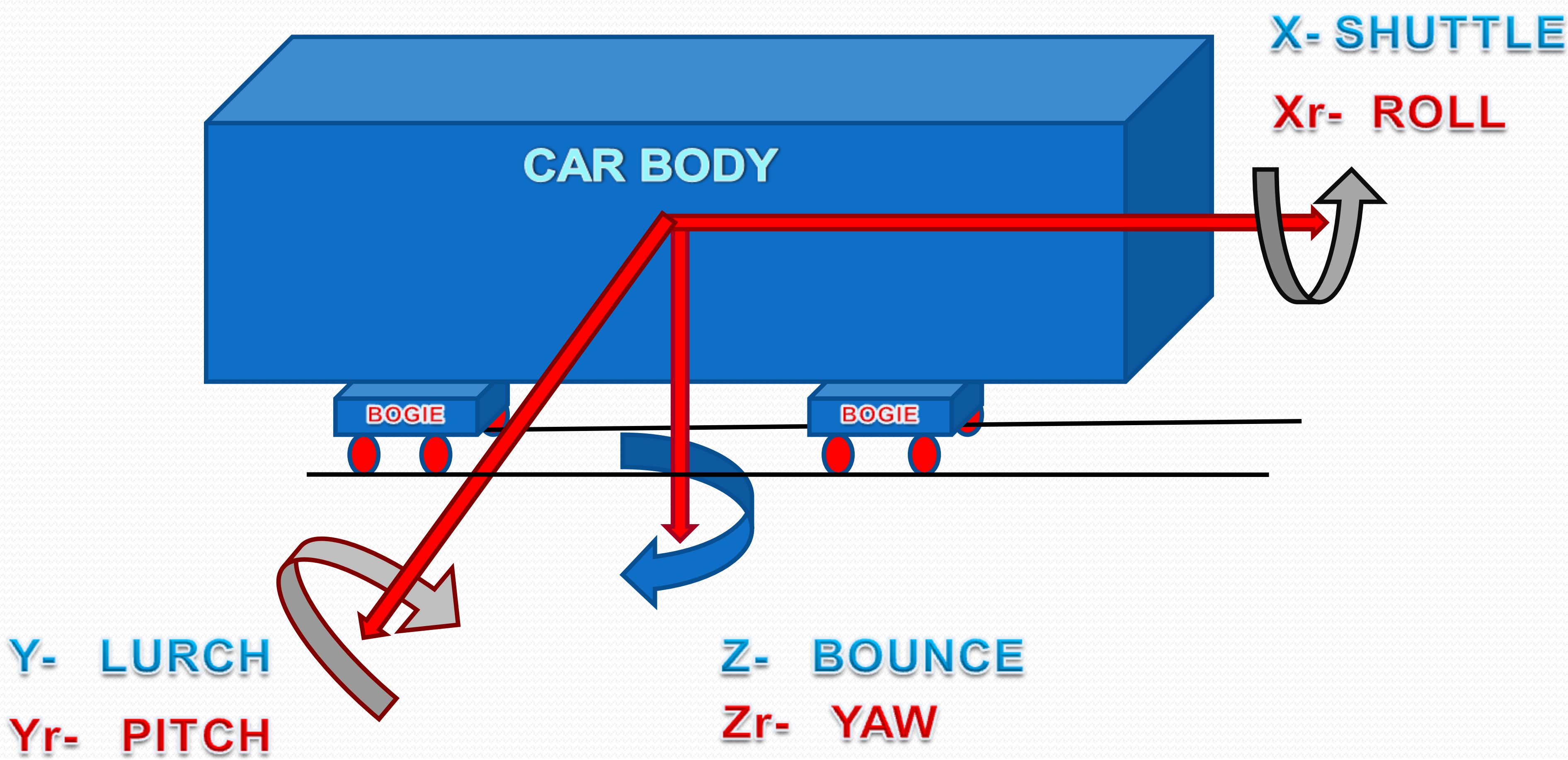
Basic requirements of Bogies

- STATUTERY (TRACK GUAGE, GROUND CLEARANCE, LATERAL DEFLECTION, SHARPEST TRACK RADIUS)
- RELIABILITY AT CRITICAL OPERATION SPEED
- GUIDE THE VEHICLE ON STRAIGHT TRACK WITH STABILITY
- SMOOTH CURVE NEGOTIATION WITHOUT SKIDDING
- EFFICIENT BRAKING FOR EMERGRCY STOPPING DISTANCE.
- ADEQUATE RIDE COMFORT FOR TARE AND GROSS LOAD
- SAFETY AGAINST DERAILMENT Y/Q
- LOW MAINTANANCE COST – NO PEPLACEMENT BEFORE IOH/POH
- ECONOMICAL PRODUCTION PROCESS.

VEHICLE DEGREE OF FREEDOM



MODEL WITH 2 DEGREE OF FREEDOM

Almost all railway vehicles consist of carbody, bogie frames and wheelsets. Therefore an improvement of the model above is to introduce as second suspended mass, i.e. to introduce a second vertical degree of freedom.

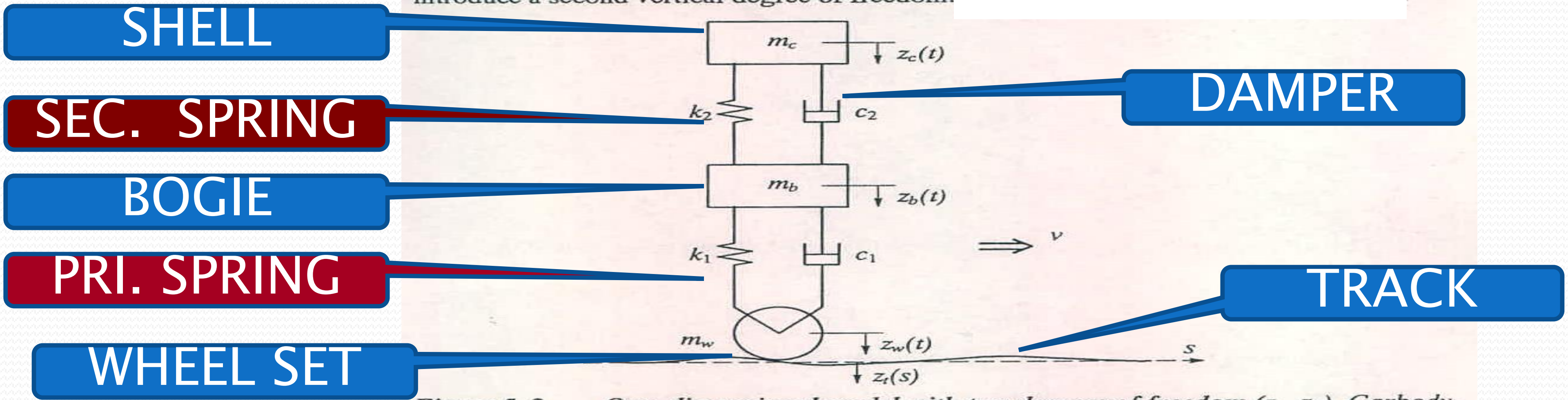


Figure 5-2 ***One-dimensional model with two degrees of freedom (z_c, z_b). Carbody mass m_c, bogieframe mass m_b and wheelset mass m_w. Primary suspension with stiffness k_1 and damping c_1. Secondary suspension with stiffness k_2 and damping c_2. Speed v. Displacements $z_c(t)$, $z_b(t)$, $z_w(t)$ and track irregularity $z_t(s)$.***

The three force equations of the system with respect to the static equilibrium can be written as

$$m_c \ddot{z}_c + c_2(\dot{z}_c - \dot{z}_b) + k_2(z_c - z_b) = 0 \qquad (5\text{-}8a)$$

$$m_b \ddot{z}_b - c_2(\dot{z}_c - \dot{z}_b) - k_2(z_c - z_b) + c_1(\dot{z}_b - \dot{z}_w) + k_1(z_b - z_w) = 0 \qquad (5\text{-}8b)$$

$$m_w \ddot{z}_w - c_1(\dot{z}_b - \dot{z}_w) - k_1(z_b - z_w) = -Q_{dyn} \qquad (5\text{-}8c)$$

Using Equation (5-2) one gets the two equations of motion in matrix form as

$$\begin{bmatrix} m_c & 0 \\ 0 & m_b \end{bmatrix} \begin{Bmatrix} \ddot{z}_c \\ \ddot{z}_b \end{Bmatrix} + \begin{bmatrix} c_2 & -c_2 \\ -c_2 & c_1 + c_2 \end{bmatrix} \begin{Bmatrix} \dot{z}_c \\ \dot{z}_b \end{Bmatrix} + \begin{bmatrix} k_2 & -k_2 \\ -k_2 & k_1 + k_2 \end{bmatrix} \begin{Bmatrix} z_c \\ z_b \end{Bmatrix} =$$

$$= \begin{Bmatrix} 0 \\ c_1 \dot{z}_w + k_1 z_w \end{Bmatrix} = \begin{Bmatrix} 0 \\ c_1 z_t' v + k_1 z_t \end{Bmatrix} \qquad (5\text{-}9)$$

or in short form

$$M\ddot{x} + C\dot{x} + Kx = F$$

EQUATION OF MOTION

WHY VEHICLE DYNAMICS .

VEHICLE DYNAMIC SIMULATIONS HELPS TO PRE INVESTIGATE THE STATIC, QUASISTATIC AND DYNAMIC BEHAVIOR OF RUNNING VEHICLE SYSTEM IN DIFFERENT DYNAMICS CONDITIONS, VARING LOAD WITH SPECIFIED GEOMETRY CONDITIONS OF TRACK AND WHEEL-RAIL INETRACTION. TO OPTIMIZE THE SUSPENSION CHARACTERISTICS FOR DESIGNED CRITICAL SPEED OF VEHICLE WITH SAFE & IMPROVED RIDING .

QUASISTATIC : WHEN VEHICLE RUNS WITH CONSTANT SPEED ON IDEAL TRACK WITH CONSTANT CURVE RADIUS, CANT AND WHEEL RAIL FRICTION.

QUASISTATIC LIMIT FOR LATERAL FORCES IN CURVES = 60 KN

(V=5.4 KMPH) AS PER UIC-518.

VEHICLE DYNAMIC MODELLING

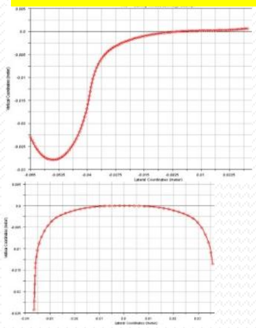
- CONCEPT DESIGN
- MATHEMATICAL MODEL
- LINKANGE
- PROPERTY FILES
- WHEEL TRACK GEOMETRY
- SIMULATION RUN
- RESULT REVIEW
- REVISION OF PROPERTY VALUES
- RE- ITERATION

Rigid Bodies with lumped mass

Bushing, Bump and rebound stops
Direction elements Damper and Spring

PWL Characteristics

PSD Data, Coinicity



```
$--------------------------------------------------------
---------------MDI_HEADER
[MDI_HEADER]
FILE_TYPE    = 'dpr'
FILE_VERSION  =  4.0
 FILE_FORMAT   =  'ASCII'
$--------------------------------------------------------
--------------------UNITS
[UNITS]
 LENGTH  =  'meter'
 ANGLE  =  'degrees'
 FORCE  =  'newton'
 MASS  =  'kg'
 TIME  =  'second'
$--------------------------------------------------------
--------------------CURVE
[CURVE]
{   vel       force}
-1.0   -1000.0
-0.28   -400.0
-0.16   -300.0
-0.09   -200.0
-0.04   -100.0
0.0   0.0
0.04   100.0
0.09   200.0
0.16   300.0
0.28   400.0
1.0   1000.0
```

Initial calculations-Run simulation -Review-results-Optimise values as per results - Re iteration till desired optimized out put

VEHICLE DYNAMIC ANALYSIS GOALS

EIGEN VALUES :	NATURAL FREQUENCY, PHASE, DAMPING
STABILITY ANALYSIS :	UNDAMPED MODE AT CRITICAL SPEED
CURVING BEHAVIOUR :	ANGLE OF ATTACK
DERAILMENT COEFFICIENT :	RATIO OF LATERAL FOCES TO VERTICAL
LATERAL WHEEL FORCES :	FORCES ON WHEEL AND TRACK
RIDE INDEX ::	COMFORT VALUES.

CARBODY BENDING FREQUENCY -10 Hz

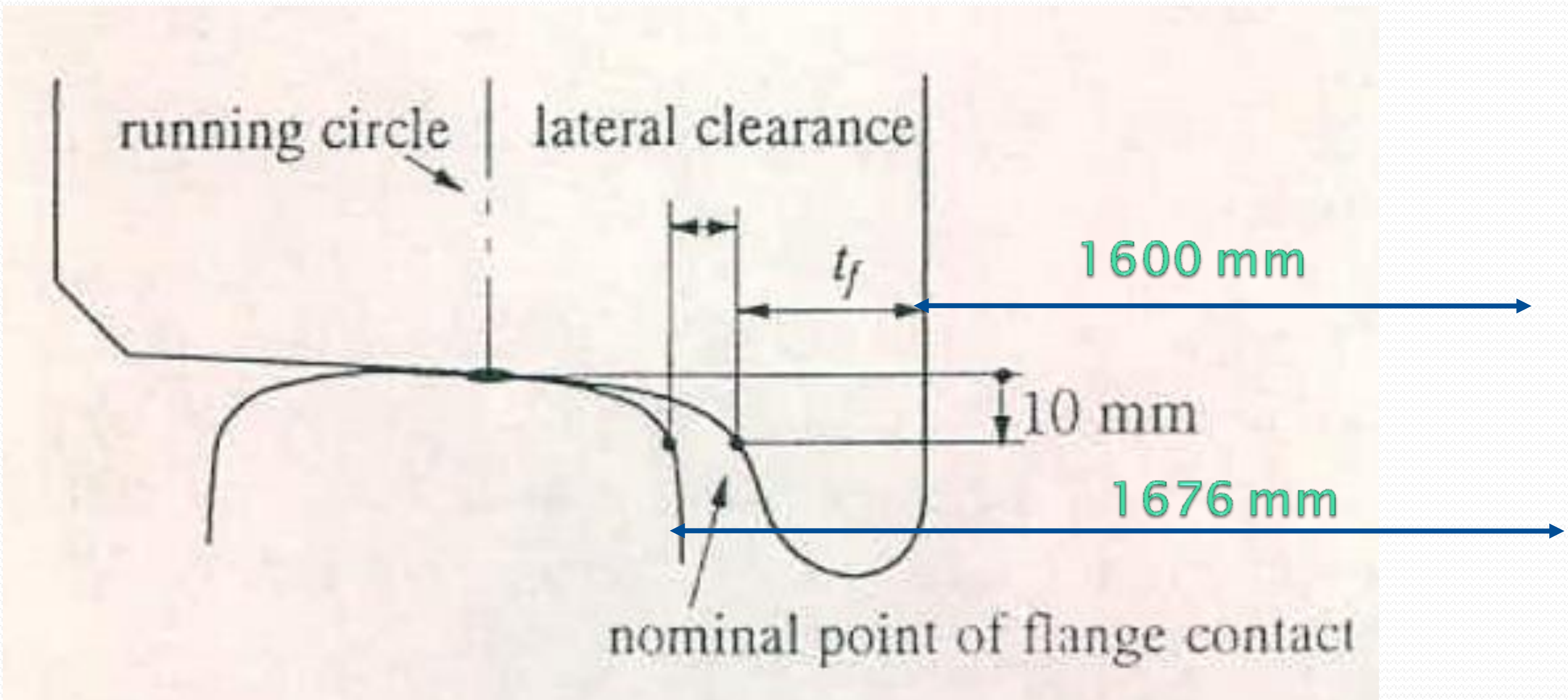
PITCHING OF BOGIE-15 Hz SEPERATED BY UNDERROOT 2

MAX. BUFFER DROP TARE TO GROSS ≤ 75mm.

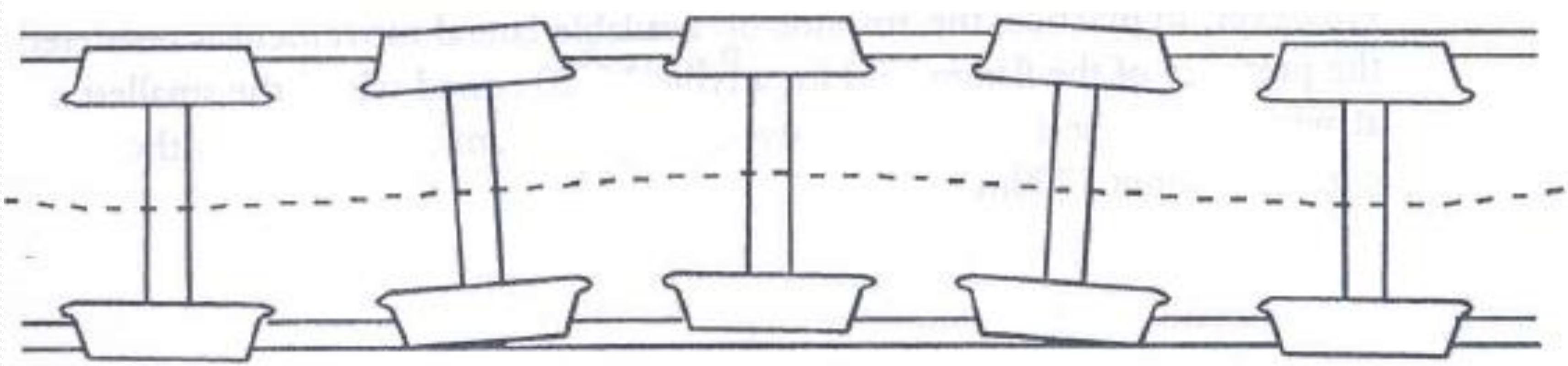
TILTING COEFFICIENT LESS THAN 0.4

LATERAL CLEARNCE OF TRACK – WHEEL

LATERAL CLEARNACE MEANS POSSIBLE DISPLACEMENT OF A WHEEL UNTIL FLANGE CONTACT IS REACHED.. BECAUSE OF THIS LATERAL PLAY BOGIE MOVES IN SINE WAVE MOTION.

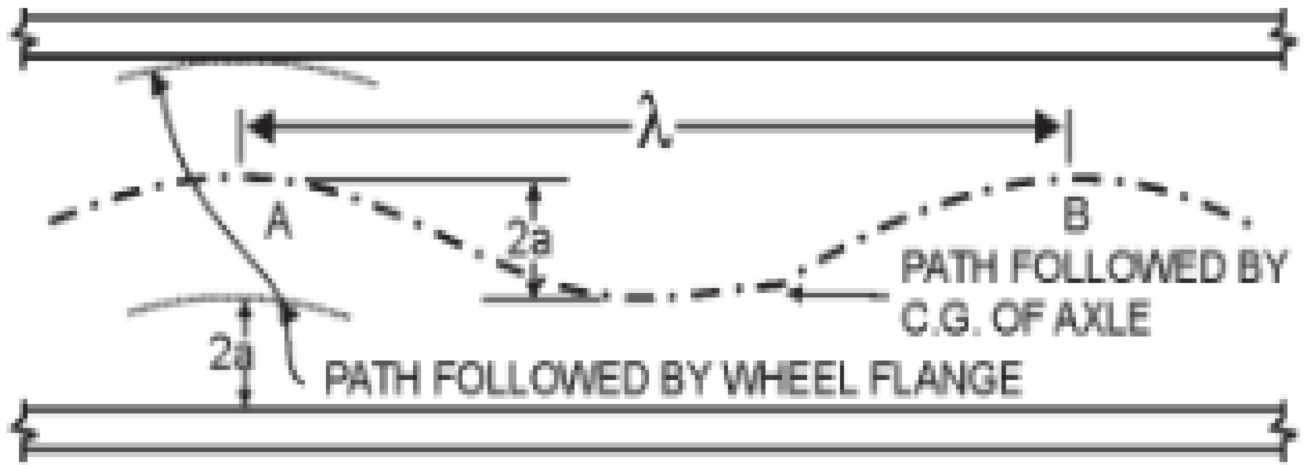


Sinusoidal motion of wheel set



- A cylindrical wheel with minor disturbance will take an extreme position and will never return back towards center line on its own.
- Taper on tread of 1:20 gives self centering effect and changed rolling radius works as differential on curves.

SINUSOIDAL MOTION OF VEHICLE

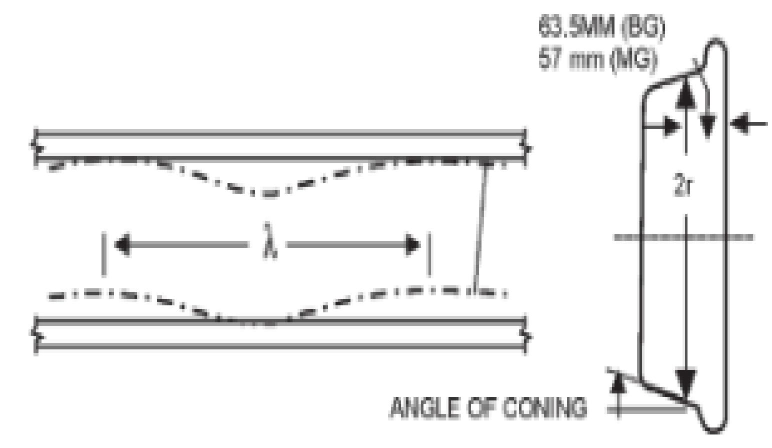


- Thus, a typical periodic motion is generated with time period = λ/v
- where v is the velocity of the vehicle
- **Lateral displacement will be y = a sin ωt,**
- ω being angular velocity of oscillations being the time when displacement is measured
- **Thin flange increase Lateral Play**

KLINGEL'S FORMULA

Wave Length λ_0 of a Single wheel

$$\lambda_0 = 2\pi\sqrt{\frac{rG}{2\gamma}}$$



G = Dynamic Gauge

r = Dynamic Wheel Radius

γ = Conicity

$\lambda_0 \ \alpha \ \frac{1}{\sqrt{\gamma}}$; **Frequency** $\alpha \ \sqrt{\gamma}$

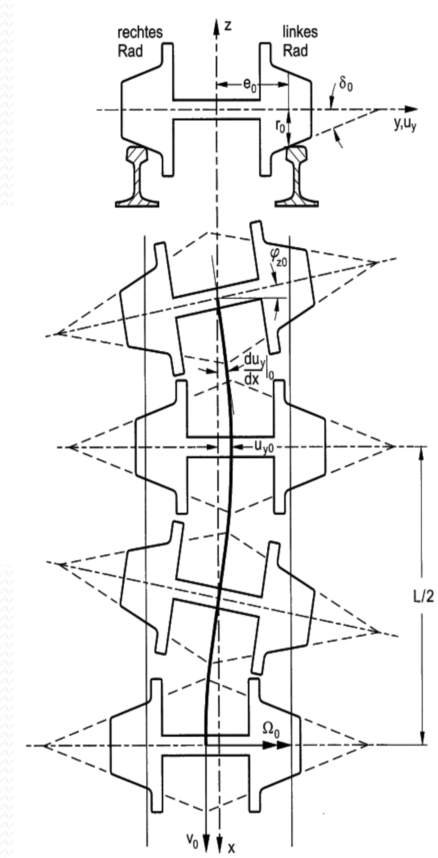
Hollow tyre increase conicity of wheel

LARGER CONICITY REAULTS IN LOWER WAVE LENGTH AND HIGH FREQUENCY RESLUTING IN STABILITY

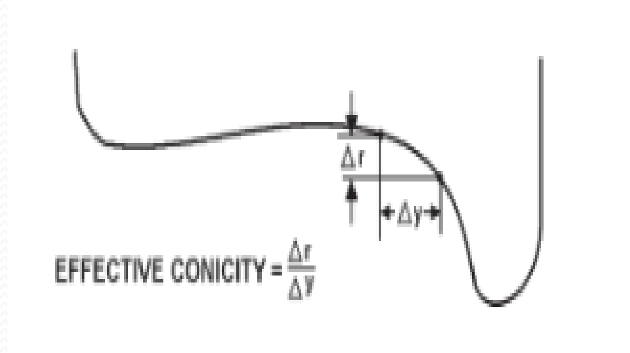
--- LOWER CRITICAL SPEED IN BOGIE HUNTING---

Effective conicity evolution due to wear

- Equivalent effective conicity characterising the wheel rail contact geometry



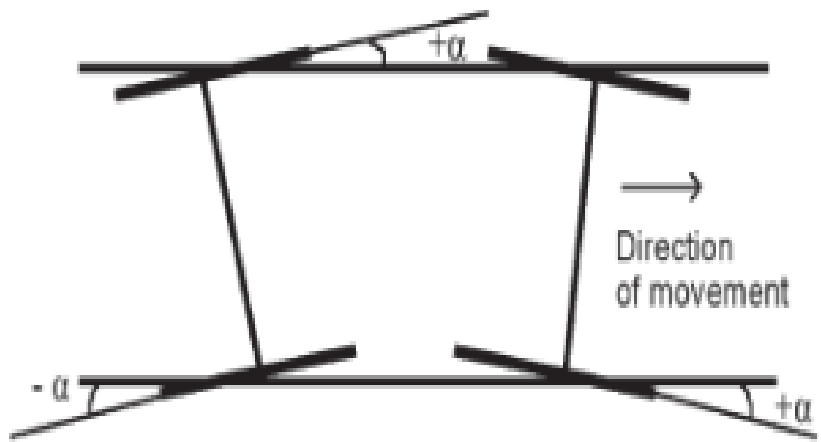
- **Effective conicity = δr / δy**
- **δr – change in rolling radius**
- **δy – lateral displacement**



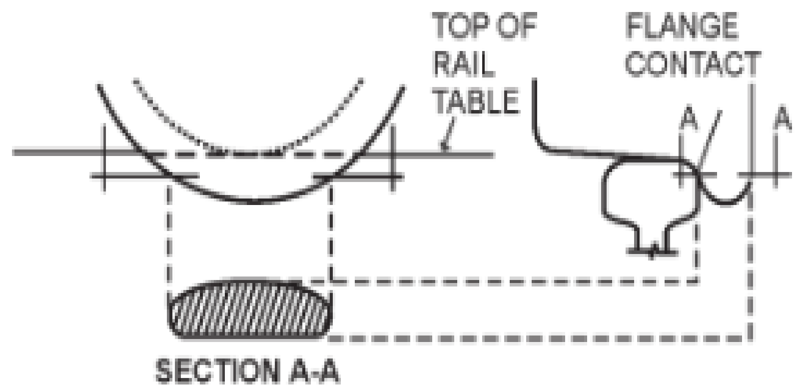
- **High equivalent conicity → more bogie hunting**

- **New wheel = 0.25 ; Worn wheel = 0.4 to 08**
- **For Ultra high speed conicity = 0.1 with tread taper 1:40**

SECTIONAL PLAN OF WHEEL FLANGE AT LEVEL OF FLANGE TO RAIL CONTACT



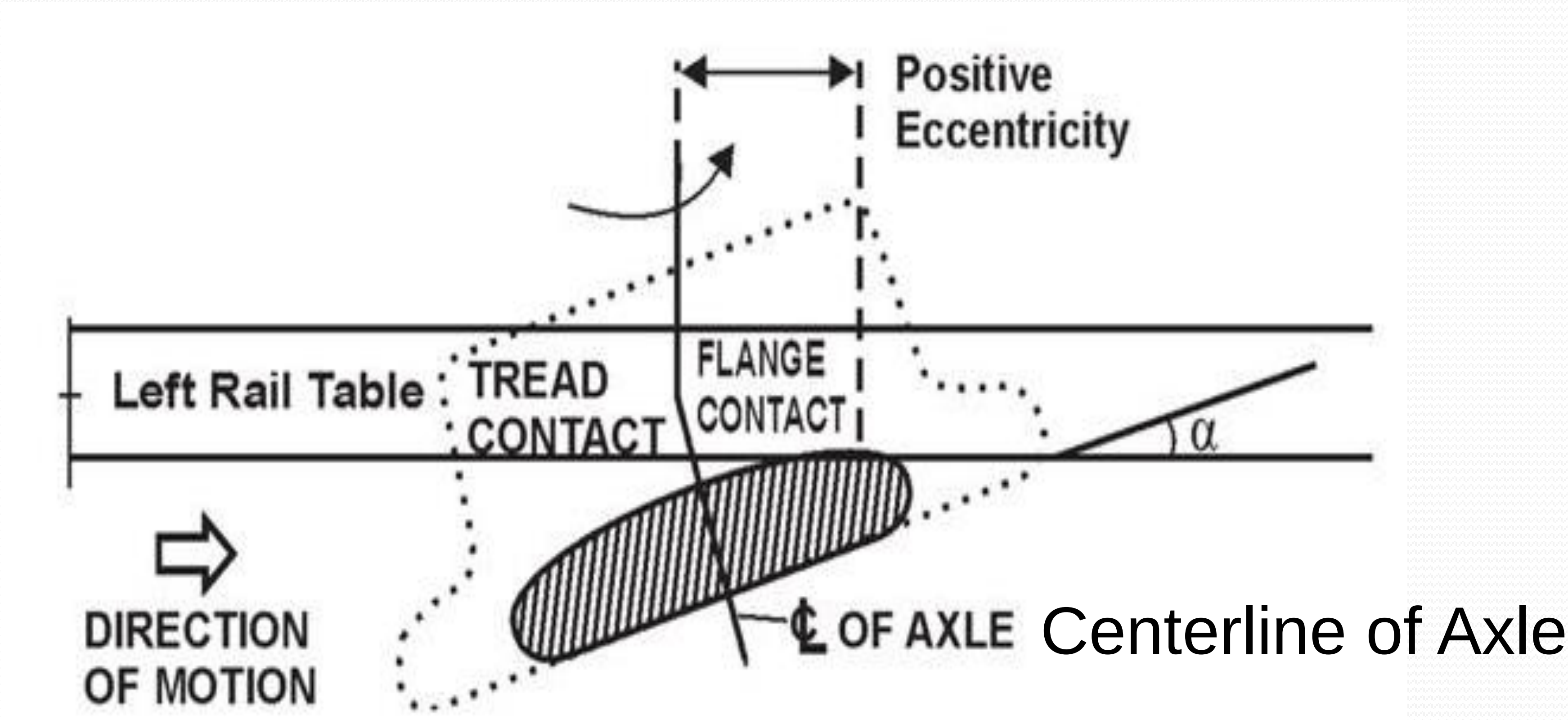
Due to lateral clearance between wheel & track, Axle may assume intermediate angular position.



Sectional plan of wheel flange at level of flange to Rail contact

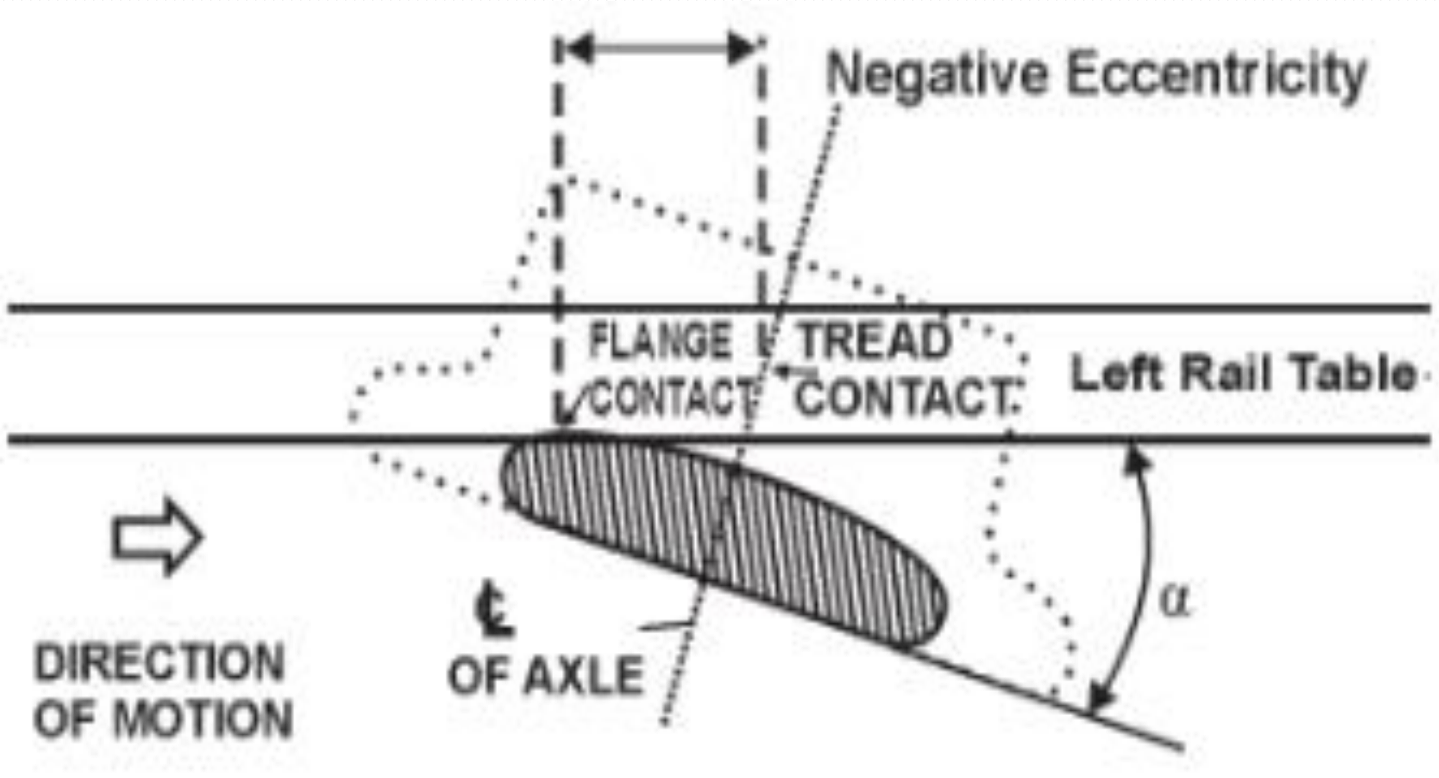
On curves wheel obliquity is accentuated in proportion to ratio of wheel base and radius of curvature.

POSITIVE ANGULARITY (PLAN)



- Point of contact of flange is ahead of tread contact
- Frictional force acts upwards thus adds in wheel climbing the rail

NEGATIVE ANGULARITY (PLAN)



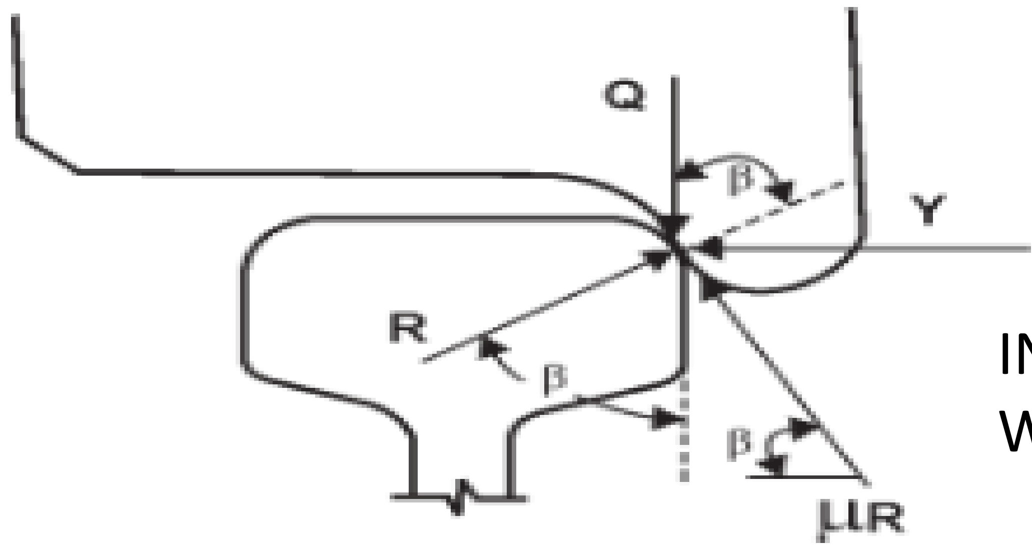
- Flange contact lags (trails) tread contact
- Frictional force acts downwards

CONCLUSIONS FROM ANGULAR MOVEMENTS

- **Frictional force acts upwards and acts as a derailing force in case of positive angularity**
- **Derailment proneness is higher when wheel makes contact with positive angle of attack**
- **Positive angularity is therefore most critical condition of the three possible conditions –**
- **POSITIVE—ZERO--NEGATIVE**

FORCES AT RAIL-WHEEL CONTACT AT MOMENT OF INCIPIENT DERAILMENT

LARGE LATERAL DISPLACEMENT ARE LIMITED BY WHEEL FLANGES RUBBING AGAINST THE SIDE OF RAIL. THE FLANGES ALSO PROVIDES REACTION FORCES TO TURN THE BOGIE AROUND A CURVE TRACK.



INCLINATION OF FLANGE WITH VERTICAL **β**= 1:2.5

Derailing force = $Y \cos \beta + \mu R$

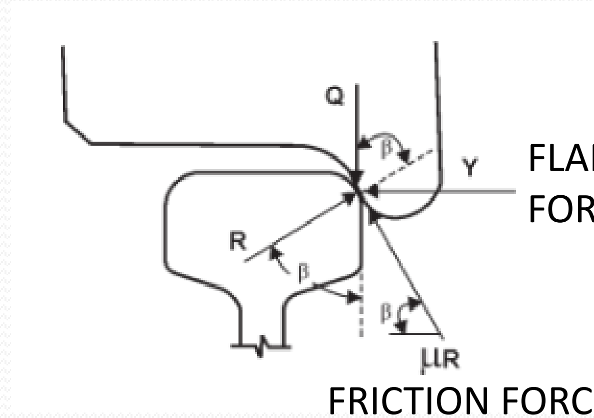
Stabilising force = $Q \sin \beta$

Nadal's Equation

FLANGE FORCE

WHEEL LOAD (Instant)

$$\frac{Y}{Q} \not> \frac{\tan\beta - \mu}{1 + \mu \tan\beta}$$

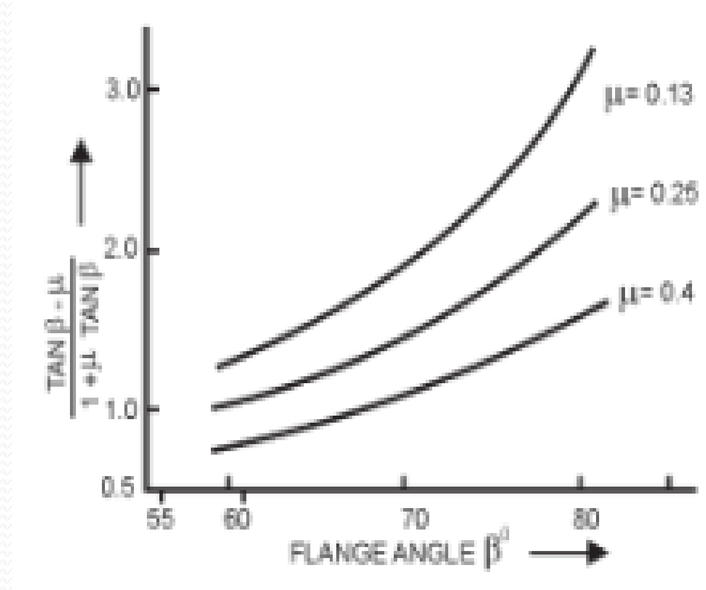


FLANGE FORCE

FRICTION FORCE ACTING UPWARD

For Safety against wheel climbing :
LHS has to be small than RHS
Y → Low
Q → High
μ → Low
tan β → Large

DERAILMENT CO-EFFICIENT SHOULD BE LESS THAN = 0.8 FOR SAFETY



Salient features – Eurofima FIAT bogie

DIP Y FRAME – TO LOWER CENTER OF GRAVITY

SHORTER WHEEL BASE 2560 mm– FOR BETTER CURVE NEGOTIATION WITHOUT WHEEL SKIDDING

FLEXICOIL SOFTER SECONDERY SUSPENSION :- FOR BETTER RIDE QUALITY IN VERTICAL & LATERAL DIERCTION

CARTRIDGE TAPER ROLLER BEARING :- FOR BETTER LIFE CYCLE AGAINST AXIAL LOADS & EASE OF FITMENT

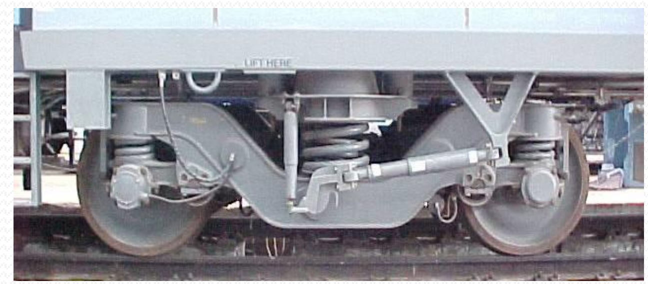
ANTI ROLL BAR – TO CONTROL ROLE FREQUENCY & DISPLACEMENT

DISC BRAKE ARRGT. – FOR SHORTER EMERGENCY STOPPING DISTANCE

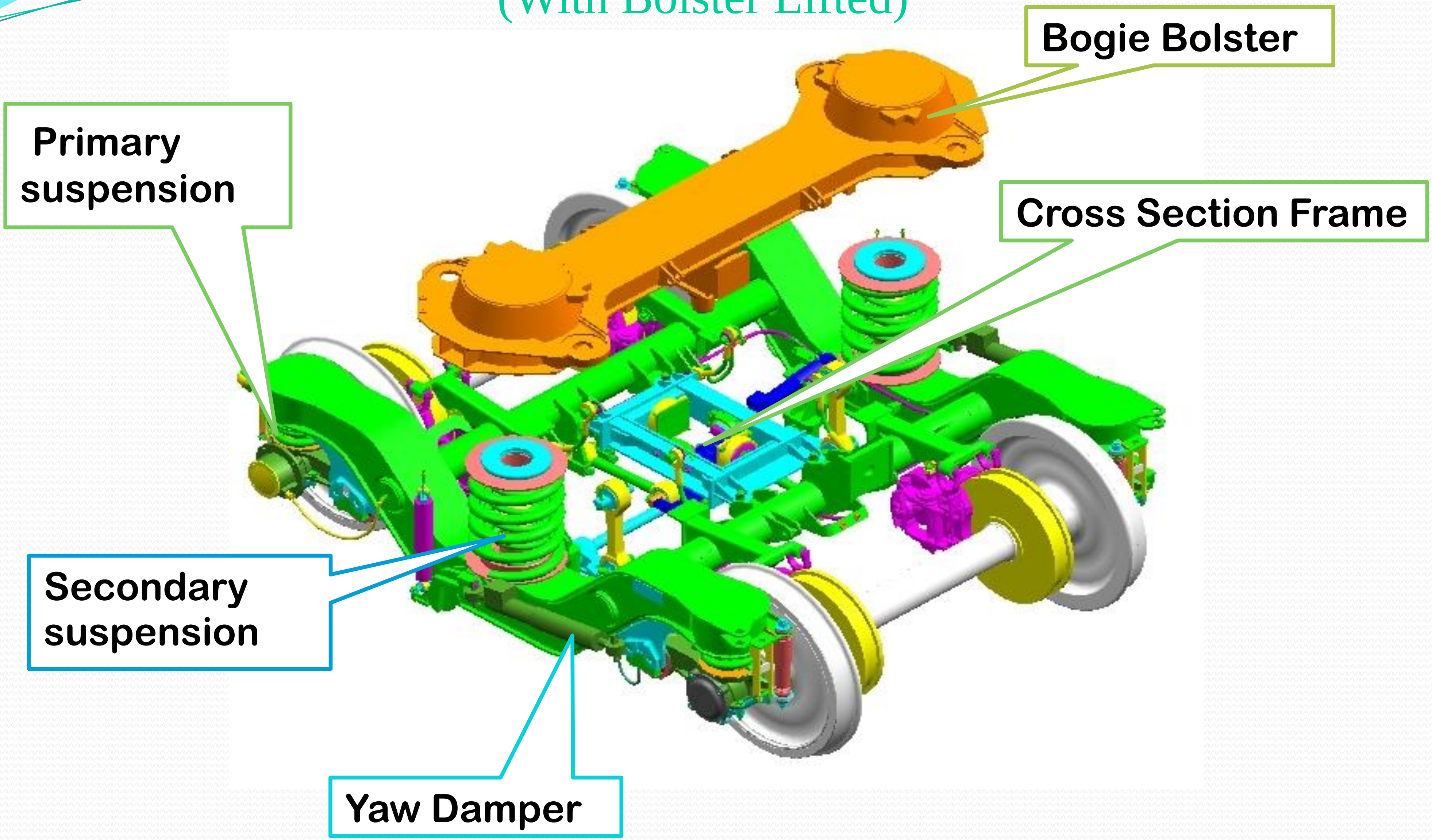
YAW DAMPER – TO SUPRESS HUNTING FORCES

LATERAL & LONGITUDINAL BUMP STOP, CURVE ROLL - TO CONTROL COACH MOVEMENT WITH RESPECT TO BOGIE.

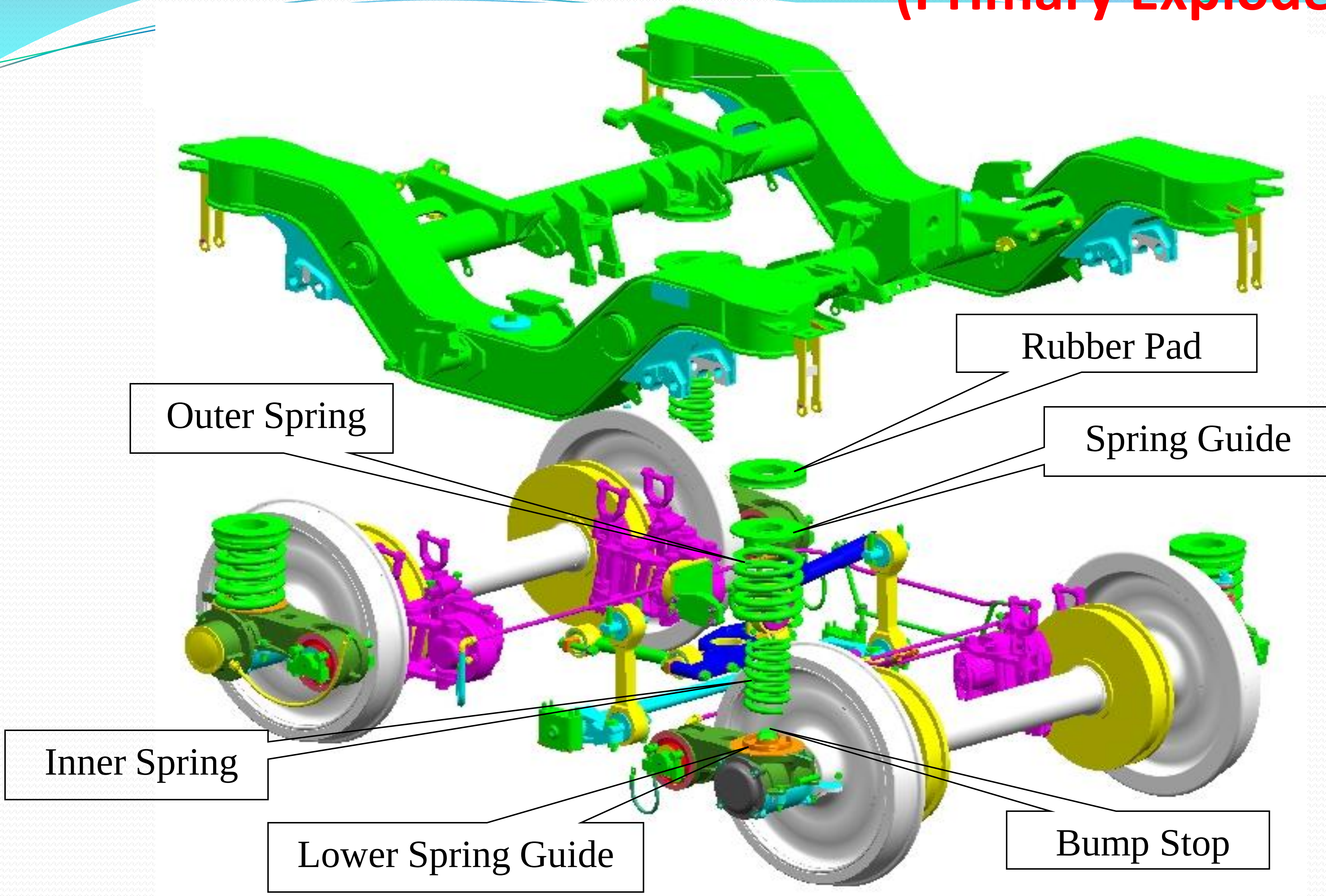
BOGIE BODY CONNECTION – FOR ISOLATION OF NOISE AND VIBRATIONS AND NON DETACHMENT OF SHELL – BOGIE DURING DERAILMENT.



(With Bolster Lifted)



(Primary Exploded)

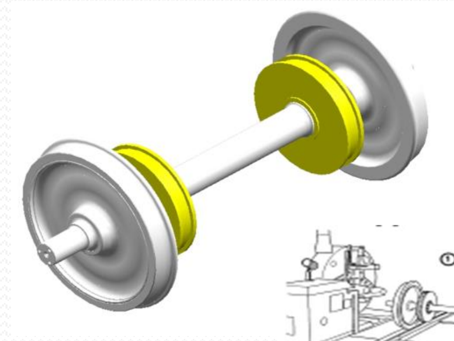


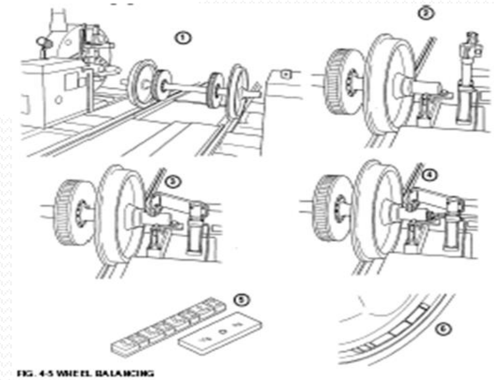
Wheelset ---

Why condemening limit = 845 mm

- Brake disks dia. = 640 mm.
- **Wheel discs Dia = 915 (New), 845 (worn).**
- New wheel radius = 915/2 = 457.5 mm
- Brake disc radius = 640/2 = 320 mm
- Ground clearance mandatory = 102 mm
- m=Margin = 457 – (320+102) = 35 mm
- Condemning limit =915 – (35x2) = **845mm**

- **Variation allowed in size of wheel discs**
- **Wheel disc one axle = 0.5 mm**
- **Wheel disc one bogie = 5mm**
- **Wheel disc one coach = 13 mm**





W.I. as RCF MDTS 168
Dynamic balance at 320 rpm
Unbalance moment should be </= 50 gm.
3M self adhesive strip or
Glue weights

Chisel Gasket Remover-Loctite 79040
Activator- Loctite 7075
Adhesive Loctite 324

Axle bearings

- CARTRIDGE DOUBLE ROW TAPER ROLLER BEARING
- PRE-ASSEMBLED PRE GREASED SEALED UNIT.
- MAINTENANCE FREE-
- FIRST OVERHAUL =1.2 MILLION KM.
- SERVICE LIFE = 3.0 MILLION KM

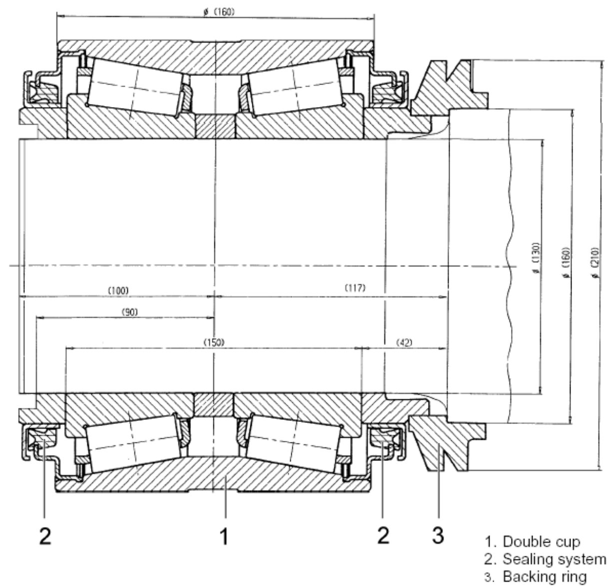


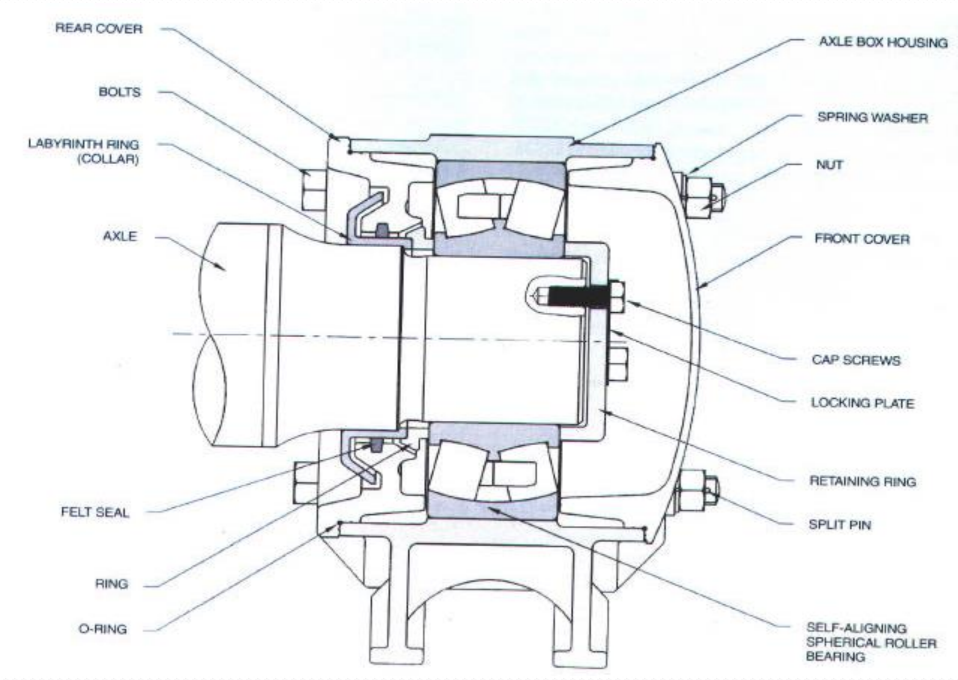
FIG. 1-4 AXLE BEARING LONGITUDINAL SECTION

Bearing Mounting Pressure
Timken- 20-25 Tonne
SKF- 28-32 Tonne
Needs to be standardised

TIMKEN
E-48999

Mounted End Play Checking with Dial Indicator
It should be in limit 0.025-0.33 mm

Self align double row spherical roller bearings



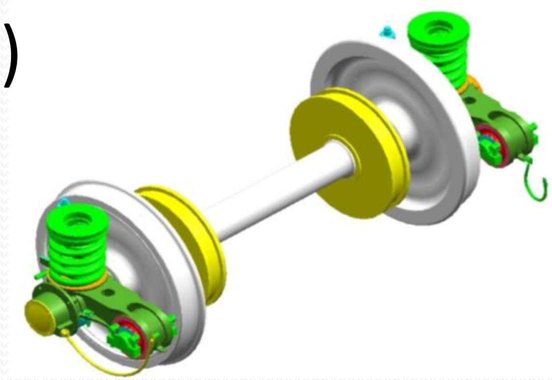
22326 C3 CK
SELF ALIGNMENT UPTO 2.5 DEG.

Induction Heating 130 -140 DEG. CEN

(Wheel set with Primary suspension-

Prud' homme proposed the limiting lateral force as: **$Hy \leq 0.85\,(1+P/3)$**

where Hy is the lateral force & P = axle load (t)

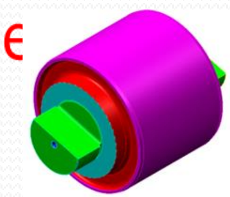


Control arm centre pivot bush for wheel - axle guidance

Existing

Axial –Lateral stiffness = 04 kN/mm

Longitudinal Stiffness = 40 kN/mm

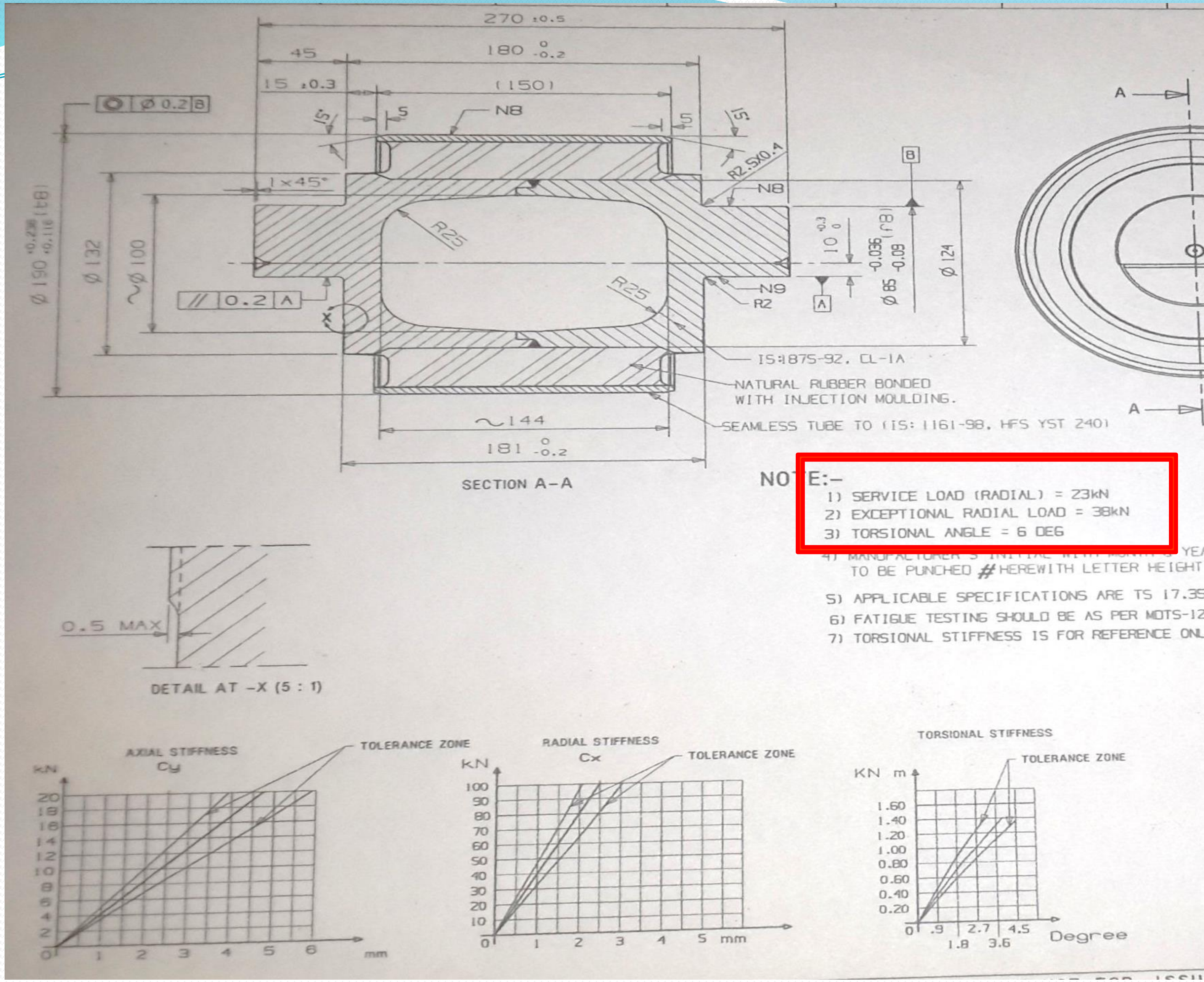


Proposed stiffness for trails by RDSO to avoid she

Axial –Lateral stiffness = 18 kN/mm

Longitudinal Stiffness = 08 kN/mm

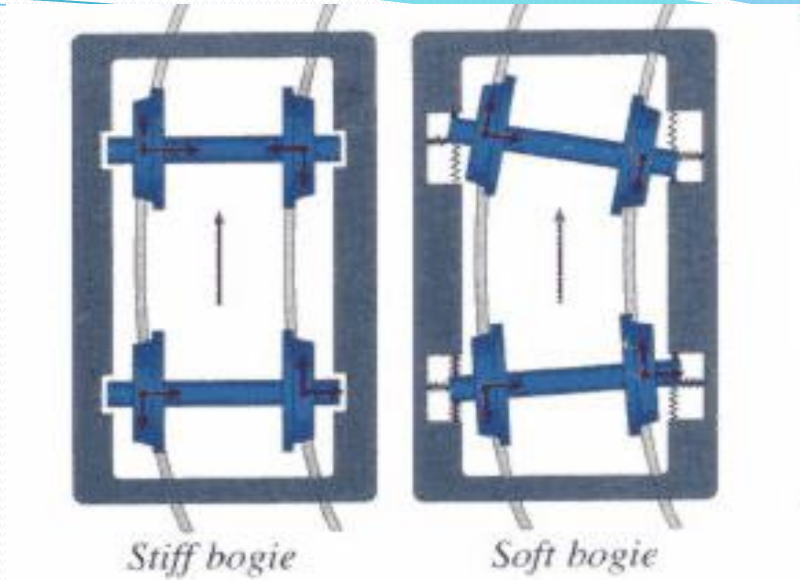
SERVICE LOAD Cx = 23 Kn aginst stiffness of 40 kN



270 ±0.5
45
180 0 -0.2
15 ±0.3
(150)
N8
R2.5X0.4
1×45°
Ø 190 +0.236 +0.116 (t8)
Ø 132
~Ø 100
// 0.2 A
R25
R25
N8
N9
R2
10 -0.3 0
Ø 85 -0.036 -0.09 (r8)
Ø 124
A
B
IS:1875-92, CL-IA
NATURAL RUBBER BONDED WITH INJECTION MOULDING.
SEAMLESS TUBE TO (IS: 1161-98, HFS YST 240)
~144
181 0 -0.2
SECTION A-A
NOTE:-
1) SERVICE LOAD (RADIAL) = 23kN
2) EXCEPTIONAL RADIAL LOAD = 38kN
3) TORSIONAL ANGLE = 6 DEG
TO BE PUNCHED # HEREWITH LETTER HEIGHT
5) APPLICABLE SPECIFICATIONS ARE TS 17.35
6) FATIGUE TESTING SHOULD BE AS PER MDTS-122
7) TORSIONAL STIFFNESS IS FOR REFERENCE ONLY
0.5 MAX
DETAIL AT -X (5 : 1)
AXIAL STIFFNESS
Cy
kN
TOLERANCE ZONE
mm
RADIAL STIFFNESS
Cx
kN
TOLERANCE ZONE
mm
TORSIONAL STIFFNESS
KN m
TOLERANCE ZONE
Degree

Cornering Forces

Soft Bogies!



Radial-steered bogies on their own allow an increase in operating speeds up to 180Km/h without increasing Rail/wheel forces compared with conventional bogies.

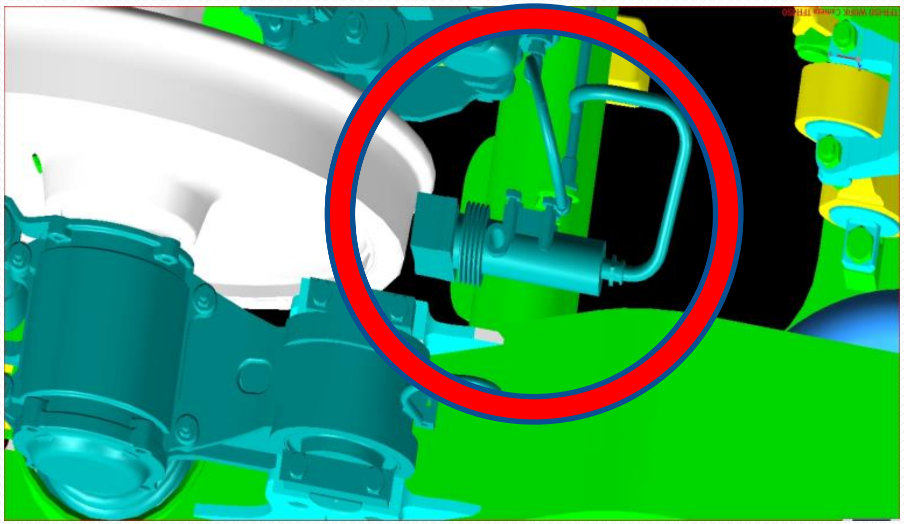
This reduces wear on both the rail and wheels - wheel life is increased by up to six times.

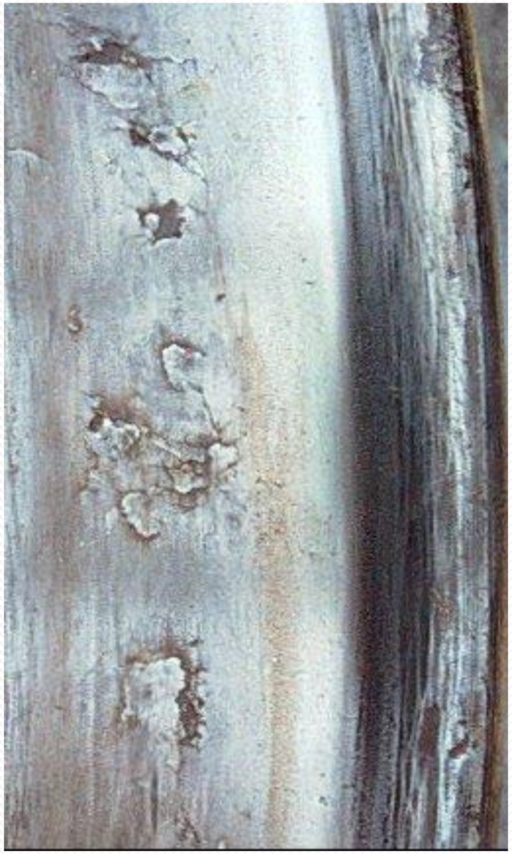
CONCLUSIONS

- **EXCESSIVE OSCILLATIONS DUE TO**
  - Slack Gauge
  - Thin Flange
  - Increased Play in bearing & Journal
  - Excessive Lateral and Longitudinal Clearances
- **Increase Derailment Proneness**

TREAD CLEANING DEVICE

- The small pieces of metal break out are grinded by tread cleaning device to avoid **shelling and spalling**





Primary suspension
High stiffness- Low deflection springs nest

- 04 nos Nested coil springs with top rubber pad, primary vertical dampers, control arm, elastic joints - connecting the cartridge bearing on wheel set to bogie frame.
- Articulated Flexible guidance.

Vertical Stiffness outer = 475 N/mm
Vertical Stiffness inner = 280 N/mm
Combined Stiffness of nest = 755 N/mm

PRI. VERTICAL DAMPERS -04 NOS.
4250 +/- 640 N @ 0.3 M/sec.

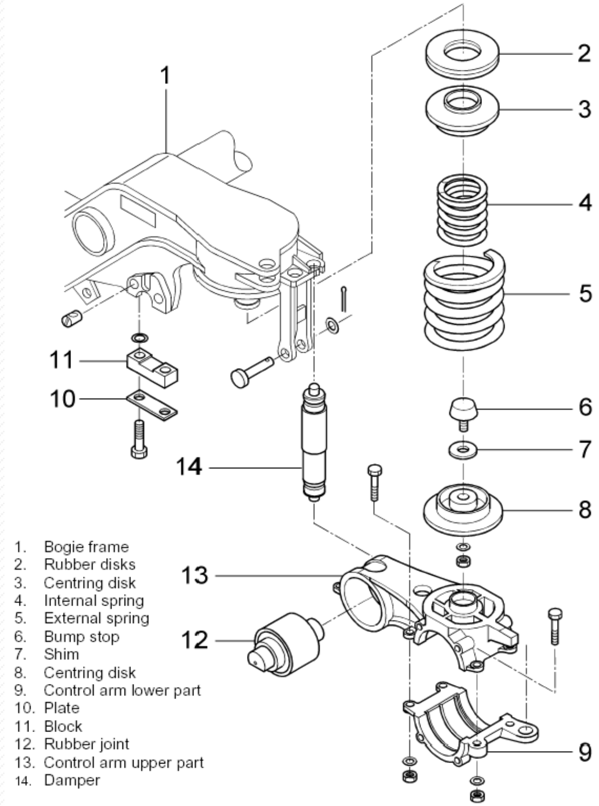
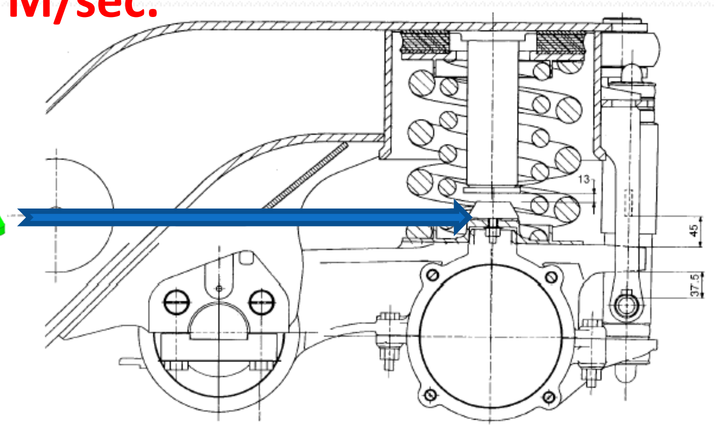


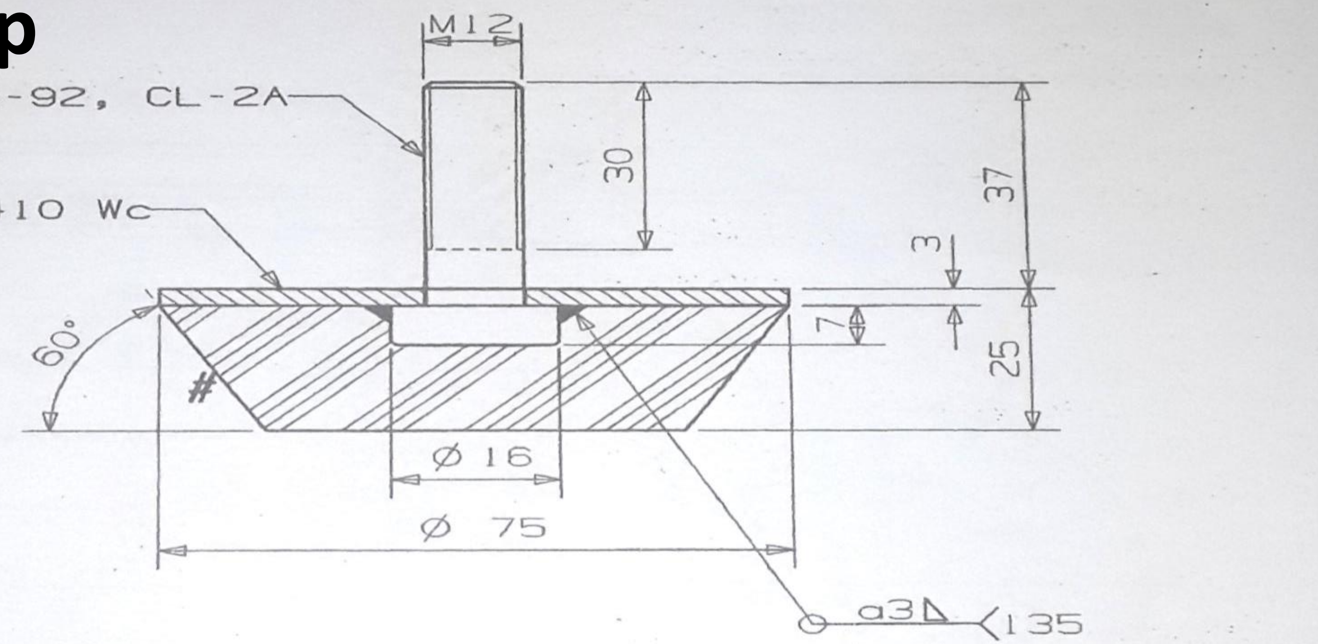
FIG. 1-8 PRIMARY SUSPENSION

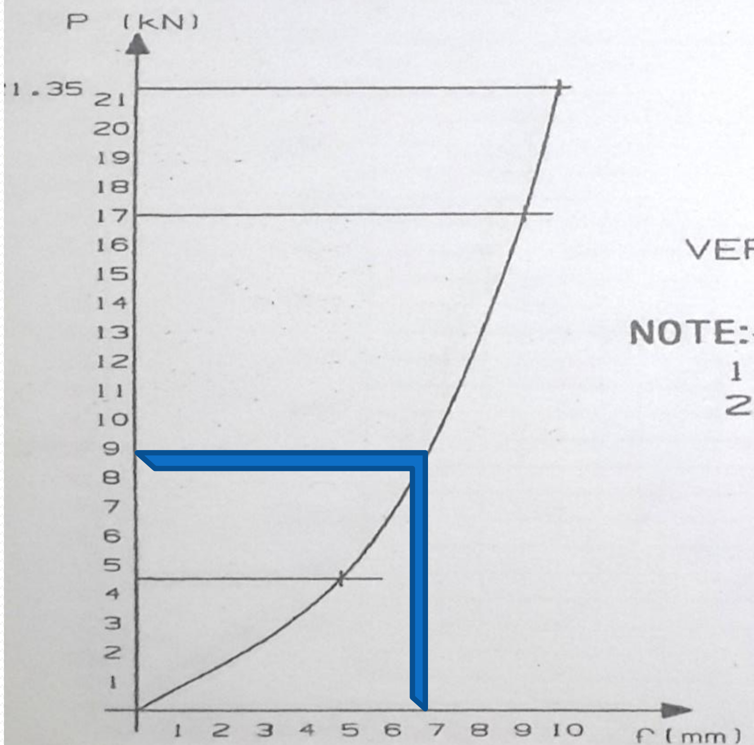
PRI BUMP STOP



LATERAL STIFFNESS 5 TIMES THE VERTICAL STIFFNESS AND LONGITUDINAL STIFFNESS. 16 TIMES OF VERTICAL STIFFNESS.

Primary Bump stop





VERTICAL STIFFENESS:- 2.9kN/mm ±12%
(17kN/9mm, 4.5kN/4.7mm)

NOTE:-

1) FATIGUE TESTING SHOULD BE AS PER MDTS-122.
2) MANUFACTURER'S INITIALS, MONTH & YEAR TO B
EMBOSSED HERE #

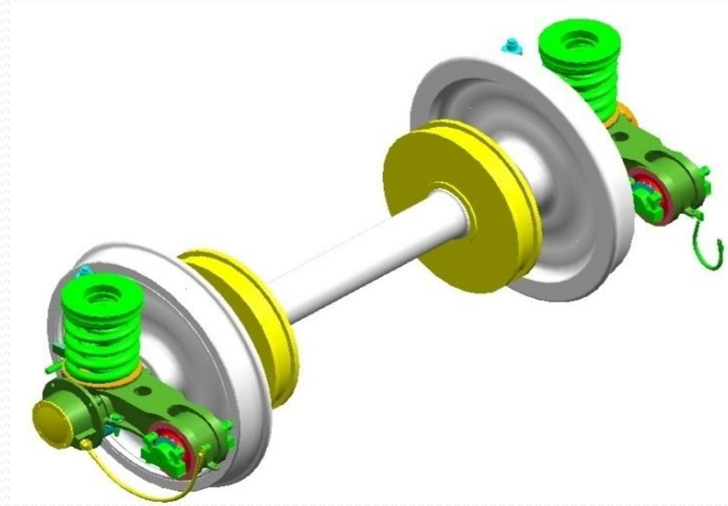
AXLE LOAD ON ONE JOURNAL
= 18/2 = 9 TONNE
DEFLECTION = 6.5mm only

WELD LENG
NIL
WEIGHT
0.235
S.AREA
NIL
LENGTH /
0.075

Primary suspension---

- Spring Design
- Stress= $G * d^{4}$ / $8 * Dm^{3} * n$ -- N/mm.

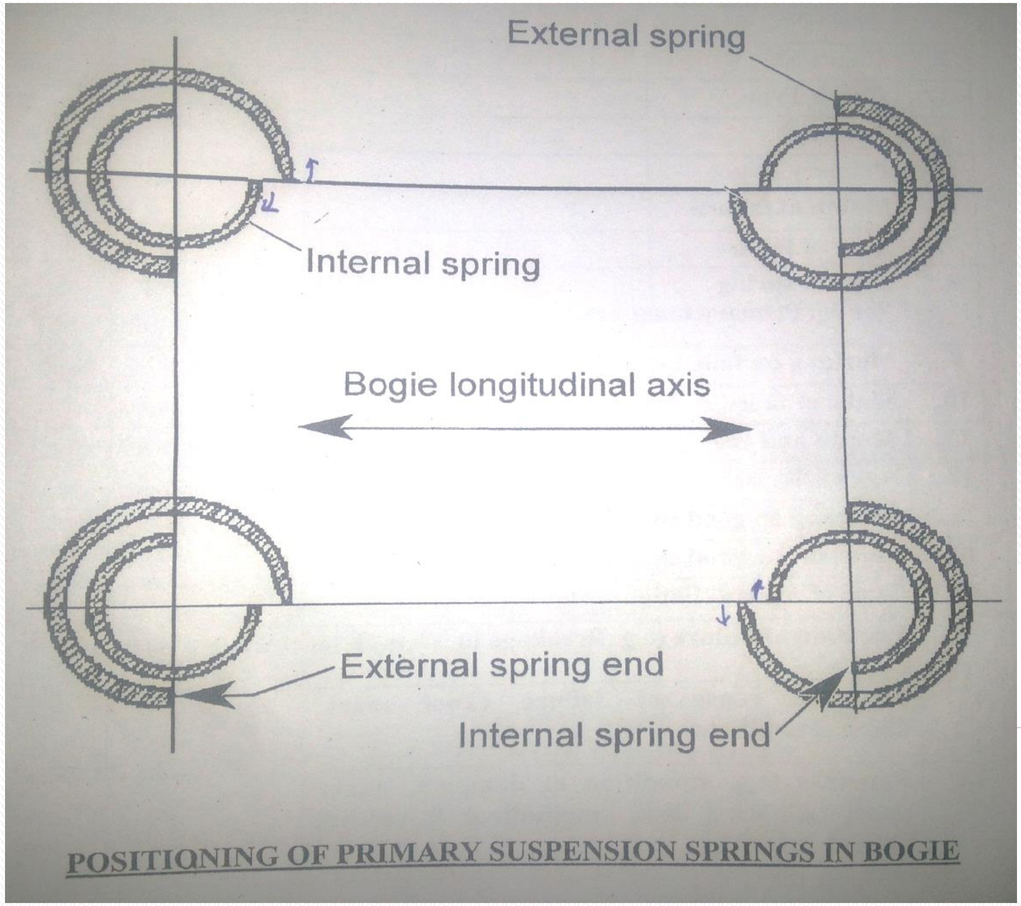
- G = MODULUS OF RIGIDITY
- D = Bar Dia.
- Dm = Mean Dia.
- N = No. of active turns



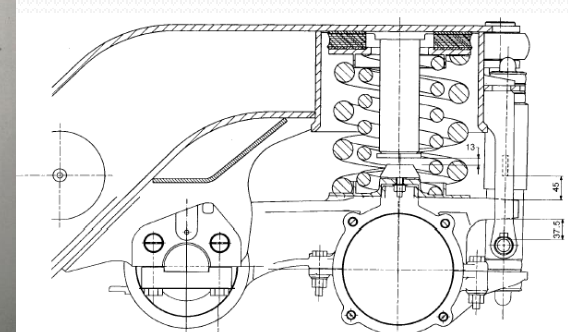
- RDSO SPEC WD-01-HLS-94 REV-3
- MATERAIL – IS:3195-92
- d<30 -60 - Si 7 ,
- 30<d<60 - 52Cr4Mo2v

Orientation of Outer & Inner Primary springs to avoid biting of coils and for balanced distribution of load on centering disc

1 - 4

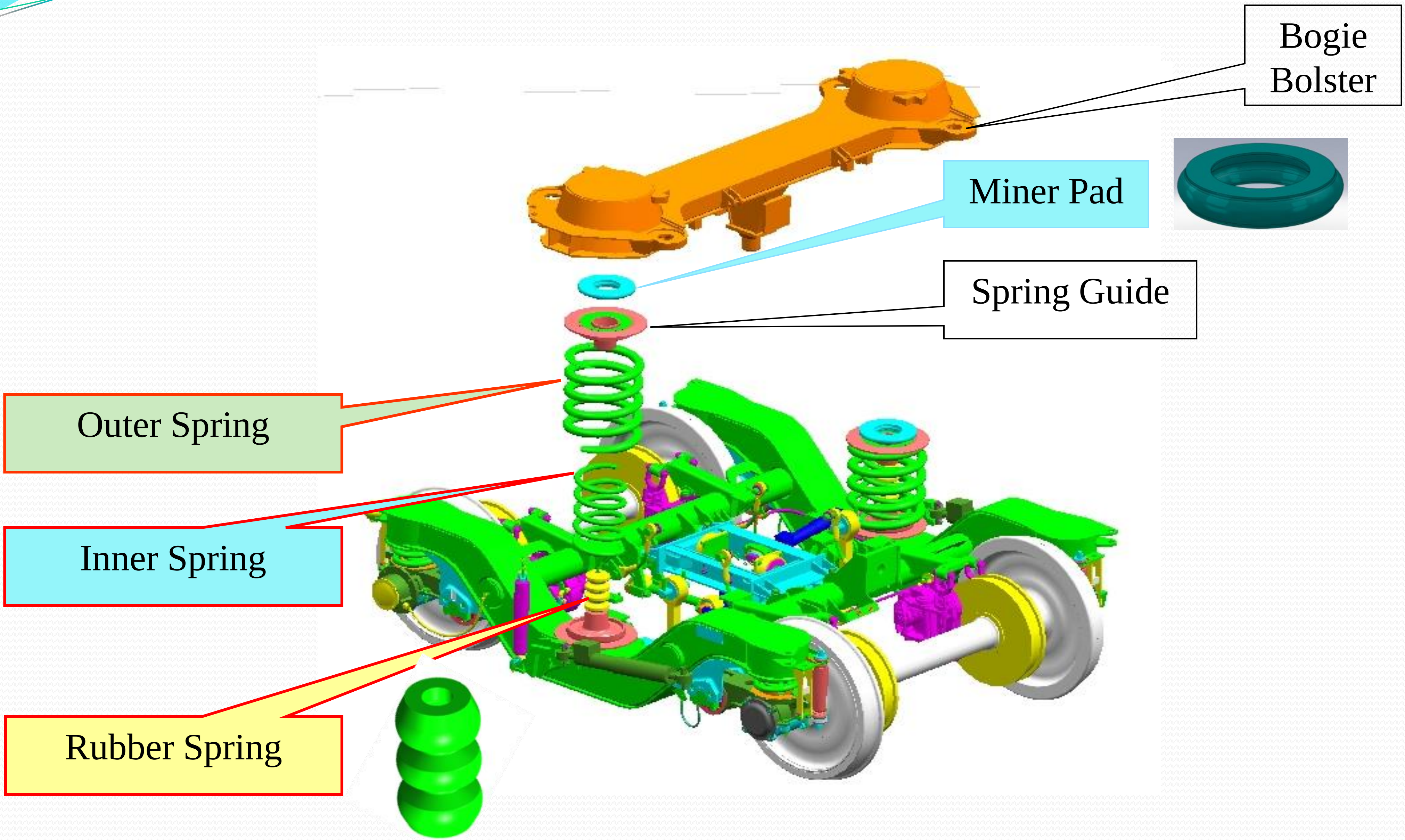


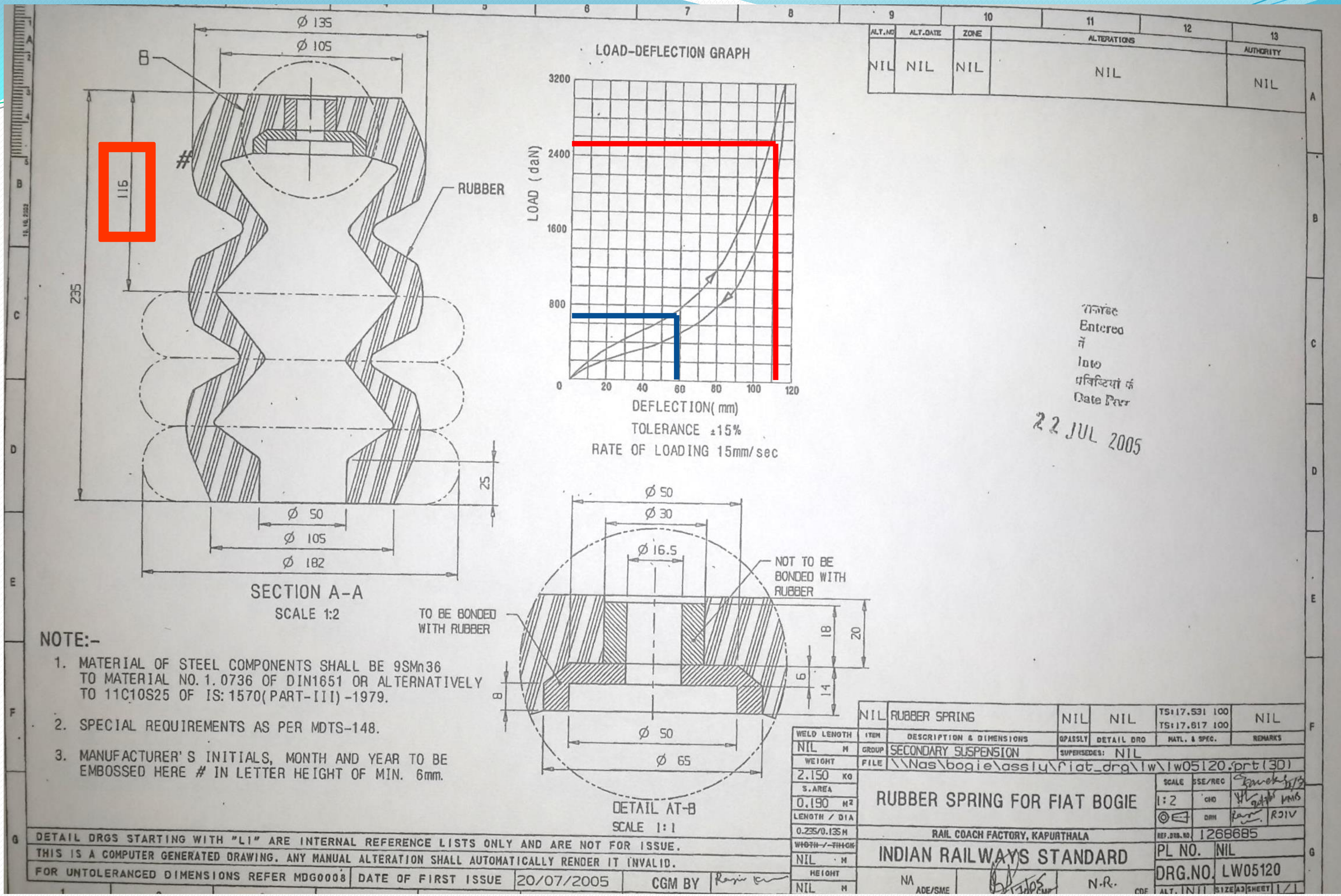
3 - 2



Bottom side of primary springs

(With Secondary Spring System Exploded)





LOAD-DEFLECTION GRAPH
LOAD (daN)
3200
2400
1600
800
0
20
40
60
80
100
120
DEFLECTION(mm)
TOLERANCE ±15%
RATE OF LOADING 15mm/sec
Ø 135
Ø 105
B
116
235
#
RUBBER
25
Ø 50
Ø 105
Ø 182
SECTION A-A
SCALE 1:2
TO BE BONDED WITH RUBBER
Ø 50
Ø 30
Ø 16.5
NOT TO BE BONDED WITH RUBBER
18
20
6
14
8
Ø 50
Ø 65
DETAIL AT-8
SCALE 1:1
NOTE:-
1. MATERIAL OF STEEL COMPONENTS SHALL BE 9SMn36 TO MATERIAL NO. 1.0736 OF DIN1651 OR ALTERNATIVELY TO 11C10S25 OF IS: 1570(PART-III)-1979.
2. SPECIAL REQUIREMENTS AS PER MDTS-148.
3. MANUFACTURER'S INITIALS, MONTH AND YEAR TO BE EMBOSSED HERE # IN LETTER HEIGHT OF MIN. 6mm.
ALT.NO ALT.DATE ZONE ALTERATIONS AUTHORITY
NIL NIL NIL NIL NIL
22 JUL 2005
RUBBER SPRING
SECONDARY SUSPENSION
\\Nas\bogie\assly\fiat_drg\lw\lw05120.prt(30)
RUBBER SPRING FOR FIAT BOGIE
RAIL COACH FACTORY, KAPURTHALA
INDIAN RAILWAYS STANDARD
WEIGHT 2.150 KG
S.AREA 0.190 M2
LENGTH / DIA 0.235/0.135 M
1:2
REF.DRG.NO 1268685
PL NO. NIL
DRG.NO. LW05120
TS:17.531 100
TS:17.817 100
DETAIL DRGS STARTING WITH "LI" ARE INTERNAL REFERENCE LISTS ONLY AND ARE NOT FOR ISSUE.
THIS IS A COMPUTER GENERATED DRAWING. ANY MANUAL ALTERATION SHALL AUTOMATICALLY RENDER IT INVALID.
FOR UNTOLERANCED DIMENSIONS REFER MDG0008
DATE OF FIRST ISSUE 20/07/2005
CGM BY

RESONANCE

Natural Frequency = $\dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$

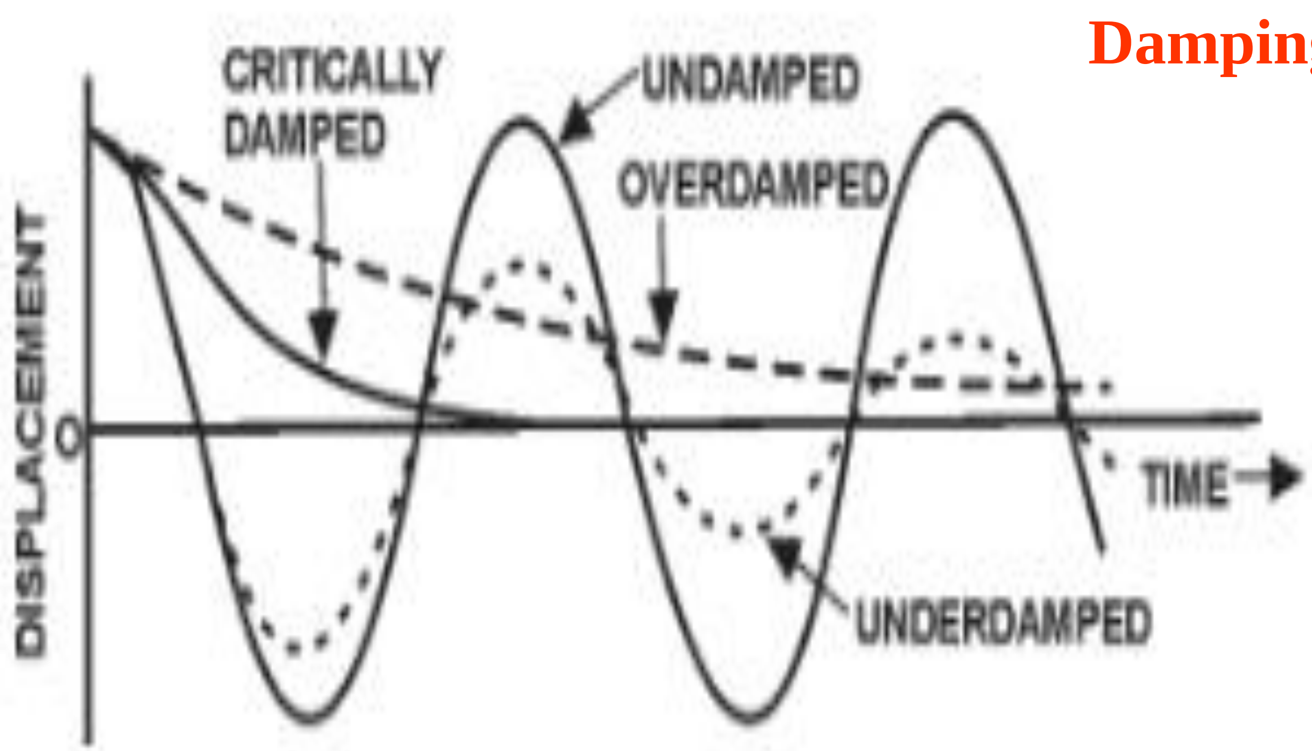
k = Spring Stiffness

m = Mass

If frequency caused by external excitation is equal to natural frequency, resonance occurs. If there is no damping in the system, the amplitude becomes infinite with time.

High stiffness >>>> High frequency >>> Poor Ride

TYPES OF FREE OSCILLATIONS



Damping 20% per cycle

Critical damping is the minimum amount of damping overshooting the equilibrium position when released from displaced position

SECONDARY SUSPENSION

NEST OF FLEXI-COIL SPRINGS INNER AND OUTER, RUBBER SPRING WITH (MINER)PAD &, PRI. VERTICAL, SEC. VERTICAL & LATERAL AND YAW DAMPERS AND ANTI ROLL BAR ETC.

- **SEC. VERTICAL DAMPERS -02 NOS.**

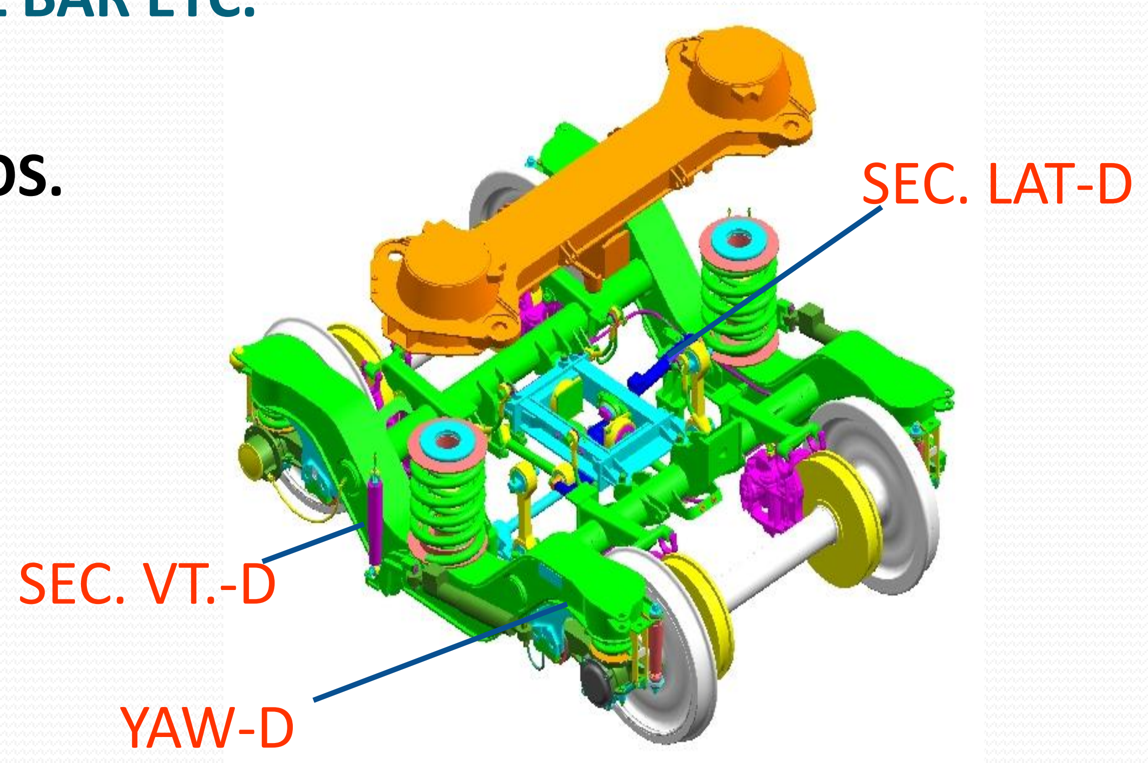
  3500 +/- 520 N @ 0.2 M/sec.

- **LATERAL DAMPERS -01 NOS.**

  8000 +/- 1200 N @ 0.3 M/sec.

- **YAW DAMPERS -02 NOS.**

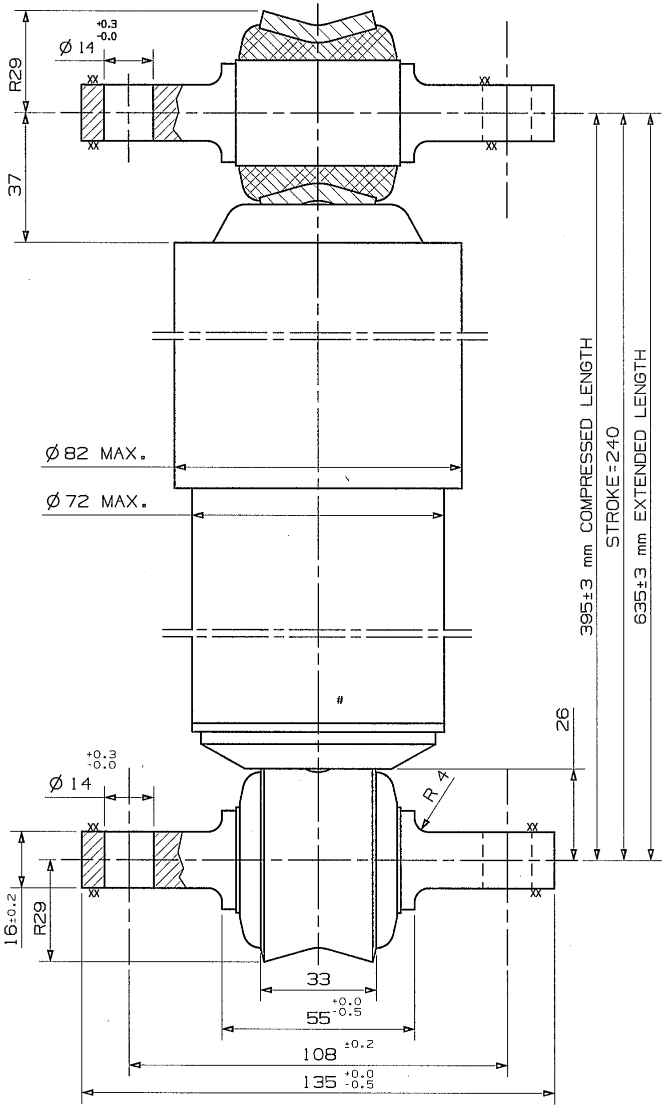
  11000 +/- 1650 @ 0.1 M/sec.

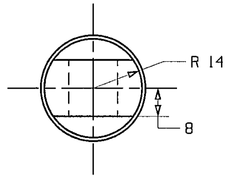


RATIO PRI AND SEC STIFFNESS
755 N/mm : 370 N/mm
67 % : 33 %

- **Combined Vt. Stiffness Sec. Spg. =370.6 N/mm**
- **Combined Lat.. Stiffness Sec. Spg. =195.6 N/mm**
- **Lateral flexibility provide better lateral ride.**

ALT.NO	ALT.DATE	ZONE	ALTERATIONS	AUTHORITY
a	20/09/2012	ALL ALL	NOTE NO 1. REVISED. NOTE NO. 4,5 & 7 DELETED & UPDATED IN TABLE	DY CME-D3 NOTING ON MD23161





END VIEW OF PIN

$$\text{Velocity} = \pi * f * c$$

$$= \pi * \frac{\text{rpm}}{60} * \text{stroke}$$

Act.disp./Force delivered by damper

$$u/F = (1/k) - (1/wd)$$

DAMPER TESTING AT 20° ± 2°C

1.	STROKE	50	mm
2.	NO OF REVOLUTIONS	76	min^{-1}
3.	VELOCITY	0.20	m/s
4.	FORCE	3500±520	N
5.	TORSIONAL ANGLE	±22°	DEG
6.	CARDANIC ANGLE	±10°	DEG
7.	RADIAL STIFFNESS AT END CONNECTIONS	8500N	mm

k = series stiffness

$w = 2\pi f$

d = Damping Cofficient

By Fourier Analysis

NOTE:-

1. # THE MANUFACTURERS NAME OR CODE,RATED CAPACITY, SERIAL NO.& MONTH & YEAR OF MANUFACTURER SHALL ALSO BE MARKED IN 10 MM HEIGHT LETTERS BY PUNCH MARK WITH MINIMUM DEPTH OF 0.25 MM.
2. XX-SURFACES ZINCED & FREE OF PAINTING.
3. PAINT SHADE TO RAL 7012.(BASALT GREY)
4. DAMPER IS MOUNTED ON VERTICAL POSITION.
5. MEASURE TOLERENCE. ON UN-TOLERENCE. DIM = ±1

Entered Into Date - 3 OCT 2012

WELD LENGTH	ITEM	DESCRIPTION & DIMENSIONS	QPASSLY	DETAIL DRG	MATL. & SPEC.	REMARKS
	NIL	DAMPER	NIL	NIL	T.S.17.560 100 03	NIL
NIL M	GROUP	SECONDARY SUSPENSION	SUPERSEDES: NIL			
WEIGHT	FILE	//ibmx3800/bogie/ug_assly/bog_sld/fiat_assly/fiat/lw05101a.prt(3D)				

SECONDARY VERTICAL DAMPER

RAIL COACH FACTORY, KAPURTHALA

रेलकोचफैक्टरीकपूरथला IRS

WEIGHT NIL KG	SCALE 1:1	SSE/REC	
S.AREA NIL M²	CHD	PKLR	
LENGTH / DIA NIL M	DRN	RANG	
WIDTH / THICK NIL M	REF.DRG.No.	FIAT 40 1300 020 139	
HEIGHT NIL M	PL NO.	00920060	
	DRG.NO.	LW05101	
ADE/SME	DY.CME	CDE	ALT. a SIZE A2 SHEET 1/1

DETAIL DRGS STARTING WITH "LI" ARE INTERNAL REFERENCE LISTS ONLY AND ARE NOT FOR ISSUE

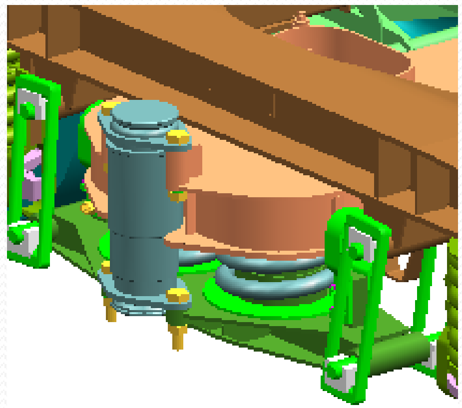
ANY MANUAL ALTERATION SHALL AUTOMATICALLY RENDER THIS DRAWING INVALID.

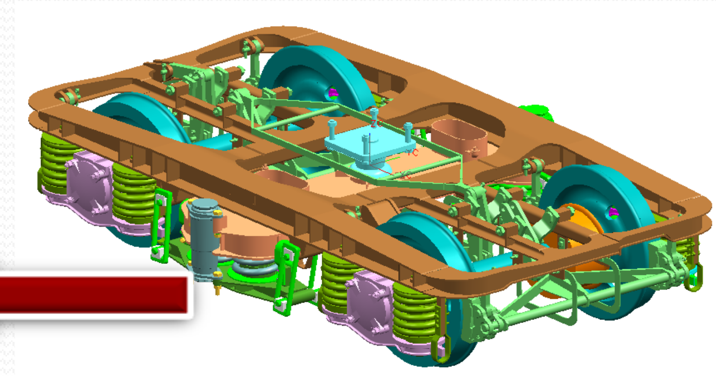
FOR UNTOLERANCED DIMENSIONS REFER MDG0008 | DATE OF FIRST ISSUE 29/01/2001 | CGM BY

Secondary Suspension

Vt . Stiff. =471 N/mm
d=42 mm ; Dm=242mm
N= 6.25 ; F.H.=400 mm

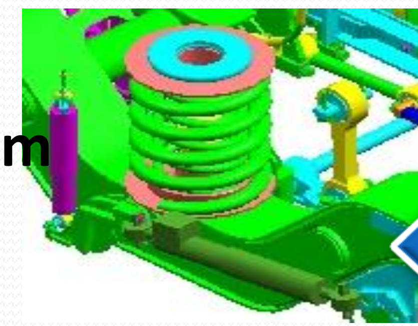
Helical coil suspension

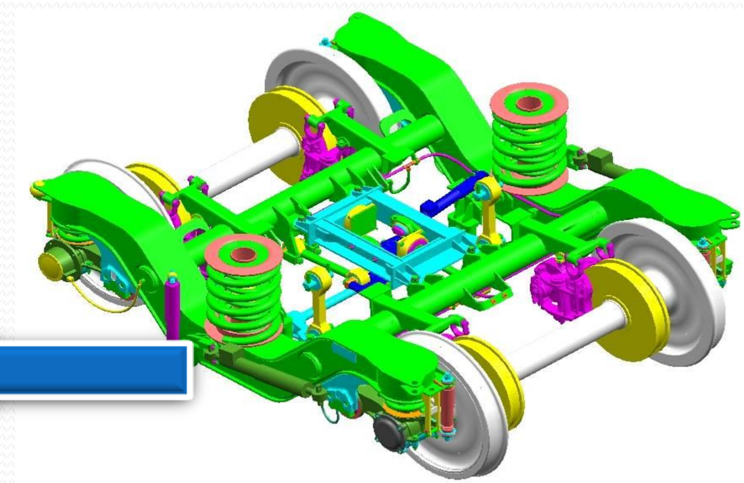




Conventional Bogie

Vt .Stiff.=241-O, 129 -I N/mm (370 N/mm)
d= outer 34 -- -Inner 26
Dm= outer 246, Inner 138
n= outer 8.3, inner=6.6
F.H. =outer707 inner 663 mm





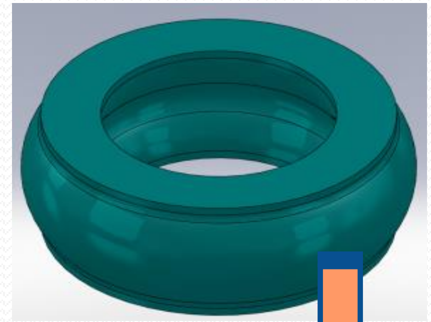
Flexi-coil suspension

Fiat Bogie

ALIGNMENT DEVIATION

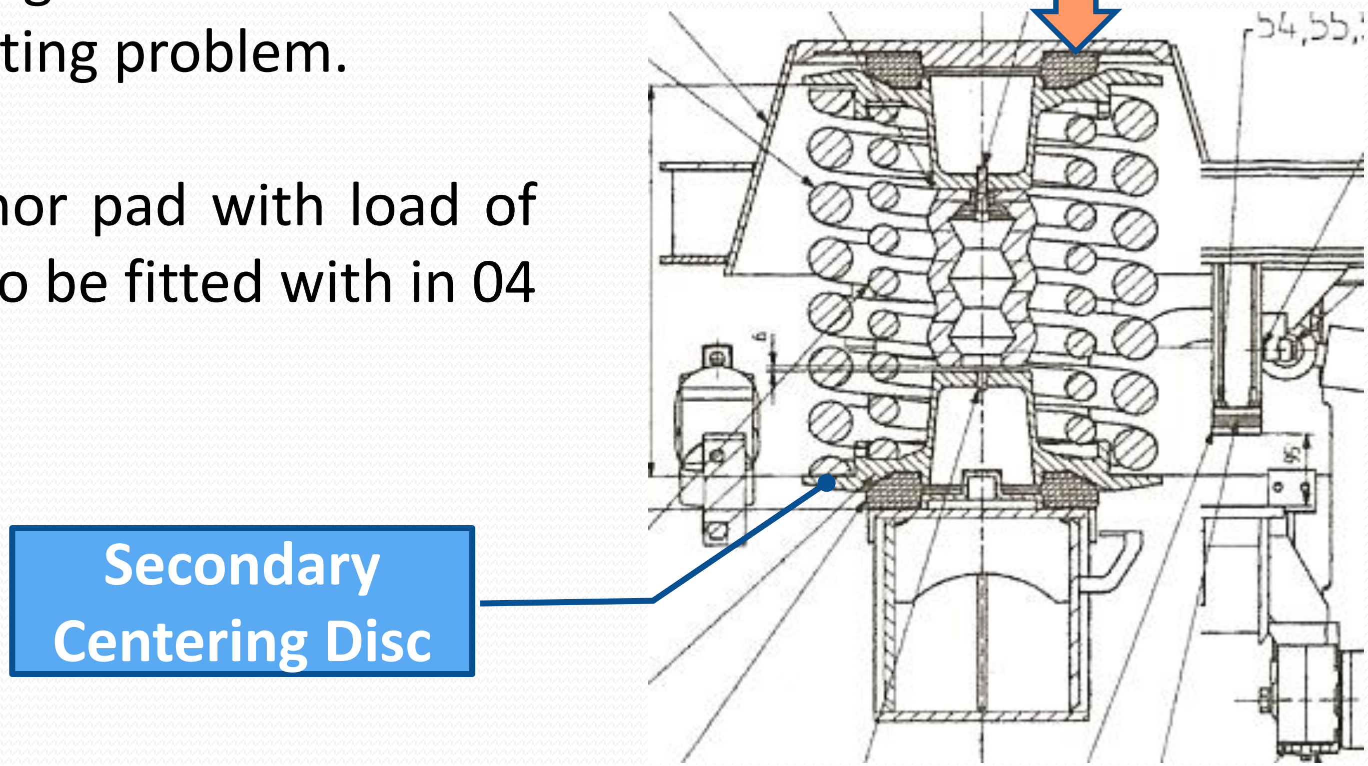
- Each flexicoil spring is provided with the following markings:
  - The positive directions of the alignment deviations is indicated with an Aluminium band (secured tightly and wound twice around the spring)
  - The length of the spring under test load and the value of the alignment deviation (in mm) are printed on a nonferrous metal band.

Proposal to avoid Shifting of Traction Centre



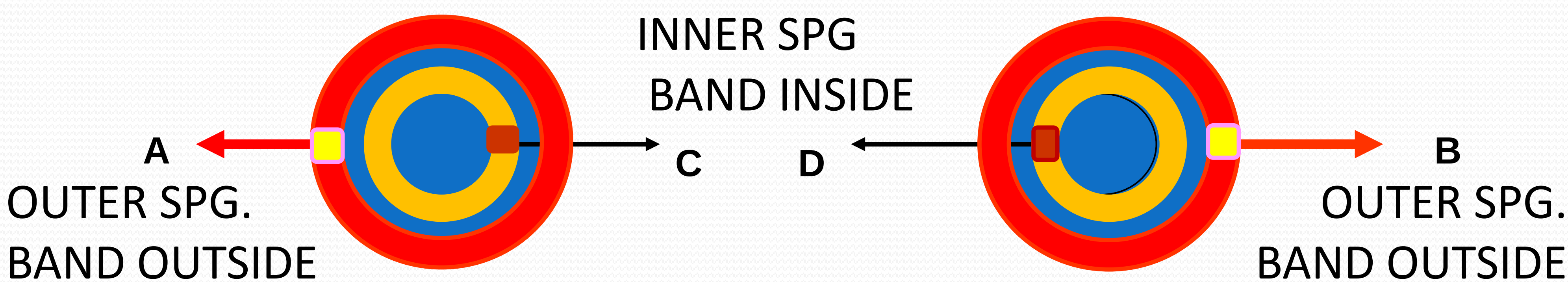
- Perforated stainless steel disc to tacked with bolster and side frame for under pressure plug locking of miner rubber pad to eliminate shifting problem.

- Pre compressed minor pad with load of 20 t before fitment to be fitted with in 04 hors (TS-17477)



ALIGNMENT DEVIATION (COUPLING INSTRUCTIONS)

- **The difference between the alignment deviations of the two outer springs not to exceed 4 mm and that of the inner springs 8 mm.**
- **The outer and inner springs with the greater alignment deviations must be situated in the same spring assembly, that is:**
- **If A greater than B, C should be greater than D**
- **A - B = 4 mm max, C - D = 8 mm max**



SPRING TESTING AND DAMPER TESTING MACHINES SHOULD BE INSTALLED IN ALL WORKSHOP FOR POH SO THAT EFFECT OF PERMANENT SET MAY BE COUNTER

SPRING TESTING MACHINE

DAMPER TESTING MACHINE

CANT ON CURVES

NO CANT - ROLLING　　FULL CANT - NO ROLLING　　DEFICIENT CANT - PARTIAL ROLLING

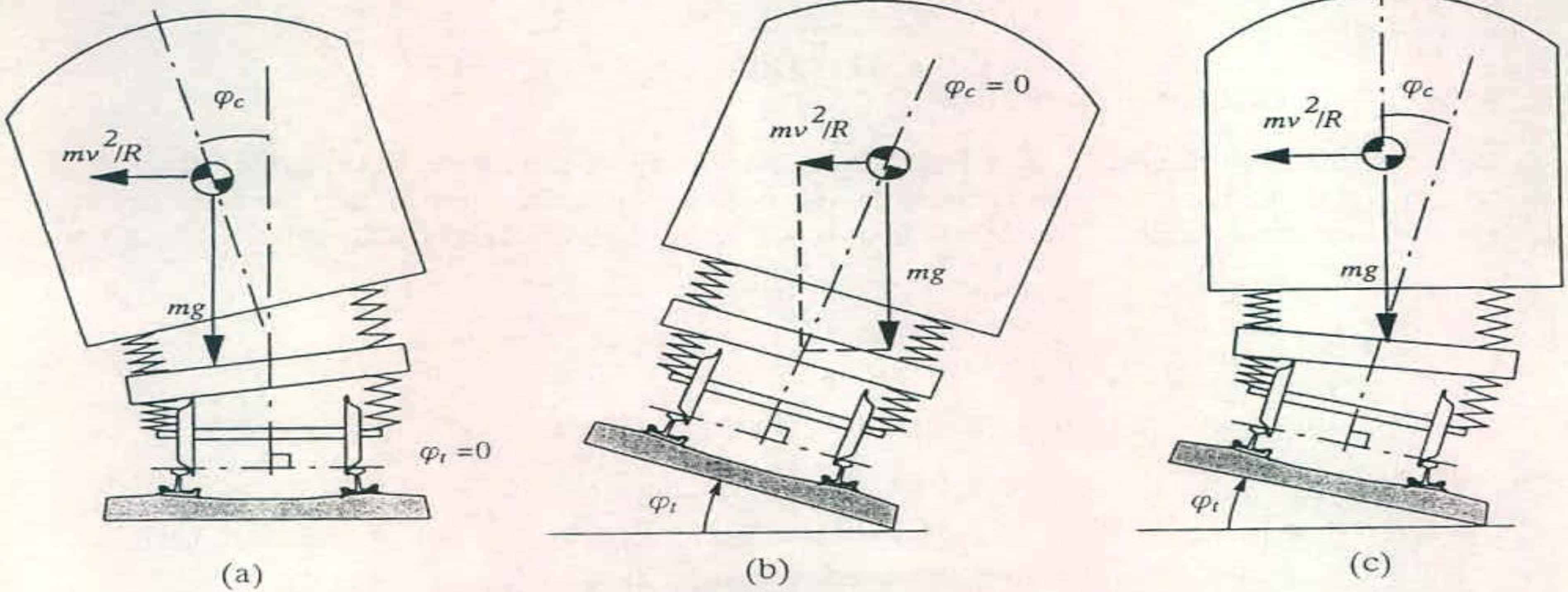


Figure 4-4 *Rolling of carbody for quasistatic curving. Centrifugal force mv^2/R, gravitational force mg, roll angle φ_c and cant angle φ_t.*

(a) No cant leads to rolling towards the outer side of the curve.

(b) Full compensation of track plane acceleration, $a_y = 0$, gives no rolling at all.

(c) Cant is not sufficient for compensating the track plane acceleration. The carbody rolls towards the outer side of the curve, as in (a).

SUPER ELEVATION

CENTRIFUGAL FORCE (F) = MASS (M) x ACCELERATION (a)

$$F = \left(\frac{W}{g}\right) \times \left(\frac{V^2}{R}\right)$$

WHERE V= SPEED METER/SEC.
R= RADIUS OF CURVE
W= WT. OF VEHICLE IN T.

TAN ϕ =SUPER ELEVATION / GUAGE

= e / G

= CENTRIFUGAL FORCE / WEIGHT

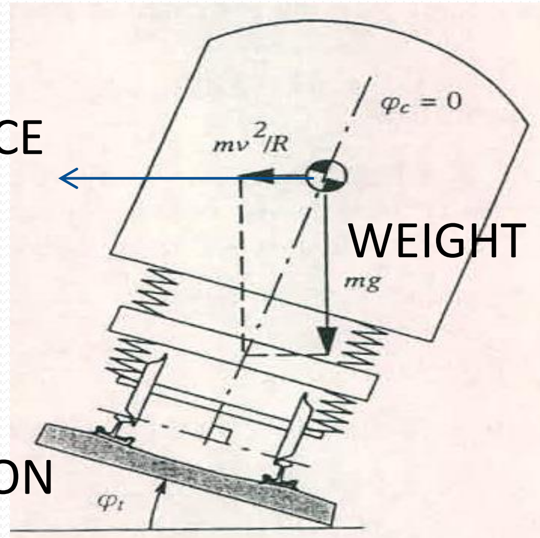
= F / W

HENCE e / G = F / W

$$e = \frac{G \times F}{W} \; ; \; \frac{G \times W \times V^2}{W \;\; g \;\; R} = \frac{G\,V2}{g\,R}$$

Super elevation **e =** $\mathbf{\dfrac{G\,V2}{127\,R}}$

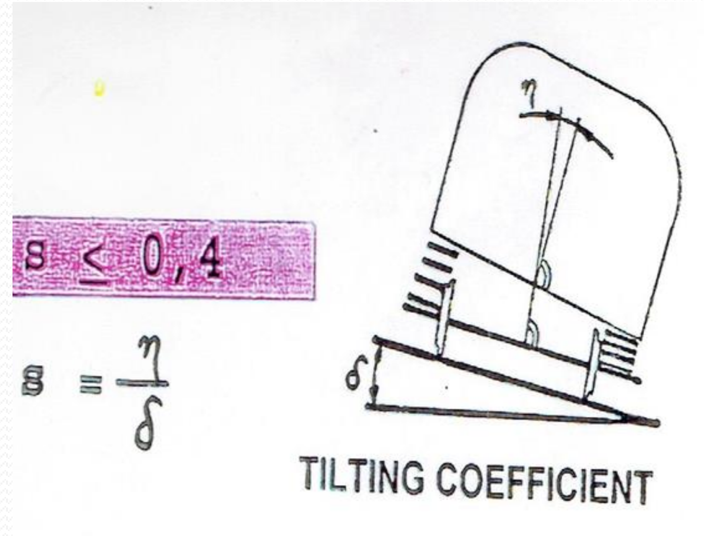
WHERE e = Super elevation in mm.
R= Radius of curve in Meters
V = velocity in KMPH
G = Dynamic Guage in mm (1750 mm in BG)

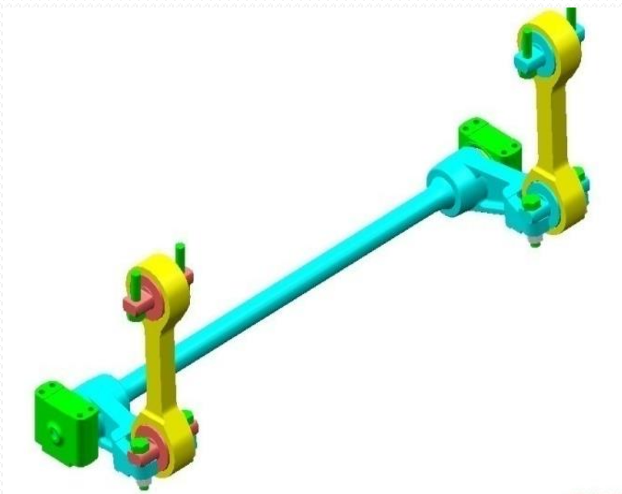


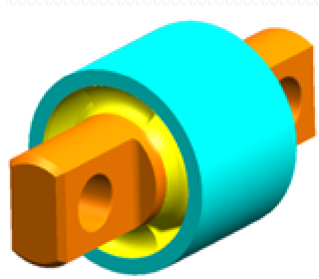
Degree of curve = 1750/ R in meter
175 M Curve = 10 degree

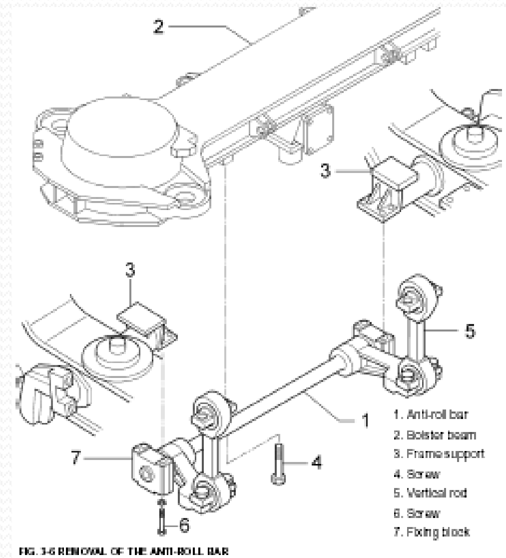
ANTI-ROLL BAR :

- **ANTI ROLL BAR USED TO CONTROL EXCESSIVE ROLLING MOTION AND TO CONTROL ROLL FREQUENCY. LOW ROLL FREQ. CAN LEAD TO NAUSEA ASSOCIATED WITH SEA SICKNESS.**
- **TILTING CO-EFFICIENT AS PER UIC-515-1 & 4 SHOULD BE LESS THAN 0.4 AT HIGH SPEED ON THE SHARPEST CURVE WITH MAX. PERMITTED CANT DEFICIENCY FOR KEEPING THE VEHICLE WITHIN DYNAMIC MOVING GUAGE AND FOR PASSENGER COMFORT.**
- **UIC-515-4 , Wind pr. 600 n/m^2 , Lateral force=43.2 kN , Tilting Momentum=108 kN**





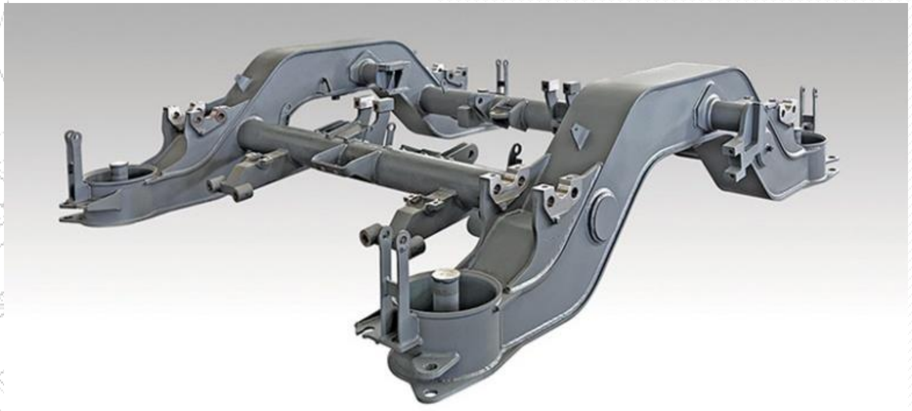




BOGIE FRAME

- Y-DIP SIDE FRAMES OF MATERIAL S355J2W+N EN10025 Part-5 in place of ST5 2.3
- TWO SIDE FRAMES CONNECTED BY TWO BRAKE BEAM ASSEMBLY
- (CROSS TUBES- DIN.1630-ST52.4 OD=168.3 THK=14.2 MM)

  WHICH SUPPORTS :



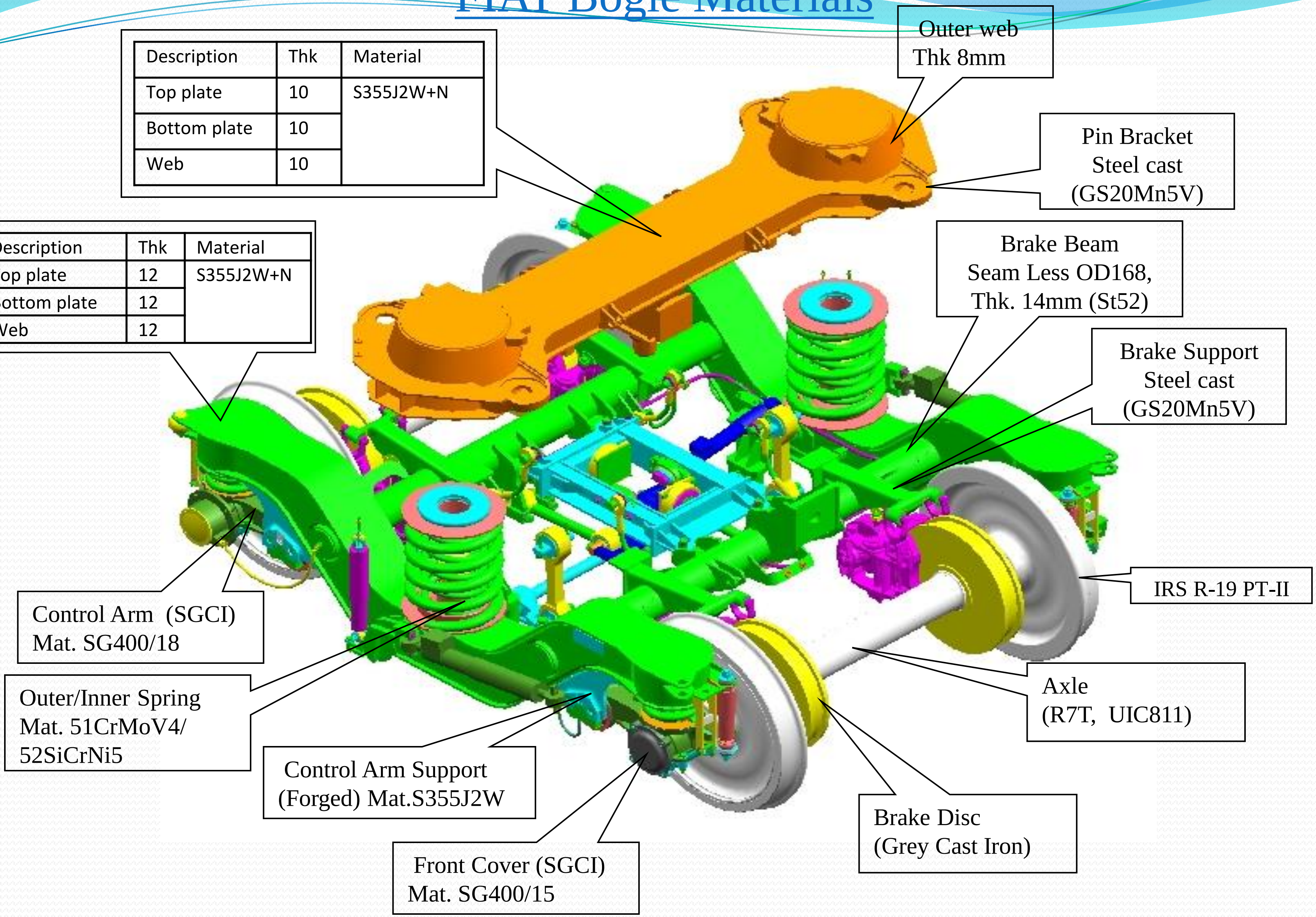
- CONTROL ARM BRACKETS
- SUPPORT BRAKE SUPPORT ,
- PRIMARY SPRING POTS
- ANCHOR LINK BRACKETS
- CROSS SECTION FRAME FOR LATERAL
- AND LOGITUDINAL BUMP STOPS ETC.

- Surface protection Garnet Ballast Sa 2.5DIN 8501
- Adhesion promoting Etch primer if ballsating not possible.
- Epoxy zinc phosphate primer RDSO spec M&C/PCN/100/2013
- Visco elastic aqueous synthetic resin Anti Stone Chipping Paint RCF MDTS 22283. for corrosion preention.

FIAT Bogie Materials

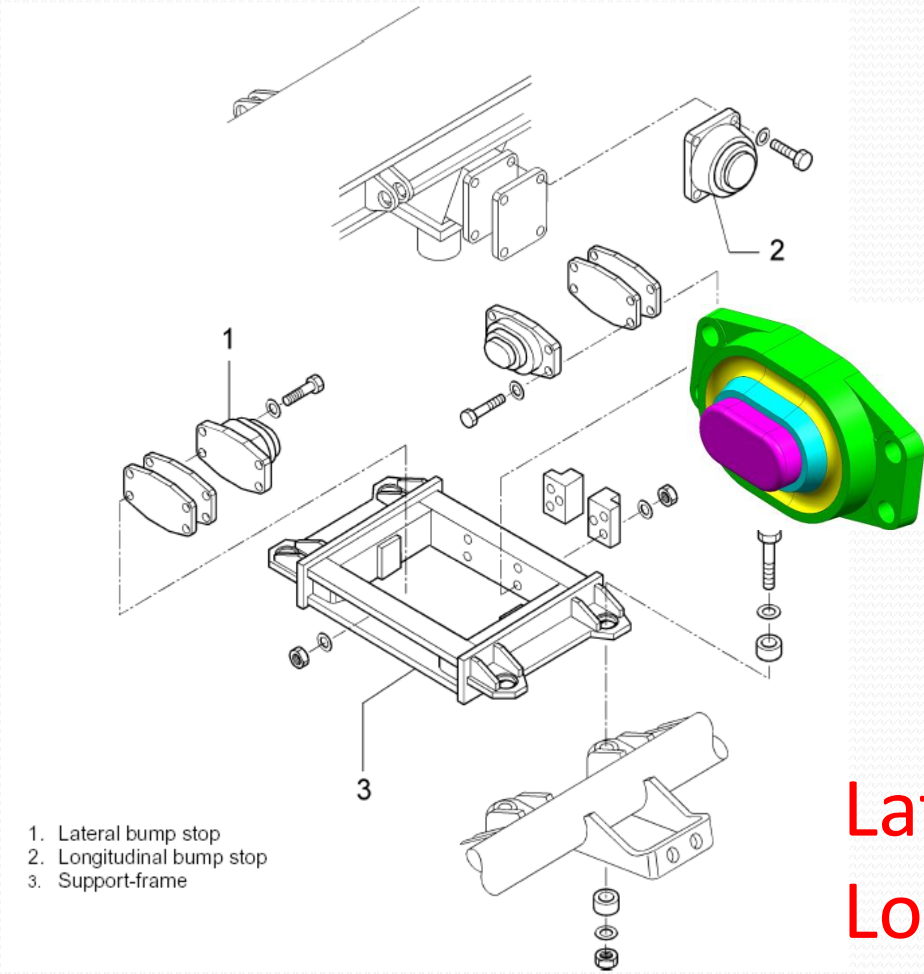
Description	Thk	Material
Top plate	10	S355J2W+N
Bottom plate	10	
Web	10	

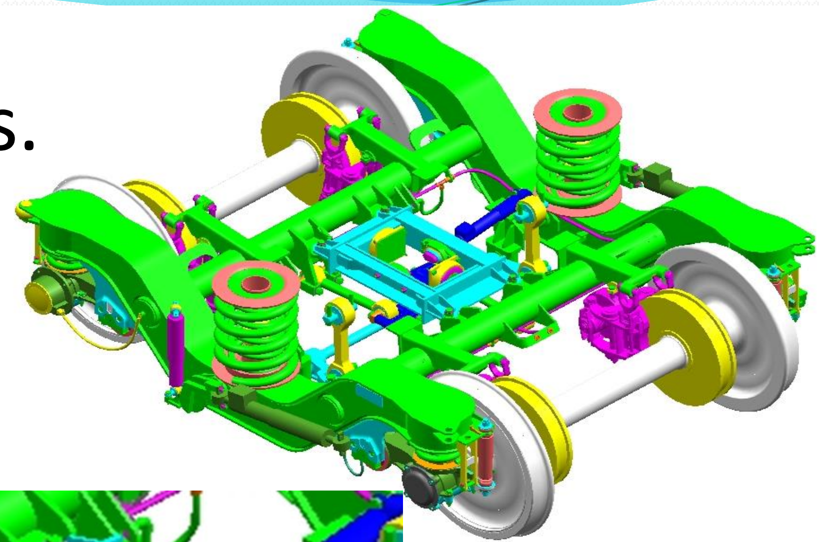
Description	Thk	Material
Top plate	12	S355J2W+N
Bottom plate	12	
Web	12	

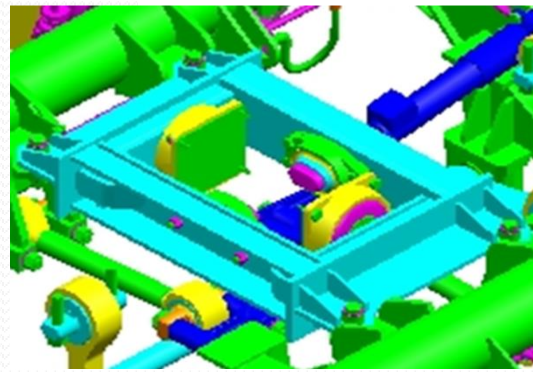


(**Without Bolster)**

Cross Section with Lateral and longitudinal stoppers.

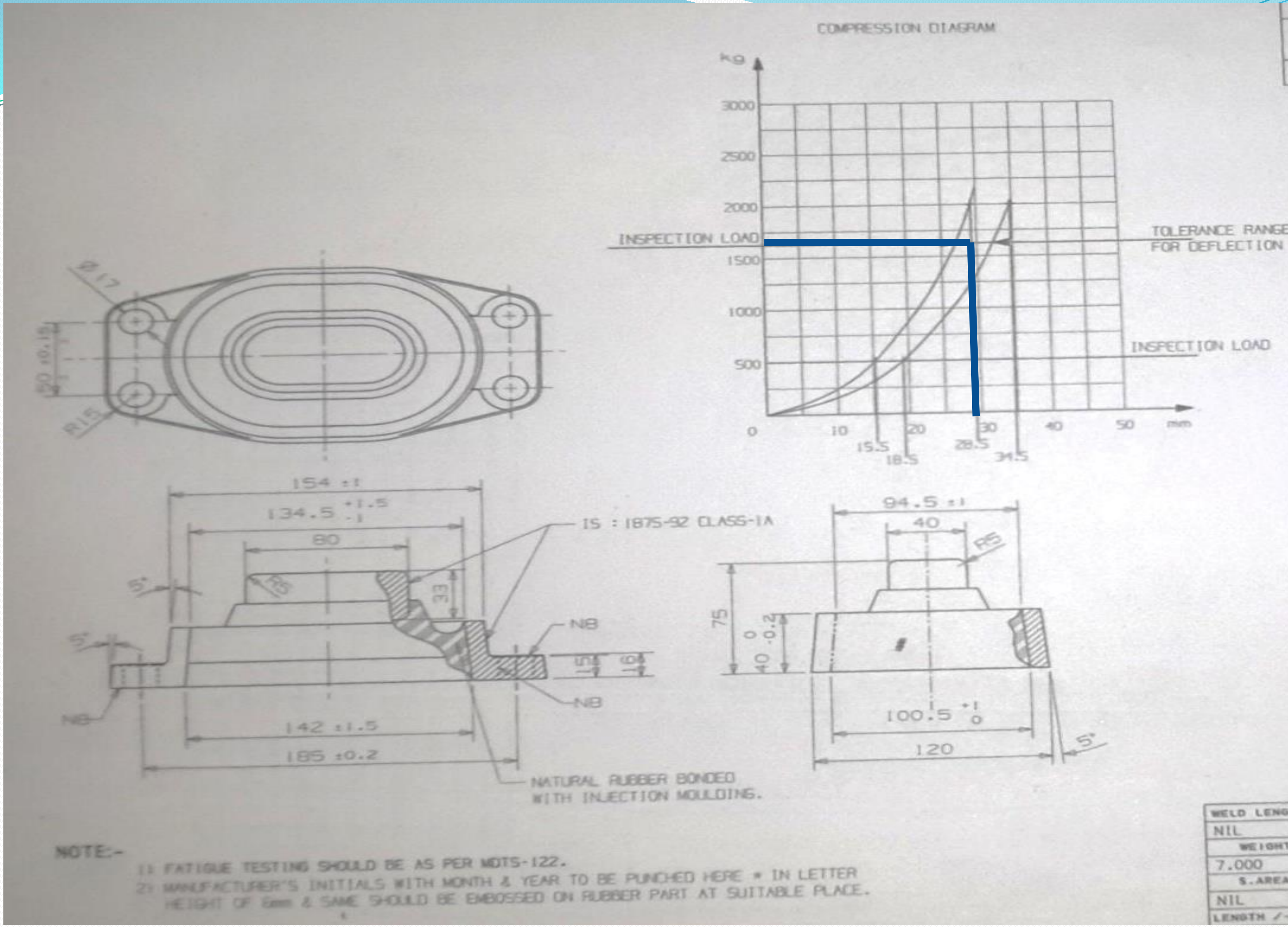




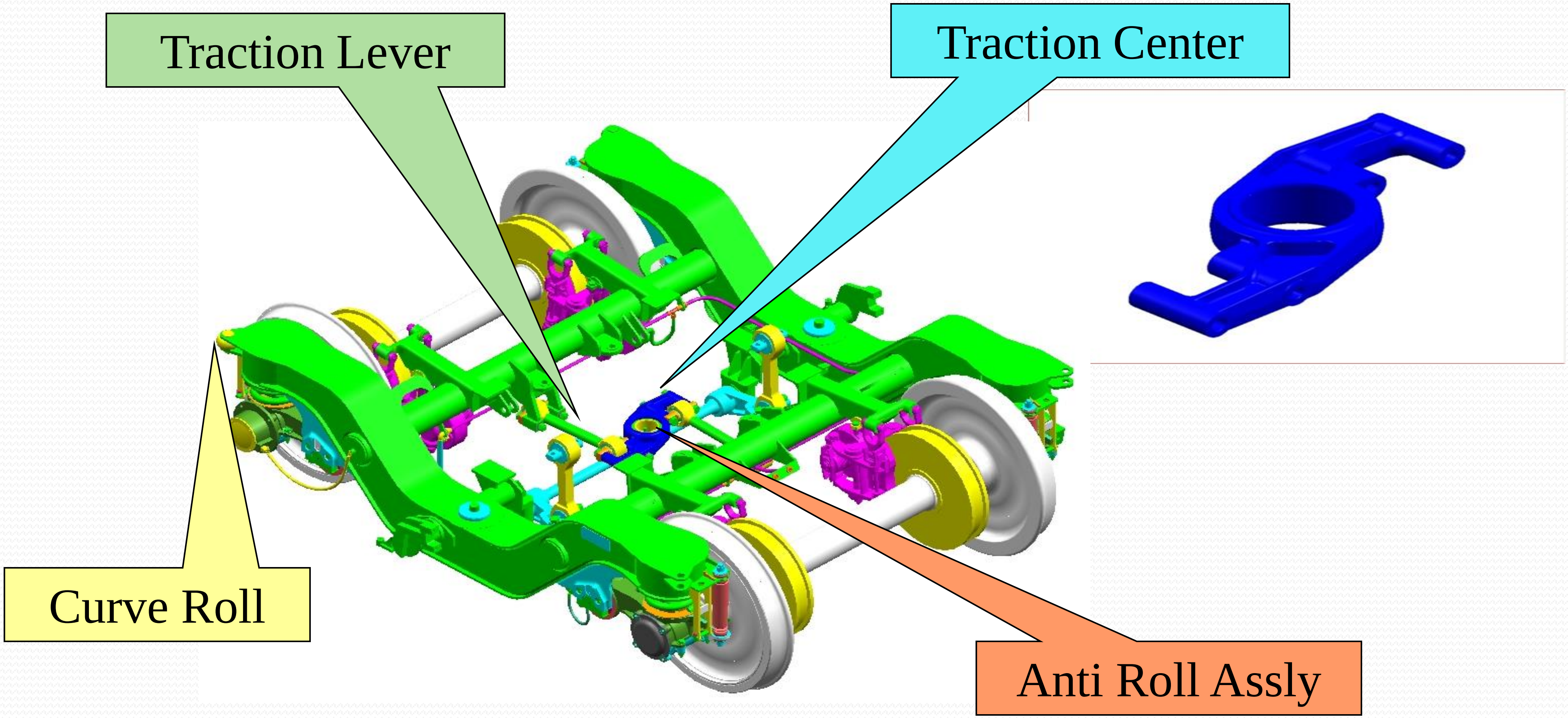


Lateral gap = 25 +/- 5mm ;

Longitudinal Gap = 8 +5/-2mm


COMPRESSION DIAGRAM
kg
3000
2500
2000
INSPECTION LOAD
1500
1000
500
0
10
20
30
40
50
mm
15.5
18.5
28.5
34.5
TOLERANCE RANGE FOR DEFLECTION
INSPECTION LOAD
Ø17
R15
154 ±1
134.5 +1.5 -1
80
R5
33
5°
IS : 1875-92 CLASS-IA
NB
15
16
142 ±1.5
185 ±0.2
NATURAL RUBBER BONDED WITH INJECTION MOULDING.
94.5 ±1
40
R5
75
100.5 +1 0
120
WELD LENGTH
NIL
WEIGHT
7.000
S.AREA
NIL
NOTE:-
1) FATIGUE TESTING SHOULD BE AS PER MDTS-122.
2) MANUFACTURER'S INITIALS WITH MONTH & YEAR TO BE PUNCHED HERE * IN LETTER HEIGHT OF 6mm & SAME SHOULD BE EMBOSSED ON RUBBER PART AT SUITABLE PLACE.

Traction center with traction levers



Traction and braking forces:

- BODY-BOGIE BOLSTER CENTER POST - TRACTION CENTRE-TRACTION LEVER/LONGITUDINAL BUMP STOP-BOGIE FRAME-CONTROL ARM-AXLES.

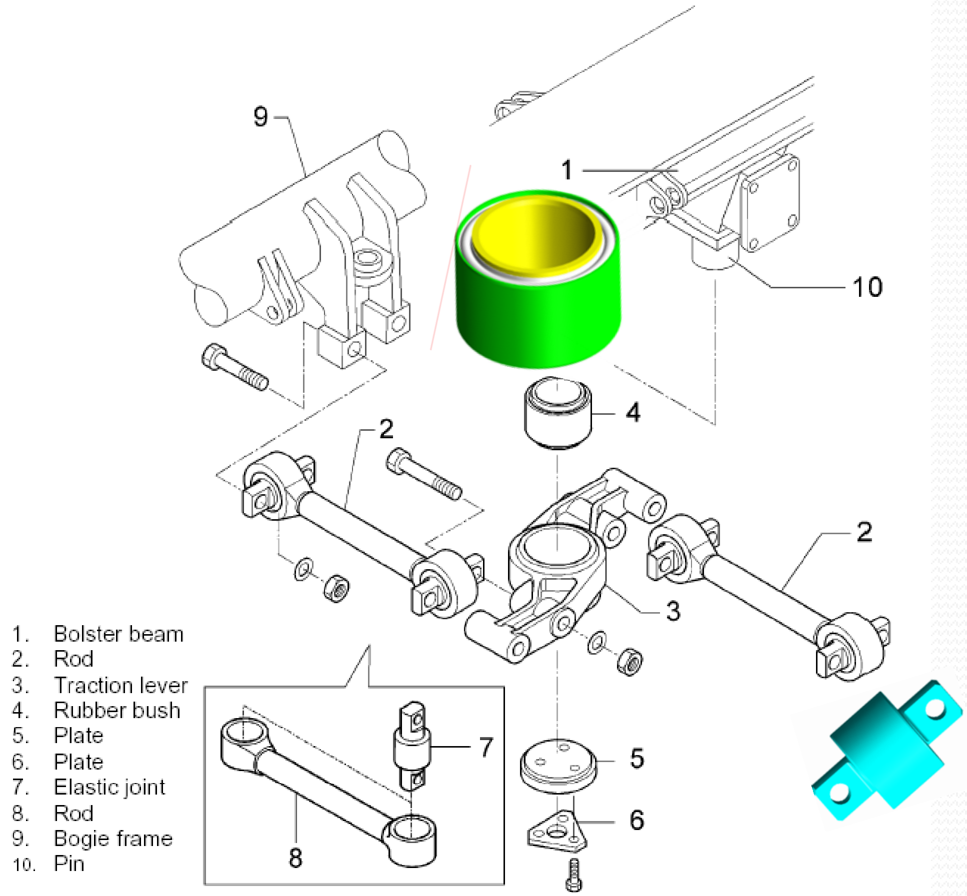
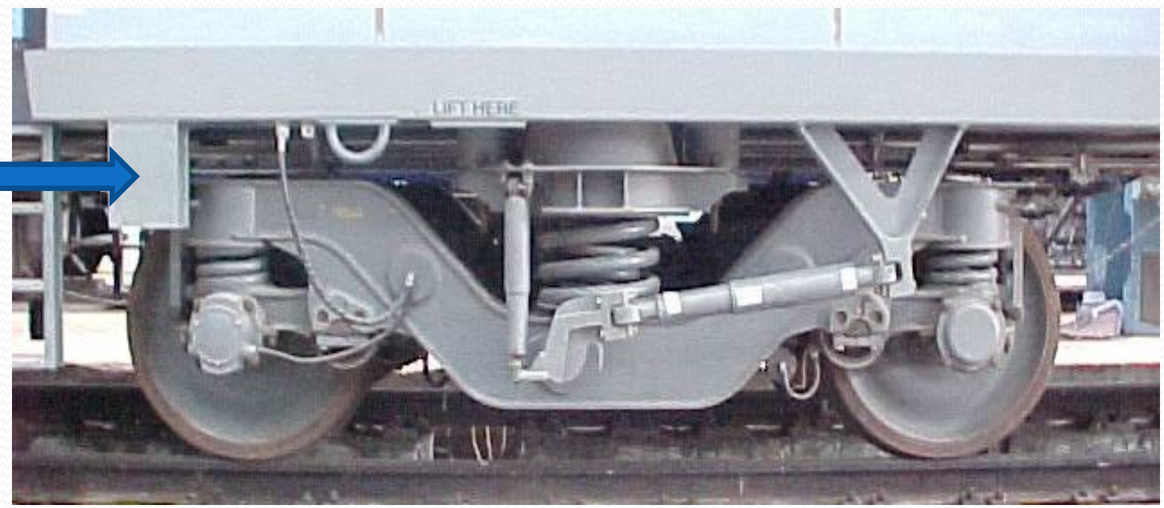


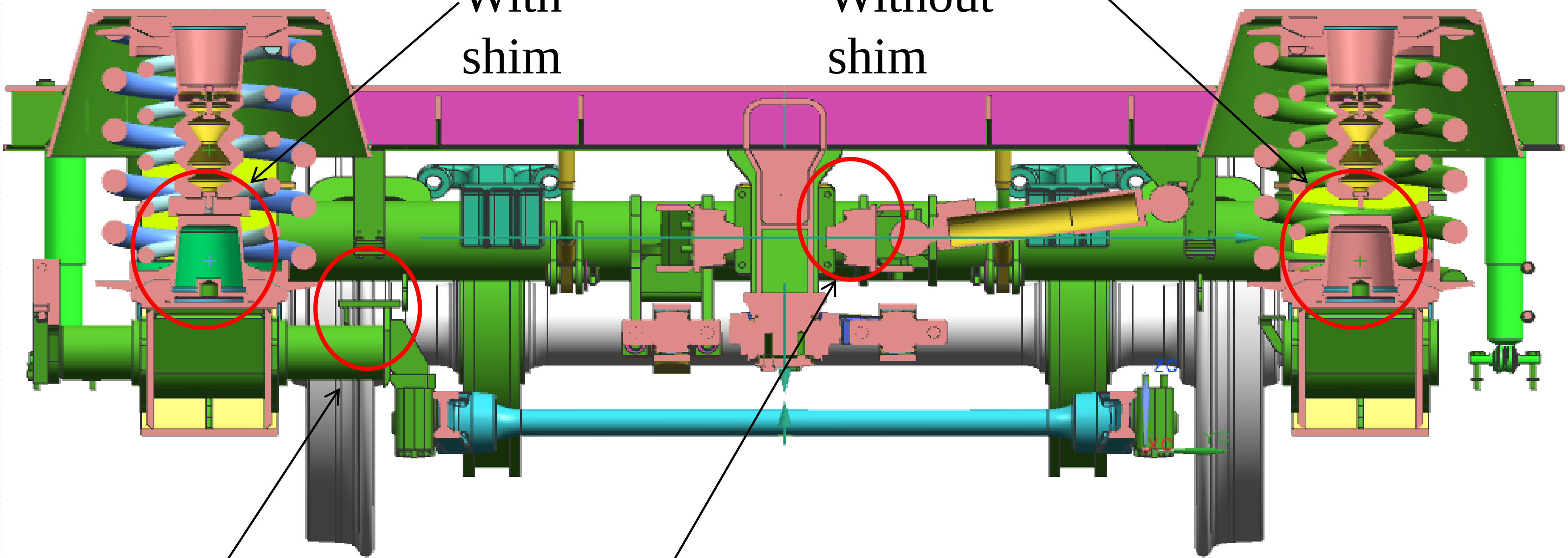
FIG. 1-11 TRACTION CENTRE

CURVE ROLL ON COACH END SIDE TO RESTRICT EXCESS ROTATION OF BOGIE WITH RESPECT TO COACH

STOPPER BRACKET NEAR FOOT STEP ARRGT. ON UNDER FRAME FOR RESTRICTED MOVEMENT OF CURVE ROLL



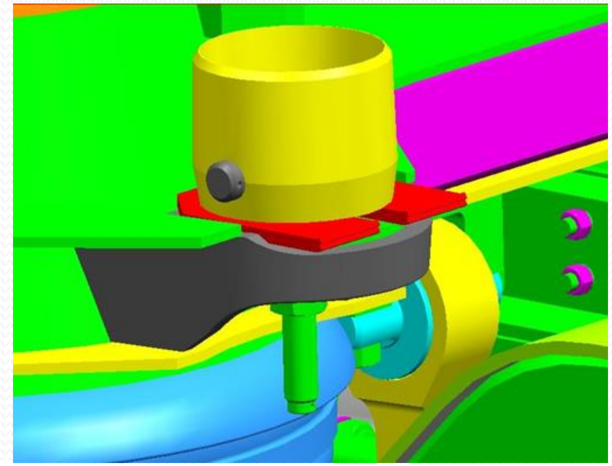
Important clearances in dynamic situation

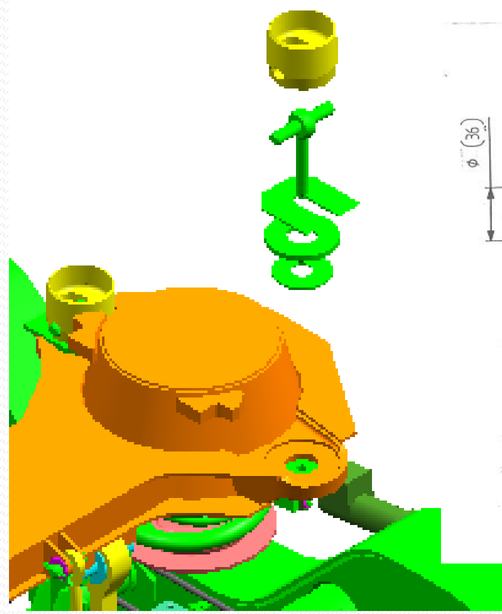


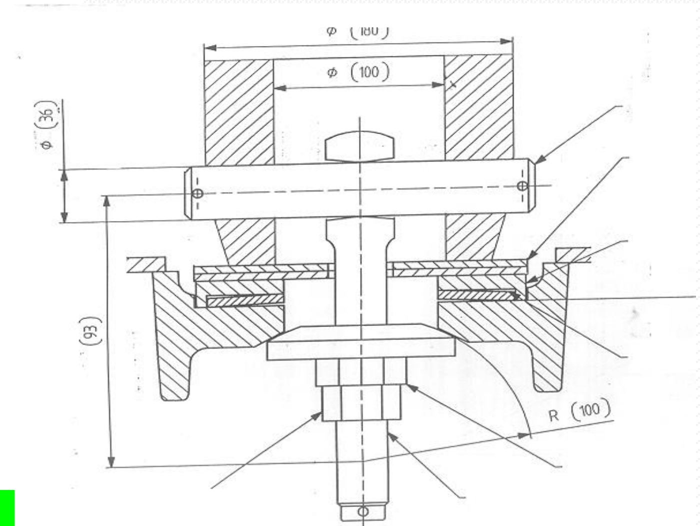
Bogie Body Connection

- 14mm shims are essentially required in new coach, in tare condition, to maintain CBC height and sole bar bottom level from level.

- As per LHB document maximum permissible limit for shims, for buffer height adjustment, is 64 mm (including mandatory shims of 14mm).

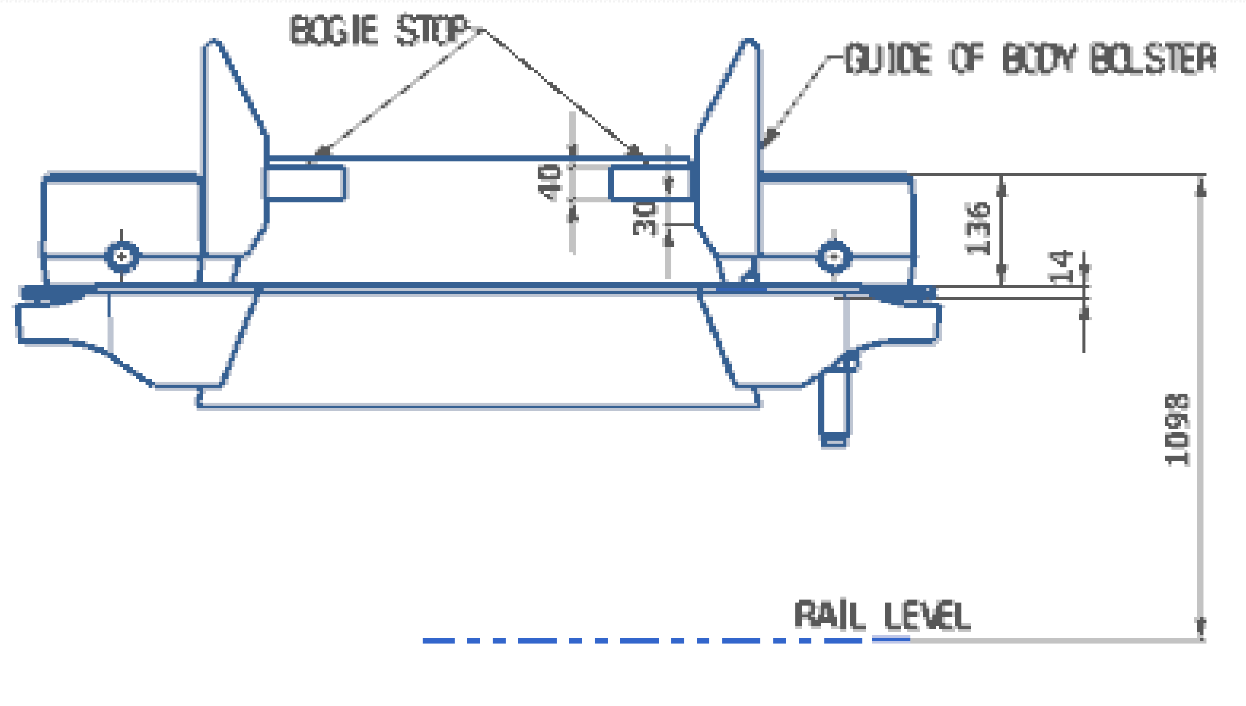


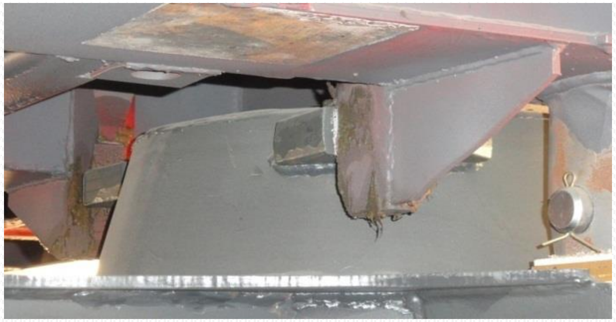




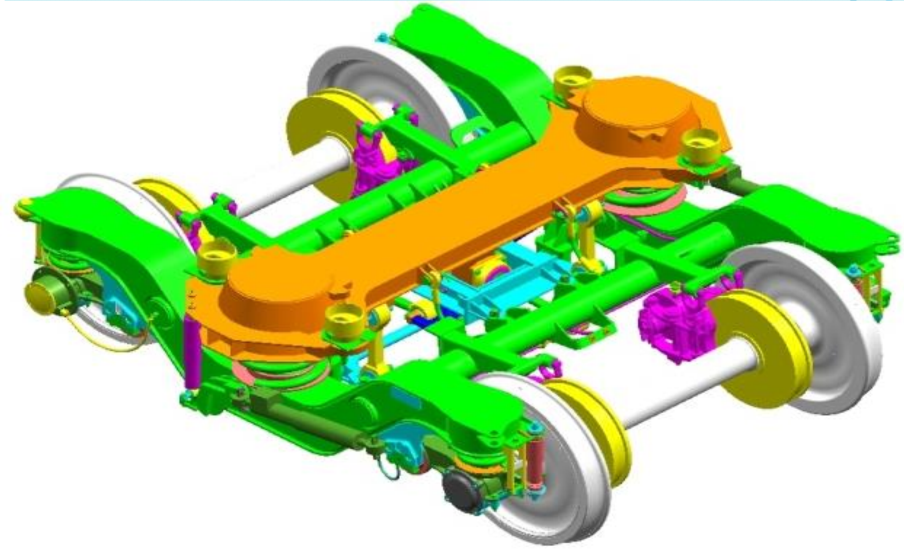
Bogie Body Connection

- ✓ **Provides rigid connection between body and bogie**
- ✓ **Capable to transmit 0.25g acceleration in lateral and longitudinal in normal operation and 5g in emergency condition**





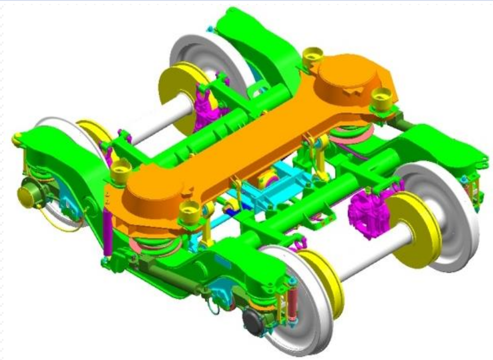
Force Transmission path



Vertical Forces	Lateral Forces	Traction and braking forces
• Body bolster • Miner Pad • Sec. Suspension • Bogie Frame • Primary Springs • Ball joint control arm • Axle	• Body bolster • Miner pad • Sec. Springs • Lateral Bump Stop • Bogie frame • Ball joint control arm • Axles	• Body • Traction center • Traction lever • Longitudinal bump stop • Bogie frame • Control arm • Axle

Force Transmission Route

Vertical Forces	Lateral Forces	Traction and braking forces
• Body bolster • Miner Pad • Sec. Suspension • Bogie Frame • Primary Springs • Ball joint control arm • Axle	• Body bolster • Miner pad • Sec. Springs • Lateral Bump Stop • Bogie frame • Ball joint control arm • Axles	• Body • Traction center • Traction lever • Longitudinal bump stop • Bogie frame • Control arm • Axle



Brake disc- Converts kinetic energy into heat energy

SPECIFICATION

Dimension -

640 mm x 110 mm; Brake Radius 247 mm

Type -

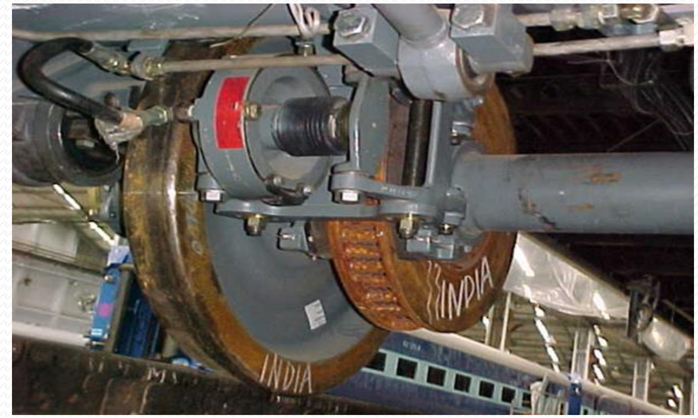
Axle shaft mounted, concentrically split,

Material -

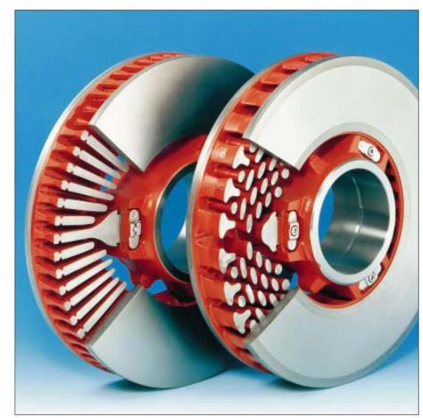
Grey cast iron Friction ring

Wear (allowed) -upto 96 mm width.

Weight - 126 kg

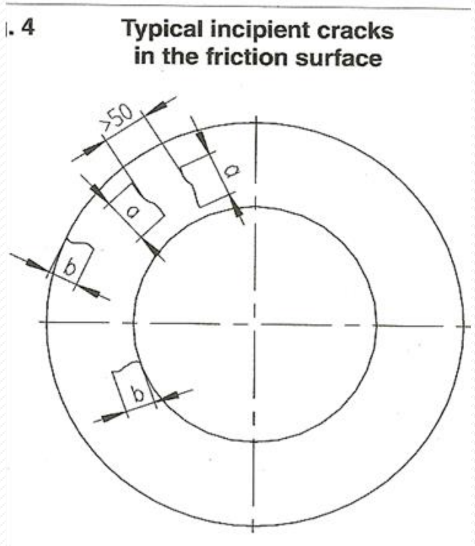


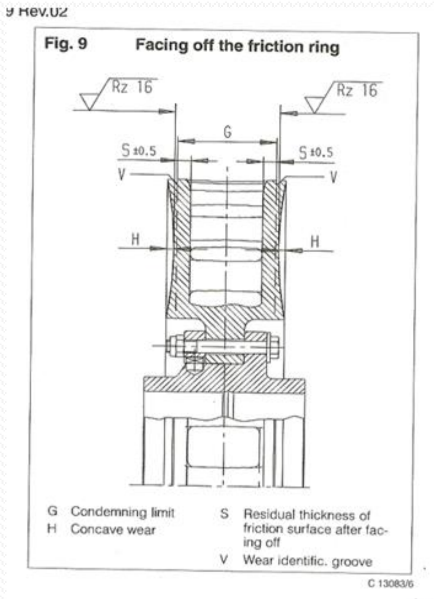
- ORGANIC PADS: Typically contain Asbestos free Synthetic rubber with nonferrous metals, organic mineral fibers, abrasives, lubricants and property modifiers such as glass, rubber, kevlar and carbon



Brake Disc

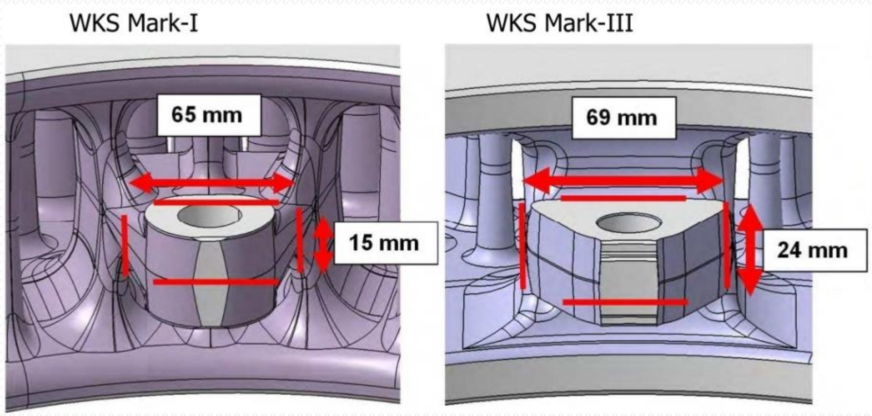
- Internally vented (Apprx. Weight 145 Kg)
- Good heat dissipation and high braking performance
- No maintenance required
- Wear checks/limits:
  - No hair, incipient crack or through cracks permitted on Hub/connected flange:
  - Incipient cracks on Disc:
  - <80mm, apart by 50mm min. permitted propagating
  - between two edges
  - <50mm, apart by 50mm min permitted propagating
  - from the edges
  - Scoring up to 1mm allowed
  - Concave wear up to 2mm allowed
  - Residual thickness up to 14mm of disc friction surface
  - Slanting wear up to 2mm allowed
  - Permitted for breakage of 4 fins max. alternatively



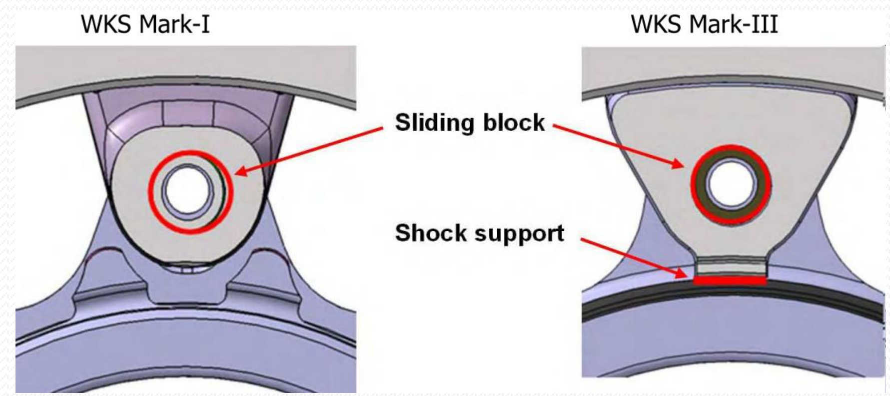


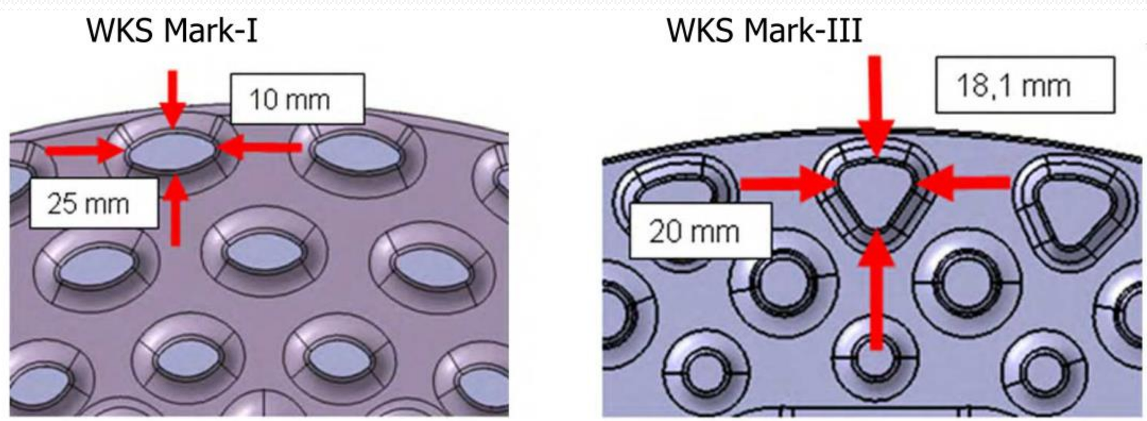
Improvements in brake disc from MARK-I ----MARK-III

Reinforced cross section of lug by +70%



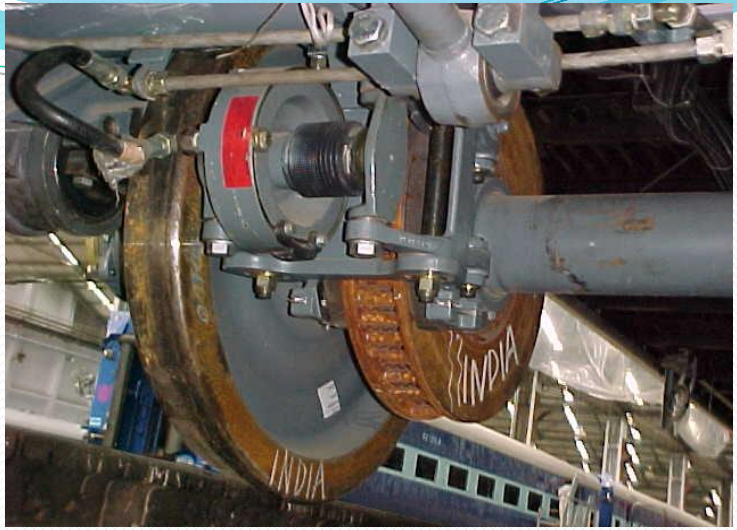
Sliding Blocks and additional „Shock Support“





Reinforced Outer Cooling Fins by +32%

Brake caliper & Brake pad



- Suitable for UIC type 200 x 2 brake pads, thickness 35mm
- Caliper ratio -2.17 (2.48 for special coaches- power car and DD)
- Brake radius - 247 mm
- Weight -67 kg (with brake pad)
- Wear limit - 28mm max.
-

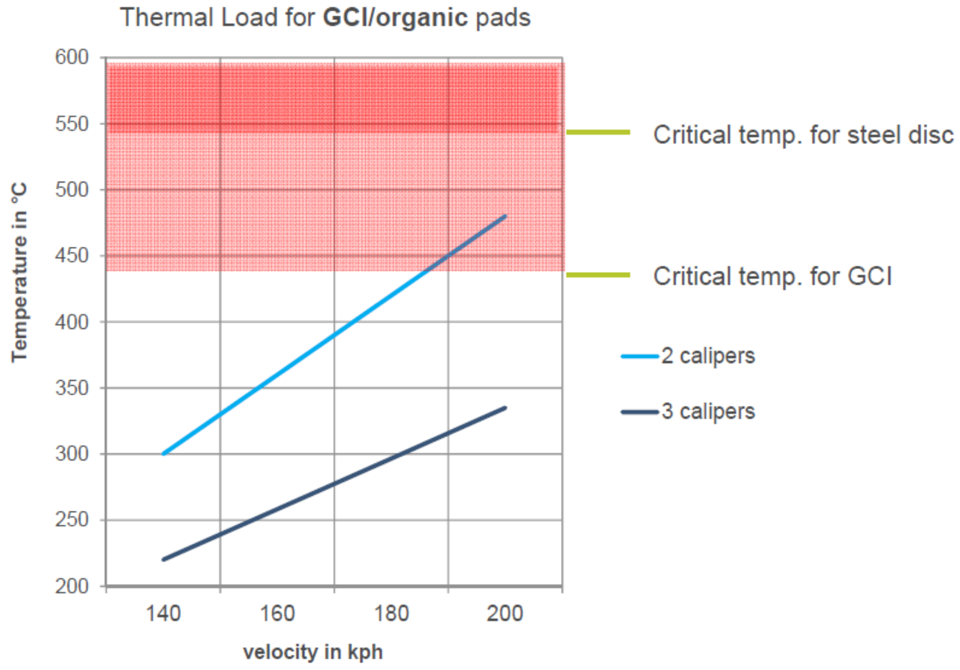
Approved 35 mm Non asbestos pads for LHB

JURID 877 of M/s Federl Mogul (Honeywell) germany
BECORIT 984 of M/s Becorit, Germany
BK 7000 of M/s Bremskerl, Germany

Friction co-eff.-0.35; Conforms to requirements in UIC 541-3 OR RDSO specification : CG/2013/CG-01

DISC BRAKE SYSTEM FOR 200 KMPH.

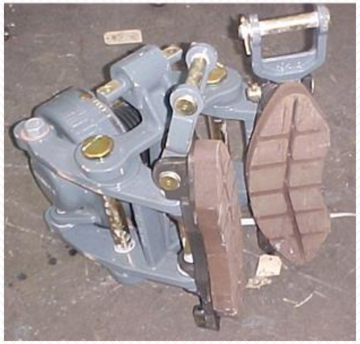
- Electro Pneumatic assist –Control panel with elctro Magnet valve advantage in achieving uniform braking & EBD
- Steel discs (instead of grey cast iron) per axle to keep the temperature of the brake discs and the pads under control
- Flexible sintered pads - provides iso-pressure even in case of wear of pads and brake energy upto 40 MJ / disc
- Life cost cycle of CS Disc + sintered 185 % in comparison to than GCI disc +organic pads

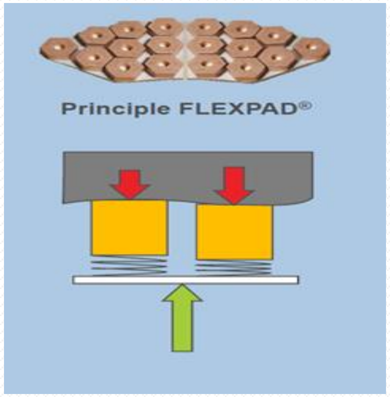


[schematic diagrams]

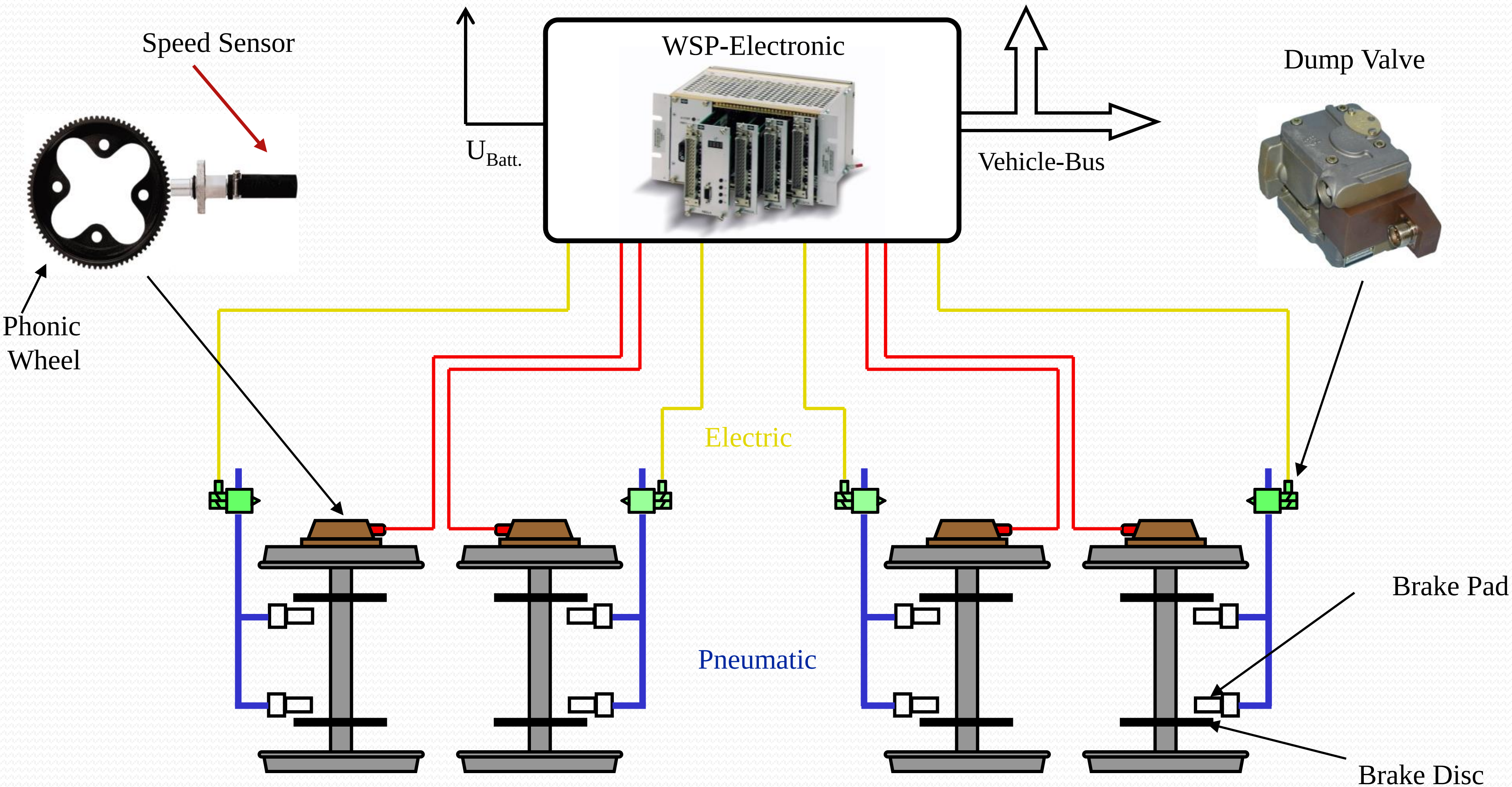
Emergency Braking Distance

Initial speed	pneumatic	With EP
160 km/h	1173 m	1017 m
180 km/h	1451 m	1275 m
190 km/h	1600 m	1415 m
200 km/h	1757 m	1562 m

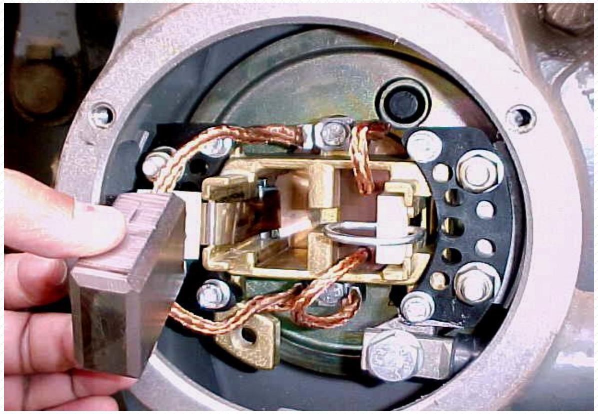


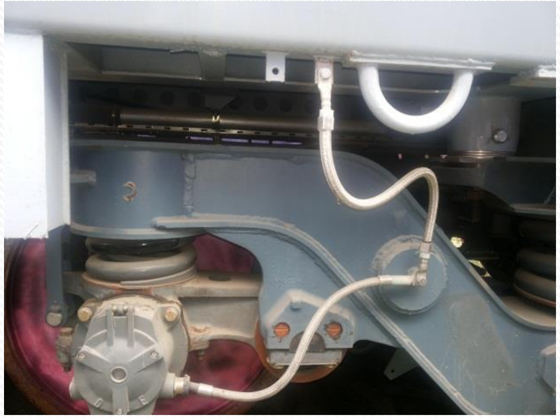


AMDBS –Schematic Layout



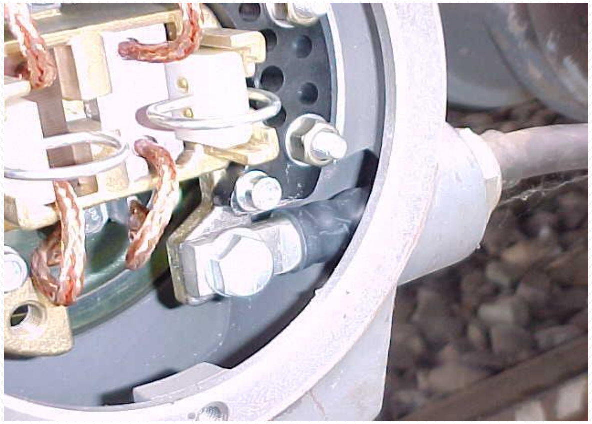
DETAILED VIEW OF EARTHING ARRGT.

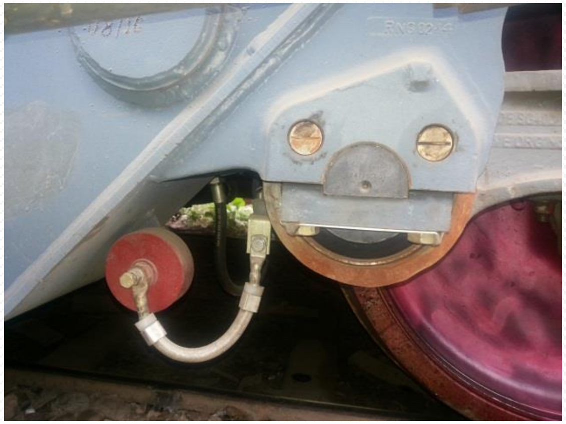




Shell body to bogie frame earthing cable

Bogie frame to axle earthing cable

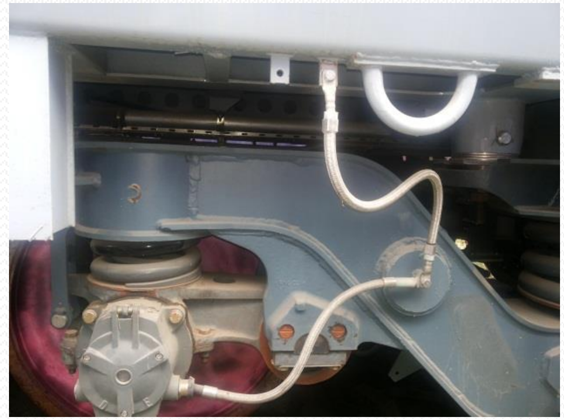




Resistor earthing cable

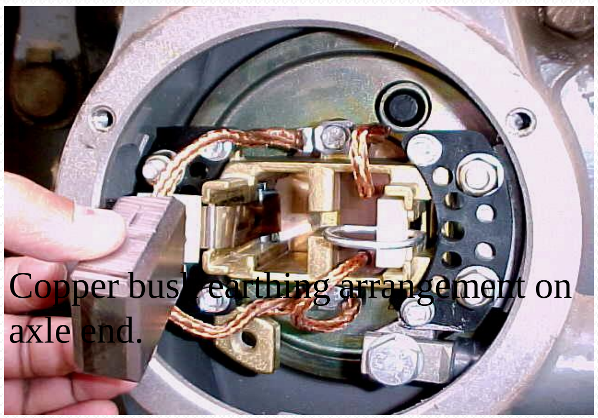
Copper bush earthing arrangement on axle end.

DETAILED VIEW OF EARTHING ARRGT.



Shell body to bogie frame earthing cable

Bogie frame to axle earthing cable



Copper bush earthing arrangement on axle end.

Resistor earthing cable

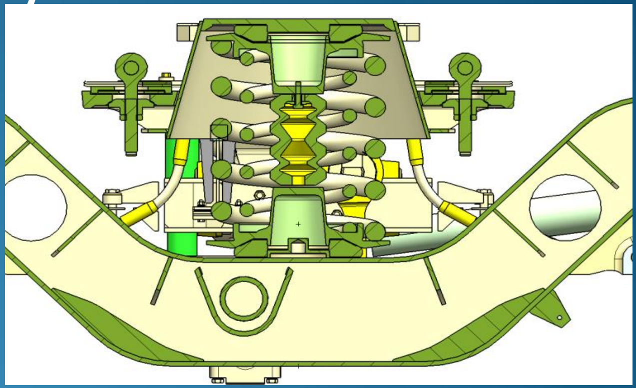
Suspension of LHB GS Coaches

LS1- With 100 seater, chair car spring, SBC underslung

LS2- Chair car springs with 32 mm shim, Suitable for 16 T pay load

Under-slung water tanks 2x685 ltrs removed

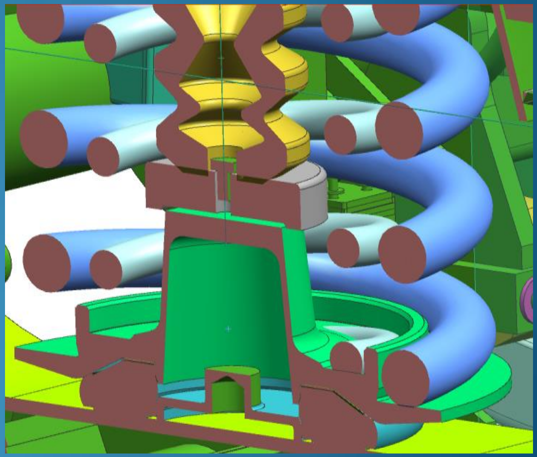
Transverse luggage rack shifted upward



LS-3 variant LHB GS/EOG coach

Shalimar springs with 32 mm shim

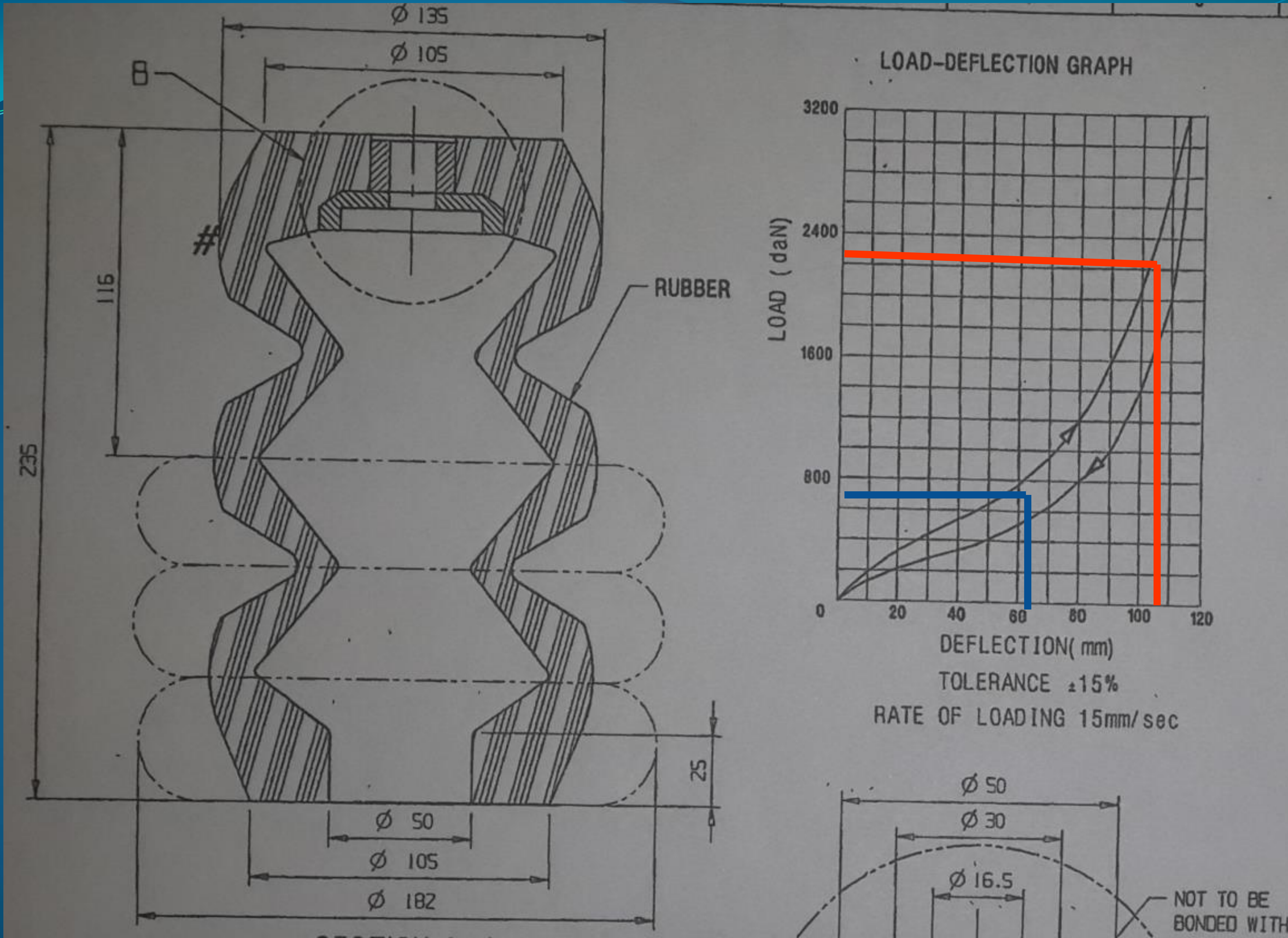
Suitable for 18 T pay load



LS-4 variant LHB GS/EOG coach

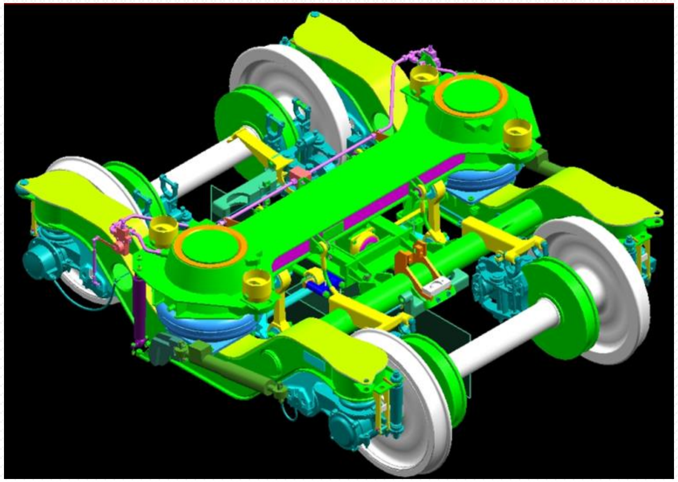
Shalimar springs with stiffer secondary inner springs with 32 mm shim Suitable for 22.6 T pay load

LS-5 WITH AIR SPRING IN SECONDARY 140 KN CAPCITY.


Ø 135
Ø 105
B
#
116
235
RUBBER
25
Ø 50
Ø 105
Ø 182
LOAD-DEFLECTION GRAPH
LOAD (daN)
3200
2400
1600
800
0
20
40
60
80
100
120
DEFLECTION(mm)
TOLERANCE ±15%
RATE OF LOADING 15mm/sec
Ø 50
Ø 30
Ø 16.5
NOT TO BE
BONDED WITH

Secondary Air Suspension

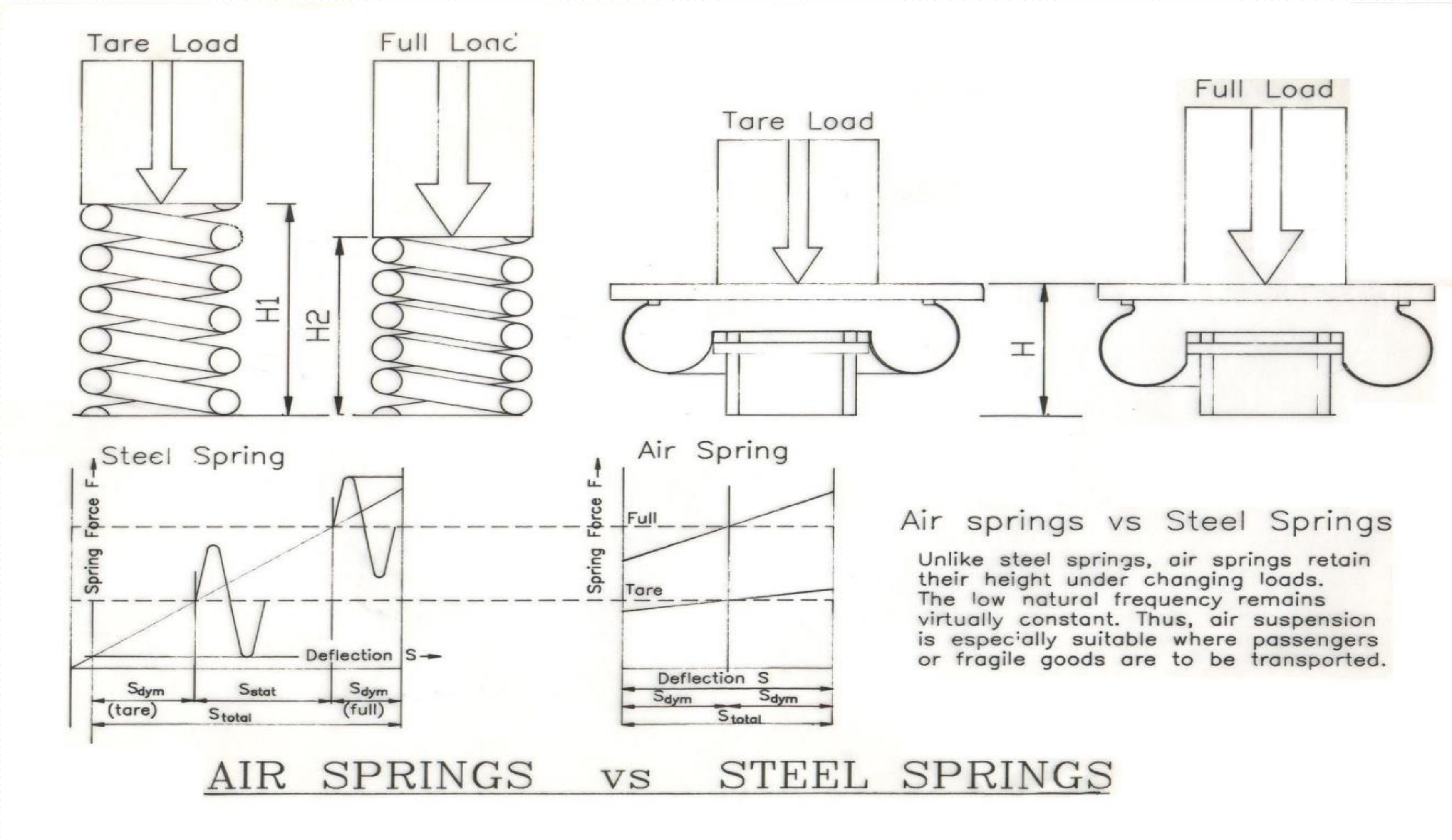
- Maintain constant height at varying load
  - Fewer variants required to be stocked for various coaches
  - Buffer height adjustments easy
  - Helps in maintaining level of coach under non-uniform loading
- Less failures as compared to helical springs



- Air spring as per rdso Spec cK-509 for
- Conv. and cK-508 for FIAT bogies
-

Advantage of Air Spring over Helical Springs.

-Constant Buffer Height at varying pay loads.



construction

- The spring consists of an air bellow fitted between two plates
  - Air pressure creates an air gap between the plates which provides cushioning
- There is an inner emergency rubber spring also
  - Comes in operation upon deflation of bellow or during overload

1.1 Airspring assembly description

Airspring system is composed of Top plate, air bellow, emergency spring and sliding plate and fasteners and O-rings. For details please see Fig1 and Table1.

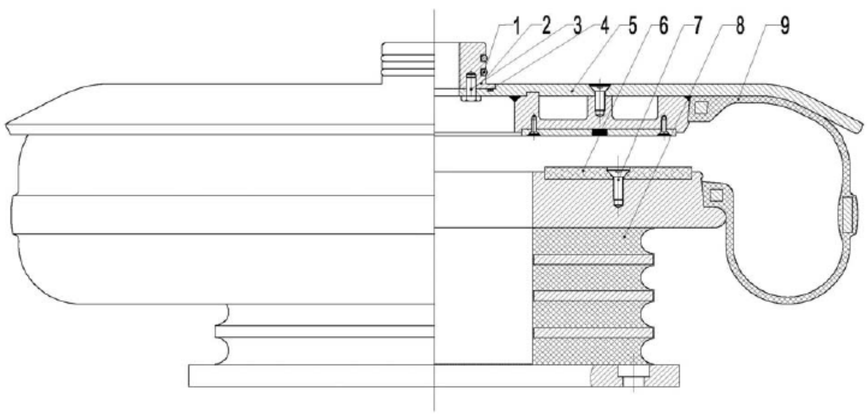
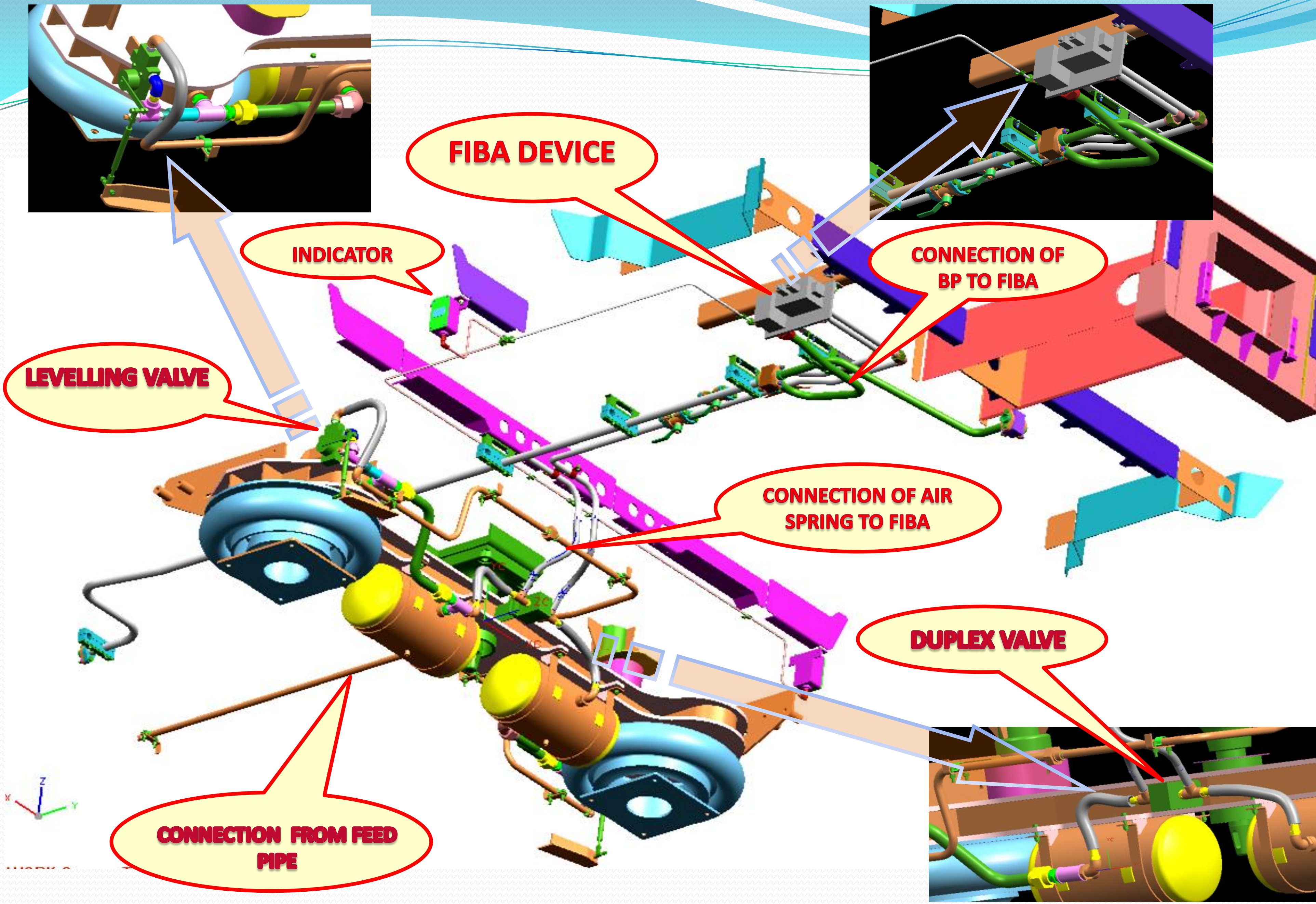


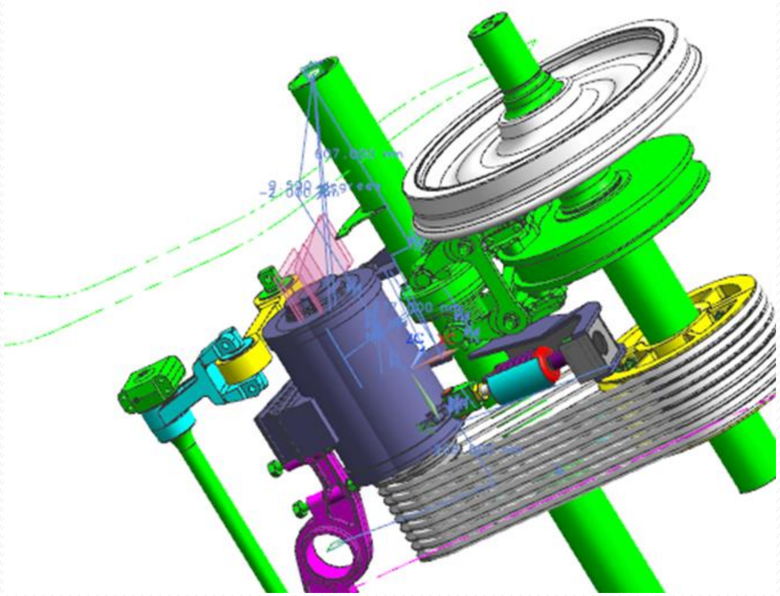
Fig1 C-K509 airspring sketch

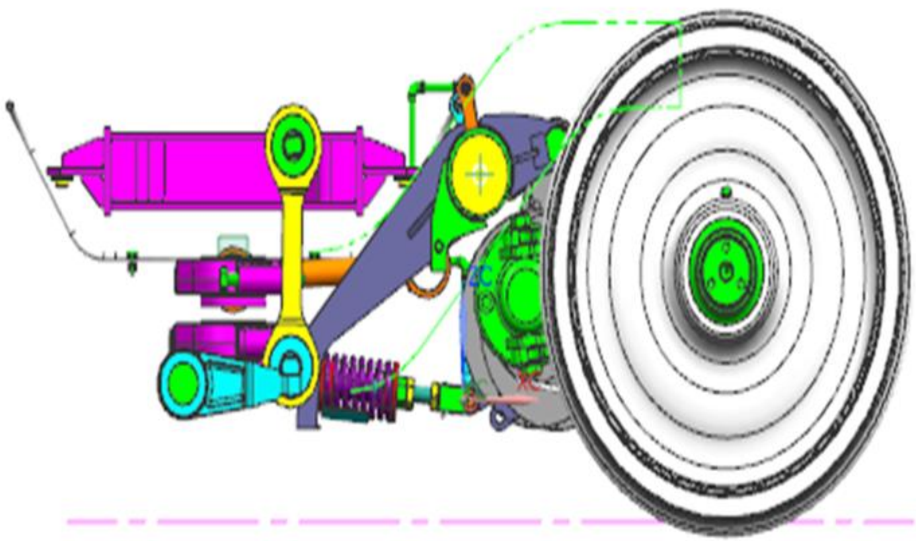
Table 1: Part list for ck509 airspring

Part	Parts name	Part number	Weight (Kg)	Quantity per unit
1	O-ring	GB3452.1 75×5.3	0.1	2
2	Air inlet	C.KH060400301	5	1
3	Hexagon socket head cap screws	GB/T 5786-2000 M8×16	0.2	4
4	O-ring	GB3452.1 87.5×3.55	0.05	1
5	Top plate	C.KH060400300	42.5	1
6	Sliding plate	C.KH060400500	1.25	1
7	Hexagon socket head cap screws	GB/T 70.3 M8×20	0.3	6
8	Emergency spring	C.KH060400200	90.5	1
9	Air spring bellow	C.KH060400100	11.25	1

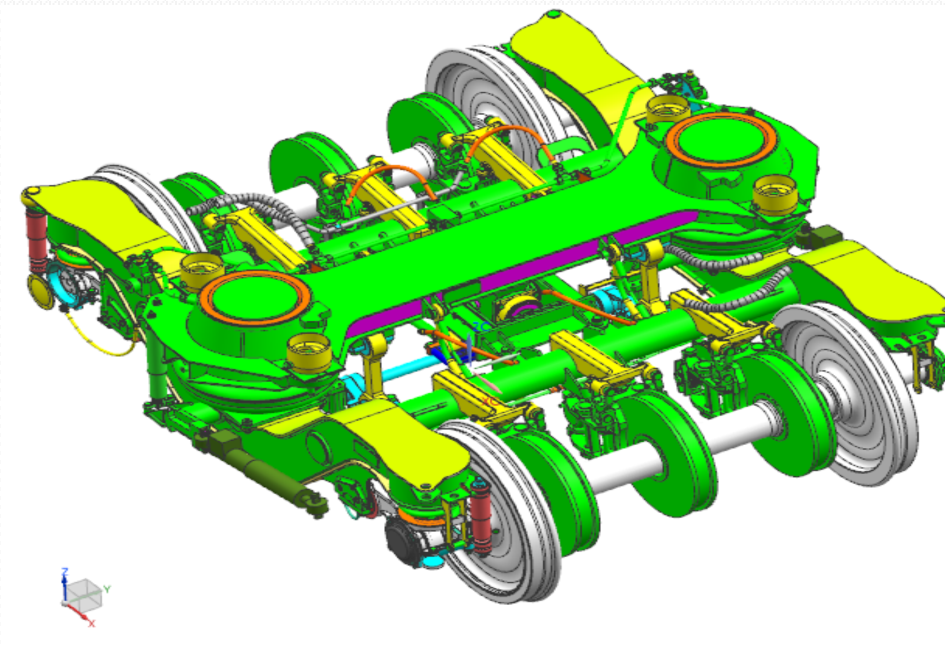

FIBA DEVICE
INDICATOR
CONNECTION OF
BP TO FIBA
LEVELLING VALVE
CONNECTION OF AIR
SPRING TO FIBA
DUPLEX VALVE
CONNECTION FROM FEED
PIPE

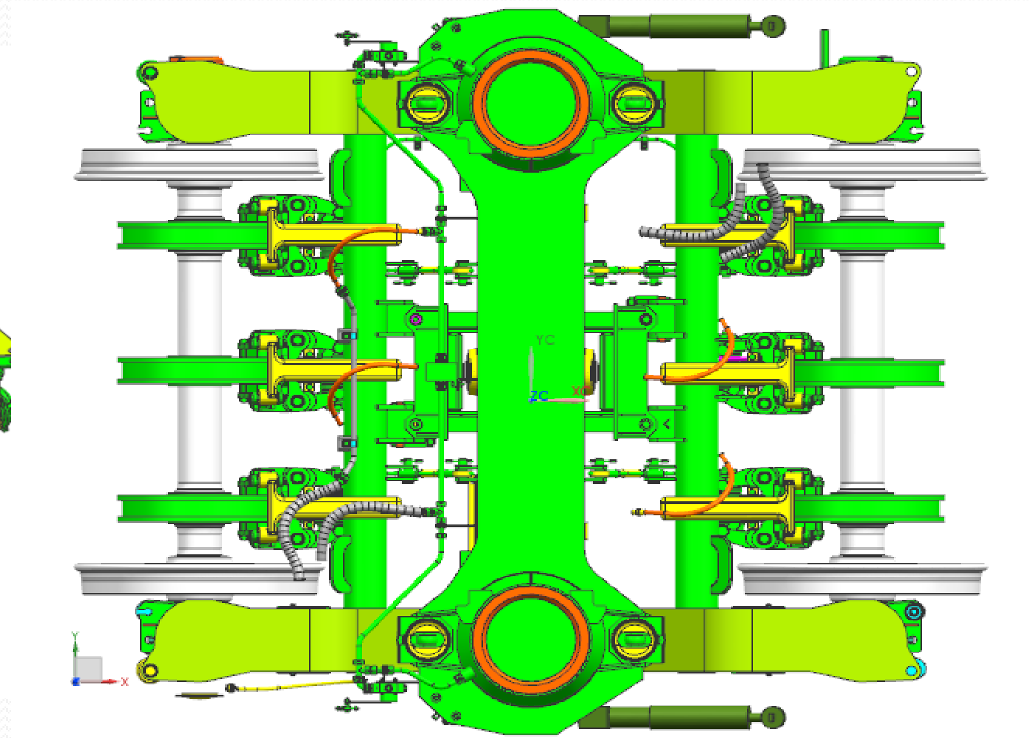
FIAT-SG with 30 kW permanent magnet alternator

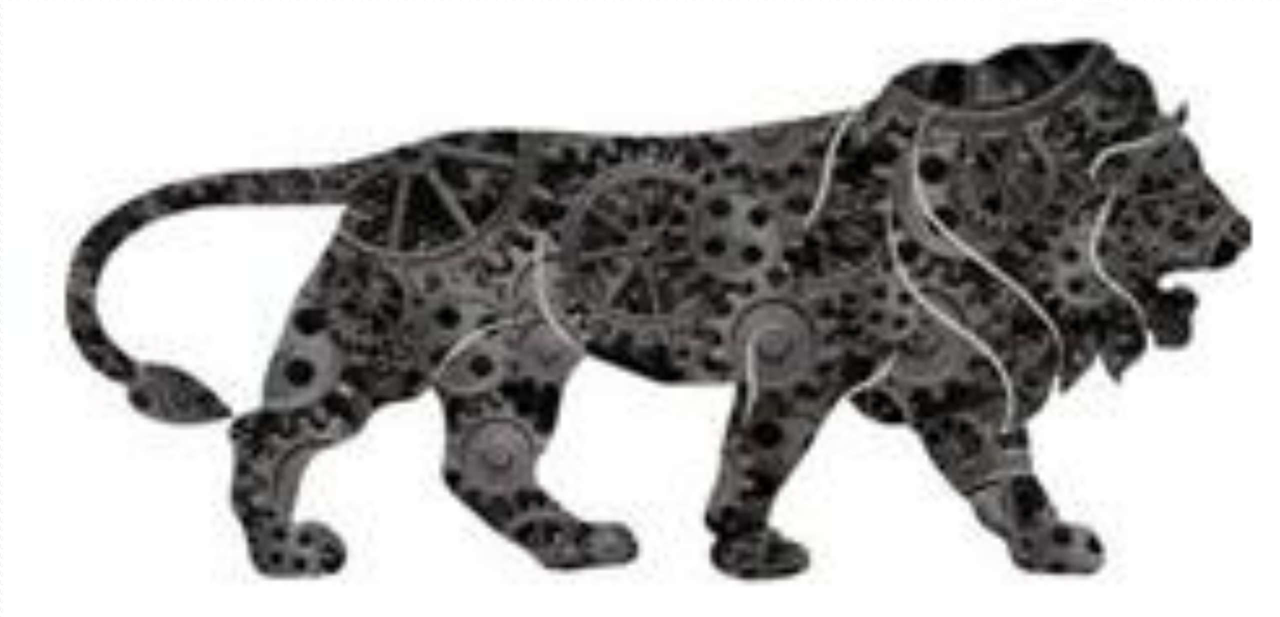




FIAT BOGIE WITH AIR SPRING AND MULTI DISC BRAKES FOR 250 KMPH







- Wheel spalling :- spalling occurs as a result of fine thermal cracks joining to produce the loss of small piece of tread material.
- Wheel shelling :- shelling is due to result of stress generated by rolling contact fatigue and leading to material flow and damage at wheel surface.
- Rolling contact stresses are major factor controlling both shelling and spalling.
- Fatigue process : dependent on magnitude and range of multi axial alternating stress component at or near the tread surface. The presence of compressive normal stress on plane having greatest range of shear stress would tend to inhibit crack nucleation and propagation. -----require information on the full thermodynamic cycle of complex multiaxial stress experienced by tread surface and sub surface elements during both wheel rotation and major breaking cycles.
- Stress in rolling contact : Elastic contact pressure between wheel and rail has magnitude proportional the cube root of the wheel loads. The associated half width of contact patch would be about 6.5mm. Orthogonal sub surface shear stress cycle changes with addition of traction as would occur in a braked wheel. Retarding force and traction at the contact increase, the max. Range of shear stress move towards the surface, and tensile stresses begin to develop at the trailing edge of the wheel contact until friction ratio exceed at least 0.25.
- Impact effect : it can effect both crack initiation and crack propagation modes. It can arise from rail joints. Wheel flats serves as sites for formation of additional flats and resulting shelling. Dipped joints or corrugation impose repeated defects on wheel as it traverses and contact pressure can be increased by factor of 3 or 4.
- Martensite formation: Thermally induced metallurgical transformation of region in the tread surface can contribute to cracking. Eventually spalls are formed by un tempered martensitic, which is very brittle -- cracks