

# **SELECTION OF ROLLING STOCK**



**POINTS TO CONSIDER WHILE FRAMING**

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**TECHNICAL SPECIFICATIONS**

**(Lecture on 13-02-2008)**

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## Need for Specification

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You only get  
what you specify.



# What is Specification?

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- Communication with supplier/  
manufacturer regarding
  - Requirements of purchaser
  - Expectations from supplier
  - Performance parameters
  - Evaluation parameters and methods
  - Boundary conditions for supplier manufacturer
  - Legal commitment if part of contract



# Features of Good Specification

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- Unambiguous-Clear, specific language
- Should be practical and enforceable
- The requirement should be quantified to the extent possible
- Should quote standard specification wherever needed
- Standards should be current
- Should not contravene statutory regulations

# Features of Good specification (Contd.)



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- Focus on end user requirements
- Specify qualifying requirements for manufacturer –prescreening
- Performance an evaluation requirement should be clear



# Scope

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- Design Development
- Construction
- Supply
- Delivery
- Commissioning



# General

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- Approval of design
- Contractors Responsibility
- Guarantee
- Exhibited drawings and standard specifications
- Service engineering
- Service manuals and spare parts catalogues
- Spare parts



# Dimensional and Performance Requirements

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- Operational Requirements
  - Maximum Operational Speed
  - Track Geometry
  - Ride comfort
  - Train length-trailing load
  - Type of traction
  - Signaling system
  - Safety
  - Economy of operation



# Comfort level

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- Comfort level
  - Level of accelerations
  - Level of ride indices
  - Level of illumination
  - Level of ventilation
  - Level of noise



# Ride Index

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- Comfort level is achieved through the proper designing of bogie suspension. After arriving out the satisfactory undamped natural frequencies of suspension, level of comfort can be calculated on the basis of Ride Index method developed by Dr. Sperling

$$\text{Ride Index} = 0.896 [b^3/f \times \phi(f)]^{0.1}$$

Where,  $b$  = Mean Acceleration in  $\text{cm}/\text{sec}^2$

$f$  = Frequency in Hertz

$\phi(f)$  = A Correction Factor

=  $0.325 f^2$  for 0.8 to 3 Hz Vertical

=  $0.8 f^2$  for 0.8 to 3 Hz Transverse

Ride index values associated with 'comfort' are considerably lower than those associated with 'safety'



# Ride Index (Contd.)

## Relation between Passenger Comfort & Ride Index

<b>Ride Index</b>	<b>Appreciation</b>	<b>Fatigue Limit</b>
1.0	very good	Over 24 hours
1.5	Almost very good	
2.0	Good	
2.5	Neatly Good	13 hours
3.0	Passable	5.6 hours
3.5	Still Passable	2.8 hours
4.0	Able to Run	1.5 hours
4.5	Not able to Run	45 minutes
5.0	Dangerous	15 minutes



# Safety

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This is the prime factor of consideration for the traveling masses. The Specification of coach should be such as to ensure safety against the following:

- Collision
- Derailment
- Fault in Coach Body, Bogie and other Subsystems Failure
- Fault due to Material Failure
- Fire
- Theft
- Ecological imbalances



# Safety (Contd.)

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- Safety against Derailment due to flange climbing

- NADAL's formula:

$$\frac{Y}{Q} \text{ not greater than } \frac{\tan \beta - \mu}{1 + \mu \tan \beta}$$

- $Y/Q$  should not be greater than 1.0 ----IR limit
  - $Y$  = Flange force/lateral force for continuous min. 0.05 (1/20) sec.
  - $Q$  = Instantaneous wheel load
  - $\beta$  = Flange angle (68 degree)
  - $\mu$  = Co-efficient of friction between wheel and rail (0.25)
- $Y/Q = 1.4$



## Safety (Contd.)

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- Safety against Derailment due to track distortion:
- Prudhomme's Limit:
- Lateral force (Limit)
- $H_y$  should not be greater than  $(1+P/3)p$

Where,

- $P$  = Axle Load in tons
- $P$  = Co-efficient to take care of track maintenance, layout of tracks etc. = 0.85

*Lateral force applied for min. 2m length of the track*



# Fire Safety

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- Location and number of fire exits
- Location of fire barriers
- Fire extinguishers
- Fire detection and alarms
- Use of fire retardant materials to
  - UIC 564-2 OR
  - DIN 5510
  - BS 6853
  - EN 45545



# Dimensional and Performance Requirements (Contd.)

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- Dimensional Requirements
  - Track Gauge
  - Maximum Moving Dimensions
  - Schedule of Dimensions
  - Sharpest curve
  - Super elevation
  - Clearance above Rail Level
  - Pay Load/axle load/track loading density
  - Gradient



# Overall Dimensions

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This takes into account the following parameters:

- Locations of fixed structures along the track on open lines, yards and platforms
- Overhead space available in bridges and tunnels including the high-tension traction lines.
- Sharpest curve.
- Distance between the adjacent tracks.
- Clear space required from under-slung equipment to rail-level.



## Overall Dimensions(Contd.)

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The limitation of overall dimensions is also based on the following factors:

- Length of the lock bar
- Curve negotiability i.E.
  - Throw at centre (middle throw)
  - Throw at ends (end throw)
- Combined throw on adjacent track



## Limitations (Contd.)

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- End Throw,  $D_e = 1000 \times (an_a + n_a^2 - p^2/4)/2R$
- Middle Throw =  $1000 \times (a^2 \times p^2)/8R$

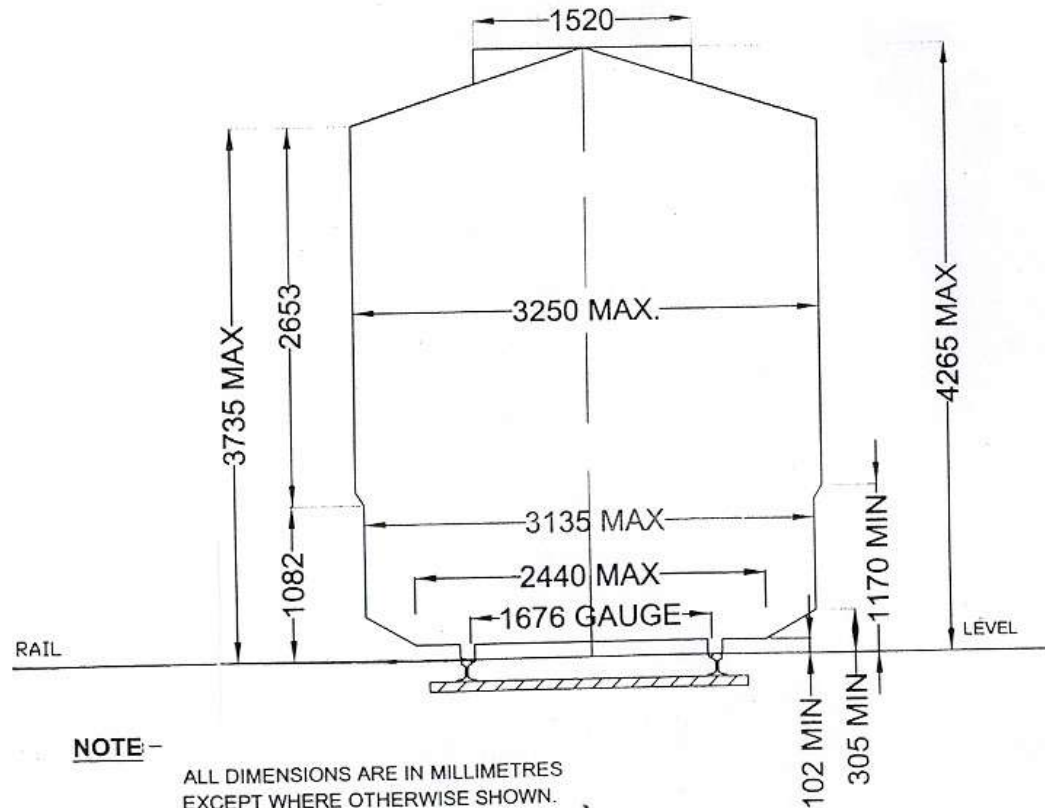
Where,

- $a$  = Distance apart of bogie centres
- $n_a$  = Distance apart of bogie centre and end of car body
- $P$  = Wheel base of bogie
- $R$  = Curve radius

# Maximum Moving Dimensions (MMD)

Diagram No. 1D (EDO/T-2202) 1676mm Gauge of SOD, revised, 2004

## MAXIMUM MOVING DIMENSIONS





# Dimensions of IR/BG Stock

DIMENSIONS	ICF / RCF			LHB	EMU	
	STD. COACH	D. DECK	LONG. COACH		MOTOR COACH	TRAILER COACH
GAUGE	1676	1676	1676	1676	1676	1676
LENGTH OVER BUFFERS	22297	22297	24125	24000	---	---
LENGTH OVER BODY	21337	21337	23165	23540	20726	20726
COACH WIDTH	3250	3050	3250 /3100	3240	3660	3660
HEIGHT OF COACH BODY	3111	3360/ 4055	3111	2941	2895	2895
WHEEL-BASE	2896	2896	3200	2560	2896	2896
DISTANCE BETWEEN BOGIE CENTERS	14783	14783	15543	14900	14630	14630
DISTANCE BETWEEN SIDE BUFFERS	1956	1956	1955	---	---	---
HEIGHT OF BUFFER/ CBC FROM RL	1105	1105	1105	---	1035	1035



# Dimensional and Performance Requirements (Contd.)

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- Environmental Conditions
  - Ambient temperature
  - Humidity
  - Rain fall
  - Atmosphere
  - Environment



# Coach Design

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- Overall dimensions of coach
- Moving Dimensions
- Reliability/Maintenance
- Body Shell
  - Suitable for end loads specified in UIC-566
  - Lifting Pads
  - Anti Telescopic Features
  - Energy Absorption
  - Air Ventilation
  - Corrosion Resistance



## Various Loads on Coach Body

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Systematic study for strength has to be conducted considering various loads borne by the vehicle. These loads are:

1. Static vertical loads
2. Static longitudinal loads
3. Combination of (1) & (2)
4. Vibrations
5. Impacts and Shocks



# Strength

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Strength of vehicle body means it's ability to withstand various loads to which it may be exposed during normal operation on track.

- End loads
- Strength of fitting and connections in longitudinal and vertical directions



# Strength requirement as per UIC 566

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## UIC-566 CONCEPT

- 2000 KN (Min.) at buffer level.
- 500 KN (Min.) at diagonally opposite buffers.
- 400 KN (Min.) at 350mm above buffer center line.
- 300 KN (Min.) at window guard-rail.
- 300 KN (Min.) at cant-rail.
- 1500 KN (Min.) at 'A' location of traction stop of CBC (automatic coupler).
- 1000 KN (Min.) at 'B' location of traction stop of CBC (automatic coupler).
- 1500 KN (Min.) at 'C' Location of flange bearing surface of CBC (automatic coupler)



# Coach Design (Contd.)

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- Body side doors and windows
- Bogie
- Wheels, Axles and Roller Bearings
- Draw and Buffing Gear
  - Screw coupling, semi-permanent or automatic Centre Buffer Coupler
- Brake System
  - Graduated release twin pipe air brakes
  - Anti skid device
  - Automatic Slack Adjuster
  - Braking distance
  - Hand Brake
  - Non asbestos Friction material



## Coach Design (Contd.)

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- Lavatories
- External Fittings
  - Door steps
  - Continuous water wiggles
  - Rain water gutters
  - Tail lamp bracket
- Passenger Alarm Signal Apparatus



# Coach Design (Contd.)

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- Interior Furnishing
  - Light weight
  - Fire retardant
  - Non toxic
- Ceiling and Paneling
- Flooring
  - Fire resistance
  - Light weight
  - Water tight overlay
- Vestibuling
  - Fire resistance



# Body Shell

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- Corrosion protection methods
- Noise insulation-level of noise
- Exterior surface finish in unpainted condition
- Vestibule arrangement
- Thermal insulation-Overall thermal coefficient to be specified



## Body Shell (Contd.)

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- Lay out should be approved by purchaser
- Exterior colour scheme
- Interior colour scheme
- Signage and notices to be displayed
- Passenger amenities list if any based on demographic data
- Seats and berths, luggage racks etc



# Power supply

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- Hotel Load from Generator Cars
- Power supply to coaches
- Emergency lighting
- Couplers
- Special Safety Provisions for high Voltage equipments
- Utilisation Voltage and load distribution on Coaches
- Batteries



# Air Conditioning

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- Air-conditioning system
  - Summer conditions
  - Winter conditions
  - Shock and Vibrations levels to be withstood
- Thermostats settings
- Insulation
- Fresh Air Quantity
- Humidity Control
- Ducting
- Air Filter
- Air Conditioning Equipment



# Air Conditioning (contd.)

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- Emergency system
- Wiring
- Circuit Protection
- Light fittings, Fans and Switches
- Control Panel



# Tests and Trials

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- Type tests
  - Squeeze Load test of shell
  - Exhaustive Stationary Bogie Frame tests
    - Dynamic fatigue testing
    - Strain measurement
  - Draw and buffing Gear
  - Principal Brake components
  - Principal Bogie components
  - Interior equipment such as chairs, luggage racks, doors etc.
  - Air conditioning equipment
  - Water/Sanitary system



# Tests and Trials (contd.)

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- Routine tests
  - Bogie clearance test
  - Air delivery test
  - Air leakage test
  - Water tightness test
  - Pre cooling test
  - High Voltage test
  - Inter vehicle coupler test
  - Test for voltage drop
  - Average illumination test



## Tests and Trials (contd.)

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- Instrumented tests
  - Sound level tests
    - Stationary
    - Running
  - Oscillation tests
  - Train Brake and Acceleration test

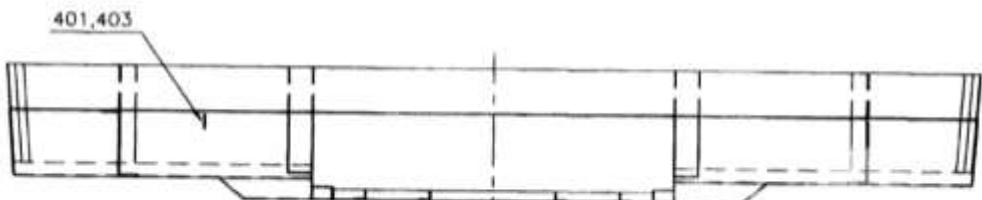
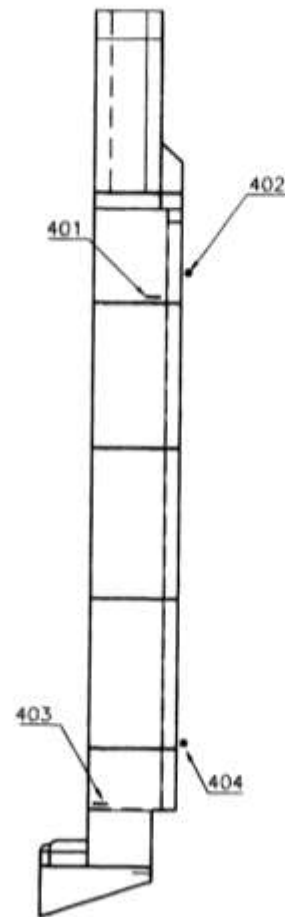
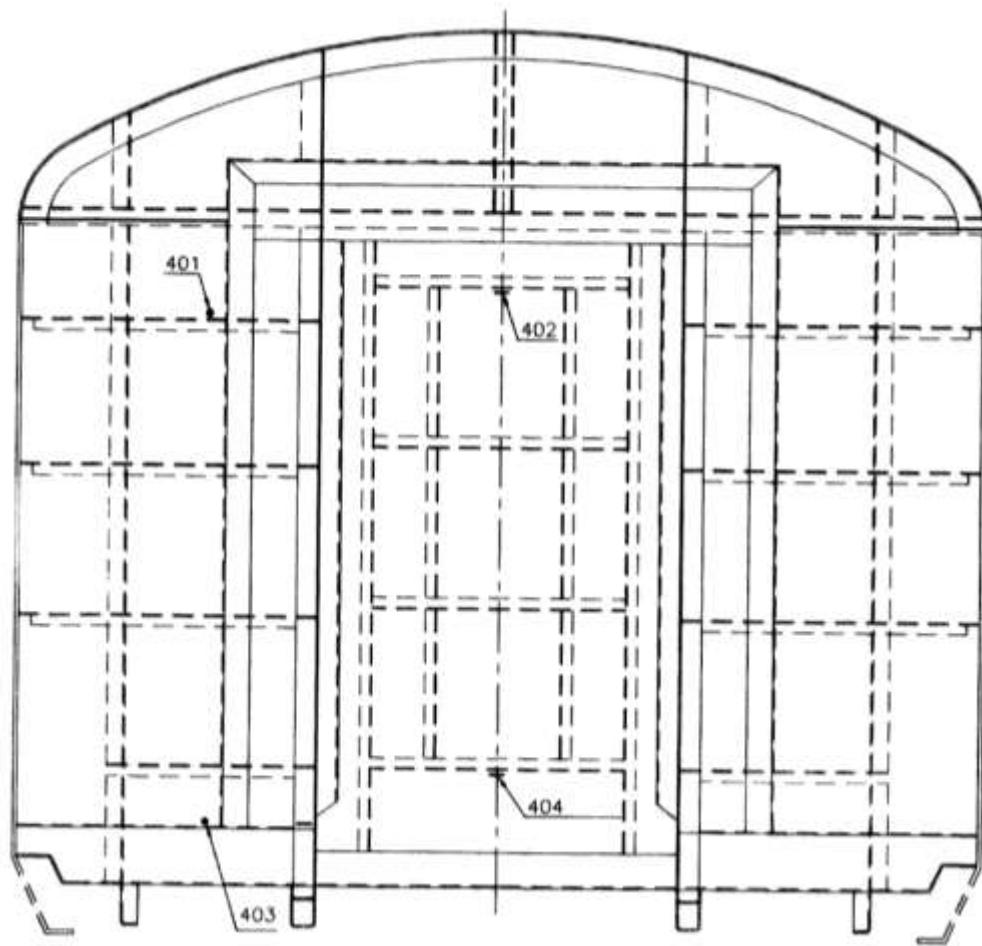


# Design Validation

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- Stress investigation (Squeeze test)
- Oscillation Trials
- Emergency Braking distance trials
- Coupler force trials
- Confirmatory Oscillograph Car Run (COCR)





LUGGAGE END

No. OF GAUGES: 401 TO 404 = 4

SUPERSEDES:-		
SUPERSEDED BY:-		LHB VARIANT SLR
REF.:	SCALE P	STRAIN GAUGE LOCATIONS ON END WALL
	C	
	T	
	D	
	JS CD/1/2003	

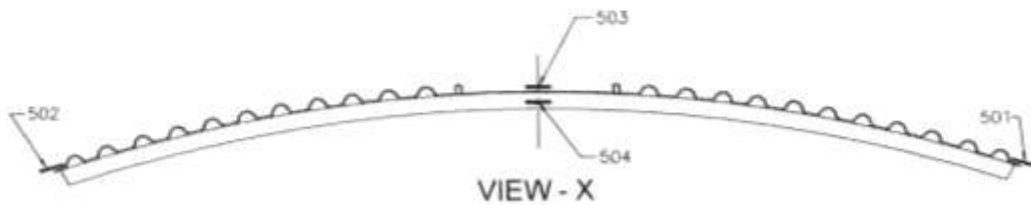
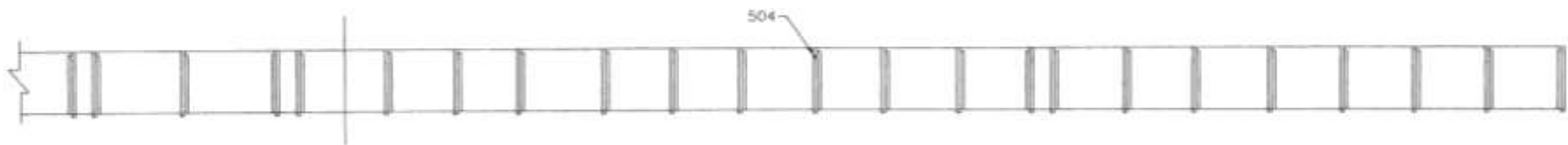
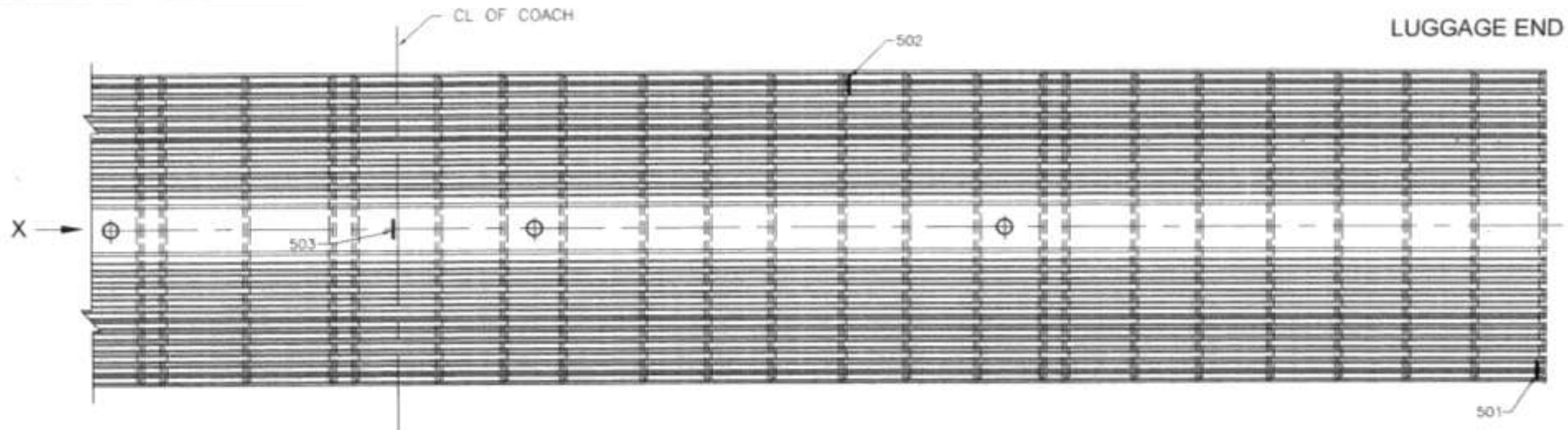
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FLOPPY No.

**BG** RDSO (C)

GROUP			

SKETCH- K3016

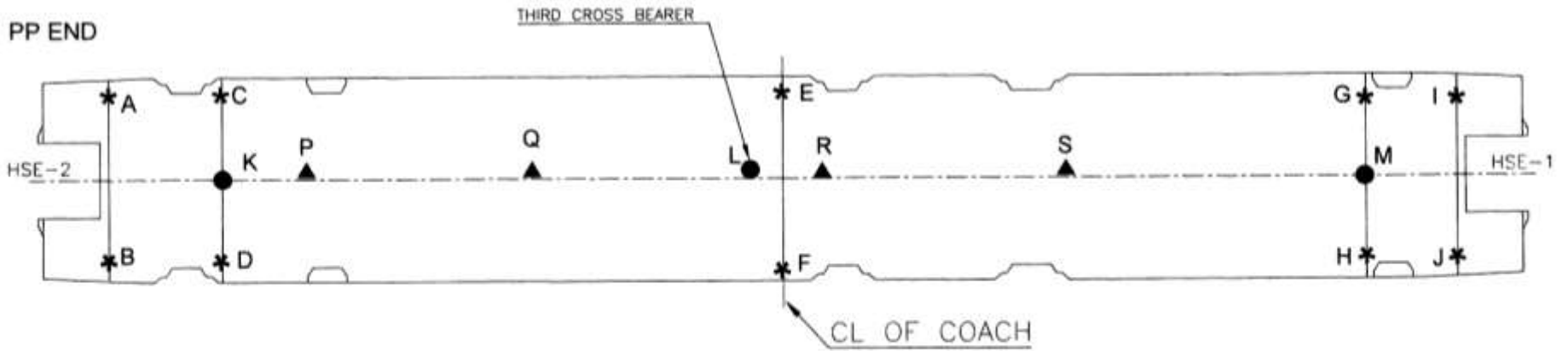


No. OF GAUGES ----- 501 TO 504 = 4  
 501 TO 503 ----- ON ROOF SHEET  
 504 ----- ON ROOF ARCH

SUPERSEDES:-		LHB VARIANT SLR	
SUPERSEDED BY:-		STRAIN GAUGE LOCATIONS ON ROOF	
REF.:	SCALE	P	C
	Z	1	D
		JSI	CD/1/2003
FLOPPY No.	BG	RDSO (C)	GROUP
			SKETCH - K3017

ALT.	ITEM	AUTHY	DESCRIPTION	CKD	DATE

PP END



1. ★ INDICATES LOCATIONS OF DEFLECTION MEASUREMENT ON HEAD STOCK CORNER A, B, & I, J AND CD, EF, GH ON SOLE BAR IN BETWEEN DOOR WAYS.
2. ● INDICATES LOCATIONS OF DEFLECTION MEASUREMENT ON CROSS BEARERS K, L, AND M.
3. ▲ INDICATES LOCATIONS OF DEFLECTION MEASUREMENT ON TROUGH FLOOR.  
 P NEAR GUARD END LUGGAGE DOOR.  
 Q NEAR THIRD WINDOW FROM GUARD END PASSENGER ROOM.  
 R & S NEAR PASSENGER AND DISABLED DOOR.
4. HSE1 & HSE2 INDICATE LOCATIONS FOR MEASURING HEADSTOCK SHORTENING.

SUPERSEDES:			
SUPERSEDED BY:		LHB VARIANT SLR	
REF.:		DEFLECTION MEASUREMENT LOCATION ON UNDER FRAME	
Z	SCALE	P	
		C	
		T	
		D	
		JS CD/1/2003	
FLOPPY No.		BG	RDSO (C)
		GROUP	
		SKETCH-K3018	

ALT.	ITEM	AUTHY	DESCRIPTION	CKD	DATE



# Factor of Safety

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Factor of Safety generally adopted are:

- Against fracture = 2.2
- Against yield
  - Non-welded structure and securing parts = 1.5
  - Welded structure and securing parts = 1.65



# Permissible Stresses

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This may be defined as the maximum stress allowed in a component for its safe working under prescribed loads. It may be represented as:

- $\text{Per. Stress} = \text{Critical Stress} / \text{Factor of Safety}$
- The critical-stress induced is expressed in three ways as under:
  - For stable loading of ductile materials the critical-stress is expressed by yield-point of the material.
  - For brittle materials the critical-stress is expressed by ultimate-strength of the material.
  - For variable or cyclic loading the critical-stress is expressed by endurance-limit.



# Normal parameters measured on coaching stock

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- Vertical acceleration – On floor above the pivot
- Lateral Acceleration - On floor above the pivot
- Spring deflections
  - Primary
  - Secondary
- Bolster swing – In case of two stage suspension
- Bogie rotation



# Criteria for assessment of stability/Riding of rolling stock in Indian Railways

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## Carriage:

- Ride index shall not be greater than 3.5, a value of 3.25 is preferred. For EMU& DMU type of stock, ride index shall not be greater than 4.0
- Values of acceleration recorded as near as possible to the bogie pivot shall be limited to 0.3g both in vertical and lateral directions. A peak value upto 0.35g may be permitted, if records do not indicate a resonant tendency in the region of peak value.
- A general indication of stable running characteristics of the carriage as evidenced by the movement of the bogie on a straight and curved track and by the acceleration readings and instantaneous wheel load variations/spring deflections



# Energy Conservation

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The following factors play important role for energy conservation:

- Resistance due to inertia of vehicle
- Resistance due to wind pressure
- Resistance due to due rolling



# Economy

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- Initial cost
- Manufacturing cost
- Coach utilization



# Crashworthy Design Consideration

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Important features of this concept are:

- Whole body shares the various loads depending upon the connectivity of various components.
- Collision energy is absorbed in predefined crash zones in progressive manner.
- Each coach to absorb it's own collision energy and distributing the collapse along the train.
- Controlled decelerations to reduce secondary impacts
- GM RT 2100(Issue.3)



# Suspension System Design

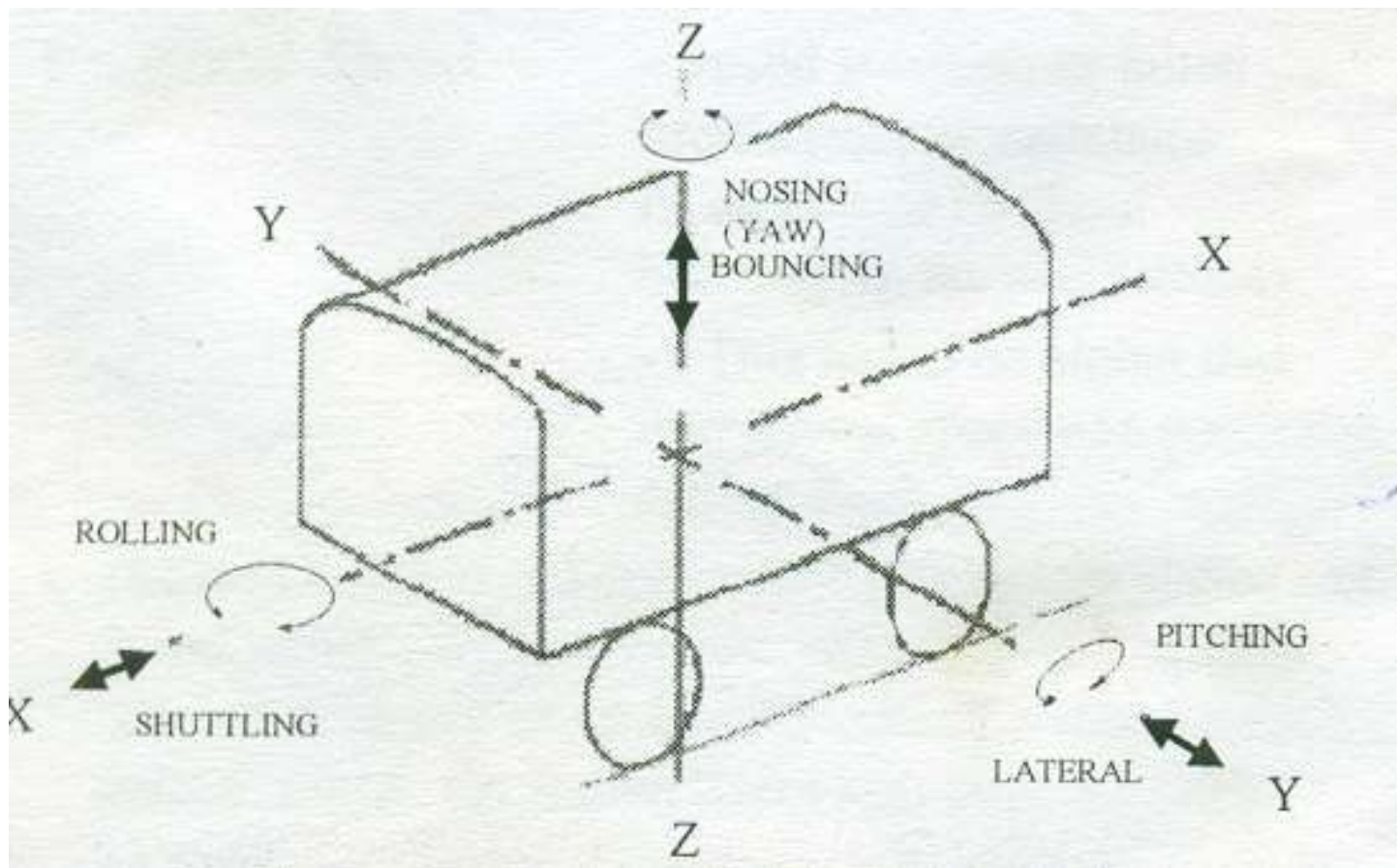
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Suspension is the system of connectivity between coach-body and wheel-set to arrest the excitation forces due to rail-wheel interaction and also to keep the vehicle safe against derailment so that passengers have a feeling of comfort and safety. In the current suspension design the following elements are used for suspension:

- Helical coil springs
- Air springs
- Rubber springs
- Hydraulic dampers
- Torsion bars
- Anti-roll bars

# Oscillation Modes of Body

- There are six modes of Oscillations:





# Oscillation Modes Of Vehicles

Axis	Mode of Oscillations	
	Linear	Rotational
X	Shuttling	Rolling
Y	Lateral	Pitching
Z	Bouncing	Nosing (also called 'Yaw')

The continued oscillation of 'Rolling' and 'Nosing' when violent is called 'Hunting'



# Sources Of Excitation

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Various force / displacement inputs through rail-wheel interaction lead to vibrations. These inputs may be classified as:

- Periodical input:- Resulting due to regular rail joints, lateral oscillations are due to gauge clearance and wheel unbalance etc.
- Random input:- Resulting from irregular alignment errors in welded jointed track.
- Sudden single input: - Resulting due to directional changes, occasional low rail joints, rail gap, switches, crossings etc.



# Fundamental Design Aspects

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- RMS value of vibration should be below 0.35g in both vertical and lateral directions
- Use of frequency sensitive damping i.e. hydraulic shock absorbers providing viscous damping at low frequencies for both vertical and lateral suspension systems which may be supported by roll control system involving anti-roll bars
- Use of rubber pads/stops providing progressive increase in stiffness

# ICF Coach



# ICF Coach



# LHB Coach



# LHB Coach Variant





*THANK YOU*