सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

A TECHNICAL GUIDE ON DERAILMENTS

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उच्च अनुरक्षण प्रौद्योगिकी केन्द्र

EXCELLENCE IN MAINTEANCE

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PREFACE

Derailments keep presenting newer challenges to Indian Railways continuously. The causes are numerous and their investigation results in discovery of newer and better remedial measures for preventing future derailments. It is in this direction that Railway Board assigned the task of preparing this guide to CAMTECH. The objective is to enable the staff and supervisors to understand the complex and intricate mechanism involved in rail-wheel interaction and the conditions resulting in derailments. This will ensure thorough analysis as well as discovery of new ideas for arresting derailments.

The Guide contains useful hints on good maintenance practices and explains the correct way of taking critical measurements with the help of simple sketches and tables. If these help railways in reducing derailments, the purpose of producing this Guide will be served.

We are extremely thankful to Shri R.Paranthaman, Retd. CWS,S.Rly for contributing many valuable ideas and suggestions during preparation of this Guide. We would also like to recognise the sincere efforts put in by Shri S.K.Lomash, C.T.A. and Shri Ulhas Borwankar, DEO during preparation of this book

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CHAPTER 1
MECHANISM OF DERAILMENT

1.1 INTRODUCTION

Safe carriage of passengers is fulfilment of the trust and faith expressed in Railways by general public. The accidents tarnish our image and question our claim of having safe and sound working procedures. The accidents may occur on account of acts of omission or commission, evasion of rules, unsafe practices, adoption of short cut methods etc. Out of various categories of accidents, most serious consequences are witnessed in collisions, derailments, fire in running trains and level crossings accidents. Human factor is found to be the main contributor in Railway accidents:

> **"The interface between man and machine has been largely responsible for errors and mistakes on the part of railway operators manifesting in unsatisfactory working and accidents."**

It is not possible to fix a single reason or set of factors for all the occurrences of a particular type of accident on Railways. The accidents normally take place due to variety of factors acting in combination with each other. The experience has established that the accidents on Railways can be largely classified into following two main categories:

i) **Equipment failures**
ii) **Human failures**

This technical guide concentrates only on derailments. Therefore in the subsequent pages, only one category of accident i.e. derailments are discussed in detail.

Definition of Derailment

Derailment of rolling stock is defined as a wheel or set of wheels leaving their due place from the rail top surface.

A derailment may be minor or major in nature i.e. just one empty wagon may derail near a station limit not affecting traffic considerably or a good number of loaded wagons may derail, capsize and foul other lines thus obstructing traffic even on other lines. It may even lead to a collision if there is insufficient time gap between the derailment occurring and movement of other trains on other obstructed lines. There may be loss of human life if a passenger train coming from apposite direction collides with the derailed stock obstructing the other line. When a derailment occurs approaching a bridge, the results are likely to be disastrous as evidenced in many cases in the past.

Derailments are therefore serious occurrences and may also cause loss of human life besides loss of Railway property. They also result in heavy interruption to through traffic of trains leading to substantial loss of railway revenue. Therefore all efforts should be made to avoid derailments. Whenever a

derailment occurs, thorough investigation must be carried out to find out the exact cause and avoid recurrence in future.

Statistics about derailments reveal that the most prominent causes are: failure of railway staff in properly examining railway equipment; inadequate maintenance of locomotives, rolling stock, track, signals etc.; and other operational irregularities.

Derailment Investigation

The derailments present a burning problem to Railways. Unless cause is obvious e.g. cattle run over, sudden falling of boulders, trees etc. on the track, sinking of track, breach or wash-away etc., it is necessary to thoroughly investigate the role of track and vehicle in causing the derailment.

While investigating the derailments, track defects, vehicle defects and other operational features have to be examined which could have caused:

- Flange force Y to increase
- Wheel load Q to decrease
- Angle of attack to increase

The above factors are explained in detail later in this chapter under "MECHANISM OF WHEEL FLANGE CLIMBING". The list of such contributory defects and operating features help in analysing and determining the most probable cause of derailment.

A derailment may be sudden or gradual due to failure of one or more of the following :

A) Operational factors
B) Track
C) Rolling Stock
D) S & T
E) Others

To investigate these, it is necessary to take a complete set of measurements and observations and to obtain such back ground information as may be relevant. Thereafter critically analyse these factors in a logical sequence. This data and analysis should enable identification of the first wheel to derail and the dynamic and quasi-static forces both lateral and vertical acting on that wheel at the time of derailment. It is also essential to determine the point of mount/drop.

If the cause is obvious e.g. tree or boulder falling on the track, breach, wash away, formation failure etc., then investigation becomes easier. If cause is not obvious then thorough investigation is required to be made by measuring various parameters of rolling stock, track etc. in order to ascertain the exact cause of derailment. The derailments occurs if a combination of factors act for a long enough period for the flange to climb the gauge face of the rail and then cross the rail table. The important theoretical aspects concerning derailments are:

1. **Derailment mechanism**
2. **Wheel off loading**

3. **Vehicle oscillation**
4. **Lateral stability of track**

1.2 DERAILMENT MECHANISM

There are two broad categories of derailment:

- **Sudden derailments** - Instant dismounting of wheel from rail.
- **Gradual derailments** - Gradual climbing of flange on the rail.

1.2.1 Sudden derailments

When derailing forces are quite high on a wheel, it may suddenly jump off from the rail table and the rolling stock derails. In this case, no flange mounting marks are available on the rail table. However the wheel drop marks can be seen on ballast or sleepers.

The possible causes for a sudden derailment are:

- Sudden shifting of load
- Improper loaded vehicle
- Excessive speed on curve or turn out
- Sudden variation in draw bar forces induced due to improper train operations(sudden braking or acceleration)
- Broken wheels/springs or suspension gear components.
- Failure of track or vehicle component
- Obstruction on track.

1.2.2 Gradual Derailments (Mounting of wheel flange)

On the track, the wheel flange travels performing lateral movements as well due to clearances between rail face and wheel flange. If the derailment occurs due to climbing of wheel flange, the derailing wheel first rubs with the inside face of the rail (see fig. 1.1) and grazing/rubbing marks are seen on the inside edge of one of the rails. Thereafter due to excessive lateral flange forces, wheel flange mounts on the rail table and drops on the other side causing derailment. In this type off accident, wheel flange mounting marks are also clearly visible on the rail

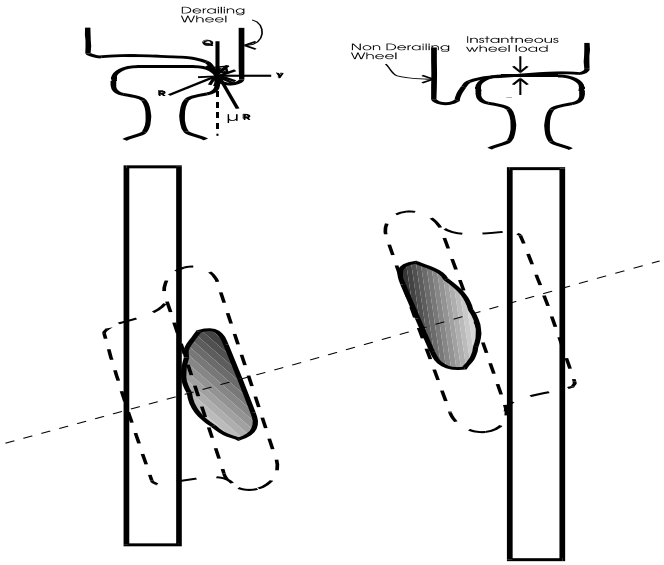

table. Fig. 1.1 Derailing and Non derailing Wheels

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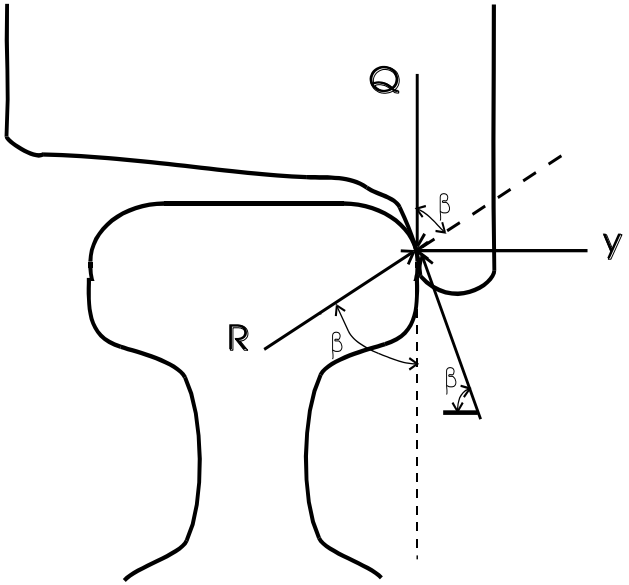
1.3 MECHANISM OF WHEEL FLANGE CLIMBING

It has long been accepted that the ratio of lateral force to vertical wheel load i.e. Y/Q has a major contribution in determining derailing tendency of the rolling stock. (see fig 1.2) When this ratio, denoted by Y/Q , exceeds for a sufficiently long period of time, a critical state occurs when wheel flange climbs and mounts on the rail table and causes derailment.



FORCES AT RAIL-WHEEL CONTACT

Fig. 1.2

The simplest equation for the upper critical value of Y/Q ratio to avoid flange mounting on rail derived by NADAL in 1908 (based on the simple analogy of a block sliding up an inclined plane) is:

$$\frac{Y}{Q} \leq \frac{Tan\beta - \mu}{1 + \mu Tan\beta}$$

Where: μ	=	Coefficient of friction
β	=	Flange angle
Y	=	Lateral flange force
Q	=	Wheel load
R	=	Normal reaction from rail
μR	=	Frictional force acting upward

For safety against derailment, Y/Q should not exceed 1.4. This is considered the critical value. For Indian Railways, this value has been further reduced and should lie between 0.8 & 1 for safe running.

For assessing the stability of a particular rolling stock, Y and Q have to be measured at the rail-wheel contact. For laying down a limiting value of Y/Q for safety, the right side expression has to be evaluated. For this, we have to decide the value to be taken for μ and β. For large majority of wheels, $\beta = 68^0$ (for new wheel profile). The value of μ depends on the geometry of the surfaces in contact. On Indian Railways, the value of μ in general is taken as 0.25. For $\beta = 68^0$ and $\mu = 0.25$, the expression works out to approximately 1.4.[1]

1 Ministry of Railways, Government of India. *Investigation of derailments.* (Pune: Indian Railway Institute of Civil Engineering,1995), p. 22.

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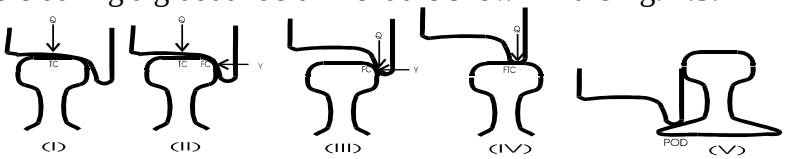
As already explained, there are two broad categories of derailments: Sudden and Gradual. Nadal's formula deals only with gradual derailment cases i.e. flange climbing. When the ratio Y/Q reaches a critical value, it has to remain above such value for certain minimum duration of time for flange to mount on the rail and derail. A higher Y/Q ratio would be needed to cause a derailment if the duration for which it acts is less. The time frame followed all over the world is 5 milli-seconds as the time duration which delineates the boundary between the two categories of derailments. The final form of the criterion adopted on Indian Railways is that derailment coefficient Y/Q should not exceed 1.0. The said coefficient being measured over a duration of 5 milli-seconds.

The various stages of wheel flange climbing on the rail table during a gradual derailment are shown in the fig. 1.3.



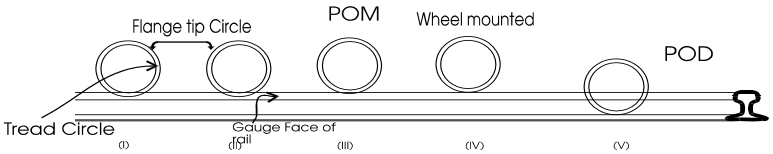


Fig. 1.3 Stages of wheel Flange Climbing in a gradual derailment

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1.3.1 Angle Of Attack

Further attempts were made to refine NADAL'S formula given above. In further detailed studies, it was noticed that to derail a wheel from the rail, another factor called "angle of attack" plays a vital role. (See fig 1.4)

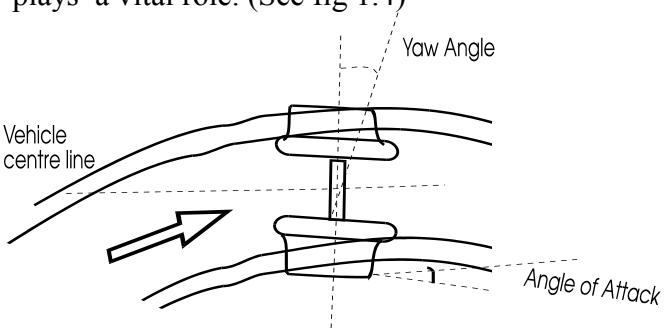

Fig. 1.4 Angle of Attack

The effect of angle of attack plays an important role in derailment. The higher positive angle of attack increases derailing tendency as the contact point of the flange with the rail is then nearer the flange tip. This requires a lesser degree of lateral force to cause flange mounting.

1.3.2 Angularity of Axle

Once the wheel lifts upto the end of straight portion of flange, no additional force is required to further lift it i.e. the rounded portion at the root of the flange does not prevent lifting. The angularity of the axle (Fig. 1.5) shifts the point of contact with flange down towards the root thus curtailing the amount of lift required to derail the wheel.

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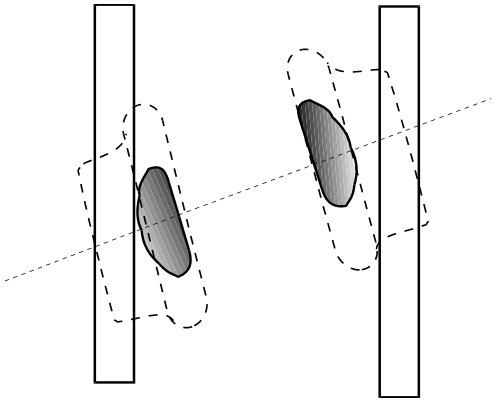

Fig. 1.5 Angularity of Axle

1.3.2.1 Zero Angularity

The wheel set is parallel to the rail and thus angularity with the rail is zero (Uniform contact with rail in both wheels). From the position of contact points of the wheel tread and flange, it may be seen that the longitudinal eccentricity between them is zero(see fig. 1.6).

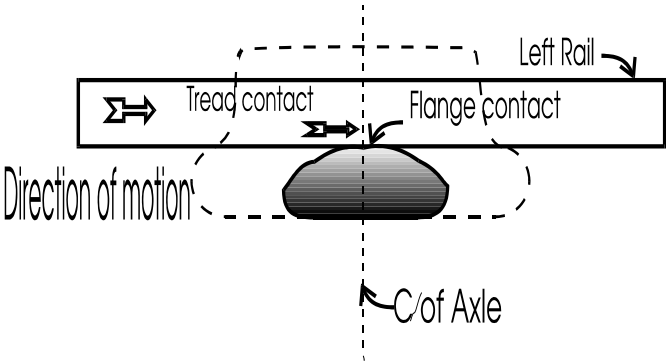

Fig. 1.6 Zero Angularity

1.3.2.2 Positive Angularity

In this case the wheel set is angular to the rail so that the wheel makes the flange contact nearer its leading edge (front contacting- contact absent in rear). The longitudinal distance between the points of contact at the tread and the flange is called positive eccentricity and the angularity here is called positive angularity. The angle between the wheel and the rail is called positive angle of attack (see fig. 1.7).

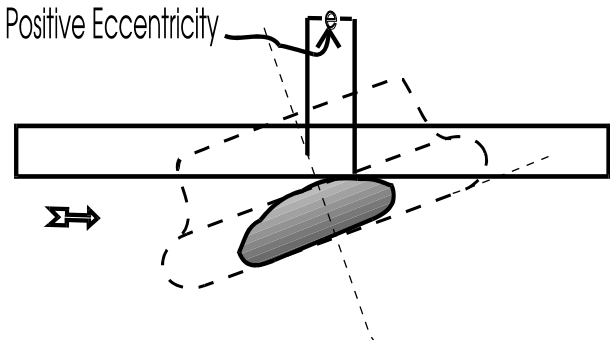

Fig. 1.7 Positive Angularity

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1.3.2.3 Negative Angularity

In this case, wheel set makes a flange contact near its trailing edge (rear contacting and front contact absent). The longitudinal distance between the points of contacts at the tread and the flange is called negative eccentricity. The angle between the wheel and the rail is called negative angle of attack (see fig. 1.8).

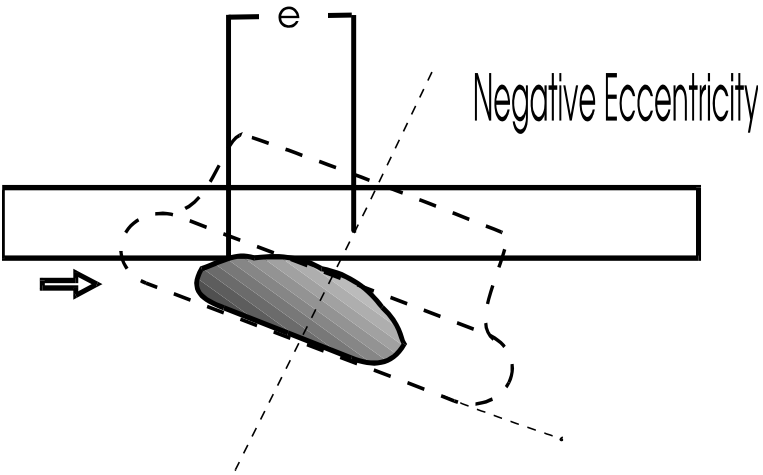

Fig. 1.8 Negative Angularity

Positive Angularity is Most Critical

In the case of positive angularity, the wheel flange rubs against the rail in a down ward arcing motion resulting in frictional forces acting upwards. In the case of negative angularity, the frictional forces will be directed downwards and in the case of zero angularity, the frictional force acts horizontally.

Positive angularity is most critical of the above three conditions. The derailment proneness is highest when the wheel makes flange contact with the positive angle of attack. On straight track, this configuration occurs only during certain period of the oscillating motion of the wheel set. But on curves, it occurs more or less throughout the period of curve negotiation.

1.3.3 Play between Wheel and Rail

A wheel set should not have a tight fit with the track gauge. In such a situation, the wheel set will tend to run at the flange slope rather than at the tread thereby increasing the derailment proneness. This may also cause undue strain on the track fastenings with more wear on wheel tread as well as rail.

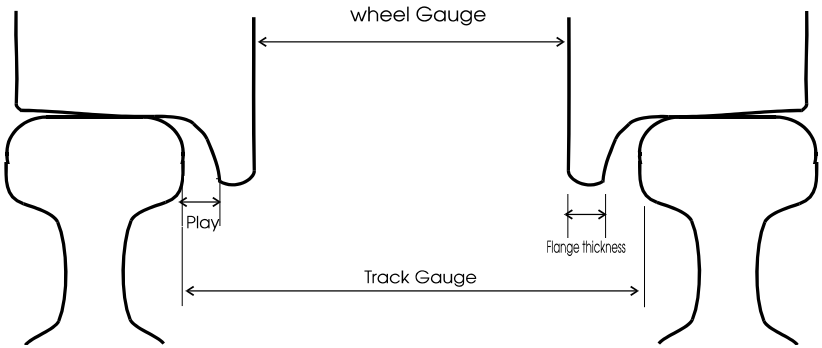

Fig. 1.9

The standard play between gauge face and wheel flange is 19 mm for the B.G. stock as calculated below (fig 1.9):

= Gauge - (Wheel gauge + Two * Flange thickness)
= 1676 - (1600 + (2*28.5)
= 19 mm

Besides the above play, certain lateral and longitudinal play is also provided on the vehicle to avoid undue straining of vehicle components. These are :

- play between Axle guard and Axle box
- play between Brass and Journal collar etc.

Due to the above play and clearances, wheel set is able to become angular to rails on run and thus it rarely runs parallel to the rail but moves with varying angularity.

1.4 WHEEL OFF-LOADING

Whenever derailment takes place due to mounting of flange on the rail, the flange first comes in contact with the gauge face of the rail. As a result, a certain lateral force is exerted on the track.. Another factor that comes into play is the off-loading of wheel. The derailment of a wheel occurs when the flange force exerted on the rail exceeds a critical value in relation to the instantaneous wheel load. Most of the derailments take place due to gradual off-loading and climbing of the wheel flange on the rail table. It is evidenced in such cases that the wheel travelled on the rail table for quite a few feet before finally falling

outside the rail. But when the wheel off-loading is considerable, the wheel may simply jump over the rail and derails leaving no marks of mounting on the rail table.

In the case of flange climbing derailments, rolling stock properties which reduce the wheel load or increase the flange forces momentarily or permanently play an important role. These may be expressed as static or dynamic properties and arise from design characteristics of rolling stock and field conditions during run.

The major cause of wheel unloading is the vehicle's dynamic response to the vertical irregularities in the track. This wheel unloading effect is perhaps the most important factor in the majority of "Flange Climbing" derailments occurring at normal speeds.

Reduction of vertical wheel load can also arise due to uneven loading. The uneven loading can occur due to lack of supervision during loading. This can also take place later due to an evenly distributed load getting shifted in transit. In either case, one side or one corner of the vehicle experiences a permanent and significant loss of loading.

For various reasons, the wheel set travels along the track executing a variety of oscillations. Lateral and vertical oscillations force the wheel set to make flange contact with the rail which results in development of lateral flange forces. The excessive lateral flange forces are found to be another main cause of derailment in large number of cases.

1.5 VEHICLE OSCILLATIONS DUE TO RAIL-WHEEL INTERACTION

For any wheel to mount and derail, the flange tip must get lifted to the top surface of the rail and then get displaced laterally to drop on the other side. The factors contributing towards oscillations and resulting in off-loading and lifting of an individual wheel under running conditions are:

1.5.1 Unequal spring characteristics
1.5.2 Vertical irregularities of track
1.5.3 Uneven loading of wagon
1.5.4 Axle Load Variations during run
1.5.5 Dynamic Aspects

1.5.1 Unequal Spring Characteristics

The most important variation in the characteristics of spring that contributes to asymmetrical distribution of weight is free camber. The variation amongst the springs in the free camber, especially those which are located at corners diagonally opposite to each other, produce unequal load distribution on the axles. The springs in service also loose some amount of free camber with passage of time. As long as the difference in camber at diagonally opposite springs is within reasonable limits, there is little uneven distribution of load.

The shifting of spring buckles in relation to the spring does not result in any significant uneven distribution of load unless the free action of the spring is restricted. The cracks on spring plates reduce the load bearing capacity of the spring but

this does not necessarily result in a derailment. But if the complete spring collapses, there is a serious danger of derailment.

1.5.2 Vertical Irregularities in Track

The variations in cross levels affect the distribution of load on the axles. For details about the measurement of cross levels, please refer to " Track Defects".

1.5.3 Uneven Loading

A vehicle is considered to be unevenly loaded when the centre of gravity of the load is not in the same vertical axis as that of centre of the vehicle.

1.5.4 Axle Load Variations during run

The distribution of the lateral forces between wheels depends on the local contact conditions between the wheel and the rail. If gradient is falling, the vehicle leans forward. Due to cant, the vehicle also leans towards the inner rail. These differences from the normal condition produce small increase in the load on the wheels situated towards the inner rail. The corresponding reduction on load takes place on wheels located towards the outer rail side. Under these conditions, derailment can occur due to lightly loaded rail which is generally the outer rail on curves.

Thus even at very low speeds, serious adverse conditions may occur due to combination of any or all of the following factors:

- Reduction in vertical wheel load due to cant.
- Reduction in vertical wheel load due to a twisted vehicle.
- Reduction in vertical wheel load due to an out of plane track.
- Lateral forces generated due to curve and other oscillations.
- Potentially high angle of attack presented to the leading wheel in a sharp curve by the out side rail .

1.5.5 Dynamic Aspects

As a pair of wheel rolls along the track , it is perpetually in a state of lateral motion due to the conical tread trying to centre itself on the rail top. The central point of contact of the wheel tread on the rail table is known as **Virtual Gauge**. (see fig. 1.10)

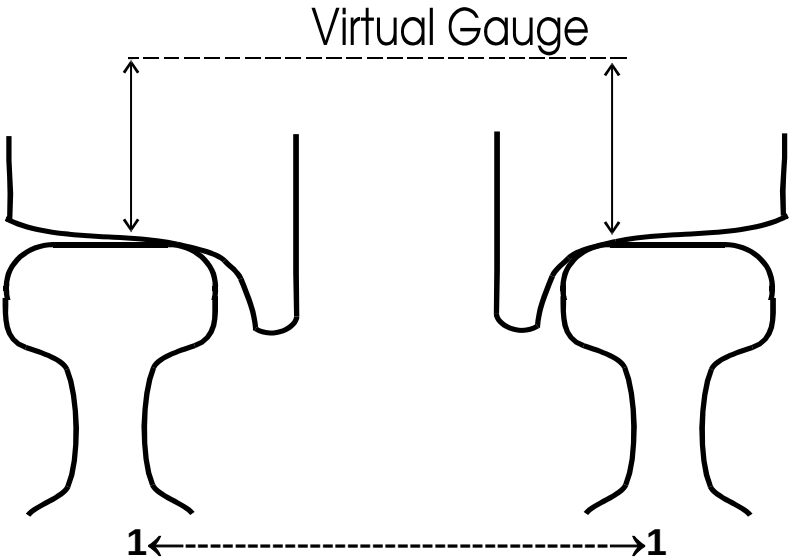

Fig. 1.10 Virtual Gauge

There are various other disturbing movements of the wheel set in motion which are known as **exciting oscillations**. These are transmitted to the vehicle body through the suspension system. While in motion, the sprung mass is subjected to following oscillations with respect to the three main axes (Fig. 1.11) :

Axis	Type of Oscillation	
	Linear	Rotational
X	Shuttling	Rolling
Y	Lurching	Pitching
Z	Bouncing	Nosing or Yaw

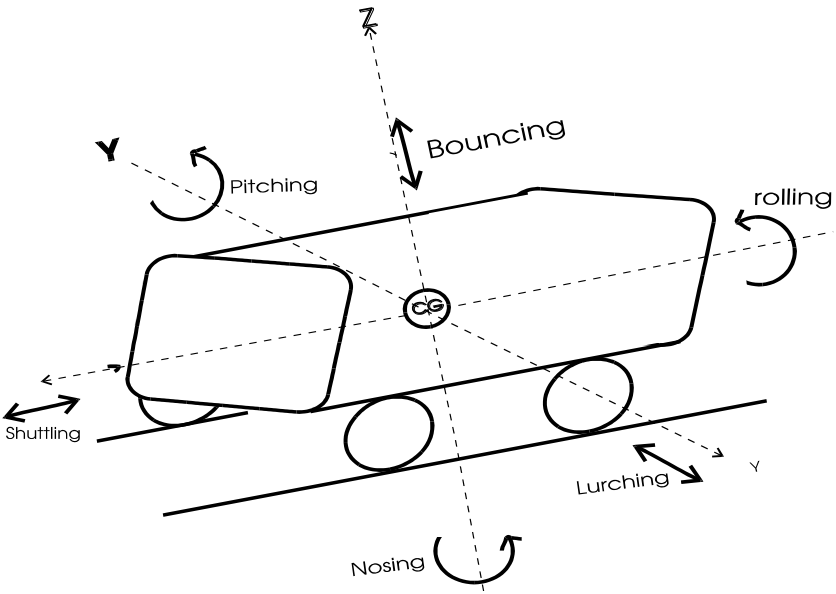

Fig. 1.11

When the amplitude of the lateral oscillations exceed the clearance between the flange and the rail, one of the flange rubs against the rail and then gets deflected back.

The amplitude and frequency of the oscillations depend upon the condition of the following :

- Track
- Flange rail clearance
- Axle load
- Speed
- Running and suspension gear characteristics

The lateral lurching and nosing oscillations give rise to flange forces. The angularity of nosing also depends upon the wheel base in relation to the track gauge. The shorter the wheel base, the greater is the angularity.

1.6 LATERAL STABILITY OF TRACK

The following are the track parameters which determine the extent of parasitic motion induced in the vehicle at a given speed:

1. Alignment of the rail
2. Unevenness of the rails
3. Gauge
4. Cross level
5. Twist
6. Packing underneath the sleepers
7. Rail sleeper fastenings
8. Efficiency of drainage
9. Formation
10. Condition of ballast
11. Radius of curve
12. Transition length of the curve
13. Super elevation provided
14. Cant & Cant deficiency
15. Versine variation
16. Gap at rail joints

Out of the above, item no. 6 to 10 directly affect the lateral stability of track. If the total effect of the above factors develops lateral flange forces to such an extent that it overcomes

the lateral stability of track, it leads to spreading of gauge and derailment of rolling stock.

1.7 PRECONDITIONS FOR DERAILMENT

It can be seen from the foregoing paras that for a wheel to mount on the rail table and derail, following conditions must be met :

(a) The flange force Y should exceed twice its instantaneous wheel load minus 70 % of the nominal wheel load[1] i.e.

$$\mathbf{Y > 2Q - 0.7\ (T/n)}$$

Where: T - total weight of the vehicle
n - denotes the number of wheels in the vehicle

(b) The wheel should be off-loaded by 65 % of its nominal weight i.e. Q should reduce by 65 %

(c) The wheel of the vehicle should run with positive angularity so that the flange of the leading wheel bites against the rail gauge face (Fig. 1.12).

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1 S.H.R. Krishna Rao, *TECHNICAL MONOGRAPH NO. 35 : DERAILMENTS* (Lucknow: Research Design and Standards Organisation, 1971), p. 31.

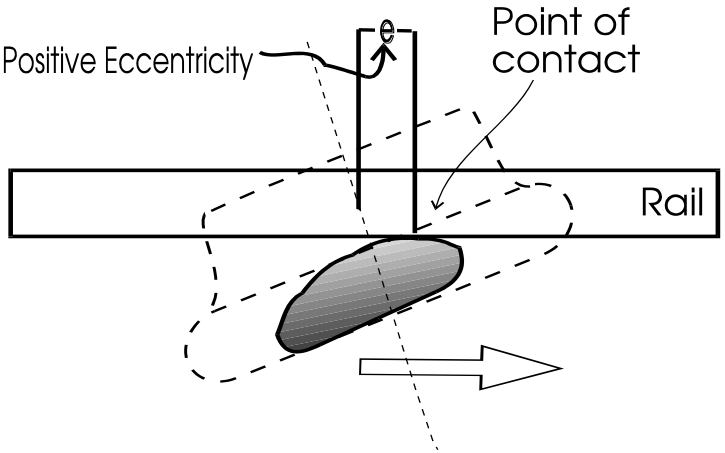

Fig. 1.12 Positive Angularity

d) Under these conditions the point of contact or the wheel flange with the rail head is ahead of the point of contact of tread over the rail head. This is called eccentricity 'e' by which the flange bites the rails.

e) These conditions continue to prevail till the wheel flange completely mounts and derails.

1.8 DERAILMENT ON CURVES

A survey of accidents for three years was taken on Central & Northern Railway. The results revealed that about 80% of the total derailments occurred on curved tracks due to climbing of wheels on the rail table leaving mounting marks. These derailments occurred due to excessive lateral forces at the flange.

In practice, vehicles negotiate curves with almost continuous contact of wheel flange with the outer rail (see fig. 1.13). Thus a continuous flange force is present which could reach large values depending on the track curvature, cant, axle load, speed etc. On higher speeds, the wheels start lurching within the rail. The lateral forces generated during lurching are capable of inducing misalignment in the track especially if the lateral resistance of the track is low. The misalignment could grow under the passage of traffic to an extent which may eventually cause derailments. The lateral flange forces occur mainly due to following reasons:

- Unsatisfactory curving characteristics of vehicle or track.
- Unsatisfactory lateral riding of vehicle.
- Misalignment of track.

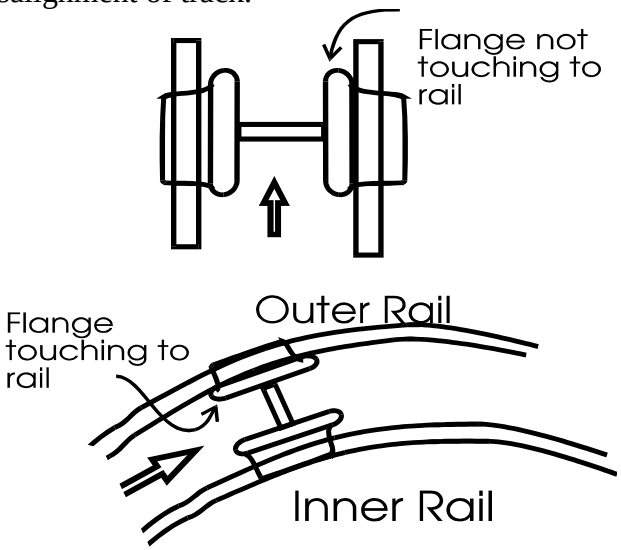

Fig. 1.13 Movement of wheel on a curve

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On negotiating a curve with significant positive angle of attack at the leading outer wheel, the derailment coefficient Y/Q may reach its limiting value. If cant is given in excess then even greater positive angle of attack will develop at the leading outer wheel which will further increase the chances of derailment.

■■■■■■

CHAPTER 2

SITE INVESTIGATION

Unless reasons for derailment are obvious from the initial inspection at site, comprehensive investigation in a logical sequence is needed to ascertain the actual cause of derailment. The site investigation is primarily concerned with identification of evidence and related data before restoring the track and vehicles. The main purposes are to :

1. Locate the initial point of derailment
2. To identify the first derailed vehicle and wheel
3. To obtain sufficient evidence to determine the course of events up to the time derailed train came to a halt and
4. To explain why the vehicle derailed initially at that particular point on the track.

The site investigation should be carried out in the following sequence :

1. First considerations
2. Site sketch
3. Flange marks
4. Operational Defects/Failures
5. Track survey and examination
6. Vehicle examination

2.1 FIRST CONSIDERATIONS

The sequence of events to be recorded i.e. how derailment occurred prima facie, from the beginning to the time the train came to a halt. The position of vehicles after derailment must be recorded. The wheel marks at the initial point of derailment are to be examined in order to establish the category of derailment i.e. sudden or gradual.

It is important for the investigators to make rapid observations and record the position of vehicles. It is also important that such a survey must be completed before the restoration work commences on the track especially in the rear of point of derailment.

2.2 SITE SKETCH

A sketch of the whole site showing the position of derailed vehicles relative to both rails as well as other evidences if any together with the track damages must be prepared. If this is not done, serious difficulties will be encountered later when this evidence is required for correlating the events relating to vehicle and track interaction.

2.3 FLANGE MARKS ON THE RAIL

The most important thing in investigating the derailments is to locate and examine the wheel mounting marks or the marks at the initial point of derailment in order to determine whether the derailment was sudden or gradual.

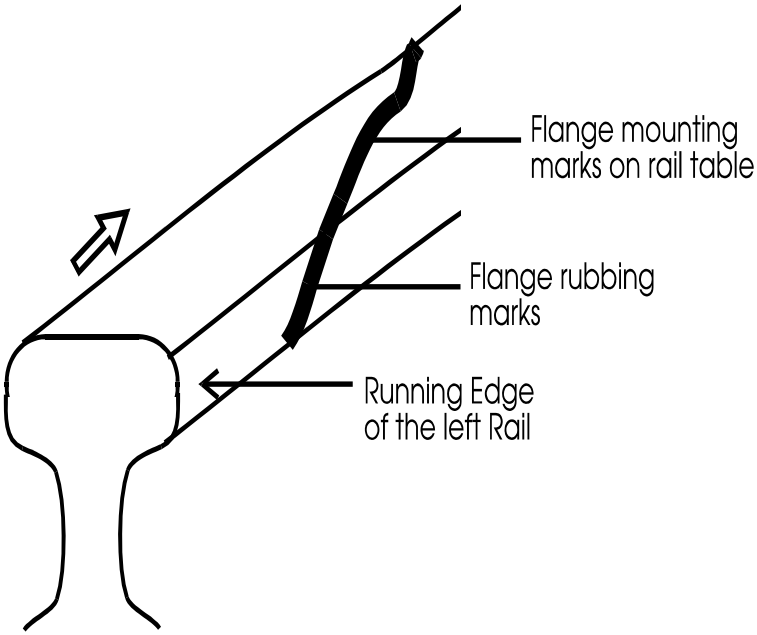

Fig. 2.1 Flange Mounting Marks

A careful analysis is required to be done on wheel mounting marks found on the rail table (Fig. 2.1). If it is difficult to ascertain the first vehicle which derailed, it is necessary to detail the damage sleeper by sleeper. The details of mounting marks must be recorded including the following details :

A. Length
B. Profile or path followed after mounting
C. Whether marks are strong or faint
D. Whether continuous or broken
E. Single/multiple marks

Preferably, photographs should be taken not only of mounting marks found on the rail but also those found on the sleeper fastenings and ballast. These marks must be carefully noted and measured.

Often many vehicles derail before the train comes to halt. This creates multiplicity of wheel mounting marks. Thus it becomes necessary to identify the particular wheel set which derailed first. This can only be achieved by matching the length and nature of various trail marks left by wheels against the position and orientation of derailed vehicles, analysis of marks on the wheel tread and flanges, damage to vehicles and wheel sets etc.

2.4 OPERATIONAL DEFECTS/FAILURES

The following are the major operational features which are significant in a derailment:

2.4.1 Speed

The speed of train plays a vital role in derailments. If speed is in excess of permissible speed, lateral forces on the flange increase and the formation may not be able to resist this increased force thereby resulting in either flange mounting or jumping off from the rail table.

Under dynamic conditions, the speed of train plays a vital part in derailment of a vehicle. Higher the speed, smaller will be the range of permissible imperfections on the track and

rolling stock. The rolling stock by virtue of its spring and suspension system responds to the disturbances and is free to perform inherent oscillations. As the rolling stock moves over the track, exciting oscillations are produced and the exciting frequency directly depends upon the speed. Conditions of - resonance may occur if the exciting frequency approaches the natural frequency. The oscillations become more pronounced while the train is coasting i.e. when the drawbar pull is absent. The amplitude of these oscillations increase with increase in speed especially if the causative factors amplifying the oscillations are present.

It will therefore be seen that the wheel load changes due to oscillations on run. The degree of track imperfections, state of maintenance on rolling stock, its suspension characteristics, disposition of load on wheels and speed are the main items of attention in the investigation of a derailment.

2.4.2 Loading

Irregular or excess loading may lead to derailment of a vehicle as the wheel may float due to off-loading..

2.4.3 Wrong Marshalling

Empty stock marshalled in between two loaded wagons forces the empty stock, specially the four wheeler units, to jump off under the impact of draw bar forces and derail.

2.4.4 Mismanipulation of Point

Due to mismanipulation of a point under movement, derailment occurs. In such cases the leading wheel or trolley will travel on one side of the track and the trailing trolley will travel on the other track. This happens on points in facing direction only. In such cases, the important points to be checked are :

A. Length of tongue rail
B. Rigid wheel base of the stock
C. Gap between toe of switch and stock rail

By examination of the above factors, one can ascertain whether the point was operated under movement. Another aspect which is not pertaining to operational failures but must be checked is whether the point was working freely and correctly.

2.4.5 Operating Staff Failure

Following problems may also result in a derailment :

- Points not being properly set and locked during shunting operation at the station.
- Operation of point under wheel movement.
- Undetected obstruction between toe of switch and stock rail
- Loose couplings

2.4.6 Improper Train Operation by the Driver

Sudden application of brakes cause bunching and off loading of light loaded wheels. This may also result in derailments.

2.5 ROLLING STOCK EXAMINATION

The details are given in Chapter 3.

2.6 TRACK SURVEY AND EXAMINATION

The details are given in Chapter 4 and 5.

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CHAPTER 3

INSPECTION OF ROLLING STOCK

The rolling stock involved in accident must be inspected in the presence of nominated team of supervisors and results should be recorded in the prescribed format (Appendix 'A').

The main items of inspection are as under :

3.1 WHEEL GAUGE

Wheel gauge is the distance between inside faces of the flange on the right and left side wheels of an axle (Fig. 3.1). There should be no variation in the values of wheel gauge - measured at four points 90 degrees apart on a wheel set. However the actual value of the wheel gauge can vary as per - tolerances given in Table 3.1 (IRCA Part III Para. 2.8.7) :

Table 3.1

	B.G.	M.G.
Standard	1600 mm	930mm
Maximum	1602mm	932mm
Minimum	1599mm	929mm

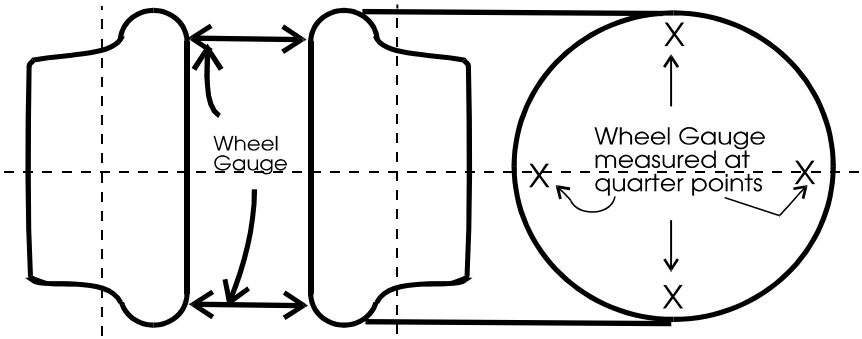

Fig. 3.1 Measurement of Wheel Gauge

The wheels are required to be gauged at three or four - quarters (as per possibility) and recorded duly indicating the following:

- Tightness or slackness of gauge
- Whether any indication exists about shifting of wheel on the axle.

Note : It must be ensured that the back surface of wheels are cleaned thoroughly before measuring the wheel gauge in order to avoid erroneous readings.

3.1.1 If the wheel gauge is more than permissible limit, there exists a possibility of a relatively newer wheel hitting the nose of crossing. This happens because the wheel gauge is one of the parameters affecting the clearance at check rail opposite the nose of crossing.

3.1.2 If the wheel gauge is less than minimum value, there is a possibility of wheel hitting at the back of a tongue rail while passing through the switch and thus damaging the tongue rail.

3.1.3 The variation in wheel gauge after lowering the coach body on wheels was examined by RDSO Lucknow and circulated to all Railways vide their letter no. MC/WA/GENL Dated 27.6.88 as follows :

> **" The question of variation in the wheel gauge under no-load and loaded condition has been examined by RDSO. The calculations for the 15 ton BG axle under tare load condition indicates that a variation of about 3 mm in the wheel gauge when measured at the top and bottom locations in the vertical plane is likely to take place due to bending of axle under coach load**
>
> **This variation in wheel gauge under loaded condition, however, has no bearing on the safety of coach operation. However, if the measurements for wheel gauge are done in horizontal plane passing through the axle then the effect of bending of the axle will not be there.**

It is therefore clarified that the wheel gauge tolerances of 1600 ± 2 mm as laid down in IRCA rule book

is required to be checked under "No-load" conditions.

3.2 BENT AXLE

A bent axle starts wobbling during motion causing severe vibrations. In order to confirm whether an axle is bent or not, it must be checked carefully on a sensitive machine or measuring table.

3.3 TYRE PROFILE

The outer periphery of a wheel which comes in contact with the rail is known as **tyre profile**. The standard tyre profile of B.G. is shown in the Fig. 3.2.

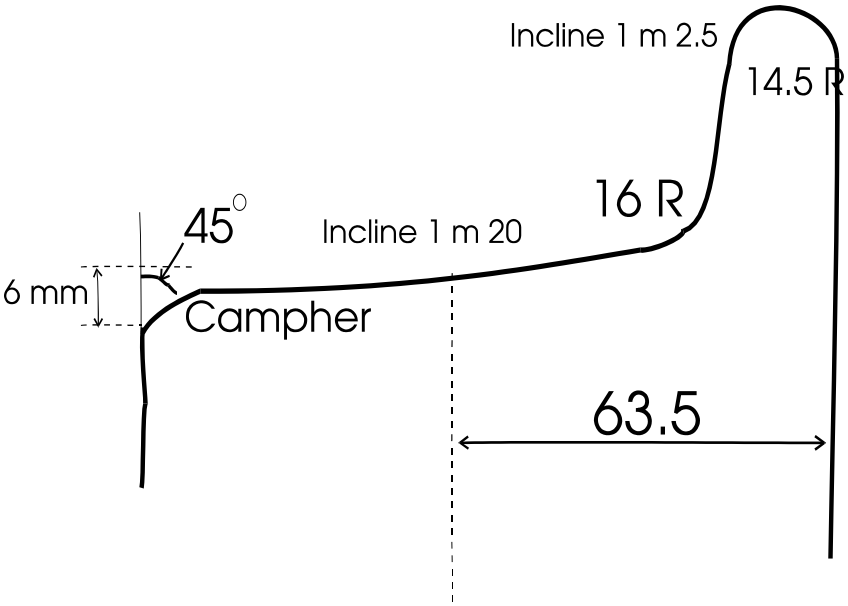

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Fig. 3.2 Tyre Profile of a new Wheel

The important features of the tyre profile are as under :

3.3.1 A chamfer of 6 mm at 45 degrees on outer edge. This is provided to avoid sharp edges and also prevent small burs (chips of metal) projecting beyond the outer surface of wheel due to spreading of small thin layer on outer periphery of the tyre.

3.3.2 An upward inclination of 1 in 20 towards inside. It is provided to ensure that the wheels remain in central position of the track and allows the outer wheel to travel on the higher tread diameter and inner wheel on a smaller wheel diameter on curves.

3.3.3 **Route radius** : A root radius is provided at the bottom of the flange. This radius for B.G. is 15 mm .

3.3.4 **Height of wheel flange** : The height of wheel flange is measured from the tread of the tyre. It is kept 28.5 mm for B.G. This height also forms an important part in determining the tyre profile.

3.4 WHEEL DEFECTS

The following aspects should be checked on the suspected wheels :

a) condemning limit
b) flat places on tyre/skidding

c) flanges - sharp/deep/thin
d) radius too small at the root of the flange

e) gauge slack/tight.
f) cracks

The above mentioned defects can be detected with the help of **Tyre defect gauge** and **Wheel gauge** meant for this purpose.

3.4.1 Thin Flange

When the flange thickness reduces to less than 16 mm for B.G., the flange is called a thin flange. It should be measured at the distance of 13mm below the flange tip (Fig.3.5).

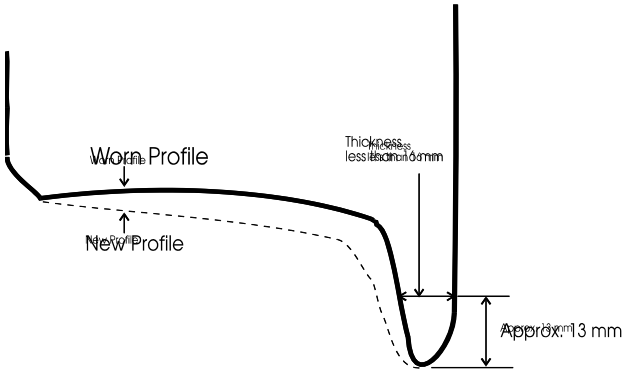

Fig. 3.5 Thin Flange

A thin flange increases lateral play between the wheel set and track and increases :

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- Lateral oscillations adversely affecting Y/Q and
- Angularity of wheel set on run

3.4.2 Sharp Flange

This occurs when the flange wears in such a way that radius at the tip of the flange becomes less than 5 mm. The flange forms a fine sharp edge. Due to this, the wheel set can take two roads at slightly gaping point or wheel may ride over the chipped tongue rail (Fig 3.4).

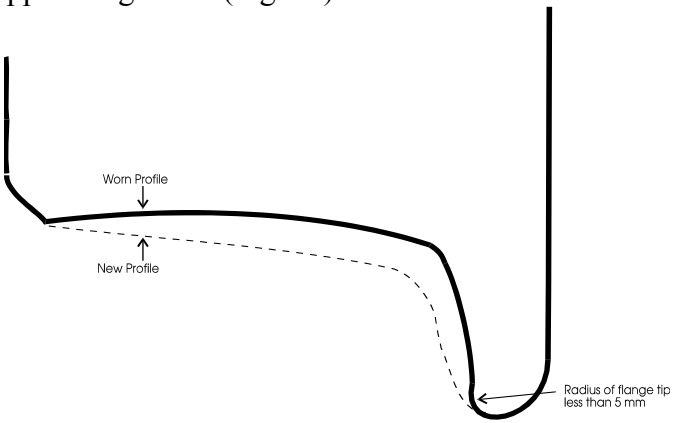


Fig. 3.4 Sharp Flange

3.4.3 Worn Out Flange

When radius at the root of the flange becomes less than 13 mm, it is called worn out flange. A worn out flange increases

the value of μ (Fig.3.5).

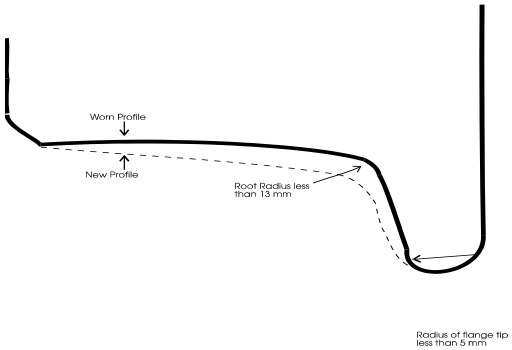


Fig. 3.5 Worn out Flange

3.4.4 Deep Flange

When the depth of flange, measured from the flange top to a point on the wheel tread (63.5 mm away from the back of B.G. wheel), becomes greater than 35 mm, it is called a deep flange (35-28.5=6.5 mm) as shown in Fig. 3.6. Under this condition, the wheel flange would tend to ride on the fish plate and check-block and may damage the track components.

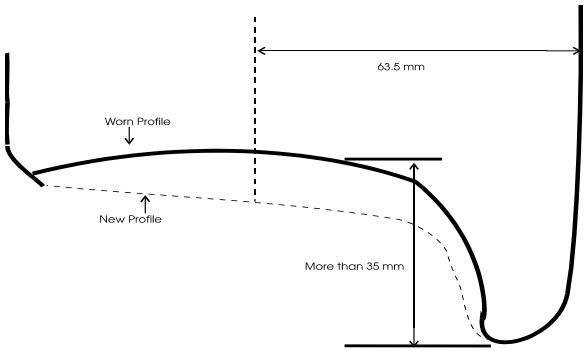


Fig. 3.6 Deep Flange

3.4.5 False flange/Hollow Tyre

When the projection of outer edge of the wheel tread below the hollow of the tyre exceeds 5 mm, the outer edge of the wheel forms a false flange and the worn tread is called **hollow tyre** (Fig. 3.7).

The hollow tyre has the danger of developing a false flange. There is no effect on angularity or eccentricity but wear on tyres has the effect of increasing the conicity of the wheel tyre. This reduces the critical speed of the rolling stock beyond which excessive hunting and oscillations take place thereby - increasing the flange force 'Y' and the chances of derailment.

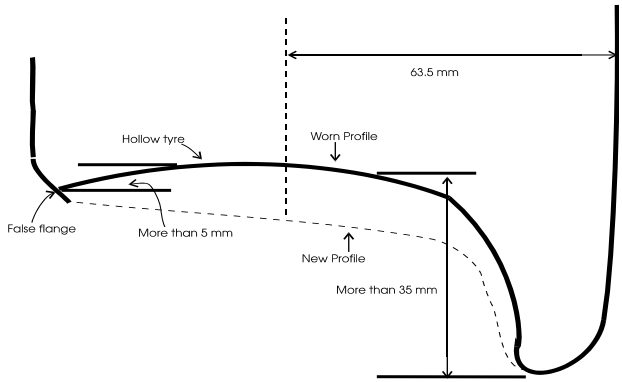


Fig. 3.7 False Flange/Hollow Tyre

A false flange may split open the points while travelling in trailing direction while negotiating the crossing (Fig.3.8). It may tend to get wedged in between the tongue rail and the stock rail.

The wheel going across the wing rail would then get lifted as instead of travelling on the tread portion,it would be travelling on the false flange. This will make the wheel to suddenly lift up and drop down near the nose of the crossing.

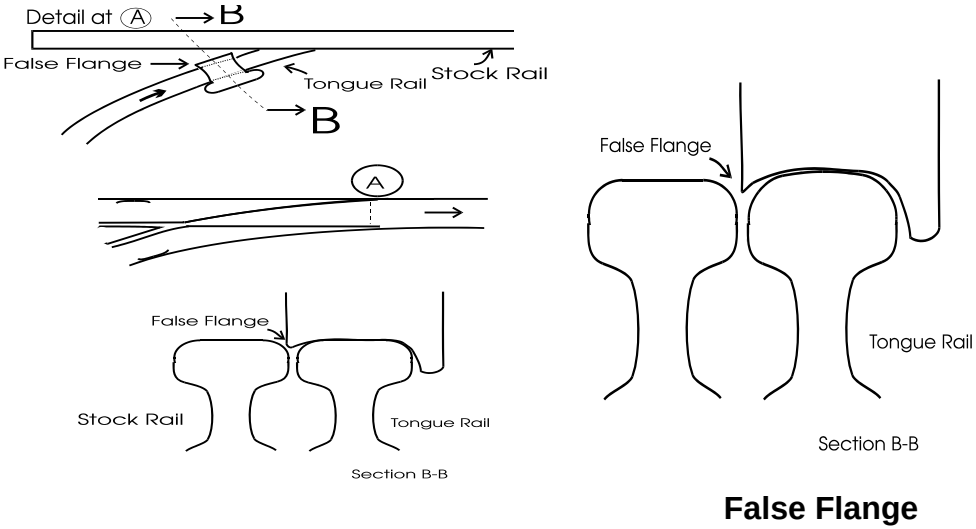


Fig. 3.8 Hollow Tyre on a Switch Crossing

Wheels having flats on tyre damage the rails due to impact and cause high contact stresses. This may cause rail fracture leading to derailments.

3.4.6 Flat Places on Tyre

The maximum permissible value of flatness on a B.G. wheel tyres is as under (Fig. 3.9) :

- Goods Stock IRS - 60 mm

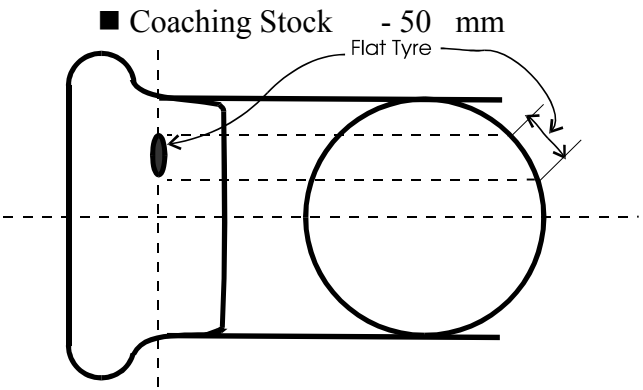


Fig. 3.9 Flat Tyre

3.4.7 Difference of Wheel Diameter on Tread

Wheel diameter is measured on the tread at a distance of 63.5 mm from the inside face of the wheel in case of B.G. (Fig. 3.10) and 57 mm in case of M.G. Two measurements 180 degrees apart should be taken for each wheel.

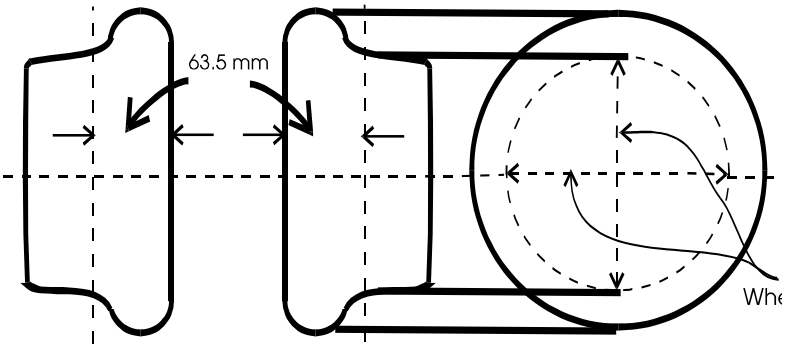


Fig. 3.10 Measuring Wheel diameter

Limits of wheel diameter variation on the same axle

The workshop leaving limits for the difference in diameter are indicated in Table 3.2.

Table 3.2 Workshop Leaving Limits for Wheel Diameter

Type of Wagon/Trolley	On the same Axle		On the same Trolley		On the same Wagon	
	BG	MG	BG	MG	BG	MG
Four Wheeled Trolleys	0.5	0.5	13	10	13	10
Six wheeled Trolleys	0.5	0.5	6	6	6	6
Six wheeled units	0.5	0.5	6	6	6	6
Four wheeled units	0.5	0.5	- -	- -	25	13

These limits of variations as prescribed in Rule No. 2.8.14.2 IRCA Part III and Rule No. 2.9.4 IRCA Part IV are to be observed at the time of fitment of freshly reprofiled wheels during periodic overhaul in workshops and repairs requiring wheel changing in sick lines. These limits do not form a part of train examination. The rejection of wheels worn beyond service limits will continue to be determined by the normal wear limits specified in IRCA Rules (Rly. Bd.

letter No. 86/M(N)960/8 DATED 22.8.86).

3.5 AXLE BOX LATERAL AND LONGITUDINAL CLEARANCES

3.5.1 Lateral. Play between B/Brass & Journal collar
Minimum - 5 mm ; Maximum. - 10 mm

3.5.2 Total lateral clearance between Axle guard and Axle box grove - 10 mm max.

3.5.3 Lateral longitudinal clearance between axle box lug and horn cheek for box type trolly :

	lateral	**longitudinal**
Minimum.	20 mm	12 mm
Maximum.	25 mm	18 mm

Due to spring suspension, the lateral motion induced by track irregularities is dampened. Experiments have established that the lateral force due to hunting is much higher for a vehicle beyond above clearances. On the other hand, below minimum limits given above, freedom of wheels during run gets restricted beyond desirable limits.

Bent axle guards will not be able to move up and down

freely and the axle box will get jammed making spring assembly ineffective thus increasing proneness to derailment.

3.6 BUFFING GEAR

3.6.1 Buffer projection limits from head stock

	For long case buffers	For short case buffers
Max.	635 mm	456 mm
Min.	584 mm	406 mm

A. Buffer projection for POH stock should not be less then 625 mm for long case and 445 mm for short case buffers.

B. No dead buffers shall be permitted from the sick line. The buffers shall be considered dead when the projection is below the prescribed minimum Limits.

C. Buffer heights in BG Stock shall be within the limits shown above and it should be measured on level track.

Note: The measurement should be taken from the centre of the buffer socket to the top of the rail head. The buffer height should never be taken from the centre of the buffer face because it will not give correct value.

While recording buffer height, it should be ensured that

buffer bolts are in tight condition and buffer is not drooping. If it is drooping, the amount of drooping should be measured and recorded.

To make up buffer heights to maximum permissible limits, a packing piece of required design and size may be inserted :

For Goods stock : between axle box crown & bearing spring buckles.

For ICF coaching stock : between lower spring (Dash Pot spring) & axle box wing.

3.6.2 Displaced Buffer

Buffer displaced 35 mm in any direction from its normal position in case of goods stock and 38 mm for coaching stock are called displaced buffers.

If buffers of adjacent stock are not in the same level due to different conditions of loading or spring characteristics, the buffer draw gear takes an inclined position. In case of sag on the track or brake application on a down gradient, the buffers exert compressive forces. It makes the lighter vehicle prone to derailment due to lifting because of vertical component of the - buffing force.

3.7 SPRING AND SPRING GEAR

In four wheeler stock, laminated springs are normally used. However in coaches now, mostly coil springs are used.

The defects in these can be classified into three main categories :

3.7.1 Defects affecting the functioning of springs

If the defects are such that normal functioning gets hampered, the load transmission system is adversely affected. The particular wheel on which this spring bears can't adjust itself to any unevenness in the track and the wheel will become prone to derailment due to lack of dampening force.

3.7.2 Variation in performance of different springs on the same vehicle

The difference in working camber amongst the four springs under load should not exceed 13 mm. The springs having different cambers may cause derailment due to off-loading effect.

DESIGN CHARACTERISTICS OF SPRINGS

TABLE 3.3 - B.G. WAGON HELICAL SPRINGS

Type of Rolling Stock, Drawing no. & location of spring	Free Height	Outer Dia.	Solid Height
CASNUB 22W - Drg. No. WD-83069/S-1			
Outer Spring	260 +/- 3	140	167.5
Inner Spring	262 +/- 3	86	168
Snubber Spring	294 +/- 3	98	165
CASNUB 22W HS - Drg No. WD-92058-S-5			
Outer Spring	260 +/- 3	147	137
Inner Spring	243 +/- 3	180	88

Snubber Spring	293 +/- 3	171	104

TABLE 3.4 - B.G. WAGON LAMINATED SPRINGS

Type of Rolling Stock	Drawing No.	Free camber	No. of plates
BOX, BCX, BRH	**WD-86007-S/1**	47 +6/-0	10
CRT	**WD-87024-S/1**	58 +6/-0	9

TABLE 3.5 - B.G. COACH HELICAL SPRINGS

Drawing No.	**Free Height**	**Test Load**	**Acceptable height under load**
ICF, RCF & BEML AXLE			
F-0-1-006	360	2000	279-295
WTAC-0-1-202	375	2800	264-282
WLRRM8-0-1-802	360	3000	277-293
RDSO/SK-84262	325	1600	278-291
WLRRM2-0-1202	372	3000	265-282
DL-0-1-002	372	3000	269-284
DD-0-1-001	337	2400	268-284
RDSO/SK-98017	315	1800	276-289
ICF, RCF & BEML BOLSTER			
F-0-5-002	385	3300	301-317
WTAC-0-5-202	400	4800	291-308
WLRRM8-0-5-802	386	6700	306-322
RDSO/SK-84263	345	2300	300-313
WLRRM2-0-5-202	400	6100	286-304
DL-0-5-002	422	5500	291-311
DD-0-5-03(OUTER) EMU/M-0-5-004(INNER)	416 308	4200 4200	280-299 280-299
RDSO/SK-98018 : B-15	393	6000	256-272

RDSO/SK-98018 : B-16	286	6000	256-272

TABLE 3.6 - M.G. HELICAL SPRINGS

ICF's Drawing No.	Free Height	Test Load	Acceptable height under load
MAN BOGIE - AXLE			
RDSO/SK-84259	243	2000	198-209
MAN BOGIE - BOLSTERS			
RDSO/SK-84260(OUTER) & RDSO/SK-84260(INNER)	540	3500	394-417
RDSO/SK-84261(OUTER) & RDSO/SK-84261(INNER)	540	3500	457-476
ICF BOGIE - AXLES			
MG/T-01-002 (MG/T-0-1-029)	260	1000	226-237
MG/PLV-0-1-001	250	1000	232-240
MG/AC-9-0-1-001	270	1000	236-247
ICF BOGIE BOLSTERS			
MG/T-0-5-002	280	1000	256-267
MG/PLV-0-5-001	280	1000	262-271
MG/AC-9-0-001	292	1000	266-269

3.7.3 Failure of springs

Failure of a spring may cause derailment as it results in loss of damping effect and shifts the centre of gravity of the vehicle.

■■■■■■■

CHAPTER 4

PERMANENT WAY

The track structure consists of following four main components :

1. Formation
2. Ballast
3. Sleepers and fastenings
4. Rails

These are required to be regularly and periodically checked by Assistant Engineer (IRPWM para 107), PWI (IRPWM para 123,124 & 139) as well as by P.Way Mistries, Mates and Keymen (IRPWM Part 'C').

4.1 FORMATION

The railway track is laid over a formation prepared on soil (Fig. 4.1). The strength of formation depends upon the type of soil i.e. sandy, loam clay etc. and it serves the following purposes:

- distributes the weight of train, track and ballast over a wide area of natural ground
- facilitates good drainage and
- provides a smooth and regular surface on which the ballast and track can be laid

The formation is affected by following factors:

- Sudden subsidence of embankment
- Base failure
- Ballast puncturing due to heavy rains etc.
- Muddiness

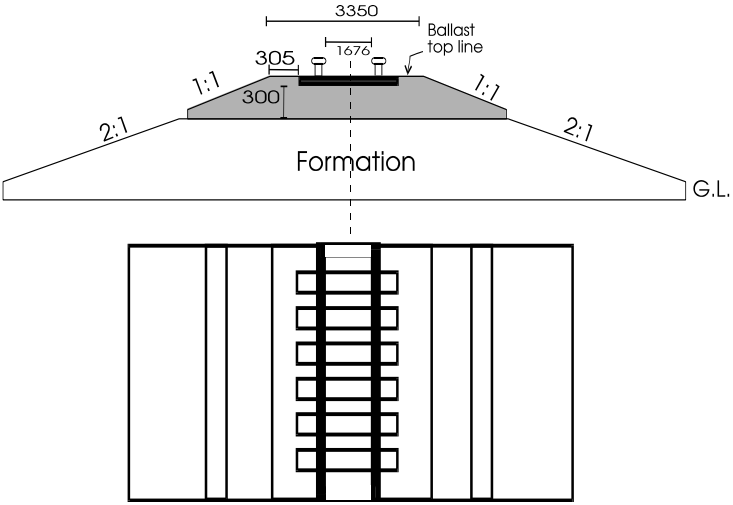


Fig. 4.1 B.G. FORMATION

The inadequate care taken in maintaining the formation may cause derailments as failure of formation results in disturbance of track geometry. The steps to be taken for avoiding derailments on account of formation failure include measures to prevent sinking of track during diversions and use of new formations specially during rains. The geometry of track should be maintained as per laid down standards for passage of traffic at stipulated speeds. Where abnormal behaviour of formation or - supports is expected, the track geometry and packing/supports must be checked regularly or as often as warranted.

4.2 BALLAST

In the track geometry, ballast plays an important role. It absorbs noise, shocks, vibrations and distributes the load transmitted by the wheels over the formation. The ballast provides a flexible base to the track and controls the lateral and longitudinal movement of track. It keeps the track in position and at required level. If sufficient quantity of ballast is not available, track may get distorted and/or buckled. The recommended ballast size is 50 mm. The profiles and minimum depths should be as given in Para. 263 of IRPWM.

4.2.1 Types of Ballast

a) Cushion Ballast : The depth of ballast below the bottom of sleeper, normally measured under the rail seat, is termed as cushion ballast.(Fig. 4.2)

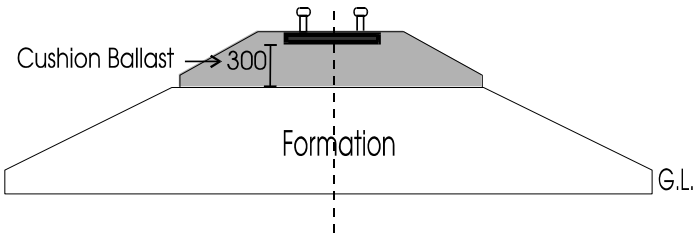


Fig. 4.2

b) Crib Ballast : Ballast provided in between the sleepers is termed as crib ballast. (Fig. 4.3)

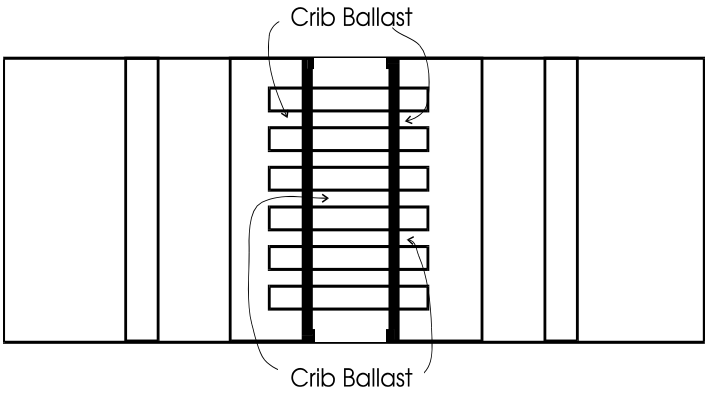


Fig. 4.3

c) Shoulder ballast : Ballast provided beyond the sleeper edge is called shoulder ballast.(Fig. 4.4)

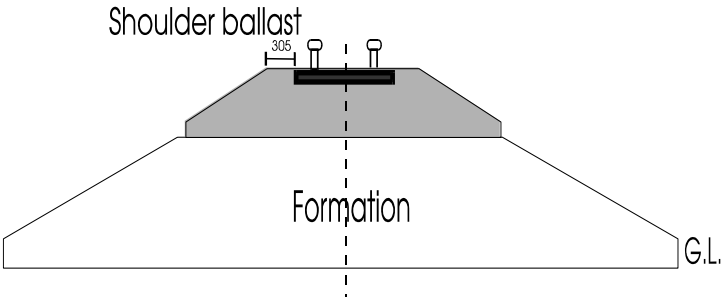


Fig. 4.4

At deep screening and relaying spots, the top table or gauge face of the rail gets smeared by ballast. This enhances friction at the flange contact area and encourages mounting of wheel specially in case of empty stock. The running surface of rail should therefore be maintained clear of ballast particles.

4.2.2 Ballast Resistance

The ballast plays an important role in absorbing shocks. The factors affecting the ballast resistance are :

- Ballast material
- Size
- Shape of ballast particle
- Ballast profile
- State of consolidation
- Type of sleeper

4.3 SLEEPERS AND FASTENINGS

The sleepers and fastenings hold the rails within desired gauge parameters. If sleepers and fastenings fail, entire geometry of the track gets disturbed and the rails may shift from their due position. The loosening or failure of fastenings also indicate lateral distortion of rails under load. Thus they perform the following functions :

- To hold the rails as per desired gauge limits
- To transmit the load from rail to a wider area over the ballast.
- To provide resilient support with ability to absorb high frequency vibrations
- To provide lateral and longitudinal strength to the track
- To permit rectification of track geometry
- Be amenable to packing and retain it
- To resist longitudinal creep of rail

- To resist overturning of rail

Types of Sleepers are :

1. Wooden
2. CST 9 Cast Iron
3. Steel trough
4. Concrete

The various f**astenings** used are bearing plates, fish plates, Screws, Spikes, Steel keys, cotters, Pandrol clips etc.

- The density and condition of sleepers should be maintained as prescribed in IRPWM. If 'M' is the Standard Single rail length in meters, the minimum sleeper densities as per IRPWM Para. 244 (4) are as follows :

B.G. a) Traffic density more than 10 G.M.T.
M+7 for Group A,B,C & D Routes
M+4 for Group E Routes
b) Traffic density less than 10 G.M.T.
M+7 for Group A,B & C Routes
M+4 for Group D & E Routes

M.G. – M+7 for Q,R1 & R2 Groups; M+4 for R3; and M+3 for S Group of Routes.

For prescribed sleeper spacing on various type of tracks, refer to IRPWM para. 244 (2) .

- The orientation of sleepers to be checked by means of the gauge meant for this purpose. (All sleepers must be laid at right angles to the rail.)

4.4 RAILS

The wear on rails play a vital role in increasing the mounting tendency of wheel on the rail table. The excessive wear may even result in rail fracture which may cause derailment.

The types of rail wear (Fig. 4.5) are :

A. Vertical
B. Lateral
C. Angular

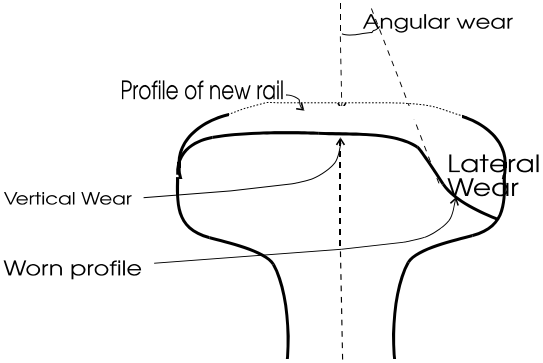


Fig. 4.5

Limits of Rail Wear

The permissible limits of rail wear (IRPWM Para. 302 iii & iv) are given below :

4.4.1 Vertical wear

Measure the rail height at the centre of rail (normally using callipers or profiling).

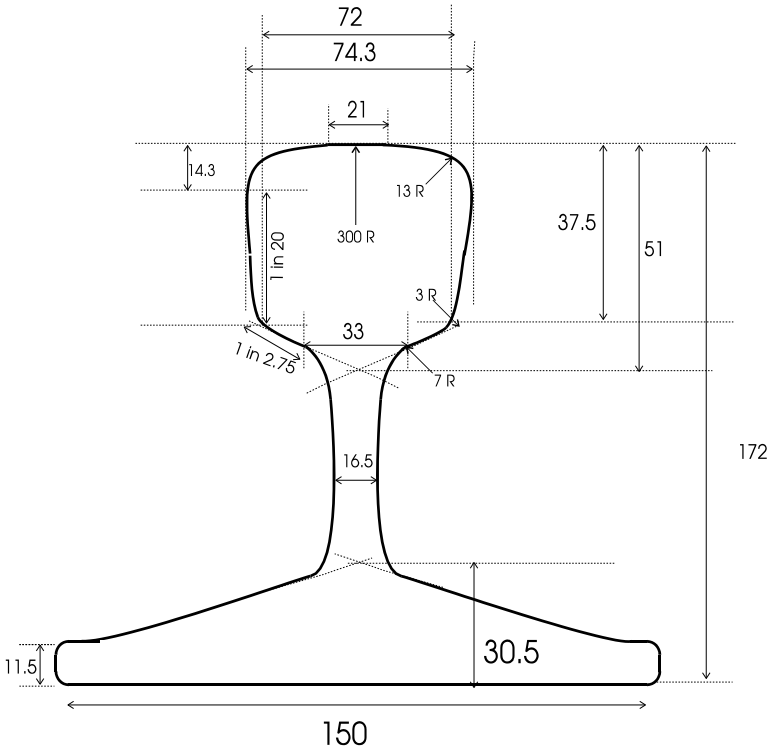
Gauge	Rail Section	Limit
	60 KG/M	13 mm
B.G.	52 KG/M	8 mm
	90 R	5 mm
M.G.	75 R	4.50 mm
	60 R	3 mm

4.4.2 Lateral wear

Section	Gauge	Category of track	Limit of Lateral wear
Curves	B.G.	A & B	8 mm
		C & D	10 mm
	M.G.	Q & R	9 mm
Straight	B.G.	A & B	6 mm
		C & D	8 mm
	M.G.	Q	6 mm
		R	8 mm

Note : The lateral wear should be measured 13 mm below the top surface of the rail.

The maximum angular wear permitted is 25^0 on all tracks. The typical profile and main dimensions of a new 60 KG UIC rail section are shown in Fig. 4.6.



60 KG/M RAIL SECTION (All dimensions are in mm)
Fig. 4.6

- If vertical wear is excessive, a deep flange may ride over the fish plate/distance block/check block and may damage the track components.

- Excessive lateral wear increases the play between the wheel set and the track which would contribute to increased oscillations and greater angularity of the flange during run.

- The angular wear is most critical. Angular wear is invariably encountered on the outer rails on sharp curves as well as on turn outs. If angular wear is excessive, the rail presents an inclined plain to the wheel on which the flange may slide upwards.

4.5 GAUGE

The distance between the two running edges of left and right rails is known as **Gauge** (Fig. 4.8). It is 1676 mm on B.G. The irregularity in gauge leads to excessive sinusoidal motions of the vehicle leading to development of attack of wheel flange with the rail. If gauge is found less than 1676 mm, it is termed as T**ight Gauge.** If the gauge is more then 1676 mm, then it is termed as S**lack Gauge**.

4.5.1 Effect Of Tight Or Slack Gauge

Due to slackness in gauge, play between flange and running edge of the rail increases. Thus excessive slackness further increases lateral oscillations, hunting, excessive flange forces and angularity due to which the wheel may drop. The main indication of slack gauge is that either one wheel remains on the track and the other drops inside the track or both wheels drop inside the track.

4.5.2 Tight Gauge

Tight gauge increases the strain on track fastenings and creates a tendency for the wheel to lift on run. Due to tight gauge, the flange of the wheel starts grinding against the rail edge. This condition causes high flange forces to occur and the flange ultimately mounts over the rail.

4.5.3 Causes Of Gauge Distortion

The following are the major causes of gauge distortion :

- Worn out fastenings due to which track could not hold the correct gauge.
- Damaged sleepers and unserviceable sleepers due to which fastening become loose.
- Fastening not properly secured and becoming loose due to high speed vibrations.
- Missing fastenings i.e. keys, dogspikes etc.

4.5.4 MARKING STATIONS FOR TRACK MEASUREMENTS

For investigating the cause of derailment, various measurements pertaining to track are required to be taken carefully. Before starting the measurements, point of mount or drop has to be ascertained jointly by nominated supervisors since the point of mount or drop is taken as reference point for many measurements (Fig. 4.7). From the point of mount/drop, stations are to be marked on the rail table at a interval of 3 meters on either side of the track up to a distance of 45 meters. Hence 15 such stations are to be marked if the cause of - derailment is normal. However if the cause is abnormal, as many as 30 stations at the rear of the point of mount/drop can be marked covering a distance of 90 meters if necessary. After completing this work, measurements with regard to track should be recorded from one end.

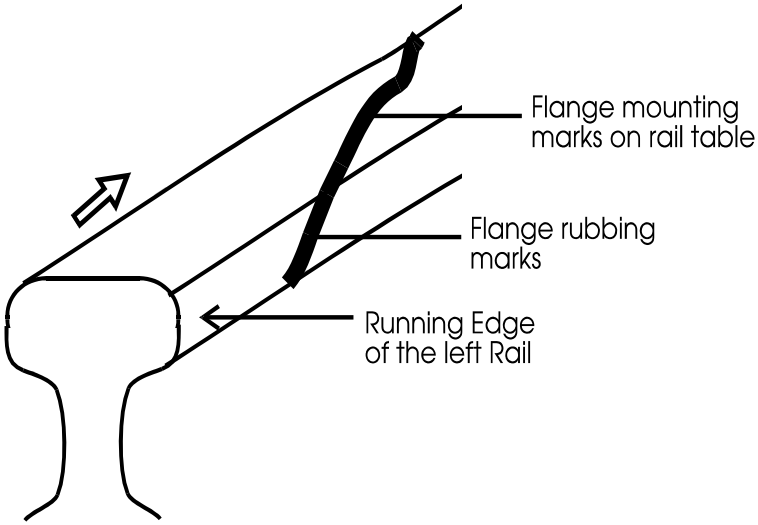


Fig. 4.7

4.5.5 How To Measure Gauge

The Gauge should be measured at stations already marked 3 meters apart with the help of Gauge-cum-level instrument. Before using this gauge, ensure its correctness as well as spirit level sensitivity. It must be ensured that both ends are properly touching the running edge of the rails during measurement. The tightest point obtained determines the correct point to test the gauge. Record the reading showing tight or slack gauge. The gauge is designed to measure slackness or tightness up to 20 mm. If tightness or slackness is found beyond measuring capability of the gauge, it should be measured by tape and recorded (Fig. 4.8). **Gauge is measured 14 mm below the rail top table.**

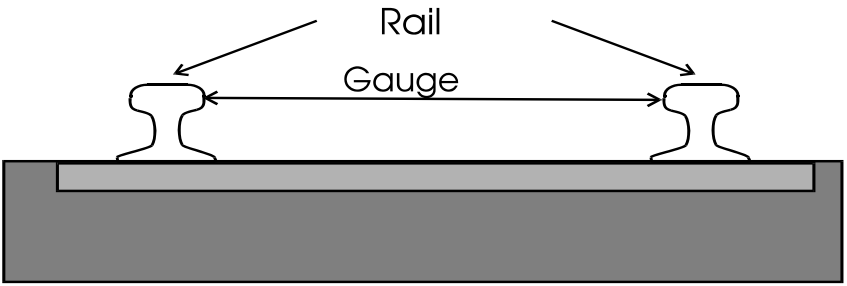


Fig. 4.8

4.5.6 Permissible Gauge Tolerances

As per Para. 224(v)of IRPWM, the tolerances for gauge are:

	TIGHT	SLACK
On straight (All Gauges)	**3mm**	**6 mm**
On curves with radius:		
i) more than 400M on B.G. 275M on M.G. and 175M on N.G.	**3mm**	**15 mm**
ii) less than 400M on B.G., 275M on M.G. and 175M on N.G.	**Nil**	**20 mm**

4.6 CROSS LEVEL

The relative difference in the height of left and right rail at a given point on the track is known as **Cross Level (on straight track)**. The fluctuating cross level differences in the track result in track **Buckling** (Para. 4.9) and help in developing undesirable oscillations on vehicles adversely affecting their stable running.

4.6.1 Effect of Variation in Cross Levels

Due to variation in Cross Levels, either one wheel is above or below the plane of other wheels of the vehicle. If one rail is higher, the wheel on that spot will be on a higher plane and will cause off-loading of that wheel. On the other hand, if one rail is lower, the wheel on that spot will be on a lower plane and will cause off-loading of the opposite wheel. Thus variation in cross levels affects the stability.

A uniform cross level difference does not matter much from the point of derailment. A cant deficiency up to 75 mm is normally permitted. If cross level differences up to this extent are uniformly available over long stretches in the track, it may not lead to unstable conditions. However the variations in cross level called **Twist** are very important from safety point of view. If the cross levels vary too frequently, the effect is the same as difference in camber of springs and this may lead to derailments. This effect is more pronounced in case of a four wheeler stock in which one of the wheel tends to float due to excessive twist and may get derailed.

Cross level is an important factor to be considered in derailments and it should be recorded very carefully. Cross level should be recorded taking left rail as the reference rail i.e. recording whether the right rail is low or high. Normally cross levels are measured from the point of mount or drop up to 45 meters on either side. Where point of mount is not clear, 90 meters in rear and 45 meters ahead may be taken for measurement. The readings are essentially recorded from sleeper to sleeper.

4.6.2 How to Measure Cross Levels

For measuring cross level, modified RDSO gauge is used which records Gauge as well as Cross Levels simultaneously. For measuring cross level, a good quality of spirit level is used and is kept at the centre of the gauge. Before using spirit level, the sensitivity should be checked i.e. whether the bubble is freely moving in the cage or not. In the gauge, space is provided for spirit level which slides freely on the gauge. The sliding portion is calibrated on either side with which the difference in cross level in mm can be read directly . If spirit level moves 10 mm to the right of the gauge, it indicates that right side rail is lower by 10 mm as compared to the left rail . If spirit level moves left side then this indicates that left rail is lower than right rail. For measuring the cross levels, always take left rail as reference rail and it should be clearly mentioned i.e. left rail is low or high. Though maximum permissible variations in cross level have not been laid down , a 13 mm variation in cross levels at stations 3 meter apart is considered limiting value. - Railway Board vide letter no 63/wg/tk/10 dated 10.11.64 has laid down following tolerances for B.G. (see Table 4.1)

TABLE 4.1

	During maintenance	**During service**
Cross Level difference	Variation not more than 4mm	Var. not more than 8 mm.
Twist on 3 metre base	Var. not more than 2mm/metre	Var. not more than 3mm/metre

4.7 TWIST

Twist is rate of variation in cross level per meter. Normally twist is calculated for the stations marked on the track 3 meters apart from the reference point. If one rail is higher than the other at station No. 1 by 10 mm and the same rail is lower than the other at station No. 2 by 8 mm, then the twist between station No 1 & 2 (3 meters apart) will work out to be :

(10 + 8)/3 = 6 mm per meter

If one rail at station No. 1 is higher by 12 mm & on station No. 2, it is higher by 6 mm, the twist will be :

(12-6)/3 = 2 mm per meter

In finding out the real cause of derailment, the twist should be measured on the wheel base of the vehicle which derailed first since this is the twist which played effectively at the time of derailment.

4.7.1 Effect of Twist

Twist has an adverse effect on running and plays an important role in derailment. The reason is quite clear. If at station 1, left rail is higher, than the left wheel is off loaded. If at station 2, right side rail is higher, right side wheel is off loaded & left side wheel is loaded more. This will cause uneven loading of wheels and this condition is prone to derailment.

4.7.2 Calculating Effective Twist

Let the wheel base of the first derailed vehicle is 4 meters. The twist will be calculated as under:

Distance from Ref. point (meters)	Cross Level reading in mm.	Twist over base of measurement (mm/meter)	Effective Change over 4 meters wheel base mm	Twist in mm per meter
0	+5	-	(+5)-(-6)=11	2.75
1	+7	2	(+7)-(+7)=0	0
2	0	7	(0)-(+2)=-2	0.5
3	+3	3	(+3)-(+10)=-7	1.75
4	-6	9		
5	+7	13		
6	+2	5		
7	+10	12		

The highest value of effective twist on 4 meter wheel base of the vehicle is between station 0 and station 4 above.

4.7.3 Permissible Standards for Twist

Track Category	Twist in mm/metre[1] B.G. (3.6M chord)	M.G. (2.74M chord)
A	0 to 5	0 to 3
B	5 to 7.5	1 to 2
C	7.5 to 10	2 to 3

4.8 TRACK ALIGNMENT AND UNEVENNESS

The track should be in well aligned position for good comfort and safety and limit the chances of flange coming in contact with the rail. **The flanges are actually the block stops for exceptional situations**. This has been clearly highlighted by French Railways (Appendix 'E'). On encountering a track irregularity, the springs start oscillating and continue to offload the left and right wheels alternatively even after the irregularity is crossed. If the natural frequency of the vehicle happens to coincide with the exciting frequency, the oscillations can develop dangerous proportions causing derailment. The lateral alignment using 7.2 metre chord and vertical alignment i.e. **Unevenness (**using 3.6 metre chord for B.G. & 2.74 metre chord for M.G.) are to be maintained within following service tolerances[1] :

Track Category	Alignment (mm)		Unevenness (mm)	
	B.G.	M.G.	B.G.	M.G.
A	0 to 3	0 to 3	0 to 6	0 to 3
B	3 to 5	3 to 5	6 to 10	3 to 5
C	>5	>5	>15	5 to 8

1 Ministry of Railways, Government of India. *Investigation of derailments.* (Pune: Indian Railway Institute of Civil Engineering,1995), p. 22.

4.9 CREEP

The longitudinal movement of rails in the track is called **Creep.** Creep on the rails vary from place to place. In some places it may be as much as few centimetres in a month whereas at some other location, it may be negligible.

Due to creeping of rails, the openings in the rail joints at the point of creep gets widened.

4.9.1 Causes of Creep

Many theories have been evolved to explain the reasons for creeping of rails in a track. Some are explained as below.

A. Wave Theory

According to this theory, a moving train sets up a wave motion in the resilient track portion of the rail. Immediately under the wheels of the train, the rails between adjacent sleepers get depressed or deflected somewhat due to vertical loading. The moving wheel pushes the elevated portion of the wave, which in turn forces the rail in the direction of traffic. The raised portion of the rail in front of the moving load is carried forward by the wheel and this helps in developing creep. The raised portion of the rail at the rear of the moving wheel then assumes its normal position.

Along with the moving wheels of the train, the

depressions formed in the rail also moves with them. As soon as the loaded wheels pass over a depression, the portion of the rail springs back to its original level. In this way, the wave motion tends to move along the entire length forward with the moving train. Similarly the impact of several wheels at a rail joint also causes creep.

The pitch and depth of the wave in the track however depends upon the following factors :

- Stiffness of the track
- Spacing of the sleepers
- Wheel base of the vehicles
- Weight of the rails quantity and quality of the ballast
- Standard of the maintenance of the track
- Track modulus of the material.

To reduce the creep, it should be ensured that the track possesses the following qualities :

- Increased stiffness
- Stable soil for formation
- Angular ballast for better interlocking

B. Change of Temperature Theory

Development of creep rail may be caused by expansion/contraction of rails due to change in temperature. The change in temperature depends upon the range of temperature and the location of the track i.e.. whether the portion is exposed to sun or remains under shade. Creep is more rapid during hot

summer as compared to cold winters

C. Unbalanced Traffic Theory

According to this theory, if heavy traffic moves in one direction and light traffic moves in opposite direction predominantly on a single line track, unequal creeping occurs between the two directions. The net effect of creep in the direction of movement of heavier traffic is more. In case of double line tracks , the movement of trains is more or less unidirectional and as such creep develops in both the tracks in the direction of movements of trains.

Besides the above theories, the creep may also develop due to the following factors :

1. Loose fittings of rails
2. Bad quality of sleepers
3. Bad alignment of curves
4. Too tight or too slack gauge
5. Gradient of the track
6. Life of the rails
7. Uneven spacing of the sleepers
8. High embankments.
9. Weight of the rails.

In fact, it is very difficult to predict the magnitude of creep. Some times, only one of the rails may also start creeping in a direction opposite to the other rail

4.9.2 Effect of creep

Though there are several serious effects of creep, the most serious is **buckling** of the track. If proper attention is not paid, a buckled track may easily derail a train. The other harmful effects are as under :

- The sleepers move out of square and position.
- The gauge and alignment of the track gets disturbed.
- The surface of the rails get disturbed considerably due to movement of sleepers from their packed loads. This causes uncomfortable riding .
- Rail joints at the starting points of the creep get opened out of their permissible limit considerably. The stresses develop in the fish plates and bolts. This may sometimes break the fish bolts and the rail ends gets battered badly. At the point where creep ends, the rail joint gets jammed and thus prevents free expansion of the rail.
- Points and crossings get disturbed and it becomes difficult to maintain the correct gauge and alignment. The movement of switches becomes difficult and even the interlocking arrangement is thrown out of gear.
- The expansion gaps become either too big or too short.
- Besides above defects, kinking of rails forcing the ballast and even smashing the fish plates and fish bolts are common

occurrences due to creep.

4.9.3 Measurement Of Creep

The measurements of creep in a track may be done in the field as explained below :

A. Fix two creep indication posts or unserviceable rail pieces on either side of the track in the formation such that their tops are about 25 mm above the rail level.

B. Fasten a string to the tops of the posts such that it passes freely below the rail bottom.

C. Make a chisel mark or a point mark on the side of bottom flange of the rail on either side of the track. Note down the time and date of marking .

D. After a particular interval of time, measure the distance between the chisel marks and the string. This distance is the required amount of creep which has developed during the given time interval .

4.9.4 Remedial Steps against Creep

The following precautions are required to be taken to prevent and reduce the creep of rails in the track :

A. Keep the sleepers always well packed with heavy angular ballast and provide wide shoulders as to resist the

movement of the sleepers.

B. Keep all the rail joints levelled so that there are less chances of impact by the moving wheels .

C. Keep the fish bolts tight and oil them frequently so that the ends of the rails move freely under thermal stresses.

D. Provide anti-creepers or anchors on the top of sound sleepers. If the creep still continues, the number of anchors may be increased per rail panel.

4.9.5 Track Maintenance against Excessive Creep

The maximum permissible limit of creep is 150 mm. In case the creep exceeds this limit, the adjustments must be made as under :

A. Measure the expansion gaps and check against the total amount of gap in the length which should be equal to the standard expansion gap required at the given temperature multiplied by the number of joints in the rail panel.

B. Remove the keys and fish plates. Insert correct expansion liners before pulling the rail back with bars.

C. Tighten up the fish plates and insert key properly.

D. In case the total gap is more than the standard gap, the required closure rails may be used with a speed restriction of 30 Km/h till the gaps are removed.

E. While adjusting the creep, the sleeper spacing should also be adjusted.

4.9.6 Track Lengths susceptible to Creep

The locations in track more susceptible to creep are :

- Steel sleeper track/CST-9 sleeper track joining the wooden sleeper track.
- Long stretches on gradients having dips
- Approaches to major girder bridges or other stable structures.
- Approaches to level crossings and points & crossings.

4.10 BUCKLING OF TRACK

Buckling of track occurs when very high compressive forces are created in the rails. A special watch should be kept at the junction of two stretches of track where one is liable to creep and the other is held against creep. Some of the examples are:

- Track laid on wooden sleepers with inadequate anchors and scanty ballast.
- Track laid on metal sleepers with loose keys butting against the track laid on new sleepers with tight

fastening.

- Track anchored with welded track.

As one side of such a junction point is held firmly, the movement of rails due to creep from the other side is restricted resulting in heavy compressive forces being exerted. This will tend to buckle the track. Jammed rail joints are therefore an indication of the track being subjected to undue strain which may result in track buckling.

4.10.1 Conditions inducing Buckling

The following conditions create high compressive forces in the rail:

- Inadequate expansion gaps
- Failure to counter act creep in time
- Non lubrication of rail joints
- Failure to remove rail closures from track

4.10.2 Precaution against Buckling

A. Greasing of fish plates should be done before the hot weather sets in.

B. The joints gape survey is done in the case of SWR and adjusted before the hot weather.

C. Adequate precautions are taken to reduce creep.

D. Over tightening of fish plate bolts is avoided - but they should be reasonably tight.

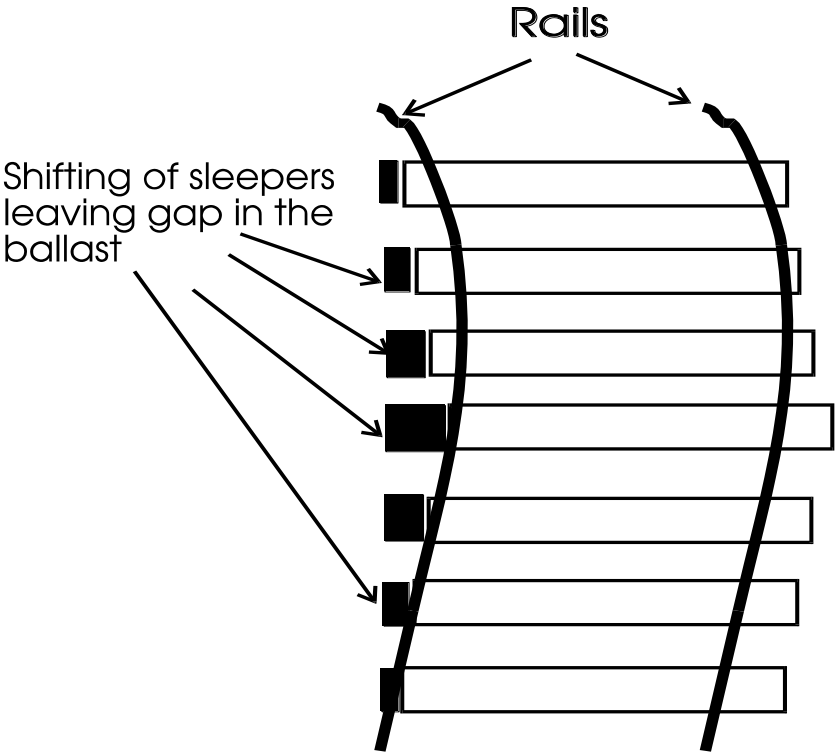


Fig. 4.9 Shifting of Sleepers in Derailments due to Buckling

It is observed in many derailments attributed to track buckling that a severe cut/dent mark occurs on the foot board brackets on the inner side of non-derailed coaches having passed the point of derailment. Corresponding grazing marks are also

found available on the top sole plate of the bogies. Another indication is the shifting of sleepers towards one side from their original position leaving gaping holes in the ballast (Fig. 4.9).

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CHAPTER 5

DERAILMENT ON CURVES

The rolling stock has higher chances of derailing on a curved track since the flange is almost continuously pressing against the running edge of outer rail in addition to the normal tread contact with the rail. The analysis made on mid-section derailments on Central Railway reveals that the number of derailments are much higher on curved alignments compared to straight track. It is therefore essential to pay utmost attention to proper maintenance of curved tracks.

5.1 ADVERSE FACTORS ON A CURVE

The curved track has higher chances of developing following adverse conditions:

- Excessive angular wear on the outer rail
- Excessive flattening of head on the inner rail
- Fracture and failure of rails
- Gauge widening
- Track distortion

5.1.1 Vehicles entering a curve at speeds higher than maximum permissible speed may cause distortion of the track or lead to mounting of wheel over the outer rail. Wheel mounting on the inner rail is also possible in case of sudden braking causing bunching of vehicles.

5.1.2 The outer rails on curves also suffer higher angular wear which may present a convenient inclined plane for the wheel to slide up.

5.1.3 Similarly a wagon stopping on a sharp curve with high superelevation (Para. 5.2) causes the outer wheels to get off-loaded. When the wagon starts moving even at crawling speed, the guiding force acting on the outer leading wheel is significantly more as higher force is needed to turn the vehicle and follow the curved path. The Y/Q ratio for the outer leading wheel thus becomes higher and the wheel may mount the rail if it exceeds the critical limit.

5.2 CANT or SUPERELEVATION

When a vehicle moves on a circular curve, it is subjected to a constant radial acceleration which produces a centrifugal force acting away from the centre in a radial direction. The value of this centrifugal force is given by the formula :

$$F = WV^2 / GR$$

Where :

F - Centrifugal force in tons
W - Weight of the vehicle in tons.
V - Speed in feet /sec

G - Acceleration due to gravity in feet / sec2
R - Radius of the curve in feet

To counter this centrifugal force, outer rail on the curves is kept little higher than the inner rail. The inner rail is normally maintained at its original level and considered as a reference rail. Raising of outer rail on curve to a specified height in this fashion is known as **Cant** or **Superelevation**. The state of equilibrium reaches when both the wheels bear equally on the rails. In this state of equilibrium, the level difference between outer and inner rail on the curve is called **equilibrium super elevation**. The equilibrium super elevation is given by :

$$e = GV^2 / gR$$

In metric system : $e = GV^2 /127R$

where:

e- Equilibrium super elevation
G- Gauge + Width of rail head in mm
V- Velocity
R- Radius of the curve

Note : The cant for each curve is normally indicated on the web of inside face of inner rail to the nearest 5mm.

5.2.1 Reasons for providing Superelevation

- To have a better distribution of load on two rails.
- To reduce wear and tear of rails and rolling stock.

- To neutralise the effect of lateral forces.
- To provide comfort to passengers.

5.2.2 Degree of Curve V/S Radius of Curve

The degree of a curve (D) is the angle subtended by the curve at its centre by a chord of 30.5 metres. The relationship between radius and degree of a curve is given by the equation :

$$D = 1750/R$$

Hence for : 1 deg. curve, R = 1750 meters
2 deg. curve, R = 875 meter
4 deg. curve, R = 438 meter and so on.

5.2.3 Effect of excessive or inadequate Cant

The maximum value of superelevation is approximately 1/10 to 1/12 of gauge. The values of maximum superelevation prescribed on Indian Railways are given below in Table 5.1. (Para. 406 of IRPWM)

Table 5.1

Gauge	Track Group	Max. cant in mm
B.G.	A,B,C –––	165
	D & E –––	140
M.G.	All Groups	90 (100 with

		special permission of C.E.)
N.G. (762mm)	All	65 (75 with special permission of C.E.)

It is very important to provide super elevation suiting the degree of curve.If super elevation is less, there is a possibility of:

- Outer rail getting worn out as it will have to bear more strain due to tendency of wheels to move away from the centre of the curve under the influence of centrifugal forces.

- The fast moving trains will have more lateral oscillations causing discomfort to travelling public.

On the other hand, excessive super-elevation has these effects:

- Inner rail will have to bear maximum strain and there is every possibility of this rail giving way due to excessive strain and cause gauge widening.

- Due to excessive super elevation, there is every possibility of slow moving goods trains getting derailed

Thus keeping in view the maximum permissible speed of the section and the volume of goods traffic moving over the section, a compromise has to be made which permits fast moving trains to traverse safely and without discomfort to passengers while permitting slow moving trains without risk of derailments. This is the purpose for which cant deficiency is provided.

5.3 CANT DEFICIENCY

Cant deficiency is the difference between **equilibrium cant** necessary for maximum permissible speed on a curve and the actual cant provided. The cant deficiency is limited due to following two considerations :

5.3.1 Higher cant deficiency causes discomfort to passengers.

5.3.2 Higher cant deficiency leads to higher unbalanced centrifugal force which in turn requires stronger track and fastening to withstand higher lateral forces.

For Indian railway B.G., cant deficiency for normal speed up to 100 KMPH is 75 mm and that of for high speed is100 mm. (Para 406 (2) of IRPWM)

The equilibrium and proposed cants to be provided on curves for various maximum permissible speeds are given below in Table 5.2. as per IRPWM Para. 406 (3).

Table 5.2

Degree of curve	Radius in meters	Max. permissible speed	Equilibrium cant in mm	Proposed cant
1	1746	160	200	100
1.25	1395	160	250	150
1.5	1164	155	285	185
2	873	135	285	185
3	585	100	285	185
4	436	95	285	185
5	349	85	285	185
6	291	80	185	185

Derailments have been noticed in which a vehicle just started moving after stopping on a sharp curve with high super elevation. The reason is that the outer wheels get off-loaded when a vehicle stands on high cant. Therefore during maintenance of curves, following precautions should be taken:

- Cross levels and gauge must be maintained within specified permissible limits.
- The cant gradient on transition should be as flat as possible to get greater tolerance for irregularities in the twist parameter.
- Lubricate the gauge face of rail to reduce wear.

5.4 TRANSITION CURVE

As soon as a vehicle enters a circular curve from straight alignment, it is subjected to centrifugal forces. This increases lateral flange force and affects the track alignment. In order to limit these and provide smooth entry to the curve, transition curves are provided on either side of a circular curve (see Fig 5.1). The change of degree is uniform throughout the length of transition curve. Thus the curvature increases gradually from zero at the straight end and becomes equal to the curvature of circular portion at the other end. The superelevation increases at the same rate as curvature so that full cant is achieved simultaneously with the beginning of circular arc. This gives gradual and slow building of centrifugal force as well as superelevation. The transitions are thus critical portions to be examined for the correctness during derailments on curves. The transition curves are usually laid in the shape of a cubic parabola.

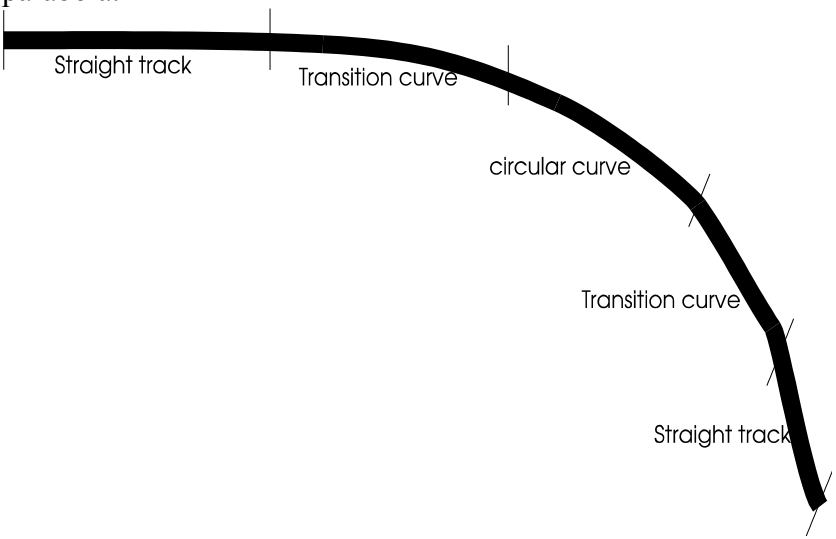

Fig. 5.1 Transition Curve

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5.4.1 Length of Transition Curve

The length of transition portion depends upon the degree of curve, max. permissible speed, amount of superelevation and the rate at which the cant is run off. The desirable length of transition curve in meters is maximum of following three values

(1) $0.008\ C_a * V_m$

(2) $0.008\ C_d * V_m$

(3) $0.72\ C_a$

Where C_a is actual cant provided in mm, C_d is cant deficiency in mm and V_m is maximum permissible speed in Kmph. In exceptional cases where enough space is not available, length should be maximum of these values : 2/3 of (1), 2/3 of (2) and 1/2 of (3) above.

5.5 VERSINE

Versine is the perpendicular distance measured in mm from the centre of the chord line to the arc between two marked stations (Fig 5.2).

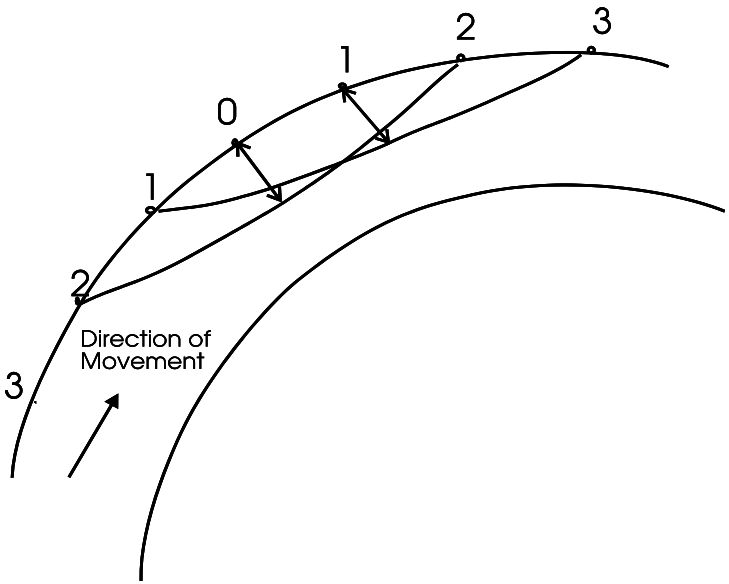

Fig. 5.2 Measurement of Versine

5.5.1 Objective of measuring versine

The main objective in measurement of versine is to check the degree and radius of curved track. The Track Recording cars are used for periodical measurements. On straight track, versine measurement is done on a 7.2 metre chord in order to check lateral alignments. For checking vertical unevenness (Para 607 of IRPWM), 3.6 (B.G.) and 2.74 (M.G.) metre chords are used.

5.5.2 How to Measure Versine

The versines on curves are measured using 20 metres

overlapping chords with stations at 10 metres intervals. For turn-out and turn-in curves, versines to be measured every 1.5 metres with overlapping chord of 6 meters (IRPWM Para. 401). A fishing/nylon wire is stretched between two ends of the chord at the inner edge of the outer rail. Care should be taken while stretching the chord or wire to ensure that it is applied at the running side of the rail at gauge point. The perpendicular distance between the rail and the chord/wire at the middle point of the chord is measured in mm which gives the value of versine for the chord.

5.5.3 To determine the Degree of Curve with the help of Versine

On a curved track, the versine in c.m. on a chord of 11.8 meters directly gives the degree of curve. Thus versine measured in c.m. on a 6 meter chord gives approx. 1/4 of the degree of curve and versine in cm. on a 3 meter chord gives approx. 1/16 of the degree of curve. Thus these values should be multiplied by 4 and 16 respectively to arrive at the exact degree of curve.

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CHAPTER 6

POINTS AND CROSSINGS

At railway stations and yards, a number of tracks are provided for receipt and despatch of trains. When trains are received or despatched, they have to cross other tracks and come to the desired line. In this process, they pass over a number of points and crossings.

A set of points and crossing consists of the following main items:

6.1 Switch assembly
6.2 Crossing assembly
6.3 Lead rail joining switch and crossing assembly

6.1 SWITCH ASSEMBLY

A switch assembly consists of two tongue and two stock rails. The stock rail is actually part of main rail while the tongue rail has a tapered edge which sets against the stock rail so as to set the route for the reception and despatch of train in the desired direction. The inner or tapered edge of tongue rail is known as T**oe** while the thicker edge is known as H**eel** of the tongue rail. The toe of the tongue rail is tapered such that it doesn't cause any obstruction to the movement of wheels.

If length of tongue rail is less, the wheel weight on heel causes the toe to jump upwards. This jumping of toe results in a

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gap between tongue and stock rail which may cause derailment. Therefore to stop jumping or rising of toe of the tongue rail, a **Stretcher Bar** is provided. This stretcher bar presses the bottom of stock rail and arrests the jumping of tongue rail. At these points, it is essential to provide sufficient room for the passage of wheel flange. This passage is made available with the help of **Crossing assembly** which guides the movement of wheels.

6.2 CROSSING ASSEMBLY

A crossing assembly is prepared by joining the following rails (see fig 6.1) :

6.2.1 V Rail
6.2.2 Two wing rails (left and right)
6.2.3 Two check rails

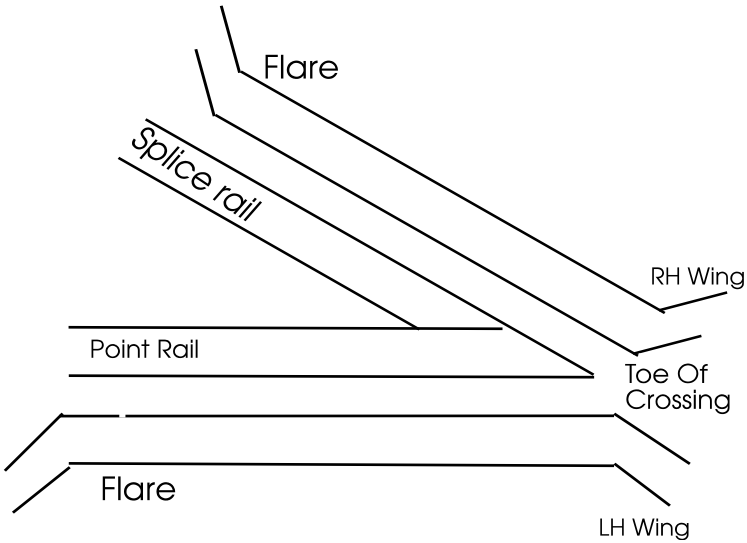

Fig. 6.1 Crossing Assembly

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6.3 IMPORTANT ASPECTS IN POINTS AND CROSSING MAINTENANCE

Some important provisions of IRPWM Para. 237 are :

6.3.1 There should be no junction fish plates at the stock rail joints (SRJ) or at the heel of crossing (HOC). At least one rail on either of the points and crossing should be of the same section as the Point and Crossing assembly rail section.

6.3.2 At all places in a point and crossing, the gauge shall be uniform except at point just ahead of the toe of the switch where it will be slightly slack. (enough to house the tip of the tongue rail)

6.3.3 Badly worn and damaged stock and tongue rails should be replaced by serviceable ones .

6.3.4 Tongue rail may be classified as worn/damaged when (IRPWM,1986 - Advance correction slip No 20 dated 16-11-98) ::

A. It is chipped/cracked over a length of 200 mm within a distance of 1000 mm from its toe.
(i) chipped length will be the portion where tongue rail has worn out for a depth of more than 10 mm over a continuous length of 10 mm.

B. It has developed knife edged tip (thickness of top edge being less than 2 mm) over a length of more

than 100 mm any where up to a distance of 1000 mm from its toe.

C. It is badly twisted or bent and does not house properly against the stock rail causing a gap of more then 5 mm at the toe (the limit prescribed in the I.R. Signal Engineering Manual.

The tongue rail can however be reused after reconditioning of the broken tip, by welding and rectification of the bend/twist by Jim crowing. It is also a good practice to replace a tongue rail having a knife edge tip as it is liable to break at that location.

The wear of the tongue rail (measured at 13 to 15 mm below the top table of stock rail) shall not exceed the following limits (IRPWM,1986 - Advance correction slip No 20 dated 16-11-98) :

Vertical wear - 8 mm for 60 Kg
5 mm for 52 Kg and 90R
3 mm for 75R and 60R

Lateral wear - 8 mm for 60 Kg
6 mm for 52Kg and 90R
5 mm for 75R and 60R

6.3.5 Slight wide gauge at the toe of switch may be adjusted by providing suitable steel packing between the web of the stock rail and the lug of the slide chair.

6.3.6 If wing rails or check rails are badly worn laterally, it could be due to wide gauge at the crossing. Gauge can be maintained properly by the provision of a gauge tie plate under the nose of the crossing, on lay out of wooden sleepers.

6.3.7 In obtuse crossings, the distance between the throat and the nose must be maintained correctly.

6.3.8 In a diamond crossing, obtuse crossing should be laid square to each other with respect to centre line of the acute crossing.

6.3.9 Maximum vertical wear on wing rail or nose of crossing shall be 10 mm.

6.3.10 The curve lead should be laid by offsets from the gauge face of the straight track. Stations at 1.5 meter intervals should be marked and the versine checked and track attended as necessary.

6.3.11 The versines of turn-in curves on loops should be recorded at stations at 1.5 m intervals during inspection of points and crossings to check the sharpness of the curve and rectified as necessary. The turn-in curve should be checked for the condition of sleepers and fastenings.

6.3.12 There should be no change of cant between points 20 meters on B.G. and 15 meters on M.G. outside the toe of

switch and heel of crossing respectively, except in cases where points and crossings have to be taken off from the transition portion of a curve. In exceptional cases however specific relaxation may be given by the Chief - Engineer.

Any work involving the insertion or removal of points and crossings on a running line must be carried out only after obtaining the sanction of the - Commissioner of Railway Safety.

PWI is responsible for the correct gauging of the switches and SI will be responsible for the correct fixing of the interlocking apparatus.

6.4 DERAILMENTS ON POINTS AND CROSSINGS

6.4.1 The derailments on points and crossings occur at switches(points) which either gape initially or open slightly under the passing wheels. Gaping points are caused by a bent tongue rail and by wrongly adjusted heel bolts. Any obstruction like a piece of stone will also result in the switches not setting home. Although, on carefully maintained interlocked points, an obstruction is detected and proper closing of points is ensured, loss of lever movement in the interlocking equipment will permit pulling of lever even in the presence of such obstruction. A frequent cause of defective points is their being forced open in the trailing direction during shunting operation. If the defect is not set right, the switches will not close effectively and there will be a

danger to vehicles passing in the facing direction. A bent rear point rod is an usual indication of points trailed through when not set.

6.4.2 Very loose heel bolts and badly packed sleepers under the heel chairs will permit the toe of switches to lift under passing wheels. Where the cause for derailment is under dispute, demonstration with loaded wagon will expose this defect.(Fig. 6.2)

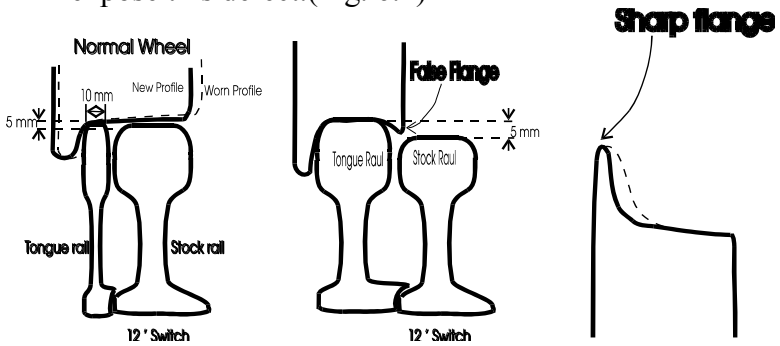

Fig. 6.2 Derailments on Switch Assembly

6.4.3 Excessive wear in switches may sometimes induce derailment due to splitting of the switch longitudinally. When the stock is also worn, the tyres of vehicle will bear on the switch head earlier then intended by design and will cause a certain amount of crushing of the metal.

6.4.4 In the design of the 100 lbs 12 feet switch, the head of the switch is 5 mm lower than the stock rail at a distance of 450 mm from the toe. Its thickness at this section is 10 mm. Therefore if the stock rail is worn out by 5 mm and the side wear of the switch is permitted to proceed too

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far, the crushing of the switch head and resulting flow of metal will prevent the proper setting of the switch.

6.4.5 In many cases where derailment occurs at facing points, the flange profile of the wheel of the derailed vehicle should be examined for sharpness(Fig 6.3). Grease marks on the vertical side of the flange will usually locate the defective wheel. Figure shows when the flange should be considered sharp.

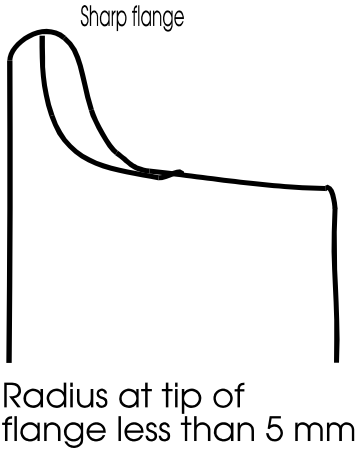
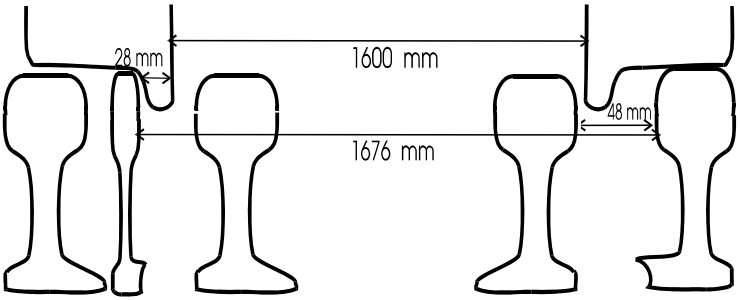


Fig. 6.3 Sharp Flange

6.4.6 Unmanned and unlocked hand points are liable to open slightly due to the play in the pins connecting the pullover rod to the lever box. It is the responsibility of the traffic department to see that all facing movements over hand points are manned by a pointsman who should ensure that the points are held down or locked.

6.4.7 Figure 6.4 shows the limiting position of a broad gauge

axle with new wheels at the nose of a crossing. It will be seen from the dimensions given that the wheel flange will hit the edge of the nose normally at the tip of the flange if the gauge is tight by 10 mm or the clearance of the check rail is 47+10 = 57mm. In this case, the wheel will certainly mount the nose.



Critical limits of Check Rail Clearance and Tight Gauge
Fig. 6.4

Hence the maintenance of the correct check block clearance and gauge at the nose of crossing is of great importance to permit the maintenance of the correct check block clearance, check rail blocks for IRS crossings are provided with three mm packing pieces which may be moved when the check rail gets worn out.

6.4.8 It is some times not realised that a high wing rail of a crossing may cause a derailment in the trailing direction. In facilitating the passage of a wheel in the trailing direction, the function of the wing rail is to progressively relieve the load on the "V**ee**" of the crossing (Fig 6.5).

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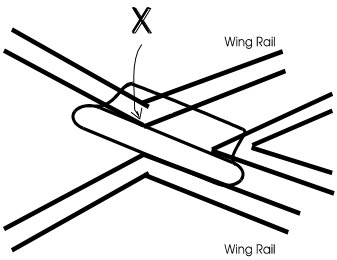

Fig. 6.5 High Wing Rail at the Crossing

This gradual transfer of the load starts at a point "X", provided the wing rail permits the wheel tread to bear on it. If the crossing is worn and the wing rail is new, the tyre may get wedged between the two wing rails and force them apart as the axle moves forward. Careless renewals of wing rails without due consideration to the amount of wear on the crossings should therefore be avoided.

6.4.9 Loose crossing bolts or incorrect assembly of crossings permitting relative vertical movement between the "VEE" and the wing rail may also increase proneness to derailment.

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APPENDIX 'A'

PROFORMA

TO BE FILLED UP IN CASE OF DERAILMENT

DETAILS OF THE ACCIDENT

1. The relevant paras in this proforma are required to be filled in by the inspectors/officers of the respective department before leaving the site of the accident and the complete proforma should be countersigned by the senior most officer present at the site of accident.

2. This proforma should form a part of the proceedings of the enquiry and should be sent along with the proceedings.

THE SKETCH OF THE SITE OF ACCIDENT

The engineering representative should prepare dimensioned sketches adequate for the preparation of a scale plan covering the entire site of accident. In preparing the sketch, due regard should be paid to the following instructions :

1) The sketch giving train no., date and kilometre of site of accident should be properly labelled.

2) The north point should be indicated.

3) It should indicate prominently the direction of the movement and also the names of the stations in rear and advance of the accident site.

4) It should cover a length of about 300 meters behind the point of mount and almost and equal distance in front.

5) Each track of the Permanent way must be denoted by a pair of lines.

6) The position of level crossing, Telegraph post, bridges, tunnels, Gradient posts with Gradient Symbols, curves , demarking the beginning and end giving details of degree of curvature prescribed, super elevation and length of transition should be indicated.

   It should also indicate:

   a) The position of all derailed vehicles and the marks left by them either on sleepers, rails or ballast.

   b) Point of Mounting with position of rail joints on either side.

   c) Point of Drop.

d) The pair of wheels of the first derailing vehicle.

e) The position in which every displaced rail/ wagon or part of rail/ wagon and detachable components were found.

f) In all the cases dimensions from nearest kilometres post and centre line of track should be given.

7. In case of accident within station limits sufficient details about the station layout should be showed in order to fully explain the movement of the effected train in relation to the topography.

8. The distance of site of accident from permanent structure to fix the site of accident precisely should be indicated.

9. The distance should be indicated to show the extent of the disturbance cause in P. Way or train composition on account of the accident.

10. Any marks of sleeper or other track fittings should be clearly indicated in their exact position in relation to the track or vehicles.

11. Broken parts of other extraneous material, if found on the site of accident, should be shown in the sketch, with details giving their precise position in relation to track.

12. If necessary, more than one sketch should be enclosed one clarifying the yard layout and the system of working it and the other giving details, such as, position of wheels marks etc. In the form, one line should be used to represent both rails of track and such portion of the station yard (in case of accidents within station limits) should be covered as may be necessary. All necessary details relevant to the issue must be embodied in the sketch. The terminal station on the down side should be mentioned on the right extremity of the sketch, the terminal station on the upside being mentioned on the left extremity. If the accidents takes place within station limits the shorter sketch should be based on the station working diagram.

13. Details of track structure should be shown in the sketch.

14. Details of damage to bridges involved, spanwise should be shown.

15. In the case of accidents to and near level crossings, full details of the level crossings should be furnished.

16. Any other details as may be considered necessary to reconstruct the scene of the accident would also be shown.

PERMANENT WAY

	SOIL	
SR. No.	Type - e.g. Sandy, loam clay, moorum, black cotton, etc.	Condition-firm wet slushy, etc.
1.	2.	3.

BALLAST					
Type stone moorum sand etc.	Depth below sleeper bottom in cm. stating whether cleaned or choked	Width of shoulder in cm from outside of			
		Rail		Sleeper	
		L	R	L	R
4	5	6.	7.	8.	9.

SLEEPER			
Type - Wooden CST9 Steel trough etc.	Condition-new/second-hand/damaged /unserviceable etc.	Density	Square or not
10.	11	12.	13.

RAILS			
Weight	Condition of wear	Rail fastening like dog spikes keys, tie bars, cotters, loose jaws, etc. ---------- No. per sleeper seat	condition tight or loose
14.	15.	16.	17.

Rail Joints		
Condition- Hogged, battered, low etc.	General remarks about cracks or fractures of fish plates fish bolts and other components	Description of anti-sabotage measures like reversed jaws welded rails, etc.
18.	19.	20.

Location of point of mount		**Location of point of derailment**	
Whether on straight, curves or transition	Whether on a falling grade, level or rising grade and on sag	Whether on straight, curves or transition	Whether on a falling grade, level or rising grade and on sag
21.	22.	23.	24.

Note :

1. Left and right are with respect of direction of train movement .

2. The data in column 2 to 19 need not be collected when the defect is obviously and indisputably on account of major obstruction on track.

3. Only broken track material which is not indisputably established to be broken after the accident should be included in column 19 and should be preserved.

4. Column 20 need be filled in only when there is suspicion about sabotage being the cause of derailment.

5. Sag extents 90 meters on either side of theoretical junction of the grade lines (column 21 to 22).

6. Entry in column 16 and 17 must invariably be filled for wooden sleeper in case of derailment on curves indicating further whether bearing plates were provided.

Track Measurements				
Station No.	Distance apart in metres.	Gauge in mm	Cross Level in mm	
			Under no load condition	under load condition
1.	2.	3.	4.	5.

Track Measurements			
Marks on sleepers or rail top	Grinding or rubbing marks on rails	Versines	Remarks regarding length of transition degree of curve and specified super-elevation, general alignment, etc.
6.	7.	8.	9.

Note:

1. Point of mount should be marked as station no. '0'. The stations ahead of site of derailment be marked serially as '+n' and in rear as '-n' for measurement.

2. The cross level will be measured on the left rail only as determined from the direction of movement.

3. Normally measurements will be take at stations three metres apart for a distance of 45 metres on either side of 0 station. They may be taken for column 3,4 & 5 may in addition be a taken individual sleepers for a length of 9 metres in the rear of 0 station. They may be taken for a distance of 90 metres in rear where the cause of derailment is not obvious.

4. This proforma need not be filled when the cause of derailment is obviously established as due to major obstruction on track, broken axle and or spring having fallen off prior to point of derailment

.

5. The measurement of versines should preferably done on 62 feet chord for curves up to 10 degree sharpness and on chords of 31 feet on curves 10degree and sharper. The versines should be recorded in both cases at 15.5 feet intervals. The value of versine should be recorded against the nearest adjacent cross level recording station.

6. Additional data regarding vertical track profile of one of the rails should be taken if the point of derailment /mount is within 200 meters of the theoretical change of grade point and the change of grades is 0.5% or more . These levels should be taken 20 meters apart and should extend for at least 200 meters in rear of the point of derailment. They may be taken as early as possible after the site of accident has been cleared.

Carriage & Wagon

SR. No .	Vehicle No.	Type ---------- Traffic Mech.		Tares in tonnes	Carrying capacity in tonnes	Building Date	Return Date	PRR/O Particulars ---------- Date Stn.	
1.	2.	3	4	5	6	7	8	9	10

Pay load in tonnes From actual labels	From Weigh.	**Commodity loaded**	Station _____ from to		**Rigid wheel base in mm**	**Whether Braked or pipe**	Position from engine	Wheel & Axle Thickness of flange in mm	Wheel Gauge dia. in mm	
11	12	13	14	15	16	17	18	19	20	21

Wheel & Axle			Axle Box (For IRS stock only)				
Any indica -tion of bent axle	Observation after measuring the profile with tyre defect gauge	Any mark of obstruction on tyre	Brass thick -ness in mm	Condi -tion of box and brass	condi -tion of sole plate	condi -tion of journal	clearance between brass and collar of journal in mm
22	23	24	25	26	27	28	29

AXLE GUARD (For IRS Stock only)				Spring and spring gear		
clearance between axle box groove and axle guard in mm	whether axle guard can work clear of axle box groove	Are the axle guard bent or otherwise damaged to prevent free movement of axle box	Remark regar -ding bridle bar	Free camber of spring in mm	Camber of spring under load in mm after rerailing on a level uncanted track	Thickness of packing plate under spring seat in mm
30	31	32	33	34	35	36

Spring and spring gear					Bogie		
Remarks on condition of spring plates and buckles	Clea-rance between shackle plate and pin	Remarks on condition of shackle plates and pins	Whether Any Spring Eye Touches Sole Bar	Buffer Height (To be taken after uncoupling & rerailing in mm	Type	Rigid wheel base in mm	Vertical Clear-ance at side bearers in mm
37	38	39	40	41	42	43	44

Bogie				
Remarks regarding free movement of bolster and pivot and their condition	Bolster spring camber under load in mm	Details of broken parts giving locations w.r.t. point of mount and derailment	Whether load is placed on more than one wagon	Any other defect in vehicles which may have contributed to or caused the derailment.
45	46	47	48	49

Note:

1. Details regarding all derailed vehicle should be given except :

   i. Where vehicle have derailed due to locomotive derailment.

   ii. The first derailed vehicle is obvious from examination of marks on tyres, where details for first derailed vehicle need only be given.

   iii. When obvious and indisputable cause is sabotage or an obstruction on track.

2. Front and rear and left (L) and right (R) are with respect to the direction of the movement.

3. For an obvious cause of derailment such as a broken axle, spring dropping on run, or some part of under gear hanging loose and causing obstruction. Only relevant particulars need be filled.

4. For an obvious cause of derailment such as a broken axle, spring dropping on the run, and/or some part of under gear hanging loose and causing obstruction, only relevant particulars need be filled.

5. The spring characteristics should also be got checked with a load deflection testing machine in addition to filling information under items, (46), (47), (48) and (49) of the proforma.

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TOOLS WHICH MUST BE AVAILABLE IN ACCIDENT RELIEF TRAIN FOR TAKING ABOVE MEASUREMENTS

For Track measurements :

1) Gauge-cum-Level
2) Stepped-Feeler-gauge set
3) Fish chord or nylon wire 10 meter
4) Steel scale 30 cm.
5) Straight edge 1.5 meter
6) Measuring tape - 20 Meter length

For Rolling Stock measurements :

1) Tyre Defect Gauge
2) Outside Calliper - 6”
3) Inside Calliper - 6”
4) Feeler Gauge set
5) Wheel Gauge set sliding type (spring loaded) with spirit level
6) Measuring tape 20 meter
7) MICO gauge
8) Template
9) Nylon wire - 20 meter

Other essential items :

1) Good quality photographic camera

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APPENDIX 'B'

Standard Dimensions of Permanent Way

SR No.	Description	BG	MG
1.	Gauge	1676	1000
2.	Slopes of formation		
	1. for embankment	2:1	2:1
	2. for cutting	1:1	1;1
3.	Centre to centre distance of track		
	1. minimum	4265	3660
	2. recommended	4725	3960
4.	Length of rail	13000	12000
5.	Clearance of check rails at level crossing		
	1. minimum	51	51
	2. maximum	57	57
6.	Clearance of Check Rail on the curves	44	41
7.	Distance between the centre of track and the face of platform		
	1. Max.	1680	1345
	2. Min.	1670	1335

SR No.	Description	BG	MG
8.	Height of passenger platform above rail level		
	1. Max.	840	405
	2. Min.	760	305
9.	Standard length of tongue Rail		
	1 in 8½ straight	4725	4116
	1 in 12	6400	5485
	1 in 12 Curve	7730	6700
	1 in 16 curve	9750	7420
10.	Check Rail clearance at turnout		
	1. Min	44	41
	2. Max	48	44
11.	Throw off switch		
	1. Max	115	100
	2. Min	95	89
12.	Min Thickness of Blunt nose	6	6
13.	Size of ballast of track		50
50			
14.	Top width of Ballast	3353	2286

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APPENDIX 'C'

Calculation of Gauge slackness which may cause derailments

Gauge	= 1676 mm
Wheel Gauge	= 1600 mm
Difference	= 1676-1600 = 76 mm
Thickness of flange	= 28.5 mm
Thickness of both flange	= 28.5 * 2 = 57 mm
Play between rail and flange	= 76-57 = 19 mm
Condemning flange limit	= 16 mm
Wear permissible for both flanges	= (28.5-16)*2= 25 mm
Slack permitted up to 4 degree curve	= 13 mm
Total permissible play between flanges & running edges of rail	= 19+25+13 = 57 mm
Width of tyre	= 127 mm
Slackness required to derail a stock	=127-57= **70 mm**

The above calculations are normally advanced to prove that the slackness in gauge to the tune of 70 mm can not be a cause of derailment. However this logic applies only in case of wheel dropping purely on account of slack gauge. In actual practice, even lesser than 70 mm gauge slackness may cause increased lateral oscillations and build-up of excessive flange forces thereby resulting in derailment of stock.

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APPENDIX 'D'

Extract from INDIAN RAILWAYS PERMANENT WAY MANUAL (1986) CHAPTER VII

ACTION DURING ACCIDENTS INCLUDING BREACHES AND PRE-MONSOON PRECAUTIONARY MEASURES

704. Action at Site- *(1) By Permanent Way and other Engineering Inspectors - (a) Protect Train*.- Any engineering staff available at the site of accident shall assist the Guard and Driver to protect the train in accordance with General Rules 6.03 and 9.10 (1976). The Inspector should ensure that protection has been afforded to the train in front and in the rear, in accordance with the rules. In the case of double line, if the other line is also affected by the accident, steps shall be taken to protect both the lines. If no infringement exists, trains must be controlled and passed cautiously on the unaffected track.

(b) *First Aid and Rescue*.- The Inspector should arrange for first aid to injured passengers and Railway staff and rescue of trapped persons. If there is any Medical Practitioner on the train, his assistance should be obtained.

(c) *Advice to nearest Station Master*.- After a rapid survey of the position, particulars should be sent to the nearest

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Station Master as in Para 702 above. In case of controlled sections, a field telephone should be got commissioned at once.

(d) *Line Clear examination*.-If the engineering official has reached the site and no traffic official is available, he should carefully secure the line clear token or ticket and any caution order, where necessary. If the accident has occurred in a station yard, the train register book must be seized and if necessary, statement of staff concerned recorded; if line badges are in use, it should be recorded as to in whose possession each line badge was. The position of block instruments, signals, points, point levers, indicators, key etc. should be noted and recorded, jointly with the Inspectors of the other concerned departments, available at site.

(e) *Preliminary clearing operation and preservation of clues*.- (i) In all instances in which the means taken for the restoration of communication are likely to obliterate marks on the road and other evidence needed at a joint enquiry, the senior official who arrives first on the spot should carefully examine the track, train or vehicle and as soon as possible make notes, sketches, etc. and hand over the same to his superior or produce them at the enquiry. He will, when the nature of the accident is such as will involve the question of eye-sight of any of the staff, verify (in case of those permitted to wear glasses) that they had worn glasses at the time of the accident and had carried a spare pair of glasses with them.

(ii) In all cases of accidents, the cause of which might possibly due to sabotage, it is essential that the clearance and restoration operation are not commenced till the Police officials

arrive at the site and intimate their agreement to the commencement of clearance and restoration work, after making thorough investigations.

A factual note of the conditions obtaining at the site prior to restoration work should be prepared and signed jointly by the senior most of the Police and Railway officials, such difference of opinion may be recorded on the joint factual note.

This should not, however, be allowed to interfere with rendering of first aid to the injured, which is the first essential in all accidents.

(iii) In other cases, clearance and restoration operations can commence well before the arrival of the Police and it is not necessary that all the rails, sleepers and fastenings involved in an accident should be preserved, but only those, whether serviceable or otherwise, which wear wheel marks, etc., specially between the points of mount and drop. In all cases of serious derailments, these are essential for a later reconstruction of the scene and should bee preserved and/or recorded by the first responsible officials to reach the site of the accident, as these would be valuable evidence to ascertain the cause of the accident.

(iv) After the injured persons have been attended to and arrangements made for the onward journey of the standard passengers, the Railway officers at the site of the accident should arrange to record the preliminary statements of the staff concerned, as any delay in doing so, might result in some facts being suppressed or some evidence being fabricated during

subsequent enquiries.

(v) In case sabotage is suspected, the procedure as outlined in clause (ii) above should be followed. In addition it should be ascertained promptly from the C.R.S. if he would like to inspect the site, etc. before the commencement of clearance and restoration work and then action should be taken in accordance with his wishes. Before clearance and restoration operations are commenced, all relevant clues, materials and damages and the deficiencies on Rolling Stock, etc. must be noted and preserved. In other serious accidents, however, the same procedure as outlined in Clause (iii) above should be strictly followed.

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707. Examination of site and preparation of sketches. The first Engineering representative to arrive at site shall attend to the following :-

(1) He should examine the entire site inclusive of track over which the train has passed immediately before derailing, noting down any unusual features observed, especially any parts of vehicles or other material lying on or near the track.

(2) A dimensioned sketch should be prepared covering the entire site of accident, showing all relevant features inclusive of track leading upto point of derailment, showing position of derailed vehicle, point of mount and drop and other relevant details. All the details given in Annexure 7/1 should be incorporated in the sketch.

(3) He should record the particulars as detailed in para 708 (1).

(4) An examination of the derailed vehicle/vehicles for defects not caused by the derailment but which may have been the cause of the derailment should be made. He should make out notes for inclusion in the joint report.

(5) He should examine the gang-chart/diary books to ascertain the date when track was last attended.

(6) Details of Engineering works in progress, if any, at the site of accident, caution orders in force and nature of protection should be noted.

****

708. Recording particulars at site of accident. - (1) *Permanent Way particulars*.- Permanent way particulars shall be recorded jointly with the Inspectors of the other concerned departments as per Annexure 7/2. These records will inter alia include particulars of the track structures, the condition of the track components, track geometry and other relevant details.

(2) *Particulars with respect to Rolling Stock and Signalling*.- Engineering representative should associate himself with the concerned representative of the other departments in recording measurements of-

(a) The locomotive and tender;

(b) Carriages and Wagons; and

(c) Signalling and telecommunication equipment.

(3) *Operating particulars*.- The following operating particulars should also be recorded wherever relevant :-

(a) *Speed*.- The actual speed at the time of derailment, from the speedometer graph or if the locomotive is not provided with the speedometer graph, by referring to inter-station timings.

(b) The direction of the locomotive i.e., shorthood or longhood leading.

(c) The brake power of the train.

(d) The marshalling of the train with reference to orders applicable on the section.

(e) Whether there has been sudden application of brakes.

(f) whether there was sudden opening of regulators.

(g) Condition of loading in wagons, specially unequal loading, light loading, empties between loaded vehicles, over-loading, moving loads and any infringement to standard dimensions.

(h) Particulars of Caution Orders issued to the Driver/ Guard.

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APPENDIX 'E'

Excerpts from "FRENCH RAILWAY TECHNIQUES" Special number no. 1/1978

The guiding of a Railway vehicle, be it a power vehicle or a trailer, owes nothing to the flanges which are no more than block stops for exceptional situation :

- abnormal running surface wear
- cant excess or deficiency or
- negotiations of switch and crossing work

Normally it is ensured by the action of the VISCO elastic contact forces between the conical surfaces of the wheels, both solidly attached to the same axle, and the cylindrical surfaces of the rails.

2. If the cone angle is insufficient, the restoring forces towards the centre disappear and the moving wheelset bears permanently against one of the flanges, which is not designed for that.

3. If the angle is excessive, the restoring force if excessive, of short wave length, say 20 M or less.

4. With a concity, which according to calculation and experience should be about 1/40 or 0.025, the hunting

wavelenghth is about 30 M, and the restoring force is sufficiently moderate to be easily controlled by the suspension.

5. Under these conditions, the contact between rail and wheel, far from sweeping the full clearance of from 18 to 20 mm between the wheel set and track, is confined to some 8 mm.

6. Within that width, the movement is in no way random but is determined by the track parameters, gauge, levelling, inclination of the wheels and the shape of the running surfaces; as between one day and another, a given TGV wheel set make contact with the rail in accordance with practically identical trajectories(rolling lines).

7. The oscillatory graph movements of the logic about its vertical axis are in harmony with its hunting movements and their angular amplitude does not excess 2.5 M. radius or about 10 minutes of arc.

8. All other things being equal, a definite limit is set to that ideal situation by the critical speed.

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GLOSSARY

Ballast

The material used as elastic cushion between sleepers and the top of formation is called ballast.

Cant or Superelevation

On curves, outer rail of the track is raised higher than the inner rail. This difference of level is called Super-elevation or cant

Cant deficiency

The difference between the cant necessary for the maximum permissible speed on a curve and actual cant provided.

Cross level

The relative difference in vertical levels measured at the top of the left and right rails at a given point on the track.

Creep

The longitudinal movement of rails in the track is called Creep.

Deep flange

When depth of the flange becomes more than 35 mm.

Flange force

Force generated by wheel flange during movement of wheel on the track.

Formation

Flat surface of earthwork on embankments or on cuttings for laying railway track is called Formation.

Gauge

The distance between two running edges of the rails.

Gradient

Amount of slope in longitudinal direction in a railway track is called gradient or grade.

Hollow tyre

Tyre hollowness exceeding 5 mm.

Point & Crossing

Assembly of components which enables the trains to move from one track to other is called **Point & Crossing.**

Running edge of the rail

The rail edge on which wheel flange contacts the rail.

Sharp flange

Flange worn out in such a way that radius at the tip of flange reduces below 5mm.

Stock rail

Rail of the main line track against which tongue rails fit .

Switch

Stock rail and its respective tongue rail form a switch.

Tongue rail

The tapered rails whose thicker end is known as **Heel** are fixed to the main track and the thinner end, known as **Toe** of the switch.

Thin flange

Flange thickness below 16mm.

Throw of switch

The distance through which the tongue rail moves at the toe of switch is called throw of switch. Its value on Indian railway is 114mm.

Twist

The rate of change of variation in cross level per meter.

Transition of curve

It is an easement of curve in which change of degree is uniform.

Wheel base

The distance between the two adjacent axles of a bogie is called wheel base.

Wheel gauge

The distance between the inner surface of flanges of left and right wheel mounted on an axle.

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