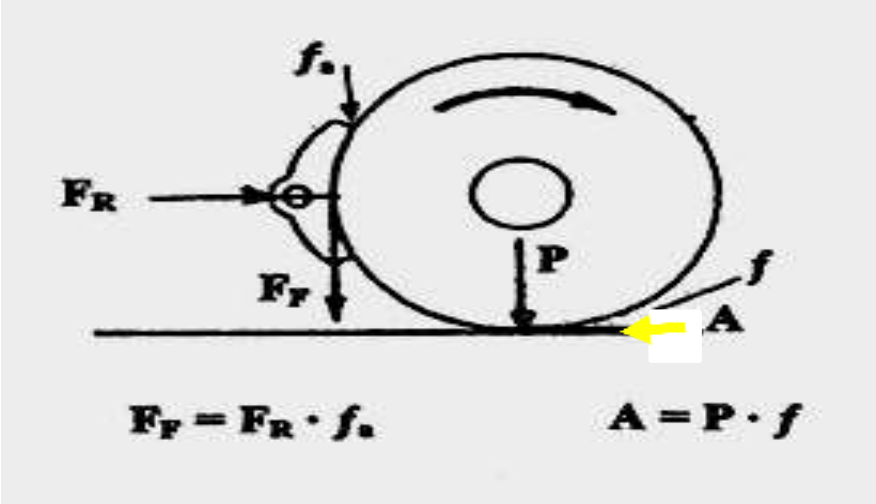
Name and Role of Brake System Components of Rolling Stock

SANJAY KUMAR
Asst. Prof./ C&W/IRIMEE

Objectives

- Concept of tractive effort and braking
- Requirements from braking system
- Understand the working of brake system.
- Name & function of Braking System Components
- The latest development in braking system

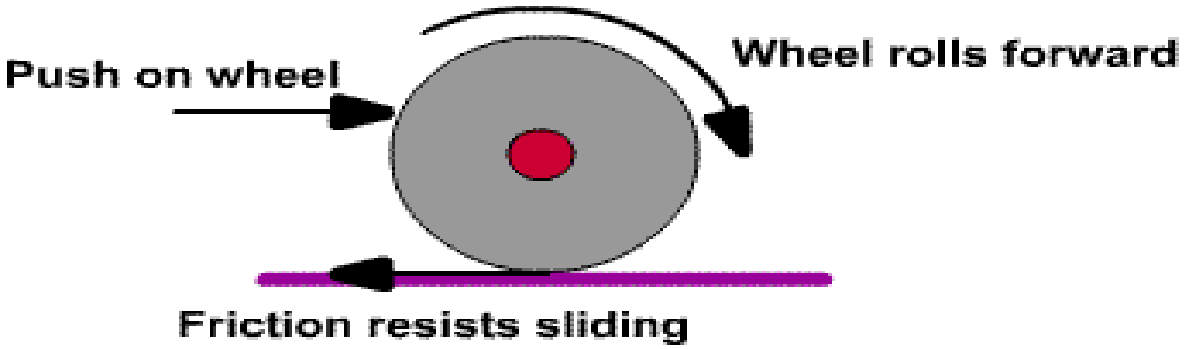
Concept of Braking



it is necessary that there is always the condition that the *braking force* ≤ *adherence*; otherwise the wheels would block, but without stopping the train, originating wheel slip, causing a reduction in braking force and facets on the tyres.

Effect of Increase in Speed Limit on EBD

- Concept of Motions
  - Roll
  - Slide
  - Skid
  - Slip



- Need of WSP system
  - To get optimum EBD at high speed..

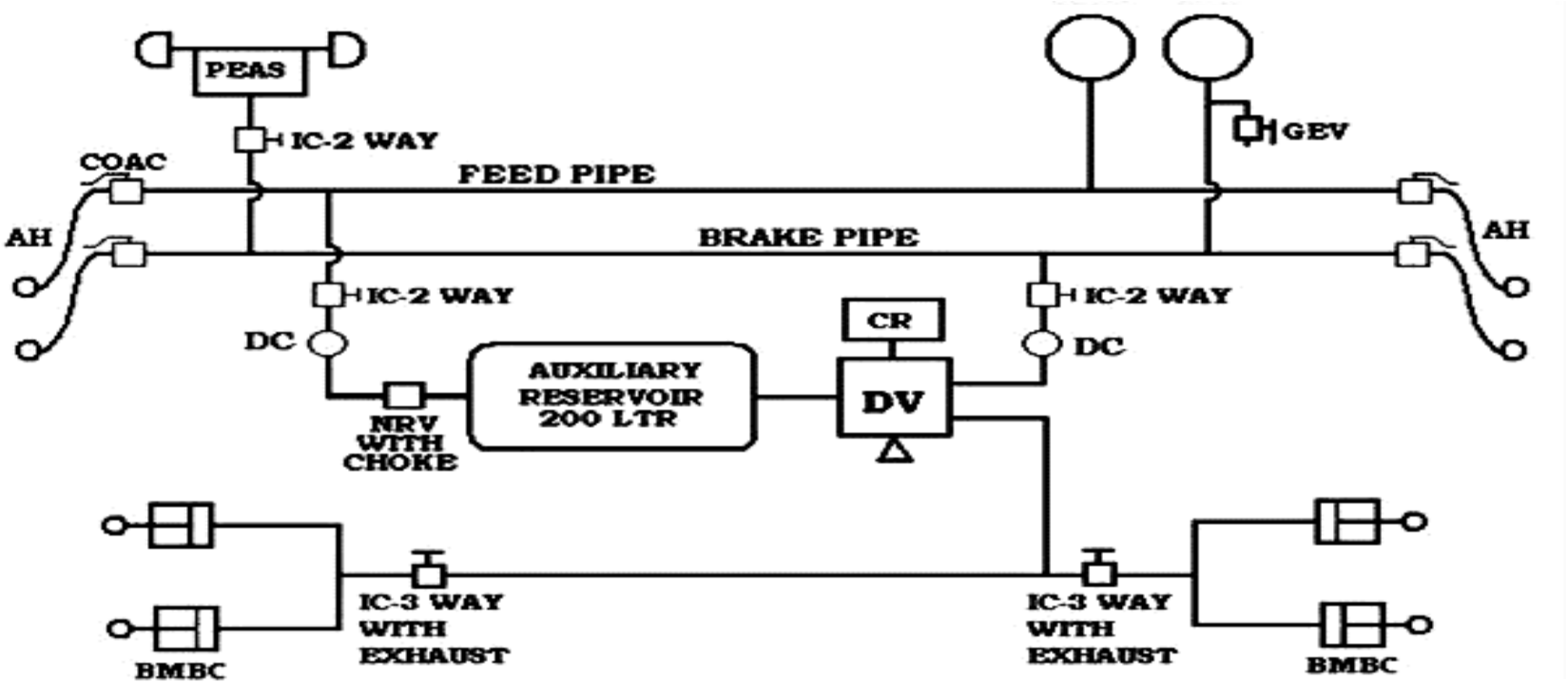
Confusion in Brake Binding

- Very often Flat Tyre/ Wheel Skidding is wrongly interpreted as brake binding.
- The incidence of wheel skidding must not be merged with brake binding.
- Brake application quality in relation with the adhesion is the basic cause of wheel skidding.

Requirements from Brake System

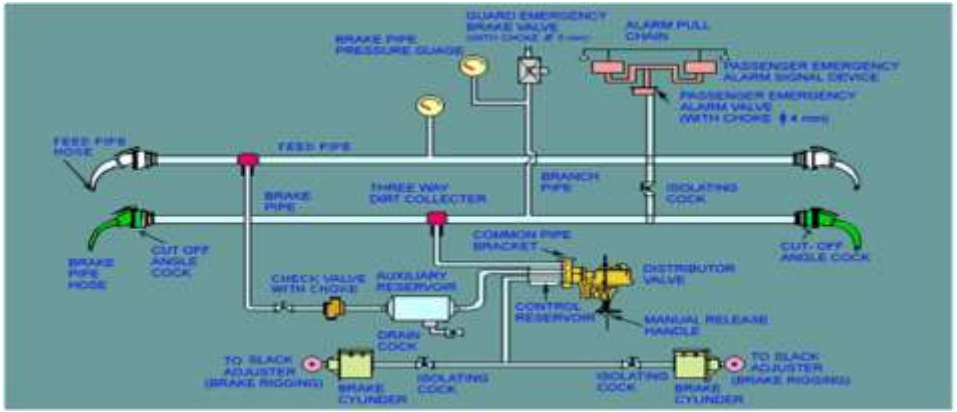
- EBD (Emergency Braking Distance) within limit.
- Controlled braking
  - Braking control to loco pilots and guard.
  - Passenger communication system in coach.
- Fail safe i.e. automatic braking when train parts.
- Brake inexhaustibility.
- Less fading of brake power during long run.
- Multiple operation

Schematic Diagram (ICF BMBC)



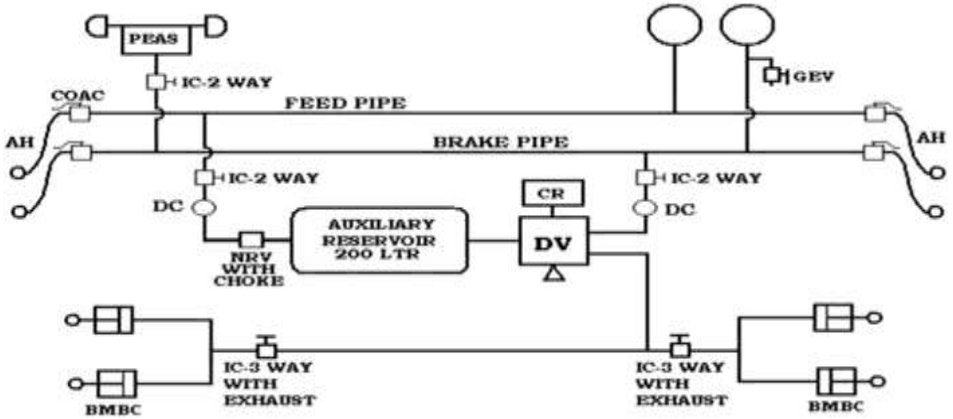
Major Components

- Common pipe bracket (CPB)
- Distributor valve (DV)
- Control reservoir (CR)
- Auxiliary reservoir (AR)
- Brake cylinder (BC)
- Brake pipe & feed pipe



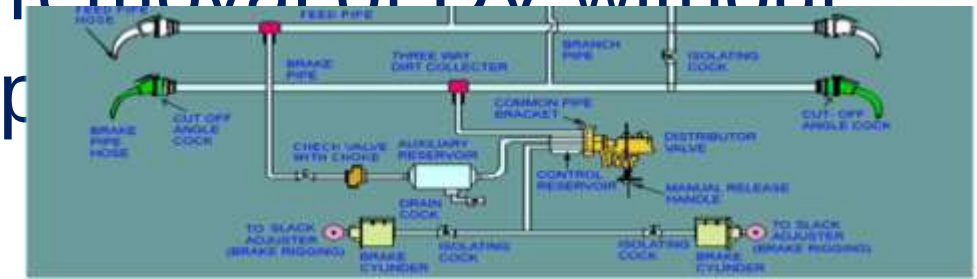
Major Components

- Air hose with palm end coupling
- Cut off angle cock
- Dirt collector
- Isolating cock (2-way and 3-way)
- Check valve with choke
- Brake riggings



Common Pipe Bracket (CPB)

- Mounted on the underframe in ICF Coach.
- Facilitates fitment of any make of DV.
- The DV along with the intermediate piece (sandwich) and the CR mounted on it's two opposite faces.
- Facilitates easy removal of DV without disturbing the pip

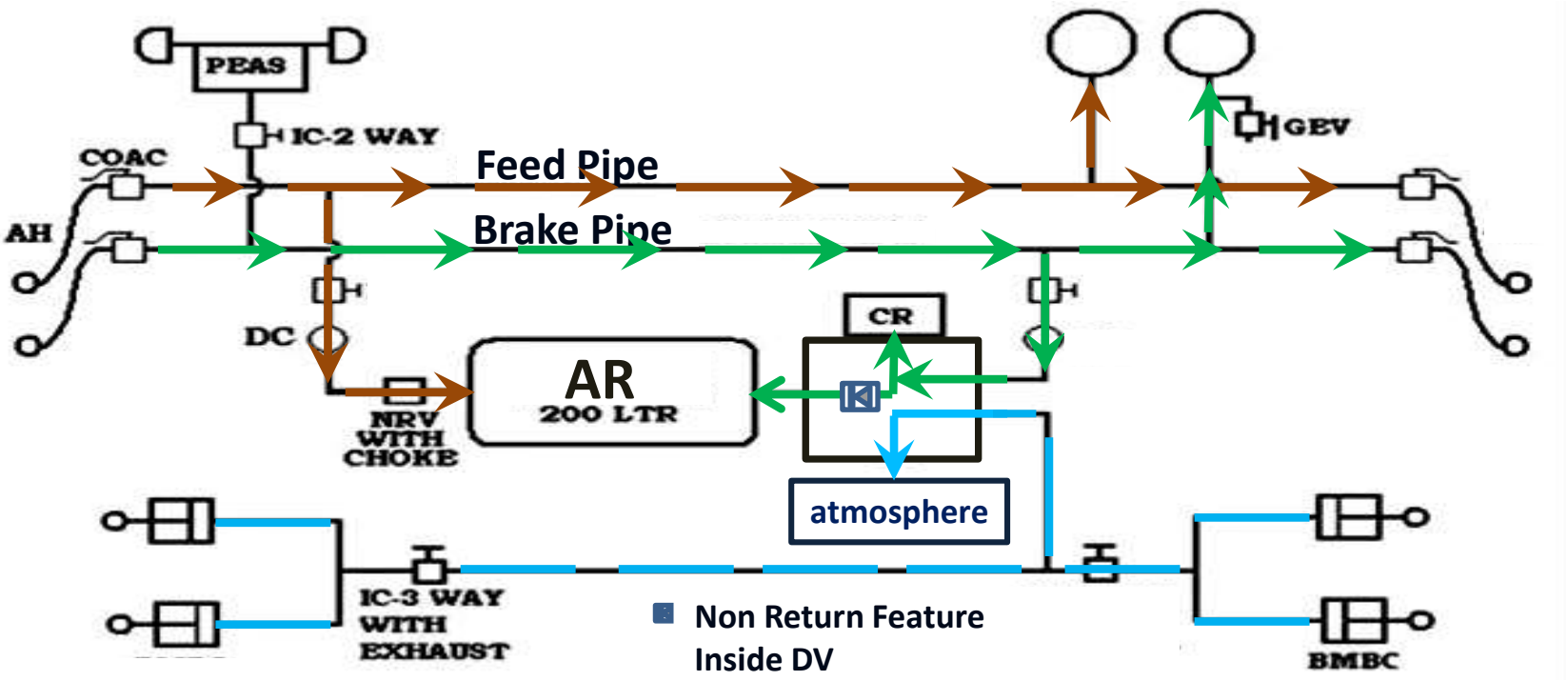


WORKING STAGES OF AIR BRAKE SYSTEM

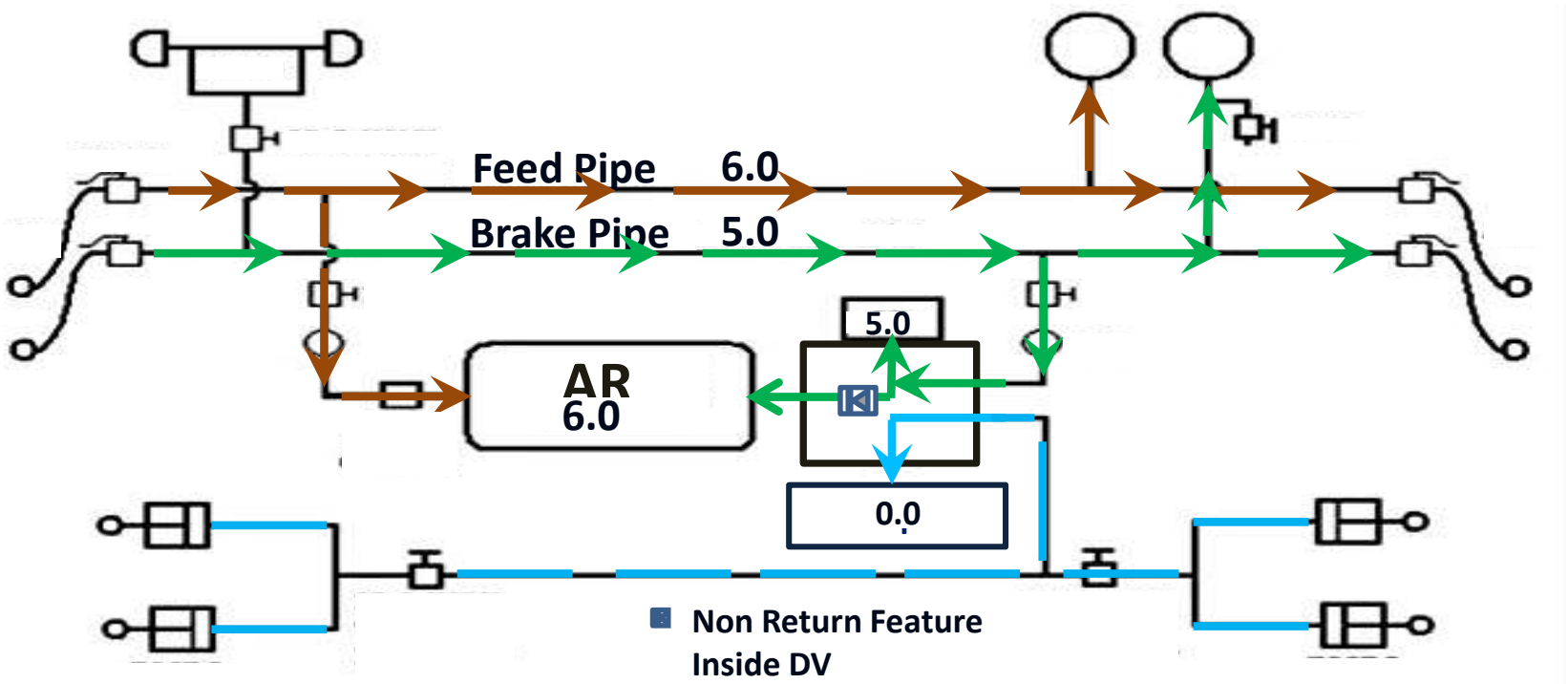
Three Working Stages

- Charging stage
  - Brake pipe(BP) charged with 5 Kg/cm^2 air pressure.
- Application stage
  - BP pressure dropped for brake application.
- Releasing stage
  - BP pressure again raised for brake release.

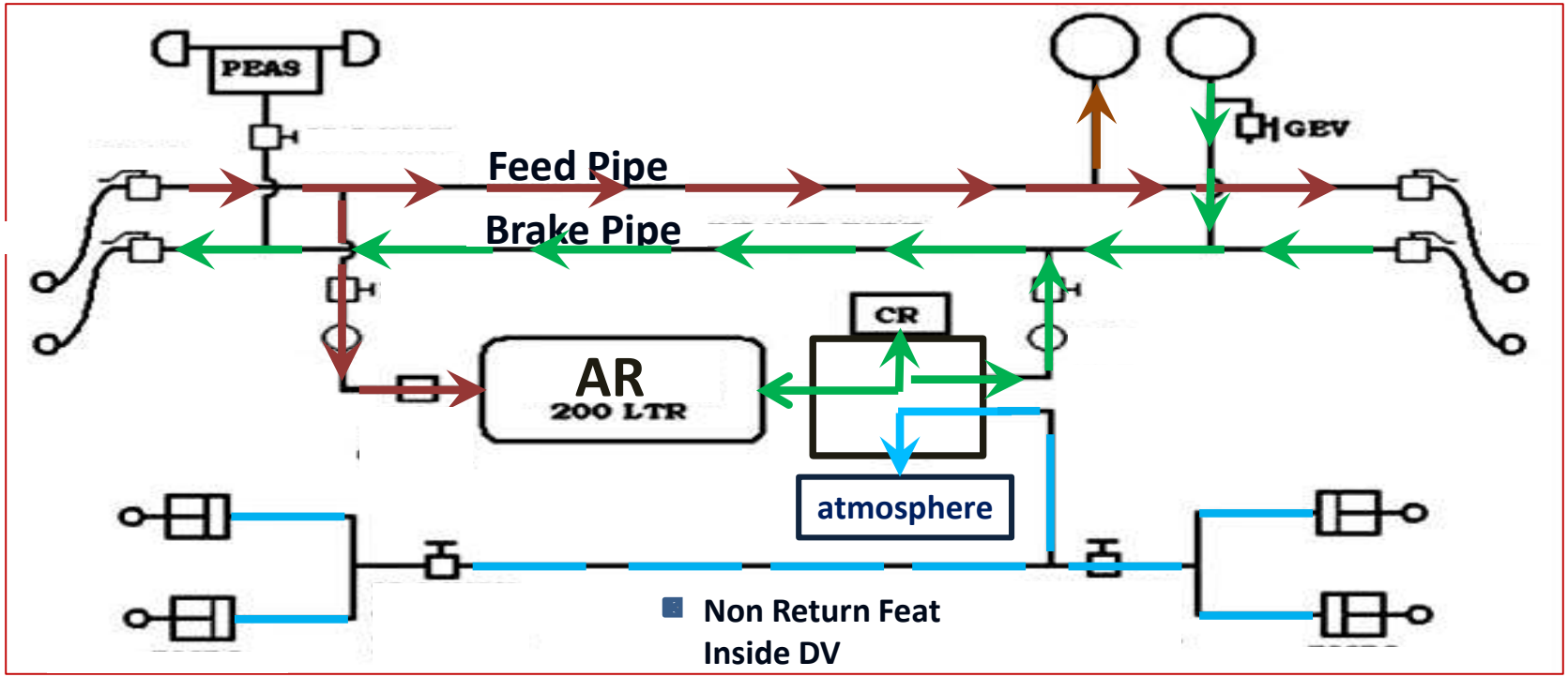
Air Flow: Charging Stage



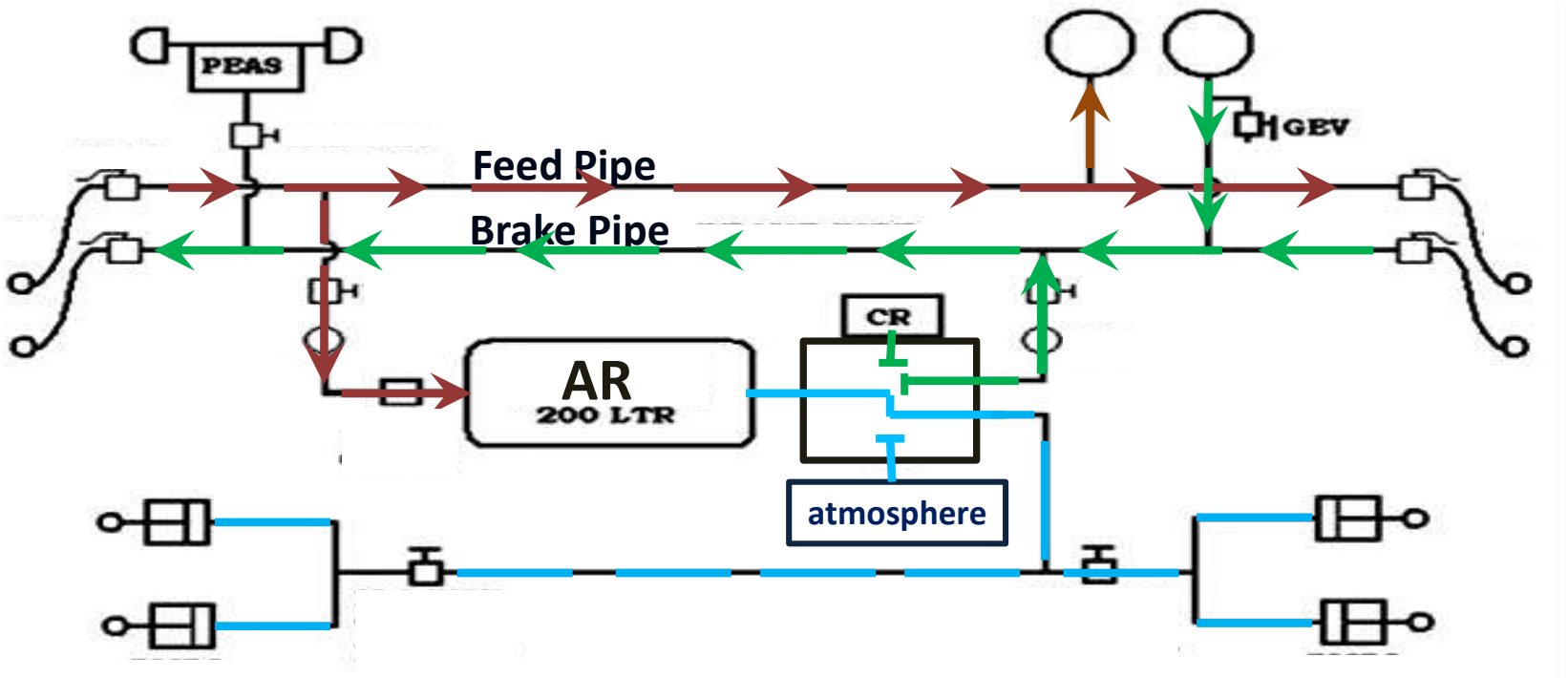
Pressures: Charging Stage



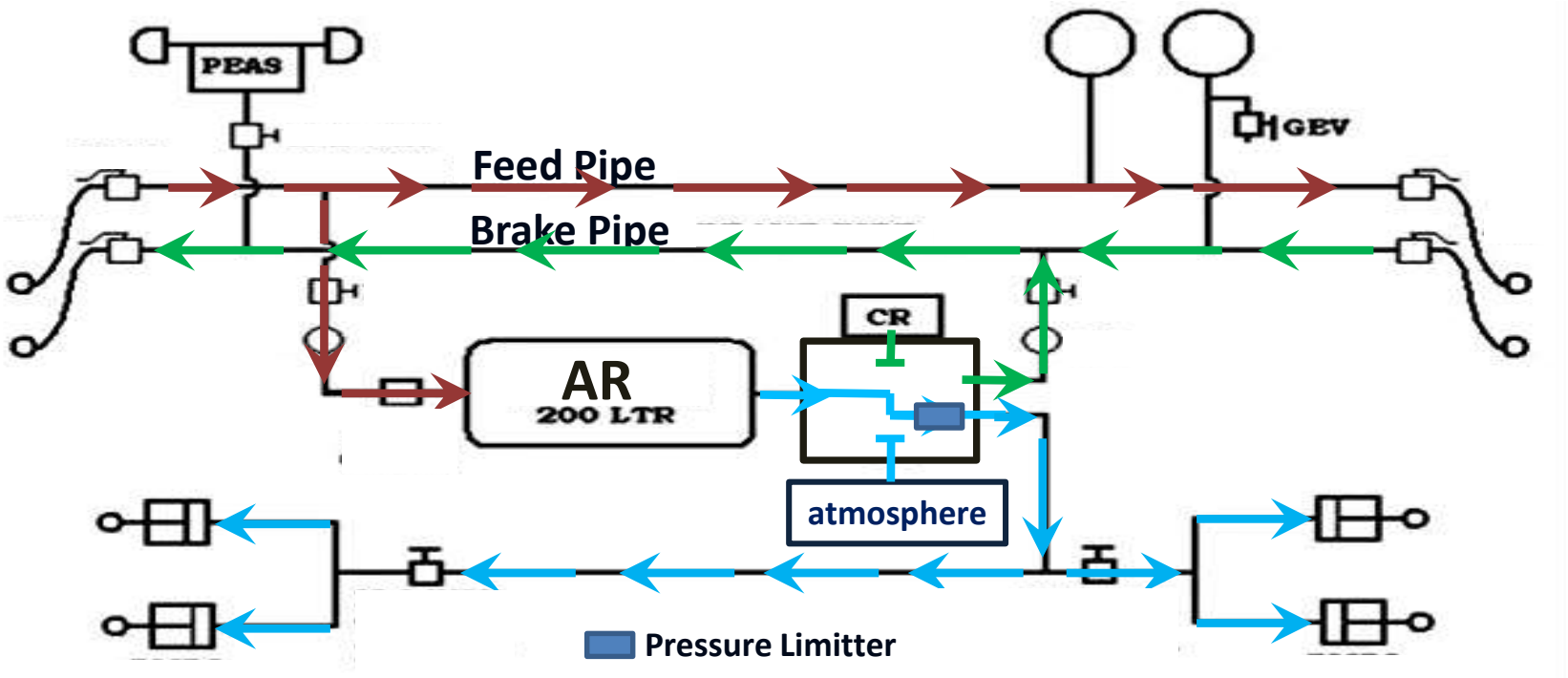
Air Flow: Application Stage



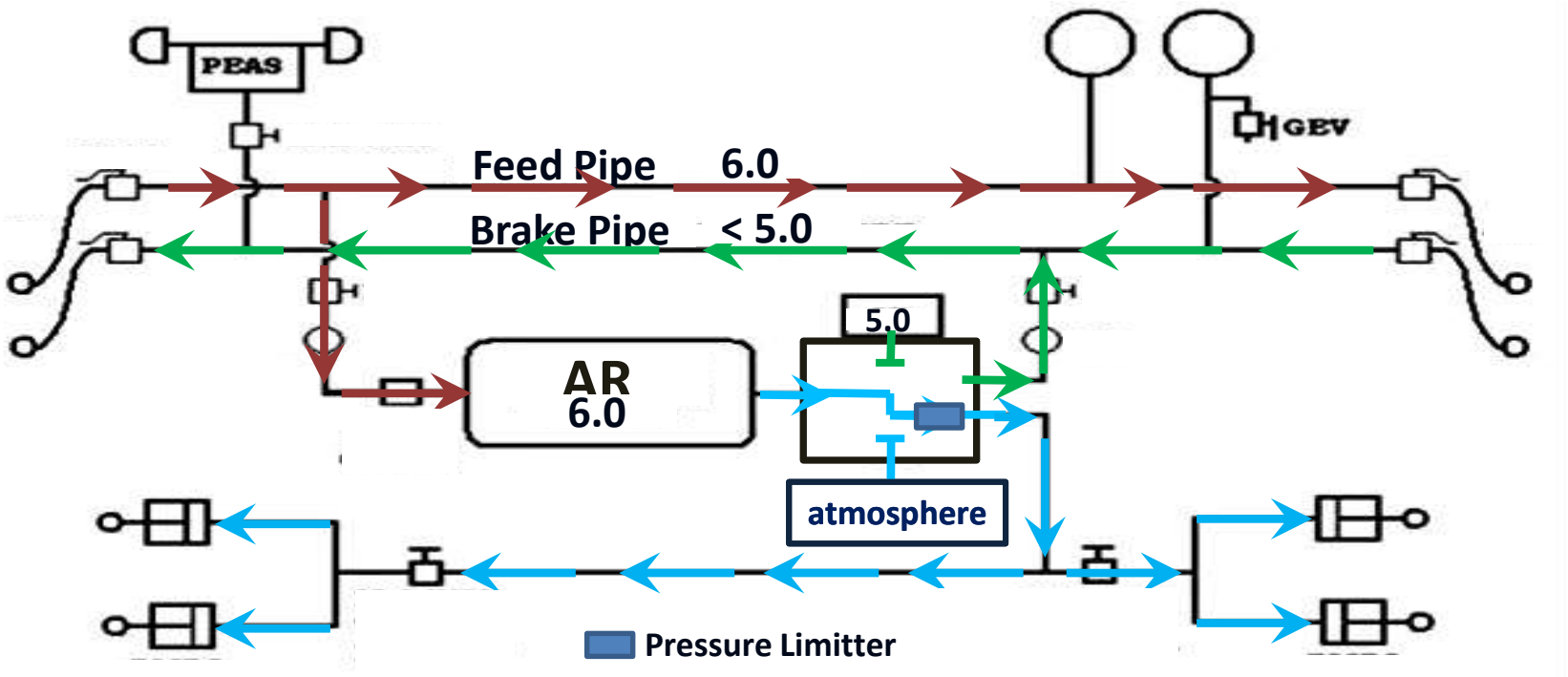
Air Flow: Application Stage



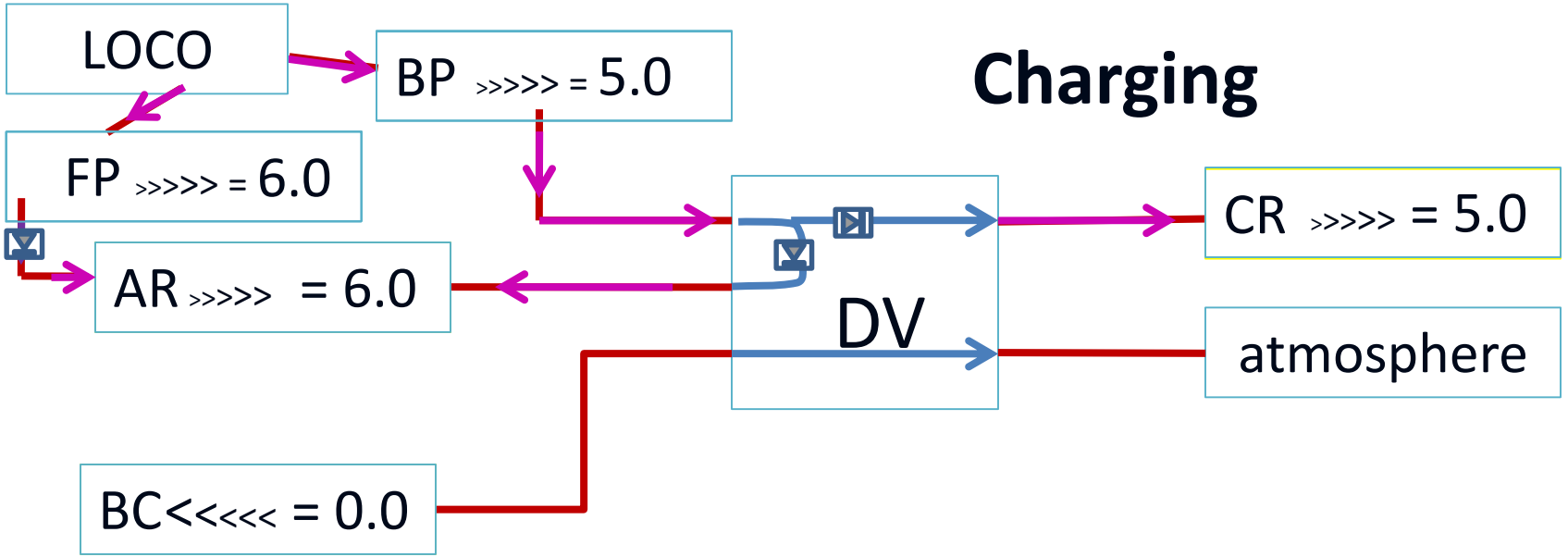
Air Flow: Application Stage



Pressure Levels: Application Stage

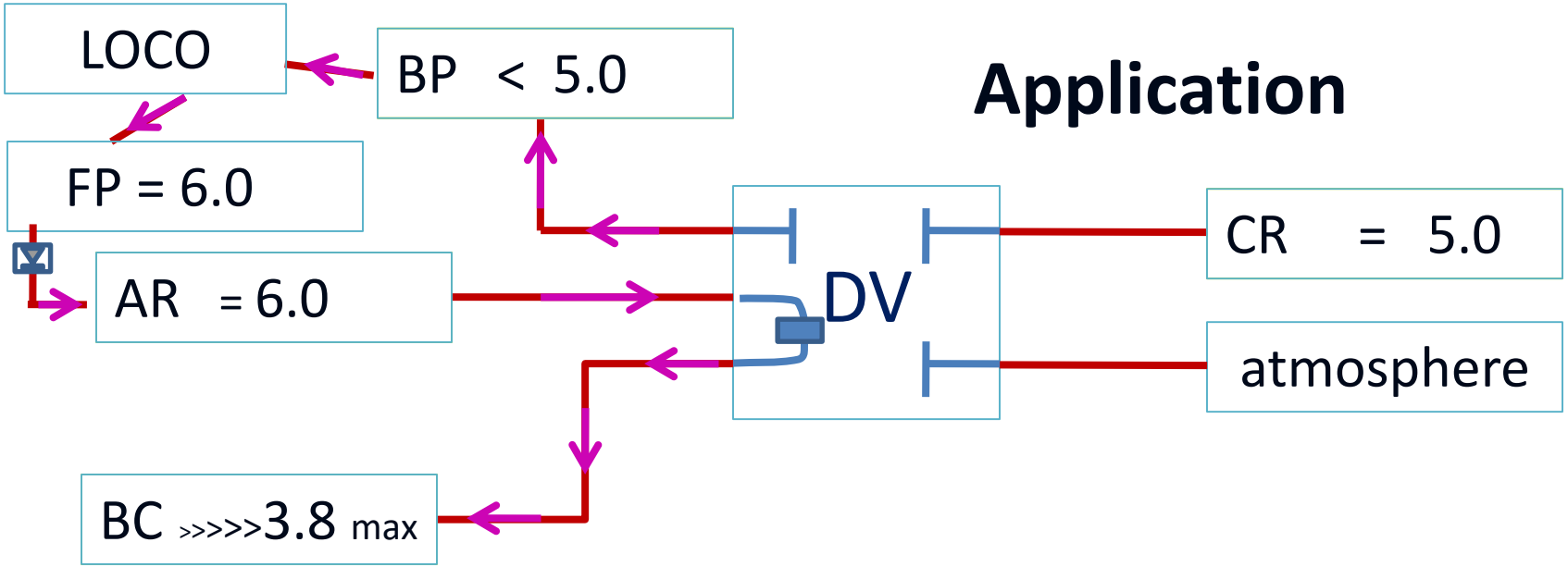


Pressure Levels: Charging Stage



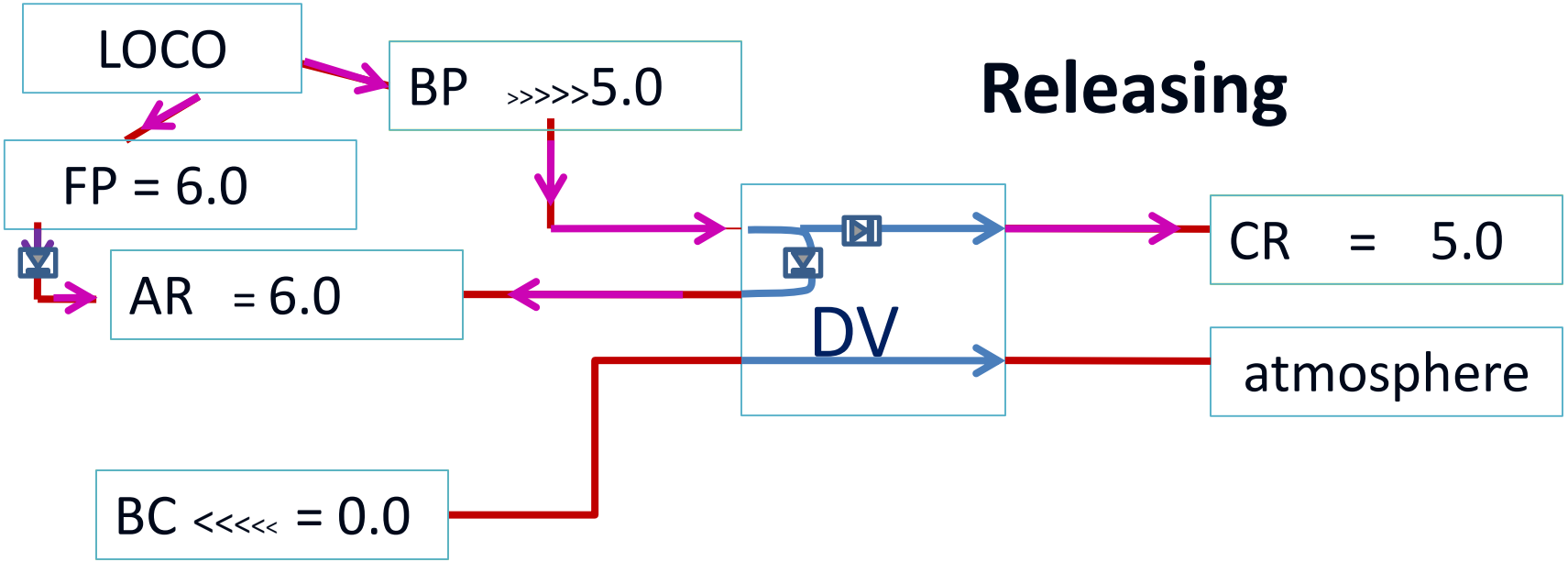
- Charging Stage: BP is charged at 5 Kg/cm^2.

Pressure Level: Application Stage



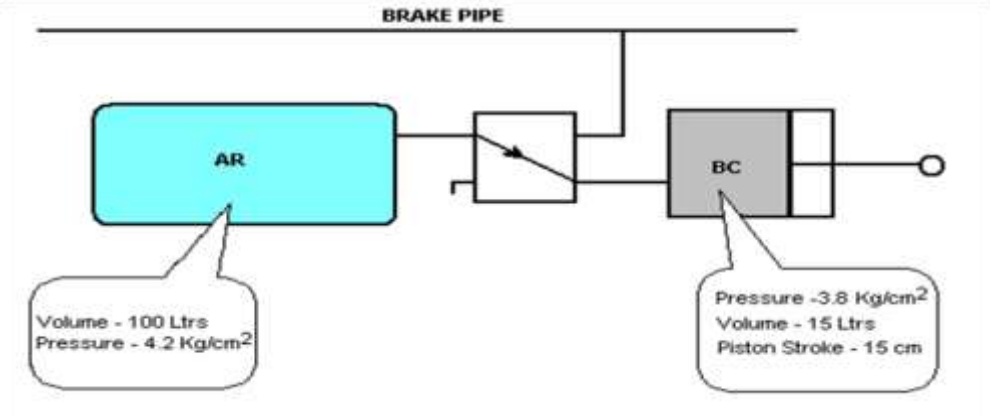
- Application Stage: BP pressure is reduced.

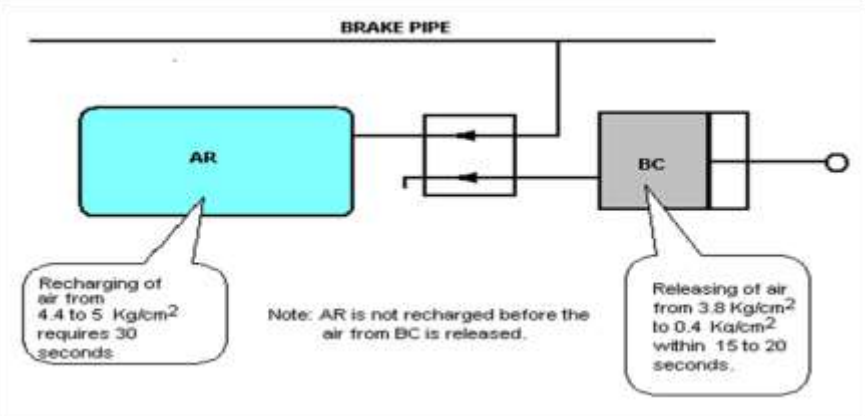
Pressure Level: Releasing Stage



- Releasing Stage: BP pressure is again raised.

Single Pipe vs Twin Pipe System





Modes of Brake Application

Description	Reduction in B. P. Pressure
Minimum Brake Application	0.5 to 0.8Kg/cm^2
Service Brake Application	0.8 to 1.0Kg/cm^2
Full Service Brake Application	1.0 to 1.5Kg/cm^2
Emergency Brake Application	Brake pipe pressure fully exhausted

MAJOR BRAKE COMPONENTS AND THEIR FUNCTIONS

DISTRIBUTOR VALVE

Function of DV

- Charges the system to regime pressure:
  - During normal/running condition.
- Helps in all types of brake application:
  - Graduated, full service as well as emergency type.
- Helps in brake release:
  - Graduated as well as manual.
- Controls the brake application & release time:
  - As per service conditions.
- Limits max. designed BC pressure.

Function of DV

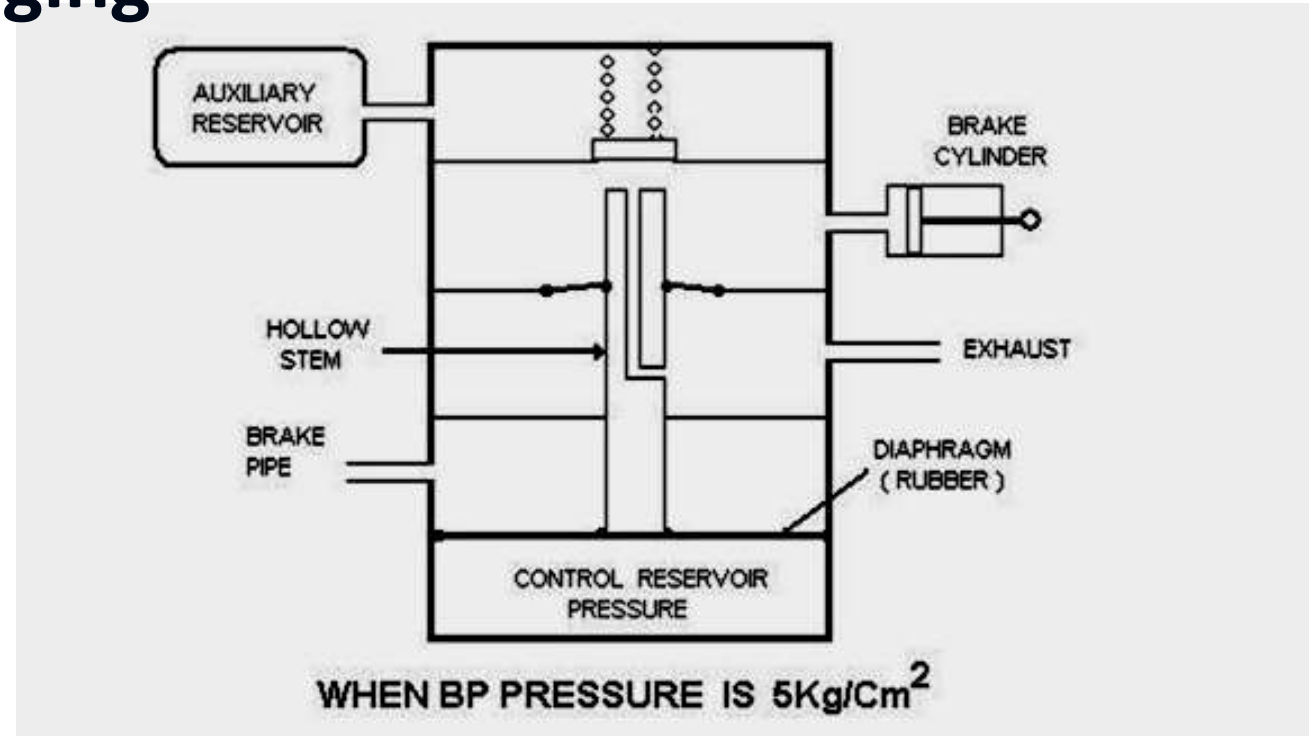
- Accelerates propagation of initial reduction of BP pressure throughout the length of the train
  - By arranging local vent of BP pressure inside the DV till BC pressure maintained at 0.8 Kg/cm^2.
- Protects overcharging of CR up to some extent
  - When the BP is overcharged after full service application for quick brake release.
- Facilitates to isolate the system if required,
- Complete system can be evacuated manually..

KE type DV

- Main subassemblies:
  - Three pressure valve
  - U-controller
  - ‘R’ charger & isolating valve with handle
  - Choke cover
  - Minimum pressure limiter
  - Maximum pressure limiter
  - ‘A’ controller
  - Quick release valve.

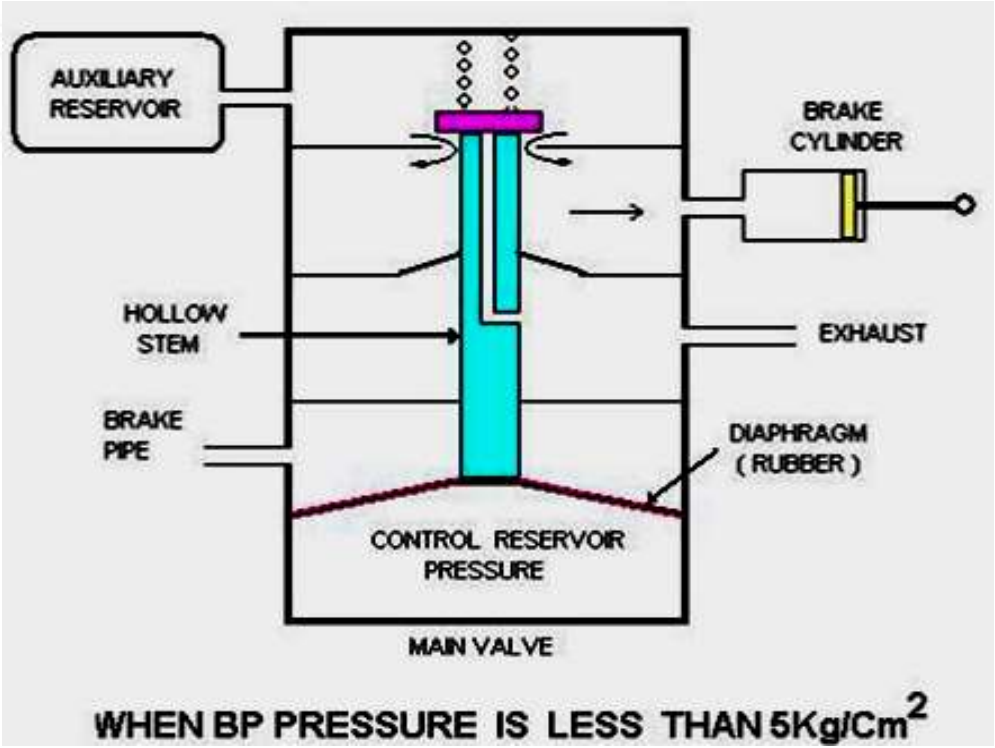
Working of Three Pressure Valve

Charging



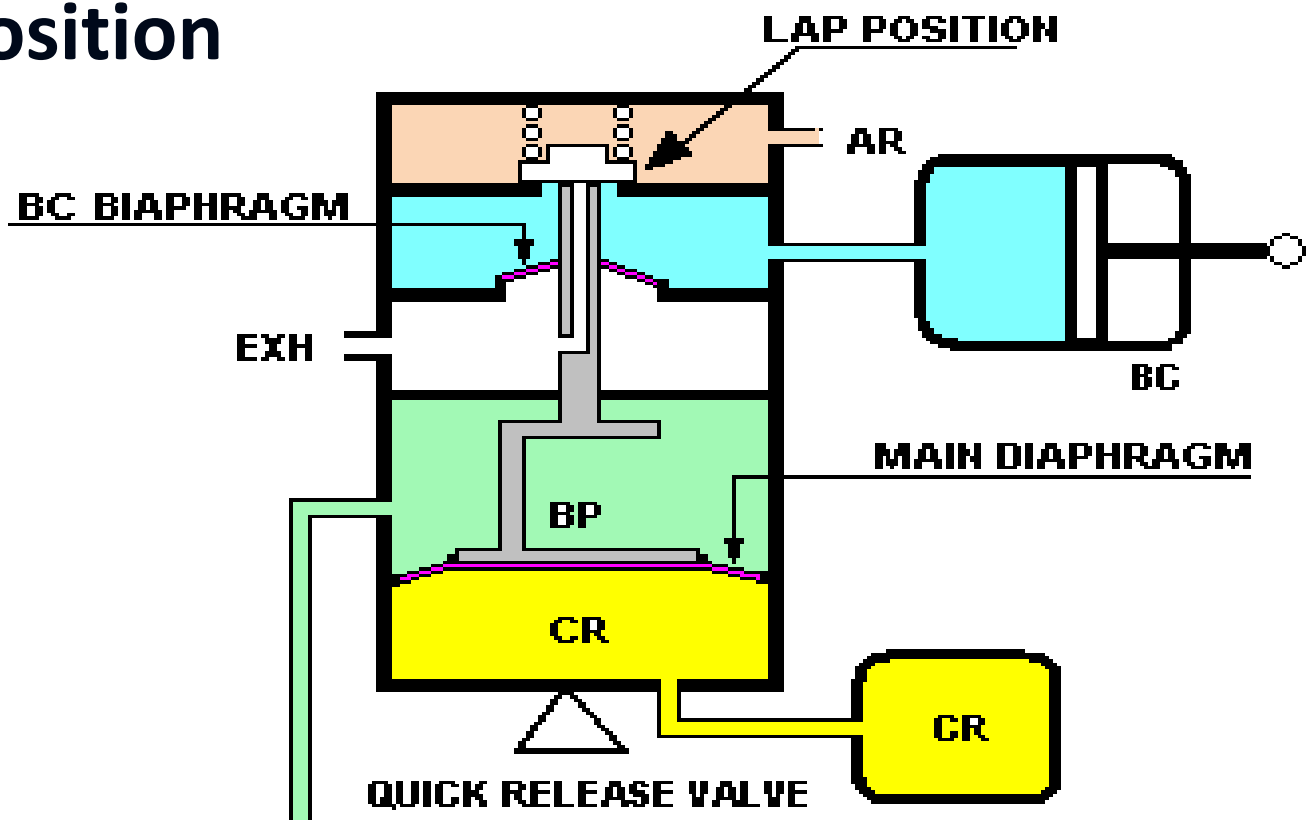
Working of Three Pressure Valve

Application



Working of Three Pressure Valve

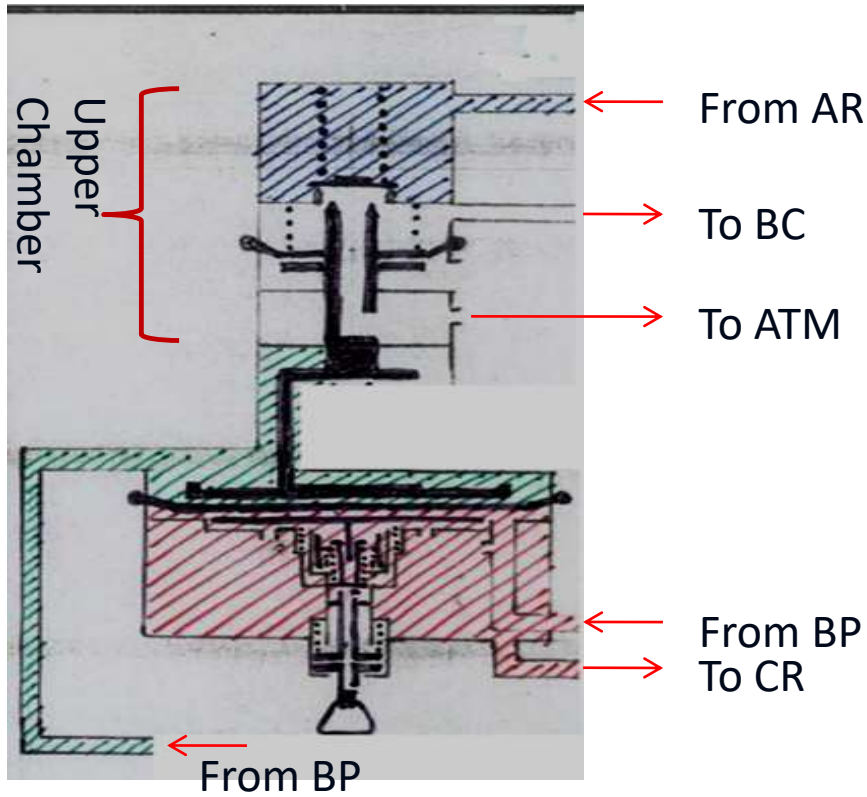
Lap Position



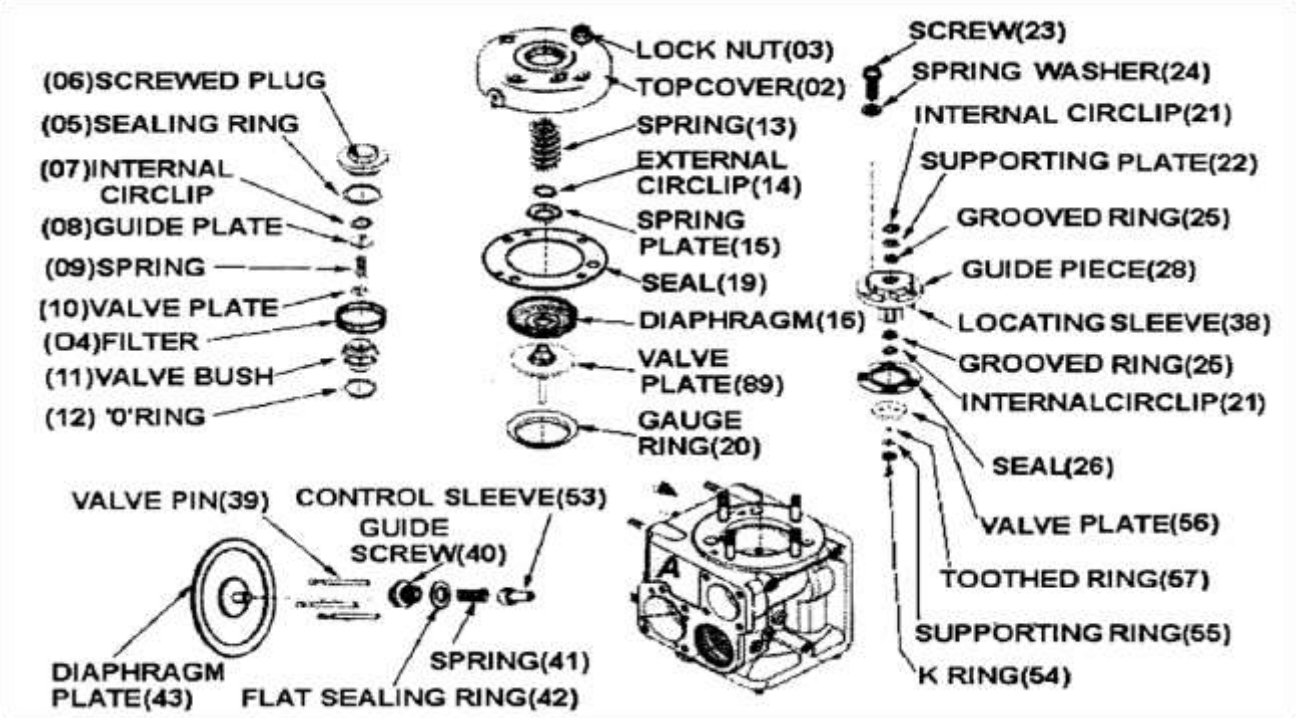
Three Pressure Valve

- Housed in the vertical central bore between the top and bottom face.
- Controls charging and discharging of BC in accordance with the change in BP pressure.

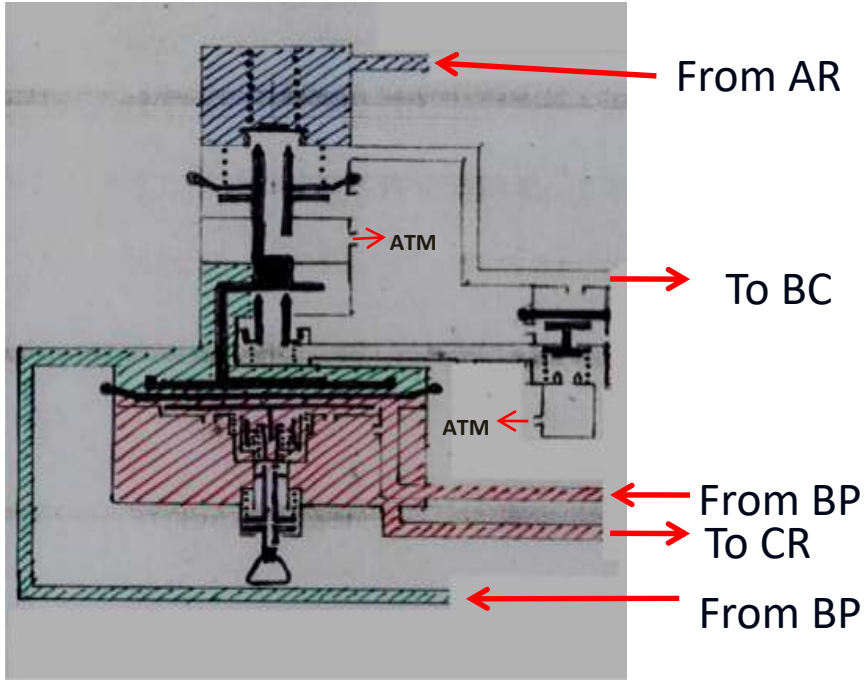
4 ZONES



Exploded View of Three Pressure Valve

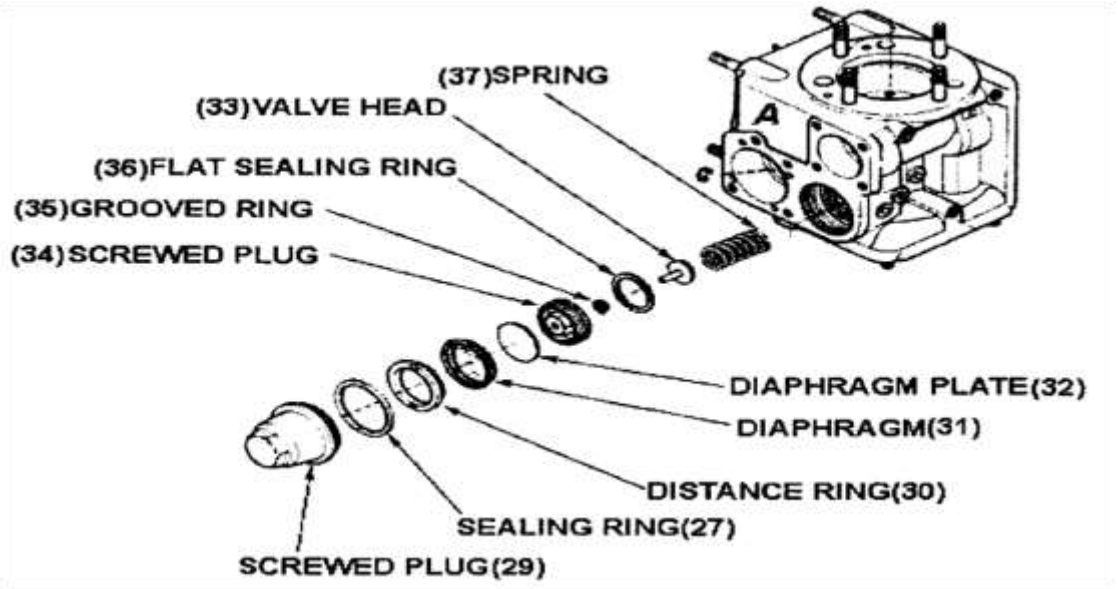


U-controller

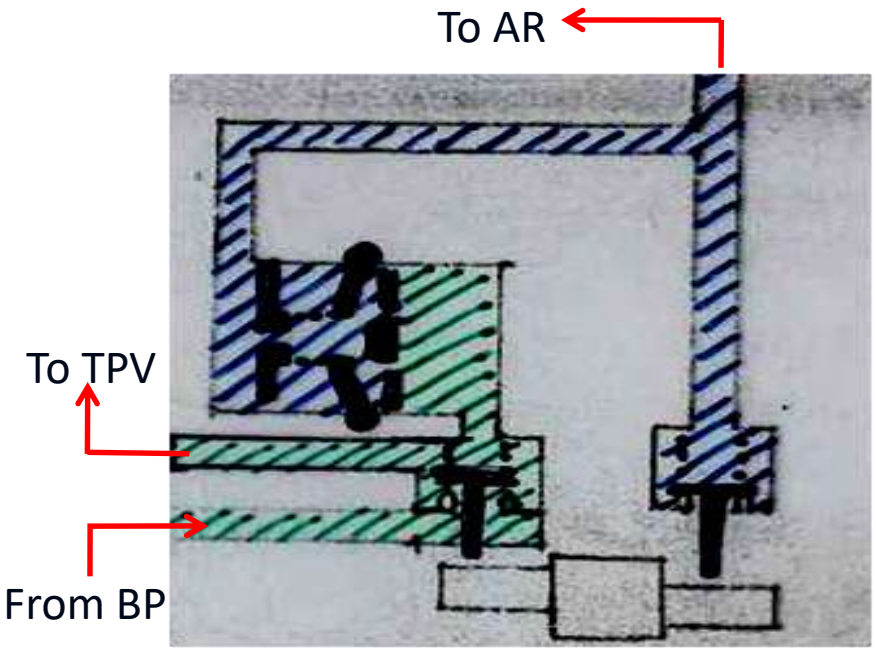


- Housed with R-charger & choke cover on one face of the DV.
- Taps off a small amount of BP pressure from DV during initial brake application till BC pressure reaches 0.8 kg/cm2.
- This action increases initial pressure reduction & causes simultaneous rapid propagation of braking impulse throughout the length of the train.

Exploded View of U-controller

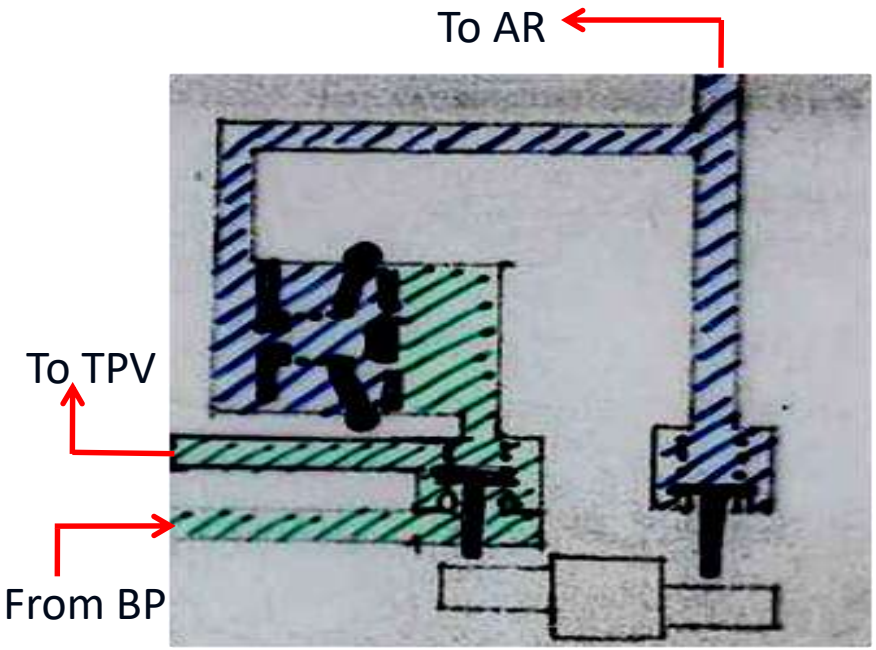


‘R’ Charger



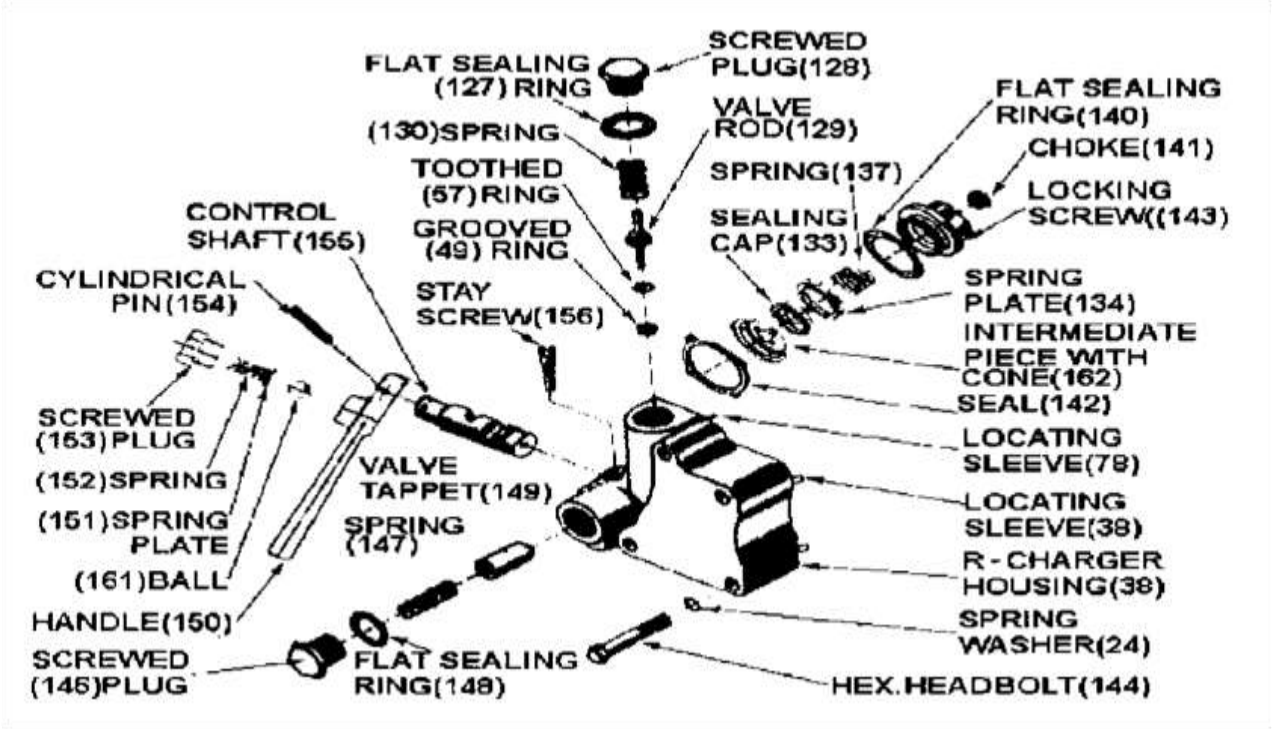
- Supplies compressed air from BP to AR when BP pressure is raised.
- Also separates AR from BP through a check valve (located inside) when BP pressure is less than AR pressure.

Isolating Valve with Handle

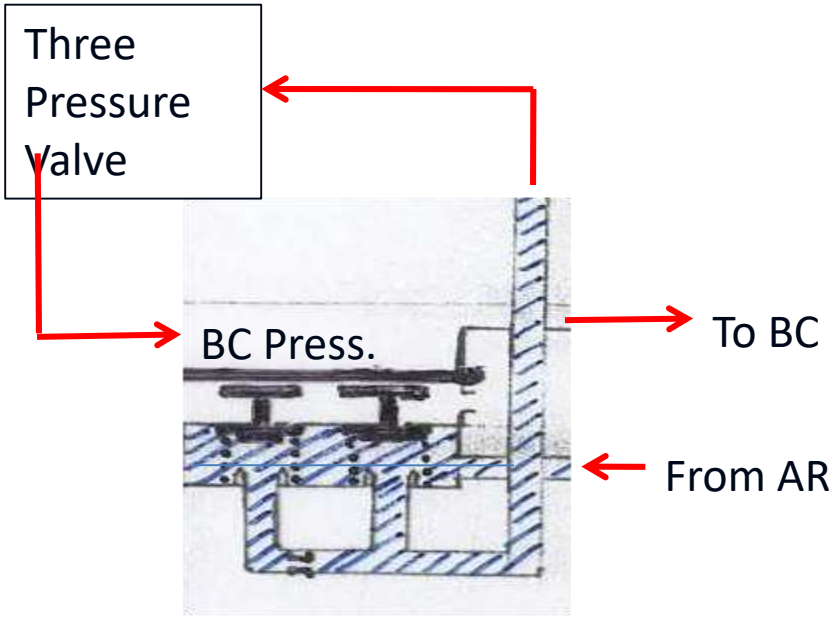


- Isolating valve with handle
  - Two positions:
    - Vertical – NORMAL
      - Connects BP to three pressure valve and R charger
      - Keeps AR isolated from ATM.
    - Horizontal – ISOLATED
      - Isolates three pressure valve and R charger from BP.
      - Connects AR to Atmosphere.

‘R’ Charger & Isolating Valve



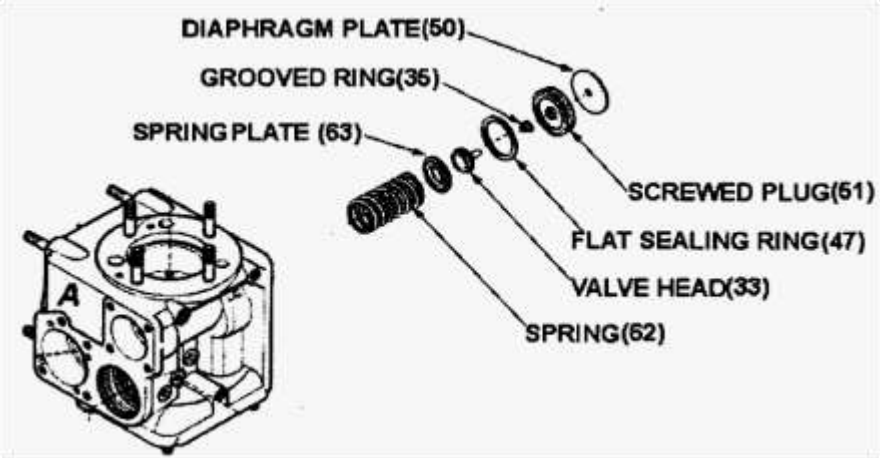
Minimum & Maximum Pressure Limiter



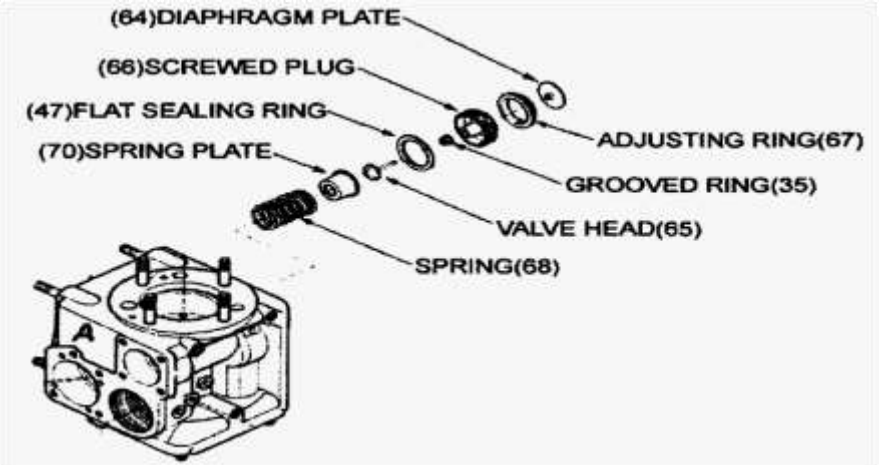
- Minimum Pressure Limiter
  - Housed with max. pressure limiter and 'A' controller.
  - Provides passage without choke to charge BC during initiation of brake application.
  - Helps in rapid charging of BC up to a pressure of 0.8 Kg/cm^2 to overcome rigging resistance.
- Maximum Pressure Limiter
  - Limits the maximum BC pressure to the required value irrespective of the BP pressure drop and AR pressure.

Exploded View

Minimum Pressure Limiter



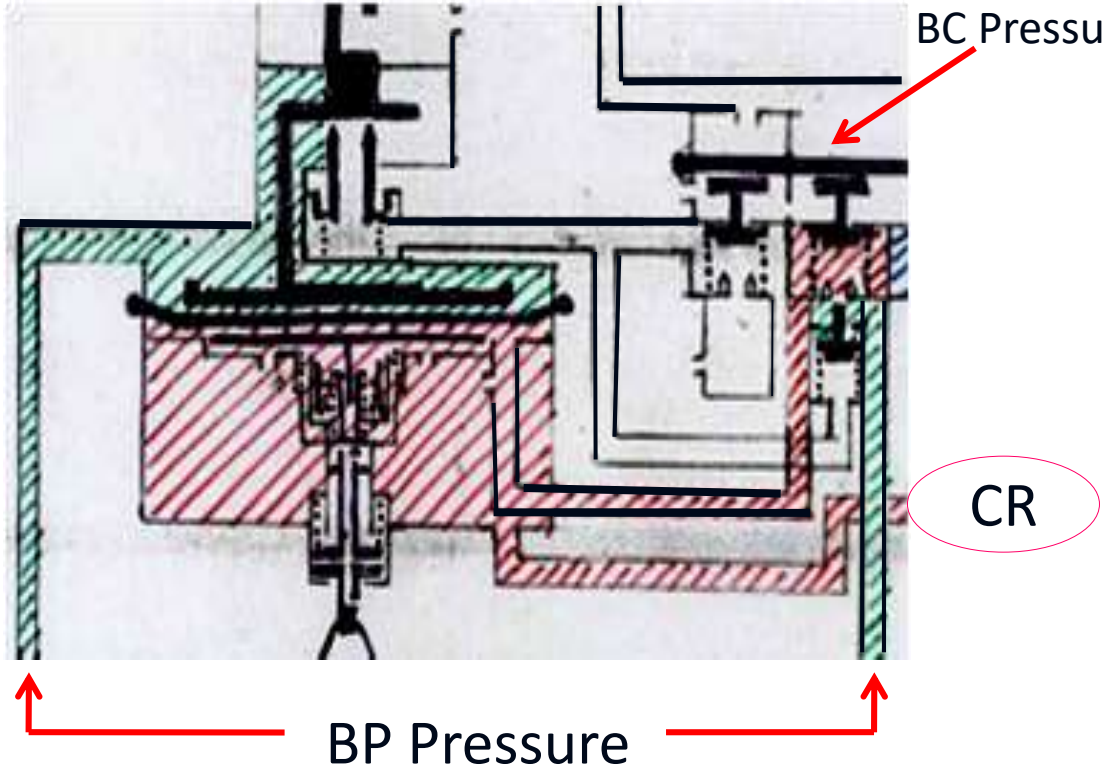
Maximum Pressure Limiter



‘A’Controller & Quick Release Valve

- ‘A’ Controller:
  - Charges CR by BP pressure during charging stage,
  - Isolates CR when brakes are applied i.e. BP pressure is reduced.
  - Also protects CR to be overcharged.

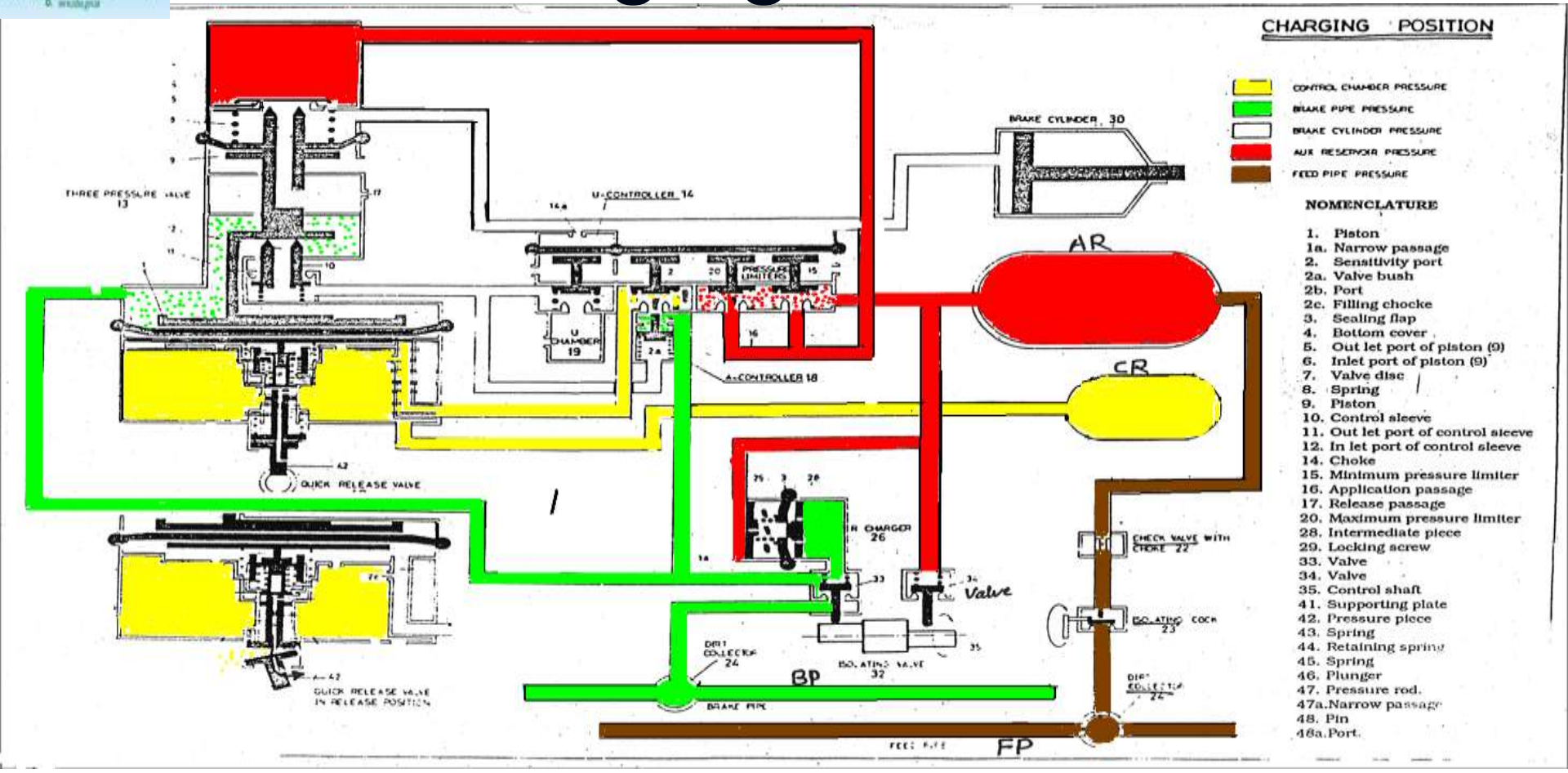
- Quick Release Valve:
  - Allows CR to be fully released by means of manually pulling of handle.



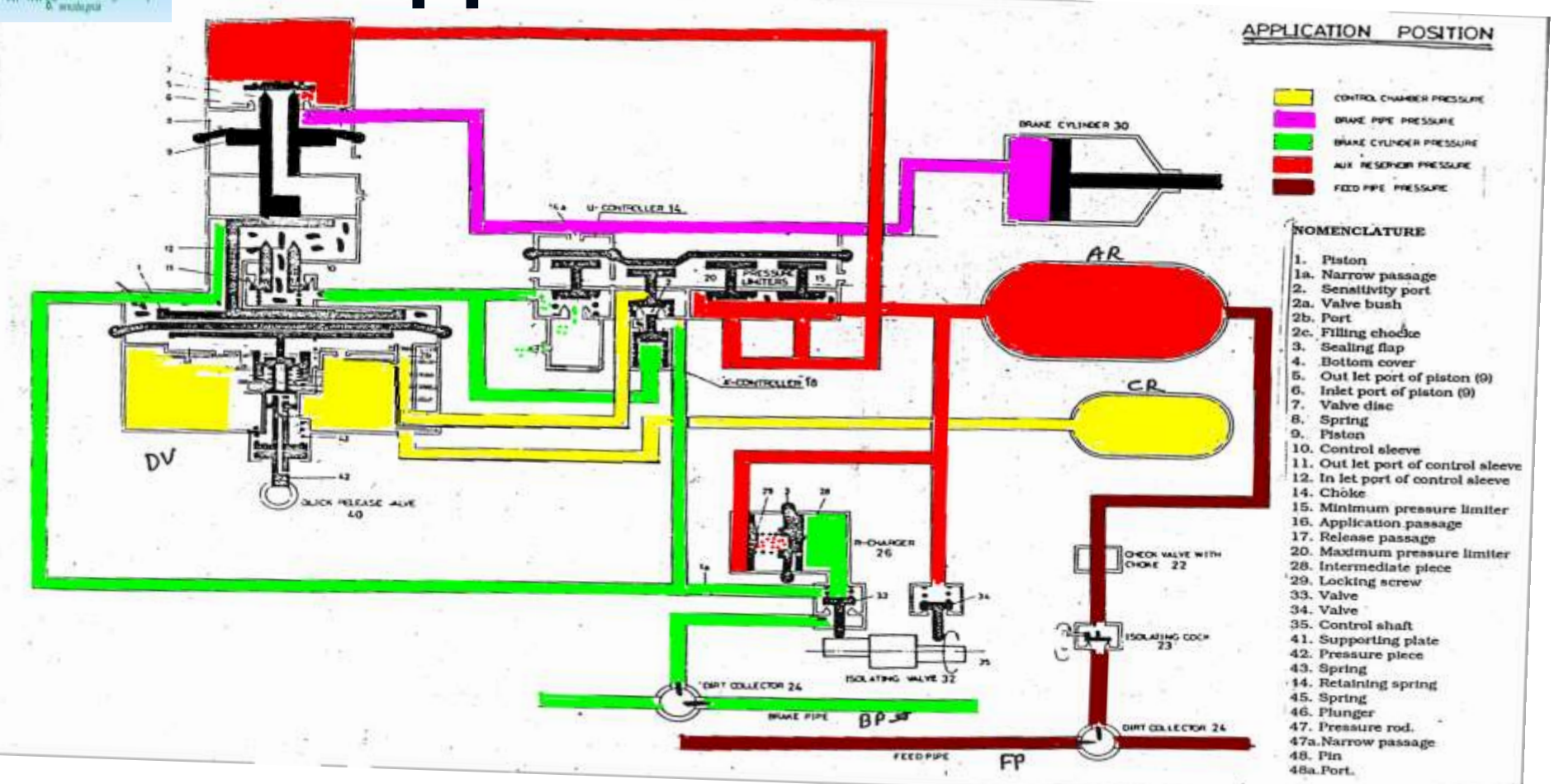
Functioning of KE type DV

- Charging stage
  - Charging of control reservoir
  - Charging of auxiliary reservoir
- Application stage
  - Emergency application
  - Graduated application
- Release stage
  - Graduated release
  - Manual Release

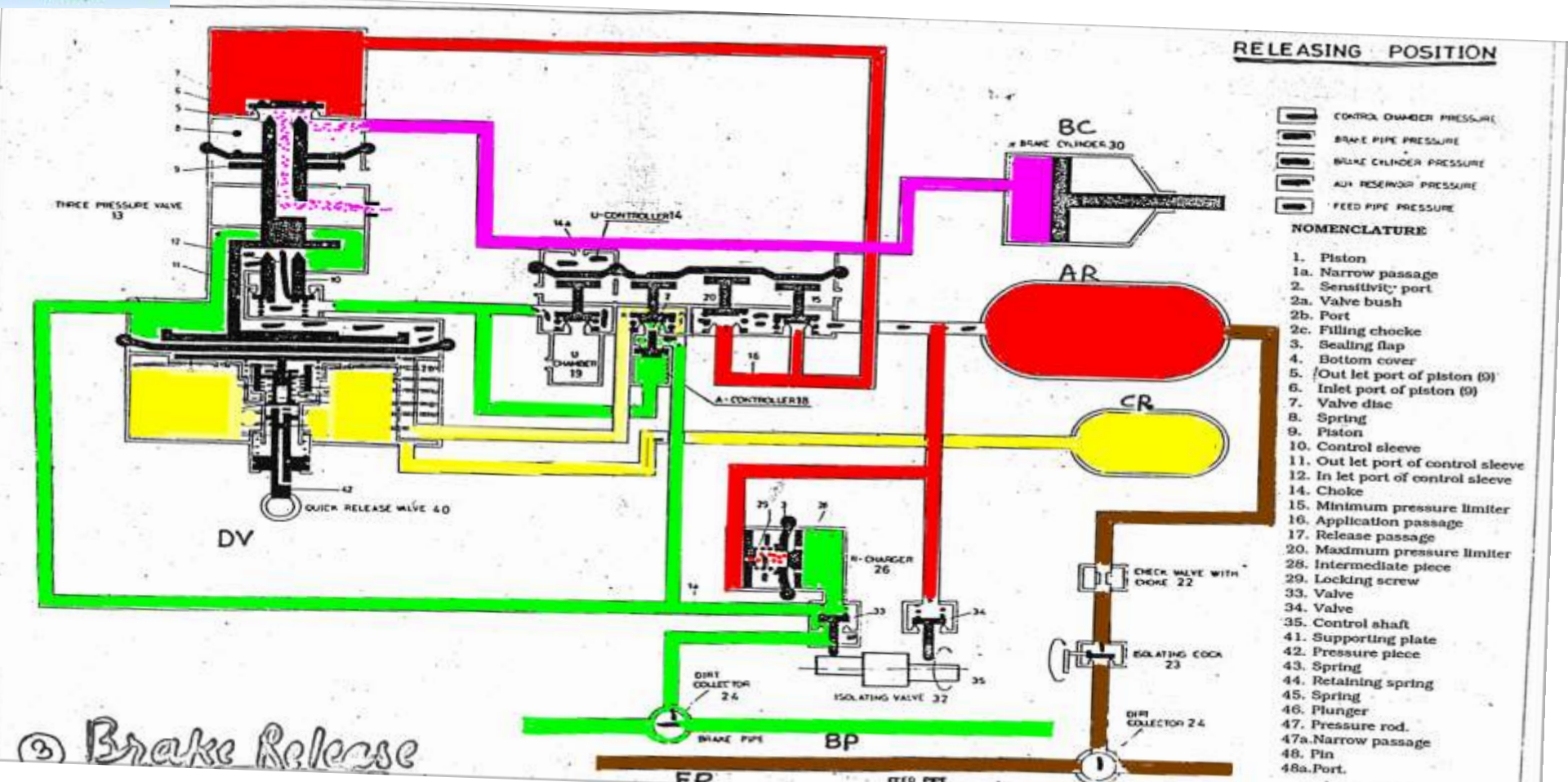
Charging Position



Application Position

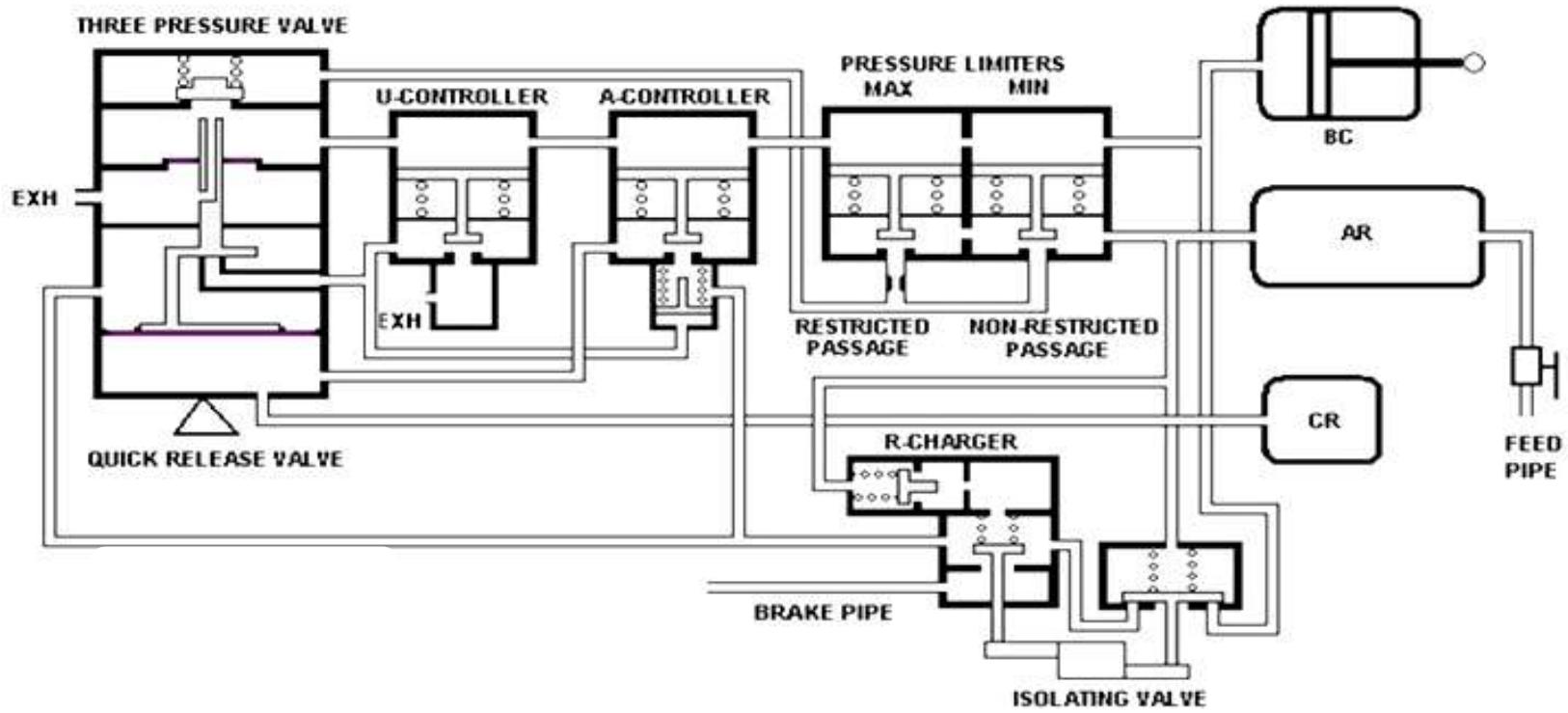


Release Position

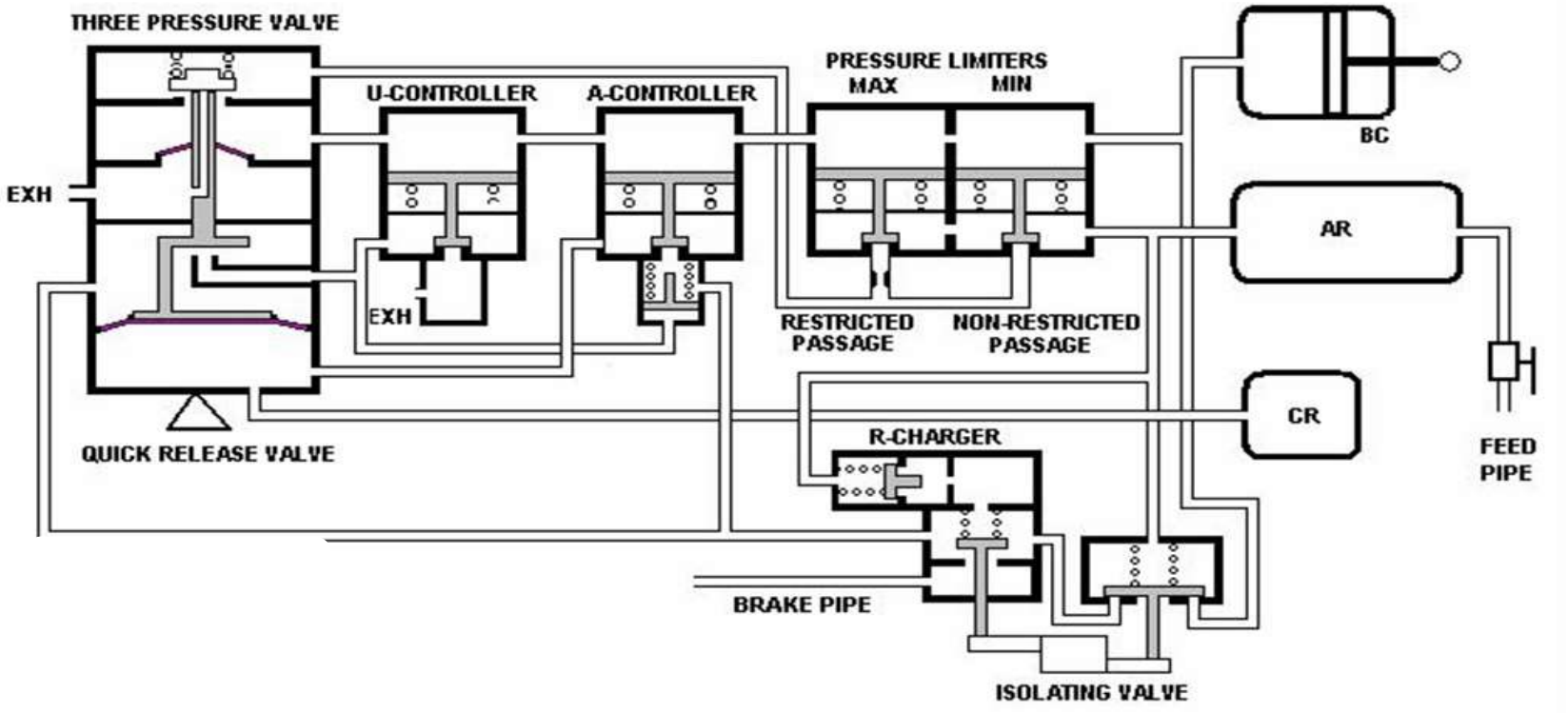


(3) Brake Release

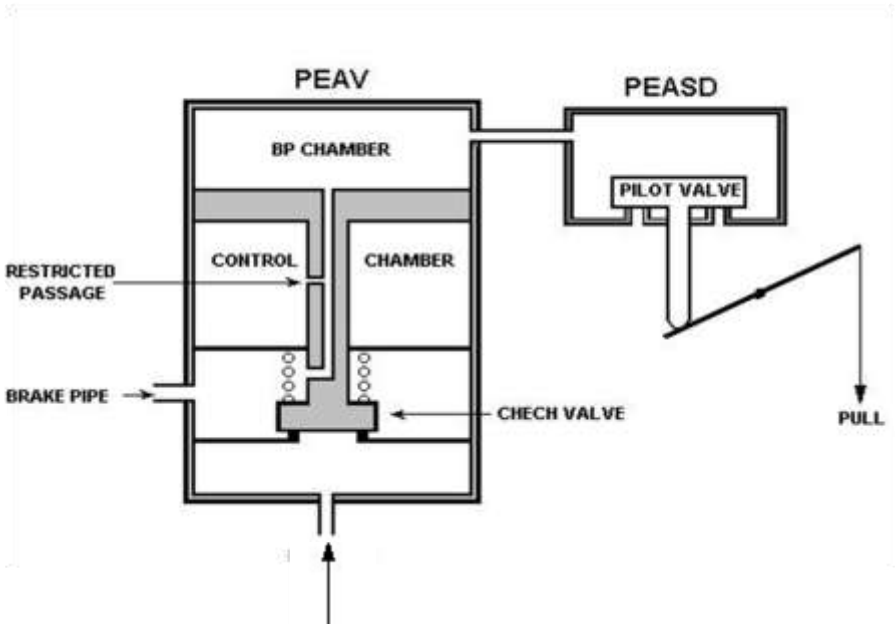
Charging Position of KE type DV



Application Position of KE type DV



PEASD and PEAV



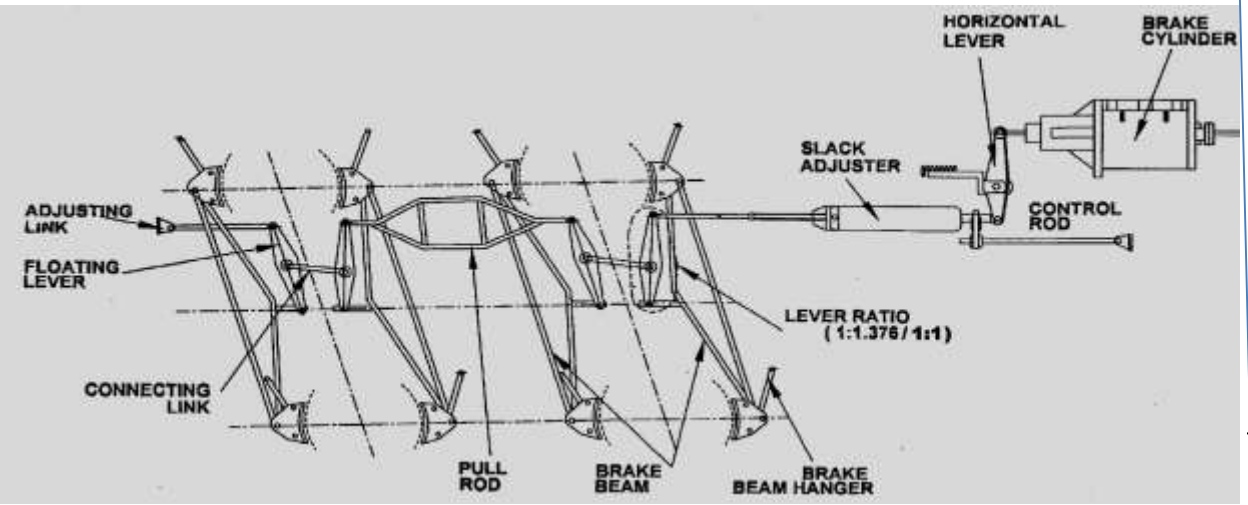
Exhaust Choke Diameter
8 mm in ICF
19 mm in LHB

Brake Riggings (Brake Gear)

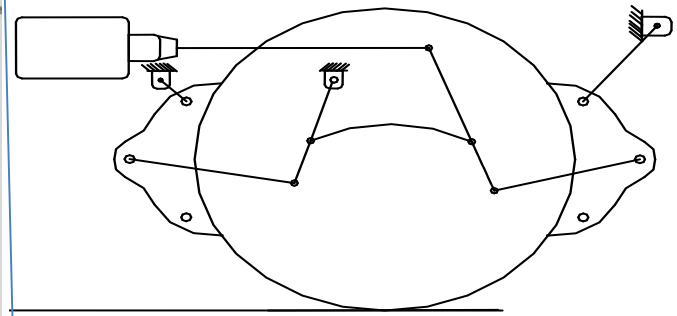
- Coaches
  - ICF Coach
    - Conventional BC fitted (Underframe Mounted)
    - BMBC fitted (Bogie Mounted)
  - LHB Coach
    - Axle mounted disc brake
  - Some other examples
    - Brake applying on wheel disc or wheel trade.
- Wagons
  - Conventional BC fitted with
    - ELB device or
    - Load Sensing Device (LSD)
  - BMBC fitted wagons with
    - Load Sensing Device (LSD)
    - Automatic BC Pressure Modification Device (APM)

Brake Rigging of ICF Coach

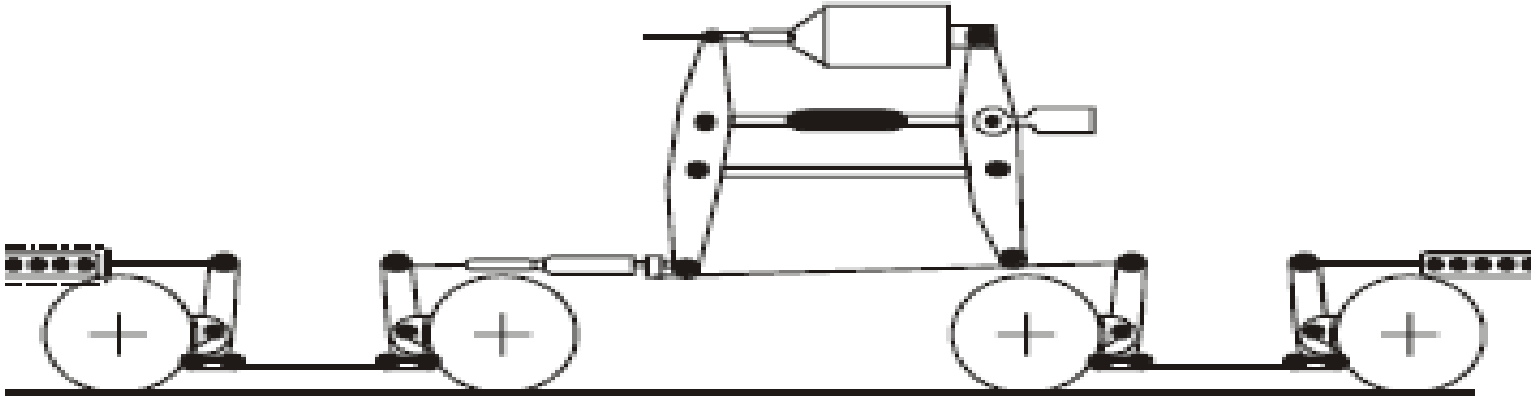
Underframe Mounted



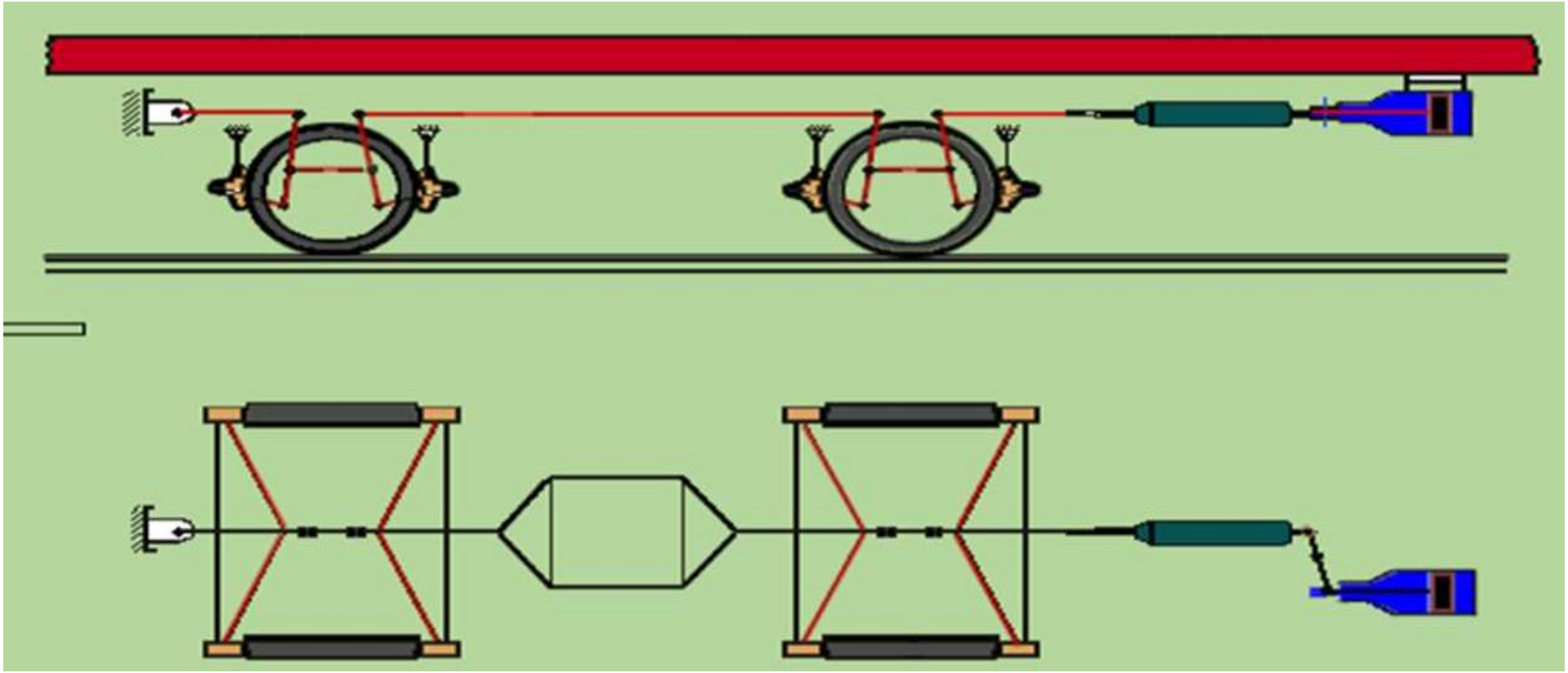
Bogie Mounted



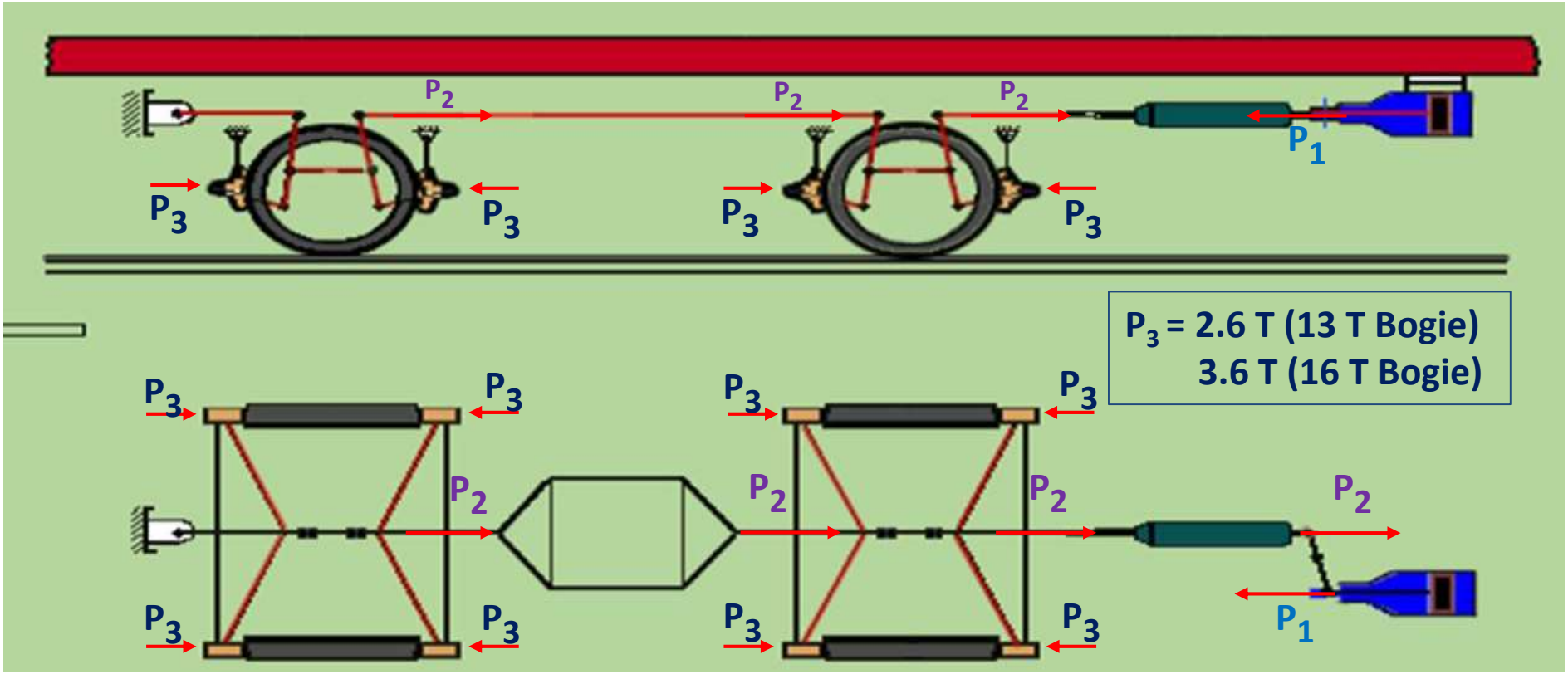
Brake Rigging in Wagon fitted with ELB Device



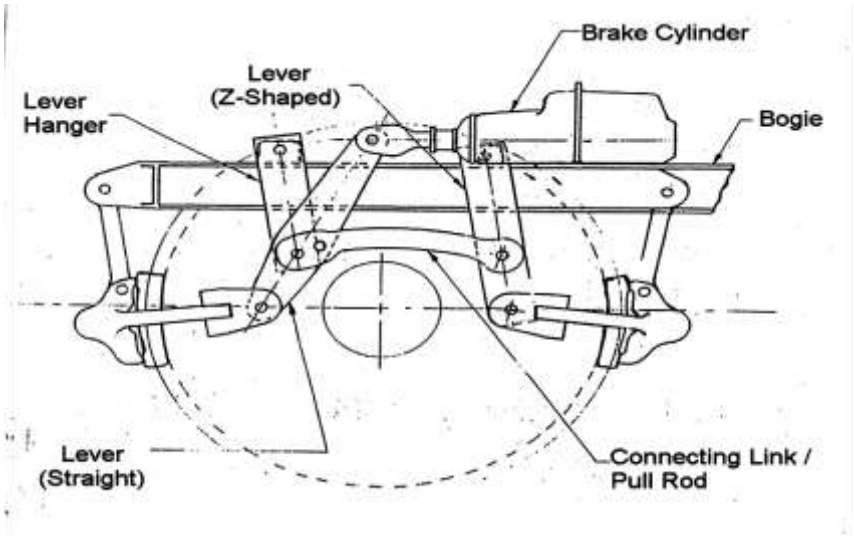
Brake Rigging of Conventional ICF

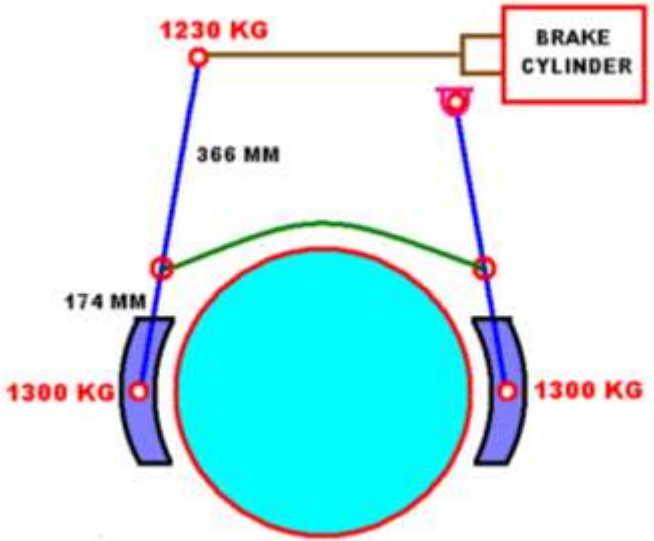


Braking Force Calculation (ICF Conventional)



Brake Force Calculation of ICF (BMBS)





Total force available on one brake block

= area of BMBC x max. BC pressure x leverage ratio x ½

= $\pi/4 \times (8 \times 2.54)^2 \times 3.8/1000 \times 1.9$ or $2.1 \times ½$

= 1.17 T for 13 tonnes bogie or

1.29 T for 16 tonnes bogie

Clearance in Brake Rigging (Slack)

- Piston stroke depends on
  - Brake block clearance
  - Brake gear bush-pin clearance
  - Elasticity of riggings
  - Wrong brake adjustment
- Scope of increase or decrease in slack
- Effect of slack on brake system
- Standard slack between brake block & wheel tread
  - whether required and how much ?

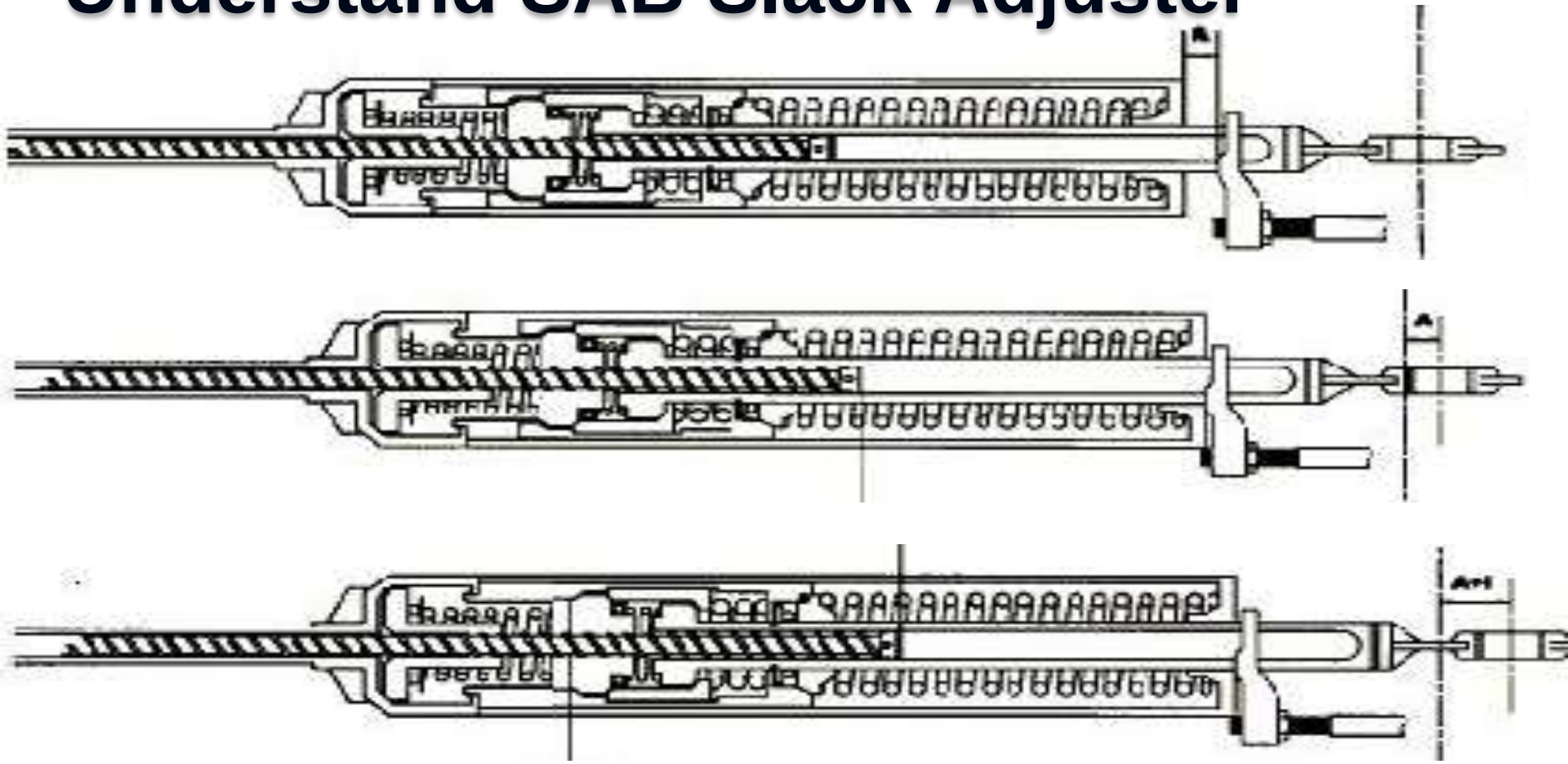
Slack Adjustment

- Necessity to maintain gap (wear aspects)
- Slack adjustment to be taken up
  - Equivalent of total wear of wheel & brake block.
- Automatic slack adjuster: two types
  - External SAB slack adjuster in wagons
  - In-built slack adjuster
    - Single acting in coaches
    - Double acting in wagons

External SAB slack adjuster

- Fitted in U/frame mounted system stocks
- Dimension ‘e’: Slack adjustment capacity
  - 375 + 25 mm for coach.
  - 575 + 25 mm for wagon.
- Dimension ‘A’: Control dimension to maintain Std. gap.
- Rapid action double acting.
- Maintainability much poor.

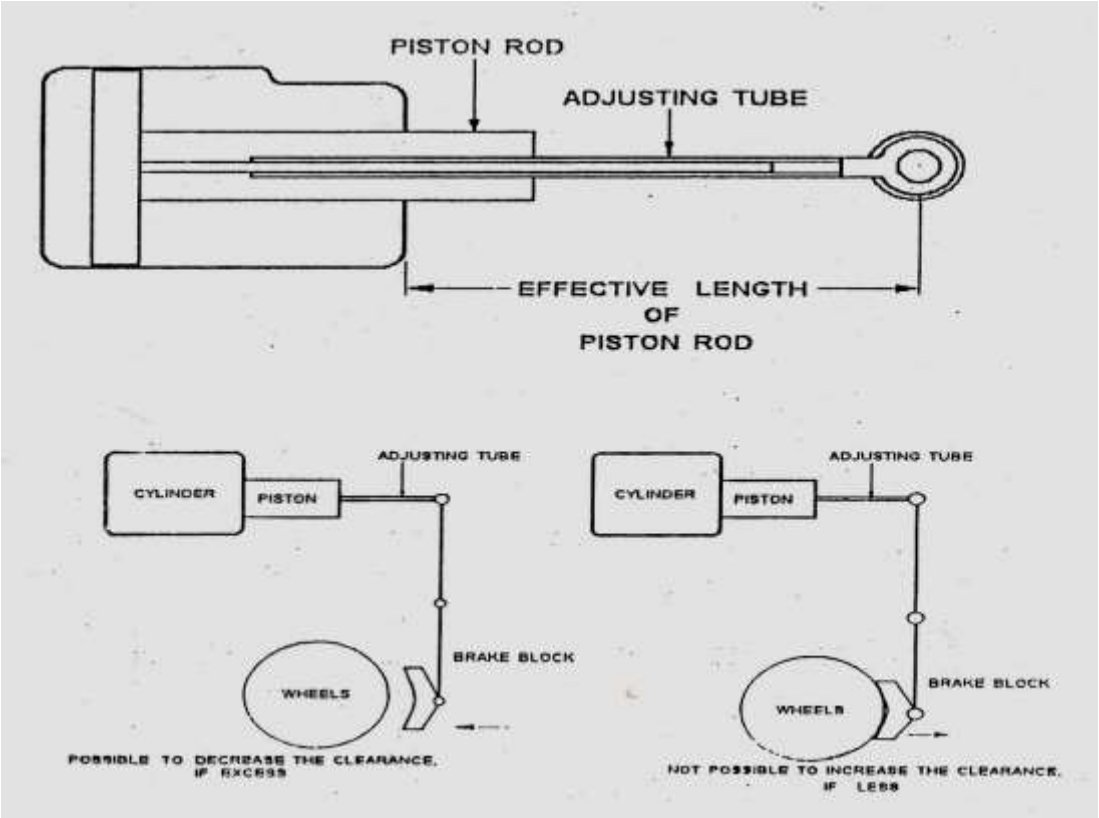
Understand SAB Slack Adjuster



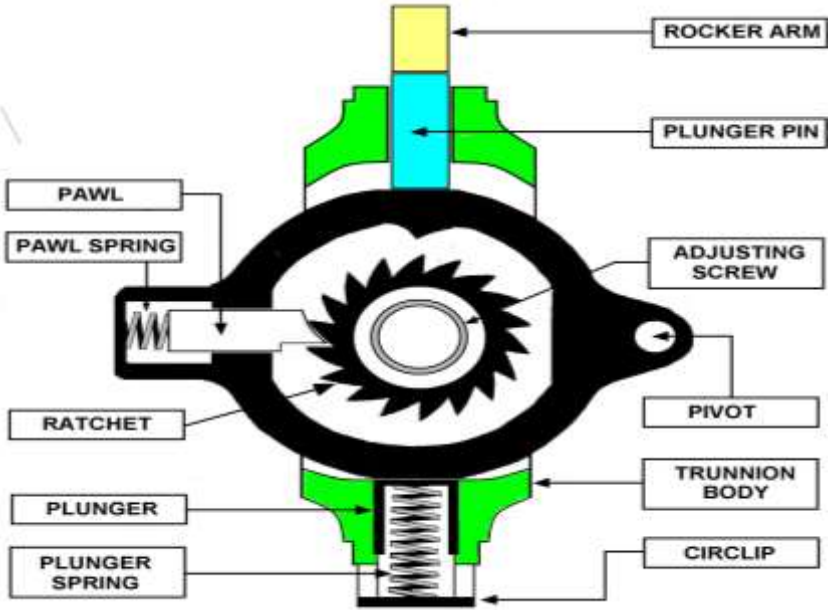
IN-built slack adjuster in BMBC

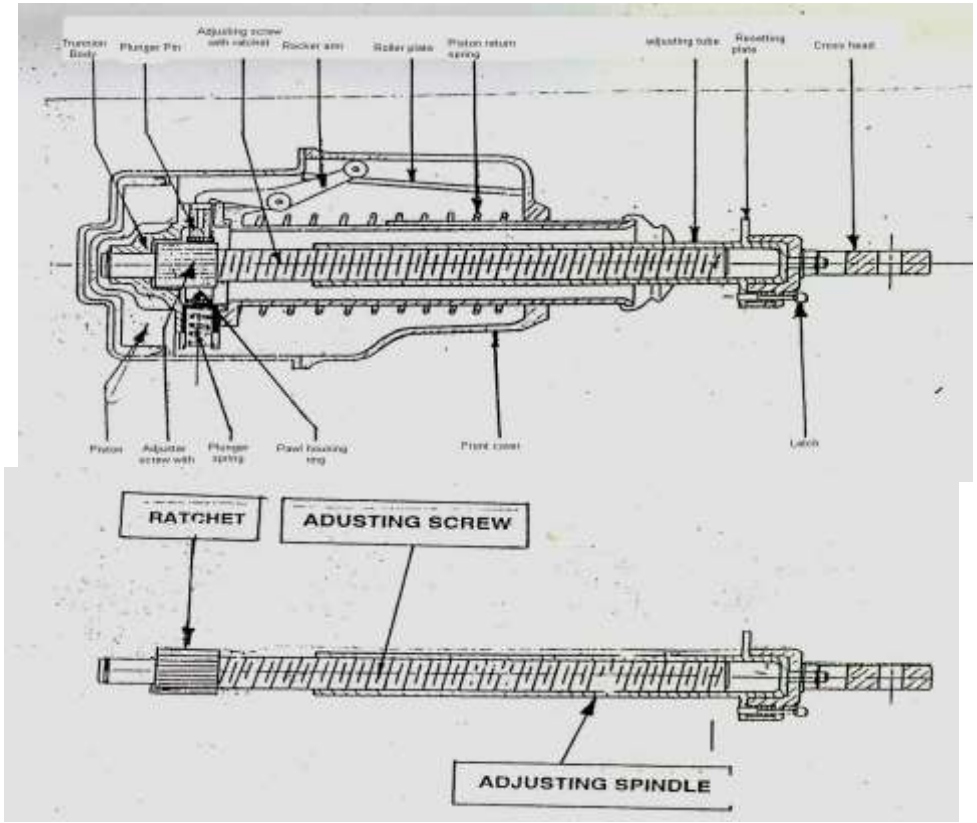
- Much better maintainability
- Piston stroke is control dimension to maintain standard gap
- Adjustment capacity:
  - 305mm (ICF coach) against 395mm requirement.
    - Therefore one time manual adjustment required in whole life of wheel i.e. after reaching wheel dia 839mm
  - 500 mm (wagon) against 456 mm required.
    - Manual adjustment not required at all.

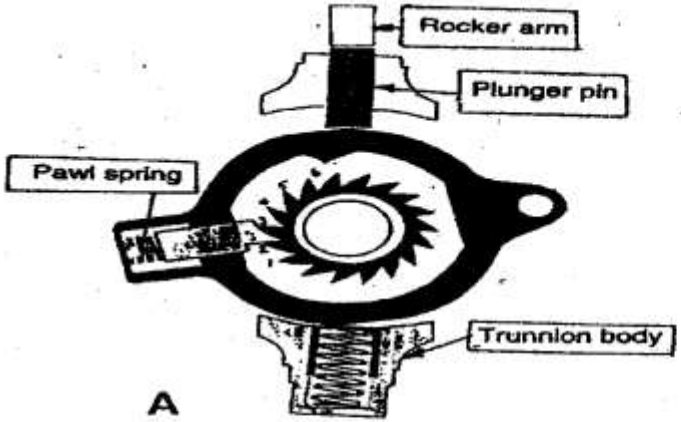
BMBC in ICF Coach

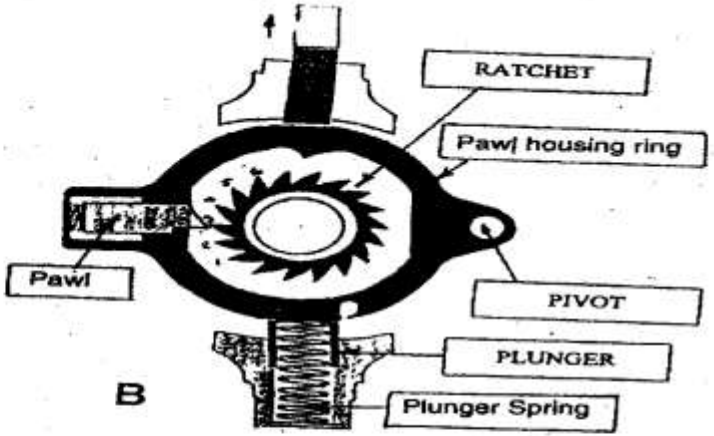


Slack Adjustment Mechanism



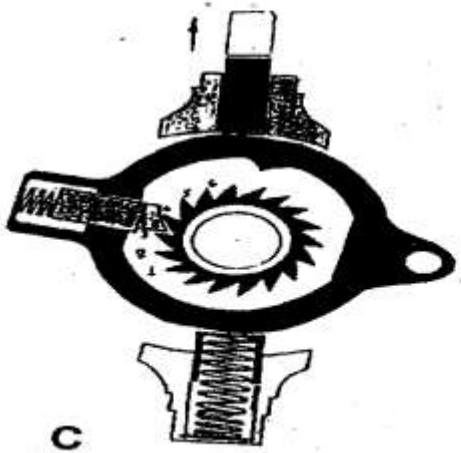


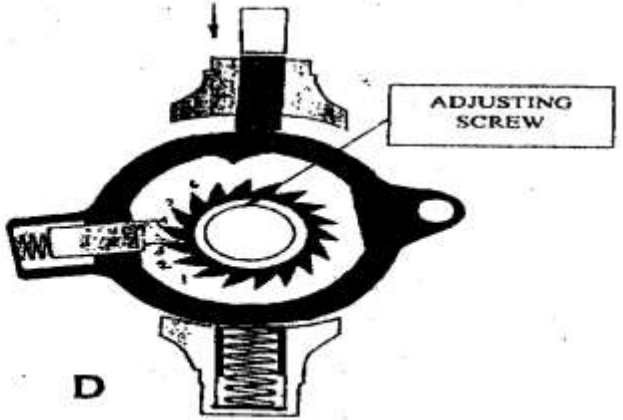




A. POSITION OF PAWL & RATCHET, WHEN THE BRAKE IS IN RELEASED POSITION

B. POSITION OF PAWL & RATCHET, WHEN THE PISTON STROKE IS WITH IN 60mm.



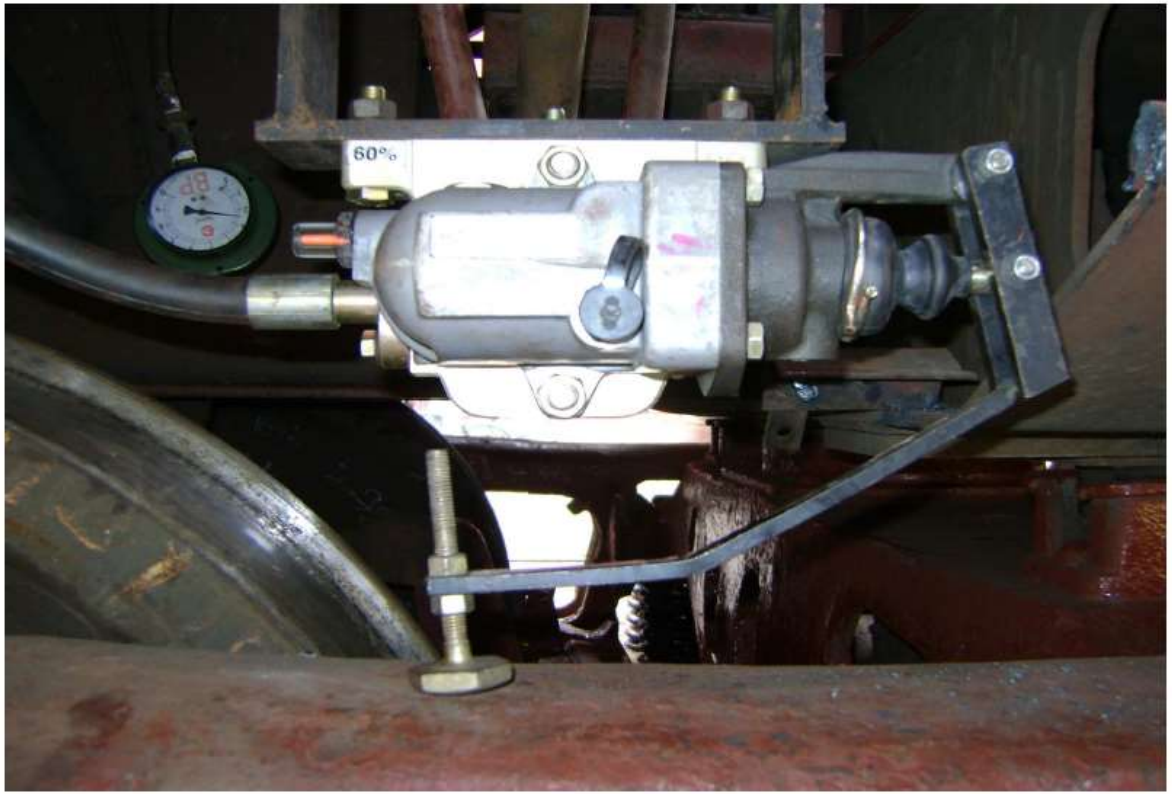


DEVELOPMENTS IN BRAKE SYSTEM

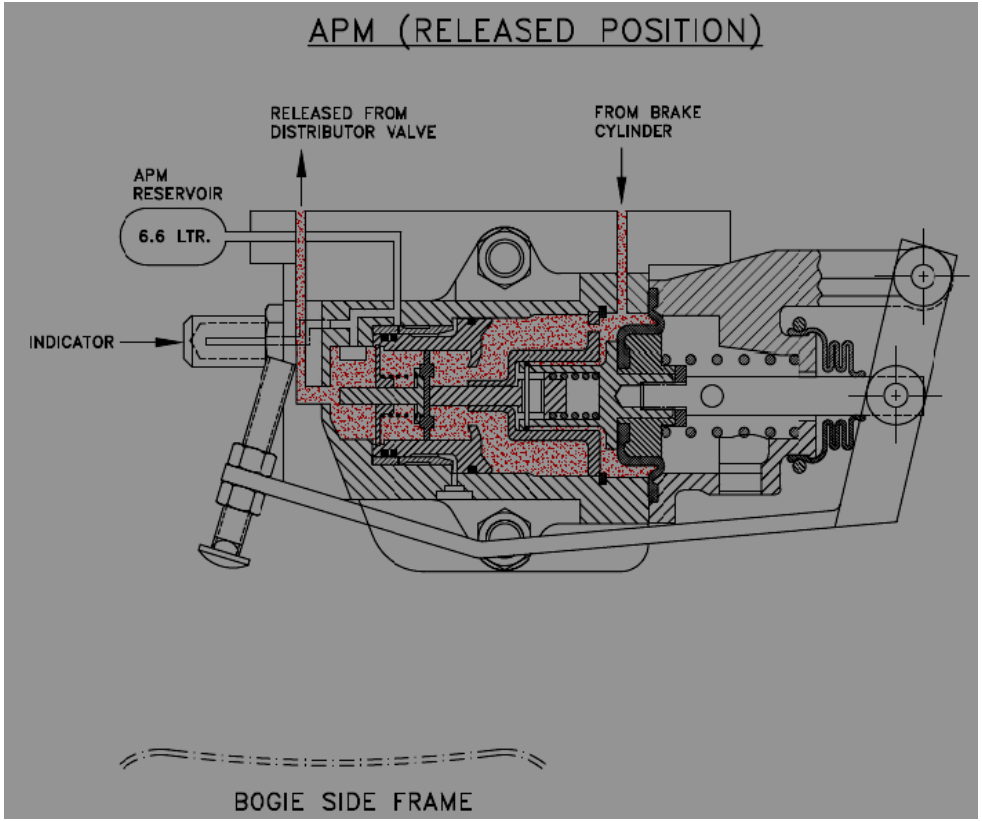
Developments in Wagon

- U/frame mounted to bogie mounted system.
- Fitment of automatic load empty device.
  - Load Sensing Device (LSD) in U/f mounted system.
  - Automatic Pressure Modulator (APM) Device in bogie mounted system.
    - Does not require two stages DV.

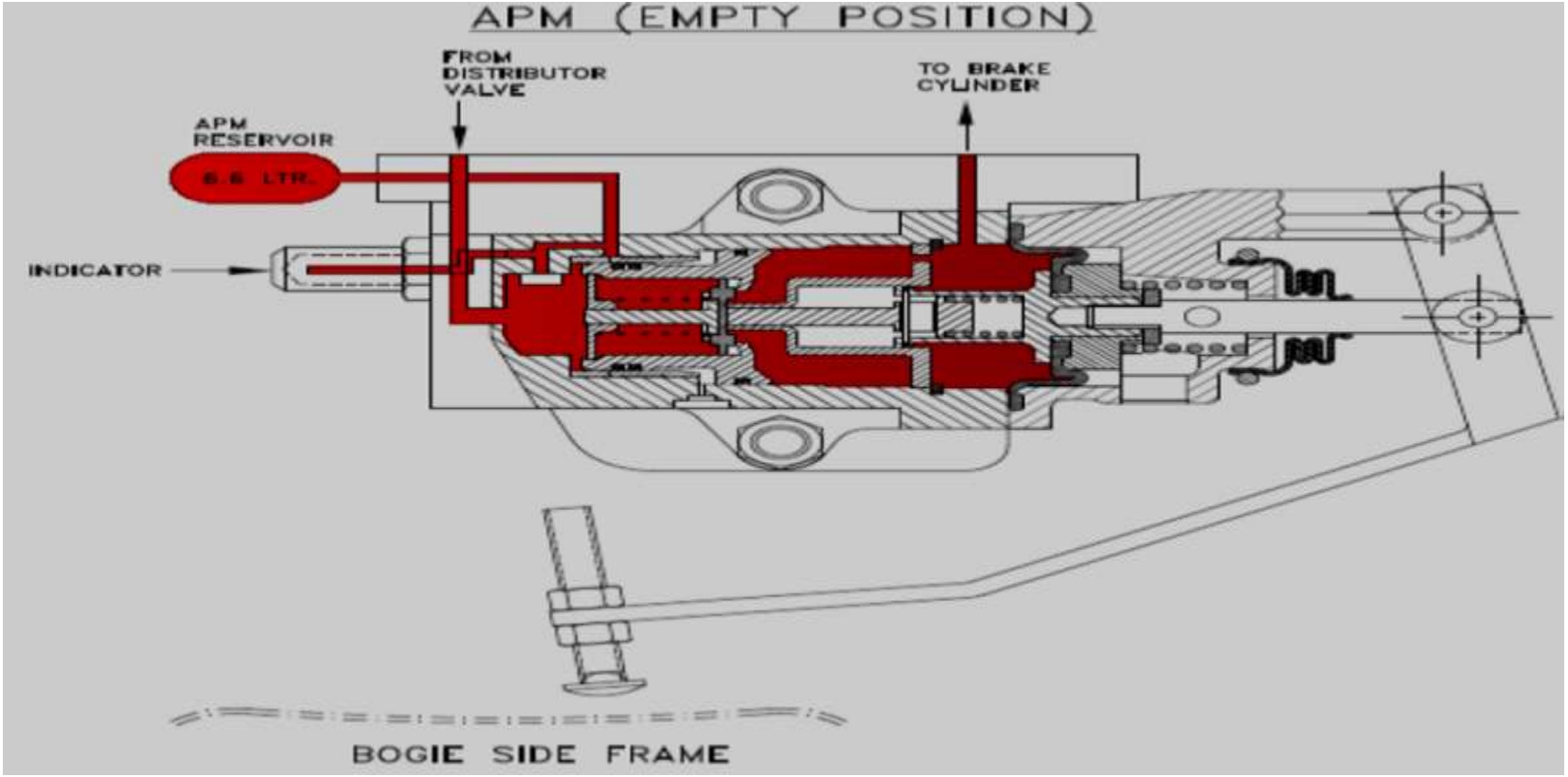
APM: EL 60 (Knorr Bremse)



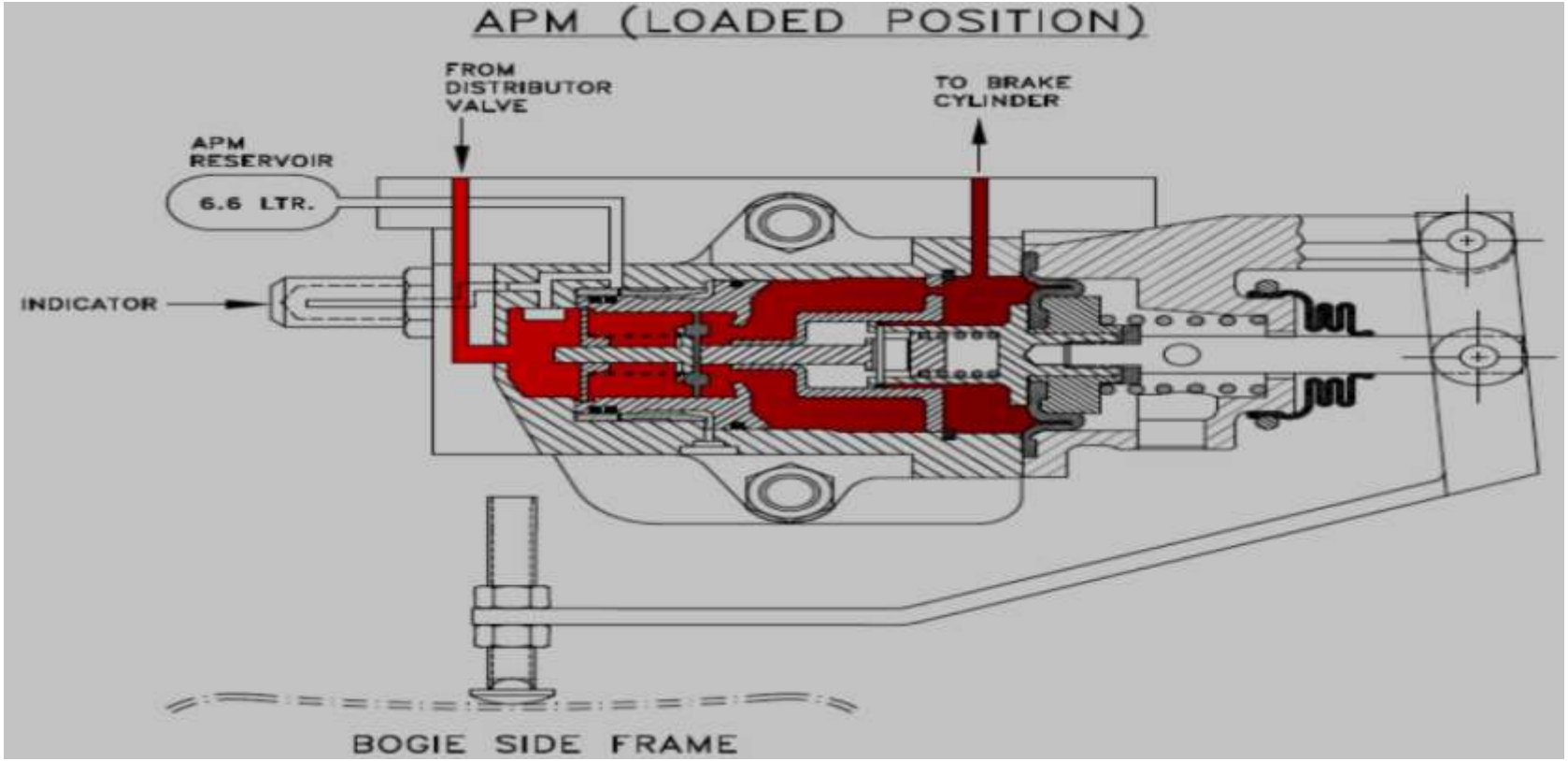
APM: Release Position



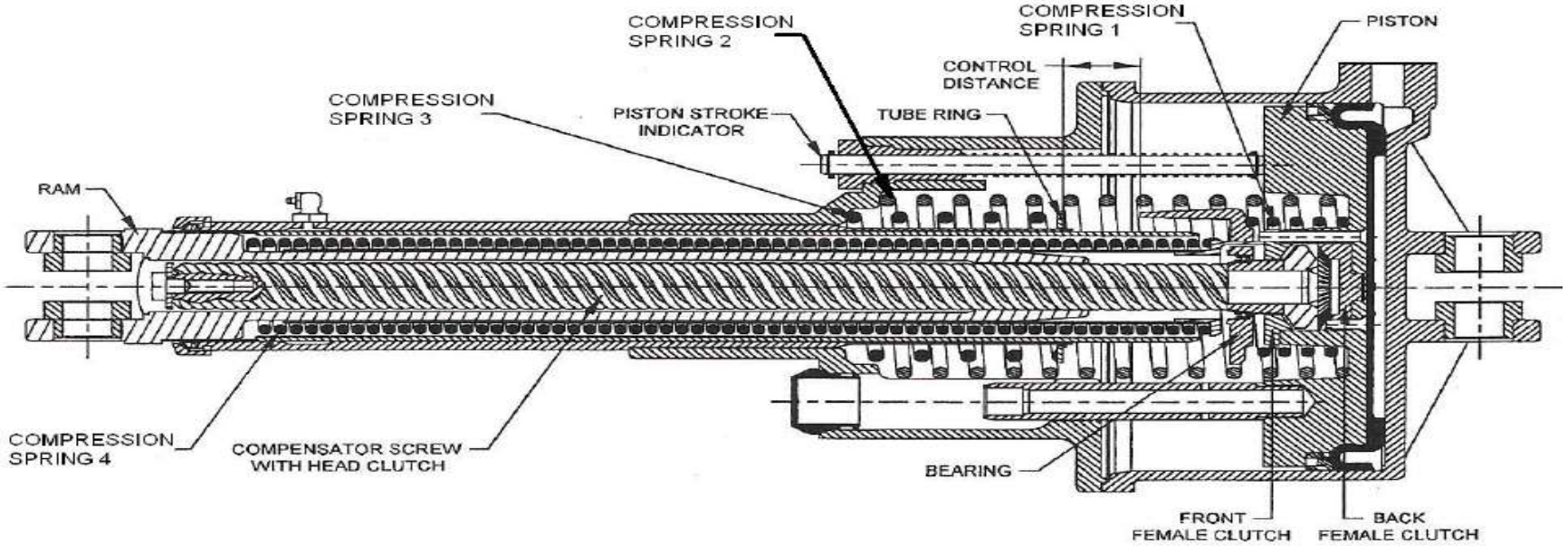
APM: Application Position (Empty)

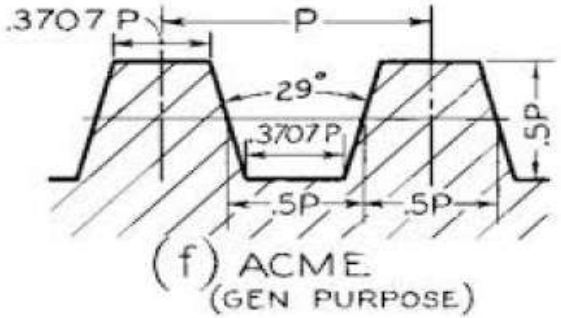


APM: Application Position (Loaded)



BLC: Double acting BMBC



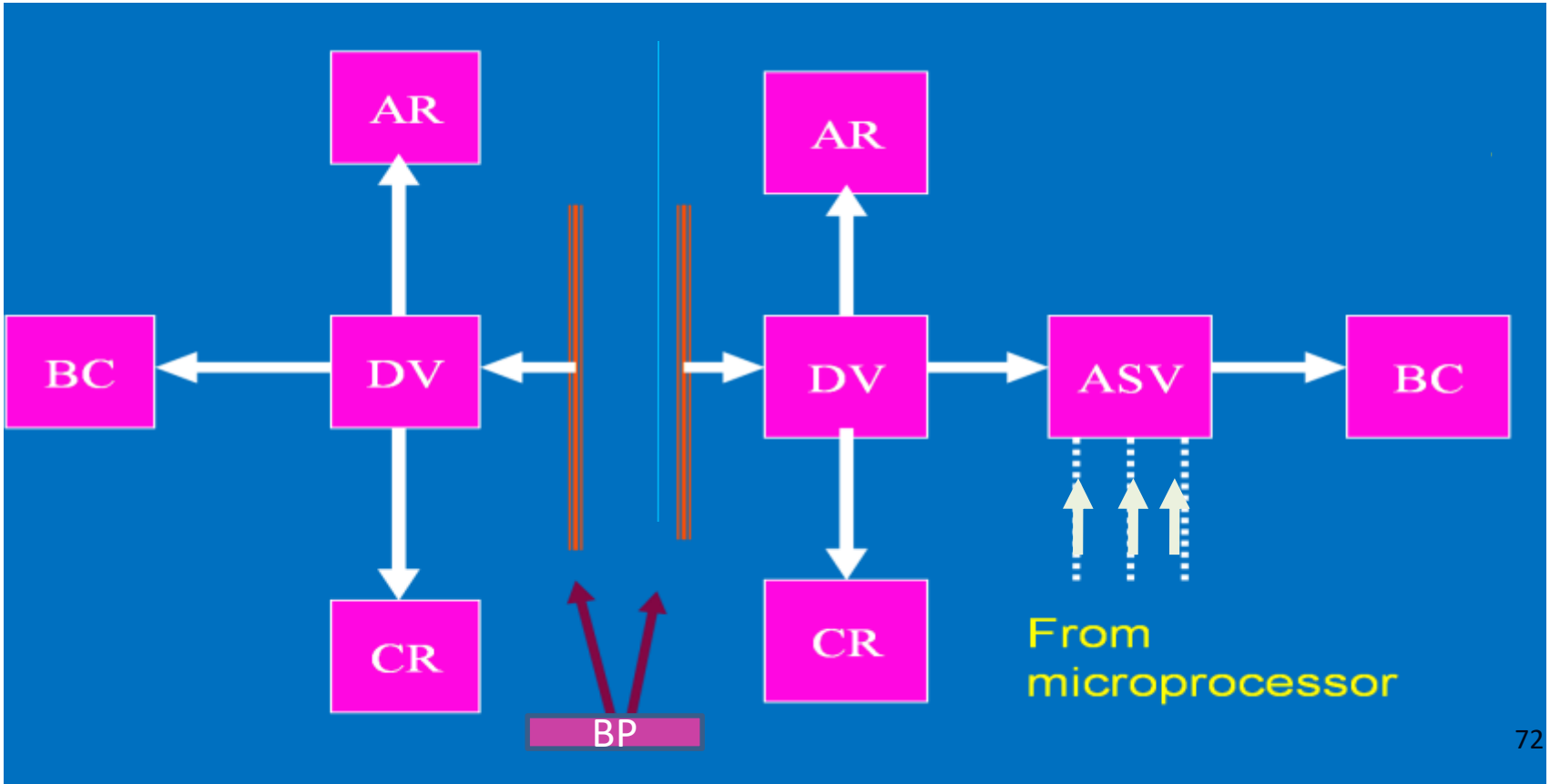


LHB COACH BRAKE SYSTEM

Salient Features

- Almost no brake rigging.
- Microprocessor based WSP.
- Wheel turning frequency reduced.
- Centralised control for complete coach.
- Use of Emergency Brake Accelerator for sharp emergency application in complete train set.
- Performance confirms to UIC 540 and 547

Schematic Diagram: ICF vs LHB

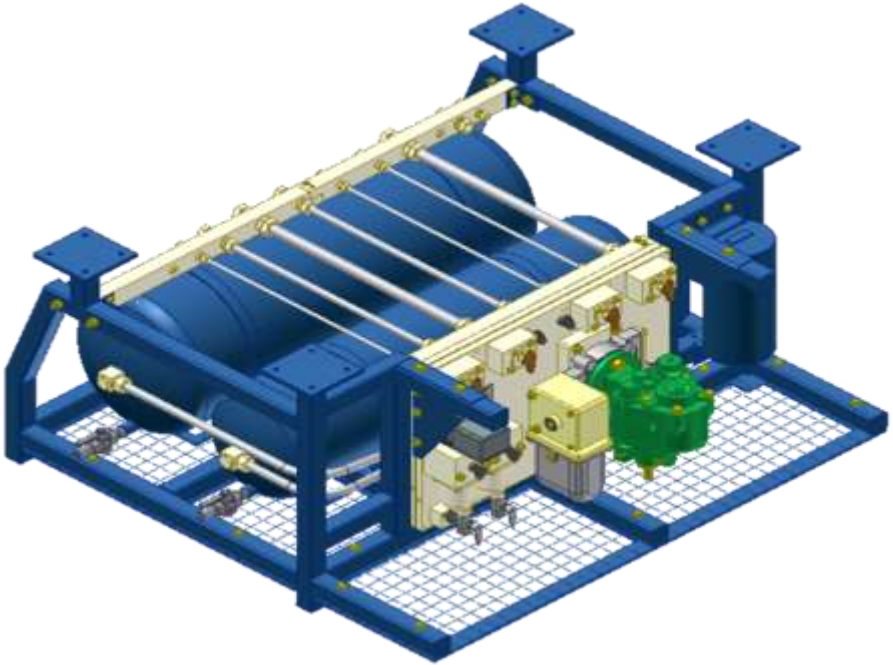


MECHANICAL AND PNEUMATIC SYSTEM OF LHB BRAKE

Brake Equipments on Under frame

Brake Container

- Consists of
  - Brake control panel
  - Reservoirs
    - One 125L for brake application only (Protected by check valve)
    - One 75L for toilets as well as brake
    - One Control reservoir 6L for DV
- Weight -350 kg (with all equipment)



Container Frame & Air Reservoirs are made from SS AISI 304

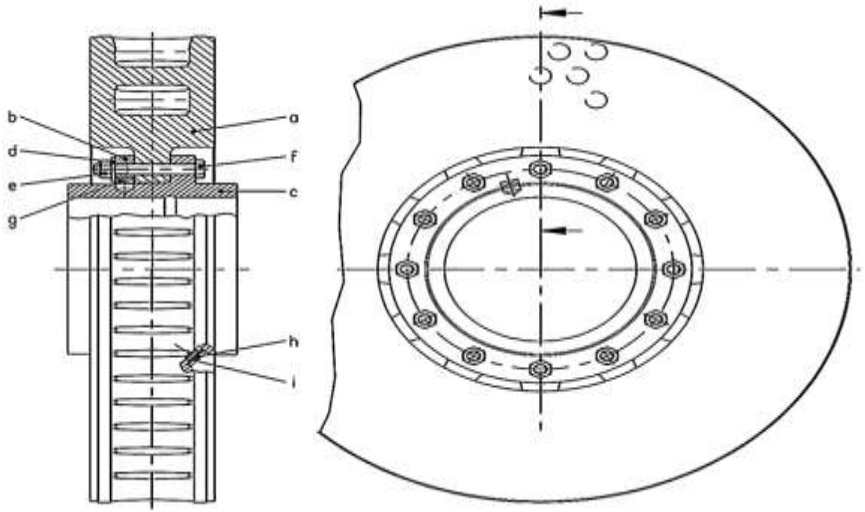
Brake Control Panel

- Consists of:
  - Test fittings (To Check FP, BP, CR & BC Pressure)
  - Isolating cocks for F P, Toilet, Bogie-1 and Bogie-2.
  - Filters for BP and FP
  - Distributor valve
  - Pressure switch (to operate WSP)
  - Check valve.

Brake Components on Axle

Brake Disc

- Consists of
  - A gray cast iron friction ring(a) with integral
    - Crosswise cooling ribs
      - Carry off the heat.
    - Hub (c)



a. Friction ring
b. Clamping ring
c. Hub
d. Spring washer
e. Hexagon nut
f. Hex-head bolt
g. Anti-twist stud
h. Screw plug
i. Sealing ring

Brake Equipments on pipe line

- Emergency Brake accelerator
  - Actuates on any rapid pressure reduction in BP.
    - Sensitive when BP drops 5 to 3.2 in 3 second
    - Insensitive when BP drop 5 to 3.2 in 6 second
  - Allows the BP to vent locally via a large orifice.
  - Venting stops at BP pressure reaches 2.5-1.5 kg/cm2

WHEEL SLIDE PROTECTION

Requirement of WSP

- Poor Adhesion
- Because of high speed as 160 km/h and the EBD of 1200 m, the adhesion could be insufficient to sustain the brake rate demanded during emergency breaking, especially when the surface of the rail is wet and slippery.

Introduction of WSP

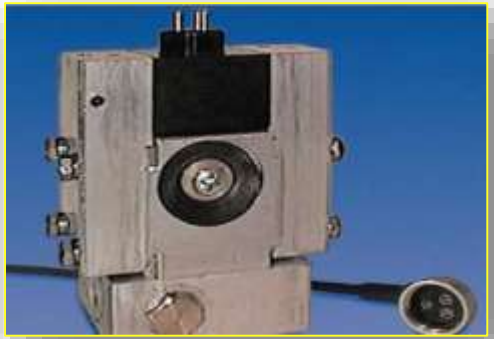
- A BC pressure regulation device.
- Adjusts the braking force to the wheel-rail friction (adhesion) so as to
  - Make optimum use of available adhesion
    - To optimize the braking distance and
    - To prevent wheel sliding.
- For 160 kmph & above WSP is recommended as must requirement.

Main Components

- The system consists of:
  - Speed sensor,
  - Anti skid valve/dump valve,
  - Microprocessor control unit and
  - Pressure switch.

Main Components

Phonic wheel and
Speed sensor

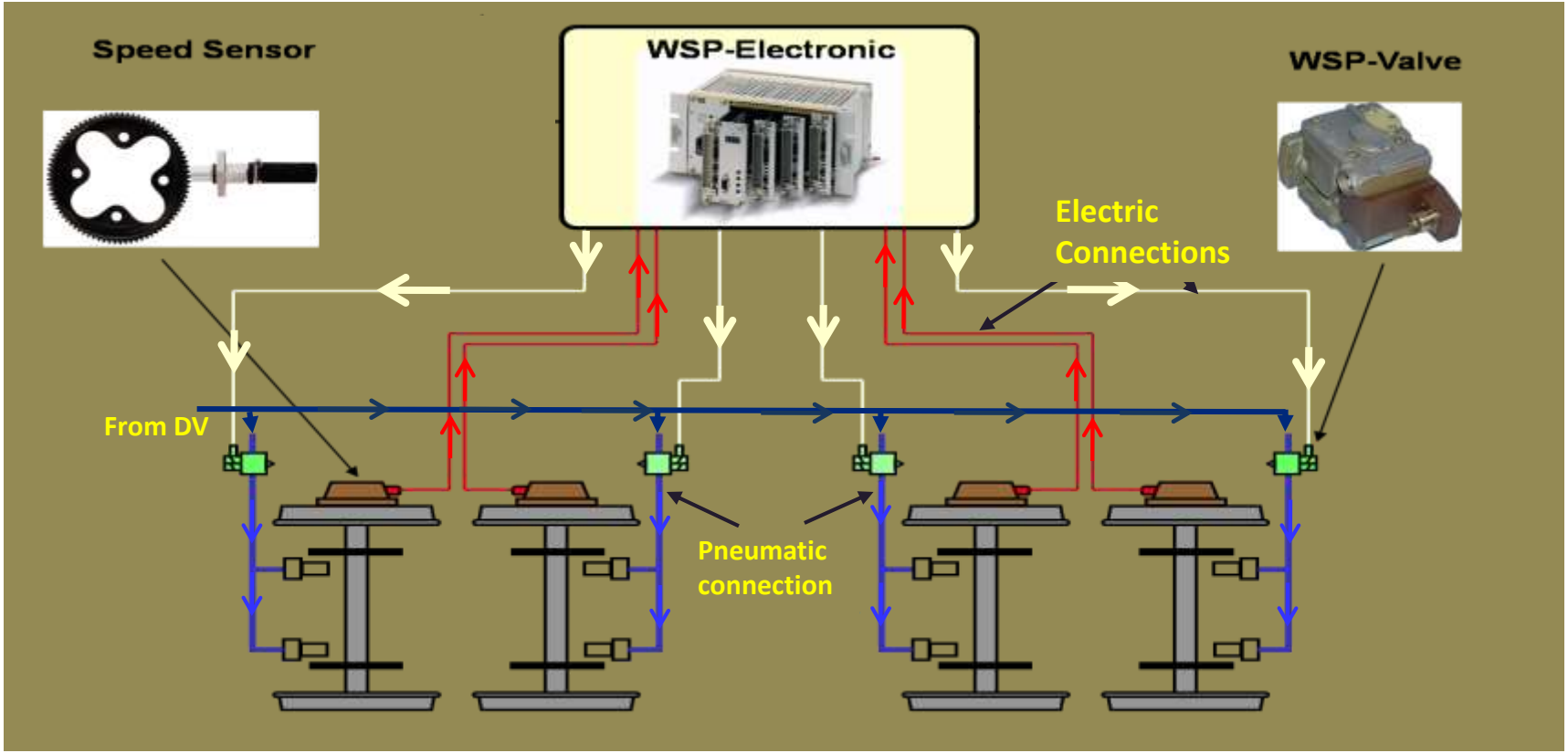


Anti skid valve/dump valve

Pressure switch

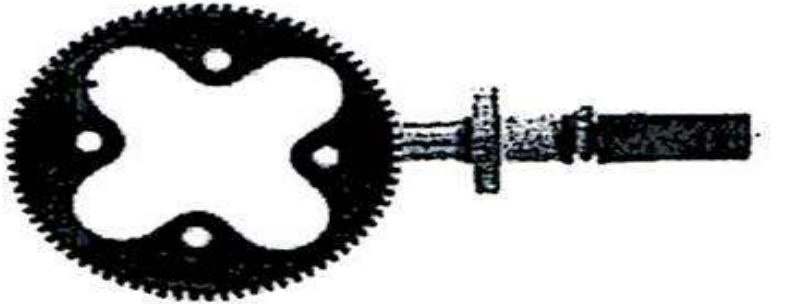
Microprocessor control unit

Pneumatic & Electrical Connections



Speed Sensor (pulse generator)

- Comprises
  - A magnetic sensor and
  - A teethed gear.
- Gap is maintained between teethed gear and sensor.
- No wear.



Rotating gear / Speed sensor

Microprocessor Control Unit

- Analyse all 4 input speed sensor's signal frequencies.
- Evaluates all the frequencies.
- Generates signals for anti-skid valve to control the BC pressure.

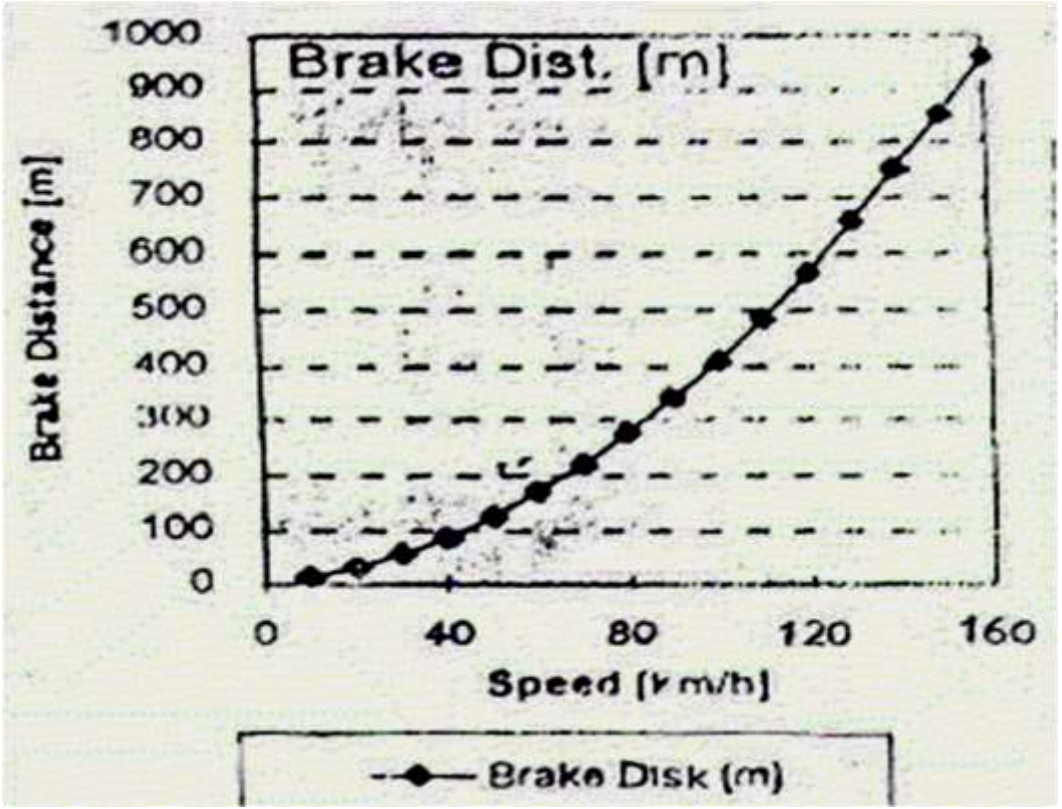
Braking Distance w.r.t. Speed of Train

Composition of Train

2 Loco+

2 Powercar+

16 C/Car



Braking Distance Test Results

- Designed Braking Distance: 1200m at 160 kmph
- Results of braking distance trial of 18 coaches loaded-16 C/car+1EC/car+1P/car at 160kmph
  - Dry rail condition,
    - Emergency application- 1077 m.
    - Full service application- 1312 m.
  - Wet rail condition
    - Emergency application- 1094 m.

Wheel Slide Protection Principle

- Operates as a BC pressure regulation device.
- Made up of two micro processor-
  - Driven modules which control the state of adhesion of the axles.
  - Supervisor module for diagnostic purposes.
- In the case of change of state of the adhesion, the device
  - does not interact with the pneumatic system, but
  - every moments, it adjusts the braking force to the present adhesion conditions.

Wheel Slide Protection Principle

- System implements 4 axles-4 channels configuration and visualizes the use of 4 pneumatic devices for each axle.
- The intervention affects one axle at a time and is of the tachometric (speed comparison) and accelerometer type.
- Speed signal derived also for CDTS.

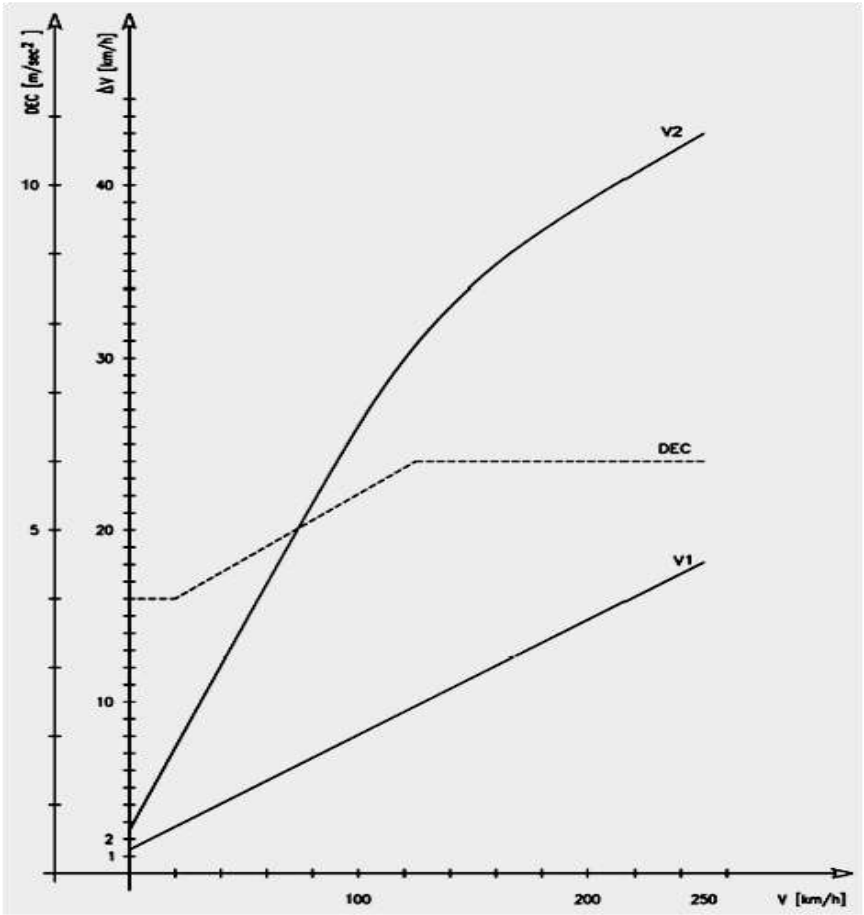
Development of the Threshold Speed

- Upper threshold speed (V1)
  - Above which the axle involved in loosing adhesion.
  - A fixed 1.5km/h + approx. 6% of the real speed is referenced.
- Lower threshold speed (V2)
  - The threshold speed gap according to the real speed of the vehicle, above which the axle involved is considered as “skidding” by the system,
  - The air pressure is discharged from the respective BC.
  - A fixed 2.5km/h + approx. 25% of the real speed is referenced up to app 100km/.

Development of Deceleration Criteria

- DEC
  - The maximum allowed deceleration for each axle above which the BC pressure is modulated.
  - The discharge of the BC may take place although the V2 threshold was not exceeded.
- The V1, V2 and DEC are a function of the instant speed of the vehicle.
- The ACC criterion is a fixed value.

Real Speed to V1, V2 and DEC Gr



Speed and Acceleration Criteria

- Speed comparison (V1):
  - V1 = Vr - (1.5 km/h + 0.06 * Vr)
- Speed comparison (V2):
  - V2 = Vr - (2.5 km/h + 0.25 * Vr)
- Axle negative acceleration criterian(DEC):
- Axle positive acceleration criterian(ACC):

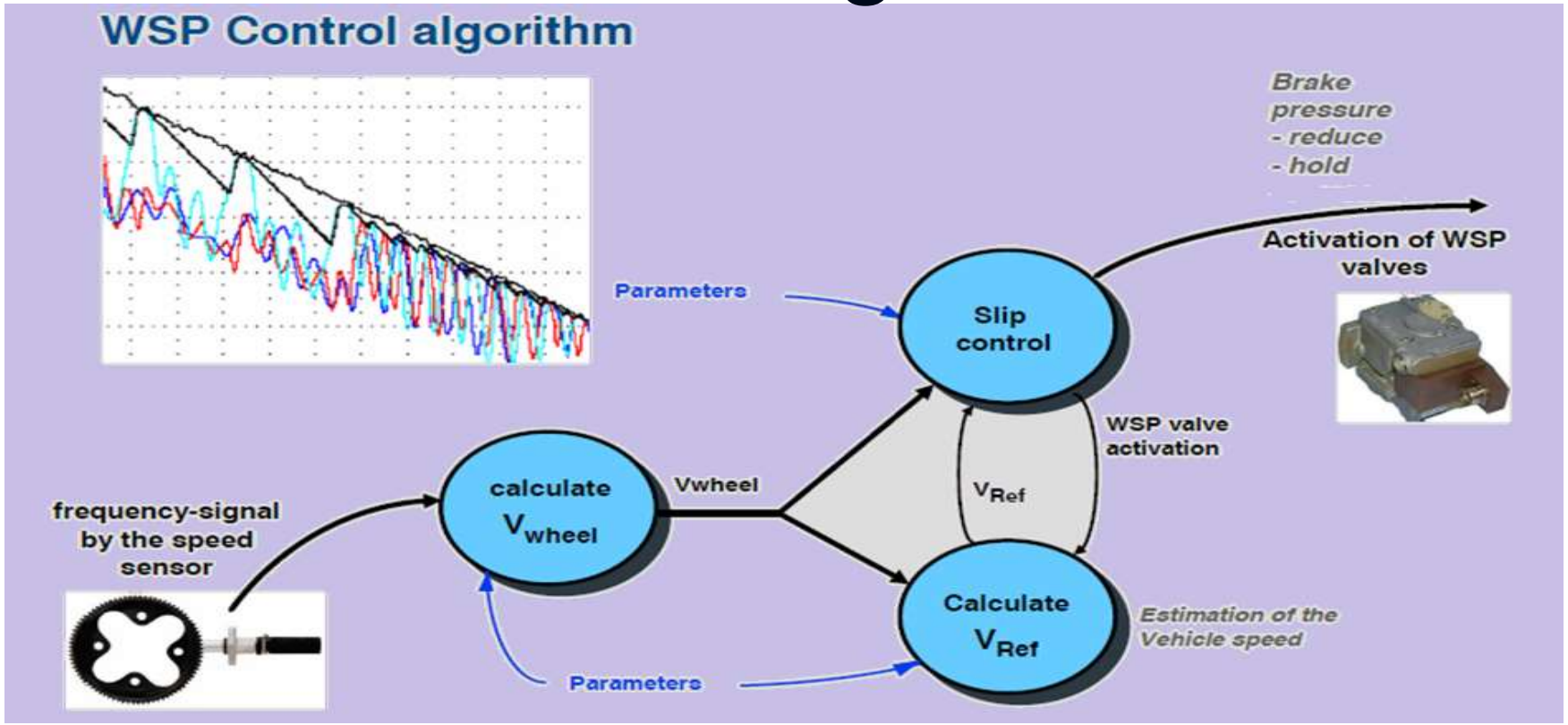
Speed Computation

- Reference speed (Vr):
  - An estimate of the real speed of the vehicle.
  - Device takes the fastest axle's speed as Vr.
  - If all the axles lose adhesion simultaneously,
    - The DEC criteria is followed until at least one axle regains adhesion.
- Peripheral speed measurement (Vp):
  - BC pressure is regulated by ASV,
    - In order to keep Vp between V1 and V2, i.e. the most favourable zone for restoring adhesion.

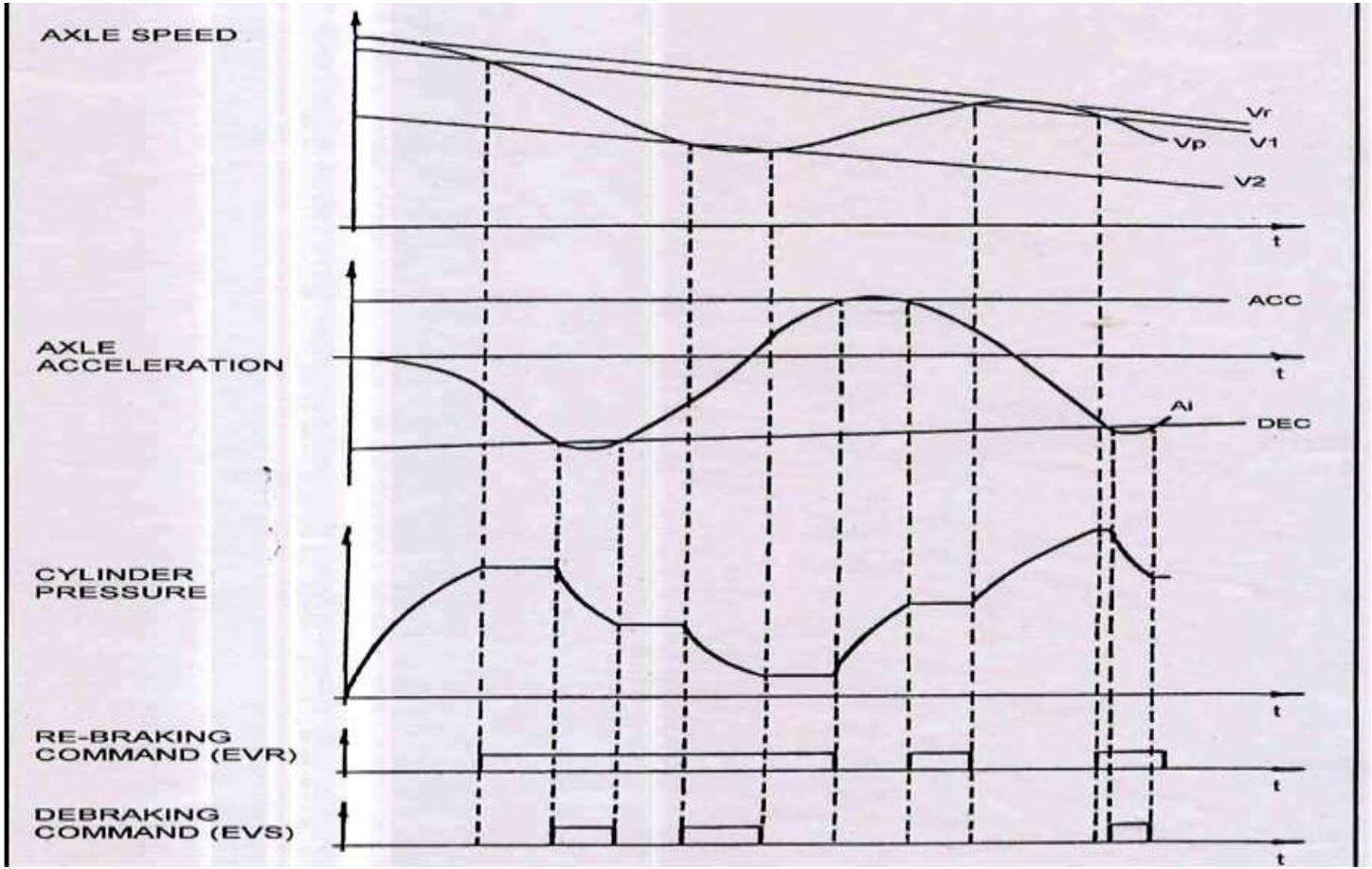
Pneumatic Assembly Control Logic

- Reduce BC pressure if
  - $Vi \leq V2$ or
  - $Ai \leq DEC$
- Restore BC pressure if
  - $Vi \geq V1$ or
  - $Ai \geq ACC$
- Maintain BC pressure if
  - $V2 \leq Vi \leq V1$ and
  - $DEC \leq Ai \leq ACC$

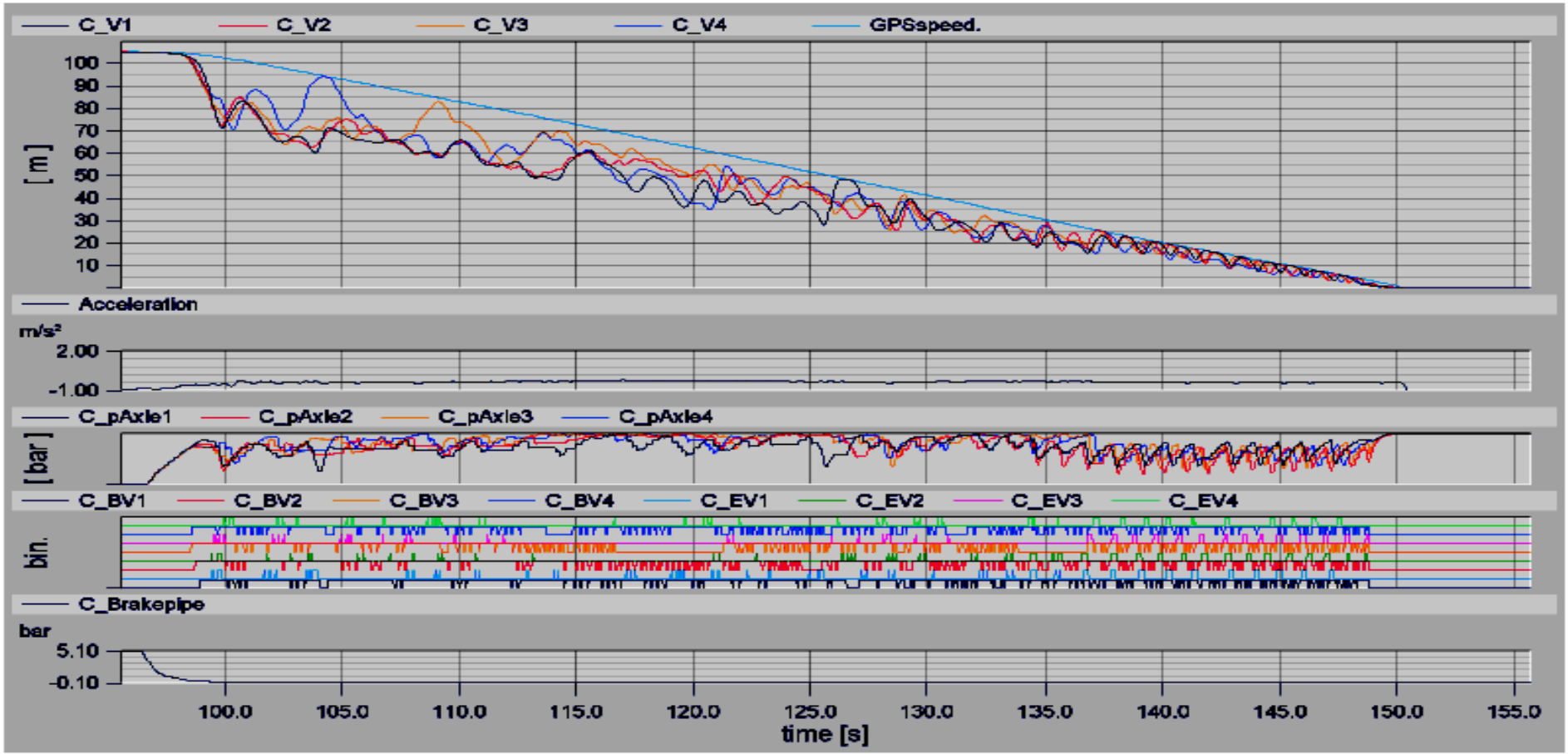
Control Algorithm



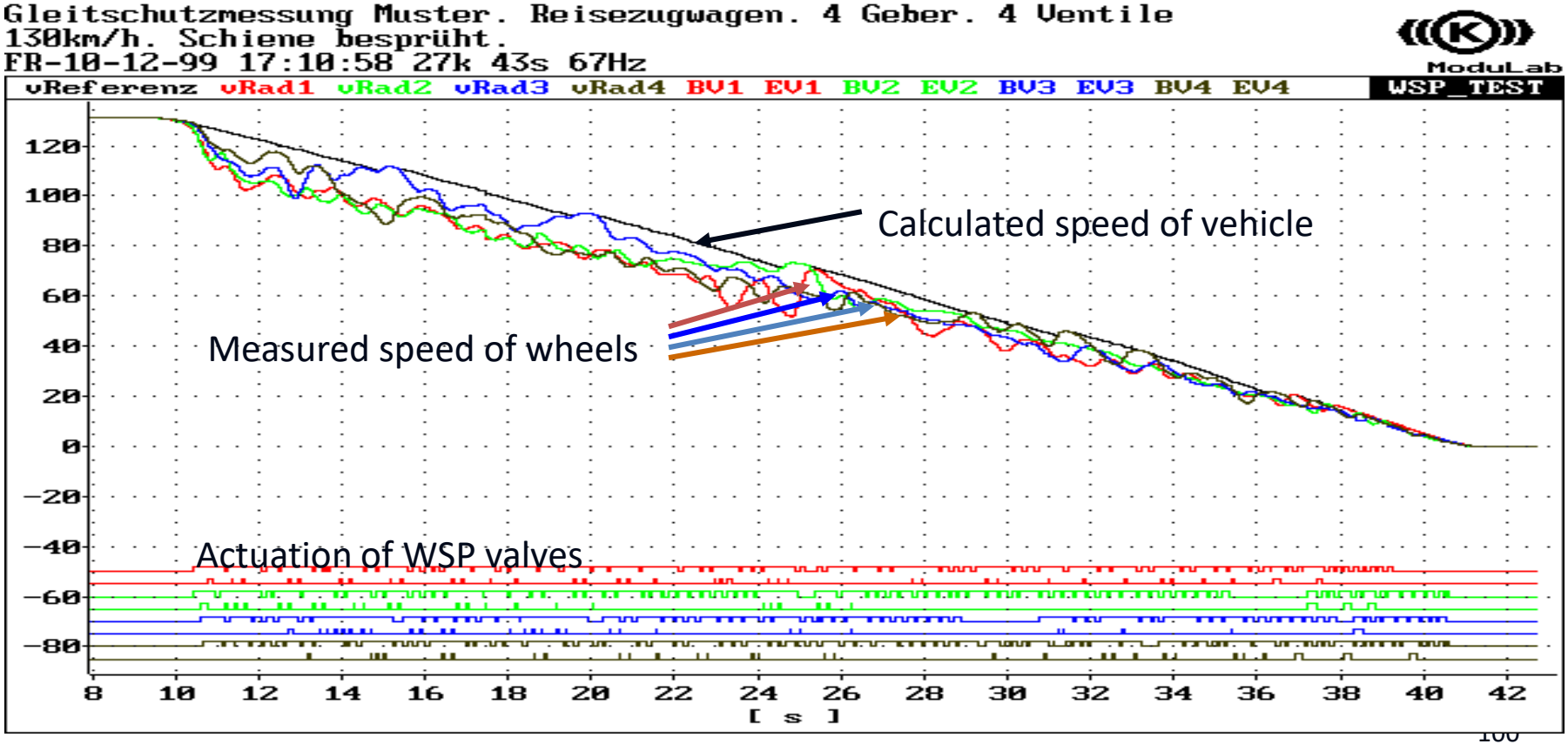
Control Logic Of Pneumatic Device



Dynamic Test Graph



WSP - Field Test Data



Difficulty in Demonstration

- Demonstrating the improvement provided by a WSP system is very difficult
  - as the natural low adhesion condition occurring at the rail can be difficult to re-create in a test track environment.

PB03 Board

- The power board supplies all the voltages for powering the boards, actuators and sensors.
- If the vehicle is left to stand idle, the control unit can be switched off to a “standby" mode of low primary current consumption (standstill sleeper mode). The unit is reactivated by a pressure switch at a preselected level in the feed pipe.

MB04 Board

- WSP is implemented entirely on board MB04. It contains all the electronic peripherals for individual wheel slide control at up to four wheels or wheel sets. The anti-skid valves are powered by 24V from board MB04. MB04 has a man-machine interface (MMI) integrated into its front panel.

Man-machine interface

MGS2 has a man-machine interface (MMI) integrated into its front panel. The MMI peripherals comprise:

– 9-pin Sub-D female connector for the RS232 interface (to connect a service terminal).

EB01 Board

EB01 is an extension board in the MGS2 control unit. It provides digital inputs and outputs. It is also utilized for supplementary functions such as door control.

WSP Fault Codes Display

- 99: System OK.
- 95: System OK, but some previous fault codes has got logged (Volatile – can be erased by pressing S3 button on MB 04 Card).
- 7201: Fault in one wheel set.
- 7301: Fault in several wheel set.
- 8888: Display Test (Shows in sequence of diagnosis / testing) .
- 89: Testing Mode (Dump Valve self testing in progress).
- 0301: Fault noted/ sourced/ related to MB 04 Card (Shows in sequence of diagnosis).
- Display – 0201 means fault noted / sourced / related to EB 01 Card (Shows in sequence of diagnosis).

WSP Fault Display Codes

99 means System OK.

95 means System OK, but some previous fault codes has got logged (Volatile – can be erased by pressing S3 button on MB 04 Card).

7201 means fault in one wheel set.

7301 means fault in several wheel set.

8888 Display Test (Shows in sequence of diagnosis / testing) .

89 Testing Mode (Dump Valve self testing in progress).

0301 means fault noted / sourced / related to MB 04 Card (Shows in sequence of diagnosis).

0201 means fault noted / sourced / related to EB 01 Card (Shows in sequence of diagnosis).

WSP Fault Codes

- Fault code in four digit appears after pressing S1 button.
- Display will show in following sequence:
  - 8888-7201-0301-3401-7201. Thus fault code is 34.
  - Ignore last two digit (01) eg If connector of dump valve 3 broken or cut during run then display will show 7201. After pressing S1 button
- In fault code first digit indicate axle number (1, 2, 3 & 4). Second digit indicate the fault number as described below:
  - 1 – Speed Sensor Open / Short Circuit. (Check wiring of speed sensor, wiring is either open or short circuited)
  - 2 – Speed Sensor Signal Error. (Check gap between speed sensor & phonic wheel teeth.) .
  - 3 – Dump Valve Short Circuit. (Check wiring pertaining to dump valve)
  - 4 – Dump Valve Open Circuit. (Check wiring pertaining to dump valve)
  - To understand fault code please refer the table in next slide.

WSP Fault Codes

Note down fault code (displayed after **0301/0201** after pressing S1 button).

Fault code display in four digit. Ignore last two digit (01) eg If connector of dump valve 3 broken or cut during run then display will show **7201**. After pressing S1 button display will show in following sequence : **8888-7201-0301-3401-7201**. Thus fault code is **34**.

In fault code first digit indicate axle number (1, 2, 3 & 4). Second digit indicate the fault number. Fault number is described below:

1 – Speed Sensor Open / Short Circuit. (Check wiring of speed sensor, wiring is either open or short circuited)

2 – Speed Sensor Signal Error. (Check gap between speed sensor & phonic wheel teeth.) .

3 – Dump Valve Short Circuit. (Check wiring pertaining to dump valve)

4 – Dump Valve Open Circuit. (Check wiring pertaining to dump valve)

To understand fault code please refer the table in next slide.

WSP Fault Codes

	Axle 1	Axle 2	Axle 3	Axle 4
Speed Sensor Open / Short Circuit	11	21	31	41
Speed Sensor Error	12	22	32	42
Anti Skid Valve Short Circuit	13	23	33	43
Anti Skid Valve Open Circuit	14	24	34	44

Failure OF WSP

- Common Reasons of Failures
  - Use of non standard fasteners for fitment of Phonic wheel on axle
  - Speed sensors missing/open circuit
  - Speed censor cables are not properly connected
  - Sensor cable fitted with loose strands
  - Dump valve leaking during brake application
  - Junction box in broken/ damaged condition
  - Water cleaning of axle box housing
  - Improper dump valve connection
  - Non maintenance of proper clearance between Phonic wheel ans speed sensors (0.9-1.4mm)
  - This Gap to be checked in quarterly schedule


Thank You