



Presentation on LHB Shell Features



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Evolution of LHM



Brief about Technology

- ✓ Contract to M/s ALSTOM LHB/GmbH in 1995
- ✓ Scope of supply (24 coaches):
 - 19 AC chair Cars,
 - 2 AC Executive Class Chair Cars
 - 3 Generator cum Brake vans w/o DA set
- ✓ Bogies by M/s. FIAT-SIG Switzerland
- ✓ All others variants developed by RCF



Important Points of LHB Coach

- ✓ Extensive use of Stainless Steel
 - hybrid Coach – “SS + Corten Steel”
- ✓ Attention to surface protection
- ✓ Longer Coach
 - approx. 2 Meters longer than ICF Coach
- ✓ Coach Ends taper (70mm)
 - to compensate excessive end throw
- ✓ Light Weight:
 - 10% lesser weight per meter length (ICF)
 - better Pay to Tare Ratio

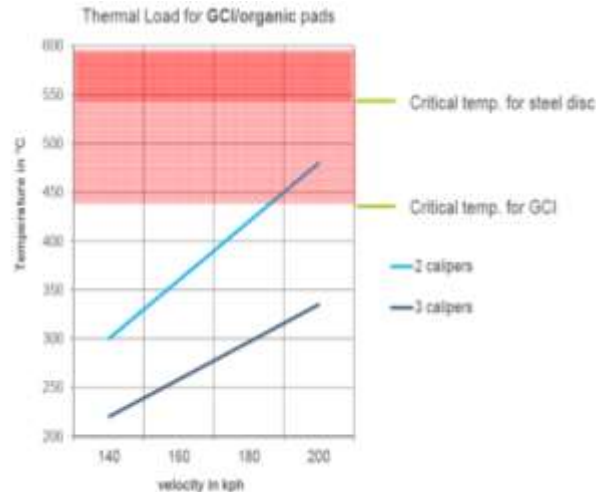
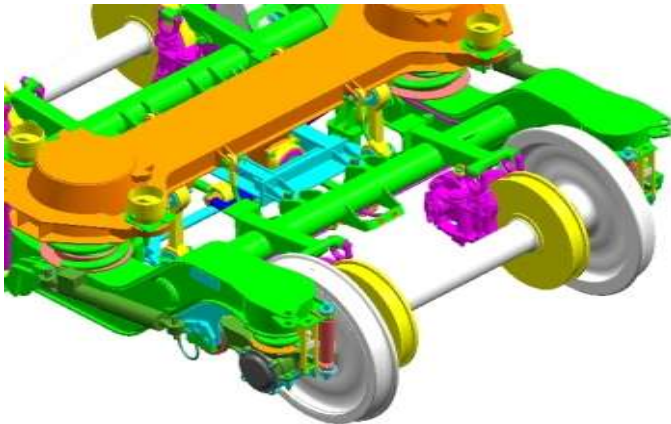


Important Points of LHB Coach

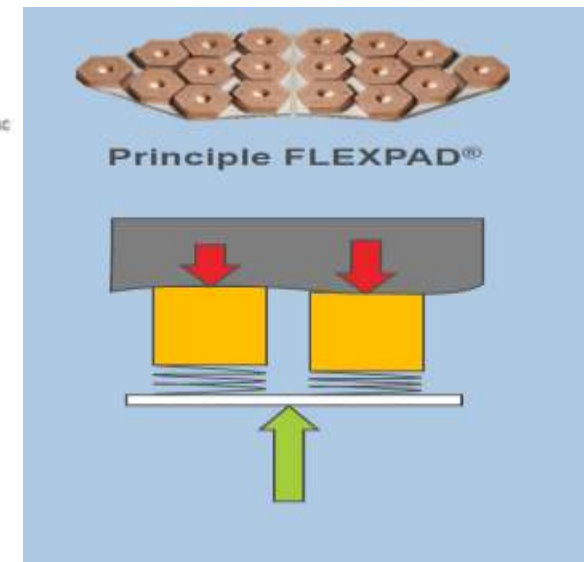
- ✓ Higher passenger comfort:
 - Ride Index 2.5 (Not exceeding 2.75)
- ✓ Strength Compliance:
 - UIC-566
- ✓ Capable of Higher speeds:
 - 160 Kmph
 - 200 Kmph with modifications in brake

Mandatory Requirement for 200 kmph

- ✓ Steel brake discs 02/axle in lieu of grey cast
- ✓ EP assist - advantage in achieving EBD
- ✓ Sintered pads in lieu of organic



[schematic diagrams]





3-discs Vs 2-discs/axle



3 x grey cast iron disc and organic pad material:

- Installation integration / interfaces:
 - Change of existing bogie design needed
- Performance / Thermal Feasibility
 - given
 - (2 disc solution with organic pad not feasible!!!)
 - Reasonable temperatures up to 350°C for EB
 - Temperature below 300°C during profile run
 - acceptable noise level
- LCC, specific wear:
 - LCC (€/brake energy) GCI/org is set to 100% (scaled)
- OE Price
 - Equipment price is lower
- Higher air consumption (plus approx. 50%)
- Weight
 - 3rd brake station needed (plus approx. 50%)
 - 3rd hose needed



2 x cast steel disc and flexible sinter material:

- Installation Integration / interfaces:
 - only small modification needed
- Performance / Thermal Feasibility
 - given, but high temperatures:
 - up to 500°C during EB
 - up to 420°C during profile run
 - squealing possible
- LCC:
 - Compared to GCI/org. the LCC is 185% for CS/sinter
- OE Price:
 - Compared to GCI/org the equipment price is higher.
- Challenges in casting quality, special suppliers needed
- 33% less weight compared to GCI/org



From technical and commercial point of view there is a remarkable advantage to use GCI/org, but the equipment weight is 50% higher



Brief Comparison

- Weight & Capacity

Type	No	Weight (Ton)	Capacity	Weight (Ton)	Capacity
		LHB		ICF	
FAC	1	43.3	24	46.2	18
ACCW	4	44.6	52	44.8	48
ACCN	7	45.6	72	48.3	64
CB	2	40.9	0	47.9	0
WLRRM	2	53	0	60	0
	16	728.7	736	779.3	658

LHB Weigh Lesser by 50.6 t

Capacity more by 78



Features of LHB Coach

- ✓ Superior Shell design:
 - complete shell interlocked
- ✓ Better Acoustic and Vibration Measures :
 - superior Insulation
 - damping elements
- ✓ Superior Brake system:
 - AMDBS with WSP
- ✓ Separation of Shell and bogie frequency





Features of LHB Coach

- ✓ Center Buffer Coupler
- ✓ Bio-Toilets
- ✓ Auto Closing Sliding Doors
- ✓ Wider Windows
- ✓ Modular Interiors
- ✓ Improved Air Conditioning System
- ✓ Use of Fire Retardant Materials



Safety Measures



- ✓ Anti Climbing Feature
- ✓ Superior Braking System
- ✓ Emergency Openable Windows
- ✓ Fire Retardant Materials
- ✓ Expandable Fire Barrier
- ✓ Proper Coach Earthing
- ✓ Public Address System
- ✓ Emergency Accident light
- ✓ Smoke & Fire Alarm System



Sound & Vibration Measures

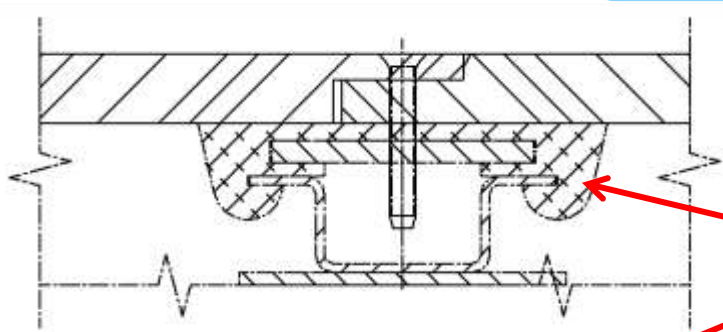
– 65 dB inside passenger Area

- ✓ Sound Insulating Paint
- ✓ Cork Sandwich floating floor with Rubber D-coupling elements
- ✓ Melamine foam Insulation around AC ducting
- ✓ Non-Metallic Interiors - FRP
- ✓ Sealed Auto closing Vestibule door
- ✓ No direct opening in lavatories
- ✓ Dampers & Silent blocks in Bogies

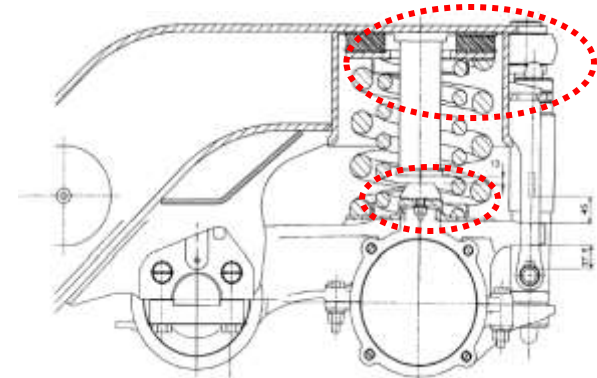
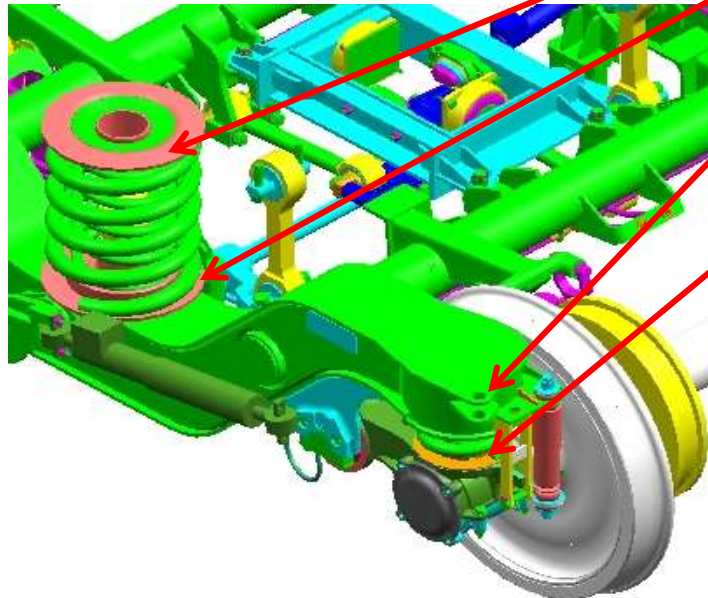
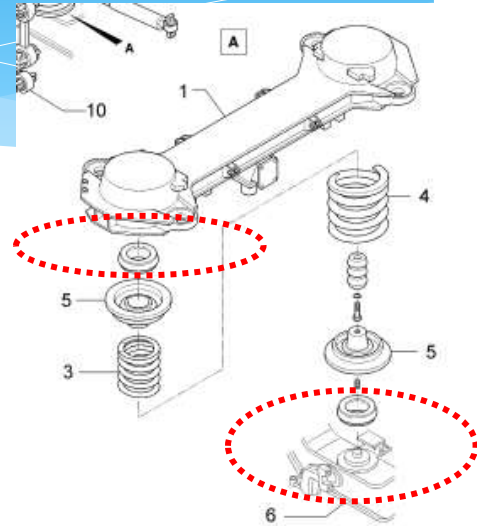




Rubber Elements between Metallic Surfaces



Rubber elements





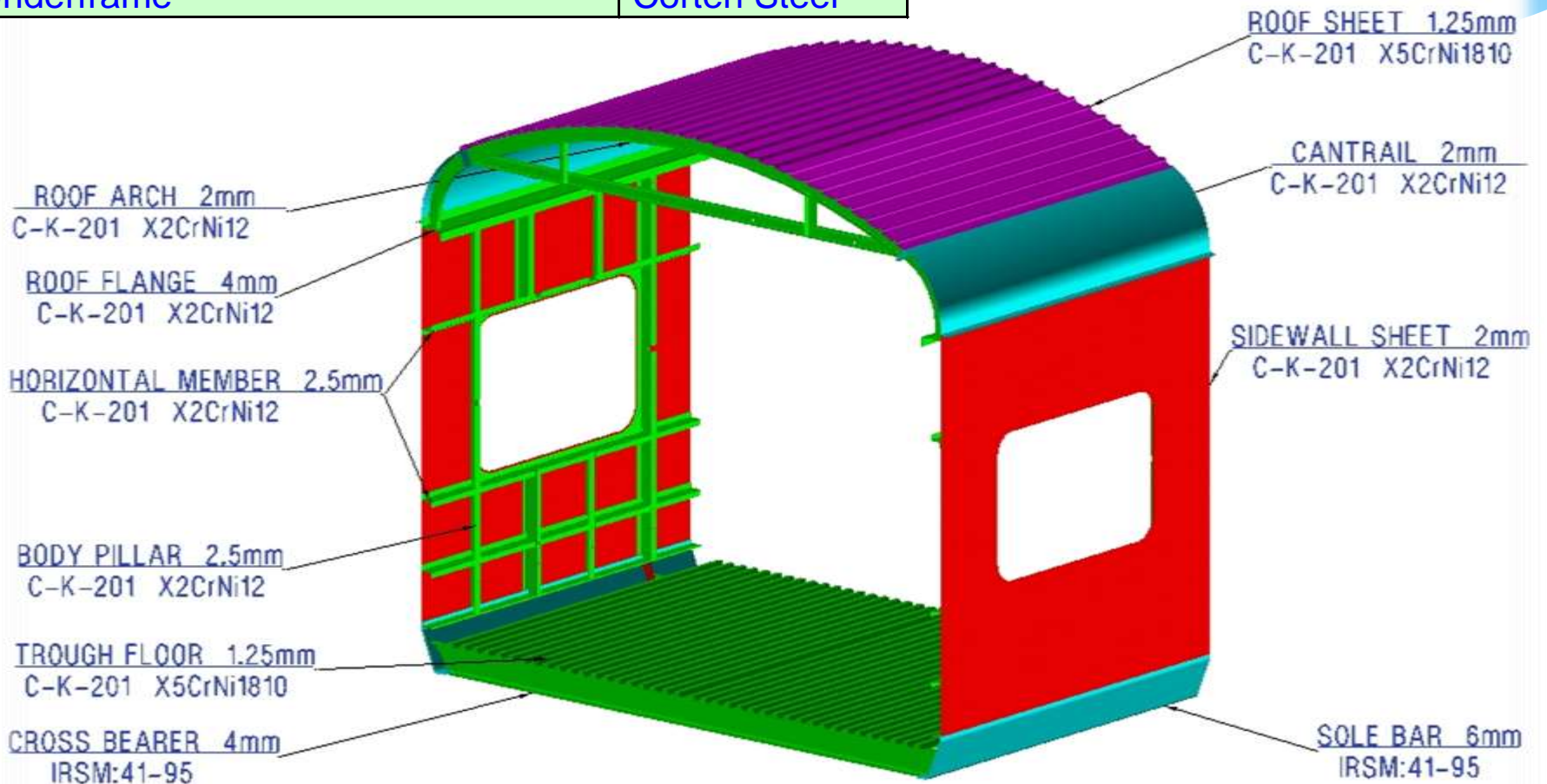
Use of Stainless Steel in LHB Shell





LHB Shell Material Composition

Side wall, End wall and Roof structure	Ferritic Steel
Roof sheet and Trough floor	Austenitic Steel
Underframe	Corten Steel



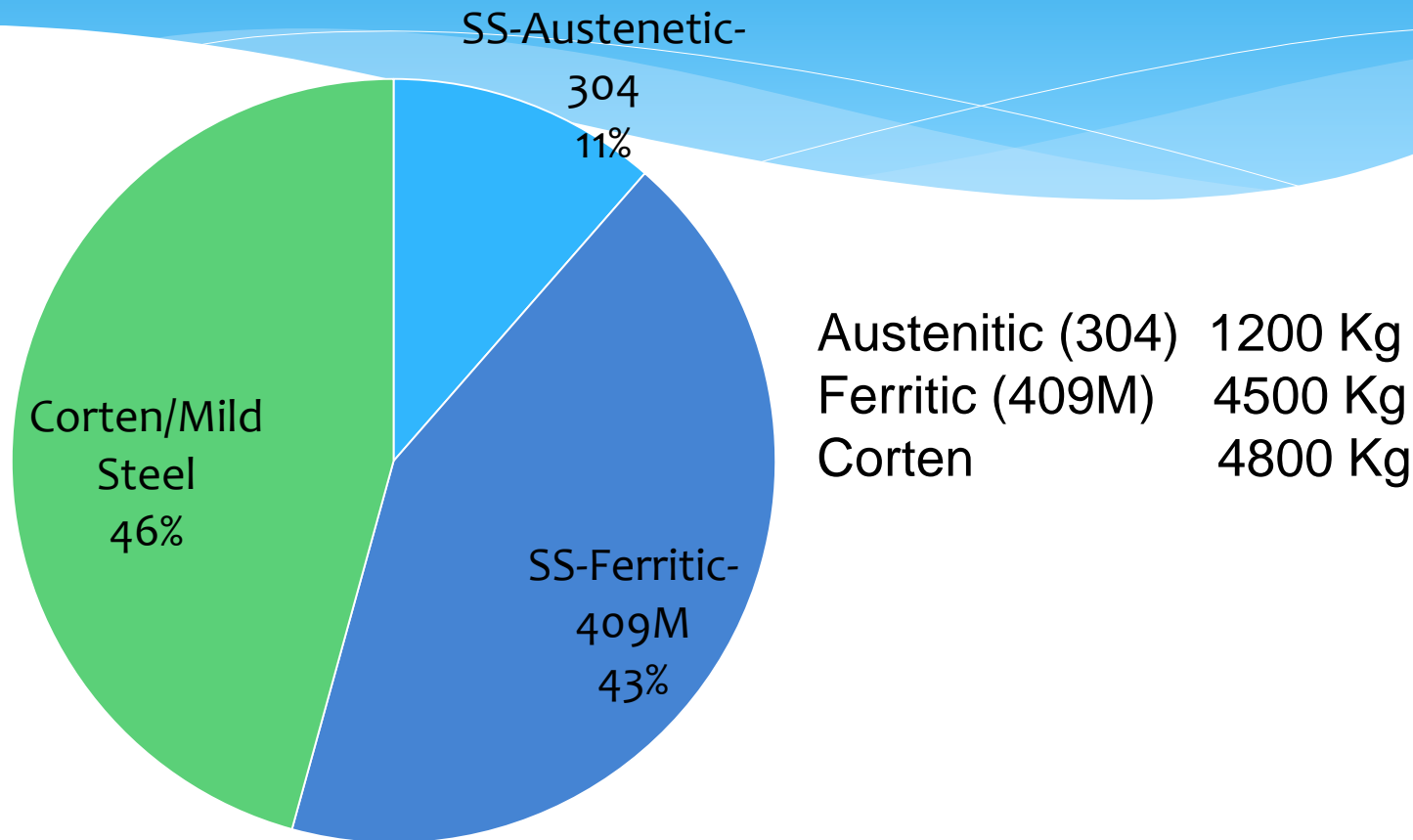


Details of Stainless Steel used in LHB Coach

Main Assembly	Application area	Steels used	Thickness	Qty of finished product
Side wall	Side wall sheets	X2 CrNi 12 Ferritic Steel	2 mm	979 kg
	Vertical pillars	-do-	2 mm	425 kg
	Horizontal member	-do-	2 mm	288 kg
	Roof flange	-do-	2 mm	270 kg
Roof	Roof sheet	X5 CrNi 18 10 Austenitic Steel	1.25 mm	654 kg
	Carlines	X2 CrNi 12 Ferritic Steel	2 mm	160 kg
	End parts	-do-	2 mm	380 kg
	Final roof arch	-do-	4 mm	56 kg
End wall	End wall sheets	-do-	2/3 mm	98 kg
	End wall frames	-do-	2/2.5/3/4/6/10 mm	260 kg
U/frame	Trough floor	X5 CrNi 18 10 Austenitic Steel	1.25 mm	680 kg
	Sole bar	IRS M41 Corten steel	6 mm	645 kg
	Cross bearers	-do-	4 mm	645 kg
	Body bolster	-do-	6 mm	750 kg
	Head stock	-do-	4/6/8 mm	1280 kg
	Coupler carrier/Center sill	-do-	10 mm	200 kg
Vendor supplied items	Water tanks	SS 316 Ti	3 mm	300 kg
	Roof ventilators	X5 CrNi 18 10 Austenitic Steel	1.25 mm	49 kg



Share of Various Steel in a LHB coach





Properties of Steels used in LHB Coaches

Shell Assemblies	Steels used and their %age compositions	UTS N/mm ²	Yield Stress N/mm ²
Side wall, End wall and Roof structure	X2 Cr11 Ferritic Steel (C < .03%, Cr 10-12%, Si 1%, Mn 1.5%)	450-600	320
Roof sheet and Trough floor	X5 CrNi 18 10 Austenitic Steel (C < .07%, Cr 18%, Ni 10 % Si 1%, Mn 2%)	700-850	235
Underframe	IRS M-41 / CortenSteel (C < .01%, Cr .35 -.6%, Ni .2 - .4% Cu .3 - .6% Si .3 - .7%, Mn .25%)	440-480	320



Stainless Steel

- high Resistance to Corrosion

Corrosion map of India



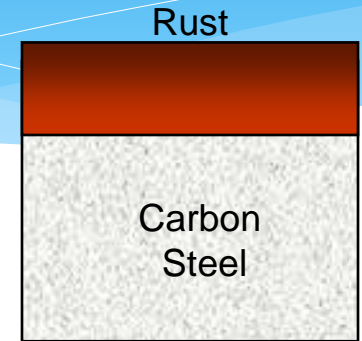
✓ Suitable even for environments like coastal area.



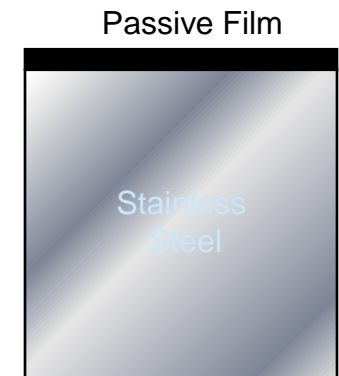
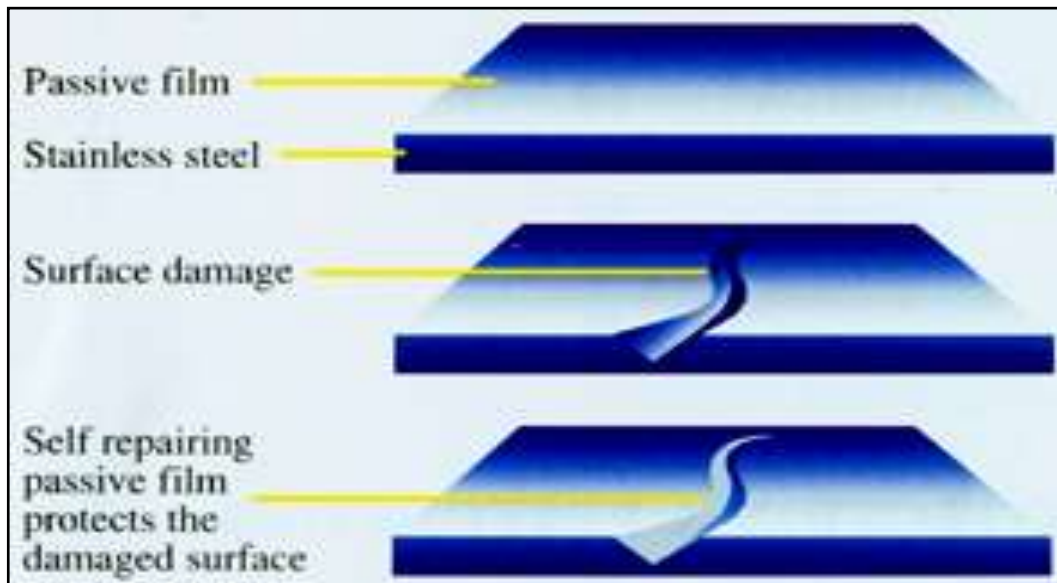
Stainless Steel (live material)

- Self repairing surface

- ✓ Stainless steels -alloys of iron containing minimum of 10.5% chromium
- ✓ Chromium forms a passive film of Chromium Oxide, which prevents corrosion



< 11% Chromium



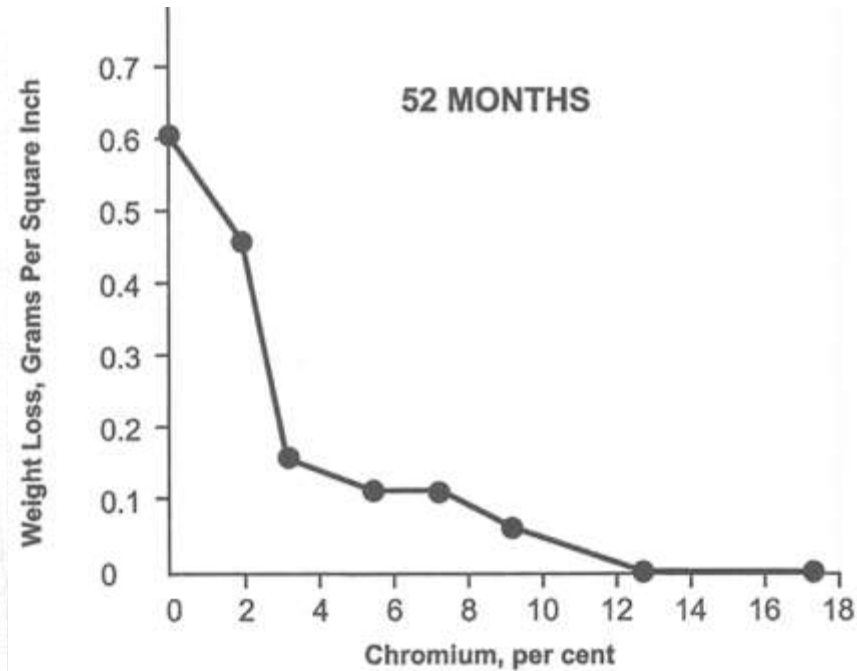
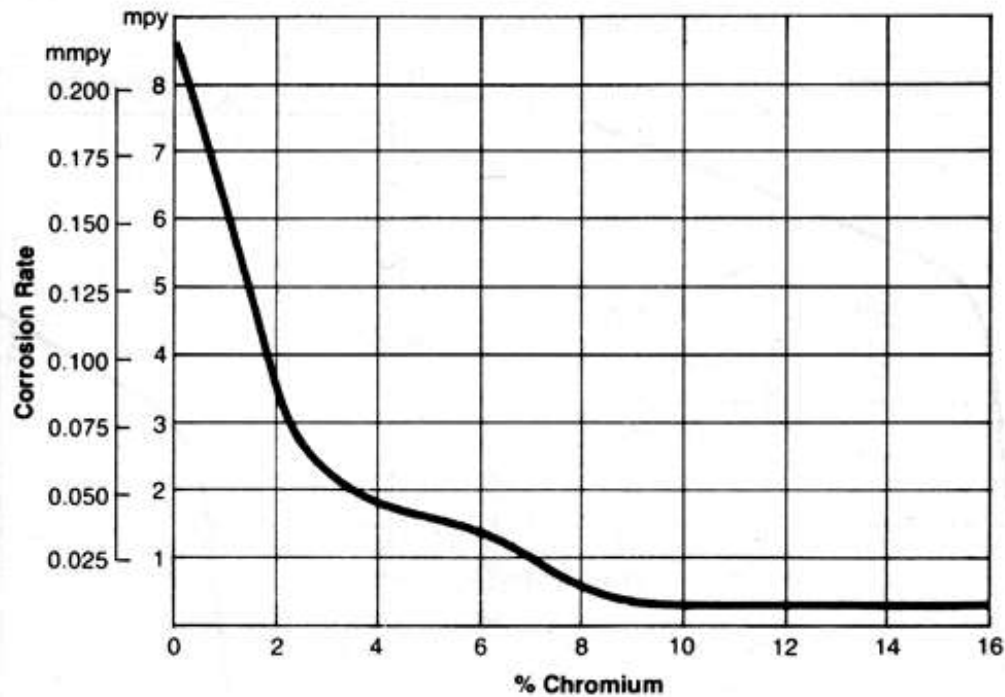
> 11% Chromium



Stainless Steel (live material)

- Self repairing surface

Effect of Chromium Content on Corrosion Rate



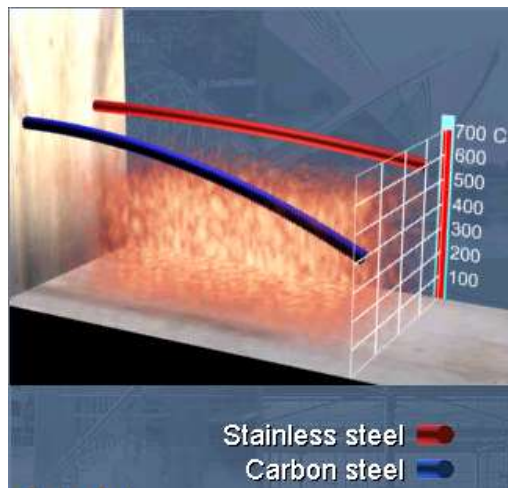


Material	Life	Remarks
Mild Steel	5-6 years	High Maintenance
Corten Steel	20-25 years	Major corrosion Repairs every 10-12 years
Stainless Steel	>40 years	Negligible Maintenance



SS – Higher Impact Resistance

- ✓ SS absorbs 2.5 times more energy than carbon steel- Less Fatal accidents
- ✓ High Strength at High Temperature - Minimum structural deformation, Retains half the room temperature strength at 500°C





Features of LHB Shell

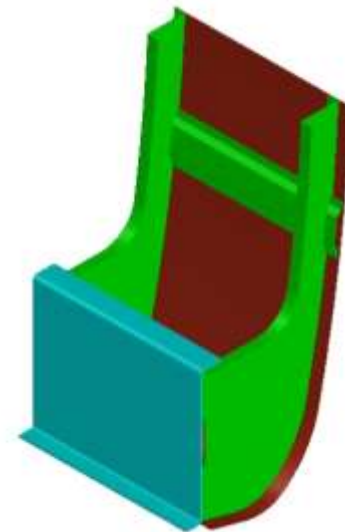




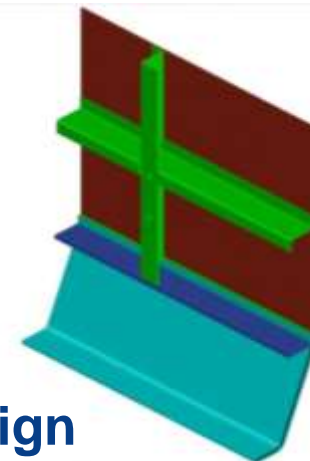
Sole Bar Sidewall Connection

✓ Elimination of pockets

- Turn under eliminated
- Clear approach for painting
- No accumulation of water and muck
- Pillar rests on solebar as compared to load transfer through a vertical welded joint in conv. Coaches



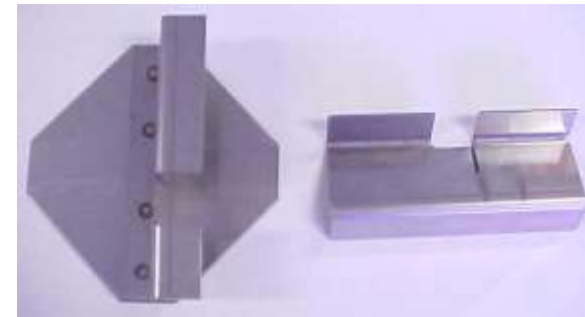
ICF Design



LHB Design

Sidewall Features

- ❑ Laser & Spot welding
 - ❑ Low heat input
 - ❑ Less distortion
- ❑ Interlocking between horizontal and vertical stiffening members
 - ❑ Better geometrical integrity
 - ❑ Resistance to distortion
 - ❑ Aligned stress flow
 - ❑ Better strength
- ❑ Reduced sidewall thickness
 - ❑ 90 mm to 60mm
 - ❑ More inside coach width



Endwall & Roof Features

□ Endwall

- Light weight
- Holes provided in stiffeners
- Overhang beyond headstock

□ Roof

- Light weight
- Corrugated roof sheet
- Spot welded to z-section roof arches with reduced height
- Single radius roof arch
- Pocket free



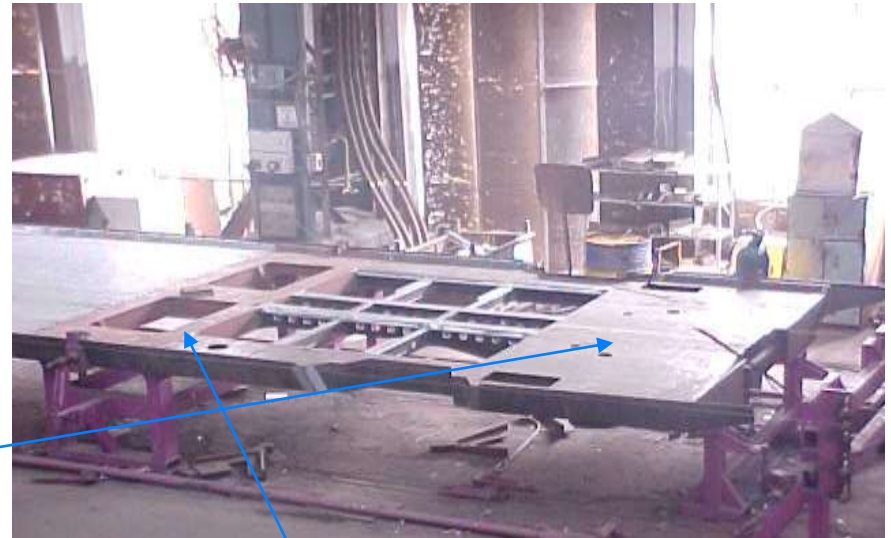
Underframe Features

- ❑ Light weight
- ❑ Provision for CBC as well as side buffers
- ❑ Even screw coupling can be fitted



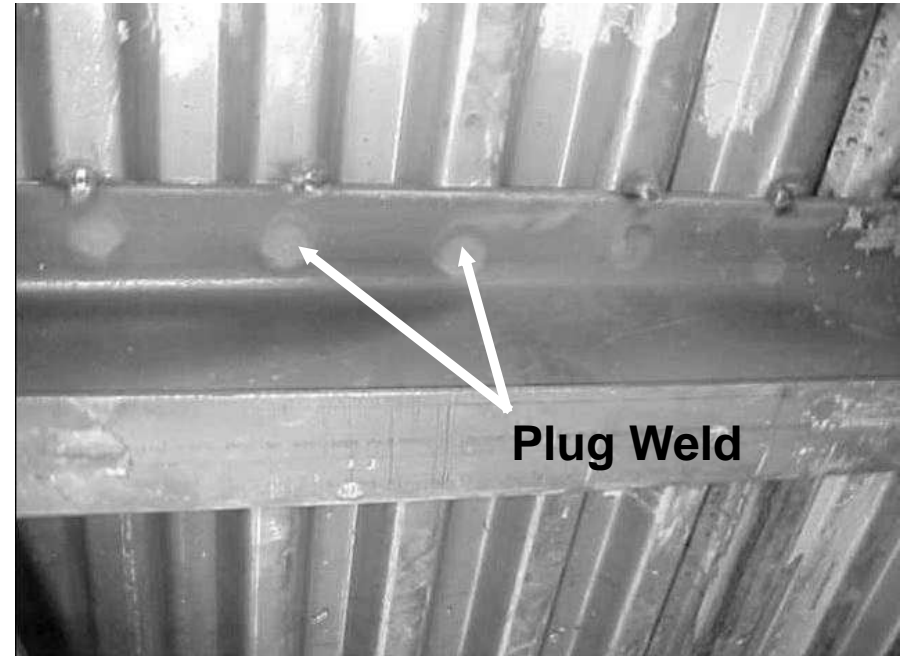
Underframe

Underframe Front Part is Made
By Joining together Head
Stock...



...And Body Bolster

Plug Welding of Trough Floor With Cross Bearers



- ❑ Under frame corrugated austenitic trough floor is plug welded from top with the cross members
- ❑ Al based weldable primer used for welding corten steel to ss to prevent bi-metallic corrosion

Structure for Underslung Equipment

Water tank mounting brackets welded on the under frame



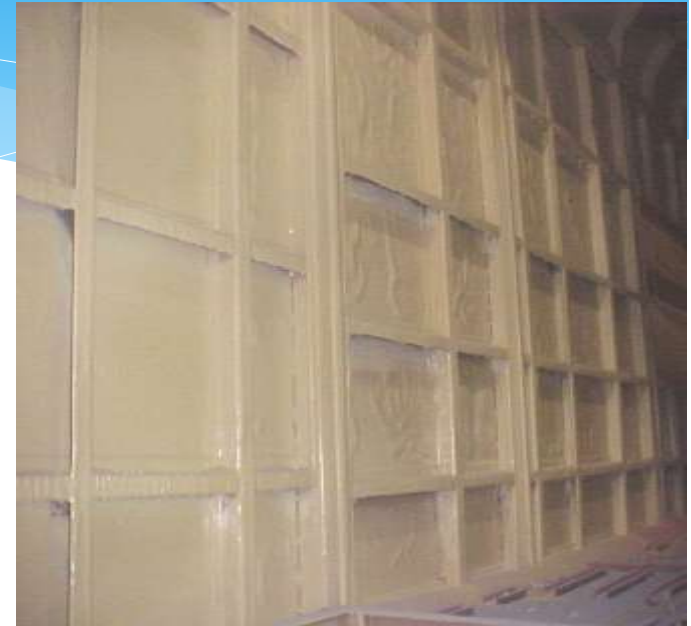
Yaw damper (connected between underframe and bogie frame) brackets welded on the underframe





Thermal and Sound Insulation

- ❑ “BARYSKIN V60db” or eq. Sound insulation PU paints on full coach shell interior, provide anti drumming sound insulation as well as corrosion resistance
- ❑ Coating of 2-3 mm thickness in the coach interior, 6-8 mm in body bolster area

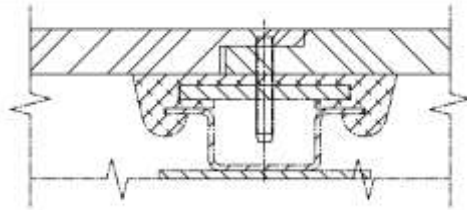




Thermal and Sound Insulation

- ❑ “Resonaflex” special type of insulation on floor and sidewall upto window sill for thermal insulation

- ❑ Decoupling elements



- ❑ Floor boards supported on rubber pads

- ❑ Floor boards made of compreg plywood and cork sandwich for better sound insulation

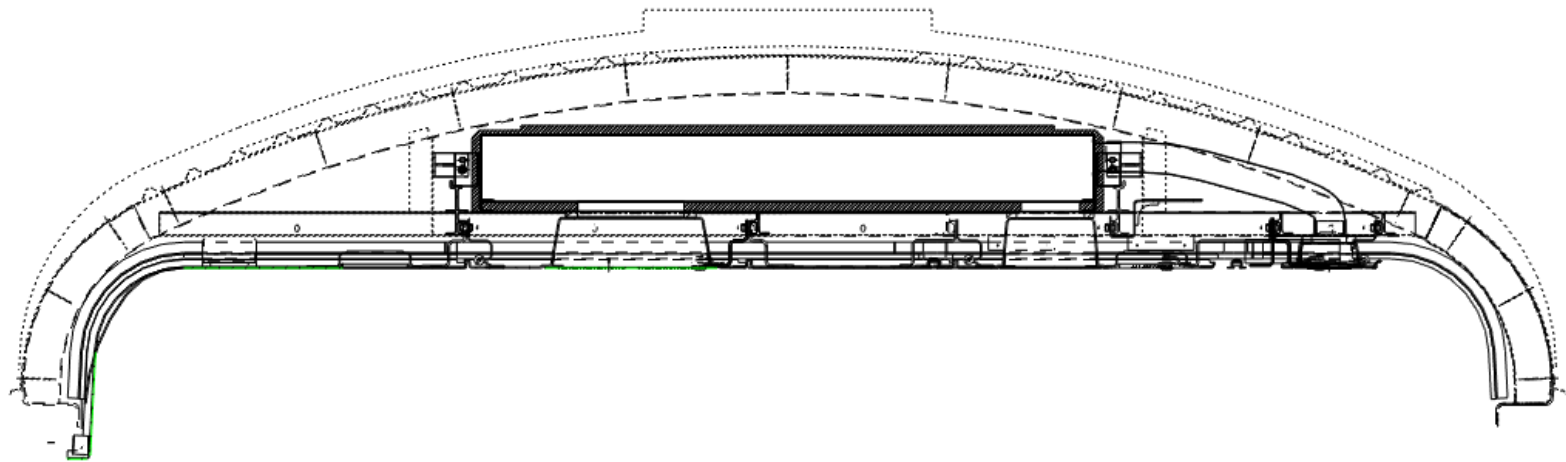
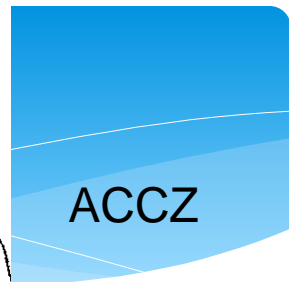
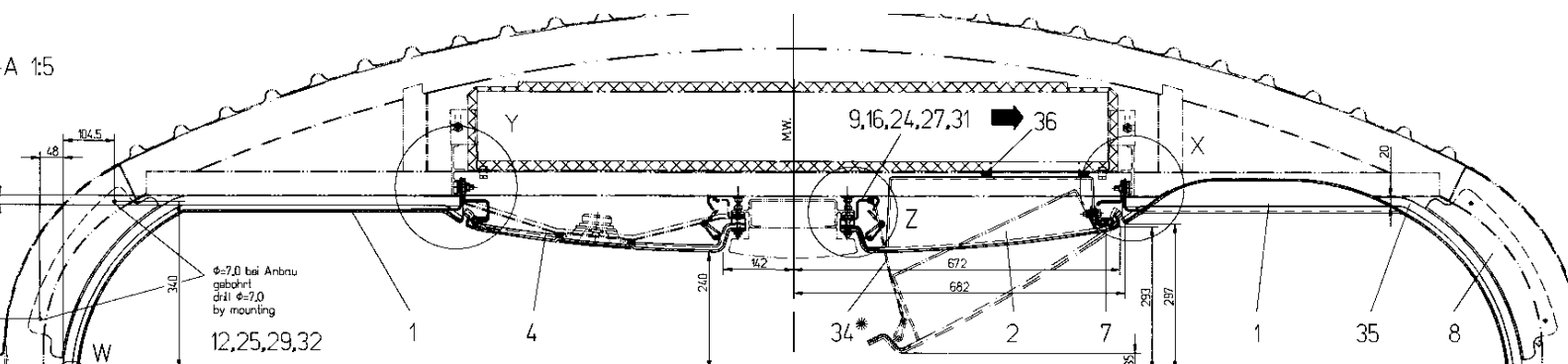


AC Ducting

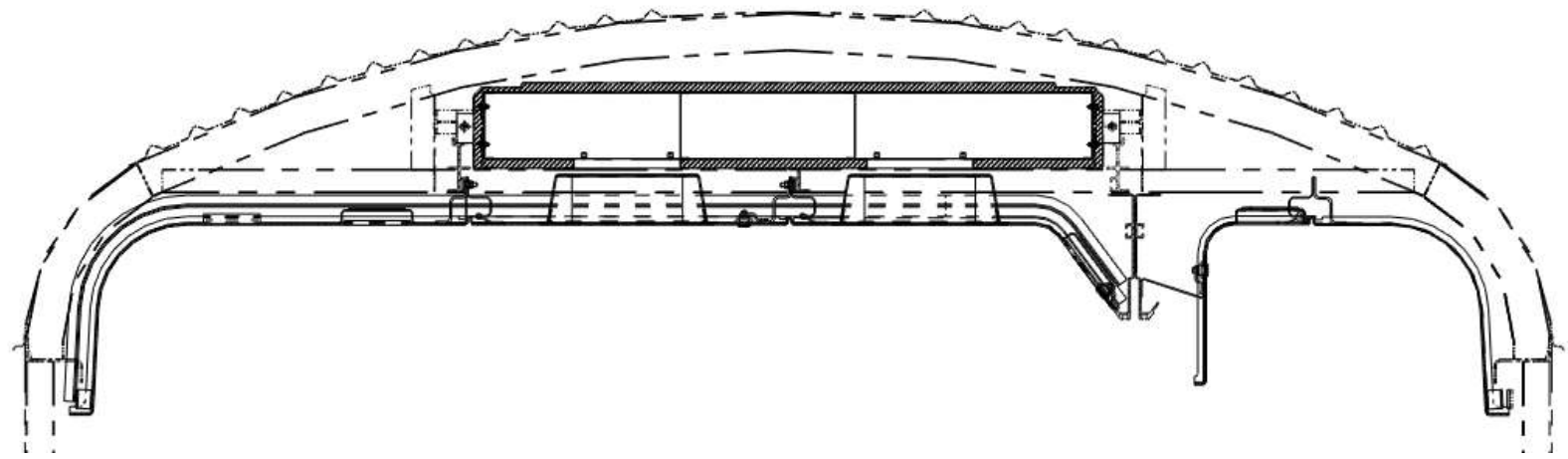
- ❑ Superior 2 tier design
- ❑ Superior thermal insulation
- ❑ Better sound dampening
- ❑ No direct blast of cool air



A 1:5



ACCW



FAC



Body Side Doors

- ✓ Hinged type swing sandwich doors
- ✓ Stainless steel body filled with phenolic resin for better heat insulation.
- ✓ Inside panel of door made up of FRP
- ✓ Provided with sealed window glass unit.





Compartment Door

- ✓ Single flap sliding door
- ✓ Stainless steel body filled with phenolic resin for better heat insulation.
- ✓ Manual opening and auto closing type door
- ✓ provided with rubber sealing at the door leaf for hand safe feature
- ✓ provided with air grill for air circulation
- ✓ Fitted with 6 mm glass for viewing





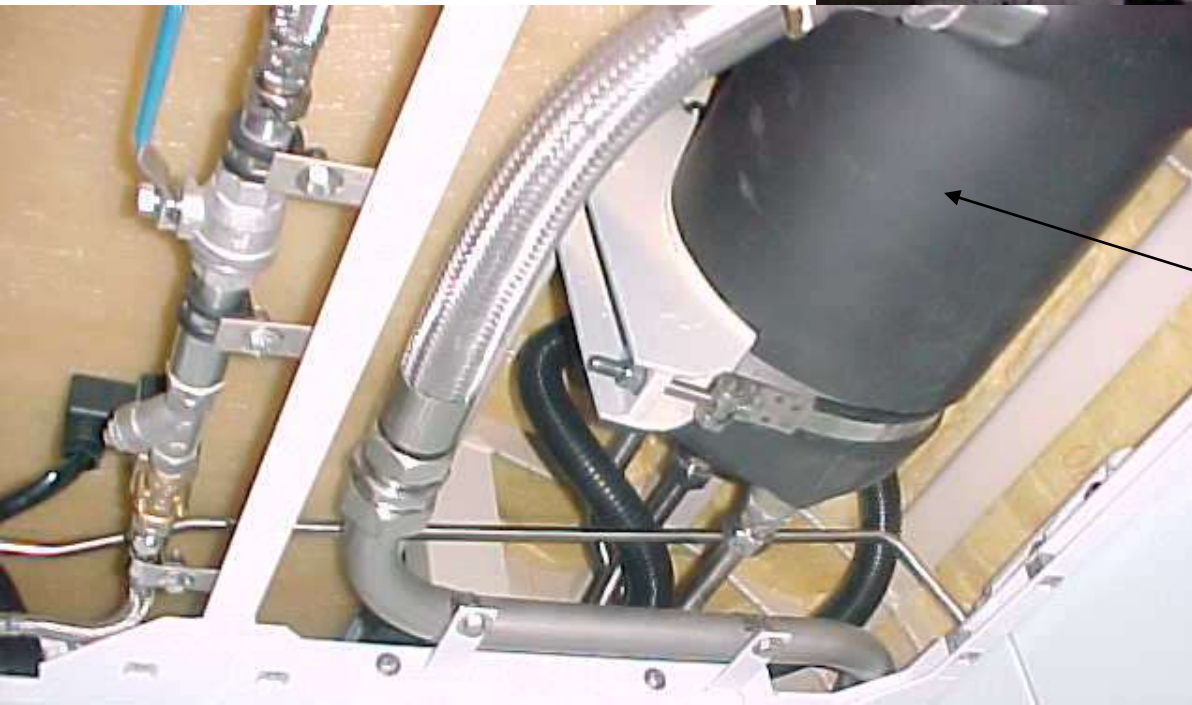
Vestibule Door / Endwall Door

- ✓ Double flap sliding door
- ✓ Manual opening and auto closing type door
- ✓ Fire barrier all around
- ✓ Provided with rubber sealing at the door leaf for hand safe feature
- ✓ Stainless Steel body filled with phenolic resin for better heat insulation and security of the coaches
- ✓ Fitted with 6 mm glass for viewing
- ✓ Door opens only 250 mm when gangway bridge plate is in folded position.





UNDER SLUNG WATER TANKS



30L WATER TANK OVER
LAVATORY



Vestibule Foot Plate

- ✓ Vestibule Fall Plate Can take later movement
- ✓ Vestibule fall plate can slide and also lift up.
- ✓ When fall plate is up, the vestibule door can not be opened more than 250mm





Sealed Window Glass Units

- ✓ The sealed window units consists of 8.4 mm outer laminated and 4 mm tempered inner glass with 6 mm Krypton/Argon gas filling
- ✓ Window glass is secured to Al extrusions by rubber profiles
- ✓ The Al frame is glued to the car body





Emergency Openable Window

- ✓ It is similar to the fixed unit
- ✓ Four units are provided each coach to allow emergency evacuation of passengers
- ✓ A handle connected to the rubber profile opens the glass unit of the emergency window





FRP Items

- ✓ Number of fire retardant FRP items have been used in the interiors for:
 - ✓ Improved aesthetics
 - ✓ Ability of FRP to be moulded into intricate shapes/curved surfaces, avoid joints
 - ✓ Better strength to weight ratio
 - ✓ Resilience to small dents
 - ✓ Scratch resistance
 - ✓ Easy repairability
 - ✓ No visible screws
 - ✓ Better maintainability
 - ✓ No problem of corrosion





Use Of Composite Materials

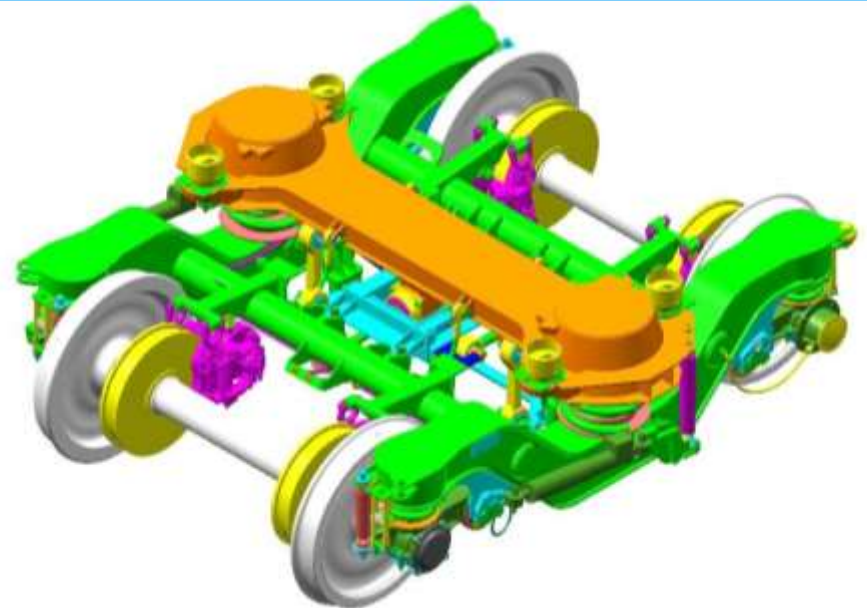
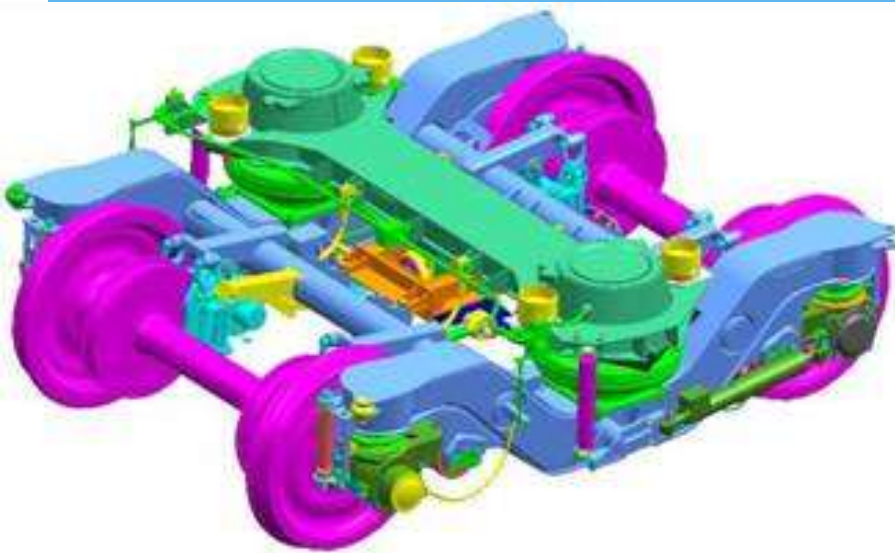
“ALUCOBOND” LAVATORY CEILING PANEL & ALUMINIUM HONEY COMB PARTITION PANELS

- IMPROVED AESTHETICS
- VERY GOOD SURFACE FINISH
- CORROSION RESISTANCE
- BETTER RIGIDITY
- HIGHER STRENGTH TO WEIGHT RATIO



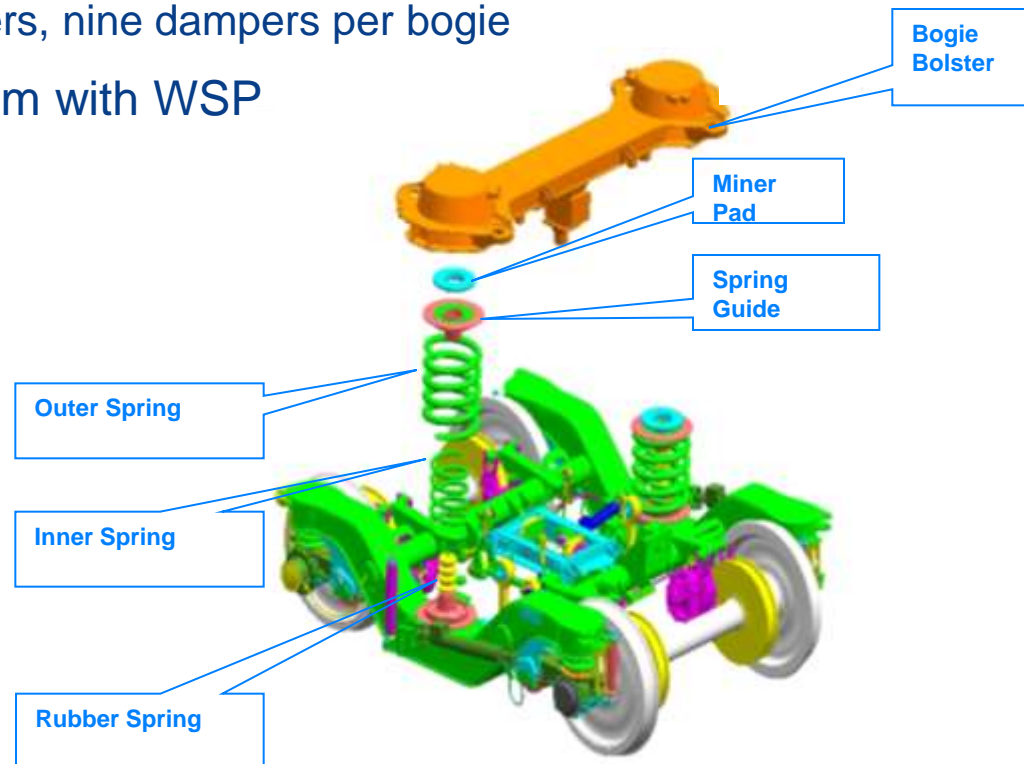


Brief about FIAT Bogie



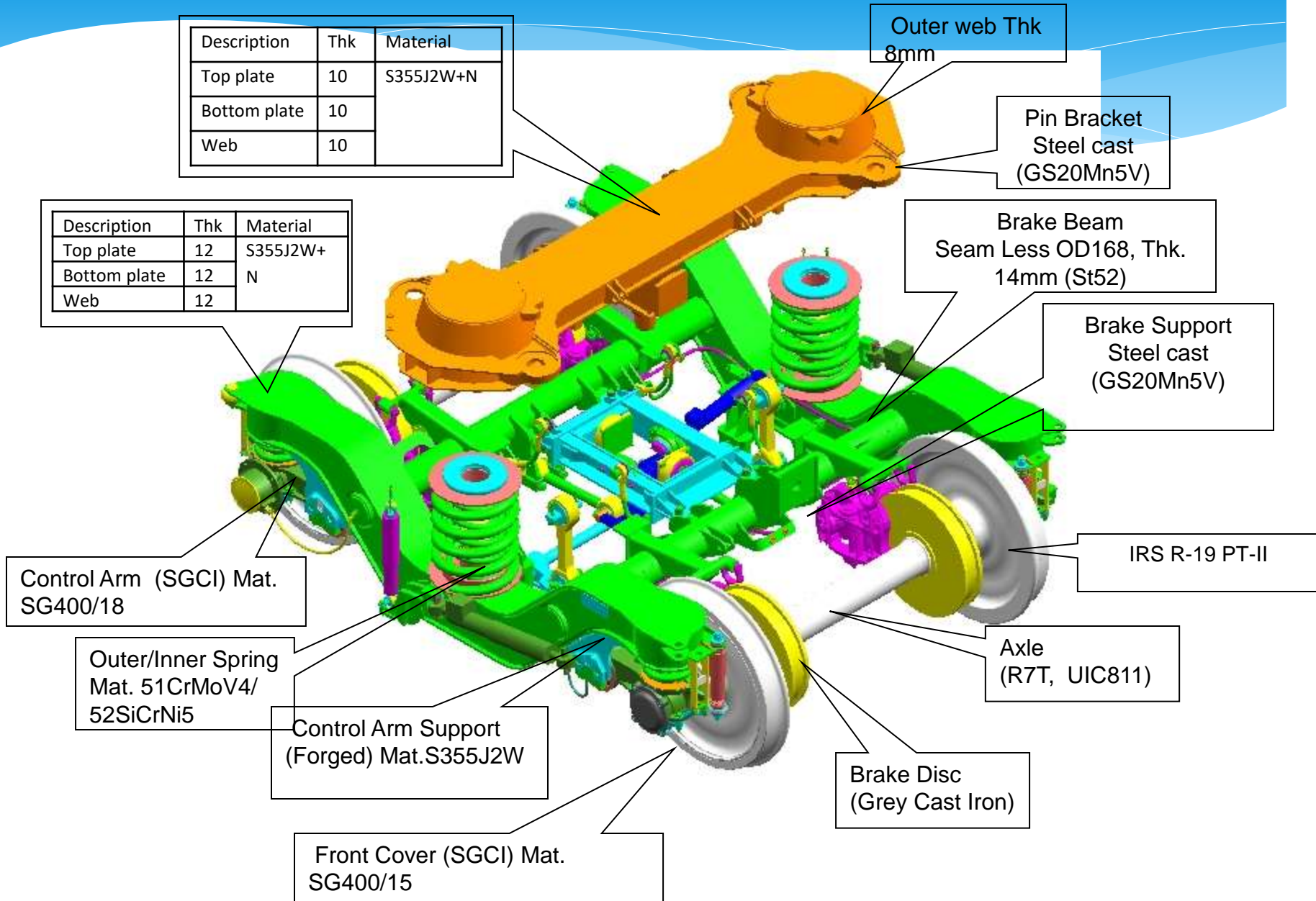


- ❑ Eurofima Y-frame design
- ❑ Superior ride quality
 - ❑ Flexicoil nested springs in secondary
 - ❑ Extensive use of elastomeric rubber- metal components
 - ❑ Yaw, lateral and vertical dampers, nine dampers per bogie
- ❑ Axle Mounted Disc Brake System with WSP
- ❑ Positive body-bogie connection



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

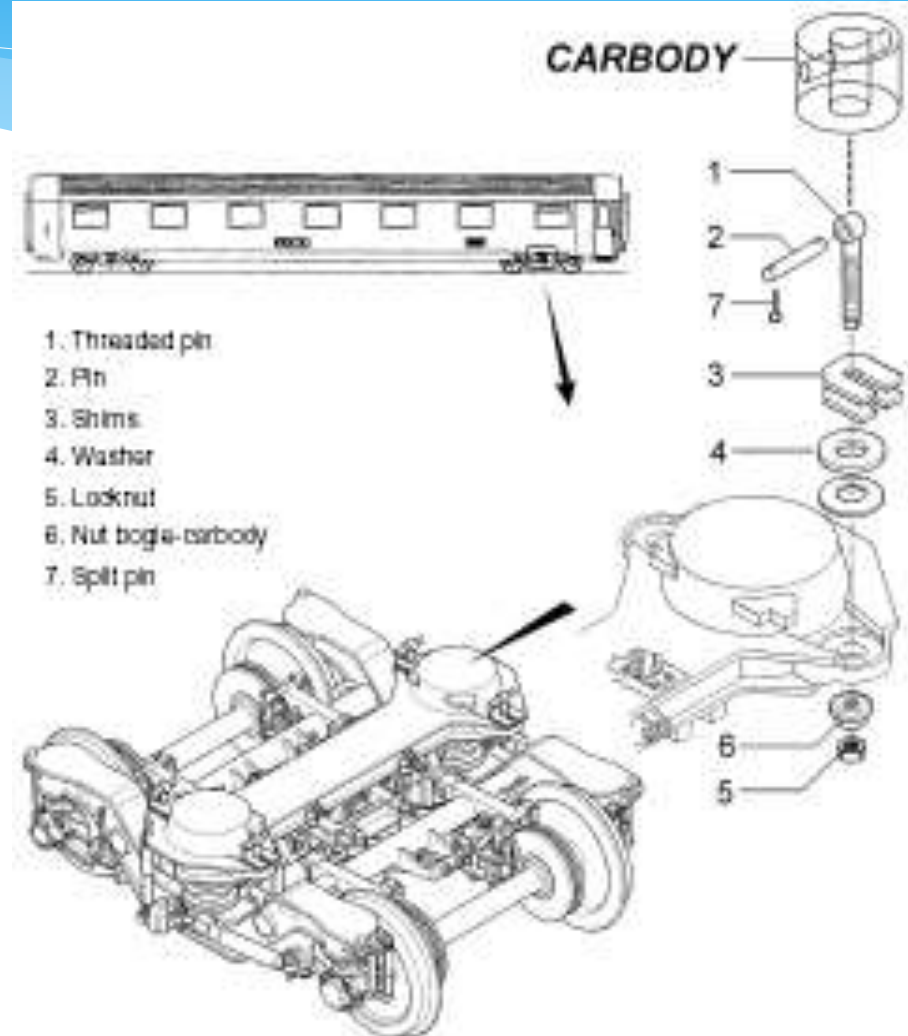
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Web	12	N





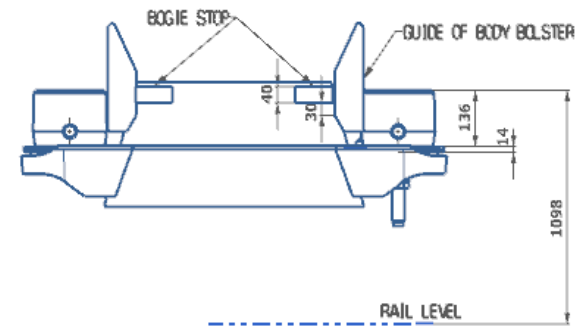
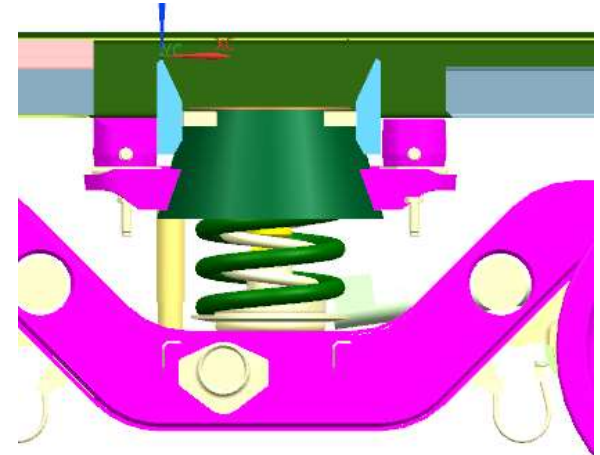
Buffer Height Adjustment

- ✓ Shims at body/bogie connection.
- ✓ Shims NOT added/removed in Primary and Secondary Suspension for wheel wear compensation or buffer height adjustment.





- Shims are provided between hub flange of body bolster and bogie bolster top.
- No limit of shims except overlap of body bolster guide vertical face (excluding taper portion) and horizontal stop of bogie bolster should not be less than 20 mm.



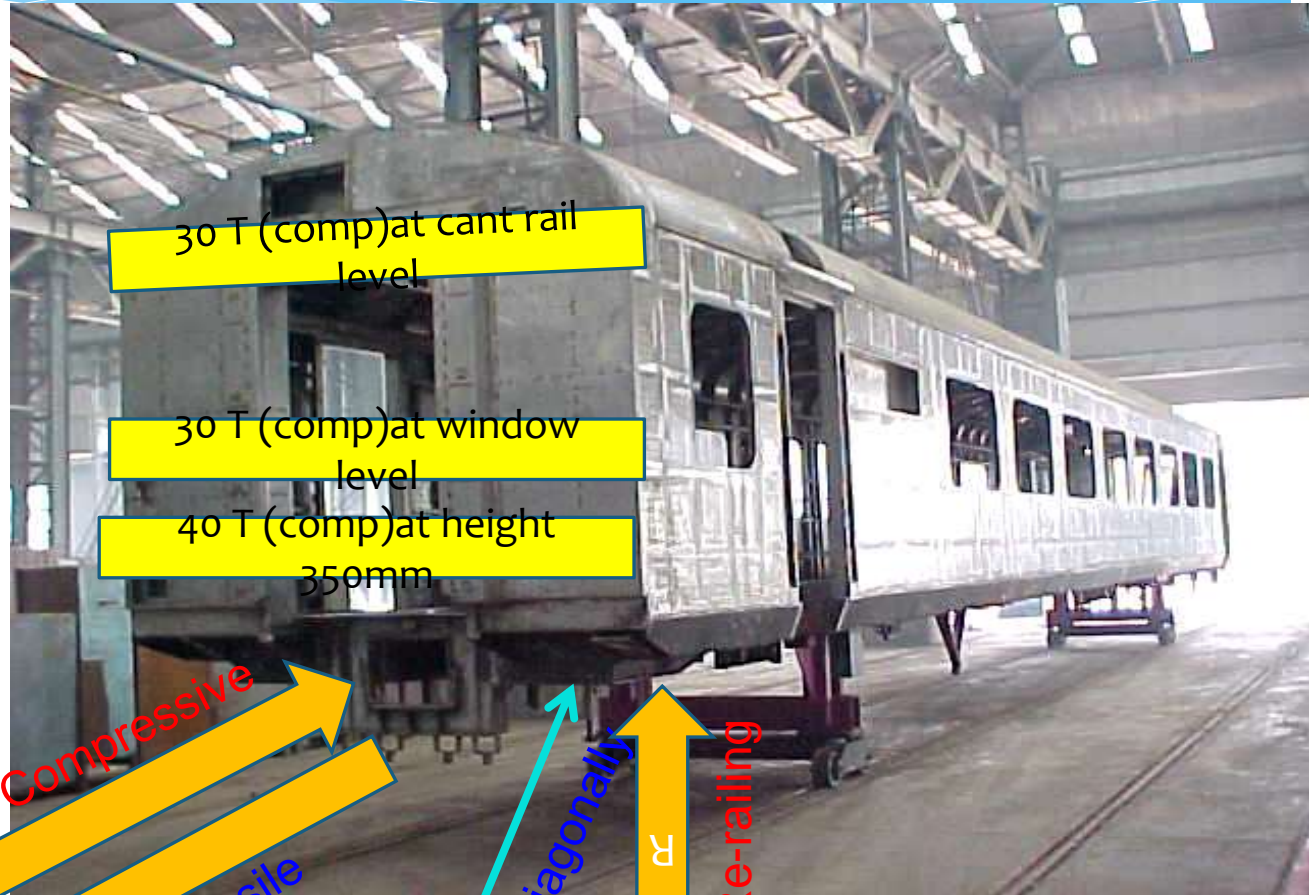


UIC-566 Compliance



Strength of LHB Shell – UIC 566

Re railing: Tare weighted coach can be lifted from one end tied with bogie, whereas other end of coach lies on the bogie; from head stock level.



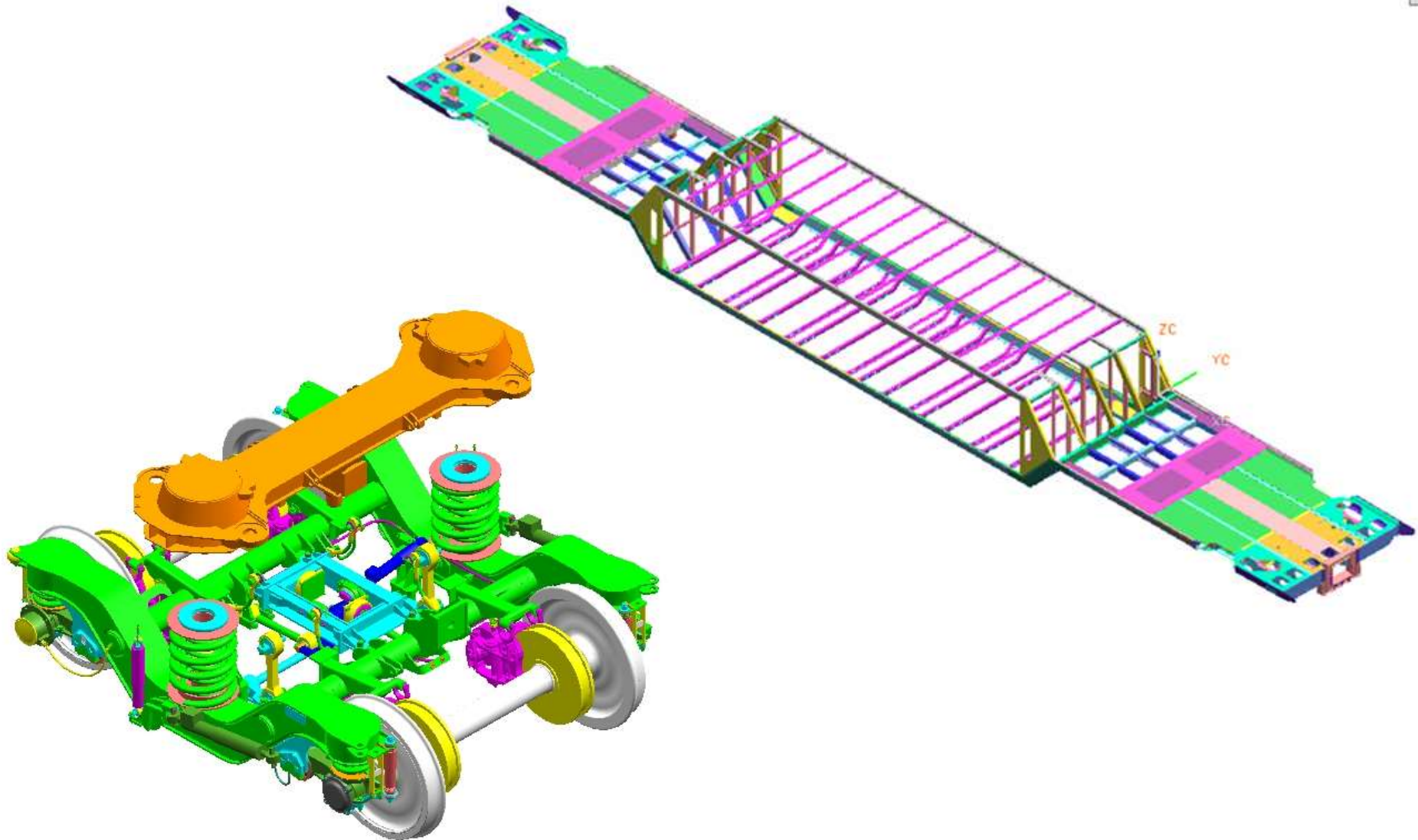


Simulations using Software

- 3D modeling & drafting – Unigraphics
- FEA – MSC Patran/Nastran
- Vehicle dynamics – Adams Rail
- Computational fluid dynamics – Star CCM
- Crash analysis – LS Dyna
- Pre-design Conceptualisation – Alias studio
- Simulation of anthropometric data – Human Jack Simulation

DESIGN DEVELOPMENT CAPABILITIES

SOLID MODELLING & DRAFTING

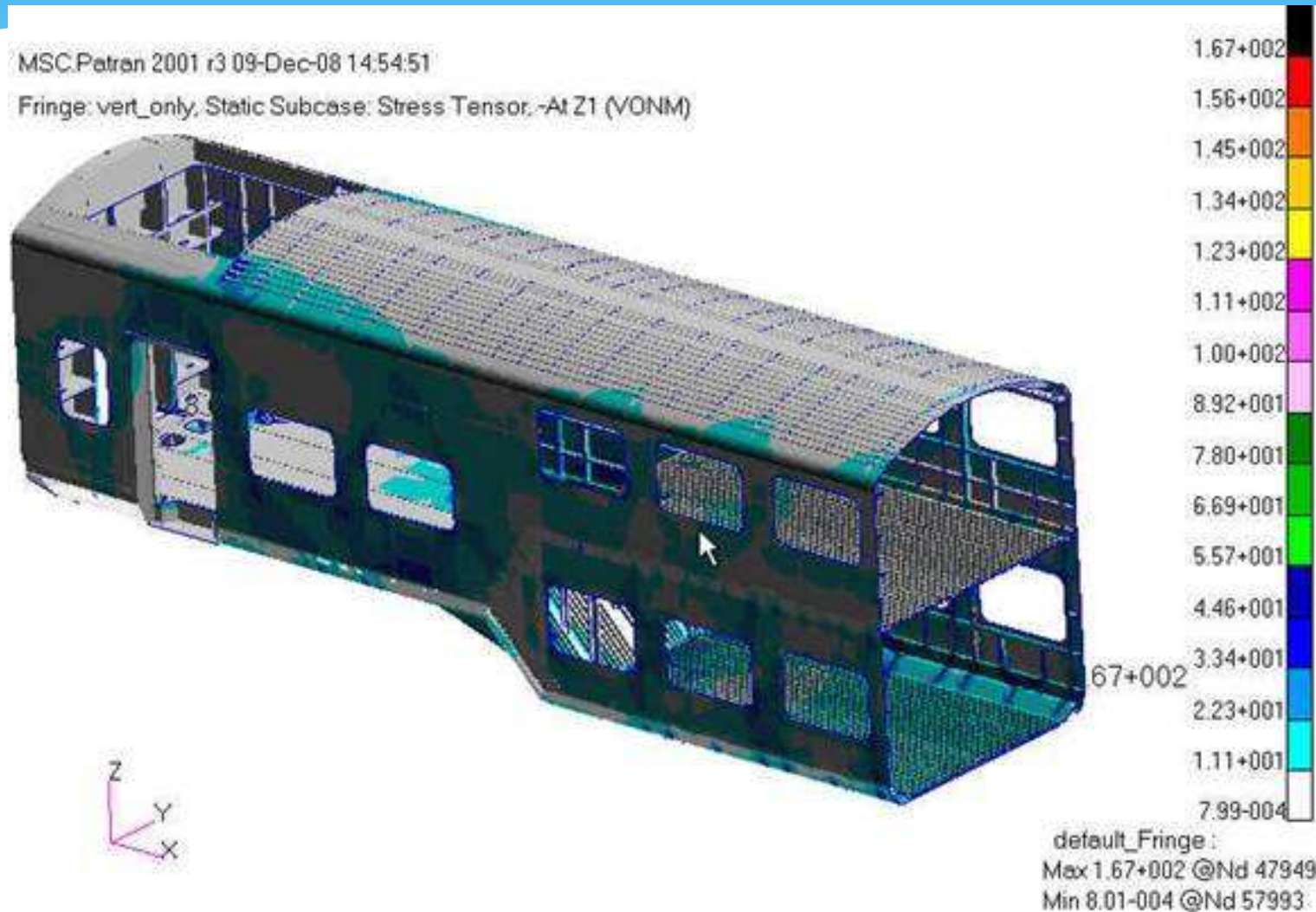




Finite Element Analysis (FEA)

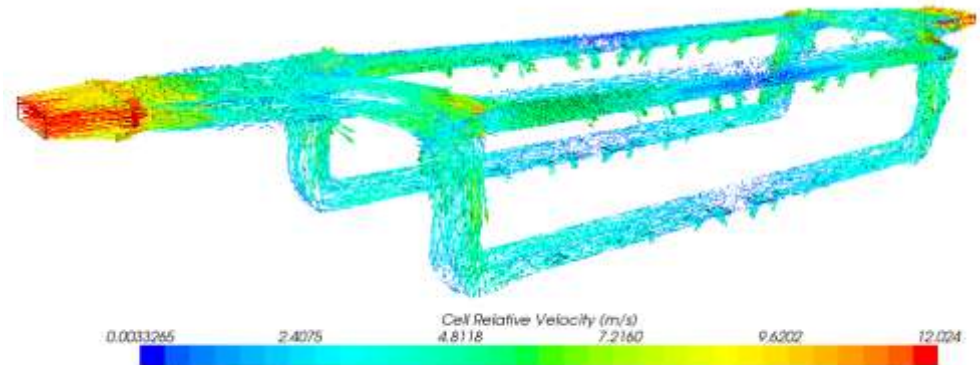
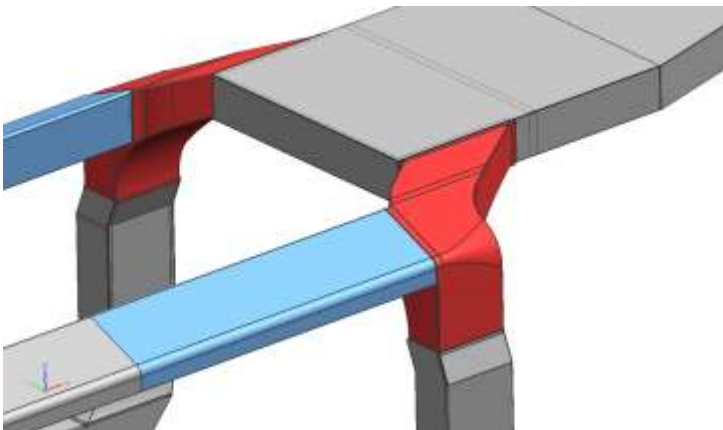
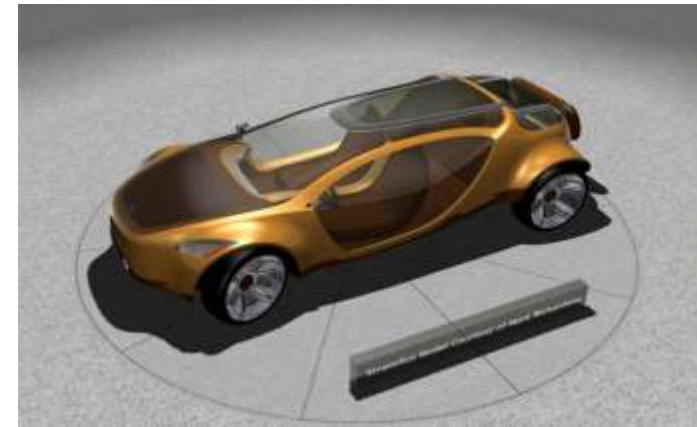
MSC.Patran 2001 r3 09-Dec-08 14:54:51

Fringe: vert_only, Static Subcase: Stress Tensor, -At Z1 (VONM)



DESIGN DEVELOPMENT CAPABILITIES

- ❑ VIRTUAL REALITY SET-UP & SHAPE STUDIO
 - ❑ Helps in development of new designs and visualization before manufacture
- ❑ CFD ANALYSIS SOFTWARE
 - ❑ Required for Computational fluid dynamics in duct design leading to passengers comfort





DESIGN DEVELOPMENT CAPABILITIES

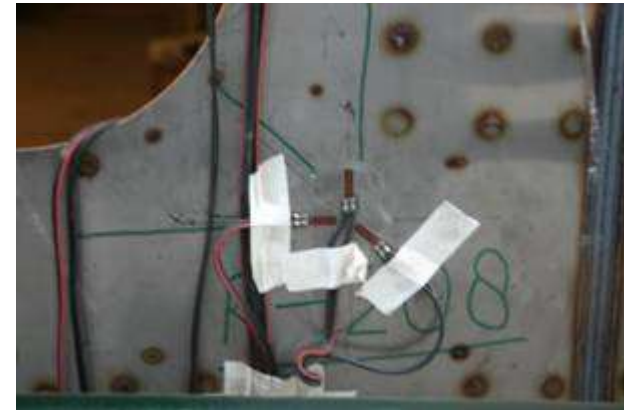
❑ JACK-HUMAN BODY MOTION SIMULATOR

- ❑ Helps in analyzing human body motion for better design of passenger amenities and equipment controls



Squeeze Testing of Shell

Application of loads on End Wall



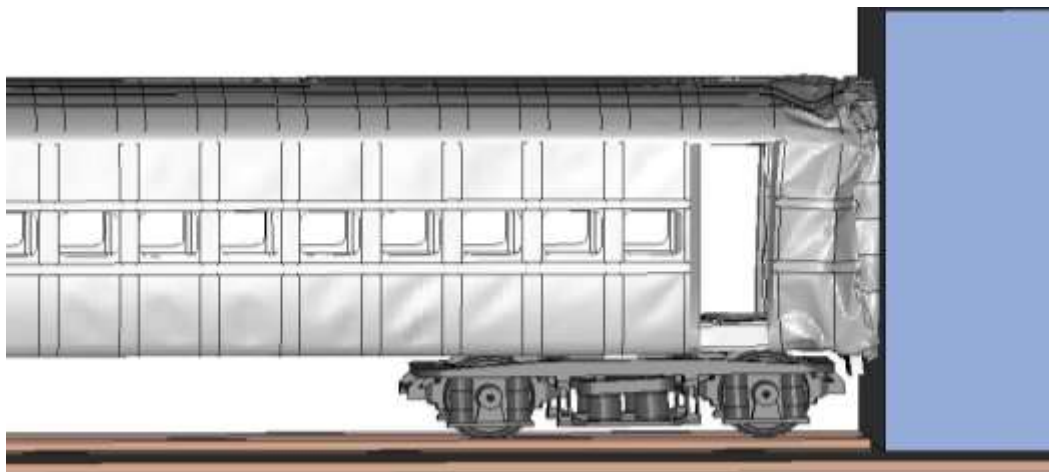
Measurements under progress



Energy Absorption

- crashworthy coach at 40 and hit with the rigid flatten wagon

- ✓ Energy developed during collision - 2.4 MJ
- ✓ Energy absorbed by draft gear - 45 KJ
- ✓ Energy absorbed by rear stop - 41 KJ
- ✓ Energy absorbed by primary absorber - 720 KJ
- ✓ Energy absorbed by secondary absorber - 470 KJ
- ✓ Total energy absorbed - 1.2 MJ
- ✓ Remaining energy to be absorbed by coach - 1.2 MJ





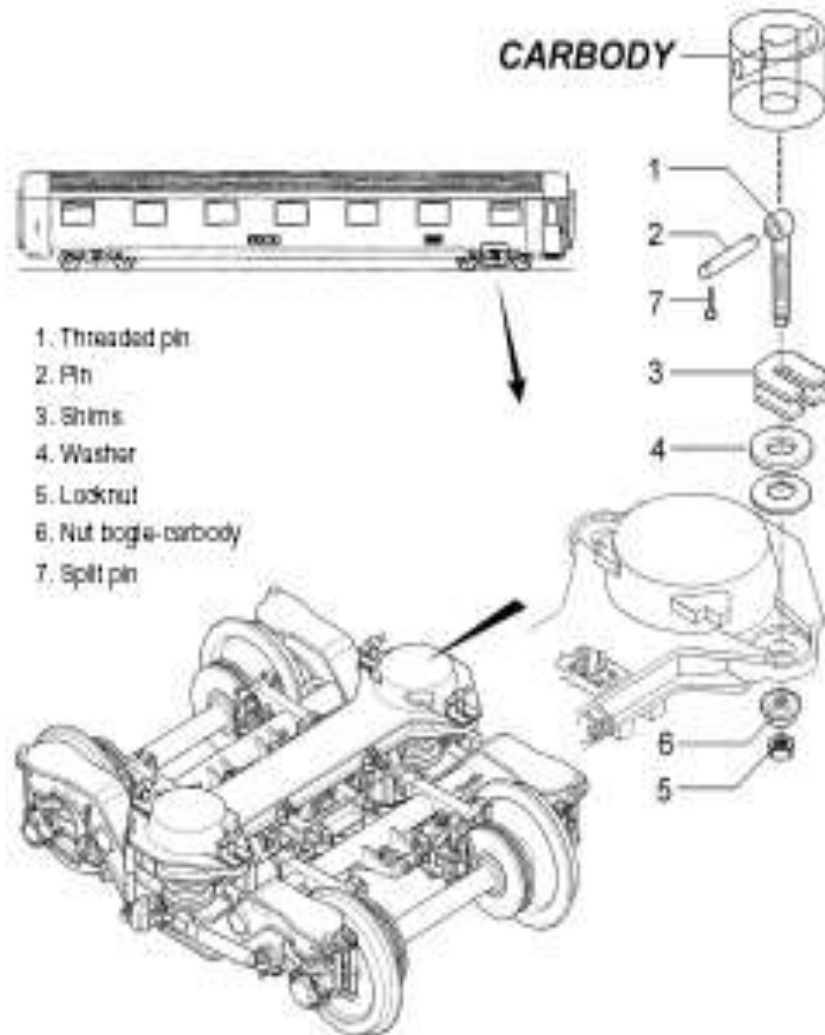
Safety Systems Act in Tendon



Safety Systems Act in Tendon

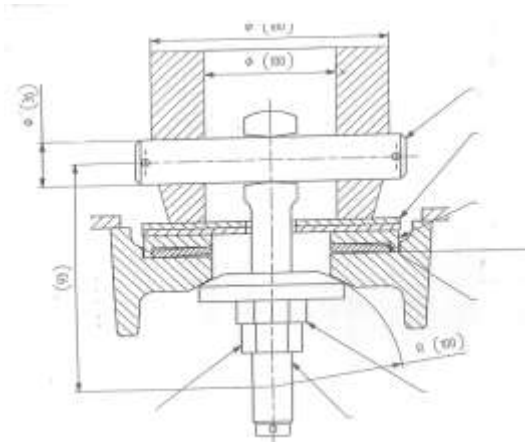
- ✓ CBC - does not permit Climbing
- ✓ Body-bogie connection – positive
- ✓ 5-g stop between body and bogie bolster
- ✓ Welded centre pivot pin
- ✓ AMDBS – no linkages
- ✓ Anti-Roll bar – prevents rolling
- ✓ Safety wire ropes – bolster and frame
- ✓ Bogie frame rotation limiter
- ✓ Yaw damper
- ✓ Positive connection of primary suspension

Bogie Body Connection



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





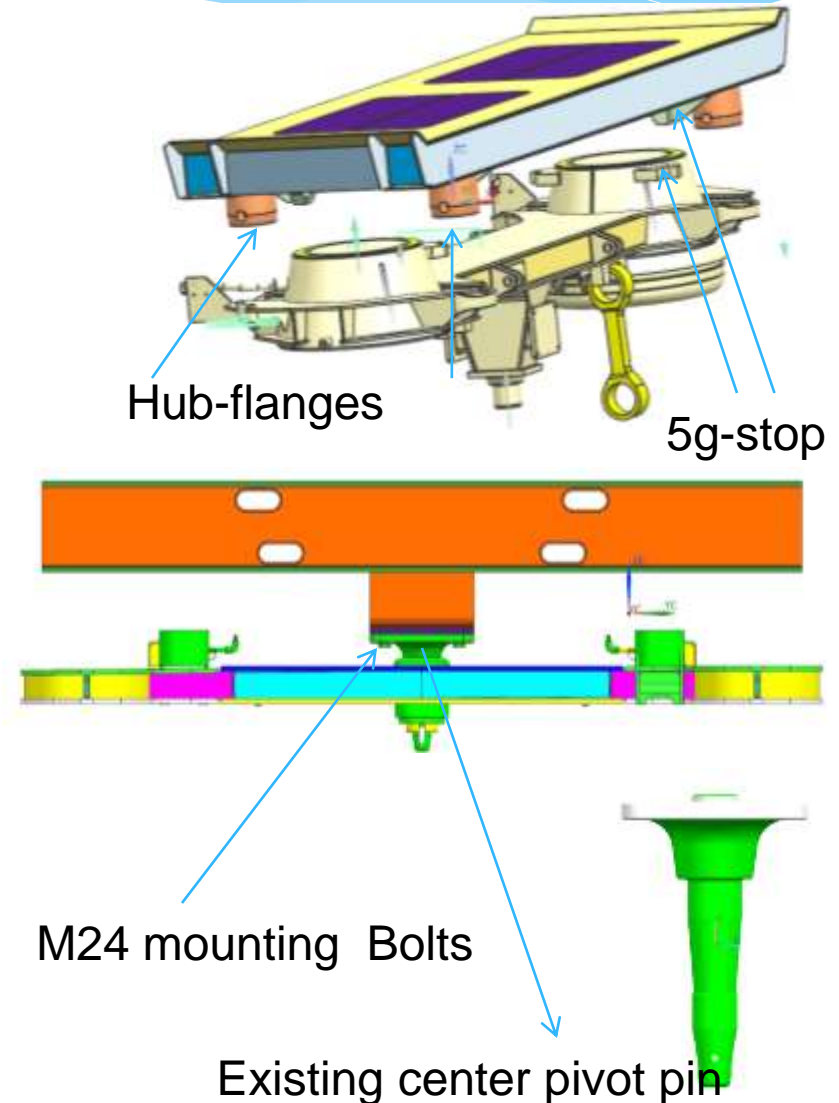
Coach Body-Bogie Connection

❑ LHB Body-Bogie Connection

- Four points per bogie- rigidly connected with eye-bolts.
- 5-g stops between body and bogie

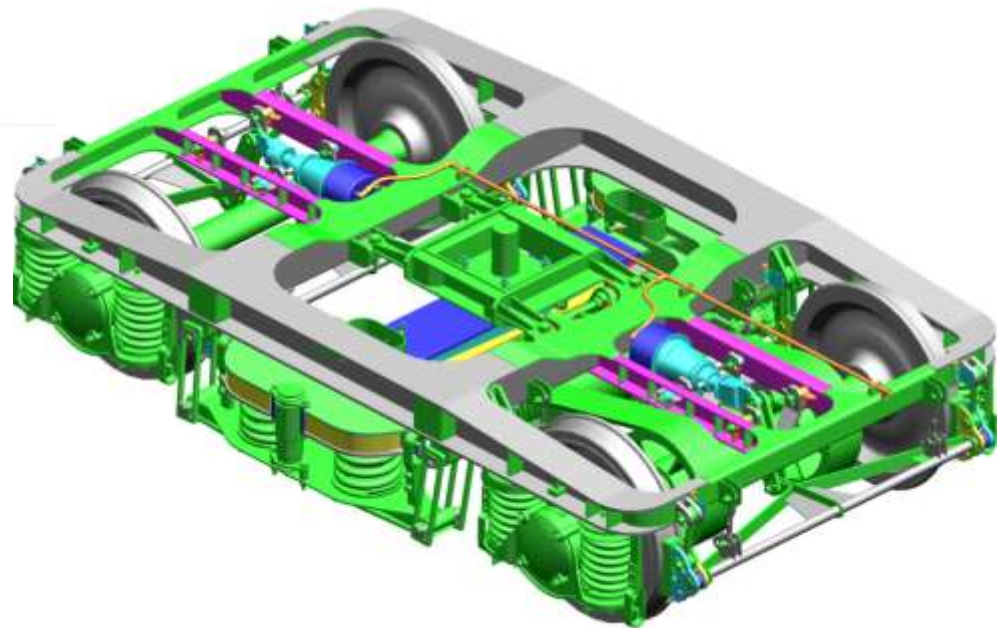
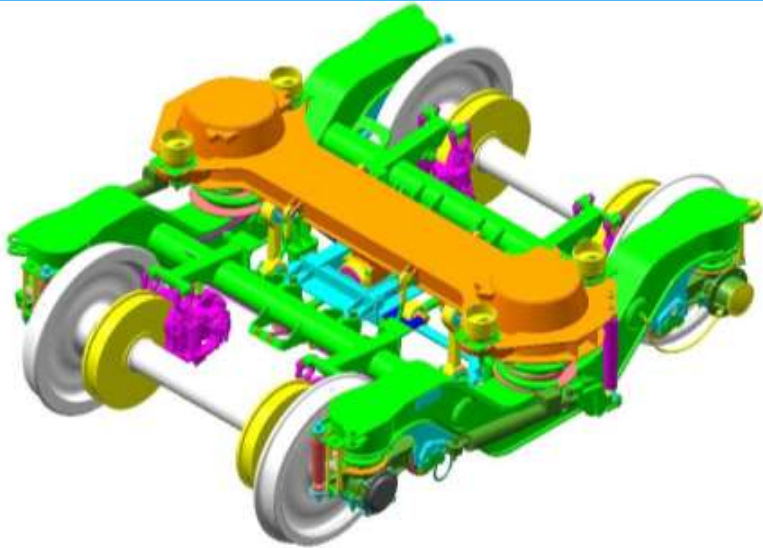
❑ ICF Body Bogie- Connection

- Floating side bearers- 2 per bogie
- Body connected through center pivot pin with four M24 bolts (8.8 property class)
- Each bolt can take load in shear - 14Tonnes
- Total load in shear per center pivot pin- $14 \times 4 = 56$ Tonnes
- Coach can take 112 Tonne in shear
- Requirement is of 5-g load i.e $225T$
($AC3T -58T-13T=45*5 =225T$)





Fiat Bogie Vs ICF Bogie



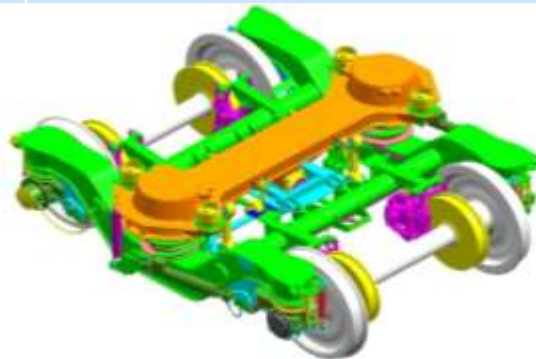


Load Transfer in HB Coach



Force Transmission Route

Vertical Forces	Lateral Forces	Traction and braking forces
<ul style="list-style-type: none">• Body bolster• Miner Pad• Sec. Suspension• Bogie Frame• Primary Springs• Ball joint control arm• Axle	<ul style="list-style-type: none">• Body bolster• Miner pad• Sec. Springs• Lateral Bump Stop• Bogie frame• Ball joint control arm• Axles	<ul style="list-style-type: none">• Body• Traction center• Traction lever• Longitudinal bump stop• Bogie frame• Control arm• Axle

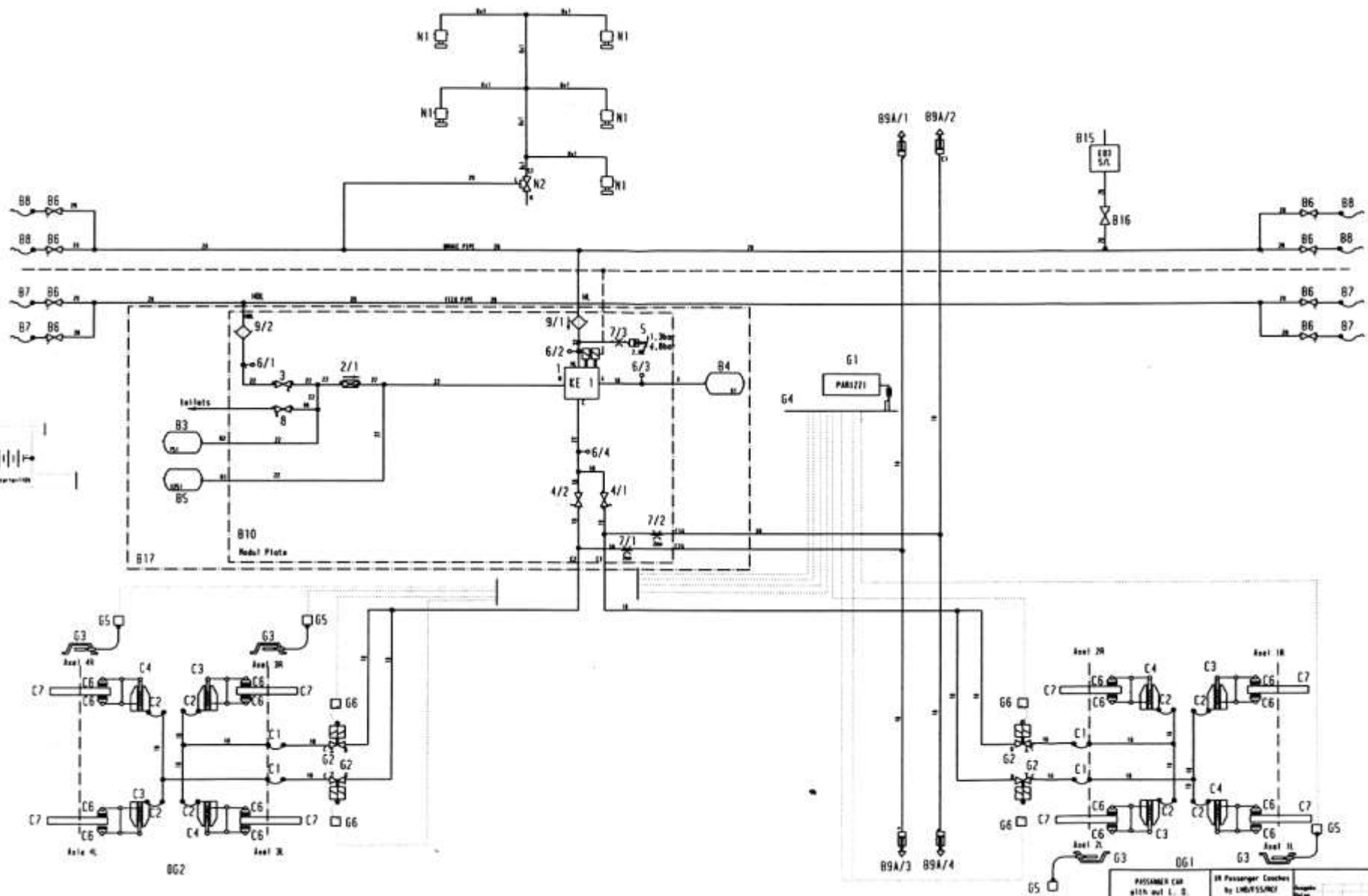




Brief about AMDBS

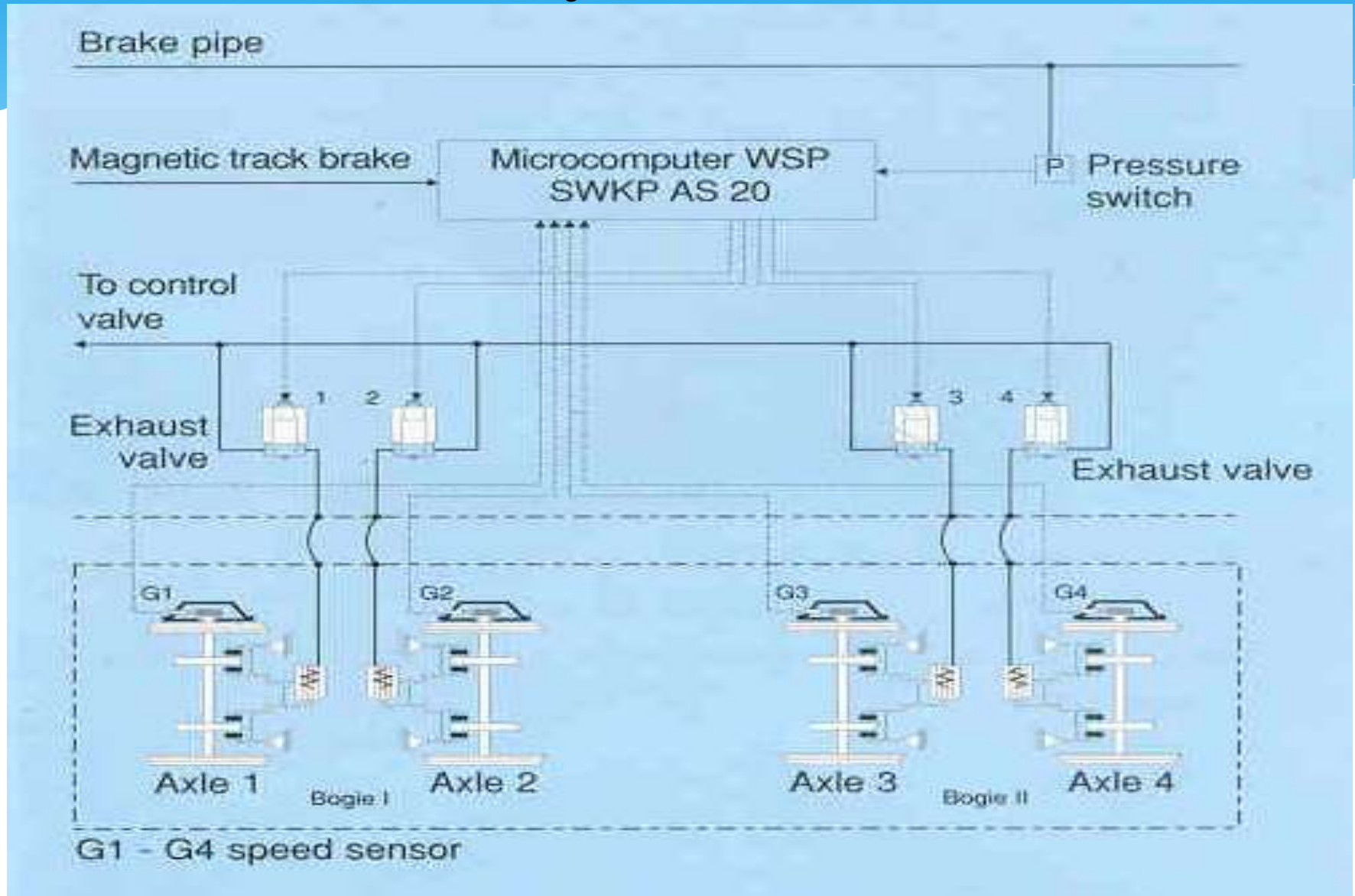


AMDBS – Schematic Layout



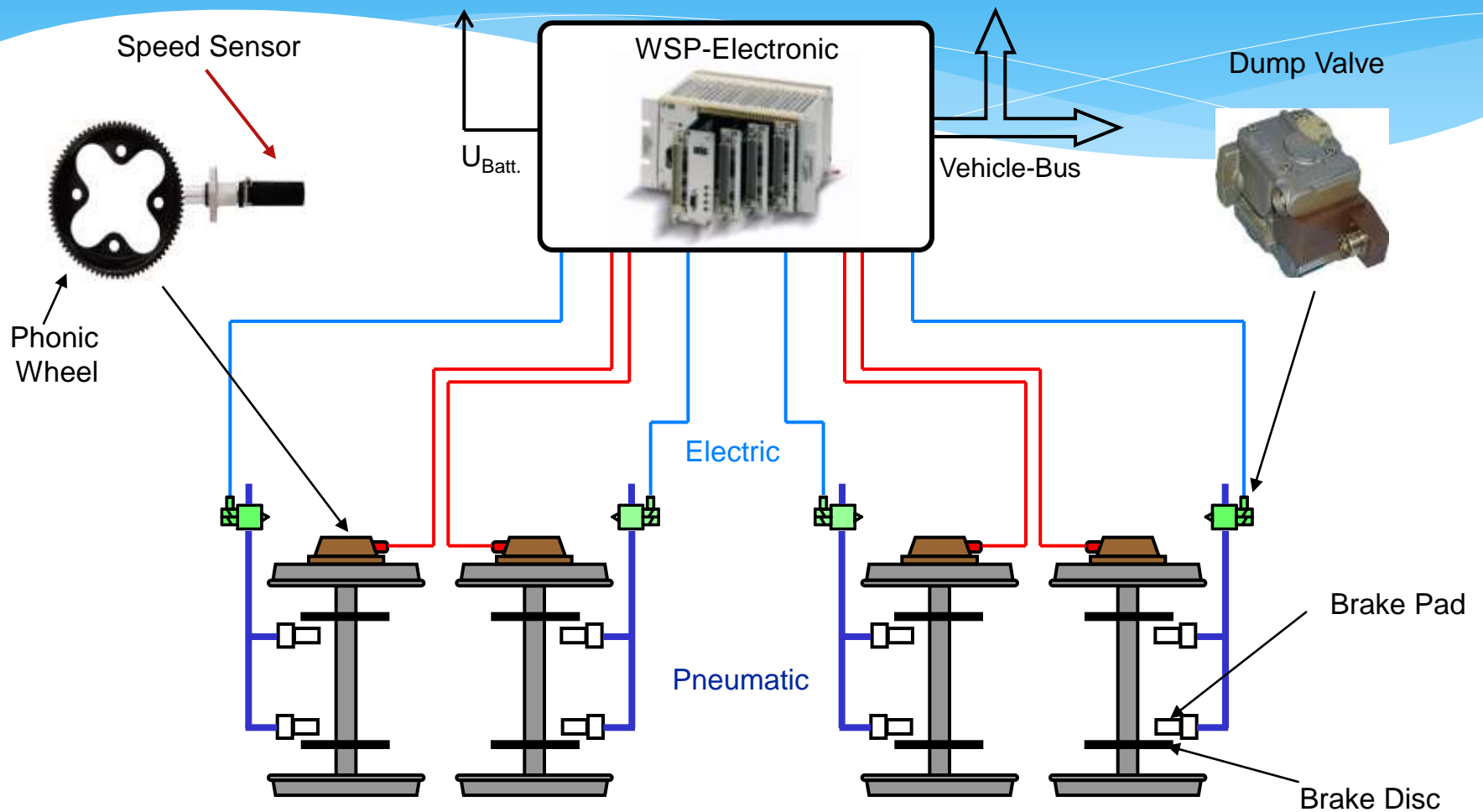


AMDBS – Schematic Layout



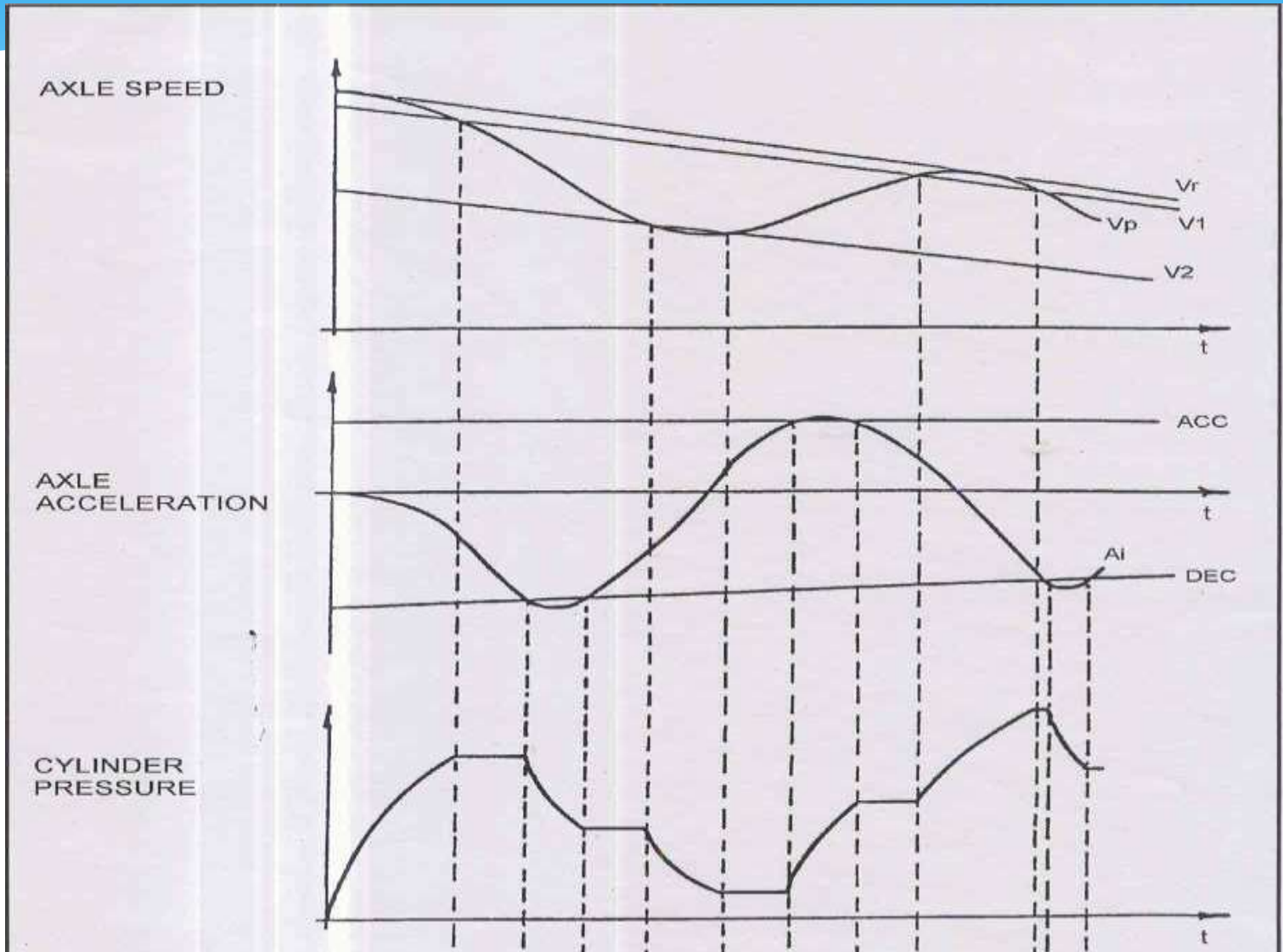


AMDBS – Schematic Layout





Wheel Slide Protection Equipment





Wheel Slide Protection Equipment

a) reduce the pressure to the brake cylinder with:

$$V_i \leq V_2 \text{ or } A_i \leq \text{DEC}$$

b) restore the pressure to the brake cylinder with:

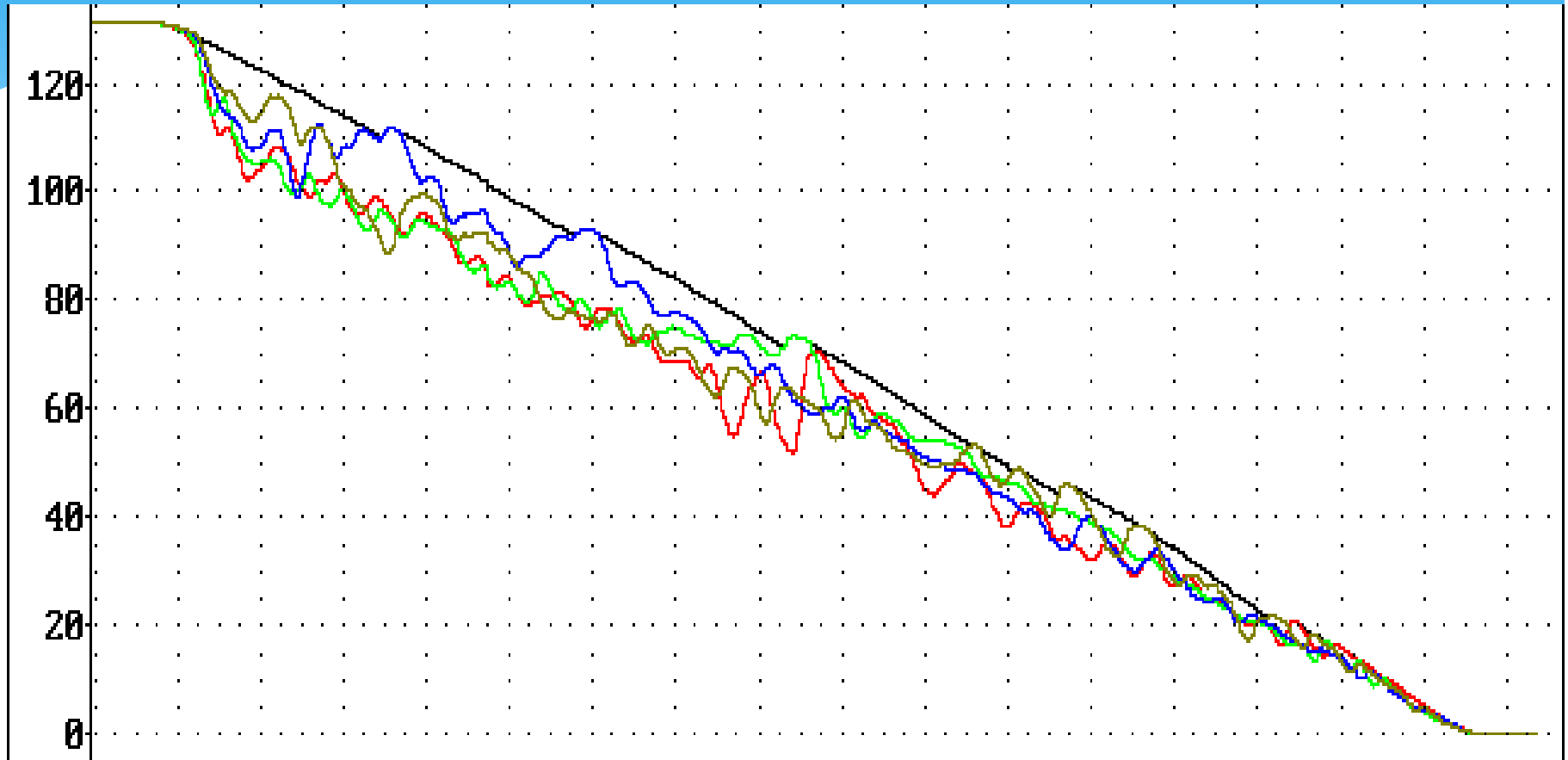
$$V_1 \leq V_i \text{ or } A_i \geq \text{ACC}$$

c) maintain the pressure to the brake cylinder if neither condition a) nor condition b) is satisfied, that is:

$$V_2 \leq V_i \leq V_1 \text{ or } \text{DEC} \leq A_i$$



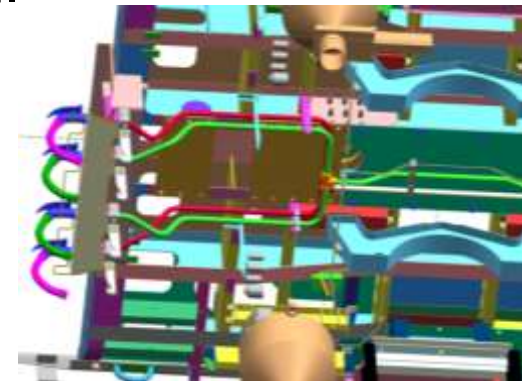
Wheel Slide Protection Equipment





Brief History of Brake Piping/Fittings of LHB Coaches

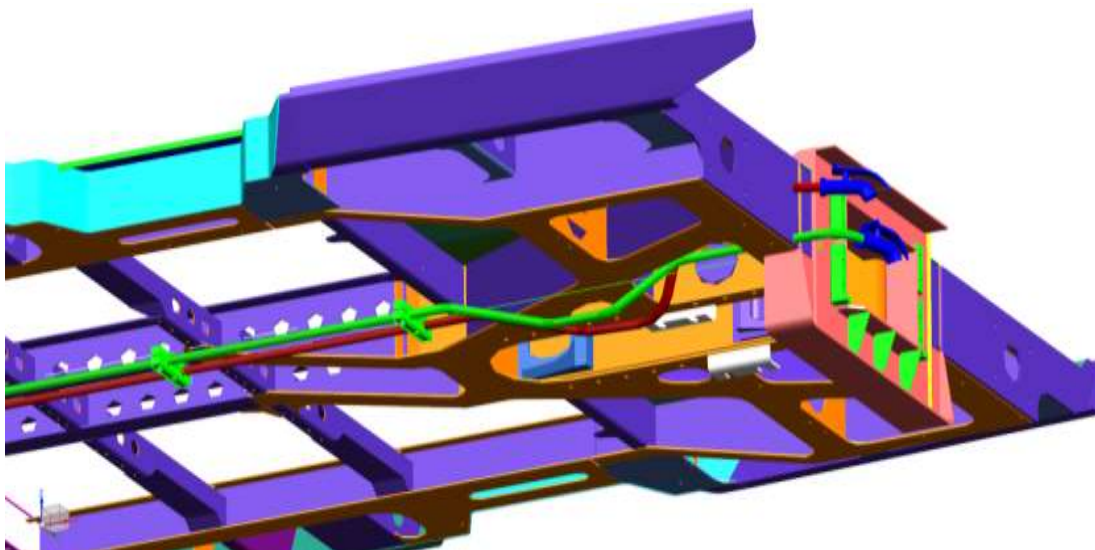
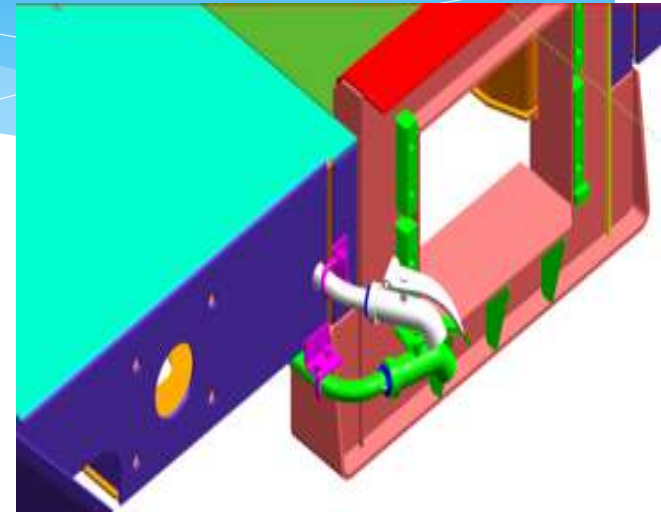
- ✓ SS pipes + single bite fittings (indigenous fittings till' July'15. These have quality issues)
- ✓ At coach ends:
 - ✓ 04 hoses, at lower height, near to rail level (prone to damage)
 - ✓ Isolating cocks fitted with single bite fittings (prone to slippage)
 - ✓ T- joint, bifurcating BP and FP, at lower height (prone to hitting)





Brake Piping Modified Since Mar'15

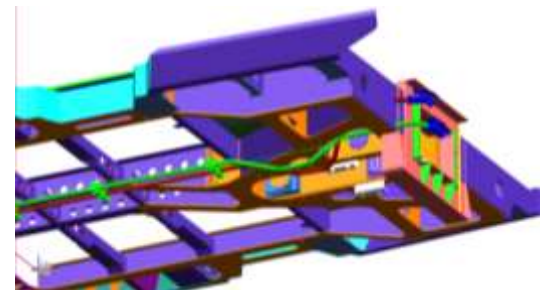
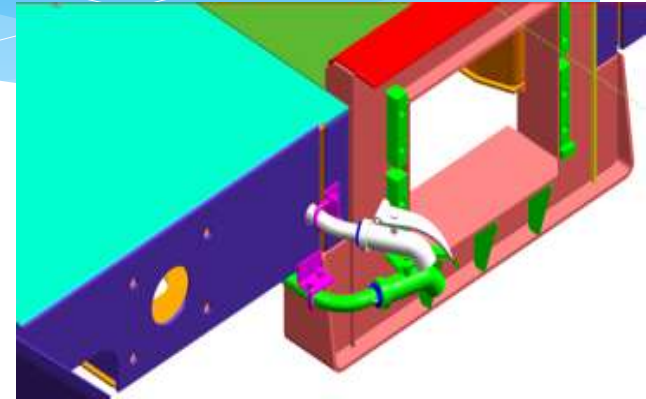
- ✓ Two pipes instead of four
- ✓ Height of pipes raised
- ✓ Conv. coach hose pipe used
- ✓ T-joint, bifurcating BP and FP, eliminated





Brake Piping Modified Since Mar'15

- ✓ Coach end joint same as that of conv. Coach
- ✓ Higher thickness pipe –same as that of conv. coach
- ✓ Threaded joint of isolating cock instead of bit type
- ✓ 12 bite joints per coach reduced
- ✓ 50 components reduced
- ✓ Couplable with coach having 04 pipes
- ✓ CAI issued - CAI/RCF/MECH/R-SS/054 vide MD46131 date: 22.03.15.



THANK YOU

