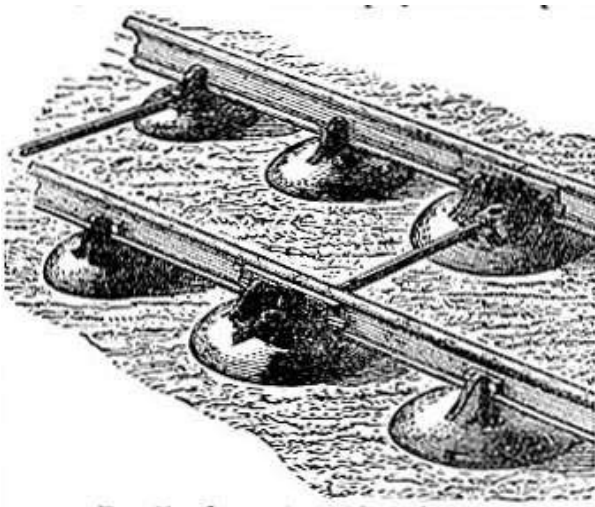
Types of Sleepers:



Note: Now-a-days in Indian Railways mono-block Pre-Stressed Concrete Sleepers (PSC)/ mono-block Pre-Reinforced Concrete Sleepers (PRC) are considered as a standard.



Wooden sleepers



Cast Iron sleepers



Steel Trough Sleepers



PRC Sleepers-Mono-block



Dual Block Concrete sleepers

Requirement of good Sleepers

The ideal sleeper should normally fulfill the following requirements:

- i) The initial cost as well as maintenance cost should be minimum (low).
- ii) The weight of sleeper should be moderate, so that it is possible to handle it easily.
- iii) The design of sleeper and fastenings should be such that it is possible to fix and remove the rails easily.
- iv) It should have sufficient bearing area
- v) It should be such that it is possible to maintain and adjust gauge properly.
- vi) It should be able to bear the load coming from rail comfortably and should not break/damage under load.
- vii) It should be „Universal Type“ and may be used in track circuiting area
- viii) It should be able to absorb the shock and vibration coming from moving train.
- ix) It should be able to provide elastic medium between rail and ballast.
- x) It should be designed in a way that quantity of loose parts and fasteners should be less.
- xi) It should have good service life.
- xii) The sleeper should have anti-sabotage and Anti-theft quality.

CONCRETE SLEEPER

Necessity of concrete sleepers:

The use of concrete sleepers in Indian Railways becomes necessary due to following reasons.

- i) Scarcity of good quality of timber.
- ii) High cost of maintenance in wooden and steel sleepers.
- iii) Introduction of high speed and heavier axle loads.

Advantages of Concrete Sleepers:

1. Concrete sleepers being heavy, gives greater strength and stability to track and are suitable especially for LWR/CWR due to great resistant to buckling.
2. Concrete sleepers with elastic fastening provide a track which can maintain better gauge, cross level and alignment and retains packing well.
3. Since Concrete sleepers have flat bottom therefore they are best suited for modern methods of tamping and maintenance (i.e. machine maintenance).
4. These can be used in track circuited areas (or) track circuited section as they are poor conductor of electricity.
5. They are neither inflammable nor subjected to be damaged by atmospheric effect (corrosion) and insects.
6. These have longer service life approx. 50 years. Compared to other type of sleepers.
7. It has anti-sabotage and anti-theft quality.
8. It is fit and forget type.
9. No chance of gauge widening.
10. Availability of PRC sleeper is easy. They can be made at the site also.
11. They can be produced on large quantities locally by installing a plant.

Disadvantages of Concrete Sleepers:

1. Due to heavy load, handling of PRC sleepers are not easy only Machine handling is recommended which is costly
2. In case of derailment, these sleepers may get heavy damage.
3. These sleepers have nil scrap value.
4. Not useful for better packing. So only machine packing is allowed.

Specification of Mono Block (PRC Sleepers):

S. No	Parameter	52 Kg Sleepers	60 Kg Sleepers	60 Kg Wider Sleeper
1	Length	2750 mm	2750 mm	2750 mm
2	Height at ends	210 mm	235 mm	200 mm
3	Weight	270 Kg	286.5 Kg	332 Kg
4	Top Width	154 mm	150mm	210 mm
5	Bottom Width	250 mm	270 mm	280 mm
6	HTS dia (Reinforcement)	3 x 3 mm	3 x 3 mm	3 x 3 mm
7	Number of Bars	18	18	16
8	Slope at top	1:20	1:20	1:20

Sleeper Density & Sleeper spacing

Sleeper Density

Sleeper Density means how many sleepers are provided in one rail length (i.e. 13 meters for B.G)

For BG sleeper density is denoted as $(M+X)$ where M = Length of rail in m

X = Variable

For example: In BG track $(M+7)$ sleeper density means $13+7=20$ sleepers per rail length. Nowadays for new laying, Doubling, Gauge renewal $(M+8)$ is considered as standard

The sleeper density depends upon the following factors:

1. Axle load and speed of trains
2. Type and strength of sleepers
3. Type of rail and its section.
4. Type of the ballast and ballast section
5. Nature of formation.

Sleeper Spacing

Sleeper spacing means center to center distance between adjacent sleepers which are provided in the rail. It depends upon the sleeper density.

Sleeper spacing is kept uniform in whole rail length but at joints it's kept close as joints are the weakest portion of track and needs more support.

Sleeper spacing at the joint is kept close in such manner so that space for packing should be available sufficiently and end of rail should be as a „bridge joint“ not supported at sleepers.

Standard Spacing for BG

Type of Sleeper	Sleeper Spacing			
	A	B	C	D
Wooden	150	610	In Between B & D is to be calculated to be equally divided in remaining length	
Metal	190	580		

Sleeper Spacing and density in LWR joint

Sleeper density in LWR track is although denoted as same as in rail length i.e (M+4),(M+7) or (M+8) but for conventional and all practical purpose it is given as number of sleeper per kilometer.

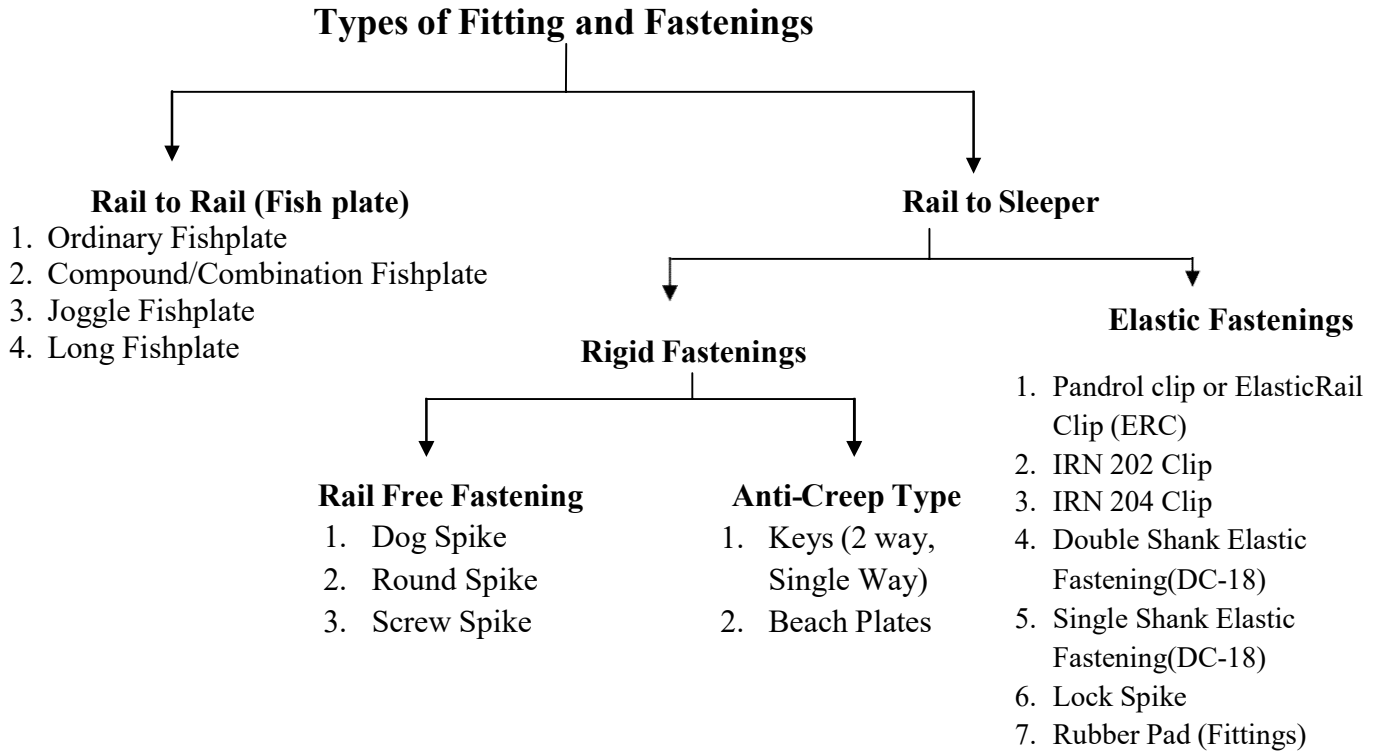
The sleeper spacing in LWR track is calculated as 1km divided by number of sleepers in one kilometer of rail.

Sleeper density	No. of sleeper per kilometer	Exact c/c spacing required as per calculation in cm	C/c spacing to be provided in the filed (cm)	
			L.W.R.	S.W.R.
M + 8	1660	60.24	60	-
M + 7	1540	64.93	65	66
M + 4	1310	76.33	76	78

Note: Normally M+4 density is only used in SWR tracks.

1. The above rail spacing (M+X) will be applied only on curve up to 4° in BG and 6° in MG.
2. Curve more than 4° in BG and 6° in MG, mid slaggery if joints are provided.
3. Outer rail of curve will be reference line for all practical purpose related to spacing.
4. In LWR track since there is no joints hence spacing will be as usual. Also there are restrictions to lay the LWR on curve for more than 4° in BG.

FITTING AND FASTENINGS



RAIL TO RAIL FITTINGS:

These fittings are used for tying one rail to another longitudinally in same horizontal and vertical plane. One of the main fittings of such types of rail is fishplate. Fishplate is called, so as its section looks like a fish.

TYPE OF FISHPLATE:

Fishplates are of following four types:

- i. Ordinary fishplate
- ii. Combination fishplate.
- iii. Joggle Fishplate
- iv. Long Fish Plate

(i) Ordinary Fishplate:

These plates are having I-section. These are used to connect similar line section together, such as 90R rail to 90R rail and 60 Kg rail to 60 Kg rail.



(ii) Combination Fishplate:

These are used for connecting the rail length of two different rail sections. Such as 90R rail to 52 Kg rail, 52 Kg rail to 60 Kg rail. The combination fishplates are designed so as to

Suit the two rail sections. No expansion gap is kept at such joints so as to give more strength. A common top table and gauge face of the two rail section is available with the help of the Junction fish

Plates or combination fish plates in spite of varying depth & thickness of the section.



(iii) Joggle Fishplate:

These fishplates are very similar to ordinary fishplate for particular rail section with only difference its mid portion is projected outside to accommodate weld material at welded joints. Hence it is used only at welded joints.

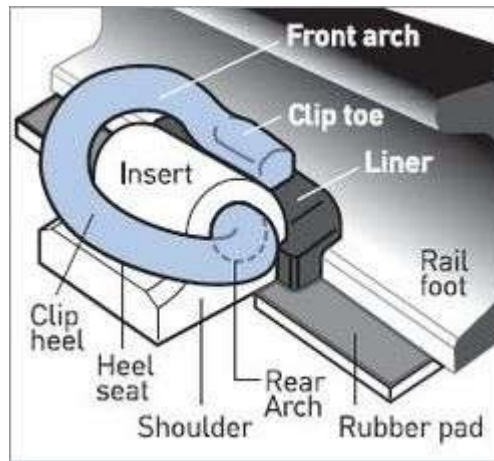


(iv) Long Fishplate:

These fishplates are very similar to ordinary fishplate for particular rail section but longer in length exactly 1 meter. These fishplates are used at the location where the higher joint strength is required. (with 6 bolts). **For Example:** near to LWR territory or at glued joint etc.



Elastic fastenings



The Primary function of the fastenings is to connect the rail with the sleepers. The Elastic fastenings serve this and in addition to that it has an additional property of elasticity after fixation (Toe Load and deflection etc.). So that it is very useful to absorb the vibration, shocks and jerks etc. coming from moving train by this additional property. These fittings are very useful for modern high speed track because these fastenings do not loosen and get off due to vibration and load effect. Hence it may be fit & forget type.

Requirement of Elastic Fastenings:

An idle elastic fastening should be able to meet the following requirement

1. It should hold gauge well
2. It should have adequate “toe load” which should not reduce under service.
3. It should provide sufficient elasticity to absorb the shocks and vibrations coming from moving train
4. It should keep the track parameter well maintained
5. It should offer adequate resistance to lateral and longitudinal track for maintaining the stability of track.
6. It should be anti-creep type.
7. It should be reusable type
8. It should be fit and forget type
9. It should have minimum loose parts so that its fixation and maintenance should be easy
10. It should be free from sabotage and anti-theft type
11. It should be cheap and have long life
12. It should be universal type so it can be used with any type of sleeper.

Type of Elastic Fasteners

1. Pandrol clip or Elastic Rail Clip (ERC)
2. IRN 202 Clip
3. IRN 204 Clip
4. Double Shank Elastic Fastening(DC-18)
5. Single Shank Elastic Fastening(DC-18)
6. Lock Spike
7. Rubber Pad (Fittings)

Pandrol Clip/ Elastic Rail Clip (ERC)



Types of Elastic Rail Clips (in Use):

1. Elastic Rail Clip- Mark-I
2. Elastic Rail Clip- Mark-II
3. Elastic Rail Clip- Mark-III
4. Elastic Rail Clip- Mark-IV
5. Elastic Rail Clip- Mark-V

Note: Material of Pandrol Clip:
Silico Manganese Spring Steel (SMSS)

All the ERCs are of two types they are

1. Flat Type-used at joint of track circuited areas.
2. Round type-normal use.

Type	Toe Load (Kg)	Toe Deflection (mm)	Bar Diameter(BD) (mm)	Weight (gm)
MARK-I	645-800	11.4	20.64	1000
MARK-II	700-900	11.2	18	800
MARK-III	850-1100	13.5	20.64	910
MARK-IV	1100-1300	13.5	20.64	855
MARK-V	1300-1500	15.5	22	1000

Note: Now a day ERC Mark-III is widely used in Indian Railway Compared to other.

Rubber Pad



It is an integral part of the elastic fastenings. It is provided between Rail and Sleepers to Perform following duties

- i. To absorb the shocks
- ii. It dampens and absorb the vibration
- iii. It resists the longitudinal movement of rail
- iv. It prevents the abrasion of rail sleeper
- v. It provides electrical insulation between rail and sleepers in the electrified areas

Note: (a) Normally in Indian Railway groove Rubber Pad of 6mm is used with PRC Sleepers
(b) But with PRC Wider Sleepers groove Rubber Pad of 10mm is used

Liners:



Liners are used with pandrol clips on PRC sleepers to prevent „dent, mark on rails produced due to toe load. In Indian Railways normally insulating composite liners are used. There are three types as follows

- i. Composite liner with Mild steel and nylon Component
- ii. Composite liner with Mild steel and nylon Component/ P.V.C Liners
- iii. Composite liner with Mild steel and Glass Filled Nylon(GFN)

Note: Nowadays in Indian Railways Liners with GFN are considered as standard liners.

BALLAST

Ballast is the layer of broken stone, gravel, moorum or any other hard material that are placed and packed below and around sleepers for distributing load to larger area of formation. This is receiving through sleepers and providing drainage as well as longitudinal and lateral stability of track.

Broken Stone – grit.

Functions of Ballast:

1. To transfer and distribute the load from sleeper to a large area of formation.
2. To provide elasticity and resilience to track for getting proper riding comfort.
3. To provide necessary resistance to track for longitudinal and lateral stability.
4. To provide effective drainage to track.
5. To provide effective means of maintenance.

Type of Ballast:

Sand, Moorum, Coal Ash as sinter, Broken Stone Ballast, Brick Ballast, Kankakee etc.

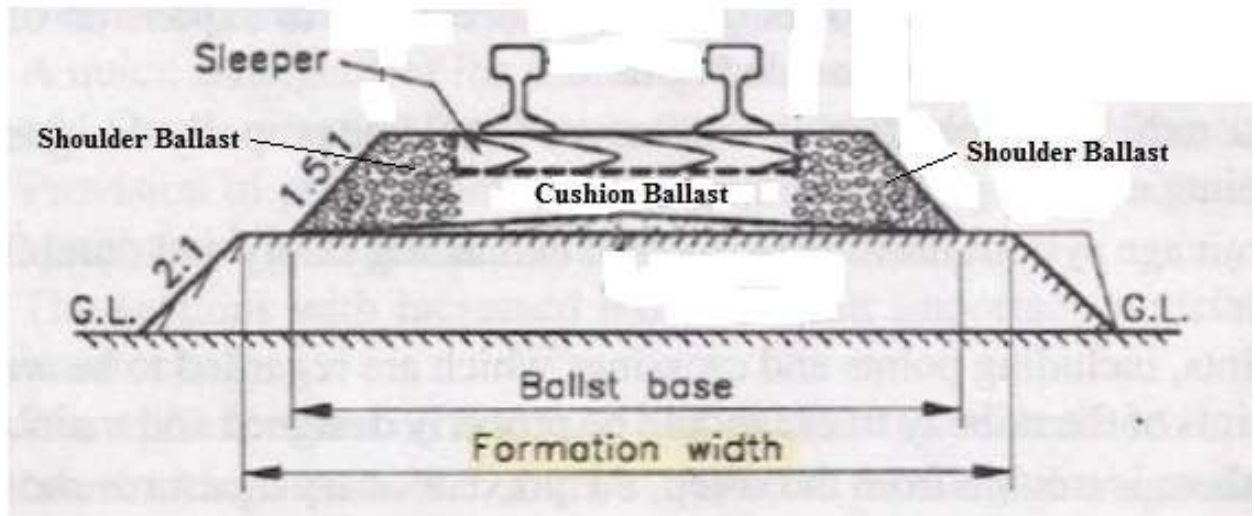
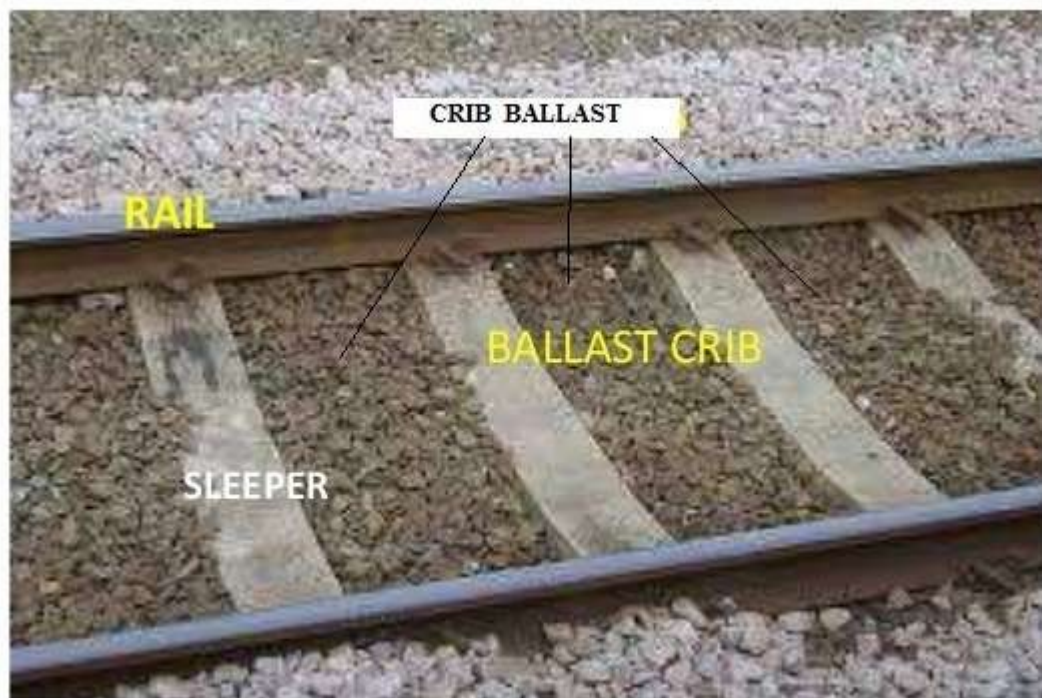
Note: Nowadays in Indian Railways stone ballast is considered as standard.

Requirement of a good Ballast:

1. It should be tough and wear resistance.
2. It should be hard and should not be crushed under moving load.
3. It should be cubical in shape and should have sharp edges
4. It should be non-porous and non-absorbent of water.
5. It should be durable
6. It should provide good drainage to water.
7. It should be cheap and economical in price and easily available.

Classification of ballast according to position in track and its use:

1. Ballast under the sleeper are known as Cushion Ballast
2. Ballast outside the track/sleeper is known as Shoulder Ballast
3. Ballast in between the sleepers is known as Crib Ballast



Function of Cushion Ballast:

1. Absorb the shocks and vibration received from moving trains through sleepers
2. To distribute the load received through rails and sleepers of moving train and larger area of formation.
3. To provide a leveled surface layer to the track this will be able to maintain the track parameter like cross level and evenness.
4. To provide elasticity and resilience to track for passenger comfort.
5. To provide drainage to track.

Function of Shoulder Ballast:

1. To provide lateral stability to track as well as resilience to buckling etc
2. To provide effective drainage to track
3. To help maintain the alignment of the track.

Function of Crib Ballast:

1. To provide longitudinal stability to track.
2. To help the sleeper for proper spacing and in a square position.

Recommended Ballast Cushion:

A & B Route: 300mm

C&D Route: 250mm

Note: Nowadays for new laying recommended ballast cushion on 60 kg PRC track is 350mm.

Ballast Specifications:

Ballast should be cubical in shape, angular, hard and free from organic impurities durable, non-porous and non-water absorbent. It should resist attrition. It should be manufactured by machine crushing preferably otherwise hand crushed ballast should be used after the approval of CTE. It should be cheap and economical. Ballast should not be flaky .

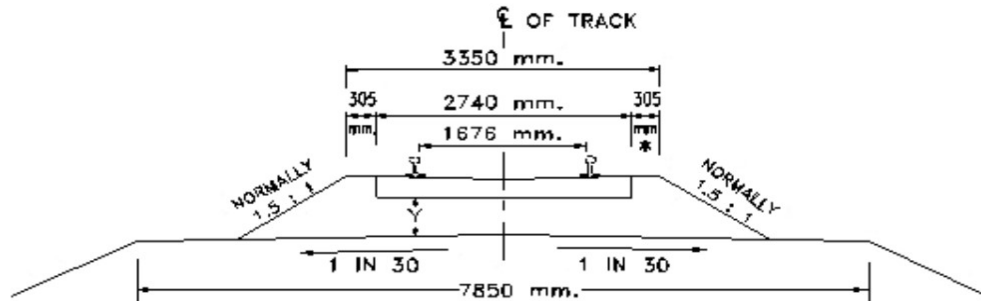
Size of Ballast and Its Gradation:

In Indian Railways standard size of ballast is **65mm** cubical.

Ballast Profile:

FOR SINGLE LINE BG TRACK

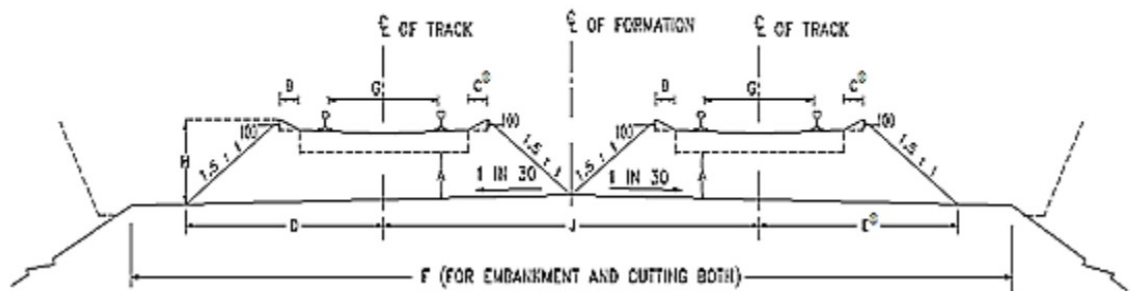
STANDARD BALLAST PROFILE FOR BG (OTHER THAN LWR/CWR)



S. No.	Depth of Ballast Cushion	Quantity of Ballast per Meter	
		On Straight and Curves of Radius flatter than 600 M	Curves of Radius sharper than 600 M
1	250 mm	1.769 M ³	1.820 M ³
2	300 mm	2.022 M ³	2.078 M ³
3	350 mm	2.282 M ³	2.344 M ³

FOR DOUBLE LINE BG TRACK

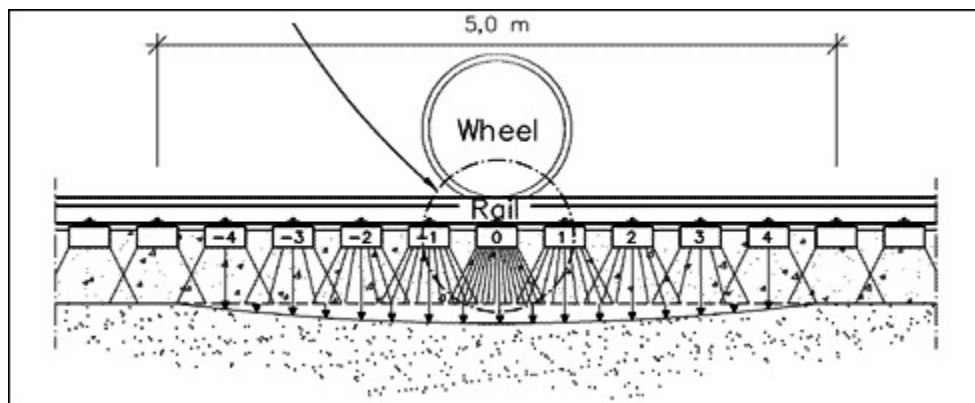
BALLAST PROFILE FOR LWR TRACK (DOUBLE LINE B.G.)



G Gauge	Type of Sleeper	A	B	C*	D	E*	F	H	J
1676 mm	PRC	250	350	500	2785	2943	13160	707	5300
		300	350	500	2864	3022	13160	760	5300
		350	350	500	2943	3101	13160	812	5300

Note:

1. The minimum clean stone ballast cushion below the bottom of sleeper ie $A=250\text{mm}$
2. For routes where speeds are to be more than 130 Kmph, $A=300\text{mm}$ or 200mm along with 150 mm of Sub-Ballast.
3. *On outer side of curves only- 500mm on sharp curve, 600mm on reverse curve.
4. Suitable slope shall be given for side slope of ballast profile.
5. All dimensions are in mm.

Pressure Distribution on Ballast:

This is given by Mr. B.M. Talbhot.

Note:

1. The pressure distribution curve under the sleeper is in shape of Bulb.
2. Pressure on sleeper is maximum in the center of its width decreases center towards end.
3. The vertical pressure under the sleeper is uniform at a depth which is equal to sleeper spacing approximately.
4. Distribution of load is roughly takes place at 45° .

FORMATION

It is prepared flat surface on which track is laid.

It is the important constituent of track which supports the entire track structure and gives a strong base to absorb the moving load of the train.

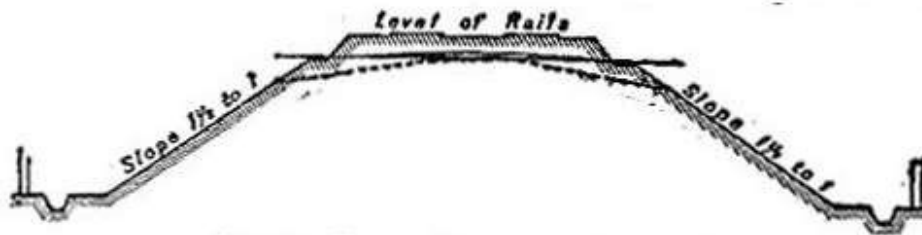
Types of Formation:

It is normally of two types:

1. Embankment
2. Cutting.

Embankment:

It is prepared by making some additional earthwork over existing ground up to required height from ground level.

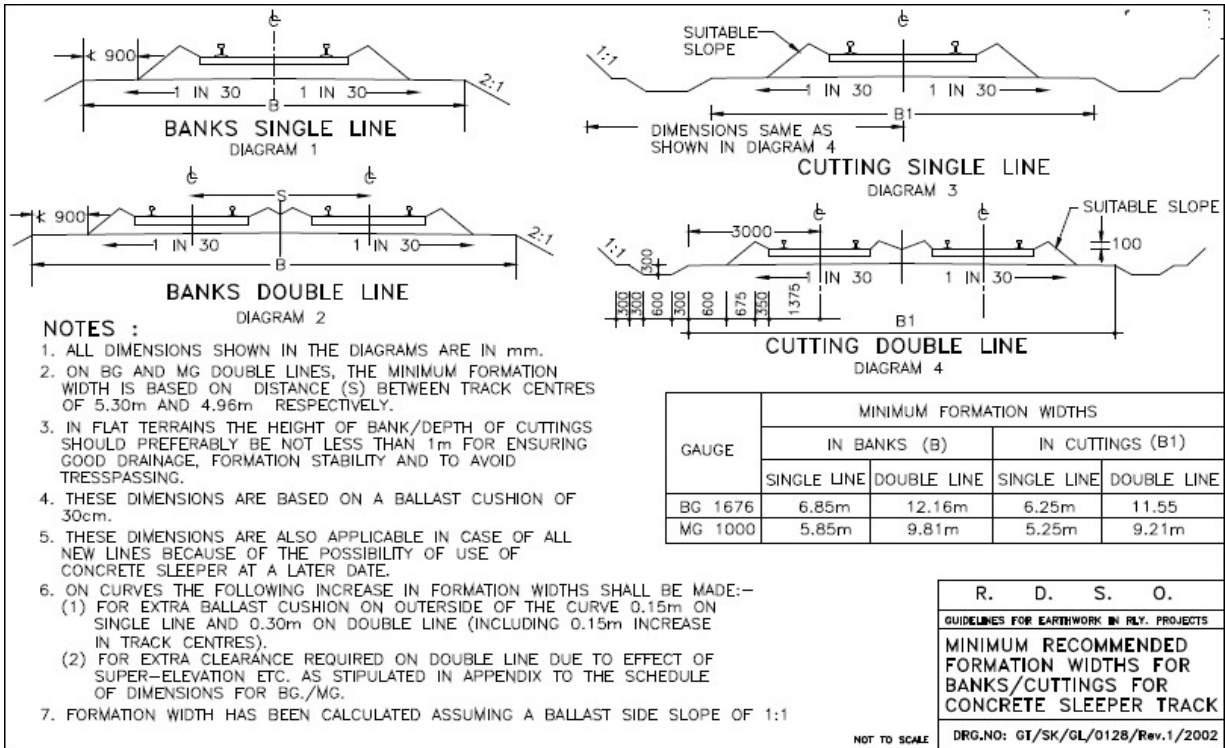


Cutting:

Formation in cutting is prepared by additional excavation of existing excess ground surface up to the required depth. Normally it is made in "hilly" areas.



Note: Zero fill formation: Formation where the track is laid on ground level is called zero fill formation.



Function of Formation:

- To provide a smooth & uniform bed for laying of track.
- To bear the static and dynamic loads transmitted to it through ballast section.
- To facilitate drainage
- To provide stability to the track.

Recommended Width of Formation:

Width of the formation depends upon the number of the track and their gauge to be laid.

However recommended standard width is as below

S.no	Type of formation	Track	BG RecommendedWith (SOD-2002) (meters)	Meter Gauge (meters)
1	Embankment	Single line	6.851	4.38
		Double Line	12.150	8.34
2	Cutting	Single line	6.250	4.27
		Double Line	11.550	8.23

Height of formation:

Height of formation depends upon the

1. Ground contour
2. Gradients
3. Maximum Flood Level (MFL).

Slope of Formation:

The side slope of both embankment and cutting depend upon.

1. Shearing strength of soil
2. Angle of repose

In actual practice the areas of soil like sand (or) clay may require the slope

		Horizontal: Vertical
For Embankment	▼	2:1
For Cutting	▼	1:1 (or) 1 ½: 1

Sub-Grade:

The formation without “Sub-Ballast” is known as Sub-Grade.

Sub-Grade Material:

Material used for making formation is known as sub-Grade material. Normally it is obtained from the borrow pit from the adjoining land.

Example: Gravel, Coarse Sand, Medium sand, fine sand and silt.

Requirement of Sub Grade Materials

1. It should be able to bear the load transferred to it by ballast section.
2. It should prevent the ballast to puncturing in it.
3. It should drain the water efficiently entering top.
4. It should not change its volume due to variations in moisture.

Characteristics of Sub Grade materials:

1. It should be dense, free from moisture and high internal friction and cohesion; otherwise, it will tend to flow (or) spread out in present of excessive moisture.
2. It should posse’s low capillary to keep the formation free from excessive moisture.

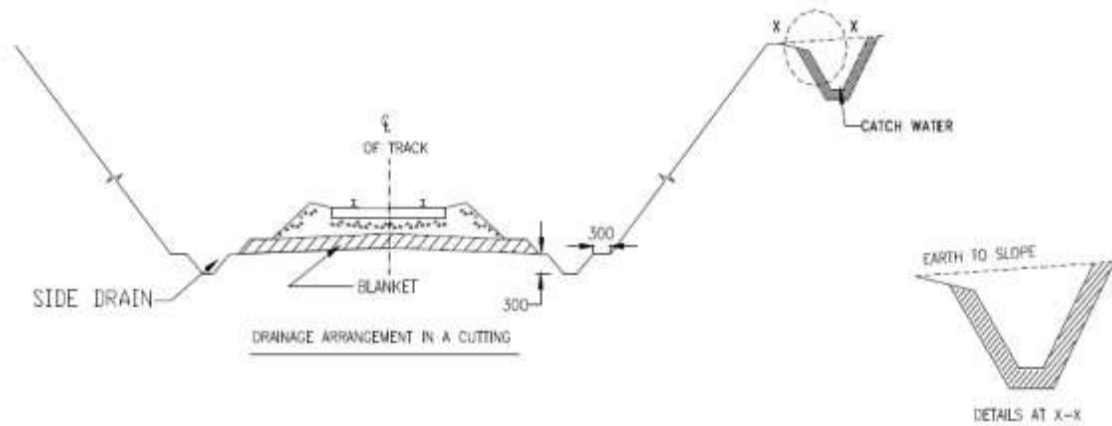
Blanket can be defined as an intervening layer of superior material which is provided on the top surface formation bank just underneath of ballast cushion. It is different than sub ballast.



- ## TRACK DRAINAGE

Presences of excess moisture of water, reduces the bearing capacity of soil as well as resistance to shear resulting the failure of Formation, Hence proper drainage of track isvery very essential.

Drains



Catch Water Drain:

In cutting formation water coming from up levels to track is interrupted, collected & drained through a drain made on slopes of cutting. This type of drain is known as catchwater drain. Maximum section area of catch water drain should not exceed 0.75 m^2 .

Side Drain

In cutting water coming from top surface of the formation is drained through a drain at neath of side slope is known as “Side Drain”.

Cess:

The width of formation beyond toe of ballast to end of formation is known as cess. This additional width beyond ballast provides stability to formation.

Recommended Track Distance (Formation Profile).

Recommended minimum track center distance (C/C distance) shall be as under

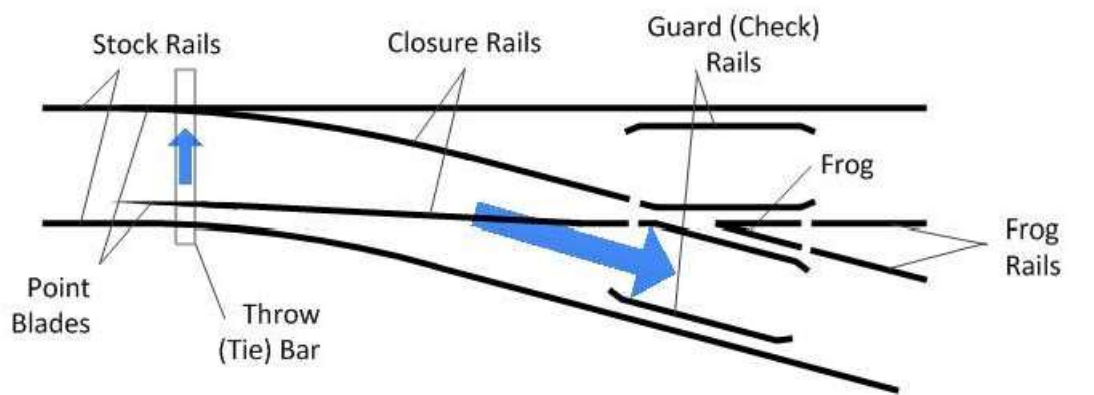
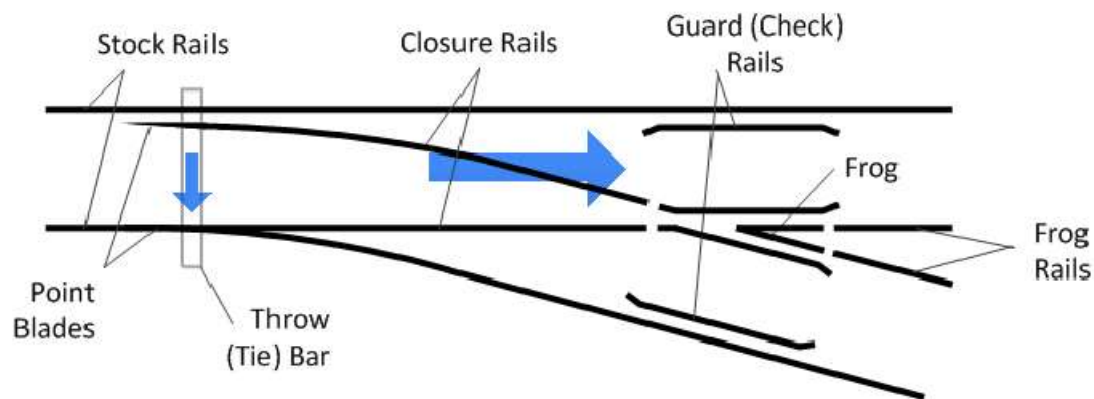
- | | | |
|-----------------------|---|--------------|
| 1. For existing track | – | 4.725 meters |
| 2. For New laid track | – | 5.300 meters |

POINTS & CROSSING

Necessity of Point & Crossing

Point & Crossing i.e. turnout are necessary due to following reasons:

1. On single line track to give path to trains coming from both directions.
2. In double line, to give path to faster train against slow train coming from same direction
3. To connect the places which are not lying on main line
4. To place/direct the passenger train to platform line (or) goods train to yard line for stay



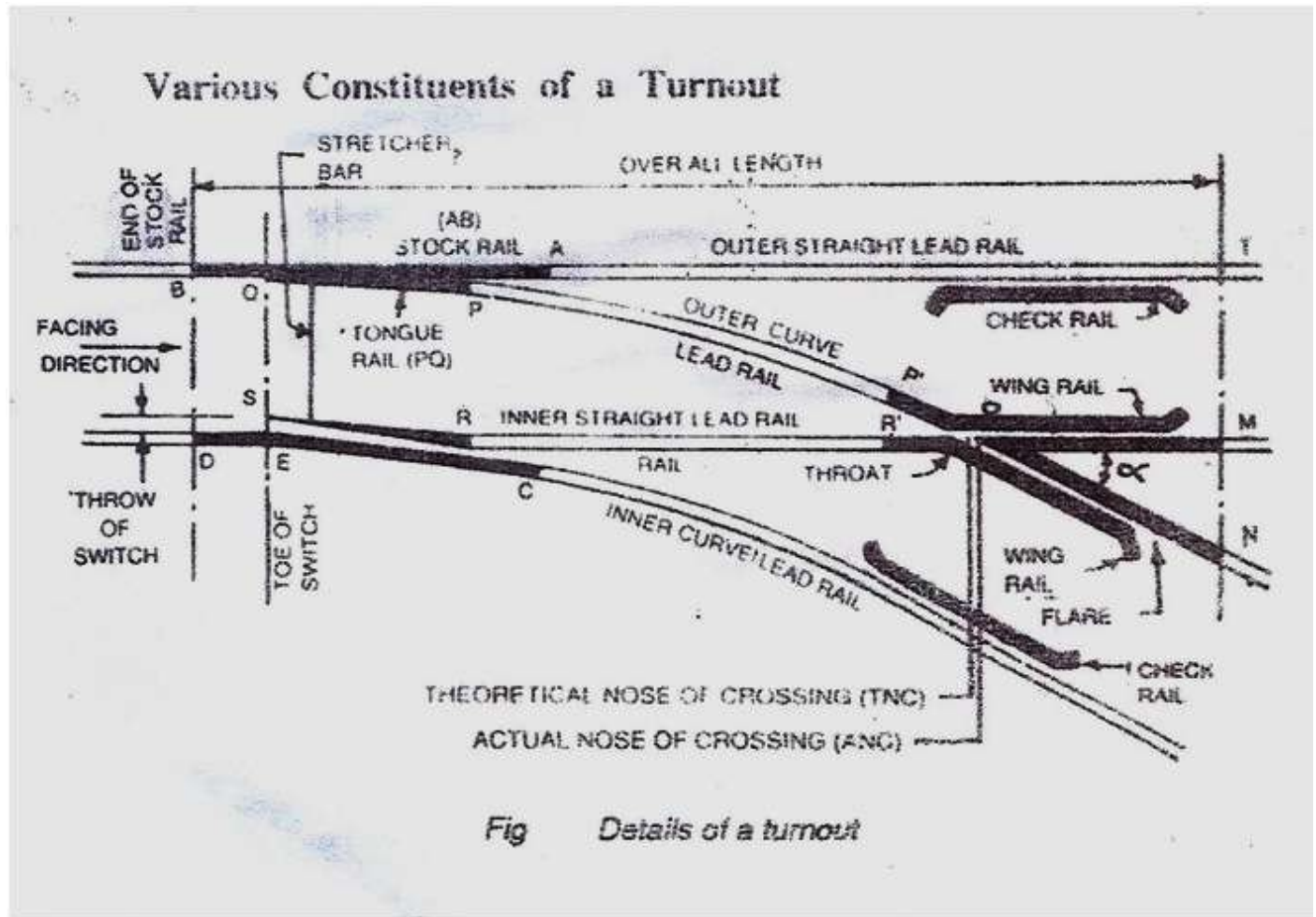


Fig Details of a turnout

SOME IMPORTANT DEFINITIONS OF POINTS AND CORSSING:

Tongue Rail:

It is the tapered movable rail made of high carbon and manganese steel to withstand wear whose thicker end is connected with running rail/ lead rail. Some time it is also known as Switch Rail.

Stock Rail:

It is the running rail in which the tongue rail is housed.

Switch:

A pair of tongue e rail with necessary connections and fittings forms a switch.

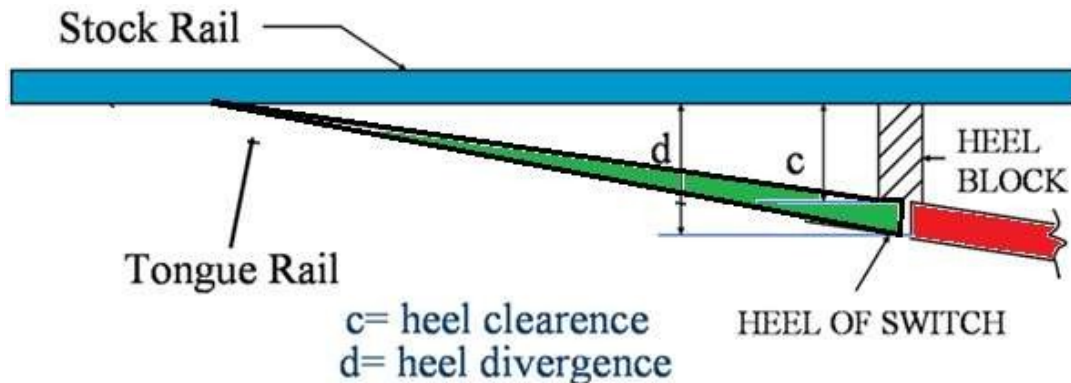
Point:

A pair of tongue rails and a pair of stock rails with necessary connections form a point.

Heel of Switch:

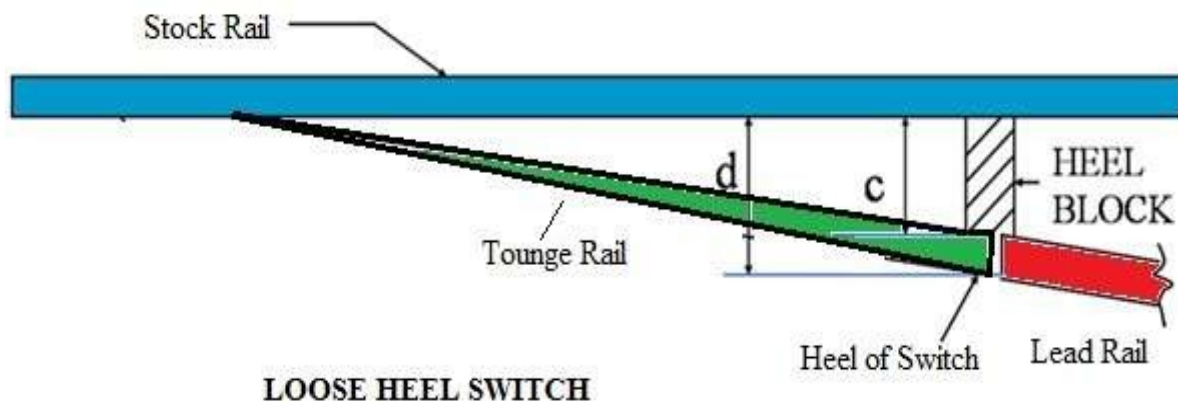
Heel of Switch is an imaginary point midway between the end of the lead rail and tongue rail in case of “loose heel switch.”

In case of fixed heel switches it is the point at the center of the heel block itself



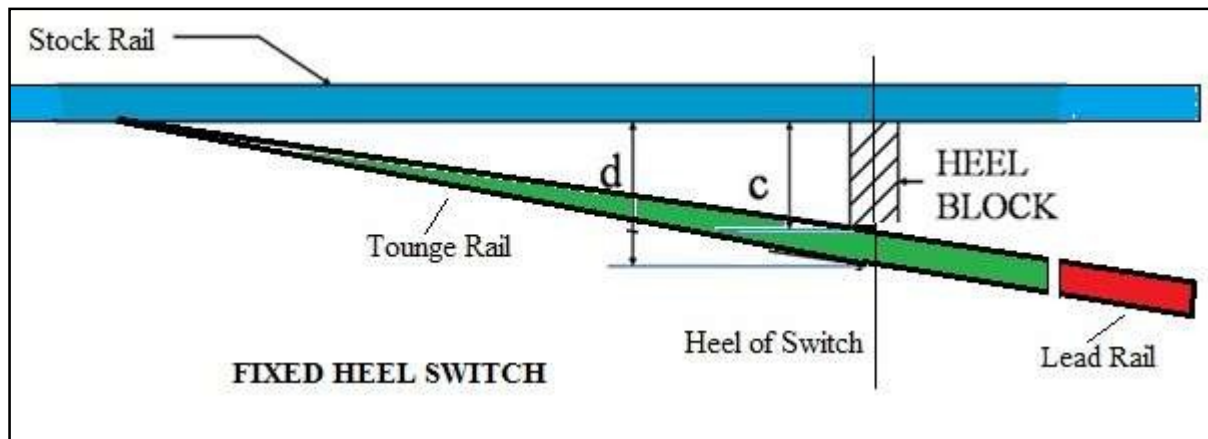
Loose Heel Type:

In this type, the switch rail or tongue rail finishes at the heel of the switch. In order to enable the free end of the tongue rail to be moved, two front bolts of the heel block are kept loose.



Fixed Heel Type:

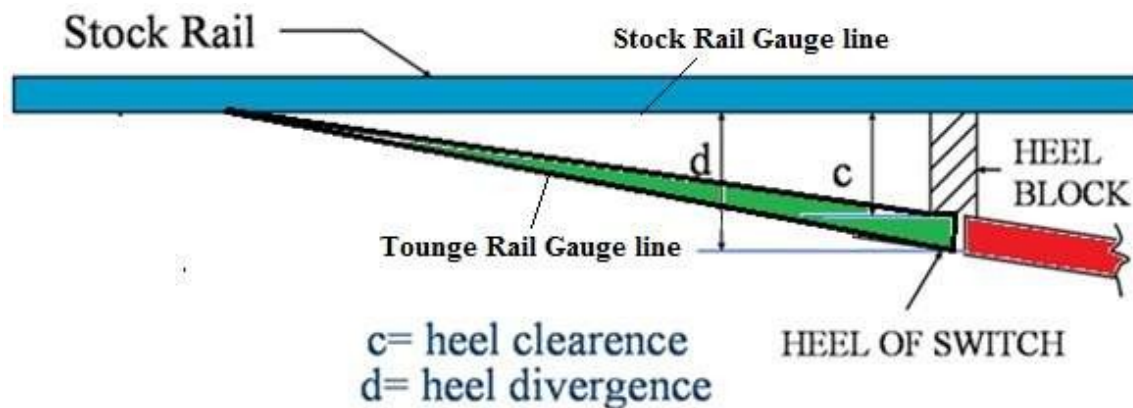
In this type of switch, tongue rail does not end at heel of the switch, but it extends further. The movement of the tongue rail is made on account of the flexibility of tongue rail by increasing its length.



Heel Divergence:

The minimum distance between gauge line of stock rail and gauge line of tongue rail at heel of switch is called Heel Divergence.

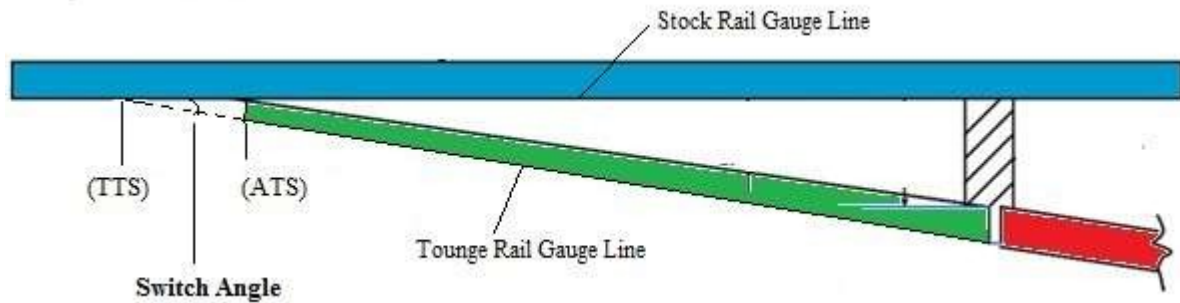
In other words it is the clearance between stock rail and running rail at HOS plus head width of tongue rail



Switch Angle:

It is the angle between the gauge lines of stock rail and tongue rail at theoretical toe of switch (TTS) in close position. This angle depends upon heel divergence and length of tongue.

In case of curved switches it is called as “**Entry Angle**”.

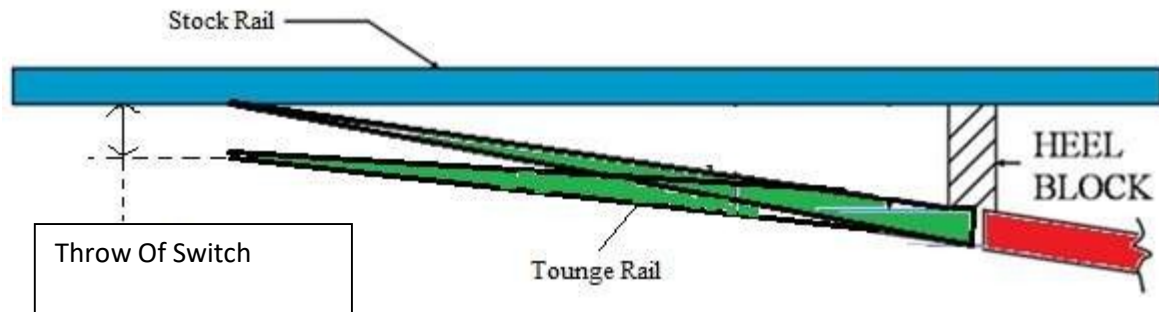


Note: In case of curved switches it is the angle between gauge lines of stock rail and tangent drawn at actual toe of gauge line of tongue rail. Hence it is called “**Entry Angle**”.

The various switch angles in BG Track are as given below:

1 in 8 ½	Straight Switch	1°-34'-27"
1 in 12	Straight Switch	1°-8'-0"
1 in 8 ½	Curved Switch	0°-47'-27"
1 in 12	Curved Switch	0°-27'-35"

Throw of switch:



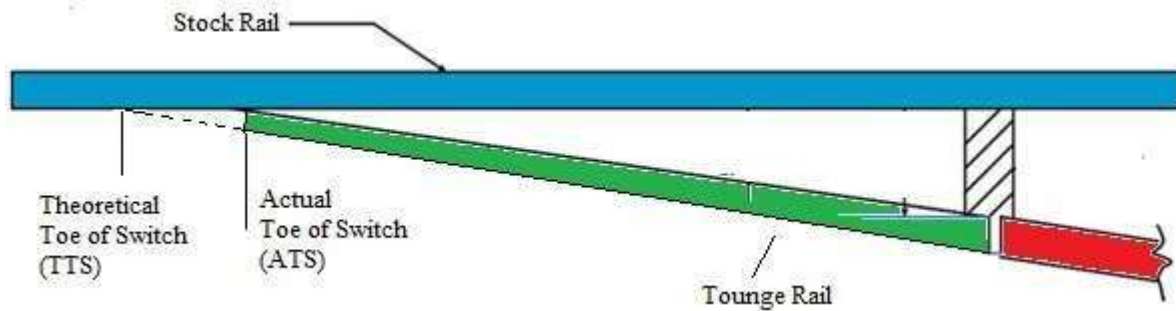
It is the distance moved by a tongue rail against stock rail at Actual Toe of Switch (ATS) at the time of making path to either side.

As per Schedule for Dimension (SOD) the maximum and minimum value of switch is as under following.

Track	Maximum Value in mm	Minimum value in mm
Broad Gauge	115	95
Meter Gauge	100	89

Toe of Switch or Actual Toe of Switch (ATS):

Thin tapered end of tongue rail is called Toe of Switch or Actual Toe of Switch (ATS).

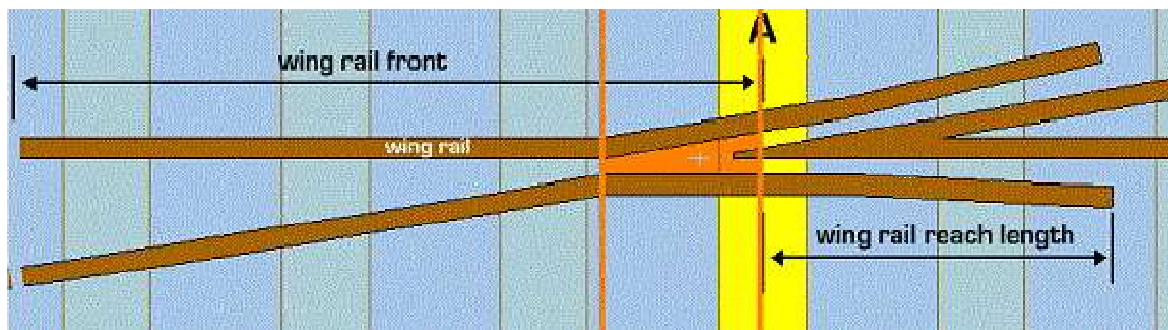


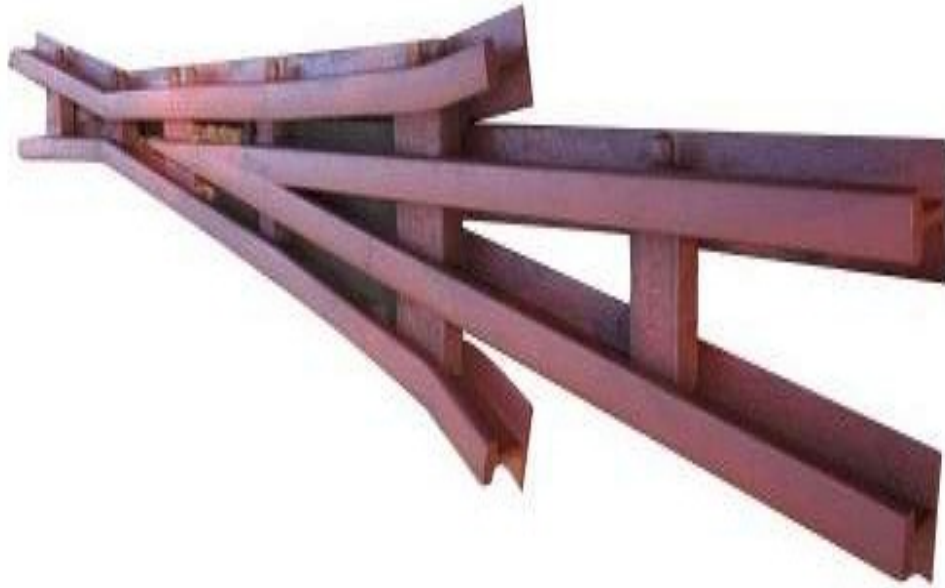
Theoretical Toe of Switch:

Theoretical toe of Switch is the point of intersection of gauge lines of tongue rail and stock rail in the closed position. It is imaginary point in field.

Crossing:

Crossing is a device introduced at the junction where two rails cross each other to permit the passing of the wheel flange of rolling stock, to pass from one track to another track. It is also known as “frog”.

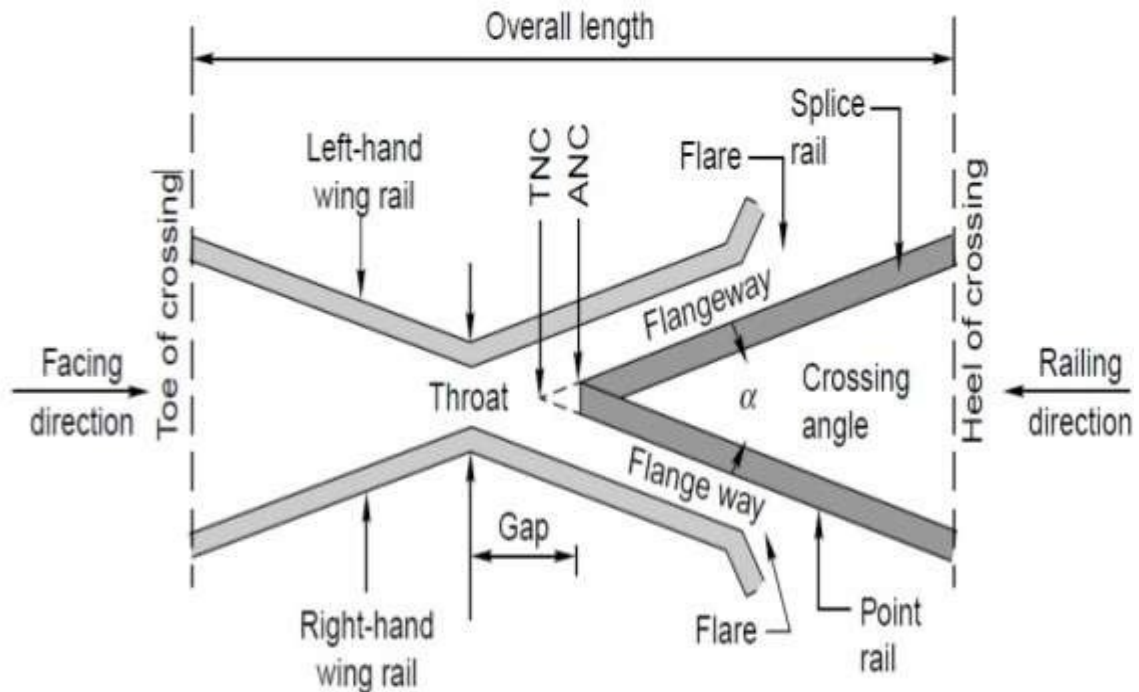




Theoretical Nose of Crossing: (TNC)

Theoretical nose of crossing is a theoretical point of intersection of two gauge lines of crossing.

TNC is used as a reference for all Calculations.



Actual Nose of Crossing: (ANC)

Theoretical Nose of Crossing is the point which is not practically possible to provide in track. Some thickness is provided (Equal to web thickness of rail section) at nose to give strength to the nose.

Hence actual nose of crossing is the point which spreads between the gauge lines of crossing at 'pointed end' which have sufficient thickness in view of giving strength and manufacturer consideration.

Throat of Crossing:

Throat of crossing is the portion at which the converging wing rail of crossing has minimum distance (closest position)

Note: Normally Throat clearance is kept 51mm.

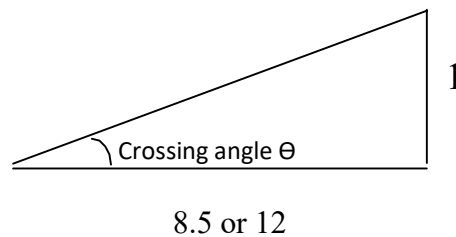
Number of Crossing OR Crossing Number:

Number of crossing is the co-tangent value of the crossing angle.

Normally it is denoted as 1 in N, where N is crossing number. For

Example: 1 in 8 ½, 1 in 12 etc

Both are standard crossing for IRS and are in use.



Crossing Angle:

Angle subtended between gauge lines of crossing nose piece is known as crossing Angle. It is measured at Theoretical Nose of crossing

The typical value of crossing angle is as below

$$1 \text{ in } 8 \frac{1}{2} = 6^{\circ}-42'-35''$$

$$1 \text{ in } 12 = 4^{\circ}-45'-49''$$

Numerical Problems (ANC to TNC Distances):

Question 1 . Calculate the distance from ANC to TNC for 1 in 12 Crossing of 60 kg rail

Answer; For 60 kg rail section, web thickness = 16.5 mm

$$\text{Now Cot } \Theta = \frac{12}{1}$$

The distance from ANC to TNC is = $16.5 \times 12 = 198\text{mm}$

Question 2 . Calculate the distance from ANC to TNC for 1 in 12 Crossing of 52 kg rail

Answer; For 60 kg rail section, web thickness = 15.5 mm

$$\text{Now Cot } \Theta = \frac{12}{1}$$

The distance from ANC to TNC is = $15.5 \times 12 = 186\text{mm} \approx 186 \text{ mm}$.

Check Rail:



At the throat of crossing wheel flange jumps from one rail to another to cross the rail in gap.(flange way gap). In order to ensure that this wheel negotiate the gap properly and does not strike the nose, the other wheel is guided with the help of a parallel fixed rail at specified distance. This rail is called check rail.

As per SOD Minimum = 44mm
Maximum = 48 mm

Turn Out:

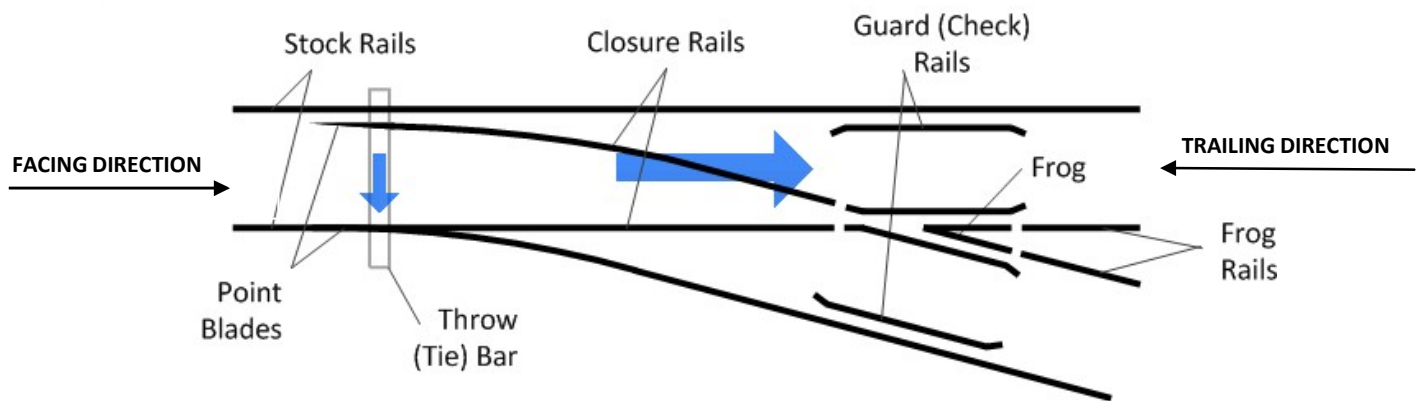


Turnout is a device which is used to direct the vehicle from one track to another.

OR

It is an arrangement of points and crossing with lead rails by means of which rollingstock (Vehicles) may be diverted from one track to another track.

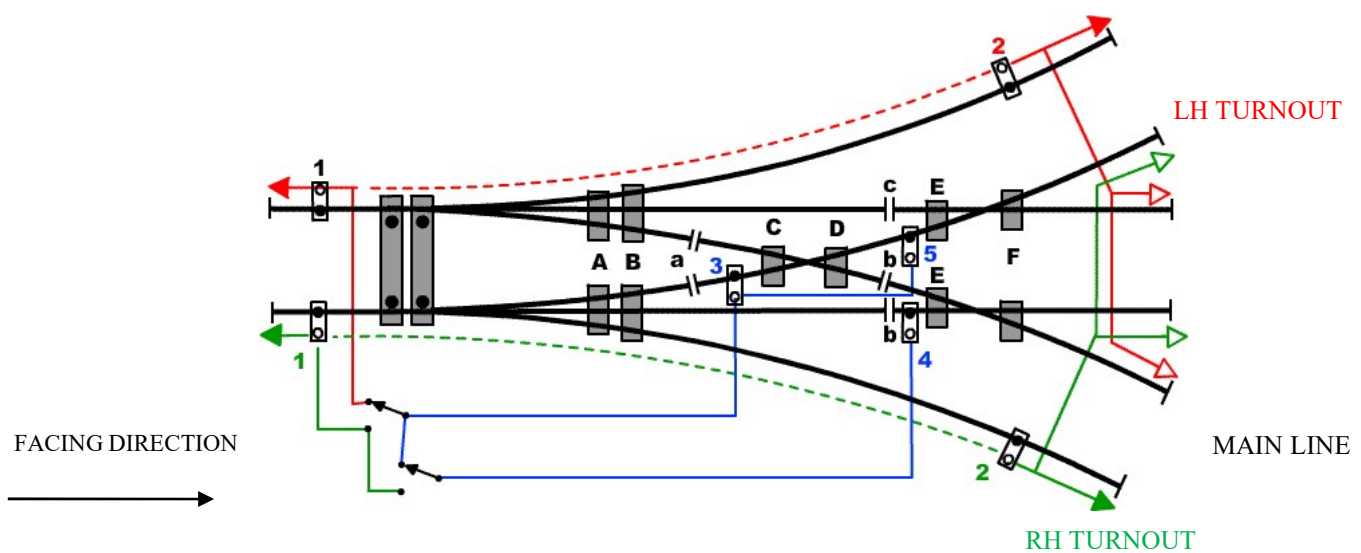
Facing Direction and Trailing Direction:



Train passing on turnout if first passes/crosses the point and then crossing. The direction of train / vehicle is to be known as **Facing Direction**.

Train passing on turnout if first passes/crosses crossing portion and then switchportion. The direction of train will be identified as **Trailing Direction**.

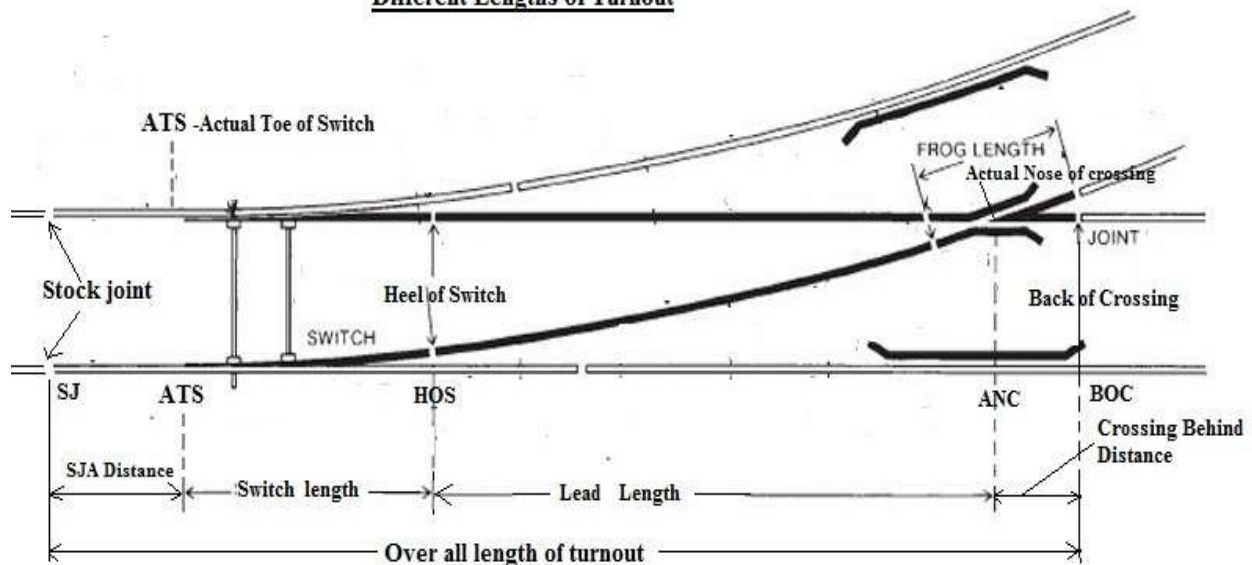
Left-hand & Right Hand Turnout:



A turn out is designated as right hand or left hand depending upon whether the traffic is directed to right or to left respectively .

The vehicle approaching to turn out from facing direction if diverts right hand then it is denoted as Right Hand T/out if diverts left hand side – it will denoted as left hand turn out .

Different Lengths of Turnout



Different Lengths of Turn-Out

Stock Joints ahead Distance (SJA Distance)

It is the straight distance from stock joint to actual toe of switch is known as Stock Joint Ahead Distance.

Switch Length:

It is a straight distance from Actual Toe of switch (ATS) to Heel of Switch is known as switch length

Lead:

Straight distance from Heel of Switch to theoretical nose of Crossing is known as Lead.

Crossing Behind Distance:

It is the straight distance from TNC to Back of Crossing is known as Crossing behind Distance.

Overall Length of Turnout:

It is the straight distance from “stock joints” to “back of crossing” is known as overall length of turnout.

Overall length of turn out = SJA Distance + Switch Length + Lead Length + Crossing Behind Distance

Fouling Mark:



Fouling mark is a point between two adjacent tracks of turnout (behind crossing), where minimum distance as per SOD lies between two track centers so that vehicle on both track can safely pass.





Accessories of Point and Crossing:

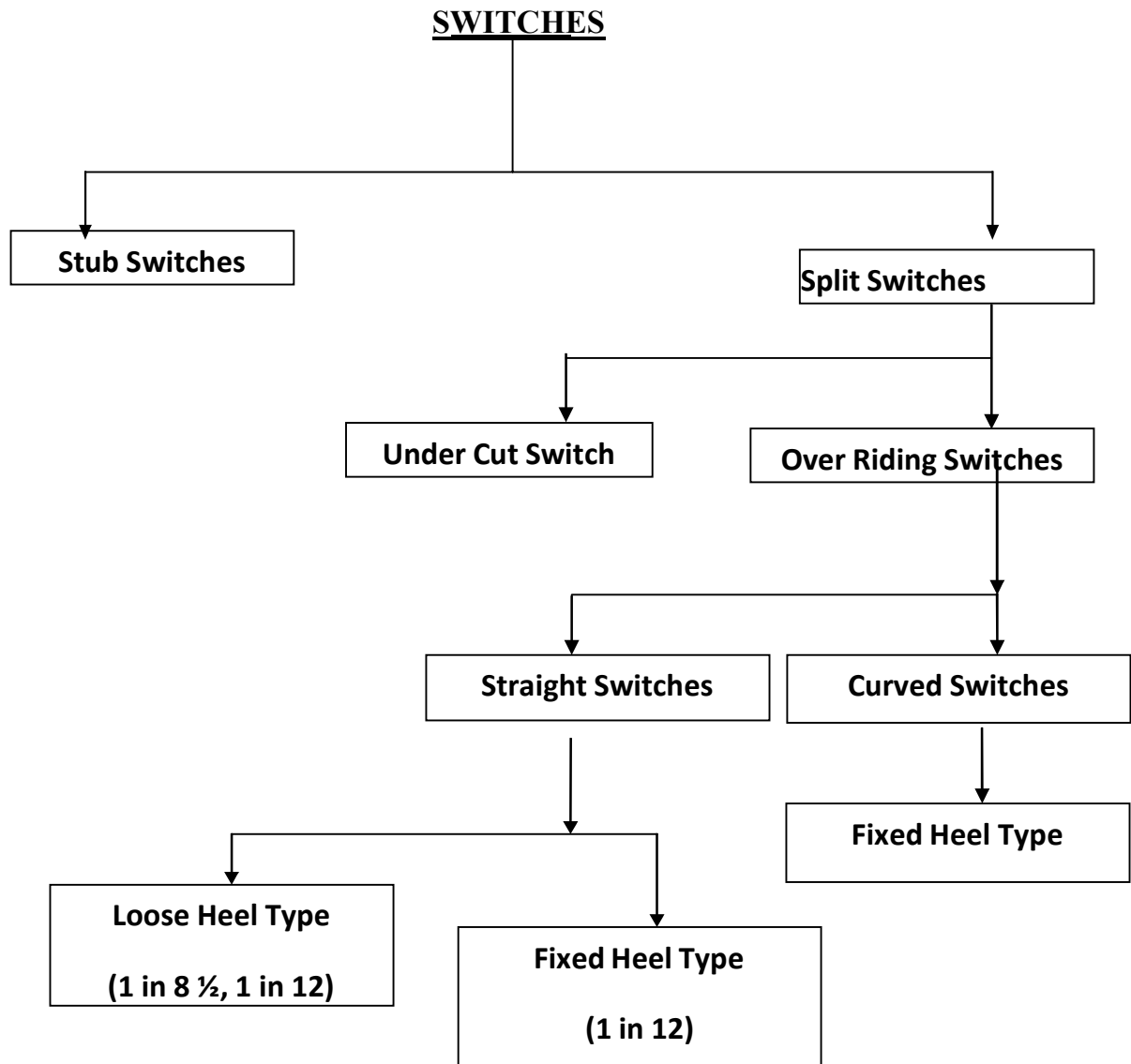
Stretcher Bars
Gauge Tie Plates
Switch Stops
Slide Chairs
Heel Block
Distance Blocks
Crossing Distance Block
Check Rail, etc

Important Notes:

- 1) Gauges are kept slack by 6mm at Actual Toe of Switch.
- 2) Exact gauges are maintained at nose of crossing to avoid hitting of the nose by moving flange.

SWITCHES

Types:-



STUB SWITCH:

In this type of switch, no separate tongue rail or stock rail is provided and some portion of the track is moved from one side to another side for giving path in either track. These switches are obsolete now.



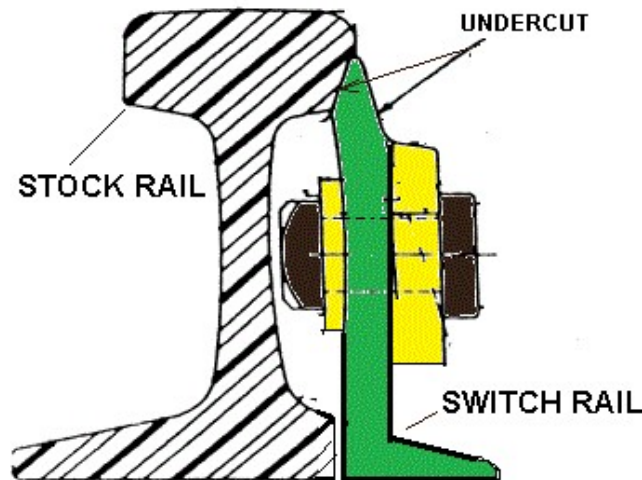
SPLIT SWITCHES:

This type of switches is in use in Indian Railways. It has a pair of stock rail and a pair of tongue rail. In split switches, only tongue rail is moved to give path to the train on either side.

There are two types of split switches:

1. Under Cut Switch
2. Overriding Switch

UNDER CUT SWITCH:



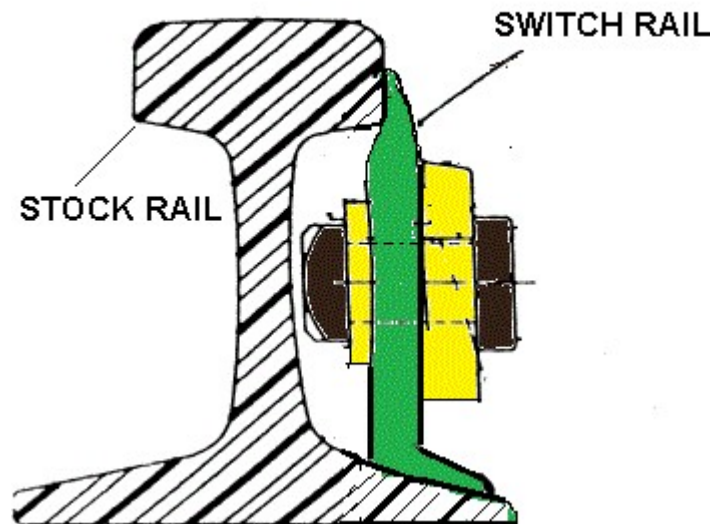
These are old and obsolete type switches for Indian Railway. Initially in this type of switches foot of stock rail is planned /cut to accommodate the tongue rail.

Under cut switches had following major two defects

1. First deficiency /defect was with tongue rail. It was planned in such a manner so that thickness of the toe was reduced to almost nil. Due to this, it worn out in very short period of service (Due to rubbing of wheel and load coming through wheel) and service life of tongue rail was very short.
2. Second deficiency was in stock rail itself. Due to planning, Cutting of the flange, it becomes weak and in under load it start to break

Due to above reasons these switches are now obsolete. To overcome above problems of undercut switches overriding type switches are designed. Which are the standard switches of the Indian Railway.

OVER RIDING SWITCH:



In this type of switch the stock rail has the full section and the tongue rail is planned to 6mm thick edge which over rides on the foot of the stock rail.

In this design the thickness of tongue rail at toe is 6mm, but top surface of the tongue rail is planned in such a way so that it never comes under load unless and until half of the head width not receive by moving wheel.

In this design, tongue rail looks weak but in fact it is very strong. After over riding on the stock rail foot, it becomes stronger. Also up keeping by 6mm at HOS to joint behind the wheel in case of fixed heel, reduces the chances of splitting of point.(In case of trailing direction moment and due to moment of false flange wheel.)

Advantages of Overriding Switches:

Overriding switches are more economical and superior design due to following reason

1. Since there are no cut in stock rail and have full rail section, it is much stronger.
2. Since manufacturing work is involved only in tongue rail, hence it is more economical and easy to manufacture.
3. Although the tongue rail has the thin edge of 6mm but it is supported by the stock rail for the entire weak portion of its length. This gives it more combined strength and chance of damage in tongue rail is eliminated.

Type of Overriding Switches

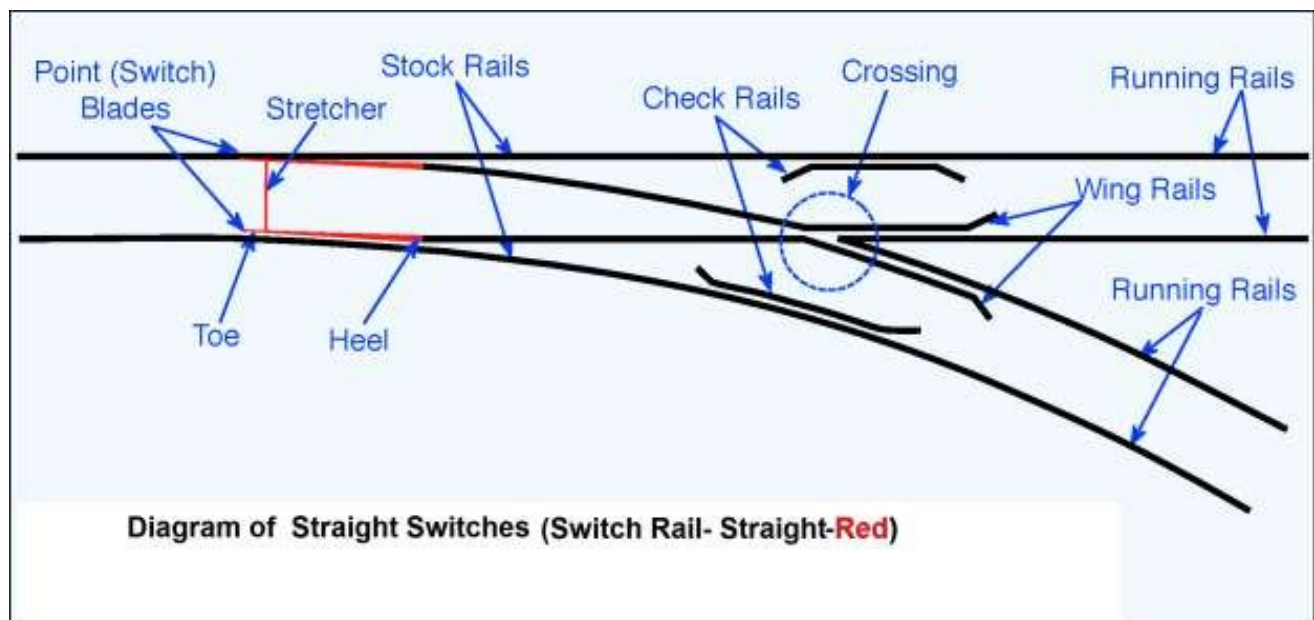
1. Straight Switches
 - a. Short with loose heel
 - b. Long with fixed heel
2. Curved Switch (Normally Longer Switches)

Straight Switches:

Switches having straight tongue rail is known as straight switches.

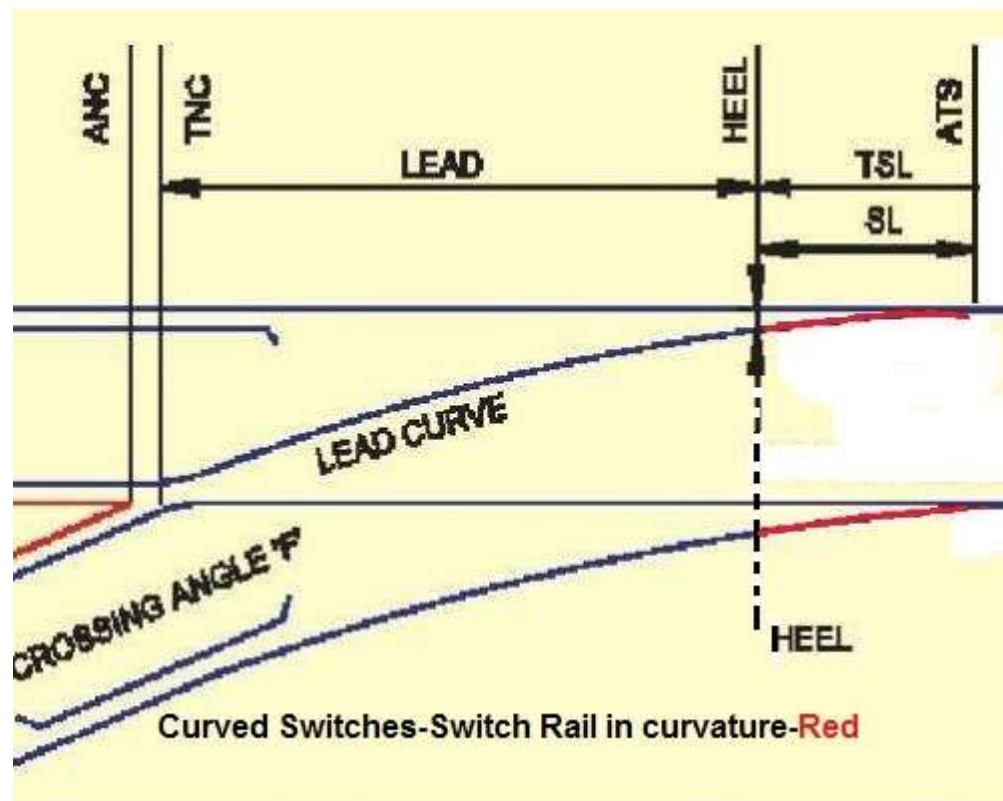
The straight tongue rail had advantage that these are simple in manufacturing and same tongue rail can be used for left hand Turn out and right hand Turnout.

But also has a disadvantage that there is an abrupt change observed in alignment at ATS resulting negotiating trains observe jerk while entry in turn out.





Curved Switches



In this case tongue rail is curved (manufactured) in a curvature of turnout from TOS to HOS resulting smoother entry of trains in turnout. But there is the disadvantage that these can be used only for a particular curvature of left or Right Turnout.



CROSSING

Classification of Crossing:

The Crossings are classified in following two aspects:

1. Based on Crossing Angle(Track Condition)
2. Based on methods of manufacturing

Based on Crossing Angle:

On basis of Crossing Angle the crossings are classified in three types

1. Acute Crossing / V- Crossing
2. Obtuse Crossing / Diamond Crossing
3. Square Crossing

Acute Angle Crossing:

An acute angle crossing or V-crossing is that in which the intersection of two gauges faces (gauge line of pieces) forms an acute angle. In Indian Railway, acute angle crossing is used for all turnouts and cross over.



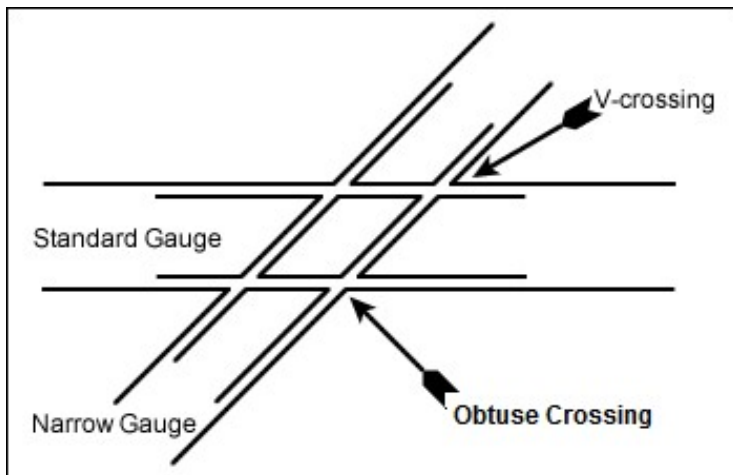
Obtuse Angle Crossing:

Obtuse crossing is that crossing in which the two gauge faces meet at an obtuse angle.

OR

When gauge faces or gauge line of a crossing intersect each other in such a way that angle between it forms an obtuse angle, the crossing is called obtuse angle crossing.

Since this type of crossing is only used in diamond layout hence it is also known as Diamond Crossing.



Square Crossing:

It is formed at the locations where two tracks cross each other at right angle. Because of unguided/Unchecked/ Unprotected flange moment at the nose (due to non-provision of checkrail), there are chances of derailment are more. Hence use of this type of crossing in Indian railway is not in practice.



Based on method of Manufacturing:

In this basis of methods of the crossing is classified into two

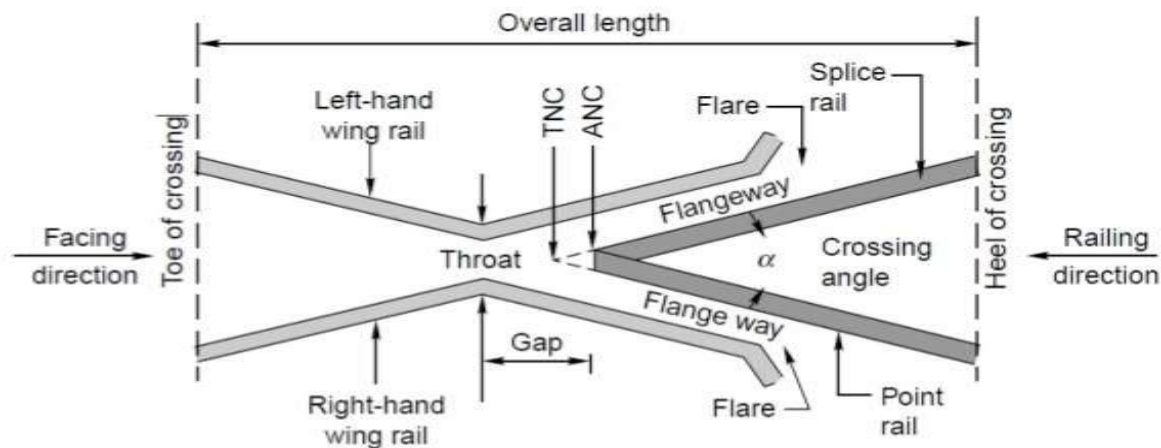
1. Built Up Crossing
2. Cast Steel Crossing

Built up Crossing:

In this type of crossing two flared wing rail and one nose or V-piece (combination of point & Splice rail) are connected by means of iron distance blocks, nut and bolts.

This type of crossing is broadly used on Indian Railways. The major advantage of this type of crossing is

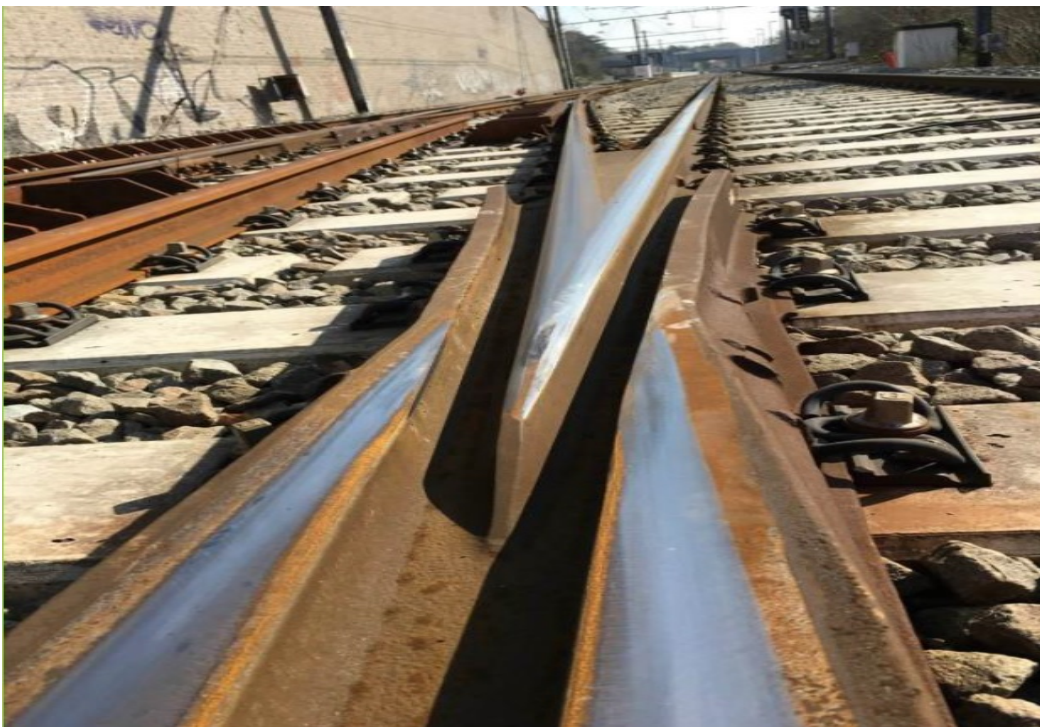
- I. Initial fabrication cost is low.
- II. Wear can be repaired at site without replacing the crossing.



Cast Steel Crossing (Cast Manganese Steel Crossing):

This type of crossing is manufactured by casting process in one piece

In this Series / Type of crossing, CMS (Cast Manganese Steel) crossing is adopted by Indian Railway and it is standard crossing for modern high speed track/Fan Shape turnout.



Advantages of CMS Crossing;

1. It is more rigid crossing in one mass and having no loose parts like bolts, nut etc:- resulting it needs very little maintenance as well as very low maintenance cost .
2. Although the initial manufacturing cost of crossing is high but due to its metallurgical composition (having high manganese percentage) and manufacturing process. It has very good anti-wear capacity even under heavier axle load.
3. Due to its chemical and physical properties it has very long life and about four times in comparison to ordinary built up crossing.
4. Very useful on heavy traffic density routes where traffic block margin is very less.

Check Rail Clearance

The equation for finding check rail clearance is as under:

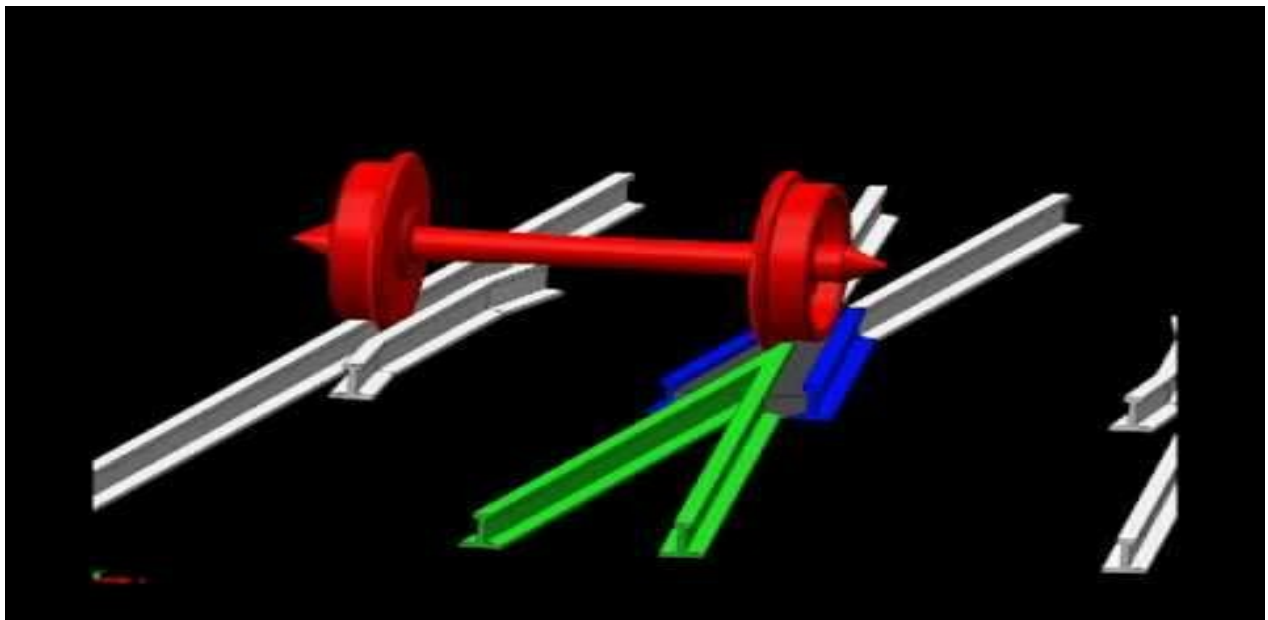
$$\text{Check Rail Clearance} = \text{Track Gauge} - (\text{Wheel Gauge} + \text{Wheel Flange Thickness})$$

For New wheel:

$$\text{Check Rail Clearance} = 1676 - (1600 + 28.5) = 47.5 \approx 48 \text{ mm}$$

For Old Wheel:

$$\text{Check Rail Clearance} = 1676 - (1600 + 16) = 60 \text{ mm}$$



It means the check rail clearance for new profiled wheel should be 48mm and maximum worn-out wheel it should be 60mm. if we will provide 46mm clearance, then old wheel worn out will hit check rail ends and if provide 60mm clearance, then new wheel will hit the nose of crossing.

Hence to overcome above problem 48mm clearance is provided in checkrail and to avoid hitting of check rails. Check rail and wing rail ends are given flared. So that entry of wheel in check rail will be smooth and easy without check rails end hitting.

To give wear out margin and to avoid frequent adjustment in CRC the check rail clearance in BG recommended as

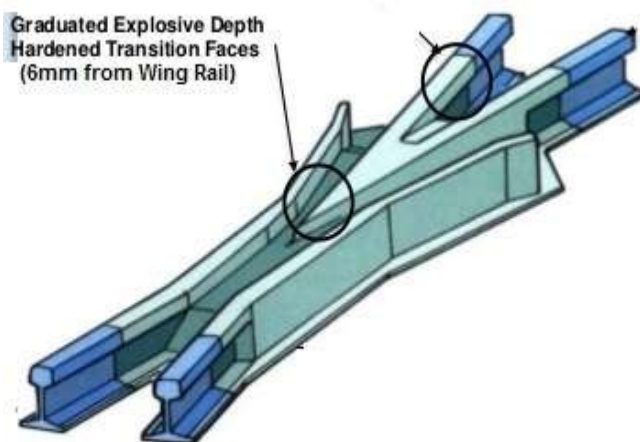
Minimum = 44 mm

Maximum= 48 mm

Note:

1. Instead of giving flare in Check rail / wing rail now-a-days the checkrail is planned in such a way so that the end clearance must be more than 60mm. this designed is specially given with CMS crossing.
2. As per equation of clearance, the track gauge is very important figure. Hence gauge in crossing portion must be very correct. Otherwise, slack or tight gauge will have adverse effect as explained above.

Ramping of Nose of Crossing:



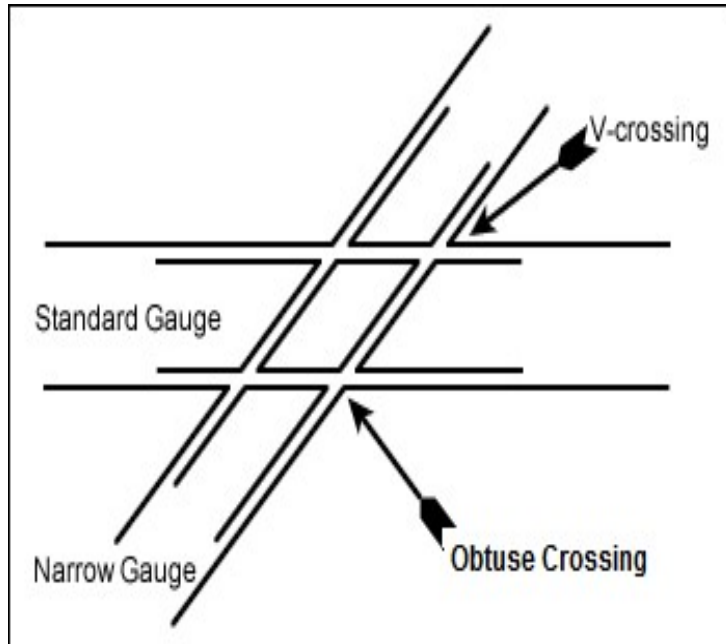
If we will trace the wheel path at crossing while moving on facing direction, we will see the contact area from wing rail is reducing and after a gap, contact area on nose is increasing suddenly. This results in heavy wear in crossing nose. Coning of 1 in 20 in wheel is also responsible for it (wear).

If nose piece will be in same level of wing rail, after arrival of wheel on nose piece from a gap and wing rails, sudden total load will impact on nose. Since thickness of nose is very less, the chances of cracking/breaking of nose is more.

To avoid this level of nose piece is kept 6mm down from wing rail level and leveled after the distance of 90mm. so that load will be impact on nose piece after achieving sufficient head thickness.

DIFFERENT LAYOUTS OF YARD

Diamond Crossing (Layout):



When two tracks cross each other at particular angle, the diamond is formed. These two tracks may be of same gauges or different gauges.

Note: The diamond consists of two acute crossing and two obtuse crossing

Limitation of intersecting angle of diamond crossing:

As per schedule of dimension (SOD) in IR, diamond crossing flatter than 1 in 8 ½ should not be laid. The reasons are following:

1. In diamond crossing, when wheel passes from point rail to elbow or vice-versa, it crosses an unprotected gap (of obtuse crossing). In 1 in 8 ½ diamond crossing the gap is less and as well as crossing will become flatter, this gap will increase. Hence to avoid longer unprotected gap, there is restriction to use diamond crossing flatter than 1 in 8 ½.
2. When intersecting angle will reduce the obtuse crossing of diamond will have tendency to come in front of each other in respect to wheel moment. This is dangerous condition and chances of derailment are more. So that there is a restriction in use of diamond crossing flatter, than 1 in 8 ½.

Provision of Strip on Check Rail of Obtuse Crossing

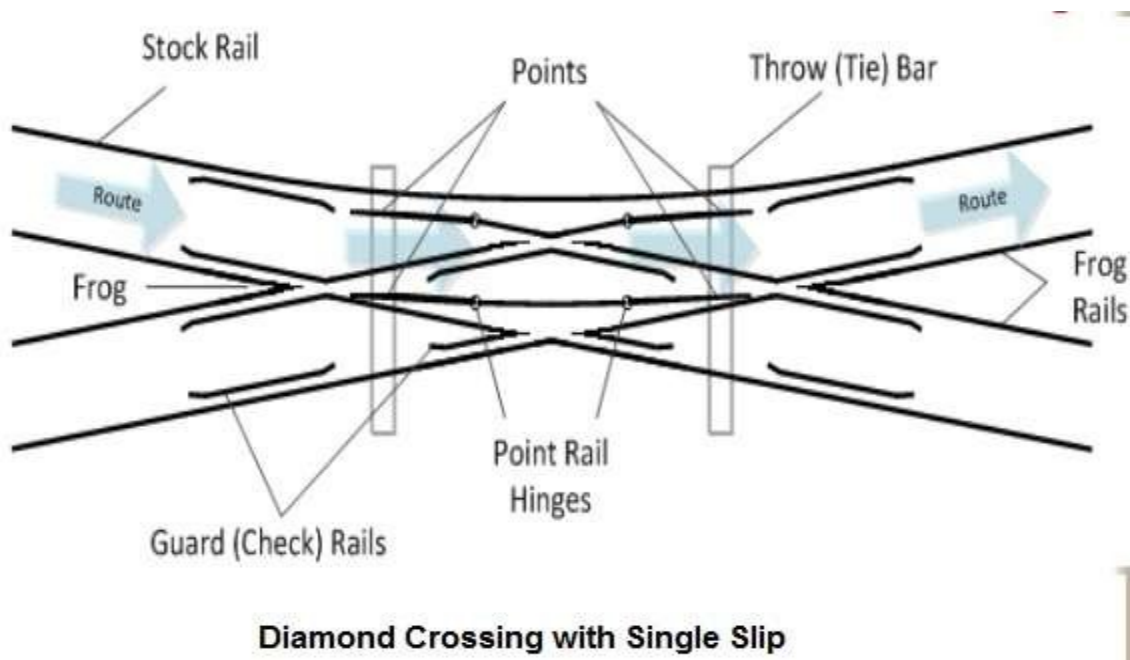
Unprotected gap of obtuse crossing in 1 in 8 ½ diamond is less and wheel passes on it with momentum in few seconds only.

But if the train/vehicle is stopped on it in such a way so that wheel is in the gap or near to gap and when train will start, the wheel will be subjected under jerk and due to this there are chances with wheel to take wrong path, resulting derailment on diamond crossing. There are so many derailments on diamond crossing like this specially with pony wheel of locomotive.

To overcome above problem, the check rail of obtuse crossing is welded with 25 mm thick steel strip for raising height. This welded strip reduces the unprotected gap as well as chances of derailment by protecting properly

Strip more than 25mm is not allowed because of there are chances of infringement of locomotive parts.

Diamond with Slip:-



Slip is an arrangement in diamond crossing through which train vehicle can be diverted from one track to another.

If we will use one pair (2 nos of switches) set of points then it will be called diamond with single slip and when we use 2 set pair (4 nos of switches) of point then it will be called diamond with double slip.

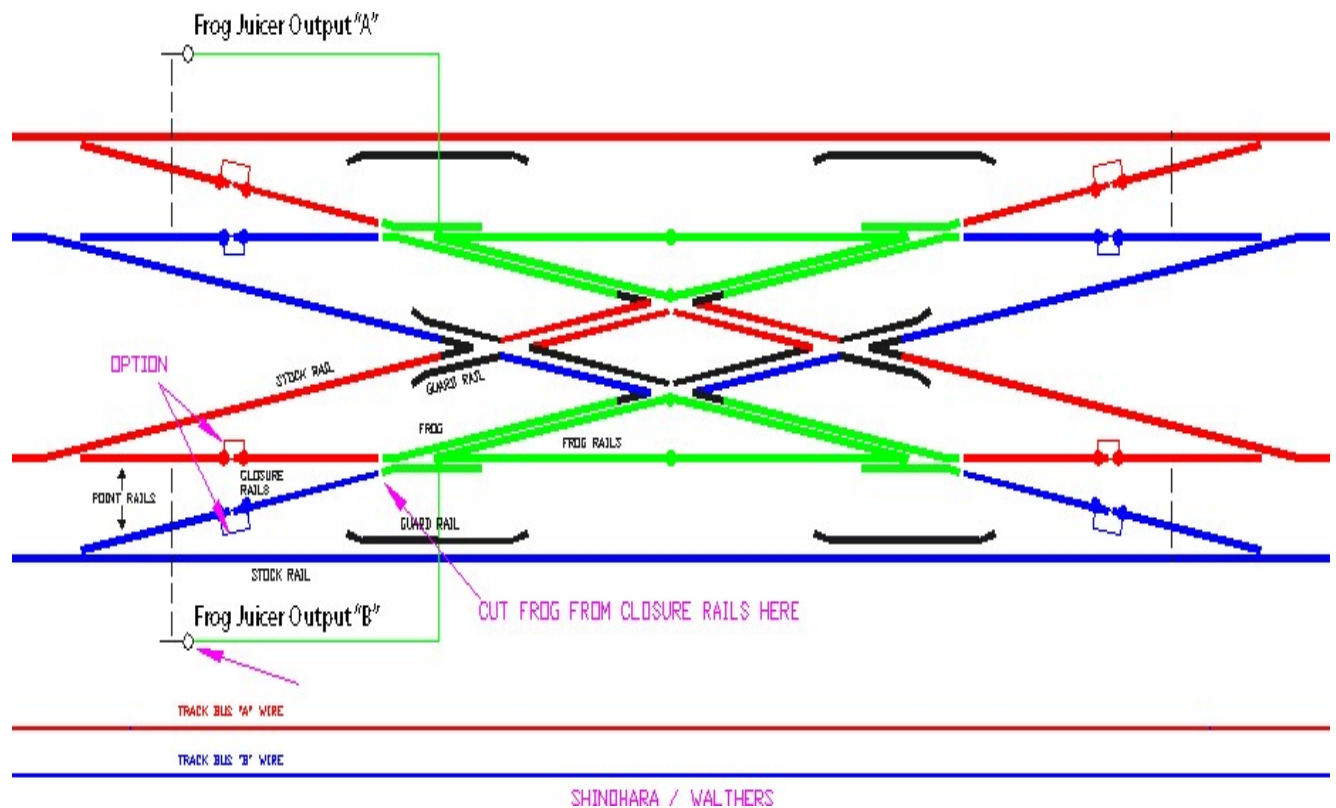


Cross Over:-

Cross over is a layout which is used to connect two through track. It has two turnouts which are connected with each other by intermediate portion.



Scissor cross over:



When two cross-over intersect each other then complete layout is known as scissor cross over.

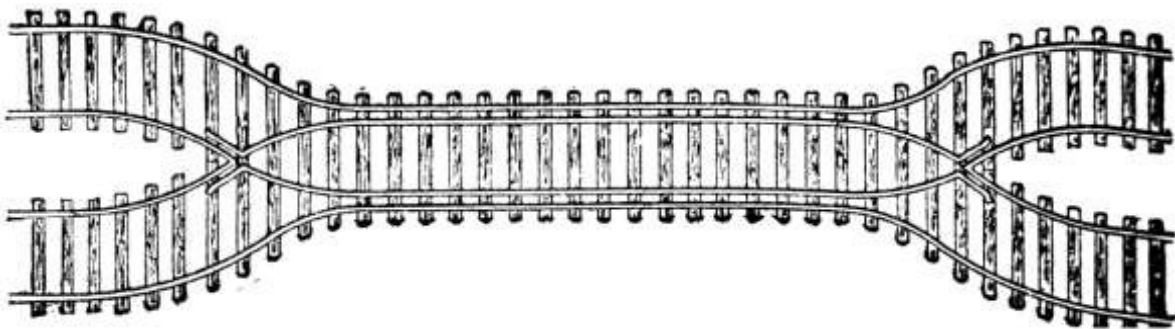
The scissor cross over is provided for a transfer the vehicle from one track to another and vice-versa. It is provided at the location where space does not permit for provision of two separate cross over especially in long platform lines.

Scissor cross over is consist of

1. Four set of turnout
2. One set of Diamond



Gauntleted track



(Line diagram)

When two tracks pass over on same formation and sleeper the layout is named as gauntleted track. This track may be same gauge or different gauge

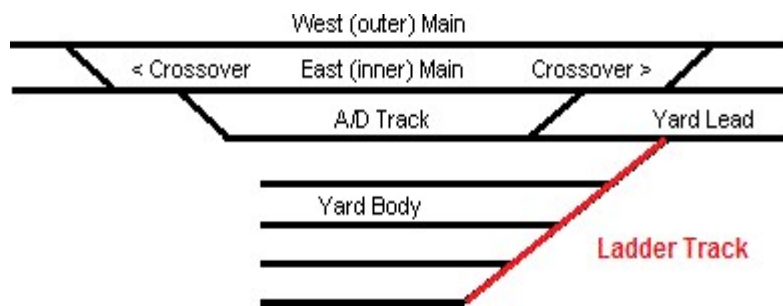
This is temporary diversion provided on double line track so that one of the track is shifted and passes through another on same sleepers.

It is useful connection where one side of the bridge or double line section is required to block for major repair or re-building.

Gauntleted track is also used where trains have to operate on mixed gauge say BG and MG.



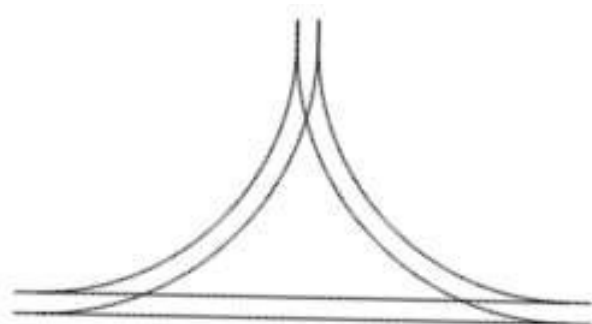
Gathering line/Ladder track



Gathering line is a slopping line in which number of parallel tracks gather or merge or branched off. This layout is very useful in yard section.



Triangle Layout



When three turnouts are laid on straight track or on curve track in such a way so that a triangle is formed in between, layout is called Triangle Layout. This is a substitute of turntable. But it has a disadvantage that it needs a longer space but maintenance of it is easy and cheaper.



RESTRICTION IN USE OF 1 IN 8 ½ TURN OUT IN PASSENGER RUNNING LINE

Restriction in use of 1 in 8 ½ turn out in passenger running line is restricted due to the following reasons:

Whenever a 1 in 8 ½ turnout is provided in passenger line, its turnout angle will be more and its “turn in curve” will be sharper. Due to engine flange force, turn in curve” will become more sharp. When a passenger train enters in a loop line by a speed more than the prescribed speed, chances of derailment on it will become more.

1. Keeping in view of this Railway Board issued a direction that in passenger running line, only 1 in 12 turn out will be used.
2. Until the removal of 1 in 8 ½ turnout from passenger running lines, there will be a speed restriction of 15 kmph on it.(Now a days it is 10Kmph)
3. Speed restriction on turnout will be as following

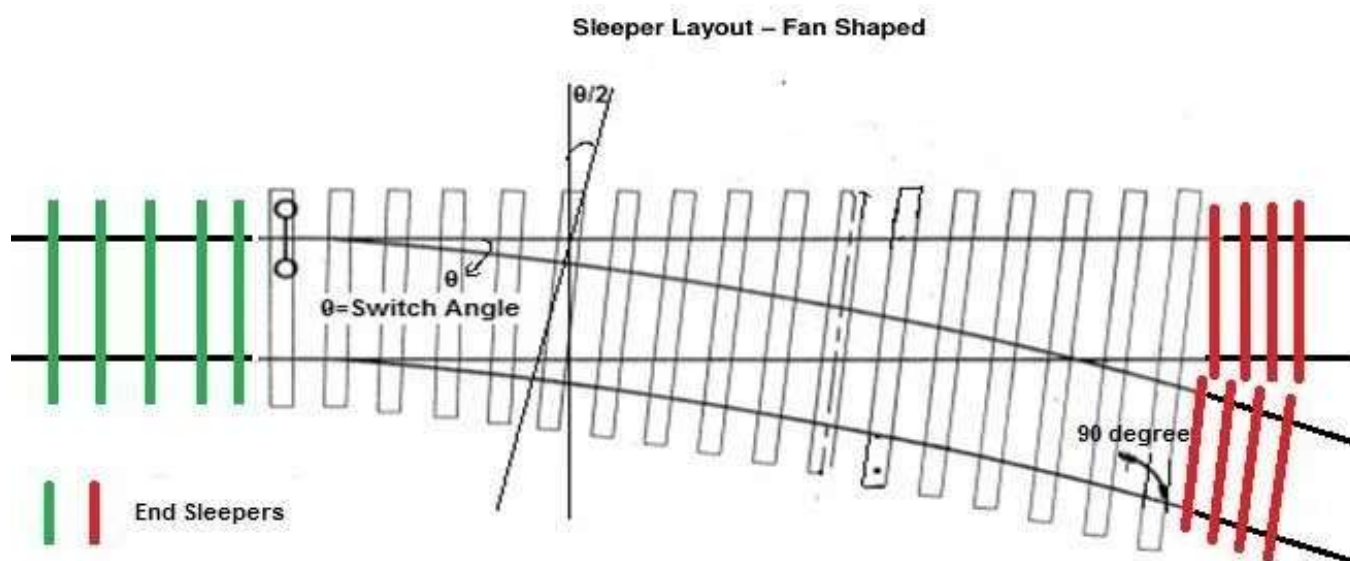
1	1 in 8 ½ Turn out	Curved/Straight Switch	15 Kmph
2	1 in 12 turnout	Curved/Straight Switch	30 Kmph
3	1 in 8 ½ turnout	Symmetrical split curved switch	30 kmph

Important Notes for Point and Crossings:

1. No gradient will be provided in approaches of turn out upto 30 metres.
2. If contrary split switch is provided in any turnout , then speed restriction will be 10 kmph.

FAN SHAPED TURNOUT

Special Features:



S.No.	Turnout	1 in 12	1 in 8 ½	Sleepers' Positions
1.	Sleeper no	1-20	1-13	switch sleeper-perpendicular to mainline track
2.	Sleeper no	21-65	14-41	Lead sleeper- at angle of $\theta/2$ from main line, where θ =Switch Angle.
3.	Sleeper no	66-83	42-54	Crossing sleeper- perpendicular to crossing turnout track.

1. The position of Switch sleeper will be perpendicular to mainline track
2. The position of sleepers on lead curve will be at angle $\Theta/2$ from perpendicular drawn on mainline from that point.

Where Θ is the angle between main lines and tangent drawn to lead curve through the point.

3. The position of crossing sleeper will be perpendicular to crossing turnout track.

Note :

Top view of this turn out looks like a fan (Hand fan), hence this turn out named as “FANSHAPED” Turn out .

Advantages of Fan Shaped Turn Out:

1. Complete one set of sleeper can be used for both types of turnout i.e. left & right, resulting to avoid unwanted inventory confusion.
2. It provides heavy, strong and robust type track structure due to PRC sleepers. Hence its lateral and longitudinal stability is very good.
3. Same set of sleepers can be used for 52kg and 60 kg rail section. Only with changing of the liner
4. CMS Crossing for different type of rail section (52kg and 60 kg) has identical footing.
5. Comparatively longer switch are used resulting in smooth entry of trains on turnout side.

Laying:-

1. Number of sleepers

Turn Out	Approaches End Sleeper	Turn Out Sleeper	Total Sleeper
1 in 8 ½	13(5+8=13)	54	67
1 in 12	13(5+8=13)	83	96

Note: S-Signal sleeper at motorized point for motor installation.

2. Precaution

MFG DATE	60 KG	RE
----------	-------	----

RE mark should always be kept in right side while laying whether it is right hand or left hand turnout.

3. Important Dimension of Fan shape Turn Out

DIMENSIONS	1 in 8 ½ in mm	1 in 12 in mm
Stock Joint Ahead Distance	1500	1144
Switch Length	6400	10125
Lead	18395	25831
Radius	232260	441360
Over All Length	28613	39975
Switch Angle	46°59''	0°20'0''
Length of Tongue Rail	7620	12356
Length of Stock Rail	12800	13000
Length of CMS crossing	3300	4350
Heel Divergence	182	175

Handling of Turnout Sleepers:

1. Switch and approach sleepers shall be loaded on BFR-perpendicular to track.
2. Lead and Crossing Sleepers-shall be loaded on BFR-along the track.
3. Wooden batterns shall be provided between two layers of sleepers-to avoid damage of sleepers.
4. Loading and unloading shall be done preferably by Crane.
5. Do not throw one sleeper on another.

PROTECTION

PATROLLING

The following are the types of patrolling in terms of track:

1. Keyman's daily patrol

In every morning every inch of track to a certain distance is watched by a keyman for any damaged (or) missing parts of the rail fastenings like pandrol clips, liners, fish plates etc.

2. Security Patrolling

- a. At the time of civil disturbances (Internal disturbances)
- b. External disturbance
- c. At the time of VIP movement

3. Weather patrolling:-

a. Monsoon Patrolling

This is done during Monsoon Season

i. Stationery Patrolling

This is done on standard points where the track invent/that may tend to wear very soon

ii. Mobile Patrolling

b. Hot weather patrolling

c. Cold weather patrolling

DAY: It is defined as the time between sun rise and sun set.

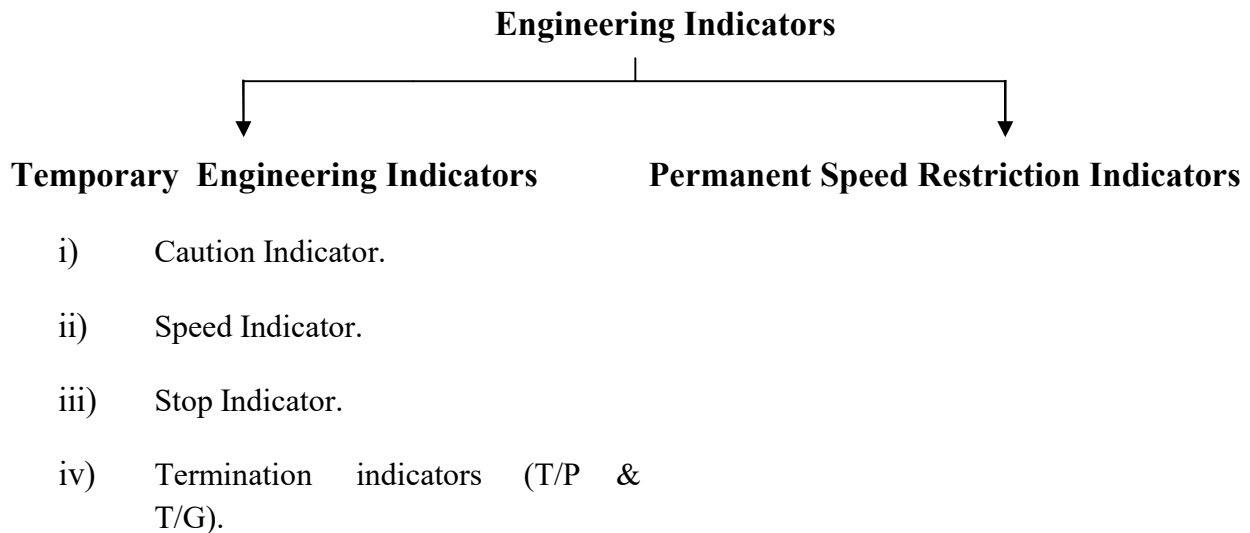
NIGHT: It is defined as the time between sunset and sun rise.

Engineering Work:-

The work related with tracks like Maintenance, New laying etc. are known as Engineering Work. Normally engineering work should not be carried out in night.

1. **Short Duration Works:** The works which are carried out only in one day. E.g.- Rail Renewal, TTM working, Welding Etc. No night involves in it.
2. **Long Duration Work :** The works which are carried out in two days (or) more than two days including at least one Night or more. For example-Major bridge repair, deep screening etc.

ENGINEERING INDICATORS

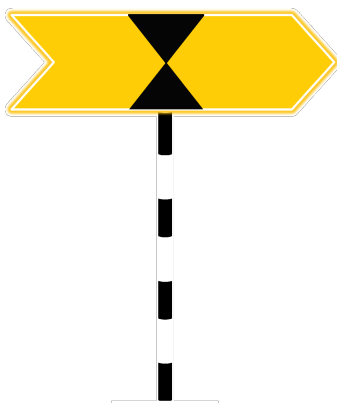
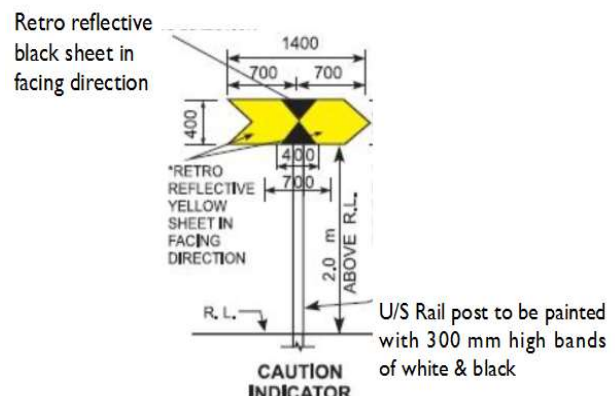


(i) Caution Indicator :-

This cautions the driver to get ready to reduce the speed. Caution indicator shall be provided at 800m in rear of the speed indicator and at 1200m where the trains are required to stop dead as in this case more braking distance is required by driver.

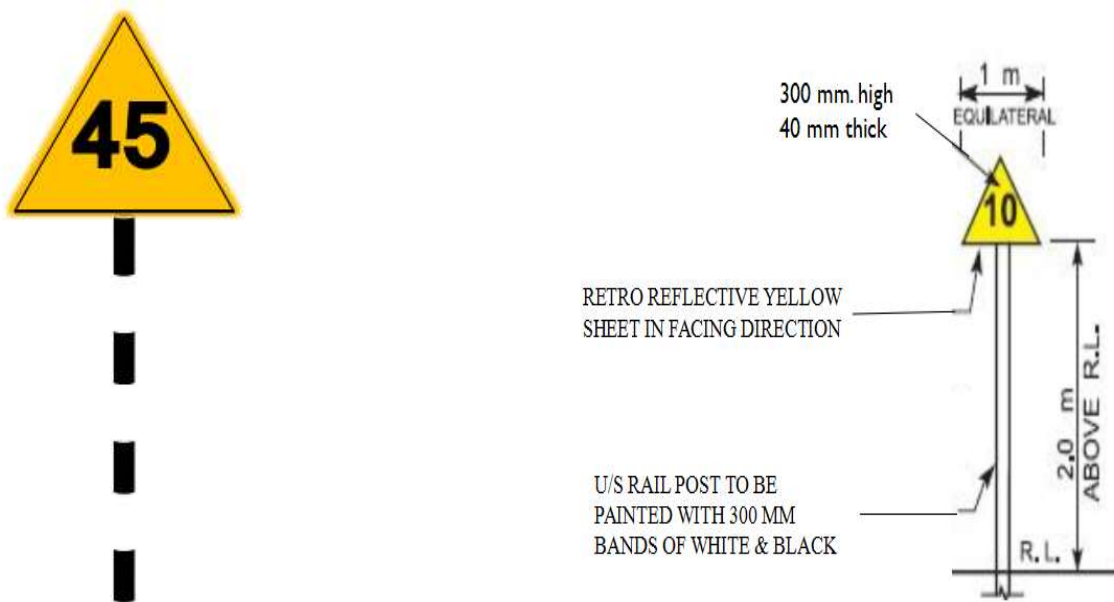
This shall consist of 1400mm long, 400mm wide. Fish tailed at one end and pointed at the other having 130mm dia. holes 2 nos. for showing yellow lights at night. The board shall be painted yellow & black.

Height of the board (bottom of the board) shall be 2.0m from rail level post will have 300mm high bend of white and black. Indicator shall be used in case of permanent as well as temporary restrictions. Temp. Engg. Indicator shall display at night 2 yellow lights to approaching trains or provided with fluorescent tape luminous paint or retro- reflective indicators (need not to lit at night).



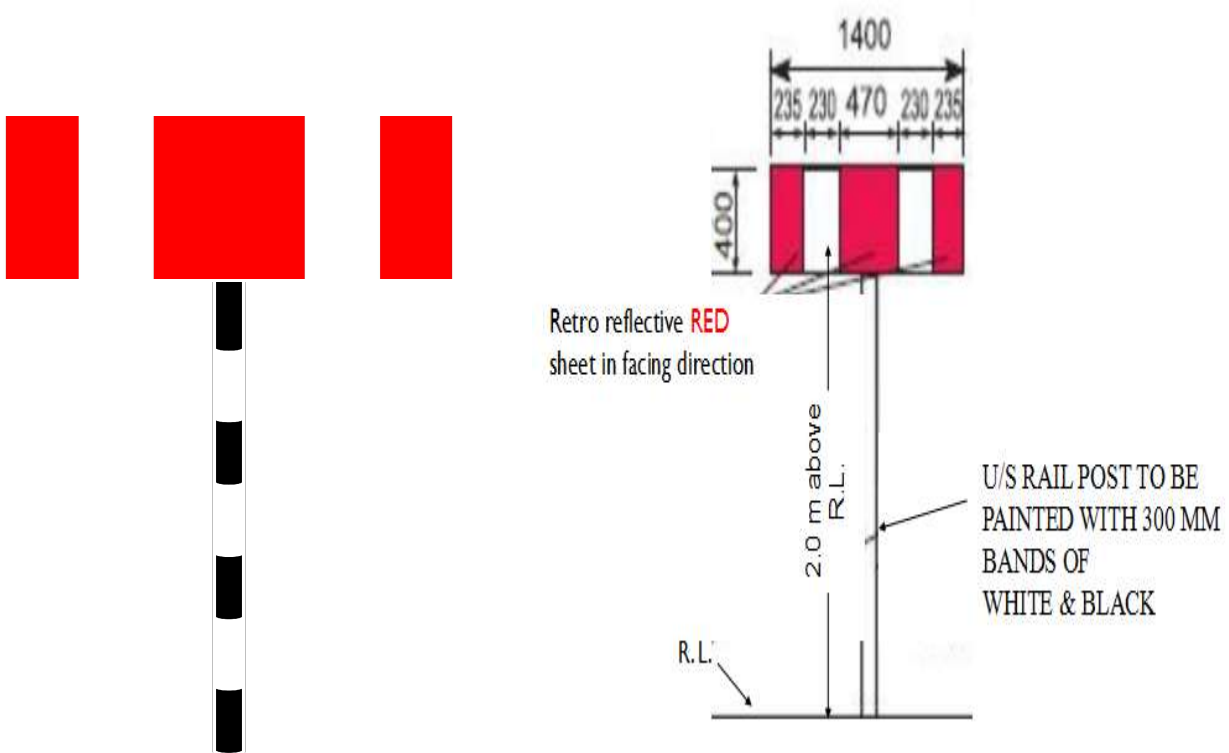
ii) **Speed Indicator :-**

It indicates to the driver to reduce the speed as indicated. This shall be provided 30m in rear from the point of commencement of speed restriction. Indicator shall consist of an equilateral triangular board with 1 meter sides having yellow base, 300mm high and 40 mm thick figures in black indicating the speed at which the train may proceed. The board shall be provided on a 2.0m high post (from the rail level to bottom of the board) painted with 300mm high white and black bands. Indicator shall be illuminated at night by fixing a hand signal lamp in front of it or provided with luminators.



(iii) **Stop Indicator :-**

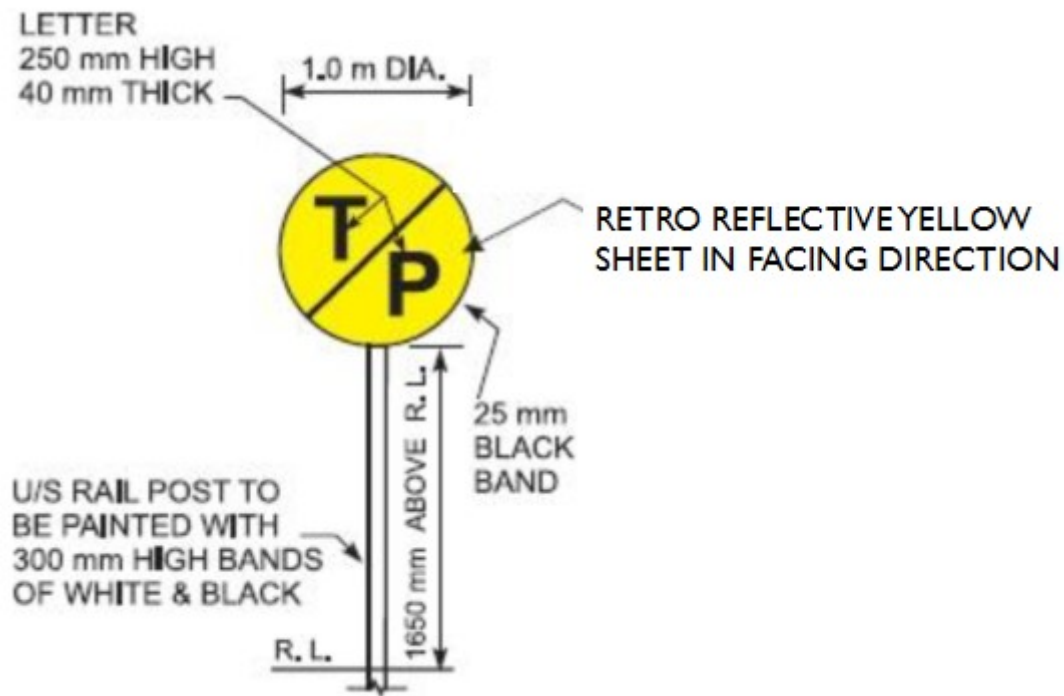
It indicates to the driver to stop the train short of indicator. Indicator shall be provided 30m m in rear of the commencement of stop dead restriction. This shall consist of a rectangular board 1400mm x 400 mm in size having 130mm dia. holes 2 Nos. for showing red lights at night painted with red and white vertical strips or provided with fluorescent tape luminous paint or retro reflective indicator. The board shall be fixed 2.0 meter high from rail level to the bottom of the board) painted with 300 mm high bands of white & black.



(iv) Termination Indicator :—

This indicates that the driver to resume normal; speed and last vehicle has cleared the restricted zone. This indicator shall be fixed at a distance equal to the longest length of passenger/goods train running in the section beyond the restricted zone.

The indicator shall be in accordance with the diagram & shall consist of one meter diameter disc painted yellow bearing 250mm high and 40mm thick letter T P and T.G. in black. The board shall be painted with 25mm thick black band at the circumference. It shall be fixed on a post 1650mm high (from rail level to the bottom of the disc) and shall be painted with 300mm high bands of black & white. The indicator shall be lighted at night by a fixed hand signal lamp or provided with fluorescent tape luminous paint or retro reflective indicator.



Temporary Engineering Indicators:

These indicators are used in connection with execution of some engineering work and removed as soon as the work is over. These indicators are flood lit at night. Retro-reflective indicators need not to lit at night. Significance of each indicator is given as below:

PERMANENT SPEED RESTRICTION INDICATORS:

(i) These indicators are same as mentioned above but used at the locations requiring permanent speed restriction (less than maximum sanctioned speed) such as weak bridge, sharp curve, weak formation turn out etc. As these restrictions last beyond the currency of the working time table hence mention of such restrictions are made in the working time table. Indicators provided are not lit at night.

(ii) Siding Boards – Siding boards indicating speed restriction are provided at facing of an outlying siding letter „S“ is painted in 300 mm height with black paint on 1 metre dia circular board having yellow base. These boards are provided in addition to caution & speed indicator where maximum sanctioned speed of the section doesnot exceed 59 kmph.

Indicators (General):

These indicators are provided either to give audible warning by the driver to ensure safety or shunting operation.

<p>Whistle Indicator (W):</p> <p>Whistle Indicators shall be provided at 600 m in rear of the places where the view of driver is obstructed by cutting or tunnel or curves and where it is necessary to give audible warning at the approach of a train to those working on the track.</p>	
<p>Whistle Indicators for Level Crossing (W/L):</p> <p>These indicators shall be provided at the approaches of all unmanned „C“ class level crossing or manned level crossing where the view is not clear on either side for a distance of 600 metres and those which have normal position open to road traffic. Bilingual whistle boards shall be provided at 600 m distance along the track from the level crossing to give audible warning by the drivers of approaching trains to the road users.</p>	
<p>Shunting Limit Boards:</p> <p>A rectangular yellow board (600 x 1000 mm) with a black cross at the top and the words 'Shunting Limit' (or 'S/L') indicates the end of a shunting section. This sign normally also has black and white bands on it, and white lamps attached on both sides (although the words are only on the side towards the station). This is usually provided at class 'B' stations on single-line sections (sometimes double-line) where shunting is permitted on the block section and advanced starters are not provided.</p> <p>The sign is placed 400m to the rear of the first stop signal of the station in lower-quadrant signaling (180m in modified lower-quadrant, upper-quadrant, and MACL systems). A single white lamp may appear through a hole in the sign above the centre.</p>	

Works at Times of Poor Visibility:-

No work which may cause obstruction to the passage of train shall be undertaken during foggy or tempestuous weather impairing visibility except in case of emergency. When such works are undertaken 2 detonators, 10 m apart shall be fixed 270 m in rear of caution indicator and caution hand signal exhibited to approaching trains.

Speed Restriction:-

In case where the trains are required to pass with restricted speed from site of work, the following temporary Engineering Indicators shall be exhibited.

(i) **Caution Indicator** – At 800m in rear of the obstruction.

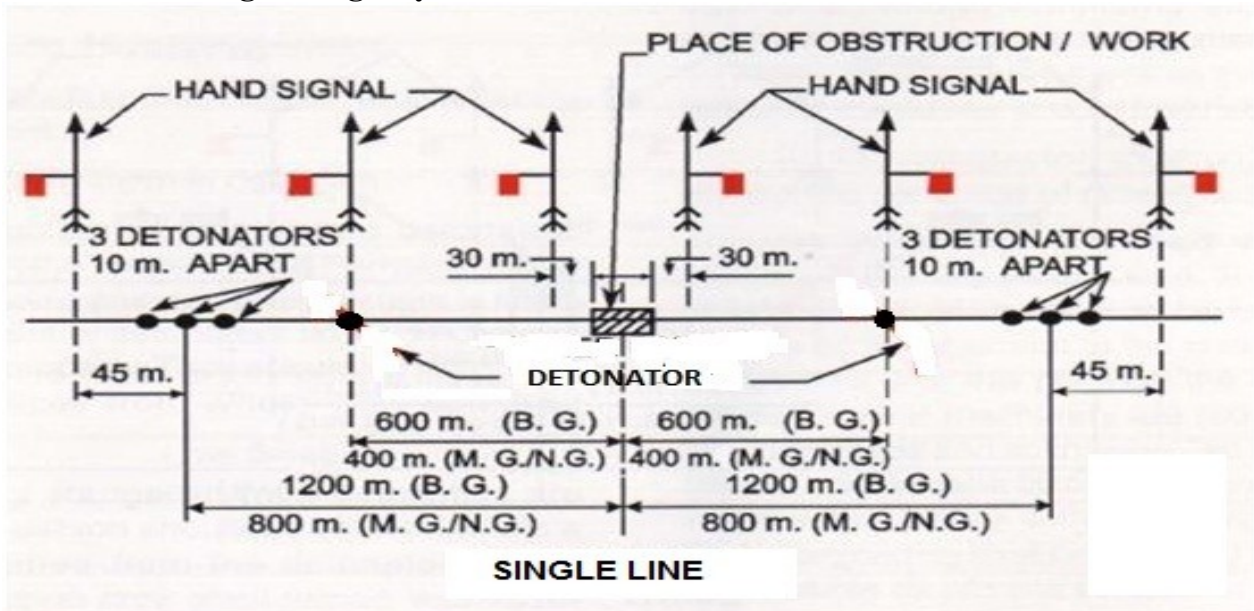
(ii) **Speed Indicator** – At 30m in rear of the obstruction.

(iii) **Termination Indicators for passenger & goods train** – At a place from where the driver may resume normal speed, which is the length of longest passenger/goods train running in the section.

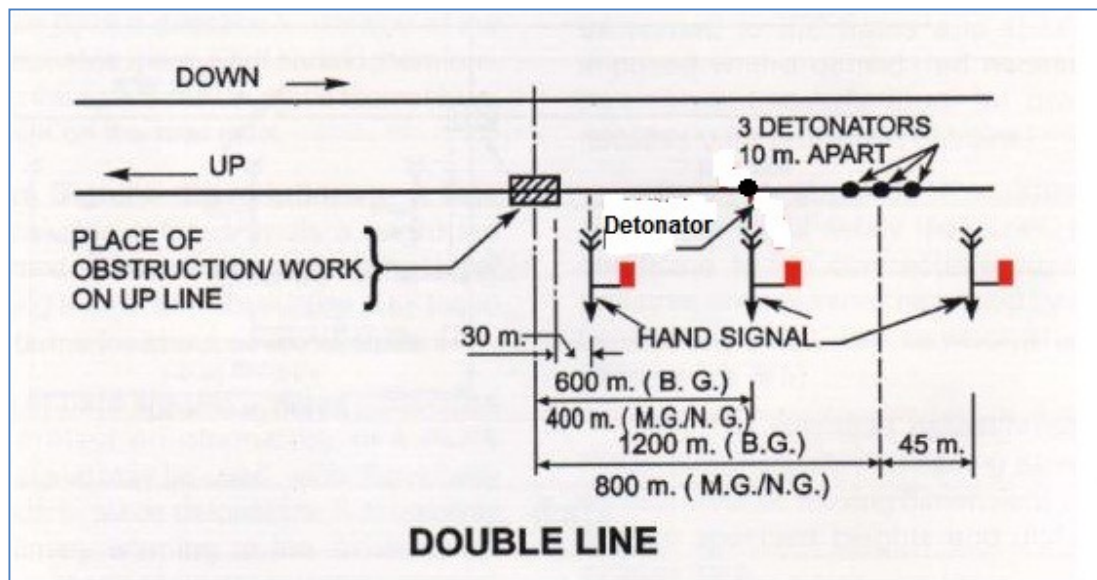
PROTECTION:-

1. Protection During Emergency
2. Protection During Short Duration Work
3. Protection During Long Duration Work
 - i. When stop dead & 10 KMPH is required
 - ii. When only speed restriction is required

Protection During Emergency:



Key Man Having (1). 6 Nos of detonators (2) 2 Red flag & 1 Green Flag

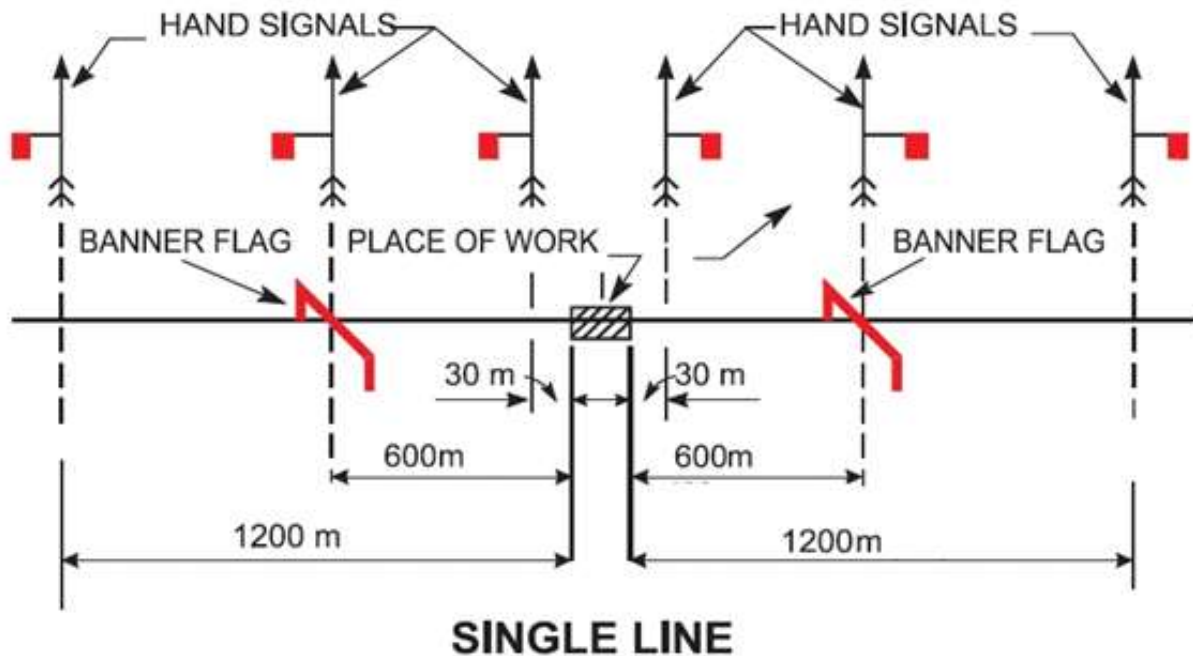


Note:

1. Red hand signal Flag (HS Red Flag) for day and Hand signal red lamp is considered as a danger signal.
2. All distances should be measured from the danger zone
3. Single line protection will be made in both direction and in double line protection will be made in direction from which the train as to come.
4. In case of emergency concerned railway person will take his own decision to stop the train in any how before reaching the danger zone.

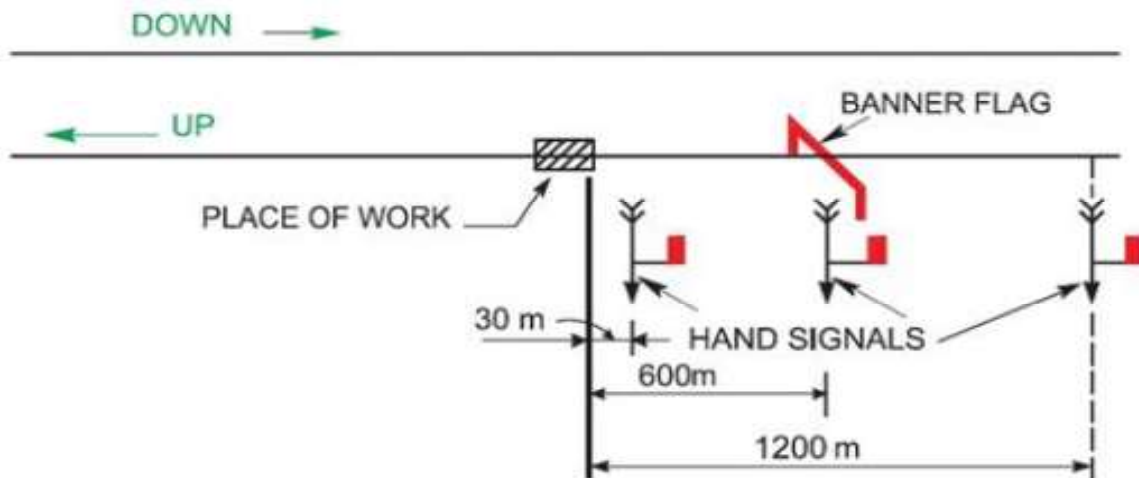
Protection during short duration work (In single Line BG Track)(6 Flag men used)

WORKS OF SHORT DURATION - PROTECTION OF LINE IN CASE OF REDUCED SPEED



Note:

1. In this protection red banner flag is considered as a stop signal
2. In this protection 3 flagmen required in one side(single line- 6flagmen , Doubleline 3 Flagmen)
3. In single line protection will be made in both direction and in double line protection will be made in 1 direction
4. In case of TTM working these flag man will also be mobiled keeping the standard distance as maintained

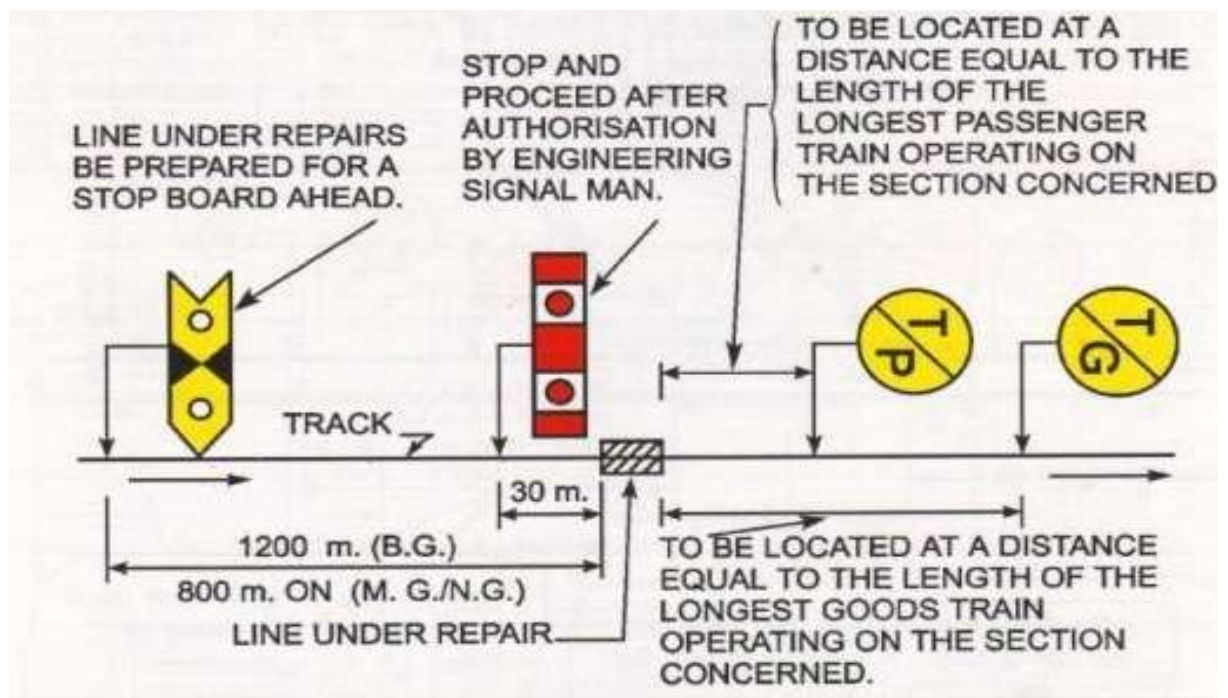


DOUBLE LINE

Note-

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.

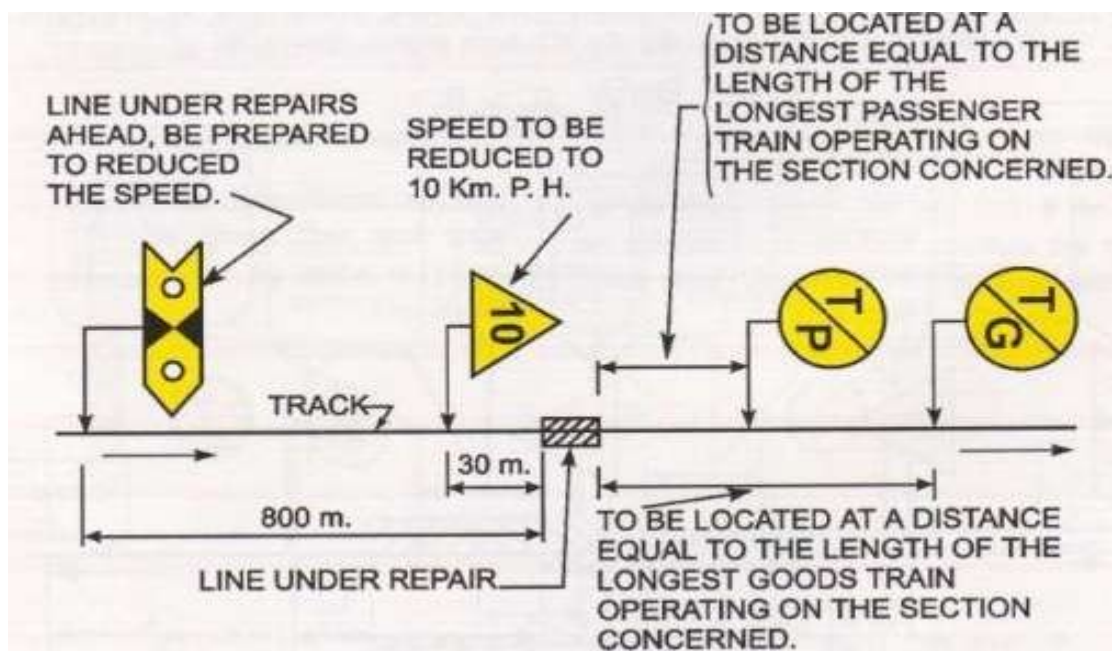
Protection During Long Duration Work (Single Line BG)



Note:

1. For long duration work protection of track is carried out with the help of caution board etc
2. During night each board will be manned and lighted only stop dead board will be equipped with a stationery patrolman (round the clock) with patrol book.
3. After passing out the train the entire danger area will be inspected by stationery patrolman and If found satisfactory then only next train will be permitted to pass out on danger one with the speed of 10 KMPH
4. All the distances shall be measured from danger zone.
5. During day H.S. Red flag & during night H.S Red Lamp is considered as dangersignal.

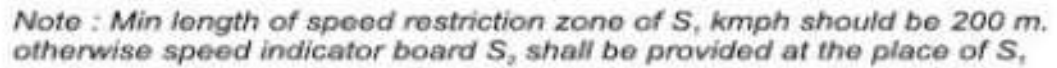
Projection during Long Duration (When Speed restriction only required)



Note:

1. During day no patrol man is required.
2. In night all board will be ignited
3. During night patrolman is required
4. All dimensions should be measured from danger zone
5. Speed restriction depending upon track condition.

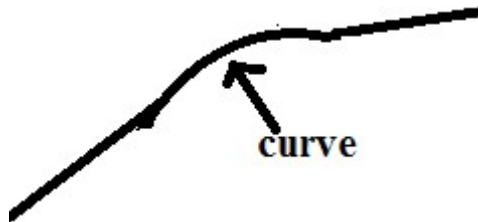
CASE - I : $S_2 < S_1$



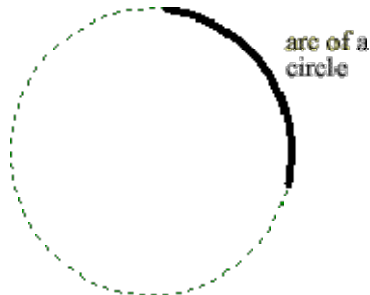
CURVE

Definitions: –

Curve: The geometrical “ARC” provided at the change of Alignment or Gradient is known as “Curve”



Arc: Any part of circumference of a circle is known as ARC.



Tangent: It is the straight line which touches the circumference of a circle only at one point. It is always at right angle to the radius at the point of contact. From any point outside the circle only two tangents can be drawn.

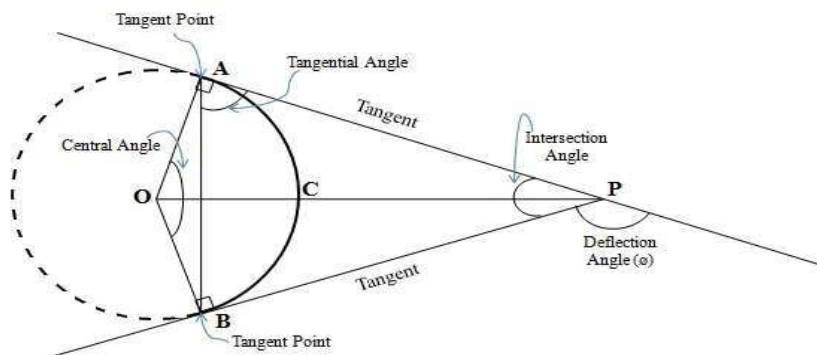


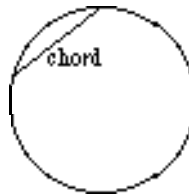
Figure 1.1

Tangent Point: It is the point of contact of Tangent and Circle (see Fig.1.1)

Tangent Length: It is the distance between the tangent point and the external point from where the two tangents are drawn. (AP & BP in Fig.1.1)

$$\text{Tangent Length (TL)} = R \cdot \left(\frac{\theta}{2}\right) \text{ Where } \theta = \text{Deflection angle}$$

Chord: It is a straight line joining two points of the curve



Short Chord: In Indian railways (Particularly on high speed), 20 mtrs length of short chord is considered as standard for track geometry measurement.

Long Chord: It is a straight line joining the two tangent points of a curve (AB in Fig.1.1.)

Longest Chord: The diameter of the circle is its longest chord.

Apex: It is the highest point on the curve which is also at middle of the ARC (Point „C“ in Fig.1.1.)

Apex Distance: It is the distance between intersection points of the tangents and middle of the Arc (CP in Fig.1.1.)

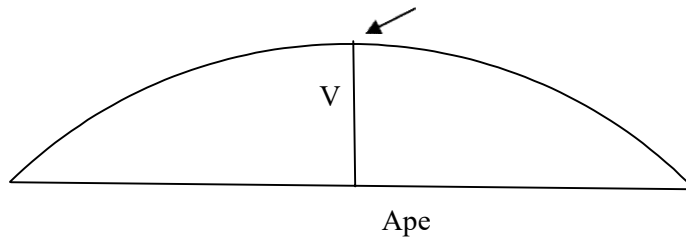
Deflection Angle: It is angle through which the curve turns. It is taken as an external angle between intersection points of two tangents (refer Fig.1.1.)

Intersection Angle: It is the internal angle of two intersecting tangents (refer Fig.1.1.)

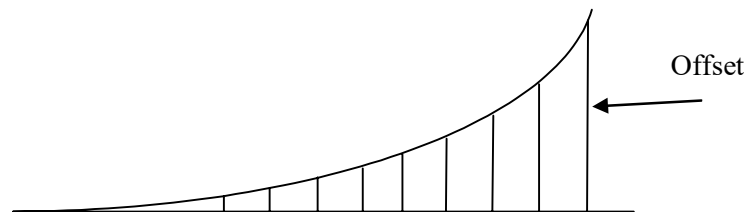
Tangential Angle: It is the angle which is formed by the long chord and tangent (refer Fig.1.1.)
It is equal to half of the deflection angle

$$\text{Tangential Angle} = \frac{1}{2} (\text{Deflection Angle})$$

Central Angle: The angle subtended at the centre of the circle by the curve selected is called Central angle. It is also equal to the deflection angle of that selected curve.



Versine : It is the perpendicular distance from the middle of the chord drawn to the curve.



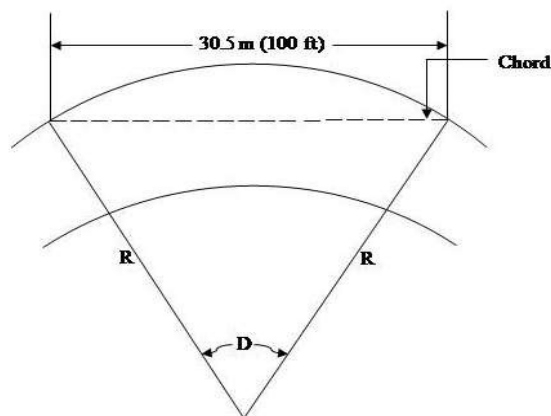
Offset: It is the perpendicular distance from the tangent to arc of circle.

Degree of Curve:

Definition:

A curve is defined either by its radius or by its Degree. **Degree of curve (D)** is the angle subtended at its centre by a chord of 30.5 meters/100 feet length.

Since railway curves are very flat (i.e., when Radius is very large, an arc of a circle is almost equal to the chord connecting the two ends of the arc) hence the degree of curve for all practical purposes is also defined as the angle subtended by a curve of 30.5metres/100 feet length at its centre.



Maximum Limit of Degree of Curve in Indian Railways

1. Broad Gauge (1676mm) :- 10^0
2. Meter Gauge (1000mm) :- 16^0
3. Narrow Gauge (762mm) :- 40^0

Relation between Degree & Radius of Curve:

Circumference of a circle = $2\pi R$

Angle subtended at the centre by a circle with this circumference = 360^0 Angle subtended at the centre by a 30.5-m chord, or degree of curve

$$= \frac{360^0}{2\pi R} \times 30.5 = \frac{1747.52}{R}$$
$$= \frac{1750}{R} \text{ approx., (where } R \text{ is in metres)}$$

The degree of the curve is thus given by the following formulae

$$D = \frac{1750}{R} \text{ (where } R \text{ is in metres)}$$

Hence radius of the curve in terms of degree of curve will be given by

$$R = \frac{1750}{D} \text{ (where } D \text{ is in degree)}$$

Value of versine in terms of chord:

Let “C” be the length of the chord AB and “V” be the Versine of the curve of radius „R”

From the property of curve we know that

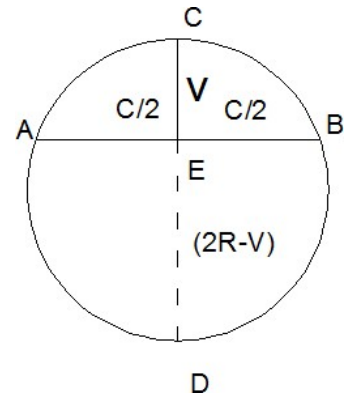
$$AE \times EB = CE \times DE$$

$$\frac{C}{2} \times \frac{C}{2} = V \times (2R - V)$$

$$\frac{C^2}{4} = 2RV - V^2$$

Since the value of V is very low, V^2 will be much lower and can be neglected

$$\frac{C^2}{4} = 2RV ; \quad V = \frac{C^2}{8R}$$



Question: Find out the length of the chord in meters for which Versine in cm is Equal to degree of the curve.

Given: Versine in cm = Degree of the curve

To Find: Length of chord “C” in meter.

Formula to be used: $V = \frac{C^2}{8R}$

In the above versine formula, the chord length “C” and radius “R” are in meters. Let us convert their units in cms.

$$\text{Then } V = \frac{C^2}{8R}$$

$$V = \frac{C^2}{8R} \times 100\text{cm}$$

$$V = \frac{25C^2}{2R} \text{ cm} \dots\dots\dots (1)$$

$$\text{We know that } D = \frac{1750}{R} \dots\dots\dots (2)$$

Equating equations (1) and (2), i.e. $V = D$ (Since from the given condition)

$$\frac{25C^2}{2R} = \frac{1750}{R}$$

$$C^2 = \frac{1750 \times 2 \times R}{25 \times R} = 140$$

$$C = \sqrt{140}$$

$$C = 11.8 \text{ mtrs}$$

NOTE: It means Versine measured in cm on **11.8 mtrs** chord length is equal to the degree of the curve

[In FPS System: Degree of curve = Versine on 61.8 ft chord]

Numerical Problem:

1. Find out the value of degree of curve having following radius
a. 1750 mtrs b. 825 mtrs c. 1000 mtrs d. 3500 mtrs

Solution

Formula used: $D = \frac{1750}{R}$

a. $D = \frac{1750}{1750} = 1^\circ$

b. $D = \frac{1750}{825} = 2^\circ$

c. $D = \frac{1750}{1000} = 1.75^\circ$

d. $D = \frac{1750}{3500} = 0.5^\circ$

2. Find out the Radius of the curve having following Degree
a. 0.5° b. 1.5° c. 3° d. 2.9°

Solution

Formula used: $R = \frac{1750}{D}$

a. $R = \frac{1750}{0.5} = 3500 \text{ mtrs}$

b. $R = \frac{1750}{1.5} = 1166.66 \text{ mtrs}$

c. $R = \frac{1750}{3} = 583.33 \text{ mtrs}$

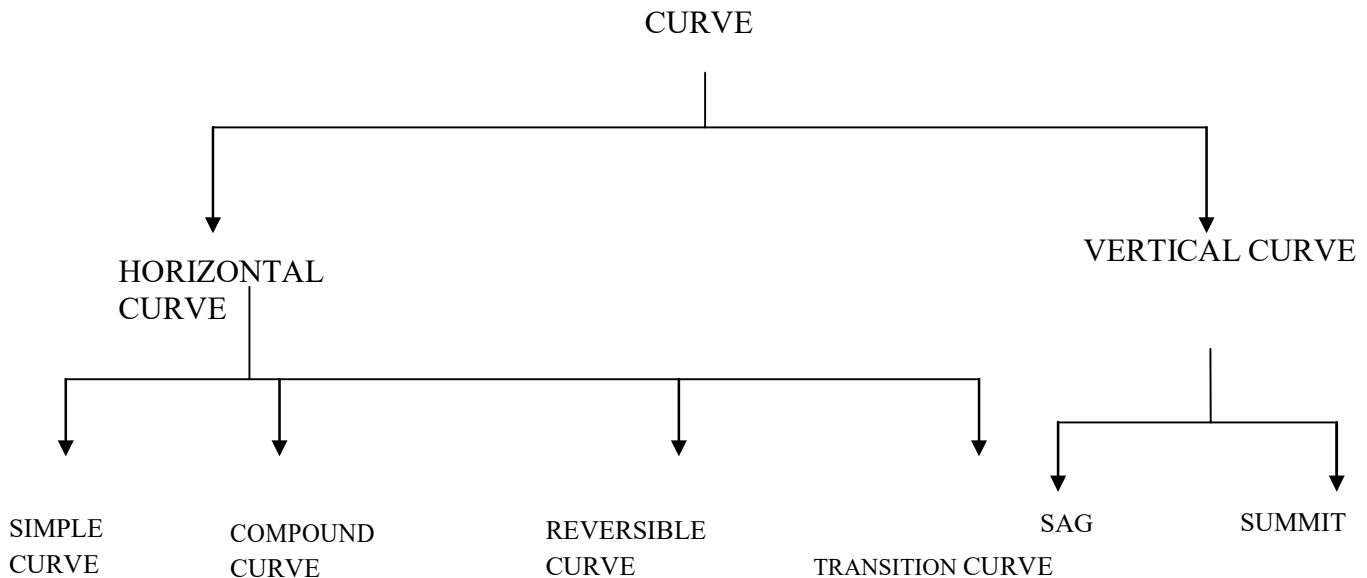
d. $R = \frac{1750}{2.9} = 603.448 \text{ mtrs}$

Necessity of curve:

Although laying and maintenance both are easy in straight line but due to the following reasons. It is essential to lay Curved Track.

1. To avoid Rivers, Mountains and other obstructions.
2. To avoid construction of major bridges, tunnels and deep cuttings
3. To connect the important cities with main line.

Classification of curve:

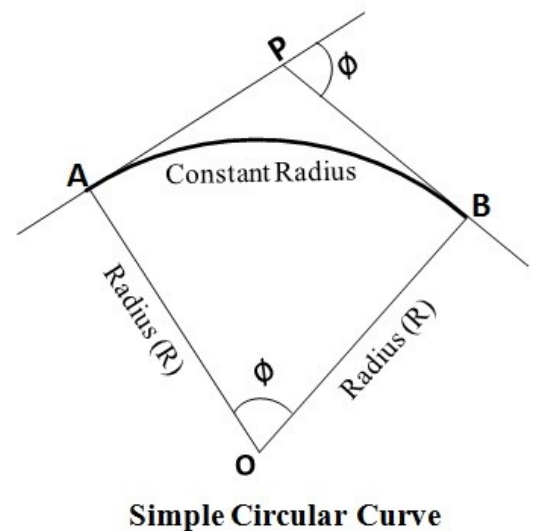


Horizontal Curve

The Curve laid on horizontal Plane is known as Horizontal Curve.

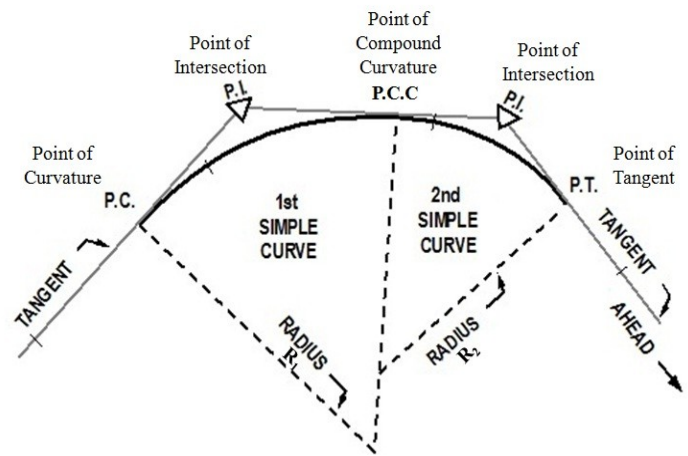
Simple Circular Curve:

Normally this curve is simple curve which connects two straight alignments (Line/Track). Since it has uniform radius and degree of curvature throughout its length, it is considered as standard and it is the most used type of curve used in Indian railways



Compound Curve:

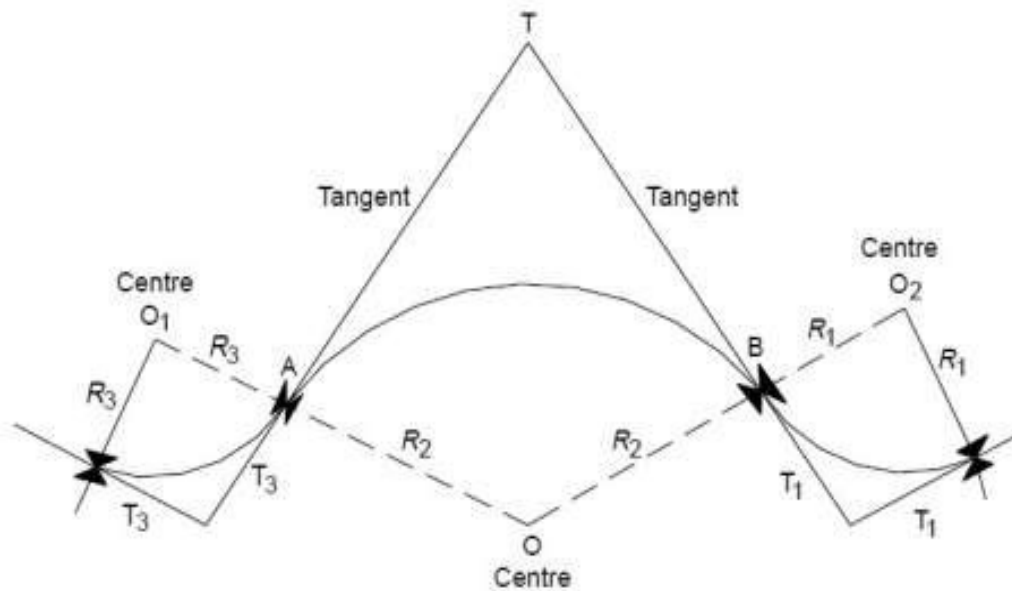
A compound curve is formed by the combination of two circular curves of different radii curving in the same direction. A common transition curve may or may not be provided between the two circular curves of a compound curve



Compound Curve

Reverse Curve:

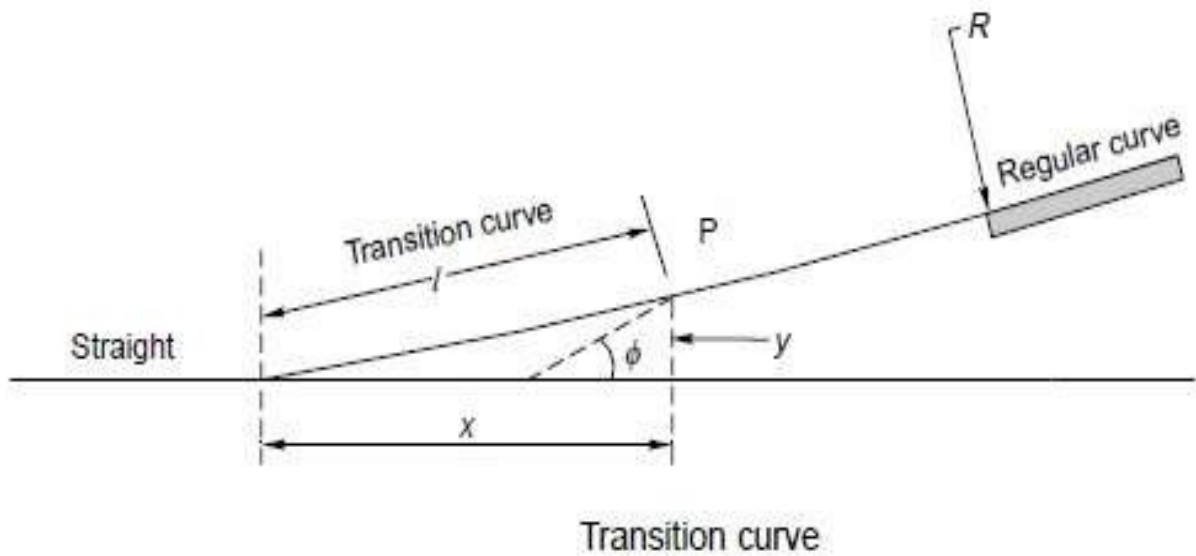
When two curves of same (or) different radius are laid next to each other in such a way that their flexures lay in opposite directions, then this is known as reverse curve. In this case the centre of the two curves will always lie in opposite direction. On account of the shape it is also known as „S” curve. There may or may not be transition curve in between the two curves.



Reverse Curve

Transition Curve:

It is a curve having varying radius throughout its length. In Indian Railways this curve is laid at both ends of simple curve for gaining /losing the degree of curve from /to straight. Its shape is cubic parabola and it is also known as easement of curve.



❖ Vertical Curve

The curve which is provided in vertical plane and used to ease on the change of gradients is called a Vertical Curve.

Necessity:

When two gradients meet each other, an angle is formed at the junction forming the “Sag”(or) “Summit”. In case of Sags there is a danger for derailment due to motion of vehicles and in case of Summits, there is danger of train parting. Therefore to eliminate the sags and summits, vertical curves are provided.

Causes of Sag and Summit:

S. No	Sag	Summit
1		
2		
3		
4		
5		

Note:

1. Since vertical curves are very short, hence for all practical purpose it is treated as simple curve.
2. Vertical curve shall be provided only at the junction of two gradients either equal to or more than 4mm/m or 0.4%.

Minimum Radius of Vertical Curve:

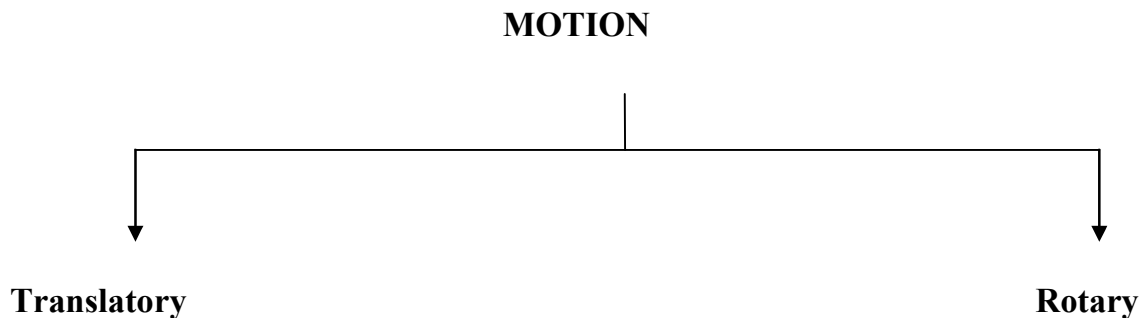
As per IRPWM and LWR manual the minimum value of radius of vertical curve is as below

BG: For A route, minimum $R = 4000$ mtrs

For B route, minimum $R = 3000$ mtrs

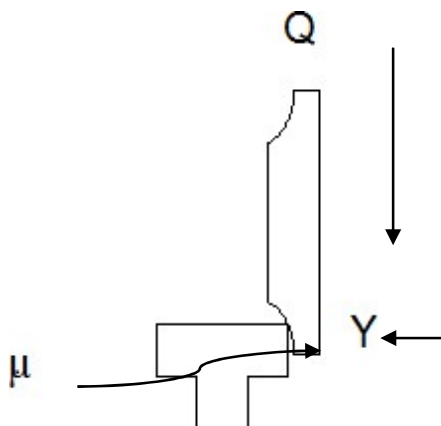
For C route, minimum $R = 2500$ mtrs

MG: For all routes, minimum $R = 2500$ mtrs

Motion of wheel on curve:**Factors Effecting μ (Frictional Force):**

The value of μ should be as less as possible. Increased Value of μ increases the tendency of derailment.

The value of μ is increased at



Q = Instantaneous load (or) stabilizing

Force Y = Flange Force (or) Derailment

Force

μ = Frictional Force

NADAL'S EQUATION:

$Q > Y + \mu$ (Safe Moment)

$Q < Y + \mu$ (Chances of Derailment)

i. Rusted Rail

- ii. New Turned Rail
- iii. Sandy Particles on Rail

Super Elevation on Curves

Cant or Super-elevation:

It is the amount by which one rail is raised above the other rail. It is positive when the outer rail on a curved track is raised above inner rail and is negative when the inner rail on a curved track is raised above the outer rail.

Necessity for providing cant:

When a vehicle moves on a curved track, it is the tendency of the vehicle to take a straight path. While doing so the flange of leading outer wheel exerts pressure on outer rail. In reverse of it outer rails also exert pressure on wheel flange, which helps the wheel to move on curve path.

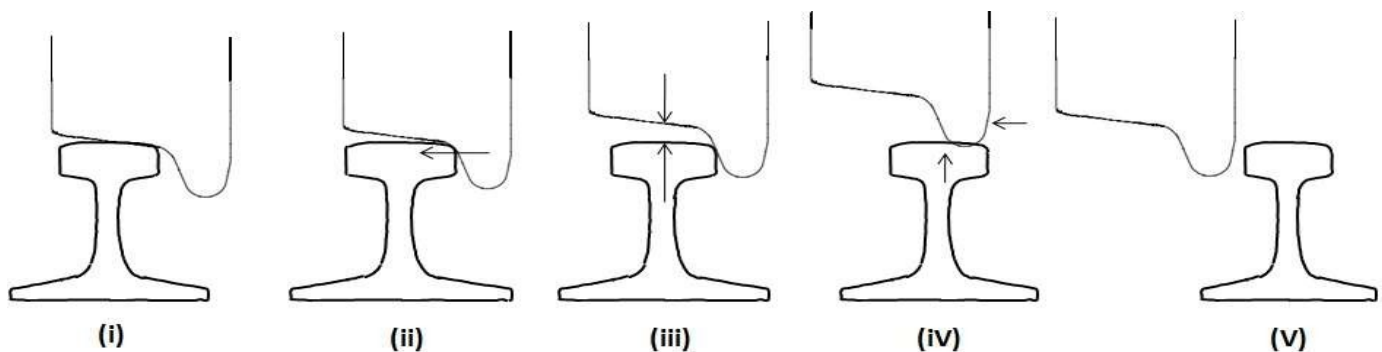
Hence the flange force is essential for motion of wheel on curve.

As soon as vehicle enters a curved path, it is also subjected to pseudo-force i.e., centrifugal force whose direction is always away from centre of the curve. Due to the centrifugal force, flange pressure increases on the outer rail.

Since the flange force is considered as a derailment force (by Nadal's equation) and due to this additional centrifugal force (mv^2/R), the amount of derailment force is increased enormously. Hence, it is essential to counter act (balance) this by another force.

In normal condition on straight track, the center of gravity of the vehicle passes through the centre of the track. It is considered as a balanced condition. Due to the additional flange force, the centre of the gravity of the vehicle gets misaligned towards the inner side of the curve and hence deviates from the center of the track. This causes the unbalanced condition which leads to derailment. Hence it is necessary to re-obtain the balanced condition i.e., the center of gravity of the vehicle should pass through centre of the track.

This force is generated by changing direction of self-weight (W) of the moving vehicle. For this outer rail is raised in comparison to inner rail, in such a manner, such that the resultant of the centrifugal force/flange force and weight of the vehicle (stabilization force) should pass through the centre of the track is at right angles to the plane of the top of rails.



Tendency of Derailment

Purpose of providing Super elevation:

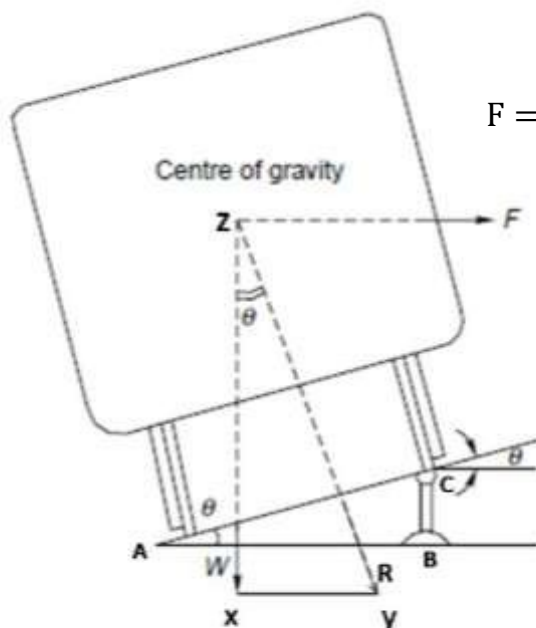
1. To counter balance the centrifugal force.
2. For proper distribution of load on both rails (Inner & Outer).
3. For better comfort of passengers.
4. To reduce the chances of wheel mounting.
5. To reduce wear and tear of the rail as well as the rolling stock.

Maximum Value of SE on BG Track

1. For Group 'A' & 'B' Routes : 185 mm
2. For Other Routes : 165 mm

Note: On all routes, maximum design cant to be limited to 140mm on track with turnouts.

Derivation of Formula for Super Elevation



$$F = \frac{mv^2}{R}$$

Given:

AB=AC= Track Gauge

BC = Super elevation

W = Weight of the Vehicle

R = Resultant of Weight „W“ and
Centrifugal force „F“

$$\text{In } \Delta ABC \quad \tan \theta = \frac{BC}{AB} \text{ --- (1)}$$

$$\text{In } \Delta XYZ \quad \tan \theta = \frac{XY}{XZ} \text{ --- (2)}$$

Equating Eqⁿs 1 & 2

$$\frac{BC}{AB} = \frac{XY}{XZ}$$

$$BC = \frac{XY}{XZ} \cdot AB$$

$$BC = \frac{F}{W} \cdot AB$$

Where,

SE (Super elevation or Cant) is in mm

G (Gauge) is in mm

V (Velocity) is in Km/hr

$$SE = \frac{G \times mv^2}{mg \times R} = \frac{G v^2}{g R}$$

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R (Radius) is in meters

$$SE = \frac{G v^2}{g R}$$

For MKS System Putting Value

$$\text{Track gauge} = \frac{G}{1000} \text{ meter}$$

$$V (\text{Speed in Km/hr}) = \frac{1000}{60 \times 60} V \text{ m/sec} = \frac{5}{18} V \text{ m/sec}$$

Thus,

$$SE = \frac{G v^2}{g R} = \frac{G}{1000} \times \frac{5}{18} V \times \frac{5}{18} V \times \frac{1}{9.81} \times \frac{1}{R} \times 1000$$

$$SE = \frac{G \times 25 \times v^2}{18 \times 18 \times 9.81 \times R} = \frac{25G v^2}{3175 R} \text{ mm}$$

$$SE = \frac{G v^2}{127 R} \text{ mm}$$

Equilibrium Speed and Equilibrium Super Elevation

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 cant provided.

For a particular curve on a particular speed super-elevation provided by Formula $\frac{GV^2}{127R}$ is known as Equilibrium Super Elevation and the particular speed is known as Equilibrium Speed. Provision of Equilibrium Super Elevation in track is not possible due to the following reasons

1. Provision and maintenance of much cant in track is not comfortable.
2. It's effect on slow moving track will be as below
 - a. Chances of derailment of inner wheel will increase.
 - b. Reaction on inner rail is increased.
 - c. In storm, chances of overturning of wagon will be increased.

Note: The equilibrium state means effect of centrifugal force (C.F) on curve is totally counter balanced and resultant of C.F and vehicle weight (W) passing perpendicularly to rail level plane in centre of track.

Cant Deficiency:

When a vehicle runs on a curved track at a speed more than the equilibrium speed, cant deficiency is observed.

The difference between the super elevation required for maximum permissible speed on the curve and the actual super elevation provided on the curve is known as cant deficiency.

$$\text{Cant Deficiency} = C_{\text{mps}} - C_{\text{Actual}}$$

Where, C_{mps} is the Cant on Maximum Permissible Speed C_{Actual} is the Actual Cant Provided.

Maximum Value of Cant Deficiency on BG Track:

For Nominated Rolling Stocks = **100 mm/150 mm**

Note 1: For Rolling stocks permitted with 150 mm cant deficiency, cant deficiency to be limited to 115 mm on track with turnout with crossing on outer rail and on track with expansion device.

Note 2: Nominated stock shall be permitted cant deficiency of 100 mm/115 mm/150 mm after found satisfactory during oscillation trial and specified as such in speed certificate

issued by RDSO.

For other Rolling Stocks not covered above = 75 mm

Adverse Effect of Cant Deficiency:

1. Wear and Tear of outer rail & outer wheel flange will be increased.
2. Lateral disturbance of track due to unbalanced centrifugal force
3. Discomfort to the passengers.
4. Chances of Derailment of vehicle/wagon will be increased

Cant Excess:

When a vehicle runs on a curve at a speed lower than the equilibrium speed, cant Excess is observed.

It is the difference between the actual cant and the theoretical cant required for such a lower speed.

$$\text{Cant Excess} = C_{\text{Actual}} - C_{\text{minimum Speed}}$$

Maximum value of Cant Excess = 75mm

Adverse effect of Cant Excess:

1. Wear and tear of inner rail and inner wheel flange is increased.
2. Chances of derailment of vehicle are increased due to „Off-loading“ of outer wheel.
3. Discomfort to passengers.
4. In heavy winds, Chances of overturning of vehicle is increased.
5. Chances of displacement of consignment in wagon

Maximum permissible speed (MPS) of the curve-

The highest speed which may be permitted on a curve is known as Maximum Permissible Speed of the curve.

The speed is permitted by taking into consideration of the following factors

- i. The radius of the curvature

- ii. Actual cant Provided
- iii. Cant deficiency/Cant excess
- iv. Transition Length of the Curve

When the maximum permissible speed (MPS) on a curve is less than the maximum sectional speed (MSS) of the section of a line, permanent speed restriction becomes necessary.

So a permanent speed restriction is imposed on that particular curve.

Maximum Sanctioned / permissible Speed of Section (MSS)

The highest speed permitted by Commissioner of Railway Safety (C.R.S) for a particular section is known as Maximum Sanctioned / permissible Speed of Section (MSS)

This depends upon the track structure and locomotives used for that section. Driver should never cross this speed in any case.

Booked Speed:

It is the Speed on which a particular train is allowed or booked to run in a particular section. Normally this speed is lesser by 10-12% from the MSS.

Cant gradient and Cant deficiency gradient

This indicates amount by which cant or deficiency of cant is increased or decreased in a given length of transition.

Ex.: 1 in 1000 means that cant or deficiency of cant of 1 mm is gained or lost in every 1000 mm/1m of transition length.

Rate of change of cant or rate of change of cant deficiency

This is the rate at which cant or cant deficiency is increased or decreased per second at the maximum permissible speed of the vehicle passing over the transition curve.

Ex.: 35 mm. per second means that a vehicle when travelling at a maximum speed permitted will experience a change in cant or deficiency of cant of 35mm. in each second of travel over the transition Curve.

Preferably it should be **35 mm/sec** in BG Track. In the worst case it should not be more than **55 mm/sec** in BG Track.

Speed on Curve for 'D' and 'E' Route (M.S.S=100 kmph)

1. Assumption of Equilibrium Speed

Equilibrium Speed = $\frac{3}{4}$ of the M.S.S. of section

2. Assumption of Safe Speed

For all practical purposes safe speed means a speed which protects a carriage from the danger of overturning and derailment and provides a certain margin of safety.

a) Transitioned Curves

The maximum permissible speed for transitioned curves should be determined (based on the assumption that the centre-to-centre distance between railheads is 1750 mm) using the following formulae:

$$\text{Safe Speed, } V = 0.27 \sqrt{R (Ca + Cd)} \text{ Kmph}$$

Where,

V = Speed in Kmph.

R = Radius in metres.

Ca = Actual cant in mm.

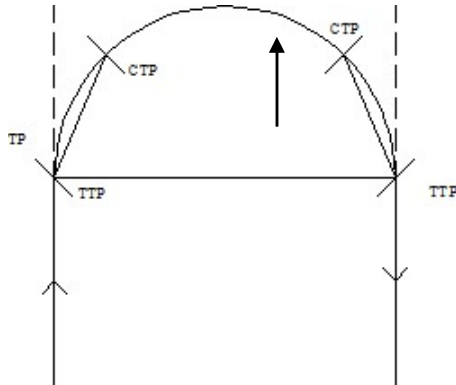
Cd = Permissible cant deficiency in mm.

b) Non-transitioned Curves

$$\text{Safe Speed} = \frac{4}{5} \text{ Kmph}$$

Where, V is the speed in km/h and R is the radius in meters.

TRANSITION CURVE



TTP – Tangential Tangent Point

CTP – Curve Tangent Point

$$C.F. = \frac{mv^2}{R}$$

$$\frac{mv^2}{R} = \text{Radial acceleration}$$

Necessity of Transition Curve:

When a vehicle passes with a uniform speed on a curve, it is subjected with radial acceleration resulting $\frac{v^2}{R}$ where v = uniform speed, R = Radius of curve

When a radial acceleration acts uniformly or rate of change of radial acceleration is less than $(0.305 \text{ meter/sec}^2)/\text{sec}$, there is no discomfort to the passengers.

When a vehicle runs on a straight track, there is no radial acceleration/centrifugal force reacts on it. As soon as the vehicle enters in a curved track from straight track it is subjected to sudden radial acceleration, which not only causes discomfort to the passengers but also infringes the safety. At slow speeds, this jerk will be less and at high speeds this jerk will be more. Hence on high speed routes transition curve is essentially provided not only for comfort but also to ensure safe running of vehicle. In order to provide smooth entry and exit of train in the curve, the transition curve is provided on both ends of the circular curve.

The radial acceleration is „build up“ (or) „ease out“ gradually in the transition length. Hence the transition curve is also known as an easement curve in which degree of curve is gained (or) lost gradually while entering from straight line (or) vice versa.

The centrifugal force generated due to the above radial acceleration is counter balanced by providing super elevation (raising outer rail of curve) on curve, at tangent point of curve. Since sudden raising of rail is not possible, hence gradual gain of super elevation and cant deficiency is carried out in transition length of curve from Tangent Point.

Objectives of introducing a Transition curve:

1. To decrease the radius of the curvature gradually in a planned way from infinity at the straight line to the specified value of the radius of a circular curve in order to help the vehicle negotiate the curve smoothly.
2. To provide a gradual increase of the super elevation starting from zero at the straight track to the desired super elevation at the circular track.
3. Easy and smooth entry and exit of the vehicle from straight to curve and vice-versa.
4. To reduce/ avoid the chances of derailment.

Requirement of an ideal transition curve

1. It should be tangential to the straight line of the track i.e., it should start from the straight part of the track with a zero curvature, at TTP.
2. It should join the circular curve tangentially, i.e., it should finally have the same curvature as that of the circular curve, at CTP.
3. Its curvature should increase at the same rate as the super elevation.
4. The length of the transition curve should be adequate to attain the final super elevation, which increases gradually at a specified rate.

Shape of transition curve:

The shape of the transition curve in Indian Railway is normally “Cubic Parabola”. The equation is

$$y = \frac{x^3}{6RL}$$

Where,

R= Radius of Curve, Y = offset,

x= Distance from TTP,

L= Length of Transition Curve

In this curve, both the curvature and cant increase at the linear rate

Length of Transition Curve for speed up to 100 Kmph

$$a. \frac{C_A \times V_m}{178}$$

$$a. \frac{C_D \times V_m}{178}$$

$$c. 0.72 C_A$$

Where,

C_A = Actual Cant

C_D = Actual Cant Deficiency

V_m = Average Speed

Curve on High Speed Route (On BG Curve)

S.No.	Parameters	For Routes other than A & B	For A & B Routes
1	Maximum Cant	165 mm	185 mm
2	Equilibrium Speed	$\frac{3}{4}$ of M.S.S	To be decided by Chief Engineer for each Section
		Safe Speed whichever is less	Maximum of 100 Kmph upto 2° curve
3	Cant Deficiency	a. 100 mm for nominated rolling stocks b. 75 mm for stocks other than covered above	
4	Maximum Cant Excess	75 mm	75 mm
5	Safe Speed For Transition Curve	1. $V = 0.27\sqrt{R(C_A + C_D)}$	
	For non-Transition Curve	2. $\frac{4}{5}$ of M.S.S	
6	Rate of change of Cant Deficiency	35 mm/sec	1. Preferable for it should be 35 mm/sec 2. In any case it should not exceed 55 mm/sec
7	Cant Gradient	1. 1 in 720 desirable 2. 1 in 360 Maximum (Not more sharper in any case)	Cant gradient so chosen that the rate of change of cant & cant deficiency at maximum permitted speed does not exceed 55mm/sec under any circumstances.

8	Track Gauge	1676 mm	Dynamic gauge of 1750 mm will be considered for speed calculation
9	Maximum speed for which 6 & 7	Upto 100 Kmph	Upto 160 Kmph

Length of Transition Curve on high speed route (minimum Length)

1. Minimum Length of Transition

$$a) \frac{C_A \times V_m}{268}$$

Where,

C_a = Actual Cant

$$b) \frac{C_D \times V_m}{268}$$

C_d = Actual Cant Deficiency

V_m = Average Speed

The larger value among the two relations, in the next multiple of 10

2. Desirable Transition Length

$$a) \frac{C_A \times V_m}{137}$$

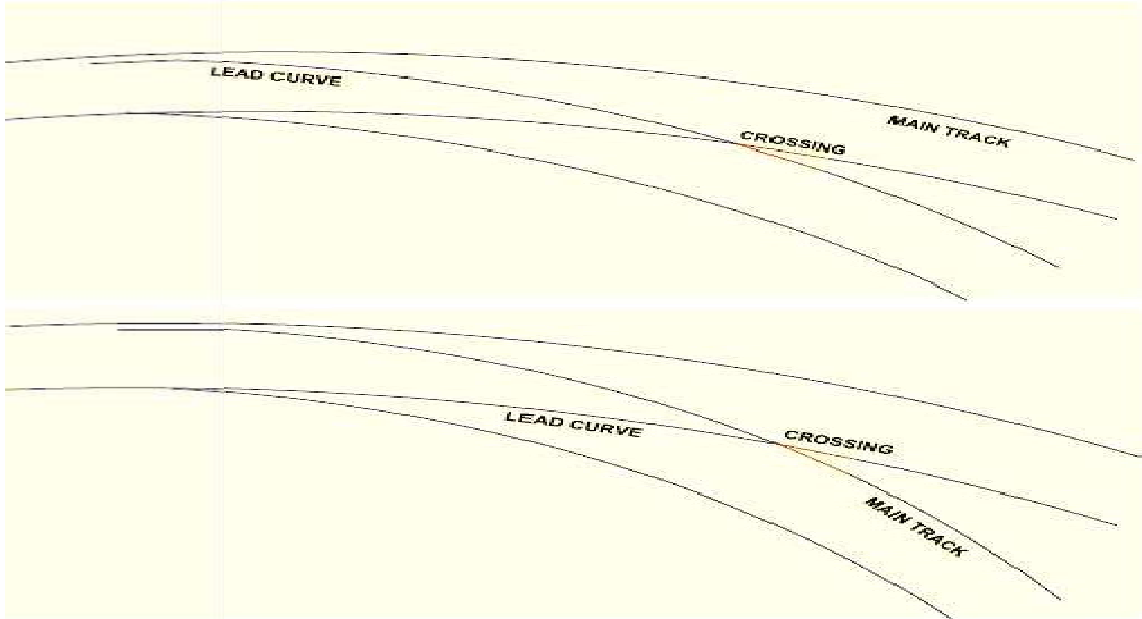
$$b) \frac{C_D \times V_m}{137}$$

$$c) 1.2 \times C_A$$

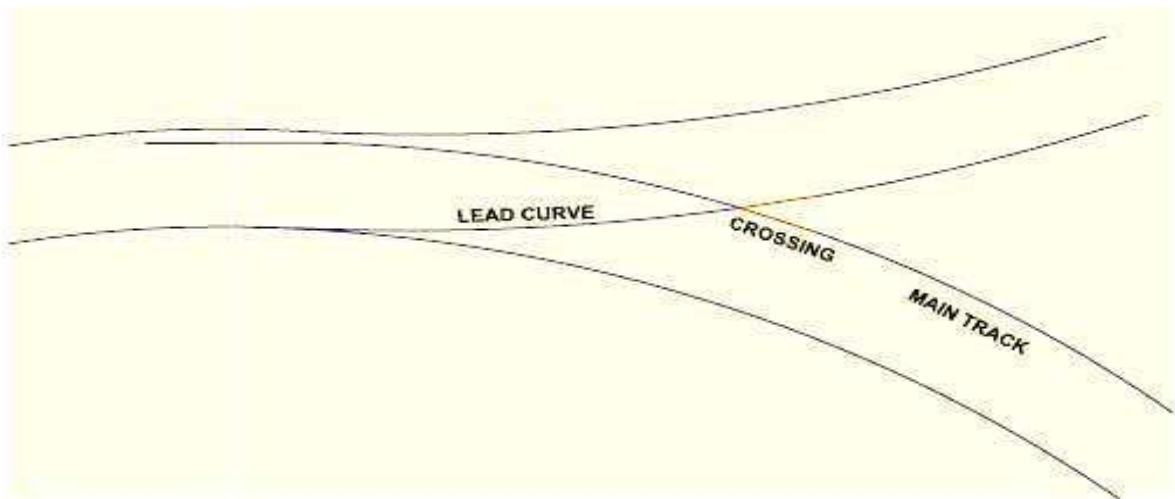
The larger value among the three relations, in the next multiple of 10

Types of Turnouts in Curve

Similar Flexure:

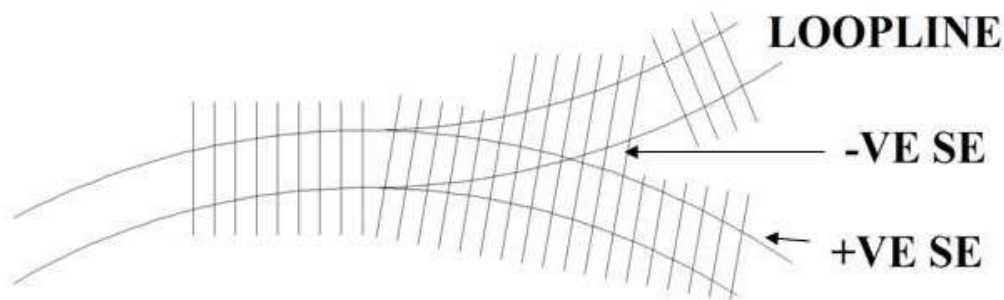


Contrary Flexure:



Negative Super elevation:

When the main line lies on a curve and has a turnout of contrary flexure leading to a branch line, the super elevation necessary for the average speed of trains running over the main line curve cannot be provided. In such cases, the branch line curve has a negative super elevation and, therefore, speeds on both tracks must be restricted, particularly on the branch line.



On the curve, the amount by which the inner rail is raised in comparison to outer rail is known as negative super elevation.

Note:

1. In case of negative super elevation, speed restriction must be provided on loop line as well as on main line as per situation.
Turnout side – Minimum Speed restriction = 30 kmph
2. Max value of negative super elevation is 50 mm.
3. For BG, Maximum superelevation on turnout = $\frac{11860}{R_t}$ mm (loop line)

Where, R_t = Radius of turnout

4. Hence, negative superelevation for turnout = Cant deficiency – Turnout Cant ($= \frac{11860}{R_t}$)
5. The negative superelevation should be rounded upto lower multiple of 5.

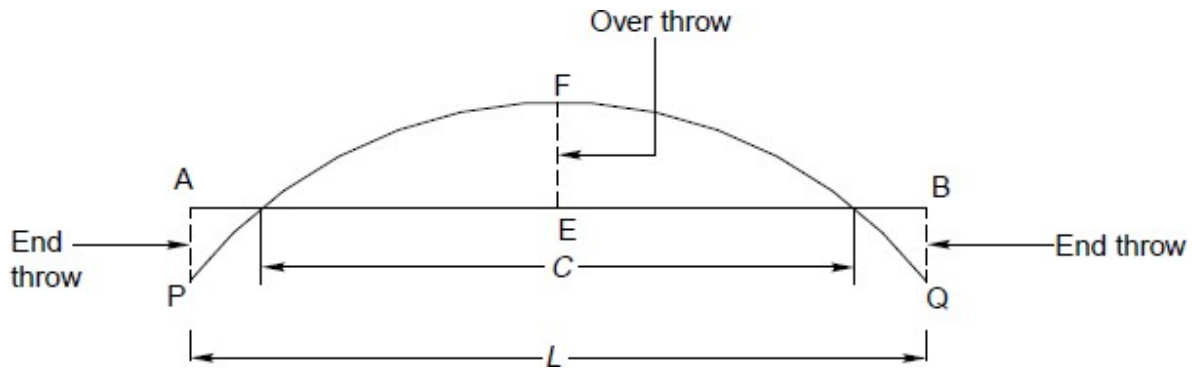
EXTRA CLEARANCE ON THE CURVE:

In schedule of dimensions (SOD), distances of various structures are given from the centre of straight track. But when a vehicle moves on curved track, these considered dimensions are not sufficient in selection with maximum moving dimensions of vehicle due to lean, learch sway, over throw, End throw, etc., resulting infringement. This occurs with open doors of vehicle. To avoid these infringements, extra clearance is provided on curved track.

Reasons for providing extra clearance on curve:

1. Effects of Curvature (over throw & End Throw)

When a vehicle negotiates a horizontal curve, its frame does not follow the path of the curve, since, being a rigid structure, it is unable to bend. The vehicle, therefore, projects towards the inside of the curve at its central point and toward the outside of the curve near its ends. The distance by which the longitudinal axis of the body of vehicle moves out from the central line of



the track is the extra clearance required.

- (i) The extra clearance required at the centre of the vehicle, which projects towards the inside of the curve, is called **overthrow** and is given by the equation

$$EF = \frac{C^2}{8R}$$

- (ii) The extra clearance required at the ends of the vehicle, which project towards the outside of the curve, is called **end-throw** and is given by the equation

$$AP \text{ or } BQ = \frac{L^2 - C^2}{8R}$$

Where, „L“ is the length of the vehicle

„C“ is the centre-to-centre distance between the bogies

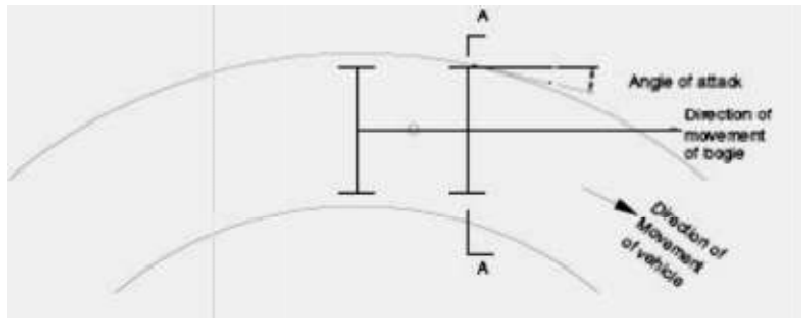
„R“ is the radius of the curve

Empirical Formula of throw for BG:

$$\text{Over Throw} = \frac{27330}{R} \text{ mm}$$

$$\text{End Throw} = \frac{29600}{R} \text{ mm}$$

These empirical formulae are based on standard BG bogie lengths and the value of R is in metres. C = 14.785 m , L = 21.34 m



2. Effect of leaning due to super elevation

On account of the super elevation provided on a curve, the vehicle leans towards the inside of the curve, thereby requiring extra clearance as shown in Figure. The extra clearance required for leaning is as follows

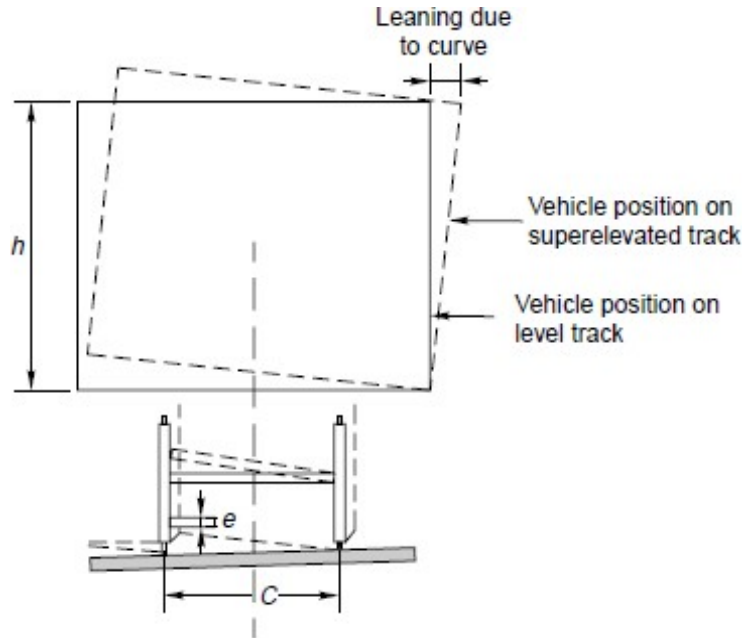
Where,

$$\text{Lean} = \frac{h \times e}{G}$$

h- height of the vehicle (=4.025 m for IR)

e- Super elevation

G – Track Gauge



3. Effect of Unbalanced centrifugal force (sway)

On account of unbalanced centrifugal forces caused due to cant deficiency or cant excess, the vehicles tend to experience an additional sway. The extra clearance required on the inside of the curve due to the sway is taken as one-fourth of the clearance necessary due to leaning.

Mathematically,

$$\text{Sway} = \frac{1}{4} (\text{Lean})$$

Total extra clearance

On summarizing, the total extra clearance (in mm) required on curves is as follows:

- **With Structure**

- Extra clearance inside the curve = overthrow + lean + sway

$$Ec_1 = \frac{C^2}{8R} + \frac{h \cdot e}{G} + \frac{1}{4} \frac{h \cdot e}{G}$$

- Extra clearance outside the curve = end-throw

$$Ec_2 = \frac{L^2 - C^2}{8R}$$

- **For platform and other Structures (To avoid gap)**

- Inside = Over throw + $\frac{5}{4}$ (*Lean*) – 51 (mm)
- Outside = End throw – 25 (mm)

- **Between two adjacent Tracks**

- Extra Clearance = Over throw + End throw + 2(Sway)

Check Rail on Curve:

Check rails are provided parallel to the inner rail on sharp curves due to the following reasons.

1. Due to uneven loading of vehicle, due to worn out wheels, due to long wheel base and due to insufficient S.E (Cant deficiency), there are always chances of mounting of outer wheel on outer rail resulting in derailment. Check rails prevent the wheel mounting on outer rail as well as decreases the chances of derailment.
2. Due to the flange force and un-counteracted centrifugal forces, outer rail gets wear out rapidly on sharp curve. Check rail prevents the wear of outer rail, but it wears rapidly itself which is cost wise not valuable because it is used with release rail.
3. It increases the lateral stability of track on sharp curve.

Disadvantages of check rail

1. Additional track Maintenance cost
2. Additional resistance provided to moving wheels resulting increase of haulage cost
3. Additional wear in inner rail.

Degree of limitations

BG → 8° and above check rail must be provided.

Check rail clearance

1. Minimum rail clearance = 44 mm
2. Maximum rail clearance = 48 mm

Note: If gauge slackness is provided on curve, check rail clearance (CRC) will also increase by $\frac{1}{2}$ of its amount.

Necessity of gauge slack on curve:

On sharp curve, gauge is kept slack for free movement of the rigid bogie wheel base to reduce the excessive wheel flange force on the outer rail. On B.G track, the gauges are kept slack as under:

1. Up to 4° Curve = Exact gauge is maintained
2. More than 4° Curve = + 6mm slack in gauge is maintained

Lubrication on Gauge faces of outer rail of curve:

On curved track, to reduce the outer rail wear it is the best method to lubricate the gauge face / inner face of outer rail.

The outer rail gauge face is lubricated to obtain the following advantages:

- 50% wear and tear of the outer rail and outer wheel are reduced
- Fuel economy increases
- Condition and parameters of the curve are maintained
- By reducing the frictional losses we can increase the speed on sharp curve
- Chances of derailment is reduced
- Haulage cost is reduced

JOINTS AND WELDING

TYPES OF THE JOINTS

1. Ordinary fish plated joints [Normal joint]
2. Joggle fish plated jointed [on ward fracture joints]
3. Insulated joints [in track circulating areas]
4. Glued Joint [In track circulating areas]
5. Switch Expansion Joint [SEJ] in end of LWR/SWR.

Defects of joints

1. **Hogged joint:** - in this defect, rail at joint bends permanently in downwards and rail at end is permanently subjected with vertical kinks. These type of joints are known as hogged joints.
2. **Battered joint:** Flattering of rail end at joints is known as battering this flattering of rail end occurred during service by hitting of wheel. This types of joint is known as battered joint.
3. **High joint** : During the work of maintenance sometimes joints are packed more than required, resulting it becomes high than running on such joints becomes very bad because these joints give some vehicle lift while passing at the wheel.
4. **Low joint** : in sufficient packing of joints gives down leveling of joints resulting bad running (or) riding of train. After sometimes these joints are converted in hogged and battered joints. if not attended with in short time period.
5. **Blowing joints:** when within dust blows from joints under the moving train the joints. In such joints there are always white dusts in surroundings of joints. These joints are generated due to
 1. Low maintenance level of the track joint
 2. Packing with dirty ballast
 3. Bad quality of soil

Maintenance of such types of joints is very necessary

6. **Pumping joints** : In raining season the blowing joint converts into pumping joints . In rainy season the water fills in the underived water packets [which are generated due to blowing of joints/ weak soils] and mud comes out while passing of trains from on it, maintenance of such joints are very difficult due to weak

Formation ballast penetration under the formation and packing does not retain under these sleepers.

Necessity for welding of rail joints

In the modern age of track technology with concept of high speed routes, the welding of joints becomes necessary due to following reasons:

1. Due to impact of moving load at joint ballast under the joint sleepers gets loosen particularly on loose / defective fish plated joints (F/P) regularly. Hence maintenance of joints need more attention money and labor
2. Due to different joints defects like hogging, battering etc the service life of track components gets reduced
3. A lot of noise pollution is created on fish plated track particularly on loose/ defective joints. Resulting discomfort to passengers.
4. Due to loose / defective joints chances of derailment are much more at fishplate
5. Chances of sabotage at fishplate joints are more and easy because it can be done by easily removal of fish plate from track
6. Service life of components of rolling stock is also reduced on fish plated track due to different types of wear and impact
7. Resistance developed by fish plate joints against rolling of rolling stocks increases fuel consumptions is more
8. 50 % to 80% extra labour / time/money is required to maintain the joint in fish plated track
9. Due to above various reasons. It is difficult to run the train on high speed on fish plated track
10. Fish plated track is not suitable for modern methods of maintenance of track.

Advantages of welding of rail joints

1. More than 50% maintenance cost reduced in welded track compared to fish plated track
2. By eliminating rail joints an uniform smooth floating track is achieved which results smooth running of train.

3. Easy to maintain track parameters with uniform ballast cushion which gives the high speed on track
4. Due to achieving uniform and good parameters on welded track , chances of derailment is reduced
5. Life of track components as well as rolling stock increases
6. Safe and anti-sabotage type of track achieves resulting curtailing in extraexpenditure on security
7. Noise pollution reduces resulting increase in comfort level of the passengers
8. Low friction pathway achieved resulting haulage cost reduced.
9. Track capacity increases
10. Fuel efficiency increases
11. Suitable for modern method of packing(Track Maintenance)

Types of Welding

The various types of rail welding techniques are as follows

1. Oxy- acetylene welding
2. Electric arc welding
3. Flash butt Welding
4. Alumino-thermit welding

Oxy Acetylene or Gas Welding

In this type of welding necessarily heat is produced by a combination of oxygen and acetylene gas. The rail ends to be welded are brought together and heat is applied through a burner. Temperature up to 1200°C to 1400°C is achieved, so that the metal of the rail ends gets melted and fusion takes place, welding the rail ends together.

Electric Arc welding

In this method the heat is created by the passage of electric current across a gap between two conductors. About 3500°C temperature is achieved causing the two rail ends weld together

Flash Butt Welding

In this method heat is generated by electric resistance. The two rail ends are brought together so that they almost touch each other. The electric energy is switched on there by

allowing an electric current of about 5 volt and 35000 ampere to pass between faces of two rails, lot of flashing takes place and considerable heat is generated rising the temperature from 1000°C - 1500°C. At this time the rail ends are pressed together with 100 bar butting pressure, causing welding of the rails.



Brief Procedure for Flash Butt Welding:

1. Pre-Straightening of rails:

The rails are straightened before these are welded in order to get a good alignment of the welded rail. Pre –Straightening can be done either manually using ordinary or hydraulic Jim Crow or by Pre-Straightening machines with the help of hydraulic rams

Pairing of rails is also done before pre-straightening of rails for better results.

2. End Cleaning of Rails

The end cleaning of rails is then done for a length of 150mm to 225mm by electric or pneumatic grinders or shot blasting/sand blasting on top, bottom and interfaces in order to ensure better conduction of electric current in the rail ends. This could be done by grinding, brushing or shot blasting.

3. Adjustment of rail ends:

The rail ends are then brought together in the flash butt welding m/c and the longitudinal and vertical alignment of the rail is corrected by suitable adjustment of the machine

4. Welding

During welding flash butt welding machine, the main processes that are involved are as follows

a. Initial Burn Off

First of all, irregularities of the rail interfaces are burnt off to make the end surfaces smooth and parallel so that when pre-heating takes place, the weld current can flow over the complete weld interfaces.

b. Pre-Heating

In this process preheating, the heat is generated by providing **electrical resistance** at the ends of both rails. The both rails are clamped and tightened in the jaws in which one jaw is **fixed** and the other is **movable** so that gap adjustment can be done in between the rails ends. The rail ends are brought into contact to allow a low voltage of **5 Volts** and high current of **35000 Amperes** flow which preheats the rail ends up to red hot stage for certain fixed time periods. Lower voltages are preferred to minimize crater damage on the rail ends. This pre-heating cycle executed in a fully controlled automatic mode once the

parameters are selected.

c. Flashing

In this process, the moving jaw is making to move forward and backward direction automatically in Flashing Condition at low voltage high ampere current. Due to this process a **flash is generated** between the ends of rails till the temperatures reaches to **1000 to 1500°C**.



d. Forging (Up setting)

Immediately after the flashing, the rail ends are butted together to a stage of fusion under a heavy butting force for 10 seconds (approximately).

The recommended butting pressure for different types of rails is indicated below:

Type of Rail	Butting Pressure / Cross Sectional Area
72 UTS rails	5kg/mm ²
90 UTS rails & Head Hardened rails	6 kg/ mm ²
110 UTS rails	7 kg/mm ²

e. Main Welding

At the last when the ends are fused and the temperature is raised upto 1500°C the rails ends are finally butted at 37 tons of flashing stroke pressure and thus get welded.

Note:

1. In this process, due to butting and flashing stroke, rails are reduced by 20 mm (approx.) in length.
2. Approximately 150 to 200 seconds are taken in welding process only.

5. Stripping or Hot Chipping

As soon as the rails are welded the stripping is done automatically or by pneumatic chisel for removing extra materials from the joints and surfaces.

6. Spray Cooling

After the hot metal is chipped off, the rails are cooled by spray cooling by a sprayer at a distance of 60 to 70 meters from the welding machines.

7. Profiling

The rails are finally ground to correct profile preferably by using profile grinding machine or trolley grinder, Hand grinders are used only in case of emergency.

8. Post Straightening

The rails are straightened by means of post straightened machines of 200 tons capacity which removes horizontal and vertical kinks, if any so as to give perfect alignment of both directions.

9. Ultrasonic Inspection

As soon as welding process is over the welded joints is ultrasonically tested essentially to detect any flaw or blow hole in it. If there is any flaw in joints, the defective joints are removed by automatic cutting machine and re-welded as process given above

10. Examination and Inspection

The rail ends are finally examined and inspected with regard to specified

tolerances so as to have finally a good welded surface, It should be ensured that direction of ingot as marked on the rail should not be changed while welding

Tolerance for Flash Butt Welding Joint

S.No	Item	Tolerance for Welds With	
		New Rails	Old Rails
1	Vertical misalignment	+0.3 mm, 0 mm at the centre of a 1 m straight edge.	±0.5 mm at the centre a 1 m straight edge.
2	Lateral misalignment	± 0.3 mm at the centre of a 1 m straight edge.	±0.5 mm at the centre aim straight edge.
3	Head finishing (on sides)	±0. 25 mm on gauge side at the centre of 10 cm straight edge	±0.3 mm on the gauge side at the centre of a 10 cm straight edge.
4	Head finishing (on top table surface)	+ 0.2 mm ,0 mm at the centre of 10 cm 0 mm straight edge.	±0.2 mm at the centre of a 10 cm straight edge.
5	Web zone (under side of head, web, top of base and both fillets on each side)	+ 3.0 mm , 0.0 mm of parent contour	+ 3.0 mm , 0.0 mm of parent contour

Progress:

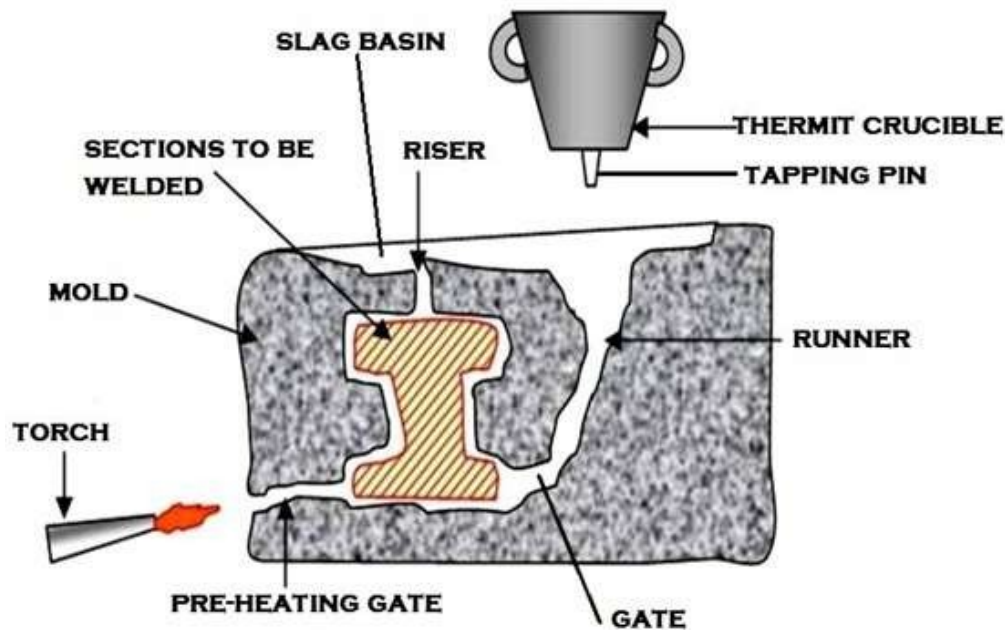
- 1.Total 5 to 6 minutes for complete welding process of one joint is required
- 2.In 8 hours of shift, progress of welding is 60 to 80 joints.

ALUMINO – THERMIT WELDING:

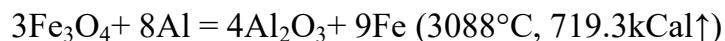
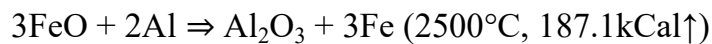
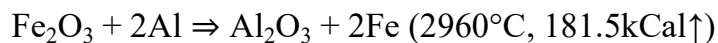
This is the only form of site welding. Its principle is that when a mixture of finely divided aluminium and iron oxide called thermit mixture is ignited a chemical reaction takes place with evolution of heat, producing iron and Aluminium oxide. The iron released from the reaction is in molten condition (2450°C), which is poured in the gap between the two rails, welding the rail ends together. The equation which follows is:



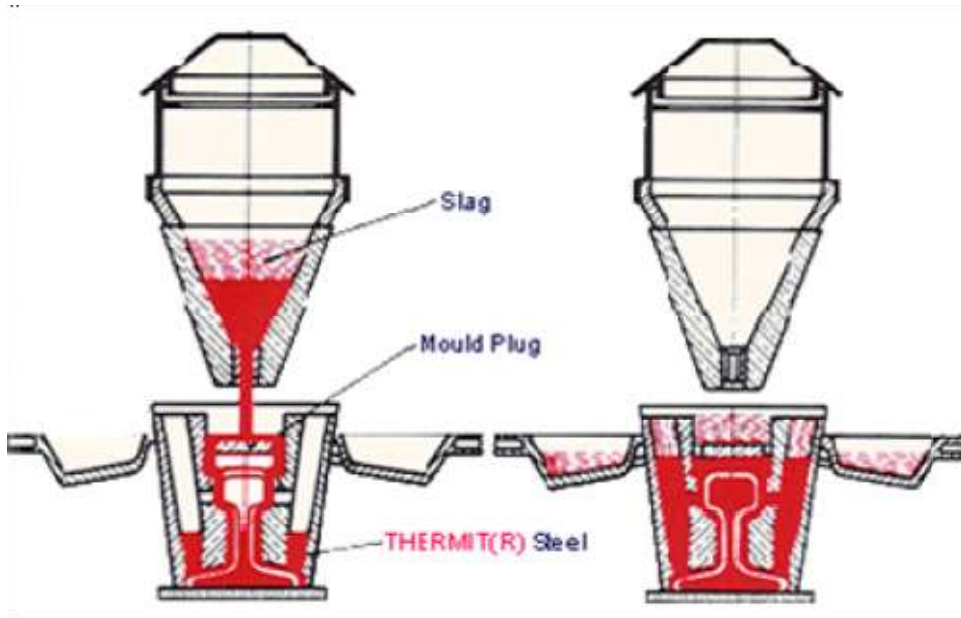
THERMIT WELDING SET-UP



Thermit reaction details: Aluminum reacts with iron oxides, particularly ferric oxide, in highly exothermic reactions, reducing the iron oxides to free iron, and forming a slag of aluminum oxide.



SKV or SPW (Short pre-Heat welding)



WORKING PROCEDURES

1. Pre Arrangement

A minimum traffic block of 70 to 75 minutes 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 AT weld

2. Fixing of Pre-Fabricated Mould

Pre-Fabricated moulds supported in moulds shoes are positioned centrally around the gap between the rails ends and secured in position by the arms of the universal mounting.

The special crucible is fixed near the rail joint in a way that when required it can be swung around and brought exactly over the joint. The hole in the bottom of the crucible is plugged with a closing pin and asbestos wool is sprinkled over it to protect it from molten steel. On the top of the wool powdered slag is put so that asbestos wool may not get disturbed.

3. Packing the Gap

After fixing the mould the gap between mould and rail shall be packed finally with luting sand to prevent leakage of liquid weld metal to protect the rail top table from metal splashes during reaction, the adjacent rail surface on either side of moulds shall be covered with metal cover or smeared with luting sand up to 15 cm on either side

4. Preheating of Rails

After fixing and luting of the mould the rail ends shall be uniformly pre- heated throughout the rail section with specially designed air/petrol/compressed air petrol/ oxygen – LPG burner as the case may be. The flame shall be properly adjusted to attain the desired rail temperature. The preheating 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 $600\pm 20^{\circ}\text{C}$

During welding time of preheating and pressure to be maintained should be as follows

S.no	Type of Welding	Time of pre-heating	Pressure
1	Air petrol burner	10 to 12 minutes	$7\pm 0.7 \text{ kg/cm}^2$
2	Compressed Air Petrol	4 to 5 minutes	$0.2 \text{ to } 0.3 \text{ kg/cm}^2$
3	Oxy-LPG Process	2 to 2.5 minutes	$7.0 \text{ to } 8.0 \text{ kg/cm}^2$

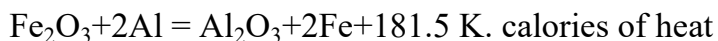


5. Filling with thermic portion

The thermit mixture or thermit portion is then put in the crucible. About 4 to 7 kg of portion is required for conventional thermit welding and 9 to 15 kg portion is required for SKV welding

6. Igniting of Thermit Mixture & Thermit Process

As soon as pre-heating is complete thermit mixture is ignited by special ignition made of barium- Pre-oxide and aluminium , violent reaction takes place inthe crucible with evolution of heat and the thermit mixture turns into a moltenbath. Te slag being lighter comes on the top and the molten iron remains at the bottom, the reaction takes place for about 15 to 25 seconds and on extra margin of about 5 seconds is kept for separation of slag. A temperature of about 2540°C is achieved during the process



7. Swinging of Crucible & Flowing of Molten Iron

The crucible is then swung round and closing pin is tapped up. Molten iron flows down and files the peripheral areas around the mould. The crucible is then further swung round and the slag flows out.

The molten thermit steel fuses around the Pre-Heated surface of the rail ends and a homogenous weld is made.

8. Chipping off Excess metal

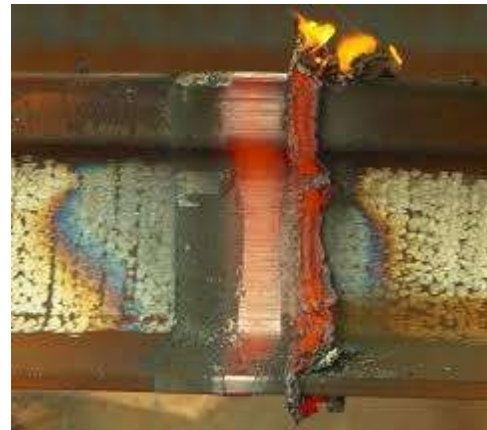
The moulds are removed after about 5 minutes. While molding only head should normally be expose and not the foot and web. The excess metal is chipped off from top of rail and the gauge face when hot.



Post Welding Operation

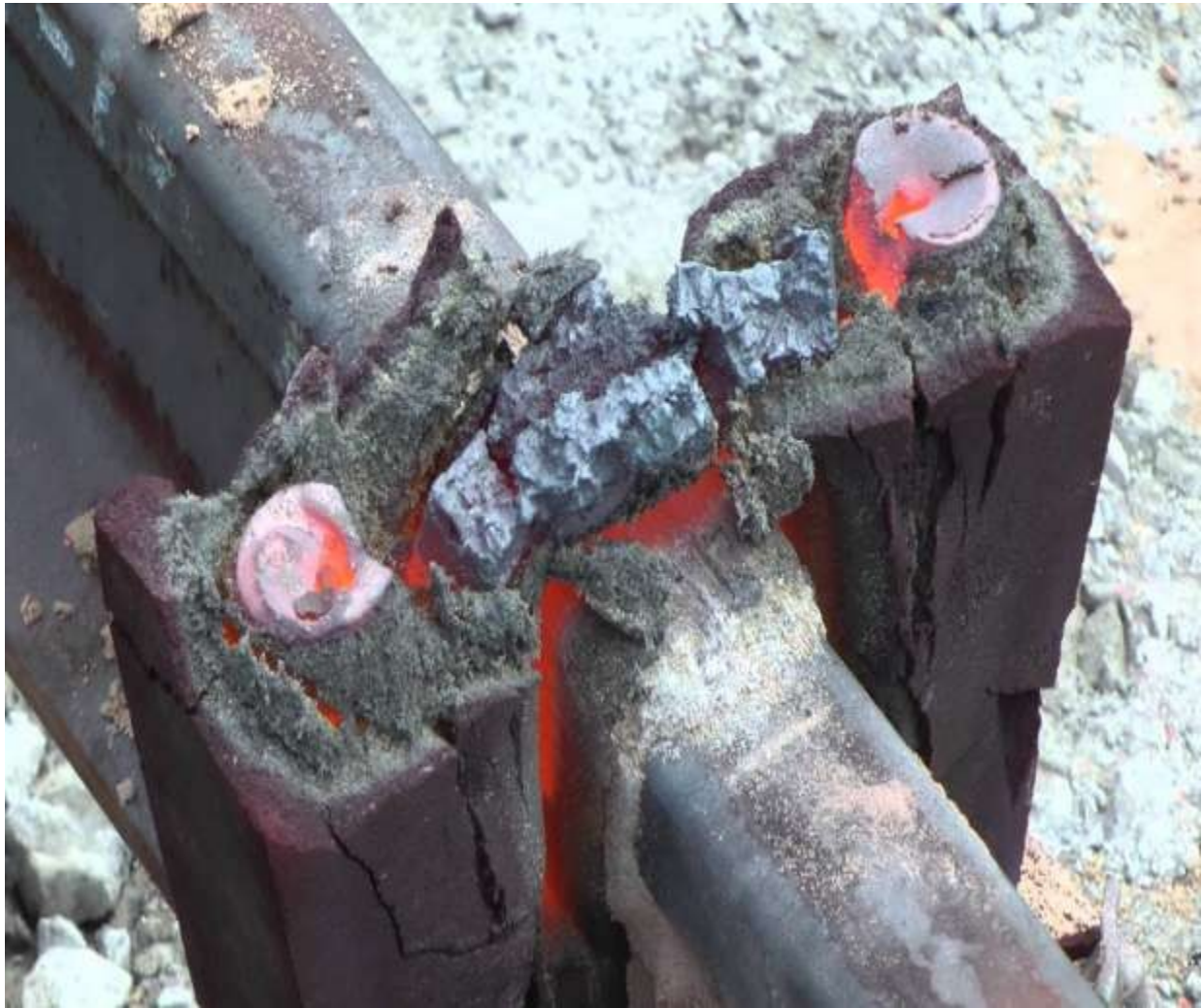
1. Cooling of rail ends : the rail ends are then cooled for **3 to 4 minutes** , controlled cooling is required to be done for alloy steel rail joints
2. Removal of Equipment : after the reaction the equipments are removed in a time sequence (i.e.) Crucible, Slag parts, Universal Mounting, Mould shoes etc
3. Removal of Excess material by weld trimmer: After solidification excess steel is removed by hydraulic weld trimmers and when weld has cooled steel vent risers are removed.
4. Finishing of welded Joints: the finishing of the welded joints is done either with hand files or portable profile grinders to bring the welded joint to the correct rail profile
5. Passing of traffic: the welded joint is now ready the sleepers are shifted to original position and properly packed. Before allowing the first train to pass on the welded joint at least 30 minutes time gap should be given after pouring the metal
6. USFD Testing: USFD testing of new welds by thermit welding should be completed within **30 days** of executing the welds, till then new welded joints should be provided with clamp and supported on wooden block.



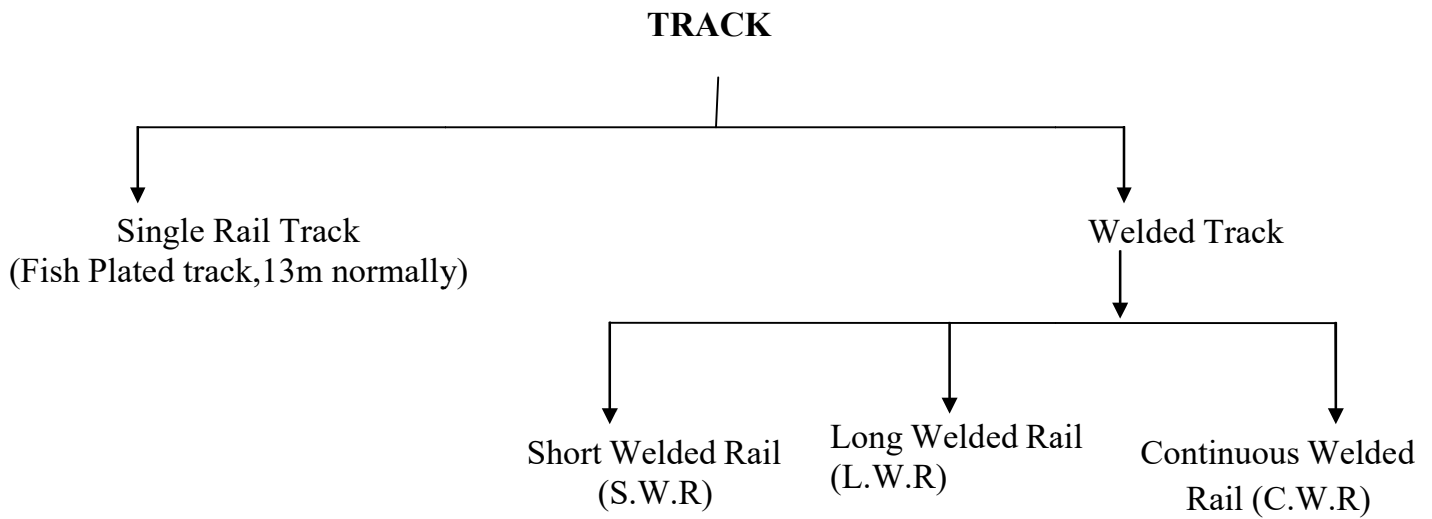


Difference between Flash Butt and AT Welding

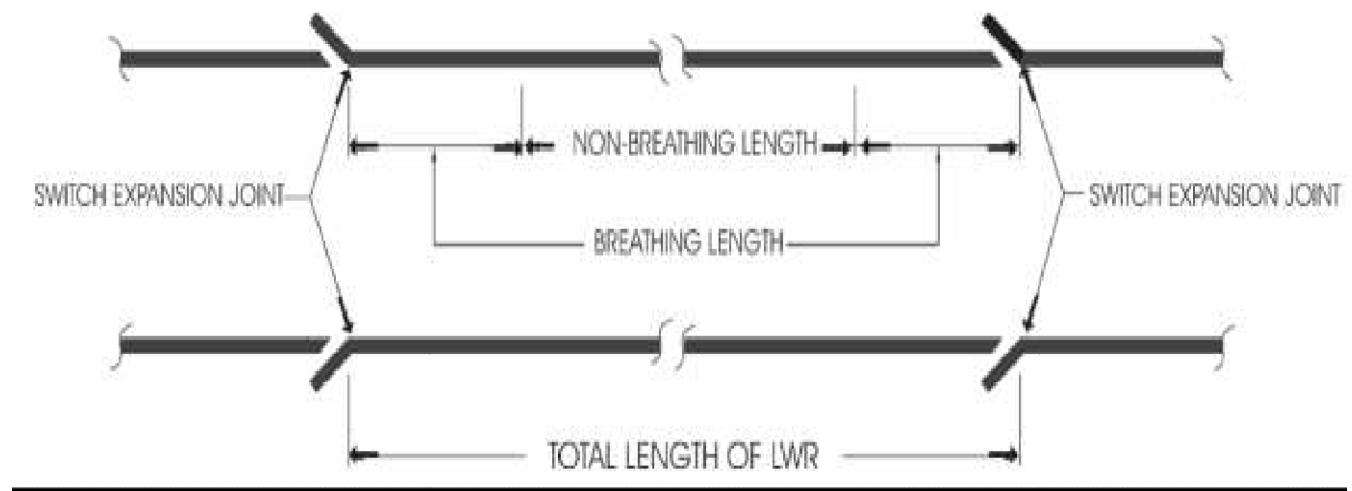
S.No	Description	Flash Butt Welding	A.T Welding
1	Principle of welding	Welding is done by passing of 5 volt, a 3500 ampere electric current between two rail ends	Welding done by an exothermic chemical reaction between Iron oxide and aluminum
2	Quality of Welding	Excellent	Good
3	Strength of Welding	Good in Fatigue	Weak in fatigue
4	Time required for welding	About 3 to 6 minutes	50 minutes but normally a block of about 1 ½ hrs is required
5	Possible places for welding	Both Site and workshop but normally done in workshop	Welding at site
6	Tolerance	Very tight tolerance	Normal Tolerances
7	Cost of Welding	Rs 700 to 900 per weld	Rs 900 to 1200 per weld
8	Quality of Welding	By help of a welding recorder	Depends upon only by good work and no monitoring is possible



RAILWAY TRACK:



Long Welded Rail



IMPORTANT DEFINITIONS:

1. L.W.R. (Long Welded Rail):

It is a welded rail, central part of which does not have any longitudinal movement due to temperature variation. Length of rail more than 250 meter in B.G. and 500 m. in M.G. should function as L.W.R.

2. S.W.R. (Short Welded Rail):

It is a welded rail, which contracts and expands throughout its length. It is generally three rail length long.

3. Breathing Length:

It is the length at each end of L.W.R. or C.W.R. which is subjected to contraction or expansion on account of variation in temperature.

4. S.E.J. (Switch Expansion Joint):

It is an expansion joint installed at each end of L.W.R.. to permit expansion or contraction of the adjoining breathing length due to temperature variation.

5. Anchor Length:

It is the length of the track required to resist the pull exerted on rail by rail tensor during distressing.

For B.G., Anchor length = $L_a = 2.5 (t_o^{\circ}\text{C} - t_p^{\circ}\text{C})$ in meter.

For M.G., $L_a = 4.5 (t_o^{\circ}\text{C} - t_p^{\circ}\text{C})$ in meter

Where, t_o = stress free temperature.

t_p = Prevailing rail temperature.

6. De-stressing:

The operation undertaken with or without rail tensor to secure stress free condition in L.W.R. at a specified rail temperature is called de-stressing.

7. Rail Temperature:

It is the temperature of rail as recorded by an approval type of rail thermometer at site.

8. Mean Rail Temperature :

Mean rail temperature of section is the average of maximum and minimum rail temperature recorded for that section for last five years.

Mean rail temperature $t_m = \frac{\text{Max}^m \text{ Rail temp.} + \text{Min}^m \text{ R.T.}}{2}$

2

Range Of Temperature:

$$= \text{Max}^m \text{ Rail temp.} - \text{Min}^m \text{ Rail temp.}$$

$$\begin{aligned} \text{Ex.} \quad &= 60^\circ\text{C} - (-10^\circ\text{C}) \\ &= 70^\circ\text{C} \end{aligned}$$

Temperature map of Indian Railway shows the range of temperature and mean rail temperature of different places in India.

Ex. – Bombay 60°C (20°C)

Range of temperature = 60°C

Mean Rail temperature = 20°C

9. Prevailing Temperature:

It is the rail temperature prevailing at the time when any operation connected with de-stressing is carried out, denoted by t_o .

10. Stress Free Temperature (t_o):

It is the rail temperature at which the rail is free of all thermal stress. At this temperature, there is no thermal stress in the rail panel.

11. **De-stressing temperature (t_d):**

It is the average rail temperature during the period of fastenings of rails to sleepers after de-stressing the L.W.R. without using tensor. If rail tensor are used, for all practical purpose, t_d can be taken as t_o . De-stressing temperature ranges are as follows.

Rail section	De-stressing temperature range (t_d-range)			
1) 52 Kg & higher section	-	$t_m + 5$	to	$t_m + 10$
2) Other section	-	t_m	to	$t_m + 5$

Permitted Locations For LWR/CWR

A. General considerations for laying LWR/CWR –

1. LWR/CWR will be laid only those locations where the track structure and permitted locations confirms the condition of IRPWM 2020 manual.
2. New constructions/doubling/gauge conversions/permanent diversion shall be laid with LWR/CWR.
3. 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 sound and without any deficiency. The approval of Chief Engineer is necessary for it.

B. Alignment

1. LWR/CWR shall not be laid on curves sharper than 440 meter radius both for BG and MG.
2. LWR/CWR may be continued through reverse curves not sharper than 875 metre radius, shoulder ballast of 600mm over a length of 100 metre on either side of common point should be provided.

C. Gradients

1. The steepest permitted grade shall be 1:100.
2. A vertical curve shall be provided at the junction of the grade when the algebraic difference between the grades is equal to more than 4mm per metre
3. The minimum radius of the vertical curve shall be kept as under

For broad gauge:

Group	Minimum radius
A	4000m
B	3000m
C,D,E	2500m

D. Approval of Chief Engineer- Installation of LWR/CWR shall have the approval of Territorial Chief Engineer.

E. LWR/ CWR shall not be laid in following locations-

1. Where rails are subjected to heavy wear, corrugation, corrosions or required to frequent renewals.
2. On weak formation where chances of deformation /settlement are more and it will lead the chances of buckling.
3. On weak/dirty soil where the pumping failures are more, resulting migration of soil into ballast and due to this frequent opening of ballast is more required.
4. On vulnerable locations of track where frequent flooding are more.

Track structure for LWR/CWR –

A. **Formation** – LWR/CWR shall be laid on stable formation.

B. **Ballast cushion**–

1. The minimum clean stone ballast cushion of 250mm shall be provided at the time of installation of LWR/CWR for the speed up to 130kmph.
2. For speed more than 130kmph, minimum ballast cushion should be 300mm.
3. Shoulder ballast should be **heaped 100mm**.
4. On straight track width of shoulder ballast cushion should be 350mm.
5. On sharp curve the width of shoulder ballast should be 500mm.
6. LWR/CWR may be continued through reverse curves not sharper than 875 metre radius, shoulder ballast of 600mm over a length of 100 metre on either side of common point should be provided.

C. **Sleeper and Fastenings** –

1. **On broad gauge** –

- i. Concrete sleepers with elastic fastenings
- ii. Steel trough sleepers with elastic fastening for speeds not exceeding 130kmph

2. **Sleeper density** – The minimum sleeper density in LWR/CWR shall be follows-

- i. For zone 1 & 2 – (M+4) – 1340 sleepers per km
- ii. For zone 3 & 4 – (M+7) – 1540 sleepers per km

D. **Rails** -

1. In **one LWR**, two different rail sections are not permitted. In case of any change in rail section, LWR should be isolated by providing SEJ at junction point.

2. For BG the **allowed rail section** are – **60kg, 52kg, 90R**.
3. The rail shall be **tested ultrasonically** and all defective rails replaced before conversion into LWR/CWR.
4. Rail ends which are bent, hogged, battered, or having history of bolt-hole cracks shall be cropped before welding for conversion into LWR/CWR.
5. New rails used in LWR/CWR shall, as far as possible be without fish-boltholes.

E. Miscellaneous

1. **Continuity of track structure:** Wherever LWR/CWR is followed by fish plated track/SWR, **the same track structure** as of LWR/CWR shall be continued **for three rail lengths beyond SEJ**.
2. **Level crossings:** LWR/CWR may be continued through level crossing. But it should not be fall within the breathing lengths.
3. **Points and crossings:**
 - i. LWR/CWR shall not normally continue through point and crossings. It should be isolated **with at least three normal rail lengths**.
 - ii. LWR/CWR may be continued through point and crossing but prior approval of RDSO required.
4. **Glued joints:** All insulations for track circuiting in LWR/CWR shall be done by providing glued joints G3 (L) types.
5. **Location of SEJ:**
 - i. The exact location of SEJ shall be fixed taking into account the location of various obligatory points like level crossing, girder bridges etc.
 - ii. Normally SEJ should be provided on straight track. If necessary it can be laid on curve but not sharper than 0.5 degree (3500 m radius) as far as possible.
6. **Bridges with ballasted deck:** LWR/CWR can be continued over bridges without bearings like slabs, box culverts and arches.

7. Bridges without ballasted deck:

- i. LWR/CWR may be continued through without ballasted deck maximum length up to 20m and with condition as given in the manual.
- ii. Rail free fastening shall be used throughout the length of bridge.
- iii. LWR/CWR may be continued through without ballasted deck length more than 20 m up to 27m and more than 27m up to 43m with special conditions laid as per LWR manual.

DE-STRESSING

In order to obtain the **stress free condition** in the weld rail panels and also to **nullify the internal stresses (Thermal stresses)** developed of the rail panel, the process which is carried out is known as the De-stressing.

De-stressing becomes necessary in following conditions :

1. If LWR is not laid at distressing temperature.
2. After the buckling and fracture repair.
3. After deep screening / BCM working.
4. After the long stretch track renewal work.
5. After major realignment of curve.
6. When the gap of the SEJ observe more than + 20 mm from the standard gap at t_d (40mm) or SEJ gap more than 120mm or tongue rail of the SEJ is disturbed from the mean position.
7. When breathing length is increases more than the prescribed limit or when the movement under the non-breathing length portion is observed.
8. After the accident if the track is disturbed.
9. After the passing of the 10 GMT load on track or 1 Year whichever is later or As per desire of the Chief Engineer.

Types of de-stressing :

There are two methods by which de stressing is carried out

1. De-stressing without the use of Tensor
2. De-stressing with the use of Tensor

De-stressing without use of Tensor

General :

1. The work of de-stressing shall be done during a traffic block under the personal supervision of a PWI.
2. It is preferable to impose a speed restriction of 30kmph before actually obtaining the traffic block and to loosen/remove fastenings on alternate sleepers to reduce total duration of the traffic block.

Factors to be considered for de-stressing:

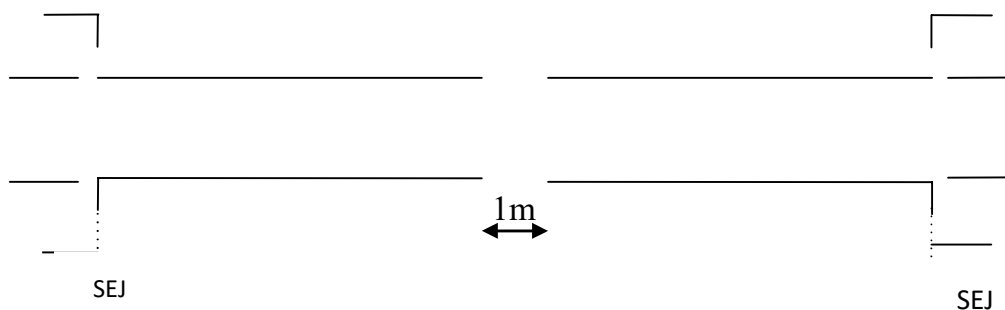
1. Designed Temperature :

The designed temperature for 52Kg and 60 Kg rail is

(T_m+5) to (T_m+10)

2. Time Period :

De-stressing is carried out in those days of year when the designed value of temperature is achieved/ attended during the traffic block working time. Pre-Block arrangement :



- 1.) Select first one Km of LWR for de-stressing first.
- 2.) **Caution:** Impose 30kmph caution for 1st one kilometer.

- 3.) Remove impeding/ accessories to free movement of rail such as rail anchors, guard rails check rails etc.
- 4.) We have to provide a rail closure of one meter (or 4meter length as convenient)in centre of the LWR or first selected length of one kilometer (about500m from SEJ). It should be done in such a way that weld population is not increased. It should be properly fish plated/ bolted / clamped.
- 5.) All fittings and fastenings must be loosened/drew and50% fittings & fastenings of alternate sleepers should be removed.
- 6.) We keep 6meter to 6.5meter ultrasonically tested rails for final welding at the site where gap is created. We need to put **rail rollers** at both side of track at every 15 sleepers. Sufficient rubber pads and fastenings should be made available for replacing worn out ones.

3. Work During Block :

- ✓ Minimum 2 hours block shall be taken for de stressing.
- ✓ As soon as block is permitted the de-stressing site should be protected with banner flag etc.
- ✓ The temperature during the entire block period should fall under the desired de-stressing temperature i.e., (t_m+5 to t_m+10)
- ✓ One team should be provided at the start of the SEJ
- ✓ Five to six persons along with black smith and cutters should be provided at centre of first closure.
- ✓ If sufficient labour is available, the work of de stressing for next 500m. Also can be taken in same block otherwise only first 500m is de-stressed and second 500m shall be de stressed in next day block.
- ✓ Remove the rail closure from centre of both rails by removing fish plate and fittings.
- ✓ As soon as traffic block is started fittings and fastenings for first 500m of both rails should be removed completely weld panel.
- ✓ Before the above step remove the rail closure from centre of both by removing fish plate and fittings.
- ✓ Put the rail pane on rail rollers. Freely tap both the panels for removing stress from one end to another (not from both). This locked up stresses are removed.
- ✓ The unserviceable fittings (rubber pads) should be removed by new ones (as we

don't have to open it twice)

- ✓ Put back the rail panels and sleepers to original position.
- ✓ Adjust the SEJ gap (at standard t_d , SEJ= 40mm)
- ✓ Fasten the rail panel from SEJ to rail closure side (side where gap is there) in a unique direction.
- ✓ Record the temperature at fastening time.
- ✓ The gap between the rail panels should be increased/ decreased depending on the nature of internal stresses present.
- ✓ Provide rail closure in between the track accordingly as required.
- ✓ Block will be cancelled.
- ✓ In next day de stressing of another 500m is done.
- ✓ Second day again block is taken at the time when required de stressing temperature is there,
- ✓ Again de-stress the panel as done earlier.

NOTE:

De stressing of 2nd, 500m can also be done in same block if sufficient labour is there and sufficient time is available.

Final repair :

- ✓ After the de stressing, rail panel may expand/contract in different modules and according to this 6m rail gap shall be provided in place 4m rail closures.
- ✓ Provide total gap for providing : Rail length + two weld gap - 2mm
 $6m + 25 \text{ mm} \times 2 - 2\text{mm}$ (saw cut)
- ✓ Replace the rail, impose 30kmph caution for next 1km and carry out de stressing as earlier

Next Day's Block :

1. During the next day block both the rails shall be welded with two teams of welders in diagonal method for providing working space.
2. After welding one joint, 2nd joint can also be welded considering the view of adjustment gap.

Equalisation of Forces :

After welding both joints equalization of forces shall be done 100 meters at both sides at panels, tapping and refastening it. Further whole length of LWR shall be de stressed in the same manner by providing gap at every 1km in stages.

- ✓ Finally after the de stressing, gap of the 2nd SEJ or both SEJ's shall be adjusted and hence de stressing work shall be completed.

Final de stressing Temperature :

It shall be the average of the temperatures at the time of fastening of LWR.

Equipments Required:

- ✓ All gang tools and blacksmith tools
- ✓ Rail cutting machines
- ✓ Qualified welders and two welding tools
- ✓ Portions of rail (60kg/52kg) of required rail section

De-stressing with rail tensor

General :

1. The work of de-stressing shall be done during a traffic block under the personal supervision of a PWI.
2. It is preferable to impose a speed restriction of 30kmph before actually obtaining the traffic block and to loosen/remove fastenings on alternate sleepers to reduce total duration of the traffic block.

Factors to be considered for de-stressing:

1. Designed Temperature :

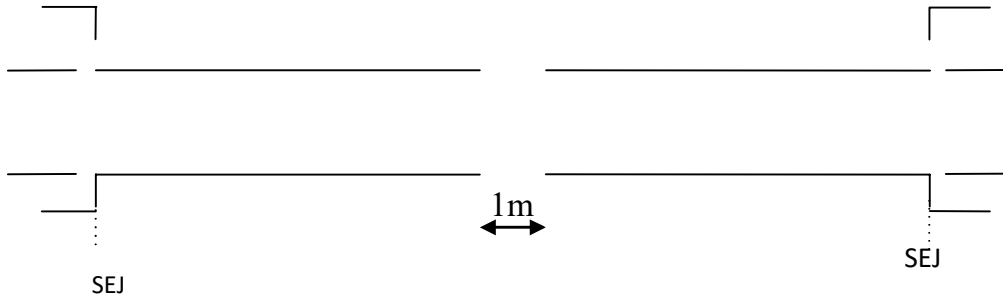
The designed temperature for 52Kg and 60 Kg rail is

(T_m+5) to (T_m+10)

2. Time Period :

De-stressing is carried out in those days of year when the designed value of temperature is achieved/ attended during the block the traffic block working time.

3. Pre-Block arrangement :

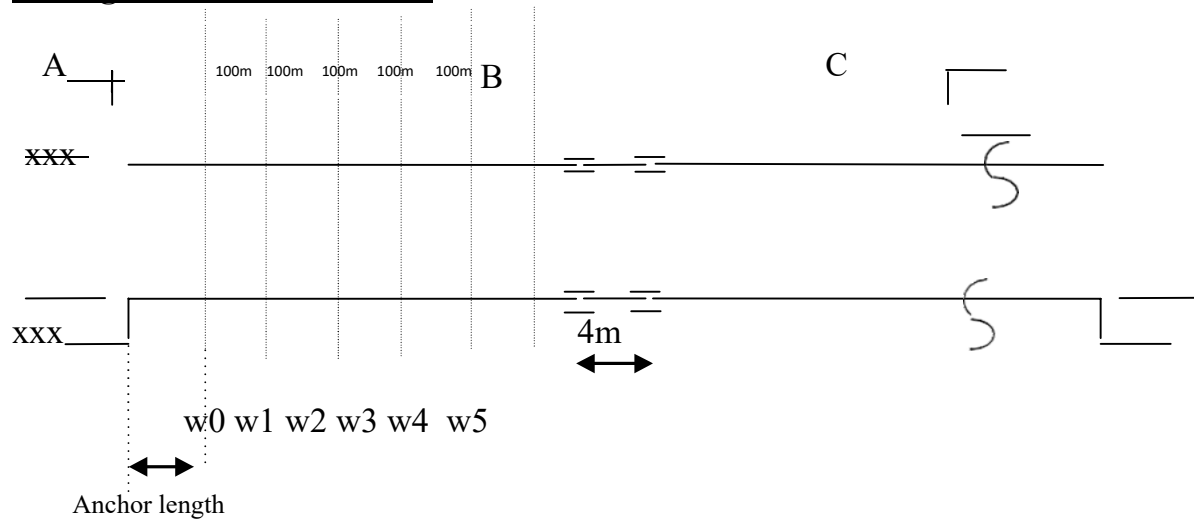


1. Select first one Km of LWR for de-stressing first.
2. **Caution:** Impose 30kmph caution for 1st one kilometre.
3. Remove impeding/accessories to free movement of rail such as rail anchors, guard rails check rails etc.
4. We have to provide a rail closure of one meter (or 4meter length as convenient) in centre of the LWR or first selected length of one kilometre (about 500m from SEJ). It should be done in such a way that weld population is not increased. It should be properly fish plated/ bolted / clamped
5. Decide Anchor length adjacent to SEJ with formula

$$\text{Anchor length} = 2.5\Delta t$$

6. Leaving **Anchor length**, all fittings and fastenings must be loosened/drew and 50% fittings & fastenings of alternate sleepers should be removed.
7. We keep 6meter to 6.5meter ultrasonically tested rails for final welding at the site where gap is created. We need to put **rail rollers** at both side of track at every 15 sleepers. Sufficient rubber pads and fastenings should be made available for replacing worn out ones.

During the first traffic block: -



- 1.) Take a traffic block.
- 2.) Create a gap of 1 meter at location B'' at a distance of about half the length of LWR from the centre of S.E.J.
- 3.) Introduce rail closure as required and fasten with special fish plate and clamps.
Allow traffic at a restricted speed. (Impose a caution of 30 KMPH)
- 4.) Mark the anchor length :-
For 52 Kg rail ----- $A_1 A_2 = l_a = 2.5$ meter per degree Celsius at ($t_d - t_p$)

Note:

$$\Delta l = L \alpha \Delta t$$

Where

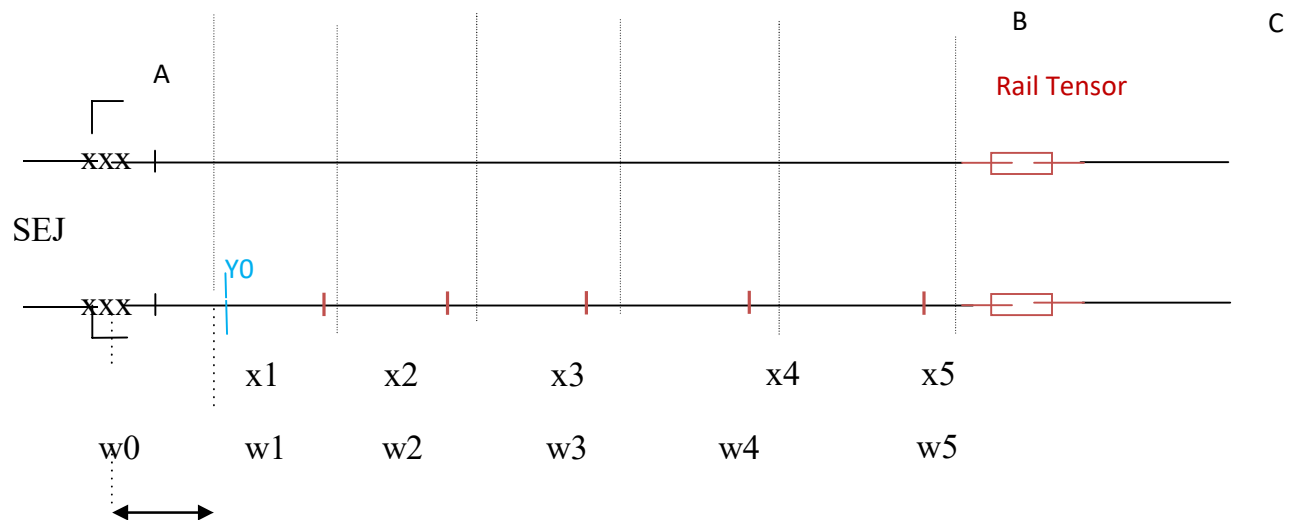
$\Delta t = (t_d - t_p)$ and α = co-efficient of thermal expansion

- a.) Anchoring of panel must provide a force greater than the pulling force
- b.) The anchoring length should be determined on the bar is of the lowest value of t_p at which the distressing is likely to be carried out.

- 5.) Erect Marker pillar W0, W1, W2 set on each of the length A to B at a interval of 100 meters.
- 6.) Transfer the mark W0 to the rail flange with the help of a chord.
- 7.) The distance W0 to W1 and W1 to W2 be marked at a interval of 100 meters. 8.) The last length W4 to W5 may be less than 100 meters.

During second traffic block

1. During the second traffic block, When the t_p is less than t_d . Carryout the de-stressing within the length A&B as below.



2. Remove the rail closure from the location B. Unfasten and mount the rails on rollers (at every 15th sleeper) in position A to B.
3. Fix the rail tensor across the location B. Apply the tension till the point W0 moves. Kinks and misalignment will be removed and friction on rollers will be minimized. Release the tension and note the movement Y0 to W0.
4. Transfer the mark W1, W2, W3, W4 & W5 on the rail with closure pencils.

5. Obtain the required extension at W1 noting (t_p) at W1 and calculating the extension as under :-
 - i. Extension at W1 = $Y_0 + 100\alpha(t_d - t_p) = x_1$ (say)
 - ii. Extension at W2 = $Y_0 + 200\alpha(t_d - t_p) = x_2$ (say)
 - iii. Extension at W3 = $Y_0 + 300\alpha(t_d - t_p) = x_3$ (say)
 - iv. Extension at W4 = $Y_0 + 400\alpha(t_d - t_p) = x_4$ (say)
 - v. Extension at W5 = $Y_0 + 500\alpha(t_d - t_p) = x_5$ (say)
 - vi. The value of $100\alpha(t_d - t_p)$ is available in the annexure IX of manual
6. Mark the x_1 from W1 backward with a different colour pencil. Pull the tensor till the mark x_1 coincides with W1 exactly. Now stop the tensor and remove the rollers W0&W1 and fasten the sleeper up to W0 to W1.
7. Proceed to part W2 and again pull tensor till the coincides of the X_2 with W2 exactly. Now again stop the tensor and remove the rollers W1&W2 and fasten the sleeper between W1 to W2.

Similarly proceed up to W5.
8. Now tensor will be released and new rail closure will be put inside the gap.
Caution will still be 30 Kmph.
9. In the **next block** (May be next day), next 500m (Portion C) will be distressed as per the above procedures.

Welding work:

1. After the de stressing, rail panel may expand/contract in different modules and according to this rail gap shall be provided in place 4m rail closures.
2. Provide total gap for providing :

Rail length + two weld gap – 1mm {6m + (25mm x 2) – 1mm}
3. Replace the rail.
4. During the next block, both the rails shall be welded with two teams of welders in diagonal method for providing working space.

5. After welding one joint, 2nd joint can also be welded considering the view of adjustment gap.
6. **Equalisation of Forces** : After welding both joints equalization of forces shall be done 100 metres at both sides at both panels, tapping and refastening it.
7. **Further whole length of LWR shall be de stressed in the same manner by providing gap at every 1km in stages.**
8. **SEJ Gap adjustment** :-Finally after the de stressing, gap of the 2nd SEJ or both SEJ's shall be adjusted and hence de stressing work shall be completed

Rail fracture on LWR

Cause:

1. Existing flaw undetected.
2. Defective Welding.
3. De-Stressing ignored.
4. Not observing the instructions in maintenance.
5. Flat tyre of running train.

RECTIFICATION OF RAIL FRACTURE

Equipment required:

- 1) Screw clamp, joggle fish plate for fracture rail welded joint and special 1m long fish plate.
- 2) Steel tape for reading up to 1mm.
- 3) AT welding and filling equipment.
- 4) Punch and hammer.
6. Equipment for De-stressing.
7. 4m long swan rail cut piece of the same rail section (This length will usually do exception like of fracture between to welds very close together in a short piece of rail are not calculated here.)
8. Rail closure: 30mm long
9. Equipment for protection of track.

10. Equipment for right working.

Action to be taken when rail fracture in LWR reported

1. Stop the traffic (It should be stop by key man/mate/gang man).
2. Emergency repair (mate/key man are authorized) then stop the train at restricted speed .that is first train at stop dead and 10 kmph but subsequent train at 15 kmph.
3. Temporary repair.
4. Permanent repair.
5. Equalization of forces in 100m length in either side.

PROCEDURE OF REPAIRS

Immediate action: Stop the traffic in emergency and protect the track with engineering signals.

The repair work will be carried out in following four steps.

1. Emergency repair
2. Temporary repair
3. Permanent repairs
4. Equalization of forces

1. Emergency repair (Fish plating)

The emergency repair is carried out immediately just after the detection of fracture by key man/gang man on duty in following step as given below:

- I. Joggle Fish plate/fish plate should be provided at weld/rail fracture.
- II. If there is a gap in fracture more than 30 mm, insert the 30mm rail piece in the gap. Fasten it with special fish plate and clamps. In case of weld failures use a joggled fishplate.
- III. Provide a wooden block to support at the fracture.
- IV. After providing joggle /fishplate and wooden block support, pass the

traffic as under:

First train with stop dead and proceed at 10kmph.

- V. Memo/message should be sent to the nearest Station Master for information of the fracture and subsequent train passing with non-stop 15kmph speed restriction.

Note:

- i. If the fracture is **multiple fractures** or any other **critically** is there and it is difficult to pass the traffic, the message of requirements shall be given to sectional JE/SSE through Driver of the train and Station Master. Message also can be sent by mobile phone.
- ii. Traffic will pass only after the Emergency Repair.
- iii. The work is to be supervised by mate/key man or any other official.
- iv. Key man/Mate shall not leave the site till arrival of the supervisory staff. After passage of each train he will check the fracture /repair and it will permit then pass the next train.

2) Temporary_repair (Rail replacement)

- i. Ultrasonically tested rail piece is taken. (Not less than 4m Length).
- ii. Arrange a traffic block as early as possible for minimum 30 minutes.
- iii. Make two punch box on the either side of the gap at a distance

$$I=L+G+2W-1mm \text{ (saw cut)}$$

Where,

I= Distance Mark

L= Rail Closure Length

G= Gap between rail at fracture point

W = Weld Gap (25mm)

- iv. Now cut the rail at punch mark and remove the broken piece.

- v. Insert the USFD tested rail piece inside the gap. (Principal is metal taken out = metal put in). Distribute the gap either side and if it is found to be more than 30mm, insert a rail piece of 30mm.
- vi. Fasten the new rail in track with special fish plate and clamp/bolts.
- vii. Remove the traffic block and **pass the traffic with 30kmph.**

Note: While making the punch mark, be ensure that there is no welds existing on outside within 4 meter.

2. Permanent repairs (Welding of joints)

- i. Take the traffic block preferably at a temperature lower than t_d and close to t_d .
- ii. Make a gap of 25mm at one end of rail piece and weld it.
- iii. If it is found that at the other end also a gap of 25mm is available. This can also be welded simultaneously at the same time.
- iv. In case 25 mm gap is not available at other end than take another traffic block at the temperature t_p , lower than t_d . Remove the fastening for some distance on either side; raise the rails on rollers and with the help of rail tensors, and pull the rail across the gap to obtain of 25mm.
- v. Release the tensor **20 minutes** after the welding so that it cools down.
- vi. After release the tensor fastens the rail completely and allows the traffic 30kmph.

3. Equalization of forces (Local De-stressing):

- i. De-stress 100meter on either side of fracture portion manually by removing fastenings, tapping and refastening the rails for **distribution of locked up thermal stresses** produce due to welding.
- ii. But it is better to be done within a block when t_p is less than t_d .
- iii. Then allow **normal traffic**.

BUCKLING OF TRACK IN LWR/CWR

Buckling of track is defined as a miss alignment of track in random manner due to thermal forces raised inside the panel due to high temperature.

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 creepresistance and torsional resistance
- iv. Excessive settlement of formation
- v. Improper functioning of SEJ.

Causes:

1. Loose or missing fittings
2. Loss of ballast resistance (lateral and longitudinal).
3. Locked up internal stresses.
4. Wrong laying not followed by de-stressing.

Vulnerable Locations:

1. Approach of the level crossing.
2. Approach of the girder bridge.
3. Approach of the tunnel.
4. Breathing length.
5. Location where track structure is change.
6. Sharp curve/reverse curve.

INDICATION:

- 1) Lifting of track.
- 2) Development of sun kinks.
- 3) Development void/gap around the sleepers.

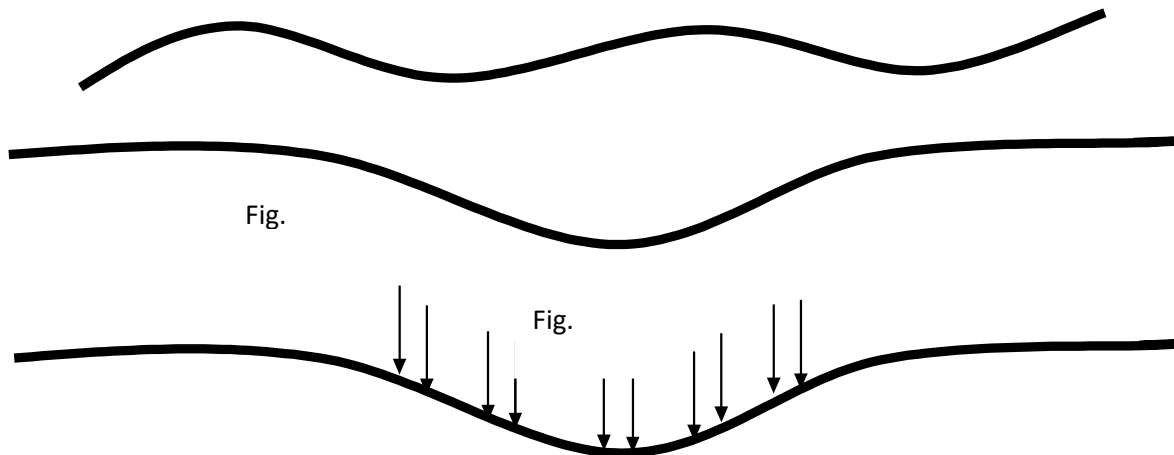
REPAIR OF BUCKLED TRACK

Immediate action: Stop the traffic immediately and protect the track with engineering signals

The repair work will be carried out in following four steps.

1. Emergency repair
2. Permanent repairs
3. Equalization of forces/De-stressing & packing

5. EMERGENCY REPAIR: -



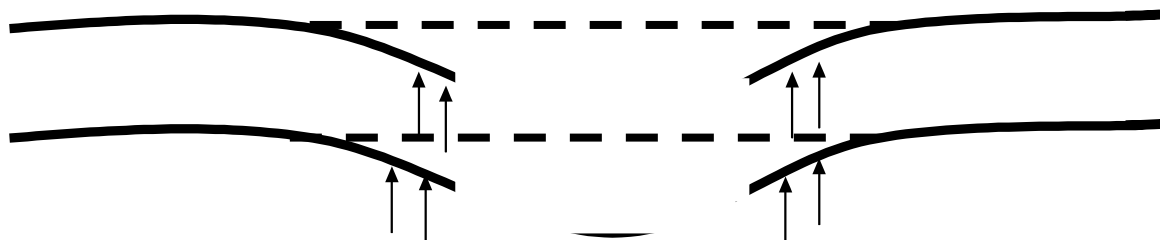


Fig. 3

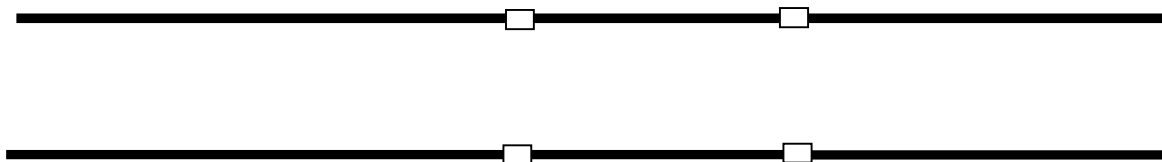


Fig .4

- i. The buckled rail should be released of compression by slewing the track outwards side. (Fig.2)
- ii. The rail on left hand side as well as right hand side, will be cut at two places to ensure that the gap may not less than 4.(Fig. 3)
- iii. Put back the normal alignment. (Fig. 3)
- iv. These gaps will be closed by providing two USFD tested rail pieces, keeping provision of two A.T. welds on either side.(Fig.4)
- v. It will be fastened by special fish plate and clamp.
- vi. At least one round packing should be done to ensure gauge and cross level etc.
- vii. After this, traffic can be resumed at a restricted speed preferably at 20kmph on PRC sleepers and 10 kmph on other sleepers

6. PERMANENT REPAIRS: -

- i. Make a gap of 25mm at one end of rail piece and weld it.
- ii. If it is found that at the other end also a gap of 25mm is available. This can also be welded simultaneously at the same time.
- iii. In case 25 mm gap is not available at other end than take another traffic block. Remove the fastening for some distance on either side; raise the rails on rollers and with the

help of rail tensors, and pull the rail across the gap to obtain of 25mm.

- iv. Release the tensor **20 minutes** after the welding so that it cools down.
- v. At least one or two round manual/machine packing of the buckled portion should be done and allow the traffic 30kmph.

7. DE-STRESSING & PACKING: -

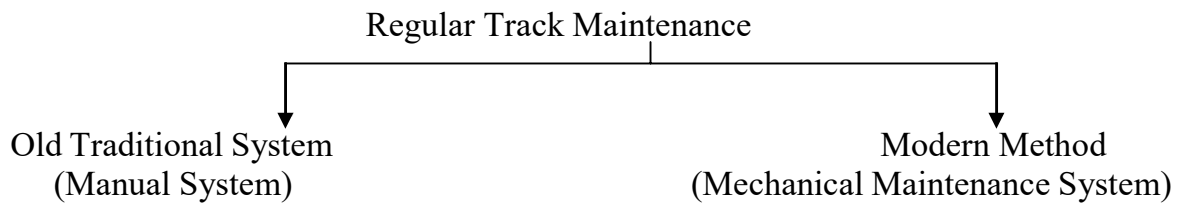
- i) After the permanent repair, the entire LWR will have to be de-stress as per LWR manual.
- ii) Resume the normal speed after several round of packing/tamping and stabilization of track.

Hot Weather Patrolling

1. Patrolling will be introduced when the rail temperature rises above:
 - (a) $t_d + 25^{\circ} \text{C}$ on PSC sleeper track with sleeper density 1540 nos. / km and above.
 - (b) $t_d + 20^{\circ} \text{C}$ on PSC sleeper track with sleeper density less than 1540 nos. / km
2. All preliminary arrangement for patrolling including selection and counseling of patrolmen should be kept ready well before start of summer.
3. PWM/PWI of units/gangs be advised to commence patrolling of their own discretion as per IRPWM 2020 manual.
4. Patrol beat for Hot weather patrolling will be 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.
 - (iii) Changes in beat length and man power deployment as given above, if found necessary, may be decided by the Sr. DEN (Co) of the division depending on prevailing local conditions, frequency of train service, weather conditions etc.,
5. The hot weather patrolman should always carry the following equipment:-

HS Flags - Red	2
Staff for Flags	1
Detonators	10
Canne-a-boule fitted with rubber ball	1

REGULAR TRACK MAINTENANCE



3 Tier System

1. Maintenance of track by track machine
2. Maintenance of track by mobile Maintenance unit (MMU)
3. Rest maintenance carried out by sectional gang

Note: MMU is a combination of road cum rail vehicle

Manual Maintenance (Traditional method)

S.No	Process	Duration	Properties Maintained	IF m/C used Which M/C
1	Through Packing	Once in a year	Track health and track parameters	TTM(Tie Tamping Machines)
2	Overhauling	Once in 4/3 Years	Shoulder , Crib ballast Screening	FRM, SBCM
3	Deep Screening	Once in 10 to 12 years	Entire Ballast Section is screened with 1": Square mesh	BCM
4	Pick up The Slacks	As per Need	Un wanted material are removed from track	
5	Special Work	As per Need	Renewal of track, Rails, Fasteners, ballast regulation, Lubrication of fittings and fastenings etc	BRM,T-28,PQRS, SQRS ,ATRTRTRT etc

PROPOSED SCHEDULES FOR DEEP SCREENING (MANUAL PACKING)

Day	Sequence of events	Speed in Kmph
1st	Deep Screening and initial packing	20
2nd	1 st through packing	20
3rd	2nd through packing	20
4 th to 9 th	Picking up of slacks as required	45
10th	3rd through packing	45
11 th to 19 th	Picking up of slacks as required	75
Speed raised to normal sectional speed, only after one round of tamping by machine in design mode and stabilisation in controlled settlement mode		

PROPOSED SCHEDULE FOR DEEP SCREENING (MACHINE PACKING /B.G.)

Day	Sequence of Events	Speed in Kmph
1st	Deep Screening with Initial Packing	20
2nd	First Machine Packing	20
3rd to 5th	Picking up of slacks as required	45
6th	Second Machine packing	45
7th& 8th	Picking up of slacks as required	75
9th	Third Machine packing	75
10th	Normal Sectional speed	

Note :

Normally all the process are not complete without through packing. In case of Deep Screening 7 Rounds of through Packing +21 days of speed restriction is provided on the track in case of Manual maintenance. In case of Machine Maintenance it is 10 days.

Through Packing:

Through packing consists 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:

1. Opening of track.
2. Examination of rails, sleepers and fastenings
3. Squaring and spacing of sleepers.
4. Slewing of track to correct alignment.
5. Gauging.
6. Packing of sleepers.

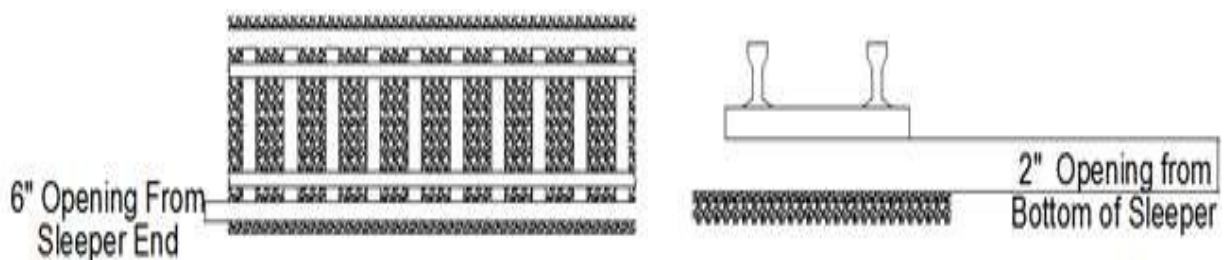
7. Repacking of joint sleepers.

8. Boxing and tying.

The sectional gang start in working season the work of through packing from one end of gang beat and goes to another end till completion of the work in that section.

Opening of Track :

Opening of ballast is carried out in both ends of sleeper up to 6" away and crib ballast under the rail seat up to minimum depth of 2" from the bottom of the sleeper by the claw.

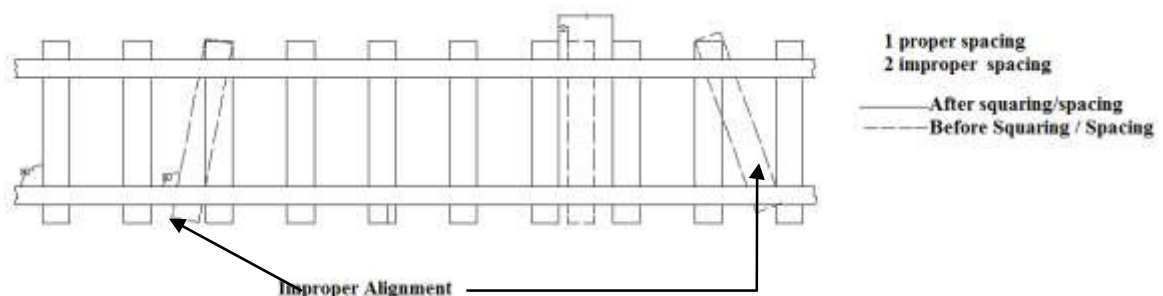


Examination of Rails, Sleepers and Fastenings –

Operation of this sequence track health is made strong. Worn-out/ Unserviceable sleepers are replaced by serviceable sleepers, missing fitting and fasteners/unserviceable fitting and fastenings are replaced by new one

Spacing and Squaring of sleepers: -

In this sequence after the replacement of Worn-out/ Unserviceable components of track, the sleepers are spaced and squared as per requirement. This is necessary for smooth /Good/Efficient running of the train.



Slewing of track to correct alignment:

In this sequence of operation the gang mate collects workmen at one place and select one rail as reference rail. This reference rail is aligned manually with crow bar and in the eye view standing 3 rail behind from the aligned position.

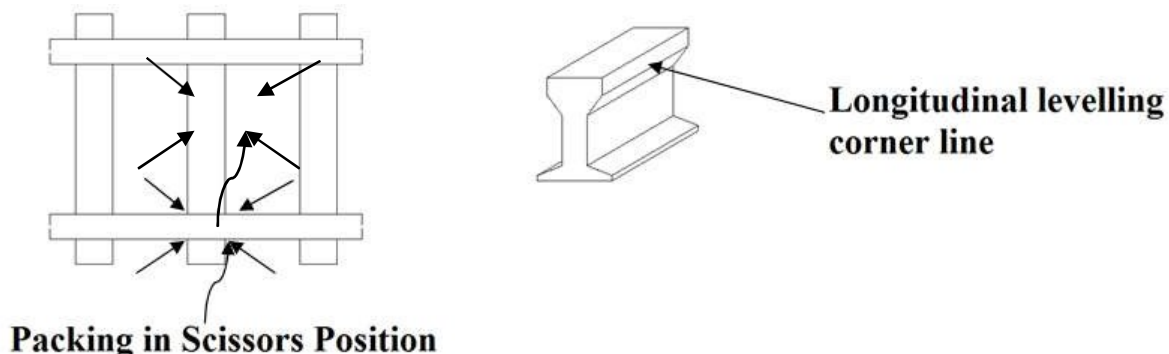
Gauging:-

After the alignment gauging to the track is corrected in second rail (other than reference rail) normally this gauging is also carried out in eye view to avoid kinks etc. No sudden change in the gauge is allowed even tolerance is permitted. After the correction the gauge correctness is checked by the gang mate with the help of track gauge measuring instrument.

Packing of sleepers

In this sequence longitudinal and cross level of the track is corrected by lifting of the track and packing of the sleepers. The work of longitudinal leveling is supervised by the gang mate in eye view from one rail behind and looking reference rail cutter face bottom corners.

After the leveling of the reference rail, second rail is also lifted and packed in zero cross level in same fashion as reference rail is packed. After the leveling each pair of gang men return in the sleeper bit and well packed in scissor's position.



Repacking of joint sleepers:

After coming back from the lunch gang mate examines the deficiency of the track generated by moving train during the period of the lunch. Such locations are identified by the mate and repacked /realigned as per need to correct alignment and leveling of track . After this each pair again packed each sleepers as a final packing and joint sleepers are specially repacked

Boxing and Tyding: –

After final packing of the track the opened ballast repositioned in the track with the help of claw and sleepers are fully boxed as per standard ballast profile of the track. Ballast deficiency is re-equipped and excess ballast are removed and collected to the cess. All the green dries are removed from the track , drains are repaired, cleared and trolleyrefuges are required..

Over Hauling of Track:-

Overhauling of the track is done for the following purpose

1. To improve the drainage
2. To make availability of the clean ballast for packing

In this process shoulder ballast and crib ballast up to 4” from the bottom of sleepers screened by 25mm manually. Since no cushion ballast is disturbed hence no caution is required for carrying out the process. After the screening all eight operations of the through packing is essential to carry out in the track then only overhauling operation willbe treated complete

Normally one fourth section of the gang bit is overhauled every year but the location around the sub-urban areas and other track circulated zone. Where chance of dirty ballast is more overhauling can be carried out in every three years.

Deep Screening

In this operation entire ballast section is cleaned by 25mm mesh manually. Since in this operation cushion ballast bed is disturbed. Hence the operation is carried out by supporting track on wooden block under the 15 kmph(20 kmph caution). This caution isrest after six round of through packing and intermediate stabilization period gradually from (20-30-50-70) to normal about 21 days are involved in this operation.

Various restrictions applied immediately after the work

After Manual Packing

- | | | |
|-----------------------------------|---|---------|
| 1. Pre-Stressed concrete sleepers | – | 20 kmph |
| 2. Other stressed | - | 10 kmph |

After BCM working (only on PRC)

- | | | |
|----------------|---|---------|
| 1. BCM | - | 20 kmph |
| 2. BCM+TTM | – | 30 kmph |
| 3. BCM+TTM+DGS | – | 40 kmph |

Note:

Normally 15kmph should be implemented on the track after immediate end of the Packing / Screening. Since nowadays the implementation of speed is not in multiples of 5 for slower speed so it is implemented in the multiples of 10.

Picking up of Slacks

Basically it is the need based maintenance. Which is carried out in the track in non-working seasons (in monsoons etc) when through packing and other maintenance work could not be carried out . in this operation only the affected portion of the track(settles track) is attended to maintain the certain maintenance standard of the track. So that safe running of the train can be assured.

The location of defect is identified by the track recording car (TRC) restart trolley in section, foot plot inspection and foot inspection only.

Normally in this operation following locations are attended regularly.

- i) SEJ, Glued Joints and fish plated joint.
- ii) Approaches of the girder bridges, Level crossings and points & Crossing
- iii) Weak formation
- iv) Pedestal and cattle crossing
- v) Breathing length of LWR
- vi) Location where ballast is dirty etc.

Precautions to be taken while Working in Track circuited Areas-

1. The Permanent way inspector should instruct the staff not to place across or touching two rails in the track any tool or metal object which may cause short circuiting.
2. All gauges, levels, trolleys and lorries used on the track circuited length should be insulated.
3. 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.
4. 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.

5. Use of steel tapes should be avoided in track circuited section.
6. Pulling back of rails should be done in track circuited areas in the presence of S&T staff, where signaling connections are involved.
7. Proper drainage should be ensured so as to avoid flooding of track, during rains, particularly in yards, where watering of coaches is done and in water columns and ash pits. It would be desirable to provide washable concrete aprons on platform lines at originating stations, in track circuited areas.
8. Ballast must be kept clean throughout the track circuited section and care should be taken to see that the ballast is kept clear of the rails and rail fastenings. The clearance from the foot of the rail should not be less than 50mm. During every packing this point should be taken note of.

Other Precautions to be taken while Working in Track circuited Areas are as follows

1. In charge Sectional P. Way Engineer shall instruct the staff not to place across or touching two rails in the track, any tool or metal object which may cause short circuiting.
2. All gauges, levels, trolleys and Lorries used on the track circuited length shall be insulated.
3. Steel or C. 1 pipes used for carrying water gas under the track shall be placed sufficiently below the rails to prevent any short circuiting.
4. While carrying out track maintenance, care shall be taken to ensure that no damage of track circuit fittings like bond wires bootlegs, jumped wires etc. takes place.
5. Use of steel tape should be avoided.
6. Pulling back of rails in track circuited areas shall be done in the presence of S&T staff.
7. Proper drainage shall be ensured in yard to avoid flooding of track during rains. where watering of coaches is done. It would be desirable to provide washable concrete aprons on platform lines.
8. Ballast shall be kept clean throughout the track circuited length and care shall be taken to ensure that ballast is kept clear of rails i.e. 50mm from under side the foot of rail.
9. Min. ballast resistance per Km. of track < 20 ohms in the station yards and < 4 ohms in block sections.

Maintenance in Electrified Areas

General Instructions to staff –

(1) General Knowledge of Engineering Staff-

- a) 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.
- b) 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.

(2) Defects in an Overhead Equipment:-Defects or break-downs in the overhead equipment including track and structure bonds noticed by the Engineering staff shall be reported immediately to the Traction Power Controller. 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.

(3) Traction Bonds - In electrified areas the return current fully or partially flows through the rail. 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.

- (a) **Longitudinal Rail Bonds** - In the case of D.C. traction system, practically the whole return current flows through the rail. Therefore, two flexible copper bonds offering minimum resistance to the flow of current are provided at each rail joint under the fish-plates. Two solid lugs at the two ends of the copper bonds are inserted in holes drilled at the two rail ends between the fish bolt holes and are pressed by using a bend press to rivet them firmly to the rail. On points and crossings and at junction fish-plates where continuity bonds of the above type cannot be provided due to space constraint, continuity of return current path is achieved by using mild steel straps or G.I. wire ropes. Absence of such bonds may cause unsafe working condition and in extreme cases may damage the rail ends.

- (b) **Cross Bonds (D.C.)** :- Cross bonds are provided between adjacent tracks at regular intervals to reduce resistance of the current to the minimum. Such cross bonds are also known as transverse bonds.
- (c) **Structure Bonds** .-All structures supporting overhead equipment either in A.C or D.C. track circuited areas are connected to the running rails for ensuring good earthing. Failure of insulator or leakage of current switches off the supply from the sub-station so that men coming in contact with supporting structure etc. do not get electric shock. Removal or tampering of such bonds can, therefore, result in unsafe conditions. Since the structures are grouted in concrete, they are likely to become charged in case such bonds are kept disconnected. Similarly other steel structures such as foot-over bridges, sheds, etc., in the vicinity of O.H.E. lines are also connected to rails through similar structure bonds.

PERMANENT WAY RENEWALS

Necessity For track renewal

- ⇒ When track materials are worn out.
- ⇒ When track structure is required to change for increasing axle load of the section.
- ⇒ When the MSS of the section is required to be increased.
- ⇒ When serviceable materials of the main line is required for renewal of the branchline .

Classification of Renewals - All track renewals can be classified generally into one of the following categories:

1. Complete Track Renewal C.T.R
2. Through Rail Renewal T.R.R
3. Through Sleeper Renewal T.S.R.
4. Through Turn-out renewal (TTR)
5. Through Fitting & Fastening renewal (TFR)
6. Through Weld renewal (TWR)
7. Through Bridge timber renewal (TBTR)
8. Through Ballast Renewal (TBR)

Casual Renewals: It is not the part of Regular Track Maintenance

Scattered renewal: It is the part of Regular Track Maintenance

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.

Scattered Renewal

In this case, unserviceable rails, sleepers and fastenings are replaced by identical sections of serviceable and nearly the same vintage track components.

These are carried out in isolated locations and not more than 10 rails and/or 250 sleepers in a gang beat in a year. Such renewals are a part of normal maintenance operations.

Types of Renewal on the basis of materials used

1. Primary Renewal
2. Secondary Renewal
3. Tertiary Renewal

Primary renewals

Primary renewals are those where only new materials are used for renewal. Normally it is done on main line.

Secondary renewals

Secondary renewals are those where released serviceable materials are used. Normally it is done on branch line.

Tertiary renewals

Tertiary renewals are those where released serviceable materials from branch line are used. Normally it is done on Yards.

When we do Renewal

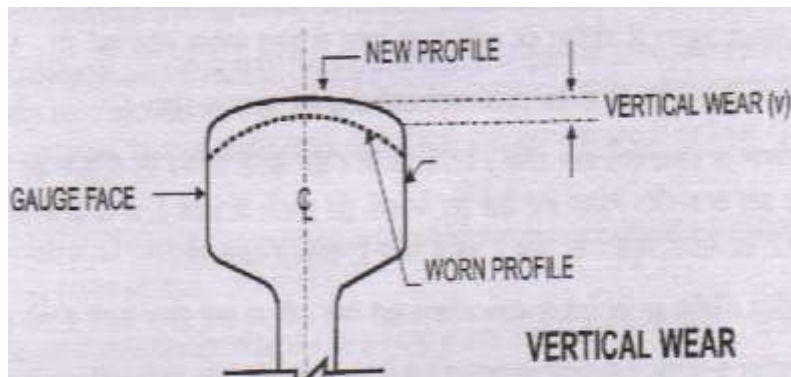
1) Safety Consideration: when it is difficult to maintain the track with safety.

2) Economic Consideration: When the maintenance cost of track becomes very high we go for renewals.

3) On basis of Rail Fracture: when the rail fracture of the section beyond limit and on basis of USFD (Ultrasonic Flaw detection Test) Testing results we take decision of rail renewals.

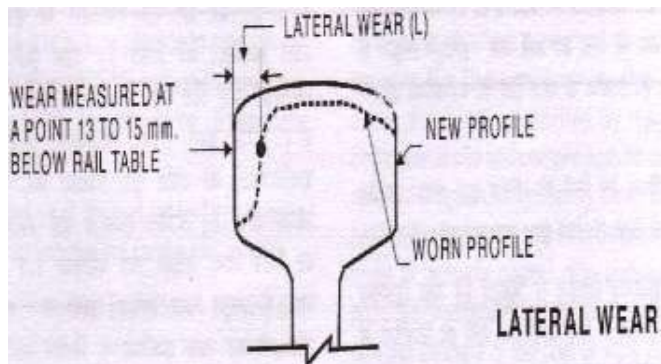
4) Due to Wear :

Vertical Wear



Rail Section	Vertical Wear in mm
60 KG	13
52 KG	8
90 R	6

Lateral Wear



Route	Straight Track	Curved Track
A , B	6 mm	8 mm
C , D	8 mm	10 mm

Percentage Loss in Weight

Gauge	Rail Section	Loss in Section in percentage
B. G	52 Kg. / metre	6
	90 R ...	5
M.G.....	75 R....	4.2
	60 R...	3.25

Till weight loss percentage for 60 kg rail has to be desired

5) Due to Corrosion

When the thickness of web reduced to more than 1.5 mm.

6) On Basis of Service life

Gauge	Rail Section	Total G.M.T. carried for T.12 Med. Manganese rails	Total GMT carried for 90 UTS rails
B. G.	60 kg/m	550	800
	52kg/m	350	525
	90 R	250	375
M. G.	75 R	150	.
	60R	125	.

Note: On major bridges and on all important bridges where height of bank is 4metre or more and on tunnel approaches. upto 100 meter either side of bridge/tunnel and on bridge. The track will be renewed after passing the half of the stipulated GMT.

7) Planned Way Renewal

Such renewal is part of major planning and it may be premature renewals. This type of renewals is carried out when we need track modernization speed to increase and gauge renewals etc.

Sleeper renewal :

- a. When sleeper are failed to retain gauges and packing they should be renewed
- b. Wooden Sleepers : when 30% sleepers are damaged due to broken, wearout, then TSR shall be done
- c. Steel sleepers shall be done when they are broken, worn out etc.

Method of Renewal :

1. Manual method
2. Machined Method
 - a. PQRS
 - b. TRT
 - c. T-28

TRACK TOLERANCE

Safety and comfort by depends upon the track geometry. Which further depends upon the “laying and maintenance Standard of track? It is never possible to lay and maintain a track without error and also it is not necessary. The level of maintenance of track as up/down (variations) as per head. For example on rajdhani routes, high class maintenance level is required while on branch line it is neither required nor possible because of “Low –Traffic” and “Costly affair”. Hence some relaxation is given in pertaining parameters for persons who are working on the track for their guide lines. This relaxation is known as track Tolerance.

The limited variations of track parameters which are acceptable in sense of safety and comfort are known as track tolerance.

Track Parameter

Gauge: vertical distance between two gauge faces of track (rail) is known as gauge.

Un-Evenness: The difference of level of both (two) rails is measured separately on a fixed base is known as unevenness of track.

On BG it is measured by 3.6 meter chord.

Twist : Rate change of X-level is known as twist. It is measured on 3.5 meter base and it is denoted as mm/meter.

Cross Level: Difference of level of both rails (measured vertically) is known as X-Level.

Alignment : Alignment of track is measured separately for left and right rail. It is measured at 7.5 meter base but on Rajdhani Route (“A” route) this is measured on 10 meter base.

Alignment is normally checked by Eye-Focus standing by 25 mtr behind from location (But Normally it is checked from distance behind three rails).

Tolerances under Loaded/ Floating Condition:

The gauge and alignment is normally not affected under the loaded condition but evenness. Cross level and twist is affected much more and its variations under load have a great importance. Different countries of world have studied but most effective results are given by Japanese National railways which are as under:

S. no	Parameters	Value under Condition Of	
		Load	Floating
1	Longitudinal Level	10 mm	6 mm
2	Cross level	12mm	6 mm
3	Gauge	G +(1 to 1.5 mm)	G mm
4	Alignment	A +(1 to 1.5 mm)	A

Note: it is impossible to maintain the track parameter same in both conditions.

Type of tolerance:

1. Safety Tolerance
2. Maintenance Tolerance
3. New Track Tolerance

Safety Tolerance:

This is the tolerance which is assumed to cross its limits. There are chances of derailment and running of the train is quite unsafe. These tolerance are suspicious and doubt full till date. Hence no railway still decided the limit of the safety tolerance in the world.

Maintenance Tolerance:

These are the tolerance which is achieved twist after the maintenance operation. This depends upon the track structure quality of tools / machines type of maintenance and standard of the supervision. The limit of maintenance tolerance is fixed to achieve certain.

In Indian railways limit of the maintenance tolerance is not fixed rigidly anywhere. But Northern railway has given direction in this field.

The length of short and long chord/base for track monitoring are as under:

SN	Parameter	Short Chord / Base (m)	Long Chord/ Base (m)
1	Unevenness	9.0 (UN-1)	18.0 (UN-2)
2	Alignment	9.0 (AL-1)	15.0 (AL-2)
3	Twist	3.0 (TW-1)	15.0 (TW-2)

Based on TRC and OMS results, various limits of PML NBML and UML for Unevenness, Alignment, Gauge and Twist Parameters for different speed bands are stipulated as under:

- (1) For Speeds up to 100 Kmph:

SN	Parameter	Planned Maintenance Limit (PML)	Need Based Maintenance Limit (NBML)	Urgent Maintenance Limit (UML)
1	Unevenness			Vertical and lateral acceleration peak of 0.30 g
1.1	UN-1	SD-5.0 mm	SD-6.8 mm Peak-20 mm	
1.2	UN-2	-	-	
2	Alignment			
2.1	AL-1	SD-3.3 mm	SD-4.9 mm Peak -15 mm	
2.2	AL-2	-	-	
3	Gauge			
3.1	Mean gauge over 200 m section over nominal gauge			
(a)	Straight	-	-8 mm to +10 mm	-10 mm to +12 mm
(b)	Curve with radius 440 m or more	-	-5 mm to +14 mm	-7 mm to +17 mm
(c)	Curve with radius less than 440 m (Permissible speed as per relevant Para of IRPWM)	-	-5 mm to +18 mm	-7 mm to +20 mm
3.2	Isolated defects – Nominal track gauge to peak value			
(a)	Straight	-	-10 mm to +12 mm	-12 mm to +15 mm
(b)	Curve with radius 440 m or more	-	-7 mm to +17 mm	-11 mm to +20 mm
(c)	Curve with radius less than 440 m (Permissible speed as per relevant Para of IRPWM)	-	-6 mm to +22 mm	-8 mm to +25 mm
4	Twist (TW-1)		5 mm/m	7 mm/m

(2) For Speeds above 100 Kmph and up to 110 Kmph:

SN	Parameter	Planned Maintenance Limit (PML)	Need Based Maintenance Limit (NBML)	Urgent Maintenance Limit (UML)
1	Unevenness			Vertical and lateral acceleration peak of 0.30 g
1.1	UN-1	SD-3.8 mm	SD-5.5 mm Peak-17 mm	
1.2	UN-2	SD-5.4 mm	SD-7.5 mm Peak-23 mm	
2	Alignment			
2.1	AL-1	SD-2.5 mm	SD-3.9 mm Peak -12 mm	
2.2	AL-2	SD-4.1 mm	SD-6.7 mm Peak-20 mm	
3	Gauge			
3.1	Mean gauge over 200 m section over nominal gauge			

(a)	Straight	-	-8 mm to +10 mm	-10 mm to + 12 mm
(b)	Curve with radius 440 m or more	-	-5 mm to +14 mm	-7 mm to +17 mm
(c)	Curve with radius less than 440 m (Permissible speed as per relevant Para of IRPWM)	-	-5 mm to +18 mm	-7 mm to +20 mm
3.2 Isolated defects – Nominal track gauge to peak value				
(a)	Straight	-	-10 mm to +12 mm	-12 mm to + 15 mm
(b)	Curve with radius 440 m or more	-	-7 mm to +17 mm	-11 mm to +20 mm
(c)	Curve with radius less than 440 m (Permissible speed as per relevant Para of IRPWM)	-	-6 mm to +22 mm	-8 mm to +25 mm
4	Twist (TW-1)		4 mm/m	7 mm/m

(3) For Speeds above 110 Kmph and up to 130 Kmph:

SN	Parameter	Planned Maintenance Limit (PML)	Need Based Maintenance Limit (NBML)	Urgent Maintenance Limit (UML)
1	Unevenness			Vertical and lateral acceleration peak of 0.25 g
1.1	UN-1	SD-3.3 mm	SD-4.9 mm Peak-15 mm	
1.2	UN-2	SD-5.1 mm	SD-7.4 mm Peak-22 mm	
2	Alignment			
2.1	AL-1	SD-2.5 mm	SD-3.6 mm Peak -11 mm	
2.2	AL-2	SD-3.5 mm	SD-5.3 mm Peak-16 mm	
3	Gauge			
3.1	Mean gauge over 200 m section over nominal gauge			
(a)	Straight	-	-8 mm to +10 mm	-10 mm to + 12 mm
(b)	Curve with radius 440 m or more	-	-5 mm to +14 mm	-7 mm to +17 mm
(c)	Curve with radius less than 440 m (Permissible speed as per relevant Para of IRPWM)	-	-5 mm to +18 mm	-7 mm to +20 mm
3.2	Isolated defects – Nominal track gauge to peak value			
(a)	Straight	-	-10 mm to +12 mm	-12 mm to + 15 mm
(b)	Curve with radius 440 m or more	-	-7 mm to +17 mm	-11 mm to +20 mm

(c)	Curve with radius less than 440 m (Permissible speed as per relevant Para of IRPWM)	-	-6 mm to +22 mm	-8 mm to +25 mm
4	Twist (TW-1)		4 mm/m	6 mm/m

(4) For Speeds above 130 Kmph and up to 160 Kmph:

SN	Parameter	Planned Maintenance Limit (PML)	Need Based Maintenance Limit (NBML)	Urgent Maintenance Limit (UML)
1	Unevenness			Vertical and lateral acceleration peak of 0.20 g
1.1	UN-1	SD-2.9 mm	SD-4.4 mm Peak-13 mm	
1.2	UN-2	SD-4.4 mm	SD-6.6 mm Peak-20 mm	

2	Alignment			Vertical and lateral acceleration peak of 0.20 g
2.1	AL-1	SD-1.9 mm	SD-3.6 mm Peak -11 mm	
2.2	AL-2	SD-2.5 mm	SD-4.9 mm Peak-15 mm	
3	Gauge			
3.1	Mean gauge over 200 m section over nominal gauge			
(a)	Straight	-	-6 mm to +10 mm	-8 mm to + 12 mm
(b)	Curve with radius 440 m or more	-	-5 mm to +13 mm	-7 mm to +15 mm
(c)	Curve with radius less than 440 m (Permissible speed as per relevant Para of IRPWM)	-	-5 mm to +18 mm	-7 mm to +20 mm
3.2	Isolated defects – Nominal track gauge to peak value			
(a)	Straight	-	-8 mm to +12 mm	-10 mm to + 15 mm
(b)	Curve with radius 440 m or more	-	-6 mm to +16 mm	-9 mm to +20 mm
(c)	Curve with radius less than 440 m (Permissible speed as per relevant Para of IRPWM)	-	-6 mm to +22 mm	-8 mm to +25 mm
4	Twist (TW-1)		3.5 mm/m	5 mm/m

New Track Tolerance :

For measurements recorded by TRC.

(a) SD Values for Unevenness and Alignment:

Sl. No.	Parameter	Speed upto 100 Kmph	Speed above 100 Kmph; and up to 160 Kmph
1.	UN-1	2.0 mm	1.4 mm

2.	UN-2	-	1.9 mm
3.	AL-1	1.4 mm	1.1 mm
4.	AL-2	-	1.3 mm

(b) Peak Values for Unevenness and Alignment:

Sl. No.	Parameter	Speed upto 100 Kmph	Speed above 100 Kmph; and upto 160 Kmph
1.	UN-1	6.0 mm	4.0 mm
2.	UN-2	-	6.0 mm
3.	AL-1	4.0 mm	3.0 mm
4.	AL-2	-	4.0 mm

For measurements recorded in floating conditions:

(a) Gauge:

For new track and through renewal of track, following tolerances would be applicable-

(i) For 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) Other parameters:

S. No	Parameter	Description of Measurement	Value
1	Gauge	Sleeper to sleeper variation	2 mm
2	Expansion gap	Over average gap worked out by recording 20 successive gaps	± 2 mm
3	Joints	Low joints not permitted High joints not more than 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	± 2 mm
7		Variation over theoretical versines: (On 20 m Chord). On curves of Radius more than 600 m	5 mm
8		Variation over theoretical versines: (On 20 m Chord). On curves of Radius less than 600 m	10 mm
9	Longitudinal level	Variation with reference to approved longitudinal sections.	50 mm

SCHEDULE OF DIMENSIONS

Present Schedule of Dimensions:

The present SOD revised in the year 2022 consist all the dimensions in metric units. All the dimensions in FPS units have been deleted. The following modifications have been done in the SOD of 1973:

Schedules:

Chapter		Sche dule	Details of Contents
I	General	1	Spacing of tracks curves bridge, rails, building and structures, interlocking and signal gears tunnels, through semi through girder bridges and safety refuges formation width gauge on straight and curves.
II	Station Yards	1	Spacing of tracks, platforms, buildings & structures, points and crossings, length of sidings.
III	Workshop & Station machinery	1	Water tanks and Water Cranes, workshops and running sheds.
IV(A)	Rolling stock (C&W)	1	Wheel and axles, height of floors, buffers & couplings, wheelbase and length of vehicles, max moving dimensions, loading gauge for goods
IV(B)	Rolling stock (3660mm wide stock)	1	Maximum future moving dimensions, loading gauge for goods.
IV(C)	Rolling Stock (Locomotives)	1	Wheels and axles, buffer & couplings, max. moving dimensions, max. moving dimension for X-class Locomotives.
IV(D)	Rolling Stock (Track Machines)	1	Wheels and axles, height of floors, buffer & couplings, wheel base and length of vehicles, max. moving dimension
V	Electric traction (DC)	1	
V(A)	Electric traction 25KVAC 50 Cycles	1	Electrical Clearances

V(B)	Electric traction 25KVAC Electric Traction with High Rise OHE	1	Electrical Clearances
	AC 50 Cycles Schedule	II	Existing infringements of schedule 1 which may be permitted to continue on 1676mm gauge railways.

SOD of year 2022 contains only two schedules

i. Schedule-1

ii. Schedule-II.

Schedule-I:

Consists of those items which are mandatory and have to be observed on all 1676mm gauge on Railways in India. This also contains certain selected items of schedule-II of 1973 version of SOD. In this schedule, dimensions have been classified under two heads namely for “Existing works” i.e. the works existing before the issue of Indian Railway Schedule of Dimensions (BG), Revised-2004. and for “New works” which would include new constructions, additions of new lines/structure, gauge conversion and doubling except the works of alteration such as shifting of a Points and Crossings, extension of siding, extension of loop line, alteration in building etc.

Schedule-II:

Consists of items included in Schedule-III of 1973 version of SOD.

In addition to above the appendix dealing with extra clearances required on curves have been modified to suit maximum speed of 160 Kmph and maximum SE of 165mm as per high speed, Rajdhani and Shatabdi routes with other parameters kept as earlier. Correction slips issued from time to time to SOD of 1973 & revised SOD of 2004 have been incorporated in revised SOD of year 2022.

Chapter Wise Details of Contents in Schedule of Dimensions:

Loading Gauge:

Loading gauge represents the maximum width and height to which a rolling stock viz, Locomotive, Coach or Wagon may be built or loaded.

On Indian Railways maximum height and width of rolling stock prescribed as per loading gauge is as follows-

Maximum Height above rail level at centre	4265mm
Maximum Height above rail level at sides	3735mm
Maximum Width	3250mm

Construction gauge is decided by adding necessary clearance to the loading gauge so that vehicles can move safely at prescribed speed without any infringements. Various fixed structures on the railways like bridges; tunnel and platform sheds etc. are built as per construction gauge so that the sides and top remain clear of the loading gauge.

Standard Moving Dimensions:

Construction of rolling stock (Loco, carriage and wagon) and movement of conventional rolling stock is based on certain standard moving dimensions provided in the SOD. Sometimes very large consignments which when loaded on ordinary or special wagons exceed the standard moving dimensions, their transportation development of industries in a region etc.

Indian Railways have evolved a standard procedure to enable quick movement of such consignments with certain restrictions regarding day or night movement, speeds loading, lashing & packing conditions depending upon the minimum clearance available to fixed structures on the routes required to be traversed. Such consignments are called “Out of Gauge” or Over Dimension Consignments.

Over Dimensioned Consignment (ODC):

When a consignment whose length, width and height is such that one or more of them infringe the standard moving dimension at any point during the run, then the consignment is called as Over Dimensioned Consignment (ODC). The movement of ODC has been standardized on Indian Railways and each zonal railway keeps the upto date list of infringements.

In case of loaded consignment extra clearance of 75mm for bounce in the vertical direction on a straight track shall be accounted for between consignment & fixed structure. But in case of curved track the following additional factors shall be taken into account.

- | | |
|-------------------------|--|
| 1. Horizontal Clearance | Allowance for lean due to super elevation and Overhead due to curvatures additional lurch on curves. |
| 2. Vertical Clearance | Vertical tilt to be added to the height of consignment. |

Classification of ODCs:

Taking into account of extra clearance as indicated above, oversized consignments are classified into following three classes –

Class ‘A’ – Permitted out of gauge loads or O.D.C.

1. It runs with the permission of
 - (a) Within Division: Divisional Railway Manager (DRM)
 - (b) Inter Divisional of same Zone: Chief Operating Manager (COM)
 - (c) Inter Railway: COM of the zone and COM of concerned Railway.
2. It runs in both day and night
3. It runs with maximum speed of Sectional Speed
4. It as gross clearance of 9 inches (228.6 mm) and above
5. It runs on the supervision of guard

Class ‘B’ – Exceptional out of gauge loads or ODC.

1. It runs with the permission of
 - (a) Local: Divisional Railway Manager (DRM)
 - (b) Inter Divisional/Foreign Railway: Chief Operating Manager (COM)
2. It runs in both day and night
3. It runs with maximum speed of 40 kmph. But in yard it will run in 8 kmph
4. It as gross clearance of 6 inches (152.4 mm) and above but less than 9 inches (228.6 mm)
5. It runs on the supervision of TXR

Class ‘C’ – Extra-ordinary out of gauge loads or ODC

1. It runs with the permission of CRS only
2. It runs in day only
3. It runs with maximum speed of 25 kmph. But in yard it will run in 8 kmph
4. It as gross clearance less than 6 inches (152.4 mm) and not less than 4 inches (101.6 mm)
5. It runs on the supervision of Traffic inspector (TI), SSE/P.Way, SSE/C&W

ACCIDENT



Accident:

Any unpleasant event which affects the normal operation of trains or any casualty or loss of property is known as an accident.

Serious Accident:

If there is any casualty or serious injury or loss more than Rs 2 crores or all is/are involved, it is known as serious accident.

Collision:

When vehicles hit each other is known as collision.

Averted Collision:

When vehicles are going to collide but collision does not happen and the distance between them is less than 200 meters, it is known as averted collision.

If the gap is more than 200 meters, it is known as **Breach of Block Rules**.

Classification of Accidents:

S.No.	CLASS	DESCRIPTIONS
1	A-Class	Collision of Trains.
2	B-Class	Fire in train, when casualty or damage more than Rs 5000.
3	C-Class	Gate accidents (train running to the road traffic or vice versa)
4	D-Class	Derailment.
5	E-Class	Other train accidents like collision of trains by the fixed structure.
6	F-Class	Averted collision.
7	G-Class	Breach of block rules.
8	H-Class	Train passing danger signal.
9	J-Class	Train parting, failure of engine or failure of rolling stock.
10	K-Class	Failure of p-way like fracture, breach.etc
11	L-Class	Failure of the electrical equipments(when the failure time is more than 3 minutes)
12	M-Class	Failure of the signal and telecommunication(when the failure time is more than 10 minutes)
13	N-Class	Sabotage as breaking in trains etc.
14	P-Class	Casualties, injuries.
15	Q-Class	other incidents like robbery in train, murder or agitation.
16	R-Class	Miscellaneous.

Sounding of the Hooters:

1. Long Hooter- 30 seconds (It indicates the gravity of accident.)
2. Small Hooter- 5 seconds (It indicates involvement of injury/ casualty)

Accidents and corresponding Hooters:

S.No.	Hooter's Sounding Pattern	Description of Accident
1	Two long — —	Accident in the locomotive shed or traffic yard adjoining the locomotive shed
2	Three long — — —	Accident at the out-station where the main line is clear
3	Three long and one short — — — ○	Accident at the out-station where the main line is clear and the relief train is to be accompanied by the medical car
4	Four long — — — —	Accident at the out-station where the main line is blocked and the relief train is not accompanied by the medical car
5	Four long and one short — — — — — ○	Accident at the out-station where the main line is blocked and the relief train is to be accompanied by the medical car

ART Timings:

1. ART (Accident Relief Train) proceeds within 30 minutes (day time)/45minutes(night) after the sounding of hooters.
2. Medical Van proceeds within 20 minutes (day time)/30minutes (night) after the sounding of hooters.

Actions Taken by Engineering Officials during accident:

The first engineering official to arrive at the site of the accident should take the following actions:

1. Take steps to protect the train.

First of all accident site must be protected with temporary engineering signals either by train guard/drivers or engineering officials. In double line, if another line is also affected-it must also be protected.

2. Coordinate first aid and rescue efforts.

The official should arrange medical aid to the injured passengers and railway staffs and rescue to the trapped passengers. If there is any medical practitioner on the train his assistance should be obtained.

3. Examination of the entire accident site.

Examine the entire site and train for any unusual feature specially any part of the vehicle or other material lying near the track.

4. Advice the nearest station master.

After the rapid survey of the position ,particulars and aids(help) required shouldbe reported to the nearest station master or sectional controller.
If the cell phone is available its help can also be taken.

5. Carry out a detailed examination of the site.

Carry out the detailed examination of the site like wheel marks on the rail head,condition of the track components and initial mounting/derail point of the wheel.

6. Draw a dimensional sketch of the site giving full details.

Prepare a dimensional sketch giving the full particulars of the site including pointof mount/point of drop etc.

7. Collect and preserve any clues pertaining to the accident.

Preserve Clues of evidence of wheel marks specially at the point of mount drop orany such clues which may help in analyzing the cause of accident.

8. Record the track geometry.

Track geometry and its parameter shall be measured and recorded in presence ofother departmental officials and with their signatures.

9. Vehicle Measurement

Record the detail of IOH/POH of the vehicle, its different measurements as prescribed and any deficiencies like break blocks etc and broken/hanging parts of the vehicle like springs etc jointly with other departmental representative.

10. Examine the operating features.

Investigate and record of various features such like speed, train formation (marshalling), loading condition, point and lever setting position of signal and other factors which might contribute the derailment.

11. Examination of the Gang Chart

The gang chart should be examined to know the date of last attention of the site.

12. Prepare a preliminary report.

Make Out a preliminary report that contains the following information:

1. The nature of accident.
2. Cause if known
3. Particulars of loss of life, injuries to passengers and staff.
4. Extent of damage to way and works.
5. Steps Taken to resumption of traffic.
6. Probable date and time when normal working is likely to be opened.
7. Whether transshipment is necessary and if so, when it is likely to be opened.
8. Details of any assistance required, such as additional labour, ballast, train bridging material etc.
9. Follow up Action: Take action to collect men and material to repair the track and restore the traffic.

Assam train derailment
-hit by Bombay Janta Exp Coming on
adjacent track at Harda(WCR)



KAMAYANI EXP DERAILEMENT



By:-IRTMTC/ALD