Introduction to wheel & Axle Wheel Defect

PROCESS OF MANUFACTURING OF STEEL:

The wheel shall be manufactured from steel made by electric or basic oxygen process. The steel shall be of killed quality for forged wheel.

The hydrogen content of the liquid steel shall not exceed 3 ppm as per standard procedure. If it exceeds, the proper anti-flaking treatment shall be carried out to maintain the hydrogen content of the liquid steel be within 3 ppm.

Nitrogen content in the steel shall not exceed 0.007 %

Chemical composition –Forged wheel:

The procedure to calculate chemical composition will be in accordance to IS: 228

The chemical composition of the steel for forged wheel

C - 0.52% max

Mn - 0.60 to 0.80%

Si - 0.15 to 0.40%

P - 0.03% max

S - 0.03% max

Cr - 0.25% max

Ni - 0.25% max

Mo - 0.06% max

Cu - 0.28% max

V - 0.05% max

Combined % for Cr, Ni & Mo must be 0.50% max

Chemical composition –Cast wheel:

The procedure to calculate chemical composition will be in accordance to IS: 228

The chemical composition of the steel for cast wheel

C	- 0.47% to 0.57% for type A used for carriage stock
	0.57% to 0.67% for type B used for wagon stock
Mn	- 0.60 to 0.80%
P	- 0.03% max
S	- 0.03% max
Cr	- 0.15% max
Ni	- 0.25% max
Mo	- 0.06% max

Combined % for Cr, Ni & Mo must be 0.40% max

HEAT TREATMENT OF WHEEL:

Wheel shall undergo any one of the following heat treatment processes:

For forged Wheel

Rim quenching and tempering: It is designated by symbol 'R'. In this process, the wheel is heated for a sufficient time to bring it to uniformly to a temperature exceeding the transformation temperature of the steel by about 25^0C, then hardening the rim with a jet of water under pressure followed by tempering at 500^0C. The wheel is left to cool in still air.

The microstructure shall be fine Pearlitic structure with ASTM grain size 6 to 8

HEAT TREATMENT OF WHEEL contd…

Entire wheel quenching and tempering: It is designated by symbol ‘Q’. In this process, the wheel is heated for sufficient time to bring it uniformly to a temperature exceeding the transformation temperature of the steel by about of 25^0C then quenching by immersion in suitable liquid followed by tempering at 500^0C. The wheel is left to cool in still air

The microstructure shall be fine tempered martensitic structure with ASTM grain size 6 to 8

HEAT TREATMENT OF WHEEL contd…

For cast Wheel

Only Rim quenching is recommended followed by tempering.

Cast wheel should undergo shot-penning operation after heat treatment as per IS: 7001. The shot size will be S-M 1400(SAE-500) to IS: 9139

ELIMINATION OF IMBALANCE:

Elimination of imbalance shall be obtained by eccentric machining of the fillet between the web and the rim on the flange side. The thickness of the metal removed shall not exceed 4 mm and the resultant surface shall be carefully blended into the adjacent material. In no case shall it be permitted to add additional mass. Drilling of holes for correction of imbalance is prohibited.

Limits for maximum residual imbalance of the finished wheel will be as follows;

For stock running at a speed $\geq$200 kmph	:50 gm-m max
For stock running at a speed $\geq$ 120 kmph and $<$200 kmph	:75 gm-m max
For stock running at a speed $<$ 120 kmph	: 125 gm-m

BRANDING

Particulars in accordance to RDSO drawing number Sk-92114 shall be marked on the outer face of the rim of each wheel either by hot/cold stamped or by electric etching of at least 10 mm size letter. If stamped, it must not have sharp edges. The particulars will be as follows:

1. Maker's code in three digits
2. Year of manufacture in two digits
3. Individual serial number in five digits
4. Contract number in short form
5. 'IR' for Railway initial
6. Drawing number
7. Letter 'R' or 'Q' to indicate rim quenching or entire wheel quenching for forged wheel/

   'A' or 'B' for cast wheel to indicate coach or wagon wheel
8. Inspector's approval stamp
9. 'UT' for ultrasonic testing

BRANDING Contd…

Position of residual imbalance shall be indicated by a paint mark consisting of radial strip of 15 mm wide. The values of imbalance shall be indicated below the end of the strip according to following code:

E1 : for residual imbalance of ≤ 50 gm-m

E2 : for residual imbalance of ≤75 gm-m

E3 : for residual imbalance of ≤125 gm-m

QUALITY CHECKS AND TESTS

QUALITY CHECKS AND TESTS:

Chemical analysis

At least 50 gm of millings samples representing the average chemical composition of a radial section of the wheel shall be taken from one of the wheel

or

One sample tensile test piece in case of spectrographic analysis

QUALITY CHECKS AND TESTS *Contd…*

Verification of residual stress

- This test is required to be done for rim quenched wheels only

Rim tensile test

- One test piece shall be taken from the center portion of the wheel tread width wise at 15 mm below tread surface.

Web tensile test

- One test piece shall be taken from the center portion of the wheel tread width wise at 15 mm below tread surface.
- Another test piece shall be taken from the middle portion of the web.

Impact test – Macroscopic examination

- The polished surface of the test piece shall be examined with a magnification not more than 5

Impact test – Metallographic examination

- The impact test shall be carried out in accordance with IS: 1499

QUALITY CHECKS AND TESTS *Contd…*

Hardness survey of rim

The test piece shall consist of a small plate comprising the complete radial section of the rim and its joint with the web. One of its faces shall be prepared in accordance with IS:1500. the hardness indentation three each at a distance of 5 mm and 35 mm from the tread and one at a point that shall be situated on the three lines. The hardness values obtained should be within 241 to 277 BHN

QUALITY CHECKS AND TESTS *Contd…*

Rim hardness

Each wheel to be tested shall be subjected to a Brinell hardness test on the plane face of the rim on the side opposite to the flange. The position selected for the indentation shall be on a circumference with a radius approximately 25 mm less than that of a running circle. The difference between extreme hardness values within a batch shall not exceed 30 BHN.

QUALITY CHECKS AND TESTS *Contd…*

Ultrasonic flaw detection

Appearance and dimension

Balancing

MECHANICAL PROPERTIES

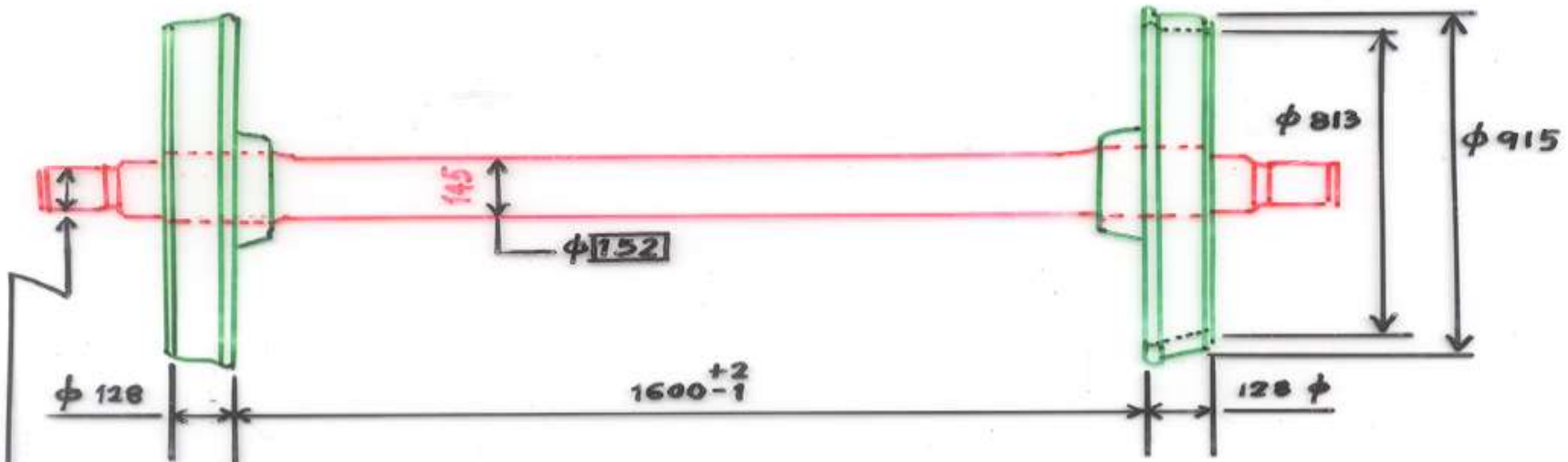
MECHANICAL PROPERTIES OF FORGED WHEEL

1.	Tensile strength	820 – 940 N/m^2
2.	Minimum yield strength	50% of UTS
3.	Minimum elongation	14%
4.	Hardness	230 – 265 BHN
5.	Minimum impact strength	15 J/cm^2 at 20^0C

MECHANICAL PROPERTIES OF CAST WHEEL

Sl	Particulars	Type A	Type B
1	Tensile strength at 15 mm below tread face	900 N/m^2 minimum	930 N/m^2 minimum
2	Tensile strength at middle of the web	800 N/m^2 minimum	800N/m^2 minimum
3	Minimum yield strength at 15 mm below tread face	50% of UTS	50% of UTS
4	Minimum yield strength at middle of the web	50% of UTS	50% of UTS
5	Minimum elongation at 15 mm below tread face	5.0%	4.5%
6	Minimum elongation at middle	7.0%	7.0%
7	Hardness range at 15 mm below tread face	255-320 BHN	271-341 BHN
8	Minimum impact strength at 15 mm below tread face	10 J/cm^2 at 20^0C	--

ASSEMBLY OF WHEEL DISC WITH AXLE



Wheel & axle complete

Permissible Variations

Wheel diameters

~~Thread circumference~~ on same axle - 0·5 mm

Dia between wheels on same bogie - 5·0 mm

" " " on same coach - 13·0 mm

WHEEL & AXLE ASSEMBLY

- Wheel seat and bore must be coated with mixture of basic carbonate white lead and boiled linseed oil. The proportion should be of 1.2 kg of white lead paste to 1 litre of boiled linseed oil thoroughly mixed.
- The pressure shall begin to rise before the movement of the wheel center on the seat has reached 20 mm.
- The pressing-on-pressure shall increase steadily and continuously in relation to the movement.
- The final pressing-on-pressure shall not be less than the value of the minimum pressing-on-pressure nor exceed the maximum pressing-on-pressure

Contd…

WHEEL & AXLE ASSEMBLY Contd…

The pressing-on-pressure in Kg per mm diameter of axle at wheel seat for BG stock be within 400 to 600. The maximum pressing-on-pressure may be exceeded by 10% if a satisfactory back pressure test is carried out. The wheel sets should not undergo back pressure test earlier than 48 hours after pressing on. During back pressure test, the wheel must not displace when 1.2 times the minimum pressing-on-pressure is applied on wheel.

A reduction of pressing-on-pressure upto 5 tonnes is permitted in the last 25 mm movement

Contd…

WHEEL & AXLE ASSEMBLY Contd…

In case of wheel having been tested for out-of-balance and the extent of position of their residual-out-of balance being known, fitting of the wheels on the axle be so arranged that the residual-out-of-balance of each of the two wheels of the same set lies in the same diametrical plane and on the same side of the central line of the axle.

The residual-out-of-balance of the brake discs must lie in the same diametrical plane as the out-of-balance of the wheels and be opposite in relation to the centerline of the axle.

Each pair of wheels and axle shall be mounted on rigid centers to check the axial and radial run out of each wheel with the help of dial gauge

Contd…

WHEEL & AXLE ASSEMBLY Contd…

Axial off center (run out) of the inner face of the rim of each wheel for wagon stock be within 1.0 mm and for coaching stock be within 0.8 mm.

- Radial off center (Run out) of the wheel tread at the taping line for wagon stock be within 0.5 mm and for coaching stock be within 0.25 mm.

- The journals shall be protected with three coats of ready mixed paint, brushing bituminous black to IS: 9862 or with any other approved anti-rust compound capable of being removed easily by white spirit or kerosene oil.

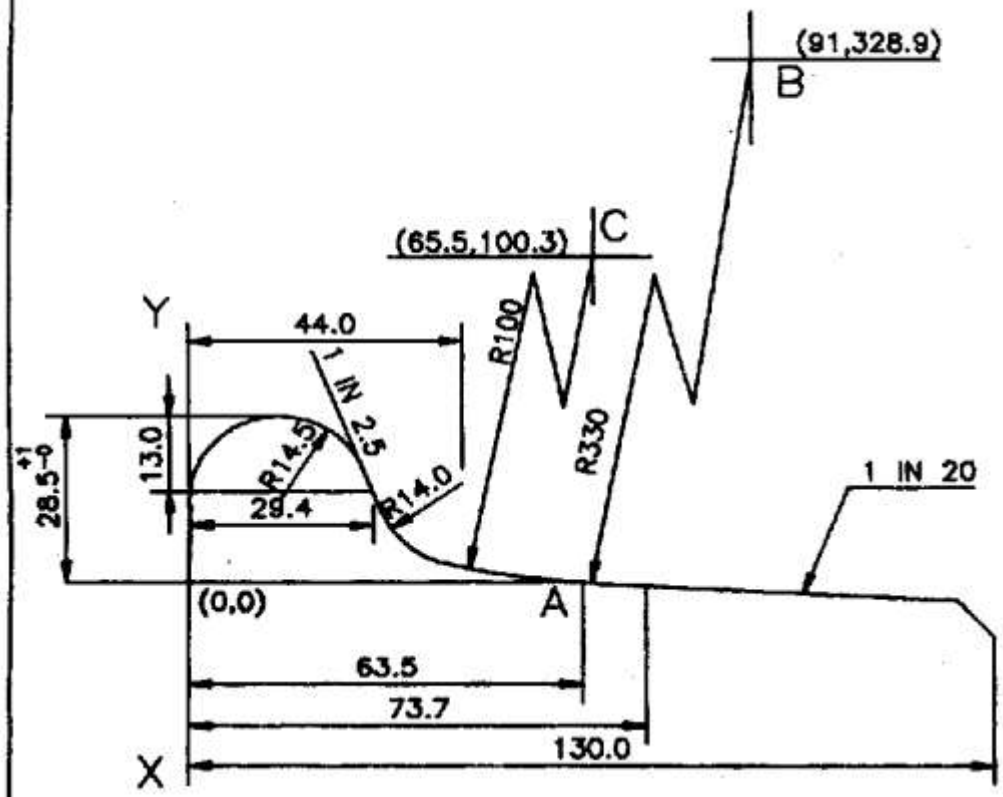
- The axle body shall be painted with a coat of zinc chromate to IS: 2074 followed by a second coat of Black Japan to IS: 341, allowing sufficient drying time between coats.

Contd…

WHEEL & AXLE ASSEMBLY Contd…

Axle ends and the journals shall be covered with minimum 5-mm thick well fitted one piece high density polyethylene to IS: 7238-74 designated as HDPE-44-MB cover and shall be secured of three PVC screws suit to the axle end holes

WHEEL TREAD PROFILE



PROCEDURE OF DRAWING:–

1. DRAW A VERTICAL LINE X–Y.
2. DRAW SEMI–CIRCLE OF 14.5R, TANGENTIAL TO LINE X–Y.
3. DRAW LINE 1:2.5 TANGENTIALLY TO 14.5R SEMI–CIRCLE.
4. DRAW A HORIZONTAL LINE AT 28.5mm FROM THE TOP OF THE FLANGE. AND LOCATE Pt. 'A' AT 63.5mm FROM THE LINE X–Y.
5. FROM Pt. A LOCATE CENTRE 'B' OF ARC OF 330R ON A VERTICAL LINE AT 91mm FROM X–Y.
6. DRAW ARC OF 330R FROM CENTRE 'B'
7. LOCATE CENTRE 'C' ON VERTICAL LINE AT A HORIZONTAL DISTANCE OF 65.5mm FROM THE LINE X–Y SUCH THAT BC= (330–100) ie 230mm.
8. DRAW ARC OF 100R WITH CENTRE AS 'C'.
9. DRAW ARC OF RADIUS 14mm TANGENTIALLY TO 100R ARC AND LINE 1:2.5.
10. DRAW LINE 1:20 TANGENTIALLY TO 330R ARC.
11. DRAW A VERTICAL LINE AT A DISTANCE OF 130mm FROM THE FLANGE END.

P ,,

NOTE:–

CO–ORDINATES OF POINTS B & C ARE BASED ON NOMINAL DIMENSION OF 28.5mm.

ALT	AUTH.	DESCRIPTION	DATE
②	J.S. 20/3/94	REVISED & REDRAWN	3/94
①	J.S. 20/ /92	CO–ORDINATES OF ARCS SHOWN	3/92

SUPERSEDED BY:	
SUPERSEDES:	
SCALE	1:1
P	
C	
D	G.V.RAMAN
T	
J.S.	

WORN WHEEL PROFILE

B.G. | R.D.S.O. (C) | GROUP X(2) | SKETCH–91146

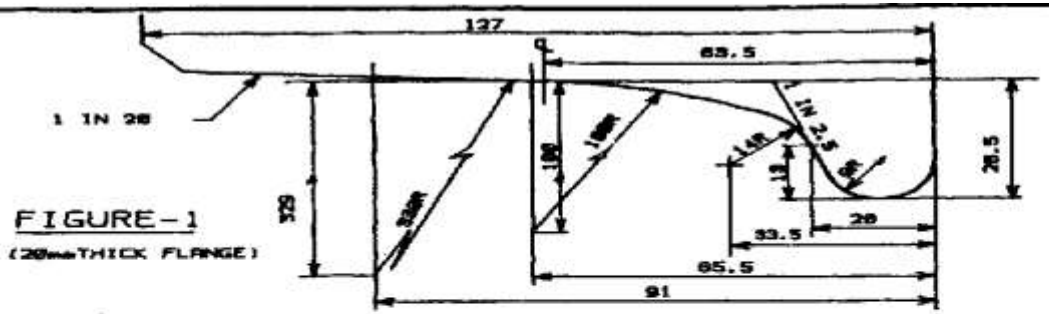


FIGURE-1

(20mm THICK FLANGE)

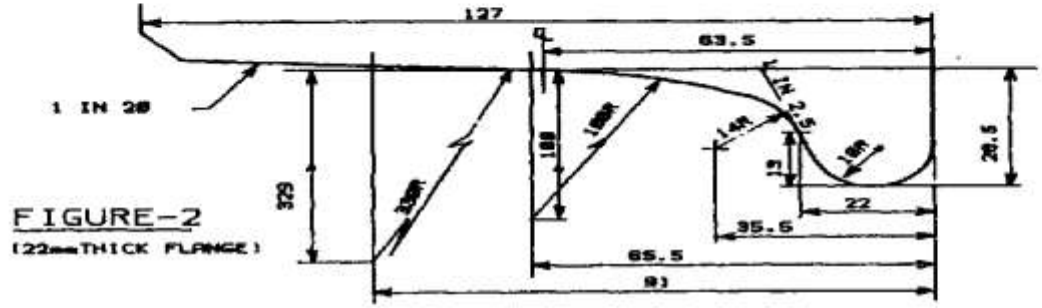


FIGURE-2

(22mm THICK FLANGE)

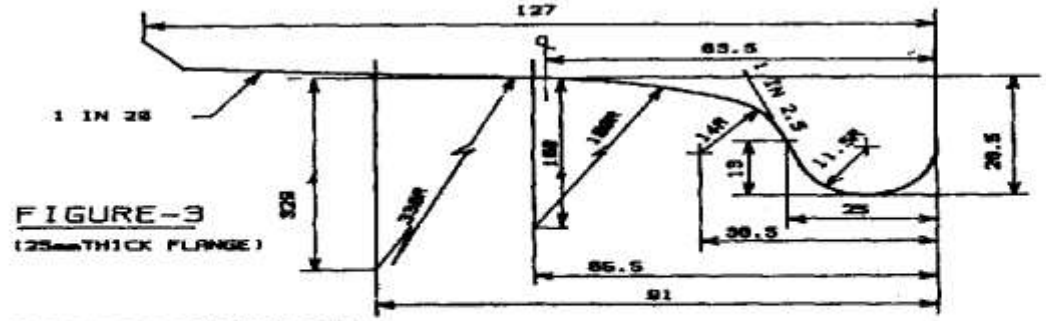


FIGURE-3

(25mm THICK FLANGE)

1. FIG.3 SHOULD BE THE LAST INTERMEDIATE WHEEL PROFILE FOR THE WHEELS MEANT FOR THE COACHES TO RUN AT MAX. PERMISSIBLE SPEEDS OF 110 kmph AND ABOVE.
2. ALL THE THREE INTERMEDIATE WORN WHEEL PROFILES (FIG.1,2 & 3) CAN BE USED FOR THE WHEELS FOR OTHER TYPES OF COACHES.

SUPERSEDED BY:-	INTERMEDIATE WORN WHEEL PROFILE FOR COACHING STOCK
SUPERSEDES:-	
SCALE 1:1	
B.G.	RDSO (C)
	SKETCH - 92082

WHEEL TREAD PROFILE DEFECTS

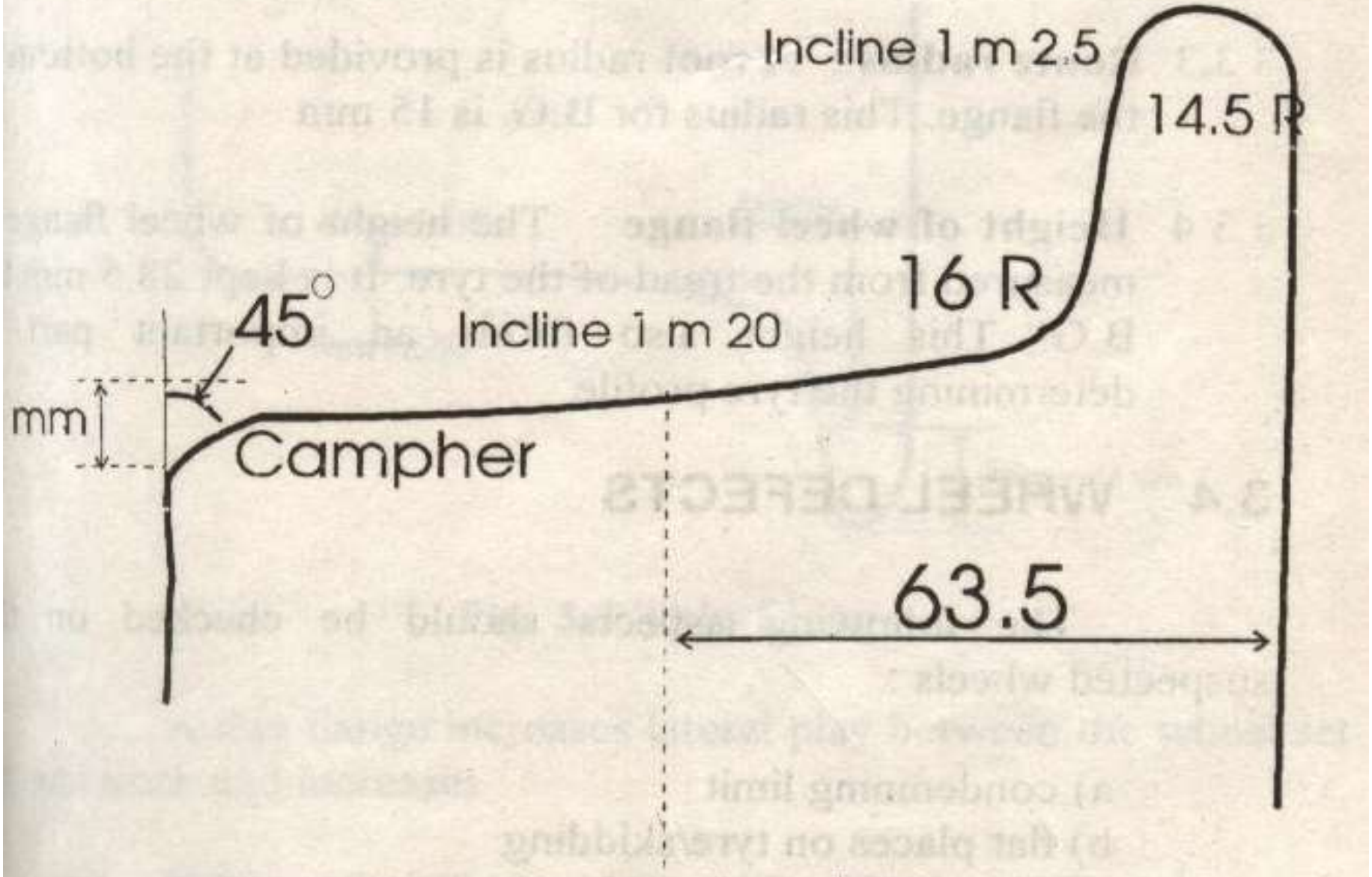


Fig. 3.2 Tyre Profile of a new Wheel

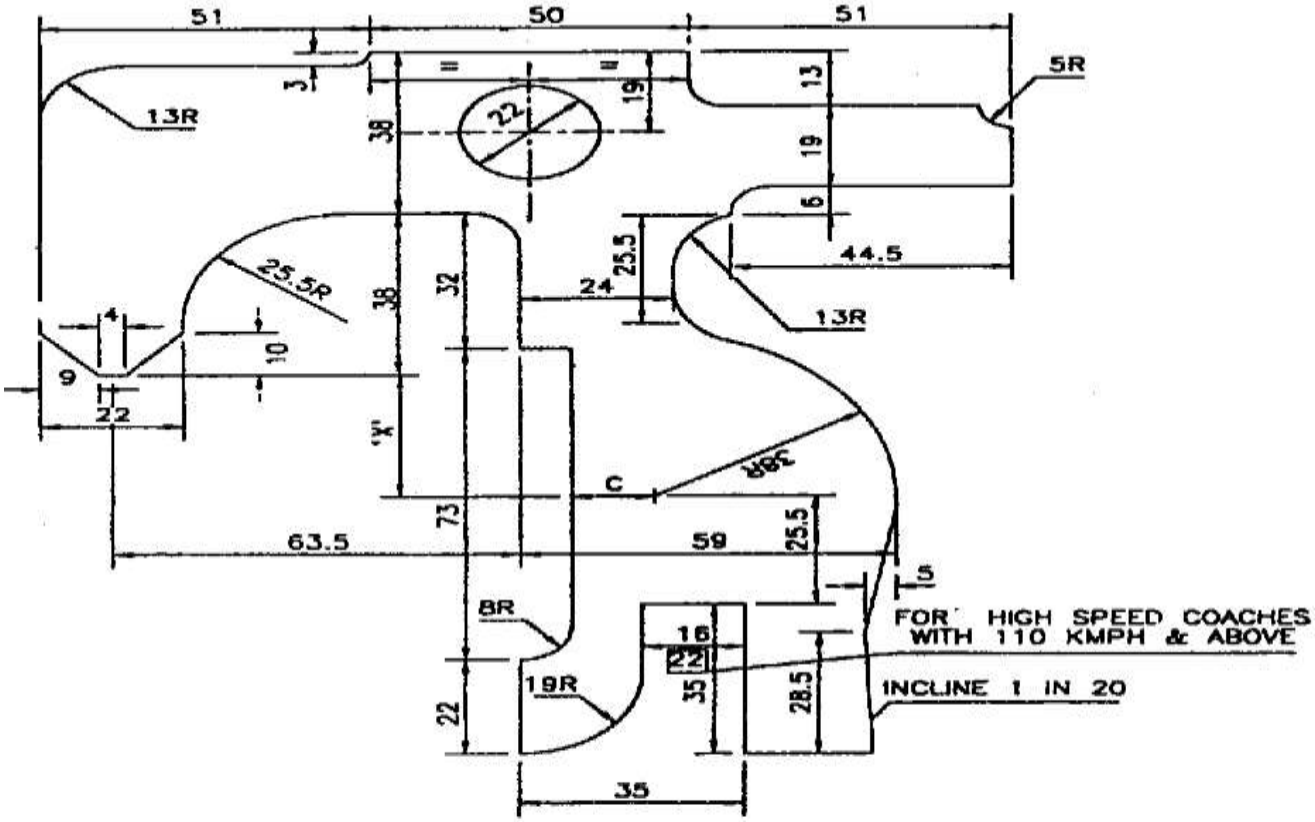
Dimensions of tyres when New

- Flange thickness – 28.5 mm
- Height at tread in center – 28.5 mm
- Top radius – 14.5 mm
- Radius at the root – 16 mm
- Flange Inclination / Taper – 1 in 2.5
- Tread inclination – 1 in 20

- **Note 1** – Taper 1 in 2.5 reduce to frictional resistance of side thrusts with rails and thus helps in reducing the amount of wear on rail and flange to the minimum possible.
- **Note 2** – Inclination/Taper of 1 in 20 given on the tread profile of wheels help in turning in curve of any degree.

Tyre Defects

- Loose tyre
- Radius at the root of flange too small
- Deep flange
- False flange or Hollow tyre
- Thin flange
- Sharp flange
- Flat places on tread



All coaches (Including EMU & DMU) 50 mm

NOTE:–

1. CONDEMNING MARK 'C' TO BE STAMPED ON BOTH SIDE OF GAUGE.
2. CONDEMNING MARKS FOR TYPE OF STOCK ON LINE ONLY NEEDS TO BE STAMPED.
3. DISTANCE 'X' AT WHICH CONDEMNING MARK 'C' FOR VARIOUS TYPE OF WHEELS TO BE STAMPED ARE AS BELOW:–

i) SOLID WHEEL OF ICF & BEML MAIN LINE COACHES	6.5 mm.
ii) SOLID WHEEL OF IRS MAIN LINE COACHES	5 mm.
iii) TYRED WHEEL OF IRS, ICF & BEML MAIN LINE COACHES	26 mm.
iv) TYRED WHEEL OF ac & dc EMU MOTOR COACHES.	38.5 mm.
v) TYRED WHEEL OF ac & dc EMU TRAILER COACHES.	28.5 mm.

Loose Tyre

- **How to check** - This is being done after the brakes have been fully released and by hammering on the tread of the tyres. The sound produced is then carefully heard and if the sound is felt to be dull the tyre is said to have gone loose.
- **Effect** – Loose tyre will work out of the rim and cause serious accident.

Radius at the root of flange too small

- The radius at the root of flange is **16 mm** when new.
- **Cause** – In service radius at the root of flange is subjected to maximum wear on curves and by snaking effect of the wheels in motion.

Root radius

- **How to check** – It is checked by the tyre defect gauge. When it is reduced to **13 mm** the gauge will fit in properly. If it has reduced further we will see light in between the gauge and the root of the flange through gap.

  This is called radius too small at the root of flange and such wheels should be rejected.

Worn Root

Root radius

- **Effect** – (1) This defect results into increased friction between the rails and the flange because of reduction in taper of 1 in 2.5 given on the wheel flange which affects hauling capacity of the locomotive besides wearing effects on the rails. (2) If it is allowed to reduce further, the flange can get broken/sheared off and cause accident due to flange forces & side thrusts .

Deep flange

- When new, The height of flange at tread in centre is 28.5 mm.
- **Cause** – While the wheel moves there is constant wear on the tread of tyres and thus the diameter of wheels at tread starts reducing due to the wear on the tread. But the top of face of wheel flange is not subjected to any corresponding wear, the flange height at tread goes on increasing.

- When this depth of tread or the height of flange fro tread increases from 28.5 to 35 mm. The tyre is called as **deep flange.**
- **How to Check** – The deep flange tyre fits in as illustrated in the sketch.
- **Effect** - (1) The deep flange becomes dangerous as it starts damaging fish plates, fish plate bolts, distance blocks, points and crossing etc.

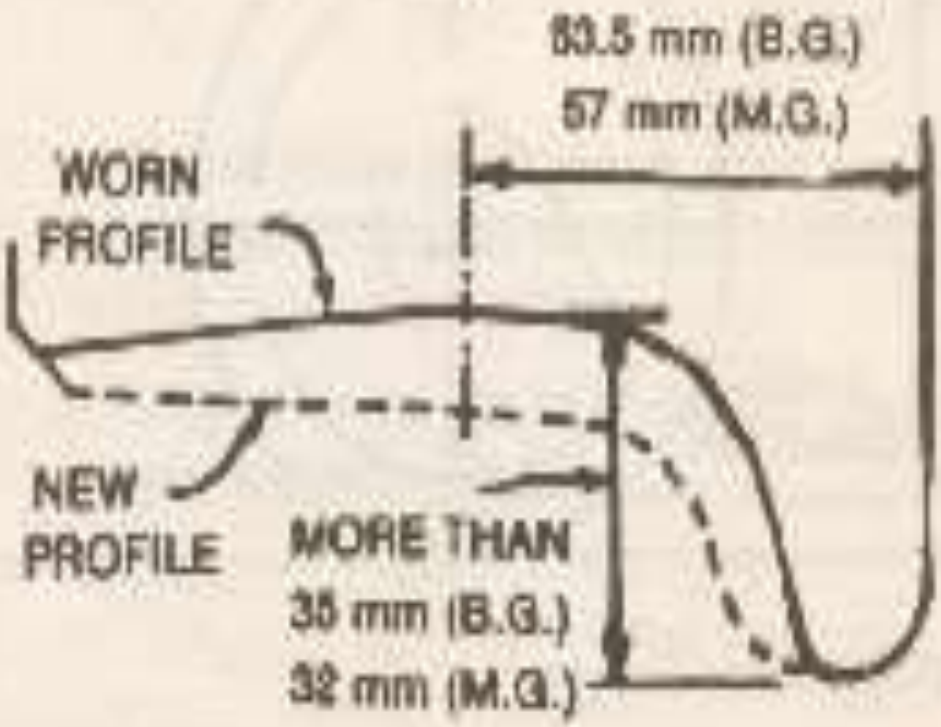


Fig 21.8 Deep Flange

Deep flange

- **Effect** – (2) The inclination of 1 in 2.5 & 1 in 20 practically vanishes which results in higher friction and there is every possibility of wheels to derail on curves for the two wheels on same axle can not be suitably converted with different diameters to suit longer outer & shorter inner rails, automatically.

False flange or Hollow Tyre

- **Cause** – False flange occurs when tread wears continuously when the wheels negotiate curves.
- **How to check** – It is shown in sketch. Rejection limit is that outer edge of the wheel tread below bottom line of the tread becomes **more than 5 mm.**

False flange

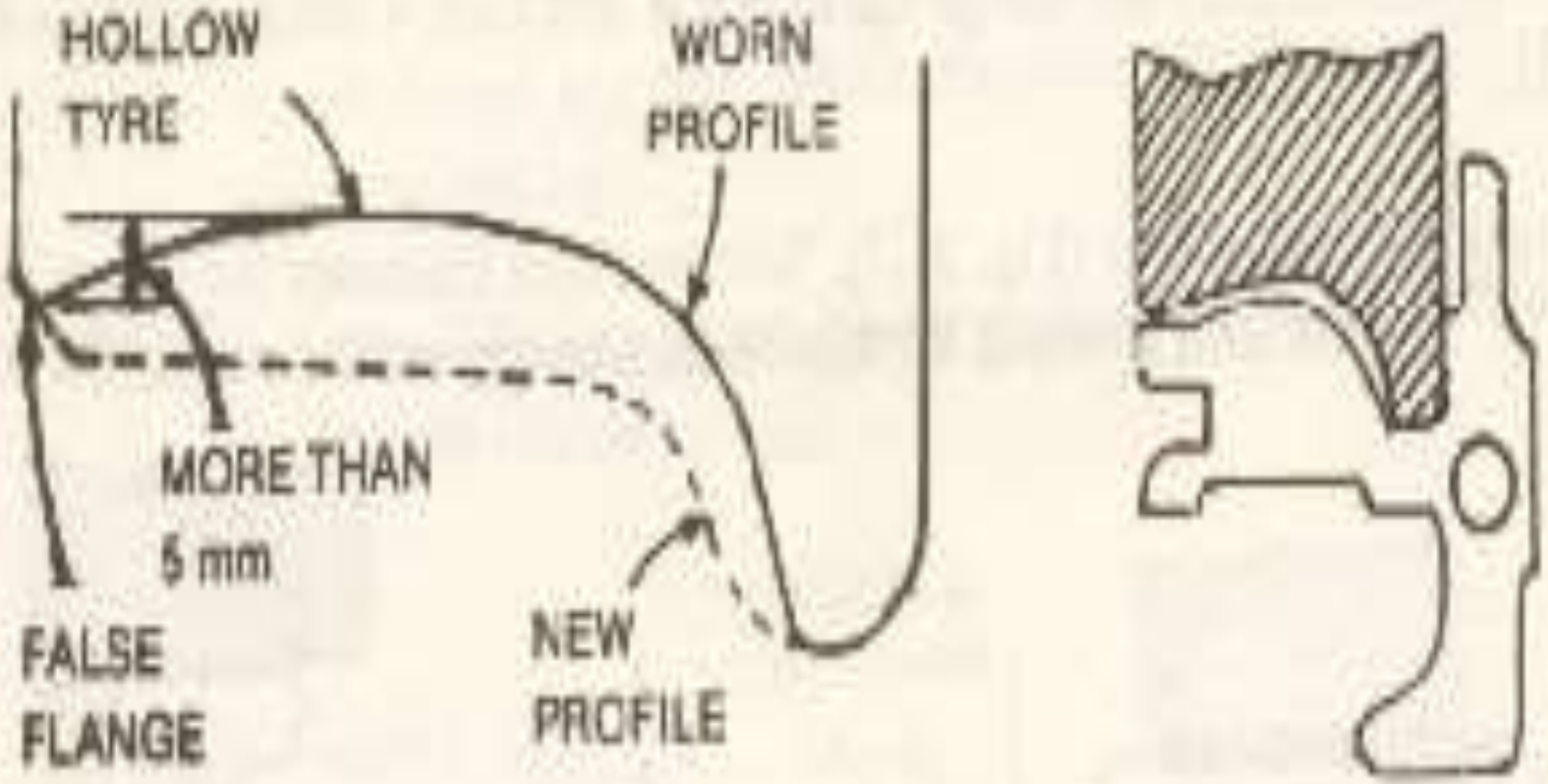


Fig 21.9 False Flange

Effect of False flange

- (1) This causes excessive hunting and oscillation and increases the flange force.
- (2) It may split open points while travelling in trailing direction.

Thin flange

- The thickness of flange is **28.5 mm** (new).
- **Cause** – (1) Flanges wear to the maximum due to the curves, side thrusts and snaking effect of the wheels.
- (2) If one wheel diameter is lesser than that of other on the same axle, the flanges of shorter dia. Wheel will wear more because this wheel will travel nearer the flange touching rail head to compensate the difference in dia in order to remain in central position. The flanges wear thin.

- **How to check** – When thickness of flange reduces from **28.5 to 16 mm (22 mm for high speed and Rajdhani)** the gauge fits in as shown in sketch and the flange is called as **thin flange.**
- **Effect** – **(1)** When they wear thin they become weaker and there are cases when thin flanges could not sustain the side thrusts and broke causing midsection accidents.

Thin flange

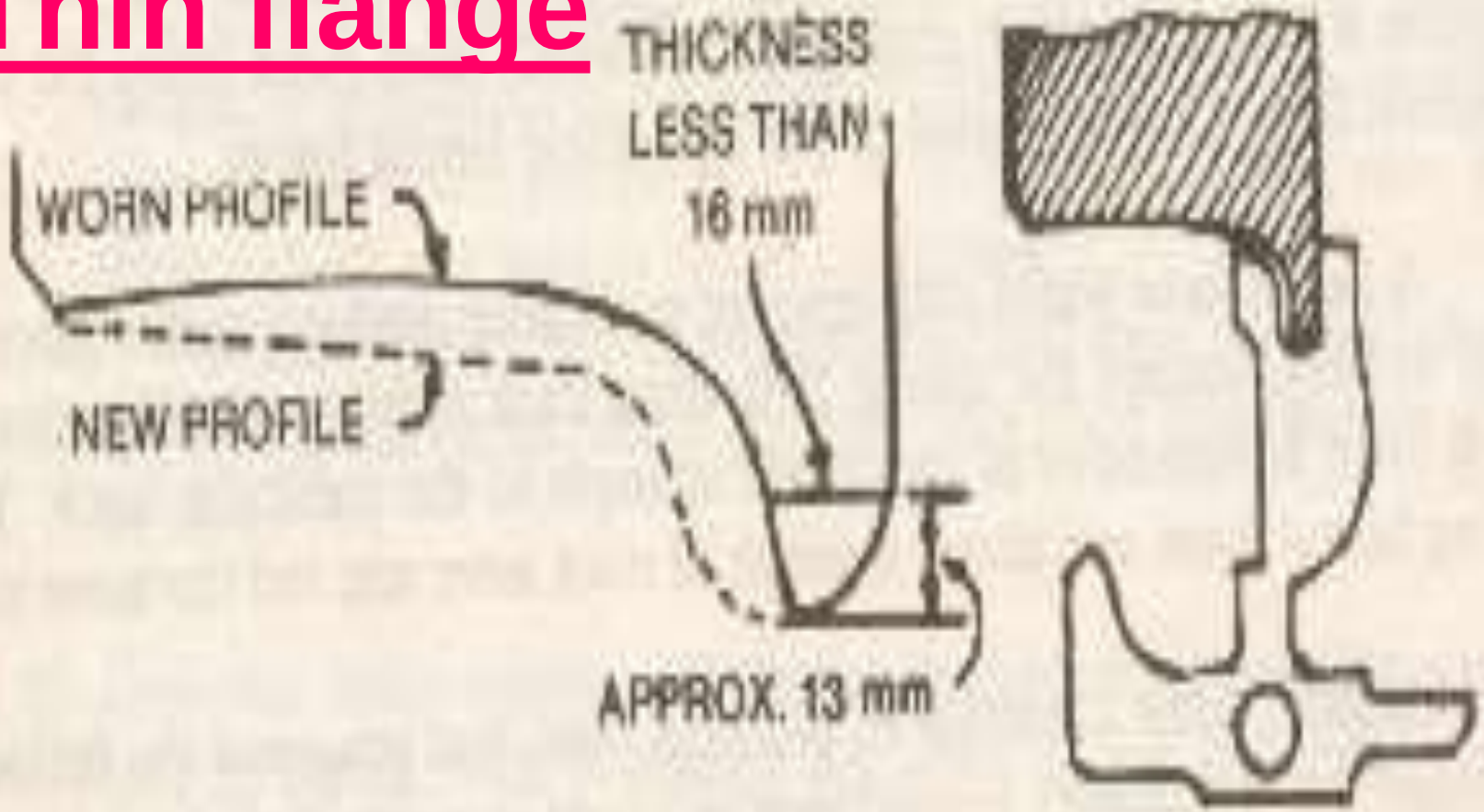


Fig 21.5 Thin Flange

Effect of thin flange

- (2) Thin flanges cut through the partly opened facing points due to any signal or permanent way or any other defect, causing two roads under the same vehicle or wagon and the serious accident follows there after.
- (3) Oscillations increase due to greater play resulting in instability of the vehicle.

Sharp flange

- The top flange is not square but has been given a radius of **14.5 mm.**
- **Cause** – (1) Flanges wear sharp when continuously the wheels negotiate curves and during snaking affect of wheels.

  (2) Also the biased wear on flanges causes sharp flanges, which can be attributed to difference in diameters of wheels on the same axle.

- **How to check** – When the top radius at the corner towards tread reduces to **5 mm**, the flange is called to be sharp flange and can be detected by feeling of hand or application of gauge as shown in sketch.
- **Effect** – (1) Sharp flange is highly dangerous as it mounts the rail at points and nose and heel of switch rails and crossings. (2) It also mounts the rail on curves and causes accident if happens to negotiate outer rails.

Sharp flange

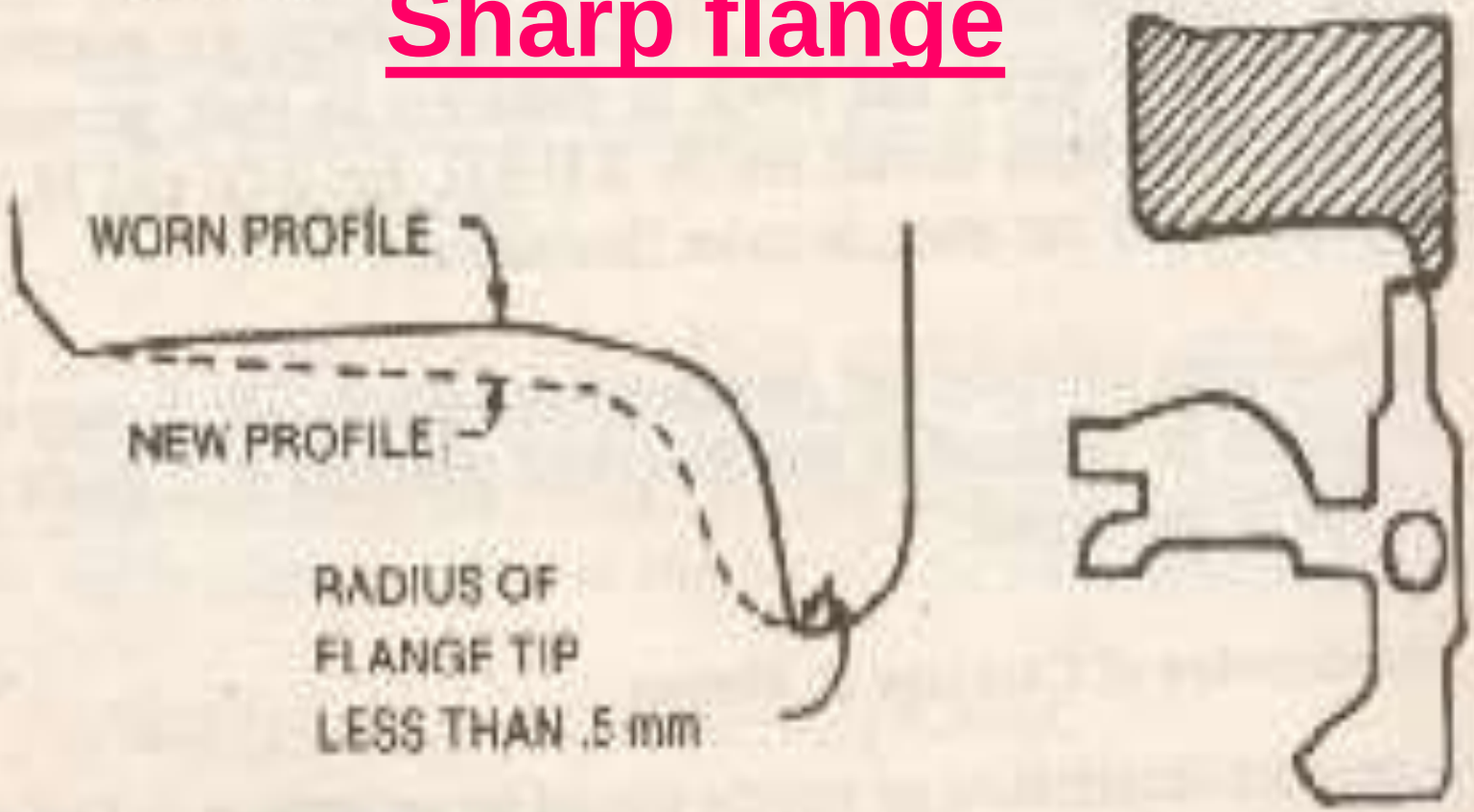


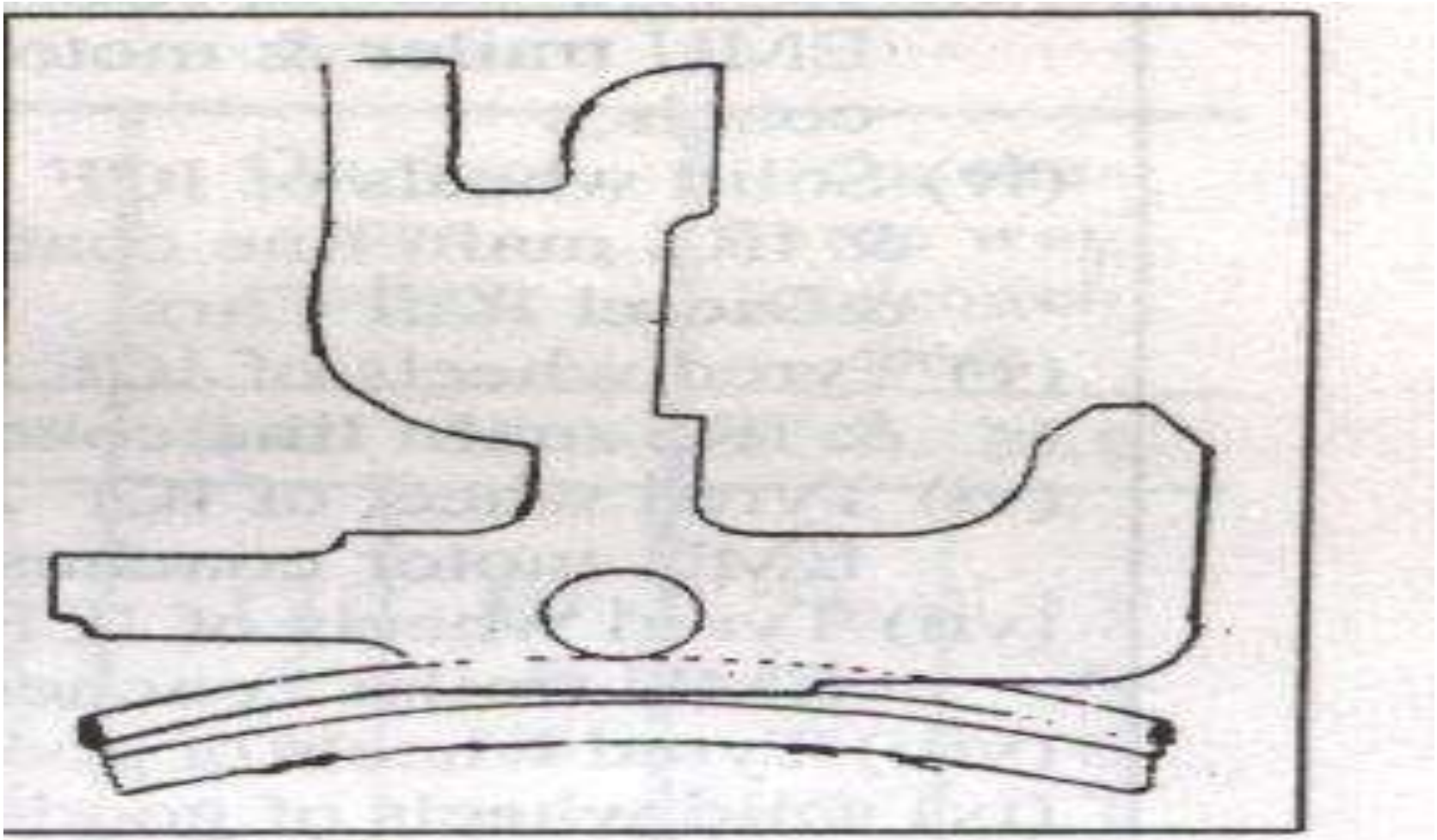
Fig 21.6 Sharp Flange

Flat places on tread

- **Cause** – Jamming of brakes, caused by missing hanger pins or entanglement of brake block with trolley and the wheel or the piston getting jammed in its top position cause skidding of wheels. The seizure of roller bearing also results in wheel skidding. When skidding occurs at a particular point of tread and continuous for some distance, the tread wears excessively at that point of contact with the rail and becomes flat to a certain length and depth. This is flat tyre.

- **Effect** - (1) This defect irks the passengers and adds to their discomfort.
- (2) This causes hot axles, journal breakage, derailments and skidding if allowed much, causes both sides false flanges on tread which is highly detrimental to safe running of trains.
- **How to check** - This should be checked with the application of Tyre defect gauge as shown in sketch.

Flat tyre



ig. 23 : Flat places on tyre tread

75 mm

Flat tyre

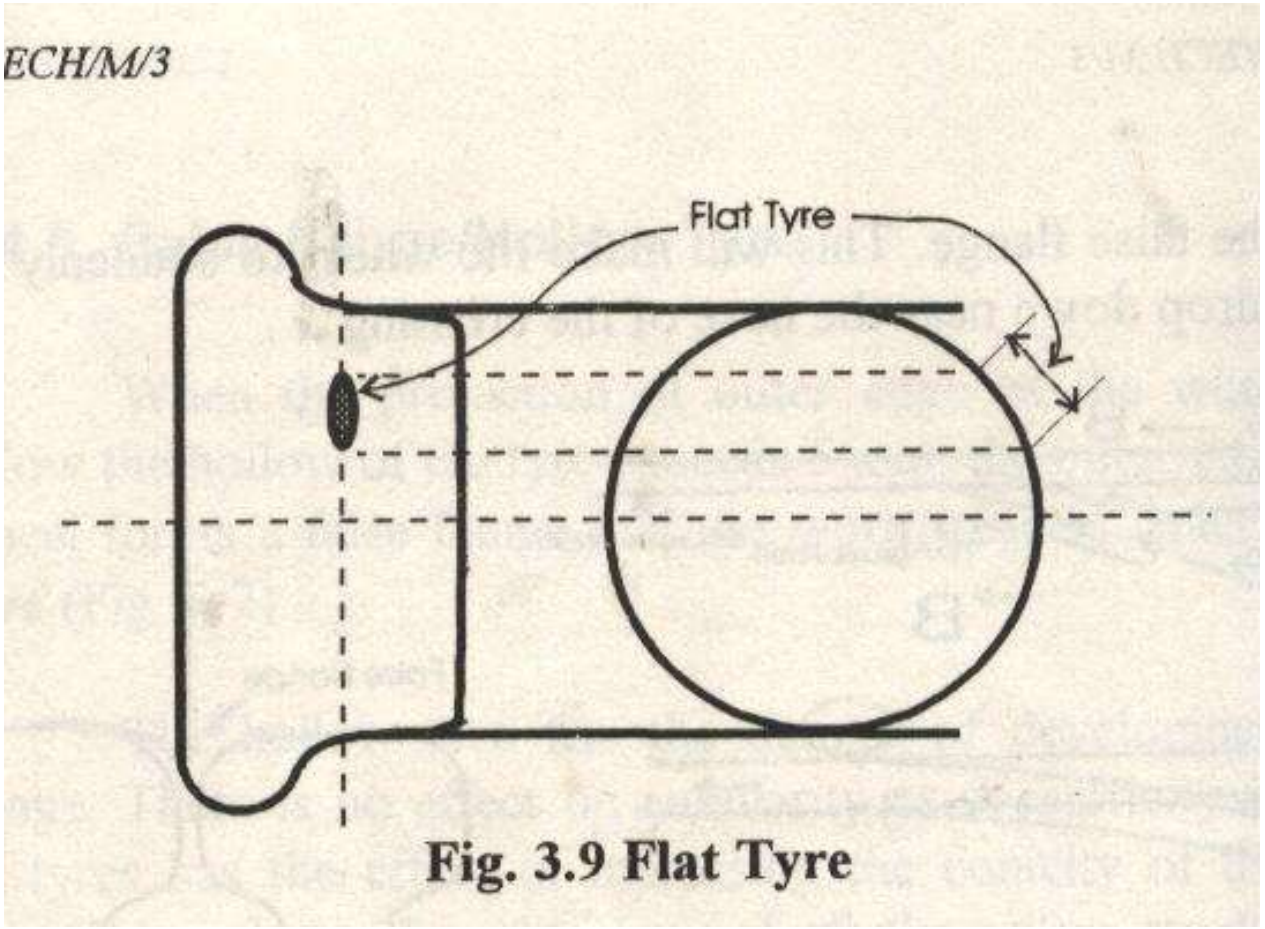


Fig. 3.9 Flat Tyre

Flat places on tread

- Max. permissible limits -

  ICF coaches - 50 mm

  Wagon - 60 mm

- No depth has been prescribed for flat places and can also not be checked easily.

Difference in wheel diameter On same axle

- **Measurement of dia.** – The wheel diameter is measured on the tread at a distance of 63.5 mm from the back of wheel.
- **How to check** – Two measurements across the quarters points should be taken for each wheel as shown in sketch.

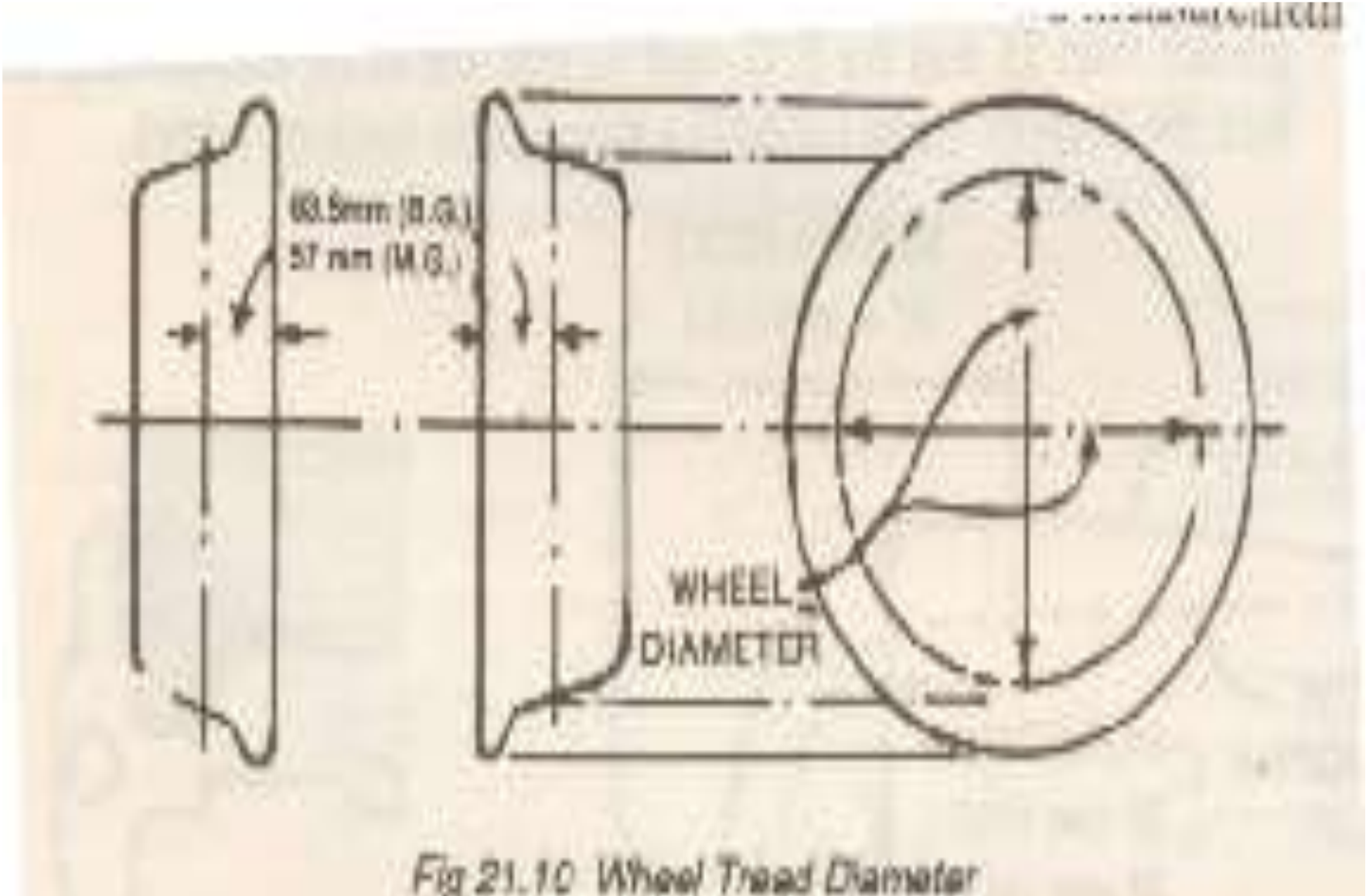


Fig 21.10 Wheel Tread Diameter

Wheel tread Diameter

- **Limitation** – The wheel diameter shall not differ in the same axle. A variation in tread diameter of more than 0.5 mm is not permissible.
- **Effect** – The variation of the wheel diameter on the same axle causes differential distance of travel by each wheel thus causing axle to take an angular position thereby increasing the potential hazard to derailment.

Irregular wheel gauge

- Wheel gauge is the distance between wheel flanges i.e. distance between back to back of the wheels on a wheel set.
- **How to check** – The wheel gauge should be checked at quarter points as shown in sketch.
- **Limitation** – No variation is permitted among values of wheel gauge measured at quarter points.

Wheel Gauge

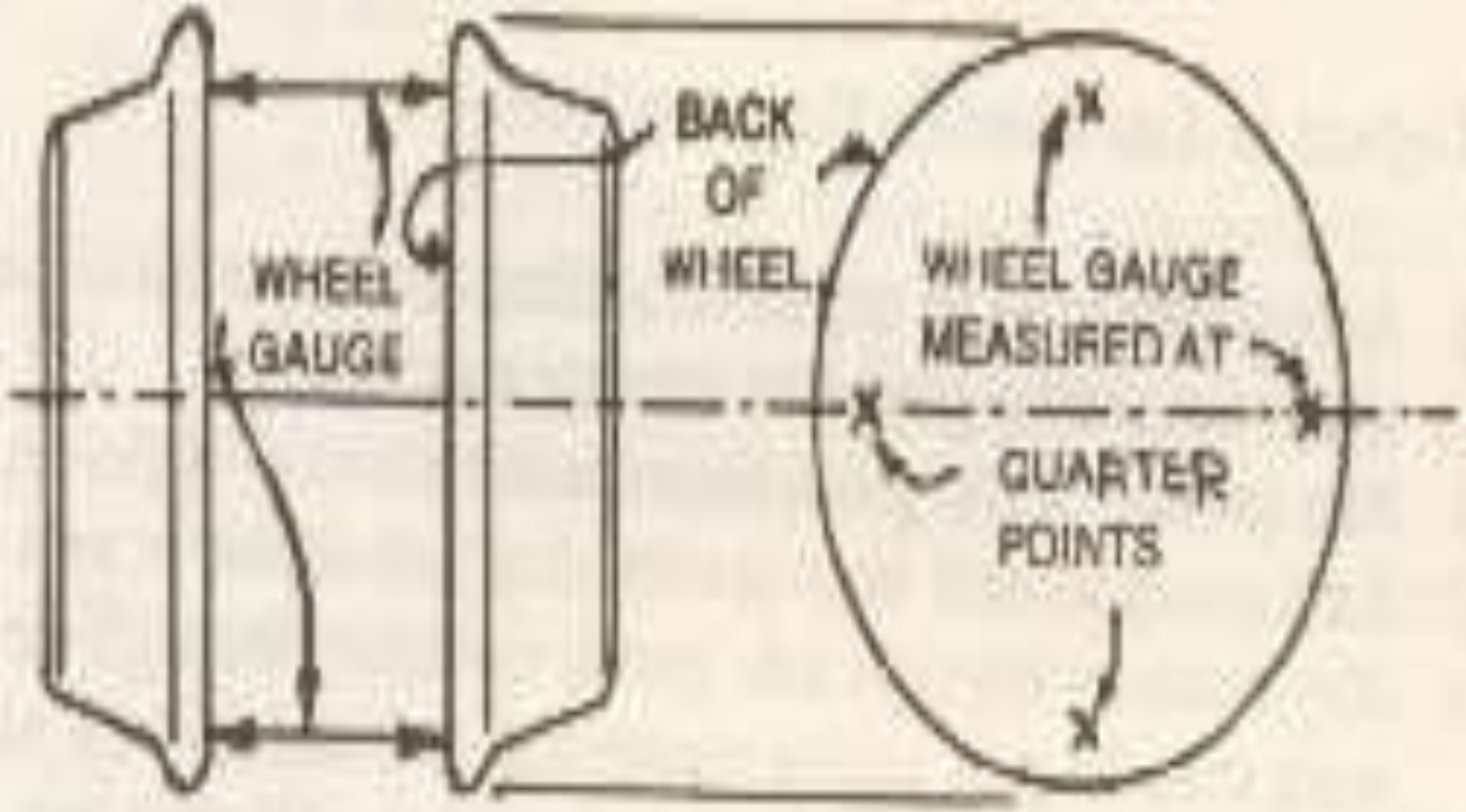


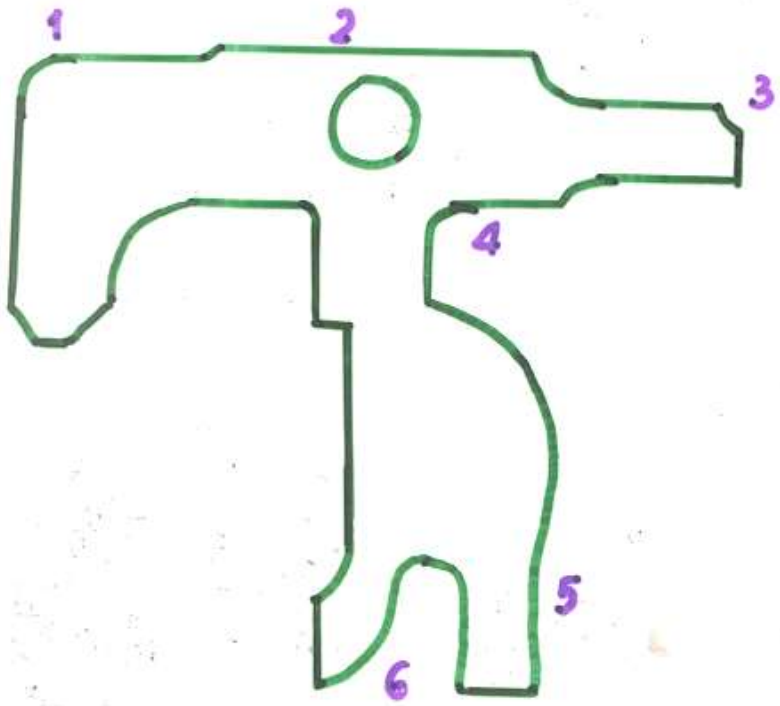
Fig 21.11 Wheel Gauge

- **Effect of irregular gauge** –

  A variation in the values will indicate a bent axle, which may result in instability. The excessive bend may cause fracture of the axle or may result in hot axle due to wobbling and may cause derailment.

- **Limitation** –

- Coach – 1598.5 to 1601.5 mm
  Wagon – 1599 to 1602 mm



1 WORN ROOT

2 FLAT TYRE

3 SHARP FLANGE

4 DEEP FLANGE

5 FALSE FLANGE

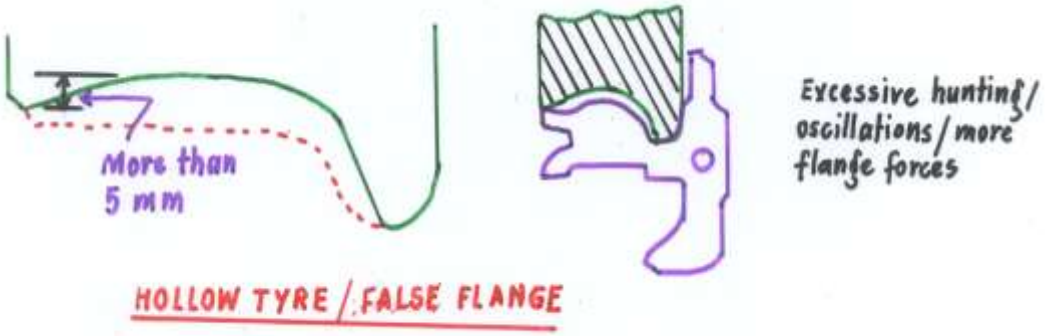
6 THIN FLANGE

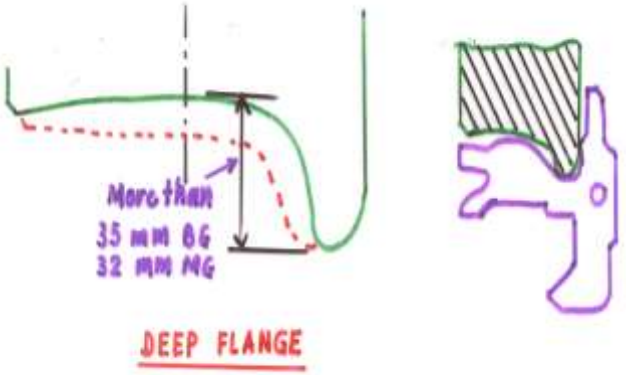
TYRE DEFECT GAUGE

Wheel deep flange or Hollow tyre

Constant wear on the tread of wheel with brake blocks.

Hard brake blocks and rails material

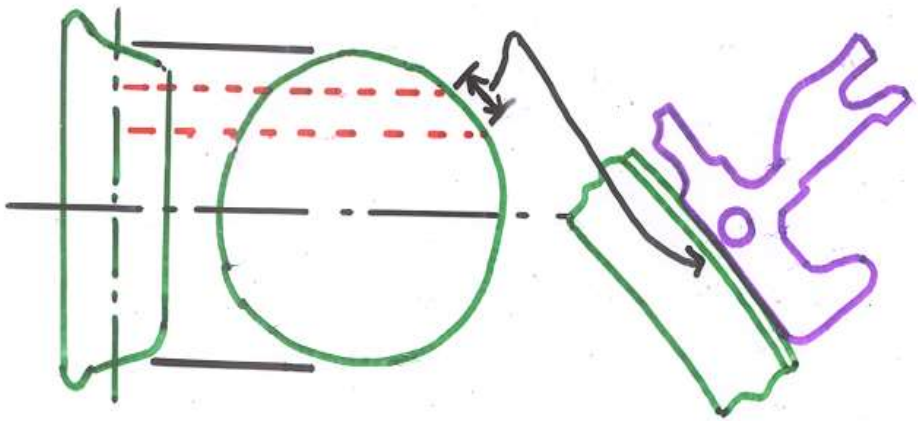




Wheel flat places on tread

Brake binding

Skidding of wheels



FLAT TYRE

Hammering action

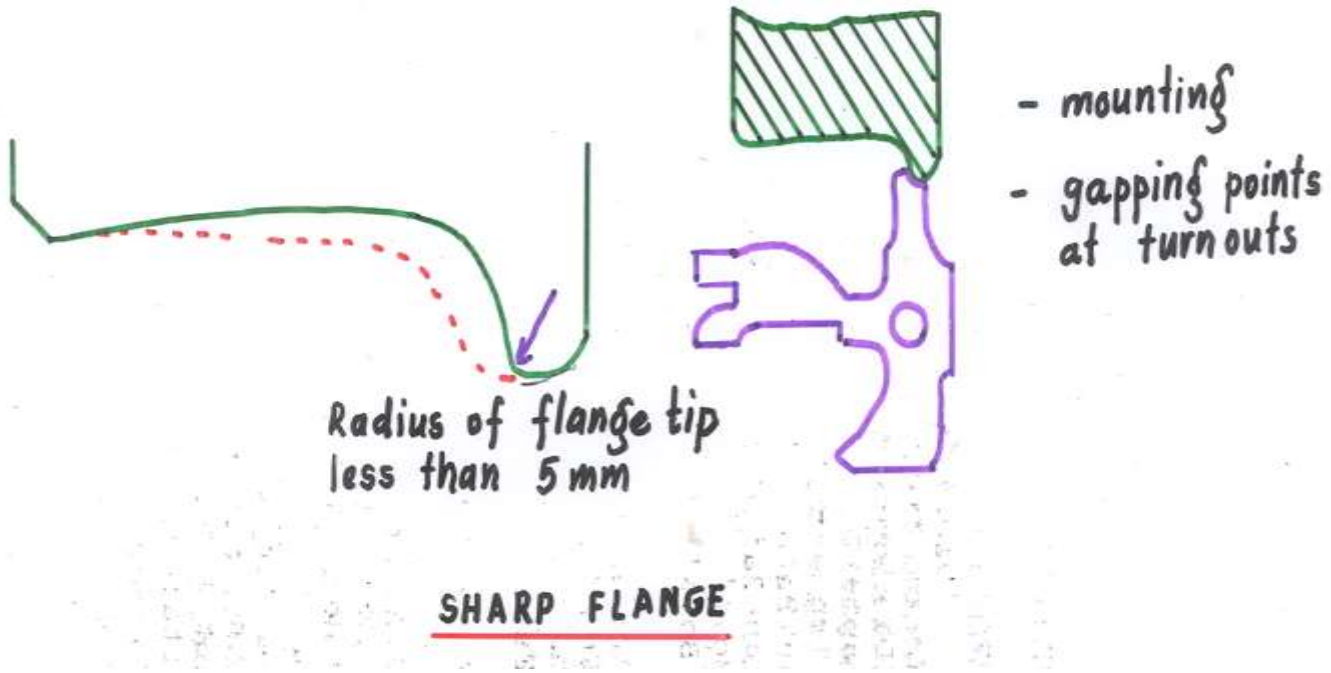
50 mm for ICF & BEML
60 mm for all BG wagons
50 mm for Diesel/Electric

Wheel sharp flange

Continuously negotiation on curves

Snaking effect of wheels

Biased wear on wheel flanges which can be attributed to difference in diameter of wheels on the same axle

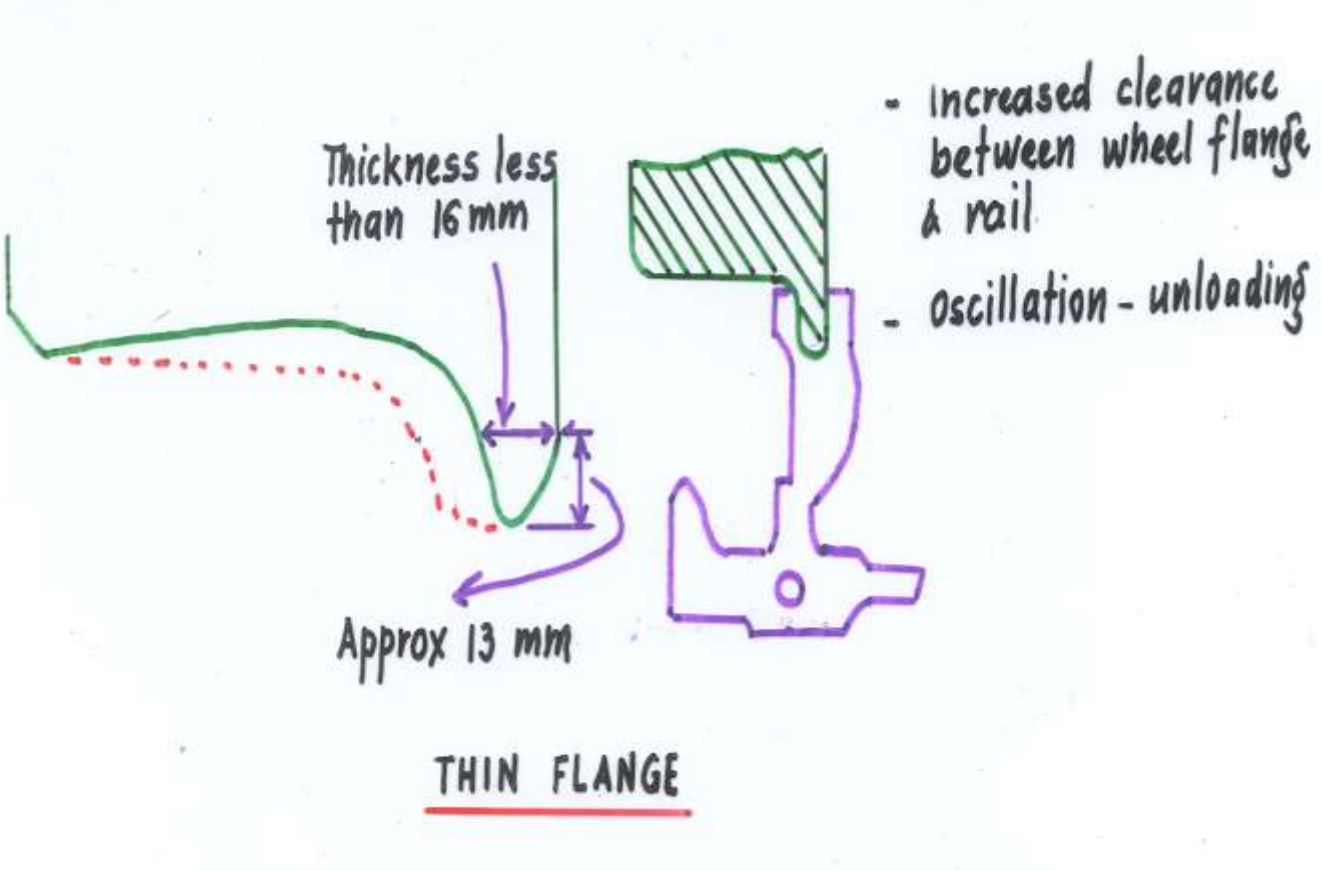


Wheel thin flange

Negotiation in the curves

Side thrusts on flanges

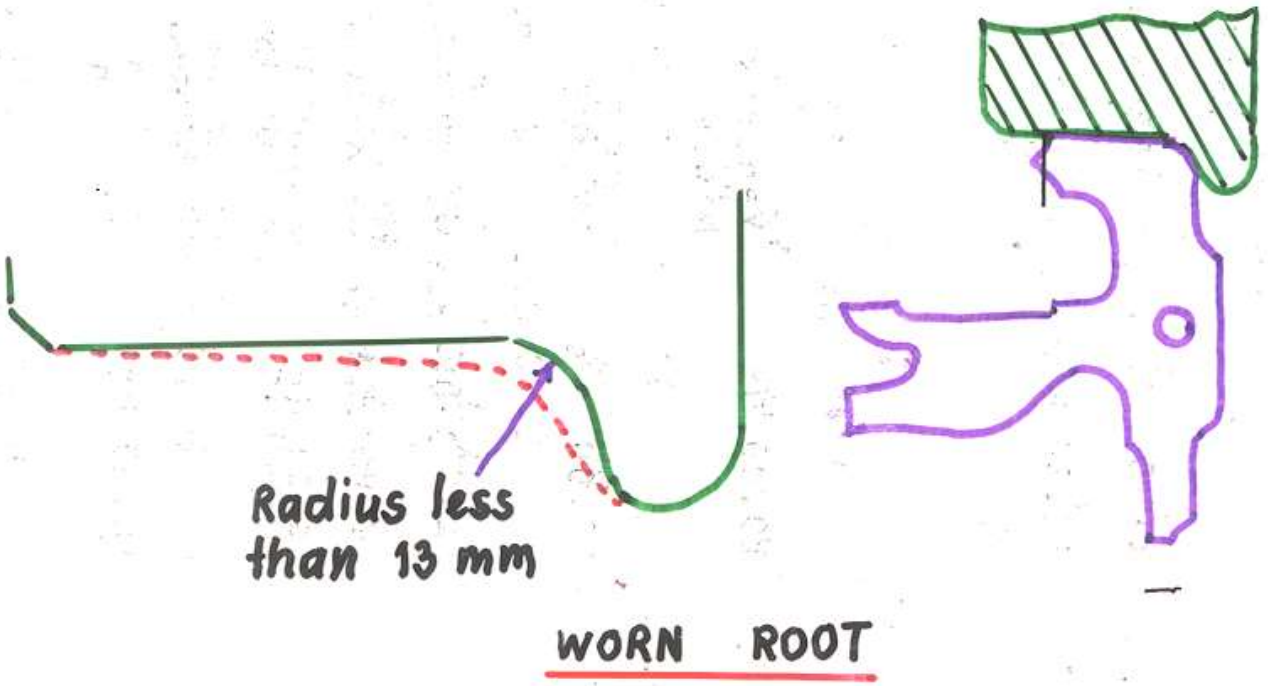
Snaking effects



Radius at the root of wheel flange too small / less root radius (LRR)

Maximum wear on curves.

By snaking effects of the wheels in motion



All wheels shall be gauged in workshops. When axles or tyres / discs are renewed, the maximum and minimum distances between wheel flanges shall not exceed the following limits over the standard dimension –

	BG	MG
Standard	1600	930
Maximum	1602	932
Minimum	1599	929

An axle, which has run hot, should be distinguished by stamping 5 mm size star on the face of the affected journal. Wheel sets with such axles must not be used in passenger vehicles.

Variation in tread diameter on the same axle shall apply only the time of tyre turning. There is no “ In-service” limit for this variation. Rejection during service is governed by tyre defect gauge.

Four wheeled Bogies

on the same axle:	0.5 mm
on the same Bogie:	5.0 mm
on the same coach or unit:	13.0 mm

Minimum flange thickness for coaches running in trains with maximum permissible speed of 110 kmph or more on BG shall be restricted to 22 mm.

THANK YOU