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## **FOREWORD**

*I am glad to know that STC Ajmer is publishing the continual series of course books. This will be useful for direct recruited SSE's & JE's. This publication will surely improve the knowledge and their awareness on safety of railways and work fields.*

*The Course book for MSE/MJR (Workshop) – III Session compiled as per laid down Railway Board module contains common and Workshop theory topics in the book.*

*I hope this book will be very beneficial to the Mechanical Supervisors with the appropriate theoretical inputs and develop confidence in training and solving problems in their subsequent career.*

*I am very much happy and congratulate Principal and his team for sharing their knowledge and bringing the relevant information in the form of book.*

**(Virendra Kumar )**  
Principle Chief Mechanical Engineer

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## **FOREWORD**

The Study material for direct recruited Supervisor Trainees with reference to Railway Board Module prepared for study, comparison and references.

STC - Ajmer has taken initiative and is going to publish a course book for MSE/MJR (Workshop) - III Session with the objective to provide relevant technical knowledge to incorporate the Railway technological up-gradation at field level.

I appreciate that this course book contains the latest relevant topics as per training module for Mechanical Supervisors. I am sure that this book will enhance the knowledge of all induction course trainees.

I am glad to congratulate Principal and his team for sharing their knowledge and for bringing relevant information in the form of book.

A handwritten signature in blue ink, appearing to be 'Sudhir Gupta', with a long horizontal stroke extending to the right.

**Sudhir Gupta**  
Chief Workshop Engineer

आर.के. मूदडा  
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### **FOREWORD**

*Mechanical Department is most responsible towards Safety of Railways. In this regard, Railway Board framed Training Module for Direct Recruited trainee Supervisors, who are required systematic and gravitational knowledge of their field as they are the backbone of Mechanical Department.*

*STC- Ajmer plays a vital role in imparting qualitative & effective theoretical & practical training to develop their professional aptitude. The main thrust of book course contents of MSE/MJR (Workshop) – III session is application oriented with the appropriate theoretical inputs and trainee can develop self - reliance in training and taking problems in their work related field.*

*I am pleased that STC Ajmer is constantly publishing course books as per module prescribed by Railway Board.*

A handwritten signature in blue ink, consisting of stylized initials and a surname, written above a horizontal line.

**(R.K Moondra)**  
Chief Workshop Manager

प्रमोद रावत  
प्राचार्य.पर्यवेक्षक प्रशिक्षण केन्द्र  
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## PROLOGUE

We take an opportunity with the inspiration of our CWM/AII Shri R.K. Moondra to present a course book MSE/MJR (Workshop) - III Session for trainees. The object of the book is to present the subject matter prescribed by Railway Board module in a most concise, compact, to the point and in lucid manner.

I feel happy to achieve this target as the course book have been received excellent reception from the faculty of STC Ajmer S/Shri Umesh Kumar Nema, Mahesh Sharma , B.L Gupta and A.C Gaharwal as they have the best knowledge of their respective fields.

I appreciate the efforts done by our experienced faculty. I would like to thank our Hon'ble PCME, Shri Virendra Kumar and CWE, Shri Sudhir Gupta for their benevolent guidance in this regard.

( **Pramod Rawat** )  
Principal  
Supervisor Training Centre, Ajmer

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# JOB EVALUATION

**Job Evaluation:** It is a method of placing a value on each job. It is concerned with the job only & not with the efficiency of the people carrying out the work.

## Objectives of Job Evaluation

1. To estimate correct wages for different jobs within the Organization.
2. To determine relative values for different jobs.
3. To categorise new jobs in appropriate grades.
4. To form a basis for resolving wage disputes.
5. To form a basis for Selection, Promotion & training.

## Procedure

1. Describe the requirements for each job in terms of skills, knowledge, responsibilities etc.
2. Give each requirement a value.
3. Total the values given under each head for the job.
4. Link the values with the wage structure thereby paying for each job in terms of its real worth.

## Methods of Job Evaluation



**A. RANKING METHOD:** Different jobs within the Organization are ranked in descending order by someone who is familiar with all jobs.

### Advantages

1. It is very simple & quick method of grading the job.
2. It is less expensive.
3. Can be easily adopted in small Organization.

### Disadvantages

1. Since it is based on subjective judgement of some individual or group of persons in reliability is questionable.
2. The relative differences in terms of abilities, responsibilities etc. in different jobs cannot be ascertained.
3. Cannot be used when jobs are complex in nature.
4. Not suitable for large Organization.
5. Difficult to fit in new jobs at proper places in the hierarchical order.

**B. GRADING METHOD:** Job based on similar skills, difficulties, responsibilities etc. are categorised one grade/group. For example jobs like turner, driller, machinist, grinder etc. requiring basic skills in operation of machines (relevant), ability to read and interpret simple blue print etc. can be grouped under one grade. Those requiring higher skills, precision or working on complicated jobs(such as tool room work) can be placed in next higher grades etc.

**Advantages**

- 1) The procedure is simple and easily understood.
- 2) It is more logical and accurate than ranking method.
- 3) A large number of jobs can be categorized under various grades.

**Disadvantages**

- 1) The system is cumbersome and takes more time.
- 2) Possibility of matching jobs with present wage structure cannot be ruled out.
- 3) It is not suitable for very large organizations.

**C. FACTOR COMPARISON METHOD:** This is a quantitative approach to job evaluation. It is similar to the grading method with the difference that the job is analysed for each of the following key factors:

- Mental efforts
- Skill
- Physical effort
- Working conditions
- Responsibility

**PROCEDURE**

1. Select a number of key jobs within the organization since these jobs are used to establish the guidelines their choice is critical hence it should be ensured that they are representative and adequately renumbered.
2. Analyse the key job for each of the above mentioned factors.
3. Break up the salary paid for the key job for each of the factors commensurate with requirement and relative importance of each job factor.
4. Evaluate the job against this comparison scale and assign wages accordingly.

**Advantages**

- 1) This provides a logical basis for arriving at wages for various jobs in keeping with the salary structure followed in the organization.
- 2) Whenever a new job comes up in the organization, the wages can easily be fixed by this method.
- 3) It is more objective way of finding wages, hence likely to be more accurate than previous methods.

**Disadvantages**

- 1) It is not very simple to work with.
- 2) The selection of key jobs for formulating the scale if not done objectively, may lead to difficulties.
- 3) The scope for subjectivity in breaking up key jobs for various jobs for various factors cannot be ruled out.



**D. POINT RATING METHOD:** This is most systematic and objective method of job evaluation. It is combined of factor comparison and grade description method. Point plans can be developed by the organization or commercially available point plans can be adopted for the purpose.

#### PROCEDURE

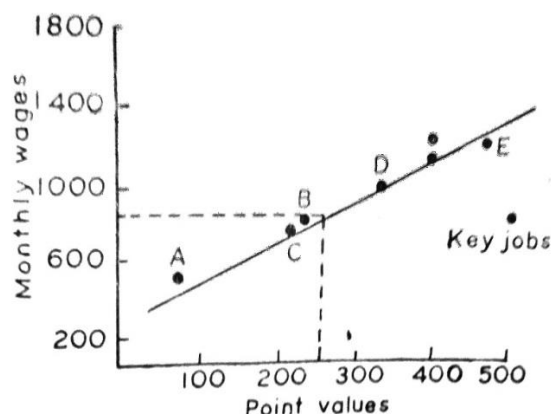
- 1) Select a few representative key jobs for the purpose of reference.
- 2) Break the job into component factors similar to those in factor comparison eg.
  - Skill education training for example initiative required etc.
  - Efforts(physical and mental effort in job)
  - Responsibility towards men, material, machinery etc.
  - Working conditions of heat, light, humidity, fumes, dust etc.
- 3) Break the factors into degrees and assign point values to each degree.
- 4) Establish maximum point value for each factor.
- 5) Establish the point value for each factor for the job to be evaluated.

#### POINT RATING

S. No.	Factor	Weight factor	1	2	3	4	5	6
<b>SKILL</b>								
1	Educational background	15	15	30	45	60	75	90
2	Relevant experience	20	20	40	60	80	100	120
3	Initiative	20	20	40	60	80	100	120
<b>EFFORT</b>								
4	Physical	6	6	12	18	24	30	36
5	Mental	9	9	18	27	36	45	54
<b>RESPONSIBILITY</b>								
6	Towards safety to others	5	5	10	15	20	25	30
7	Towards machine and equipment	4	4	8	12	16	20	24
8	Towards material and product	6	6	12	18	24	30	36
9	Work of others	5	5	10	15	20	25	30
<b>WORKING CONDITION</b>								
10	Favourable working conditions	4	4	8	12	16	20	24
11	Unfavourable working condition(exposure to health hazards)	6	6	12	18	24	30	36

The point rating for the job of fabrication Supervisors is computed below

SKILL			Grade	Point
1	Educational background	Diploma in Mech.	4	60
2	Relevant experience	2 years	3	60
3	Initiative	Not much	2	40
EFFORT				
4	Physical	Very little	1	6
5	Mental	Average	3	27
RESPONSIBILITY				
6	Towards safety to others	Average	3	15
7	Towards machine and equipment	Little	1	4
8	Towards material and product	Average	3	18
9	Work of others	Average	3	15
WORKING CONDITION				
10	Favourable working conditions	On the shop floor	2	8
11	Unfavourable working condition(exposure to health hazards)	Nil	0	0
Total Points				247



**Scattered diagrammed showing wages vs points**

The total points for the job can be compared to other jobs for key jobs and wages rates shown by scatter gram. (Showing wages vs Points for Key Job)

### Advantages

- Since this is based on assigning point values for various factors the objectivity is more.
- It can evaluate different jobs precisely.
- It need not be revised with the change in wage rates.
- Method can be easily understood by everyone (workers, union representatives and admin).
- It is very flexible and can be used in different types of organizations.

### Disadvantages

- It is cumbersome and time consuming.
- It is expensive to operate.

# MERIT RATING

It provides the means for evaluating the performance of employees on the job. It determines the extent to which requirements of a particular job are not met by different employees.

The employees are rated on the basis of:

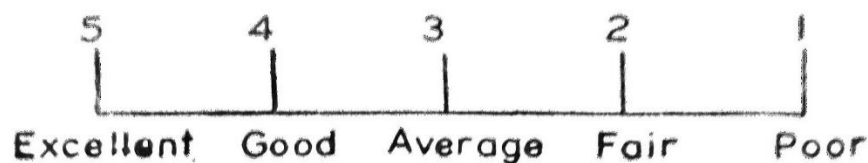
- Knowledge of job
- Ability to learn
- Ability to get work done
- Quality and dependability of work
- Initiative
- Cost consciousness
- Sociability
- Responsibility
- Cooperation
- Observance of safety
- Attendance
- Integrity etc.

## OBJECTIVES OF MERIT RATING

- 1) It helps in identifying employees for salary increase, promotion, transfers and disciplinary action.
- 2) To motivate individuals by giving a feedback on their performance levels.
- 3) Identifying training needs of individuals for development.
- 4) For getting feedback on policies regarding selection, training and placement.

## METHODS OF MERIT RATING

**A) Rating scale method** :Certain qualities are rated on a rating scale (usually a 3 point/5 point scale)



- The total points bagged by the employee provides a basis for his rating.
- The limitation of this method are obvious that any two employees getting the same rating might be quite different.

**B) Forced choice method**:A series of statements describing the individual being evaluated are given (each statement carrying a weighed score) the rate ticks the one which he thinks is relevant and then total can be made and individuals can be rated on the basis.

Various instruments are available to rate the people using this method. The purpose of this method is to make rating more objective.

**C) Critical incident method**:This technique involves the following steps:

- 1) Certain specific instances showing good or bad on the job behaviour are written.
- 2) Scale values to them are assigned depending upon their desirability for the job.
- 3) A check list is prepared defining good and bad workers.

Such a check list can be used by supervisors to rate the workers. The method reveals strength and weakness of individual workers easily.

**D) Cost accounting method:** In this method the performance is evaluated in terms of monetary returns which the organization gets from the employee.

The factors considered are:

- 1) Average value of production/ service units given in specific times.
- 2) Quality of product/ service rendered.
- 3) Cost of work spoilage attributed to him etc.

**PROBLEMS IN MERIT RATING:** Most of the merit rating methods involve judgements of some kind or other which invariably leads to some of the following:

- 1) 'Halo effect' Tendency to allow the assessment to be biased by one trait only.
- 2) The rater's own biases and ability influence the objectivity of appraisals.
- 3) Lack of sensitivity experienced by raters.
- 4) Lack of scientific training to supervisors for undertaking rating work.

# INCENTIVE

**Incentive Scheme:** The system of payments by results.

(In Railways)

(CLW Pattern Scheme 1954)

Decided in 1948

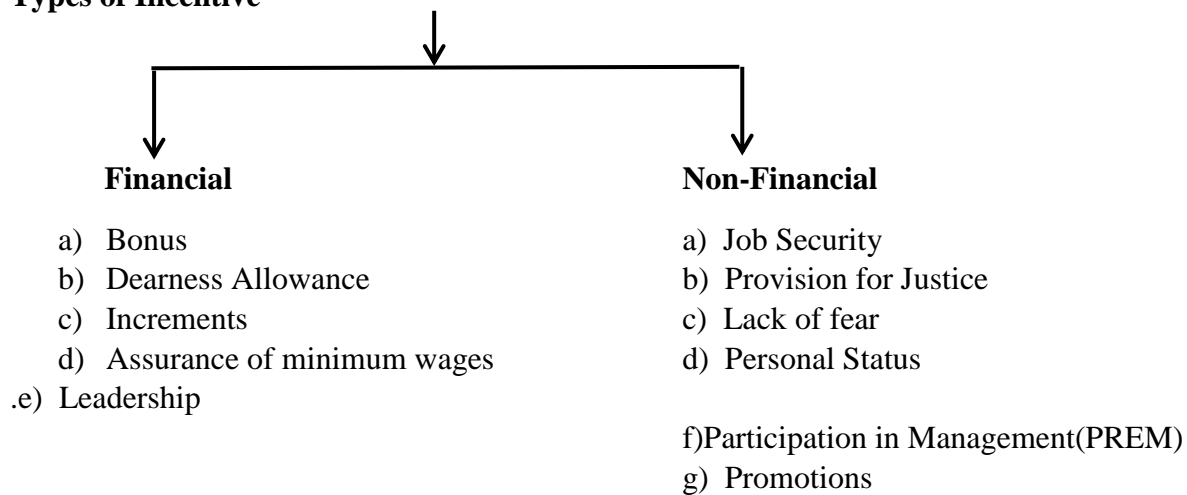
Implemented in 1958

Extended to ICF (1960)

Introduced in Railway Repair Workshops in 1958.

(1960 PCO Organized in each Workshop)

## Types of Incentive



**Introduction.-**The need to improve productivity in Railway workshops for ensuring better utilisation of man-power, machinery & Plant, and covered area was being felt even prior to Independence.

The Railway Board took a decision in 1949 to introduce some form of incentive scheme in railway workshops to afford direct financial incentive to workers who exceeded a minimum level of performance. The first formal incentive scheme was introduced in Chittaranjan Locomotive Works in December 1954.

The scheme was a considerable success and it was extended to Integral Coach Factory in 1960. The decision to introduce the incentive scheme in Railway Repair Workshops on Chittaranjan pattern was taken in 1958. The actual introduction was effected in 1960 after setting up the "Production Control Organisation" in individual railway workshops.

This incentive scheme is also known as "the system of payment by results."

## Objectives:

- Improvement in efficiency of work.
- Provide opportunities for hard workers to earn more.
- Provide better utilization of available resources.
- To facilitate higher productivity thus lowering unit cost.
- Provide for recognition of hard and consistent work.
- Guarantee a minimum wages to all workers.
- Systematic completion of work with better control.

### **Salient Features of Incentive Scheme**

- Guarantee of minimum wages to all workers under this scheme. Time is yardstick for measuring work.
- Various operations in Workshops are subjected to time study in accordance with standard practices of work measurement.
- Allowed times are so fixed that a normal ability workman may earn 33½ % bonus over his basic wages in resp. of period spent on piece work jobs.
- Allowed time includes all allowances such as fatigue, general handling, and gauging & Production bonus allowance.
- The Scheme is based on the concept that an Org. worker while working under non-Incentive conditions is assumed to be working @ rating of 60 units.
- The same worker while working under incentive conditions would be expected to improve his rating to 80 units. (i.e. 33 ½ % more) (It is expected that an Org worker would complete an operation in ¾ of allowed time).
- The time saved/lost on the allowed time in each operation is calculated separately for each worker & gain/loss cannot be carried over to the next month.
- The ceiling limit of profit is fixed @ 50% of the time taken in each operation.
- Apprentice cannot participate in the scheme.
- No provision for overtime allowance (Supervisors & EIW are paid incentive @ 80% of workers departmental efficiency).
- To calculate allowed time 200 hours are considered in a month.

### **Incentive Workers are classified as:**

- A. Direct Workers:** Workers those are engaged in work which can be assessed through time studies. (Skilled worker, grade II, and grade I etc.)
- B. Essential Direct Workers:** Those who contributed to the continuity of the work & whose services are essential but whose work cannot be assessed through time studies. Supervisors up to the rank of JE, maintenance staffs etc. are also included in this category.
- C. Indirect Workers:** Those who are not involved in production in any way like provided for cleaning, shop messenger etc. do not earn any incentive bonus. Incentive Bonus given to Supervisor on Idle. Idle time can be booked on account of the following reasons:
- (1) No power.
  - (2) Machine repair.
  - (3) Lack of material
  - (4) Lack of tools
  - (5) Waiting for work
  - (6) Crane repair
  - (7) Miscellaneous.

Idle time of direct workers		Percentage of Incentive Bonus to be debited to JE /Mistry
1.	2 % and above but less than 5 %	10%
2.	5% and above but less than 15 %	20%
3.	15% and above.	No bonus

If the data's for idle time is not available @ the time of bill, same can be adjusted in next month.

#### **JOB CARD:**

**P1 - Scroll Sheet:** Procedure of any Job.

**P2- Master Planning Card:** Copy of P1 for office record.

**P3- Assembly Specification Sheet:** For assembly of various items. (Recording of date)

**P4 – Route Card:** shows the route of manufacturing of any job & final delivery place.

**P5 – Cost Card:** Used for calculating the cost of any job.

**P6- Material Requisition Card:** Used for issue of raw material from Stores.

**P7 – Material Tag Card:** For identification of materials.

**P8-Job Card:** When a worker is assigned any job, he is issued a job card which contains work description & time. Worker has to work according to that.

**P9 – Squad Card/ Summary Card:** For lengthy job where more than 02 workers are assigned the job.

**P10 – Job Sheet:** This card is attached with P9.

**P11 – Proceeding Time Sheet for Squad work:** Filled by Time Office Clerk with actual Time consumed in job & saved time.

**P12 – Rejection Sheet:** Inspector fills the rejection sheet duly approved by AWM(P).

**P13 – Suspended Job Sheet:** For assignment of another job in between a running job.

**P14 – Resumption of Suspension Sheet:** Used to resume the suspended job card. (By JE)

**P15 – Idle Time Sheet:** Due to stoppage of job due to (failure of electricity/M&P).

Filled by JE with cause clearly mentioned & duly verified by AWM.

**P16 – Idle Time Card:** If worker is idle due to M&P, this card is filled by JE, verified by Competent Officer.

**P17 – Entrusting Job to another Worker:**

**P18 – Duty Certificate:** When Workshop employee goes on OD duty, this form is filled for his attendance.

**P19 – Request for Investigation Sheet:** Inspector fills this sheet for calculation of Actual time in completing a job.

**P20 – Alteration Time Sheet:** Planning person use P19 form to reduce/increase allowed time.

**NORMALIZING:** On completion of time study, the actual times of all the elements in the work cycle should be converted to time @ 80 rating i.e. the time which the org. worker should take to do each element when working under a correct incentive scheme. This conversion is done by following calculation.

$$\text{Normalized time} = \frac{\text{Actual time} \times \text{Observed rating}}{80 \text{ (i.e. incentive rating)}}$$

**Additional Allowances:** Following allowances are added in the normalized operational time on cumulative basis.

- a) **General Handling & Contingencies:** This includes cleaning swarf, grinding of tools, using of spanners, procuring, cutting compound etc. For this purpose an allowance of 12.5% on the operating time is given.
- b) **Gauging on machining:** 5% allowance is added to all machining operations where gauging is necessary.
- c) **Fatigue:** As it is not humanly possible for any person to work continuously with a set speed an allowance to cover Fatigue is needed. Since this varies with the types of work an allowance varying from 12 ½ to 25%.
- d) **Production Bonus:** An allowance of 33 ½ is added as production bonus.

**Example:** Let the normalized tie of all the elements as a result of number of studies (average) = 1 Hour.

**Add allowances as under.**

$$(a) \text{ Fatigue } 25\% = 1 \times 0.25 = 0.25, \text{ then add } = 1 + 0.25 = 1.25 \text{ hrs.}$$

$$(b) \text{ Contingency } 12\% = \frac{1.25 \times 12.5}{100} = 0.156 \text{ hrs.}$$

$$= 1.25 \times 0.156 = 1.406 \text{ hrs.}$$

$$(c) \text{ Bonus } 33\frac{1}{3}\% = \frac{1.406 \times 100}{3 \times 100} = 0.468 \text{ hrs.}$$

$$= 1.406 + 0.468 = 1.87 \text{ hrs.}$$

$$(d) \text{ Gauging } 5\% \text{ (Not on jobs)} = \frac{5 \times 1.87}{100} = 0.09.$$

$$= 1.87 + 0.09 = 1.96$$

The allowed time for this job will be issued as under:

Without Gauging = 1.87 hrs and with Gauging = 1.96 hrs.

In this case 75 % of the allowed time of 1.96 hrs. = 1.46 hrs. Time saved = 1.96 - 1.46 = 0.50 hrs.

This time saved is equivalent to 33 ⅓ % of the time taken which proves that the average worker will complete an operation in 75% of the allowed time when he will earn 33 ⅓ % of bonus.

**Allowed Time:** The total of the normalized time & all the allowances stated above is termed as “allowed time”.

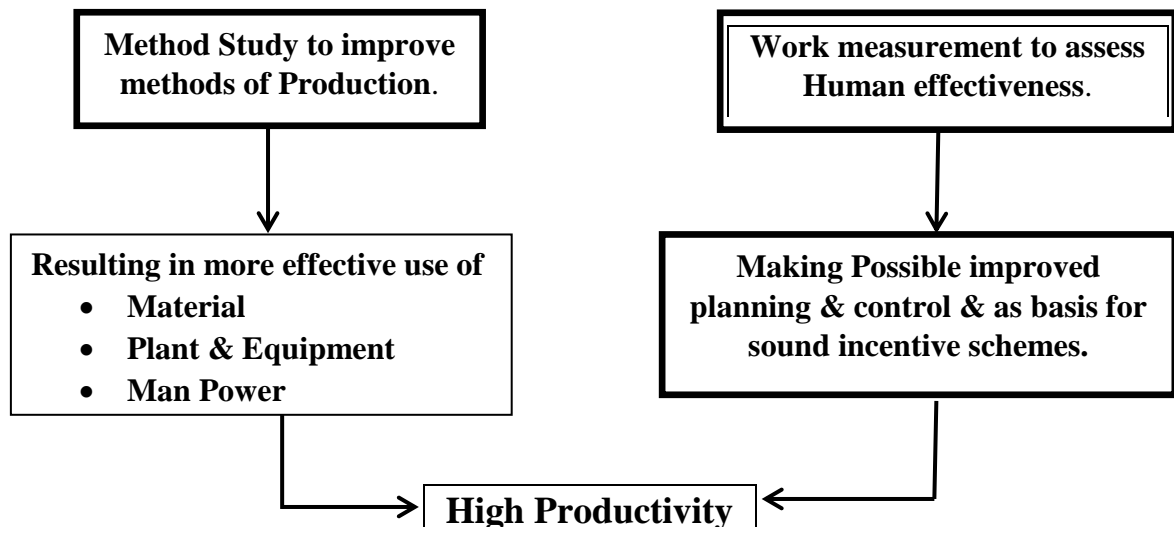
- The allowed time as issued by the rate fixing department with the approval of PE, is the time within which a worker shall complete an operation & earn bonus.
- It is expected that an average worker will complete an operation in 75% of the allowed time when he will earn 33 ⅓ % bonus.



# WORK STUDY

## INTRODUCTION:

Work Study is the study of work (human work) with the object of assisting management in optimizing available human & material resources for better productivity



**Objective:** To increase the productivity by effective utilization of available resources (Machines & Man Power).

**Productivity:** It expresses the efficiency of production in any organization.

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

Work Study helps in improvement in productivity through:-

- Most effective use of plant & equipment.
- Most effective use of human effort.
- Evaluation of human work.
- Reducing of wastage.
- Eliminating design discrepancies.
- Standardization.

Higher productivity provides opportunities for:-

1. Higher real earnings.
2. Larger supplies of goods at lower cost.
3. Better living standards.
4. Better national economy.

Productivity can be improved through following ways:

1. Savings in materials.
2. Reduction in scrap & waste.
3. Effective utilization of building/working space.
4. Optimum usage of machinery & equipment.
5. Improving inefficient methods of working.
6. Removing causes for delay.
7. Better planning of work.

## **TYPES OF WORK STUDY**

**Method Study:** It is the process of systematic recording & critical examination of the factors & resources involved in existing & proposed way of doing work.

### **Objectives:**

1. Finding better ways of doing job.
2. Elimination of unnecessary work & to reduce fatigue due to same.
3. Seeking of simpler ways of doing work.
4. Increase in profit by reducing product cost.
5. Improvement in design.

### **Method Study procedure:**

1. Finding better ways of doing job. Finding & analysing the true facts concerning the situation.
2. Critical examination of these facts.
3. Development of best possible solution under the given circumstances.

### **Steps involved in Method Study:**

1. Select - Work to be studied.
2. Record - What is taking place on the job?
3. Examine - Critically examining the facts.
4. Develop - The most practical & economic method of doing the job.
5. Install - Put the developed method in practice.
6. Maintain - Make it a standard practice by follow up checks.

**Select:** The factors to be considered while selecting a particular work for the purposes of method study are:-

- a) Technical consideration
- b) Economic aspects.
- c) Human reactions.






**Record:** Following recording technique can be chosen.

- a) Charts
  - i) Indicative process sequence.
  - ii) Using time scale (SIMO)
- b) Diagrams & Models.
- c) Photographic aids.

Charts:

- Out Line Process Chart
- Flow Process Chart
- Two handed process Chart
- Multiple activity Chart

## CHARTING SYMBOLS

S.No.	Symbol	Activity	Example
1.		Operation	<ul style="list-style-type: none"><li>•Produces: Accomplishes the work by changing the shape, size of materials/document.</li><li>•Furthers the process</li></ul>
2.		Transport	Travels or movement of workers, materials, equipment or from documents from one place to another.
3.		Storage	<ul style="list-style-type: none"><li>•Controlled storage where material, document/item is retained.</li><li>•Holds/Keeps/retains.</li></ul>
4.		Delay	<ul style="list-style-type: none"><li>•Uncontrolled storage /delay in sequence.</li><li>•Delay between consecutive operations interference.</li></ul>
5.		Inspection	<ul style="list-style-type: none"><li>•Recognised check for quality, checking accuracy / appearance.</li><li>•Checking / measuring / gauging the material/product for quantitative/qualitative/characteristics.</li></ul>

**Outline Process Chart:** In this chart material entry, operation, inspection etc. are recorded.

### Types of Flow Process Charts:

1. Man Flow Process Chart.
2. Material Flow Process Chart.
3. Equipment Flow Process Chart.

Above all, symbols are used while preparing these charts.

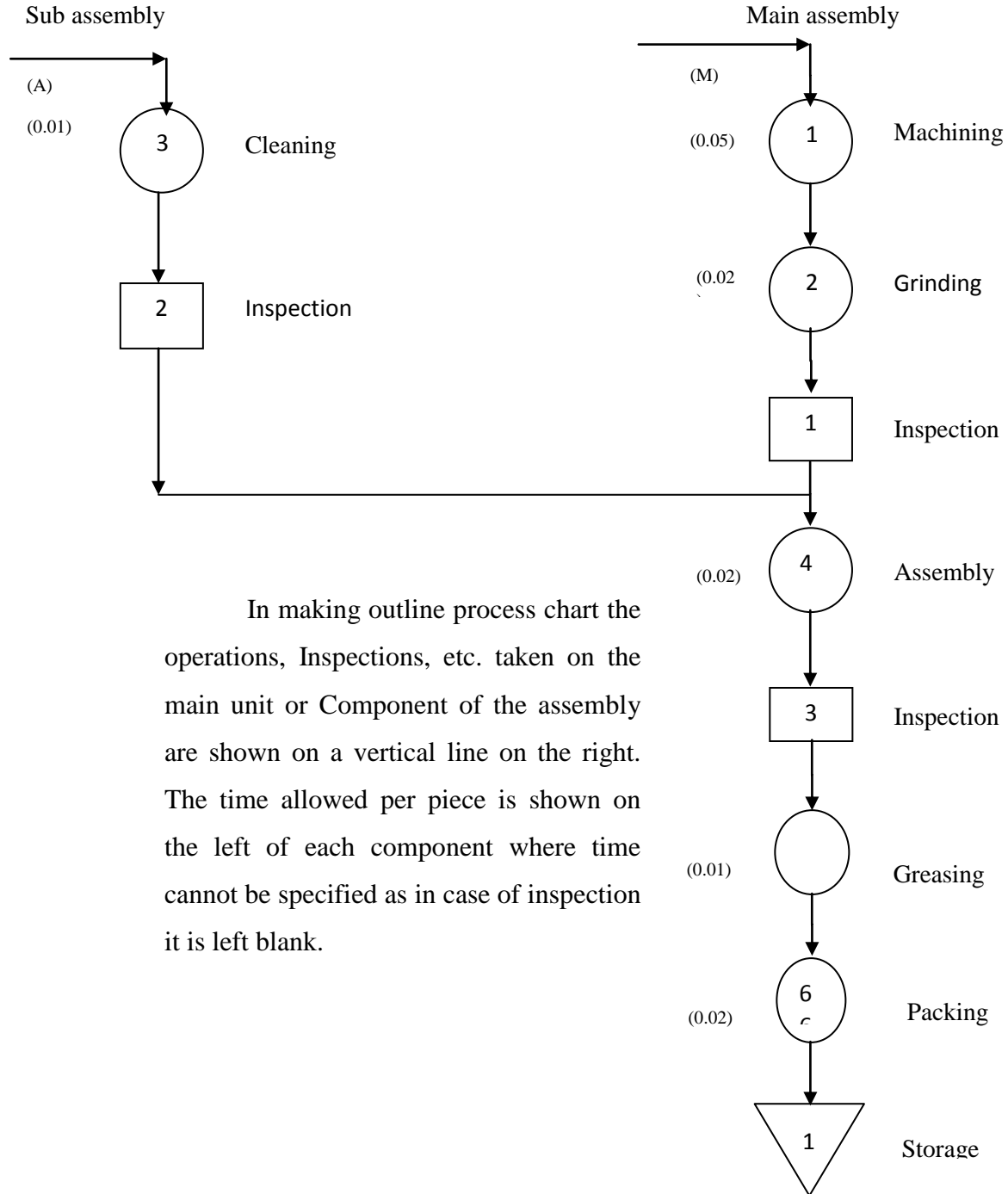
### Objectives of Flow Process Charts:

1. To visualize the complete sequence of events occurring in a process.
2. To help in examination of events in a systematic way.
3. To help in establishing the layout/improving the layout & to identify the location of various work elements.
4. Helps in establishing the basic requirement of material handling system/improvement in existing system.
5. To study various work elements & thus two methods can be compared.
6. To help analyst to select specific work element from the point of view of improvement.
7. Delays can be prevented.

## OUTLINE PROCESS CHART PISTON & PISTON PIN ASSEMBLY

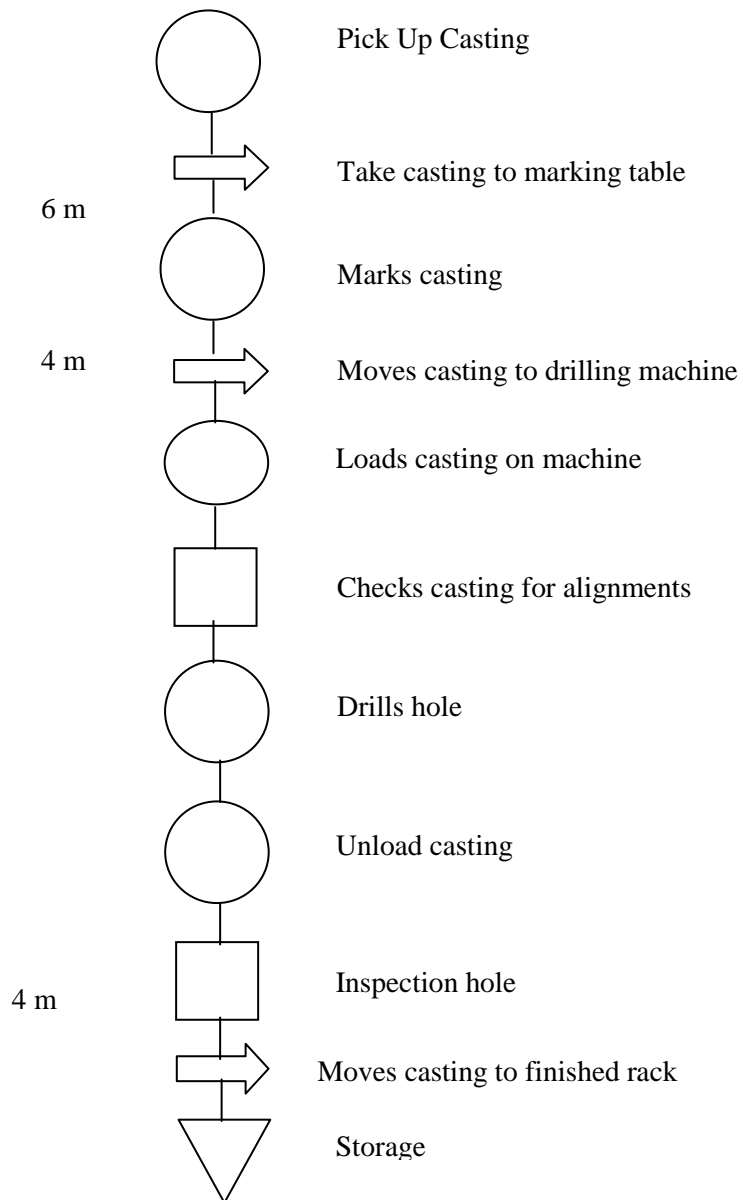
In this chart an overall view of the process is recorded where graphic representation of material entry and sequence of operations and inspections associated with the process are shown. A typical example of an outline process chart is shown below:-

### Piston and Piston pin assembly

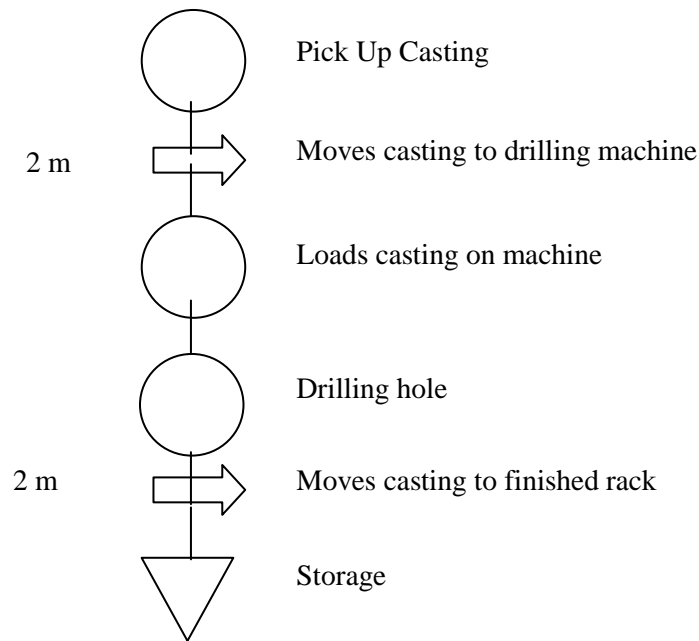


In making outline process chart the operations, Inspections, etc. taken on the main unit or Component of the assembly are shown on a vertical line on the right. The time allowed per piece is shown on the left of each component where time cannot be specified as in case of inspection it is left blank.

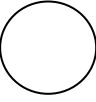



**Chart ends:** puts back casting on finished goods racks



### Proposed Method



### Summary:-

Description	Old Method	Proposed Method	Numbers	Saving	Distance
	5	3	2	7 Min	---
	2	0	2	4 Min	----
	3	2	1	----	10 Mtrs
	1	1	0	----	----


In this illustration which has been taken from an actual industrial situation, the improved method of drilling holes using a drilling jig eliminates the operations of marking, checking for alignment and inspection. It will be seen that such a simple operation with little investment on a drilling jig has resulted in enormous saving of time and led to higher productivity.

## MICRO MOTION STUDY

The Gilbreths pioneered the study of manual motions and developed basic laws of motion economy that are still relevant today. They were also responsible for the development of detailed motion picture **studies**, termed as **Micro Motion Studies**, which are extremely useful for analysing highly repetitive manual operations.

Micro motion study is used for graphical presentation of many repetitive operations of short cycle like component assembly, packaging, inspection, separation of mixed jobs, which involve quick movements of hand. In certain types of operation like pick and place objects, detailed study of such operations can be carried out.

**Therbligs:** Therbligs are diagrammatic representation of movements like search, select, hold, position, assemble, etc., having specific colors, symbols and alphabets for recording purpose.

 Search	 Use
 Find	 Disassemble
 Select	 Inspect
 Grasp	 Preposition
 Hold	 Release Load
 Transport Loaded	 Unavoidable Delay
 Transport Empty	 Avoidable Delay
 Position	 Plan
 Assemble	 Rest

Name	Abbreviations	Colour Code
Search	Sh	Black
Select	St	Light Grey
Find	F	Grey
Grasp	G	Red
Hold	H	Gold Ochre
Transport Empty	TE	Olive Green
Transport Loaded	TL	Green
Release Load	RL	Cardmine Red
Position	P	Blue
Assemble	A	Violet
Use	U	Purple
Disassemble	DA	Light Violet
Inspect	I	Burnt Ochre
Pre-position	PP	Pale blue
Rest for overcoming fatigue	R	Orange
Unavoidable Delay	UD	Yellow
Avoidable Delay	AD	Lemon Yellow
Plan	Pn	Brown

#### **Advantages of Micro motion Study:**

##### **1. Permanent Record:**

- Permits repeated study without disturbing worker.
  - Can be used for demonstration & training to others who are involved in similar activity.
2. Projecting of movie at any desired speed, pause, forward, backward is a great facility for the analyst.

#### **Limitations:**

- Very Expensive.
- In India this technique is rarely used.

#### **Memo motion Study:** Memo motion study is done for:-

- Long cycle studies.
- Study of irregular/complicated cycle.
- Study of team/gang of worker instead of one.
- In this camera takes from 50 – 100 frames/min.



S.No.	Micro motion Study
1.	Used for Study of Micro activities.
2.	More expensive
3.	Up to 1000 films/min
4.	Used very sparingly

S.No.	Memo Motion Study
1.	Used for study group work/long cycle works.
2.	Relatively less expensive
3.	Up to 100 films/min
4.	Used a great deal.

### SIMO CHART

(Simultaneous motion cycle chart) It is often based on film analysis used to record simultaneously on a common time scale the therbligs performed by different parts of the body of one/more workers.

S.No.	Left hand description	Therblig	Time	Therblig	Right hand
1.	Searching and lifting work piece.	SH, H	400		
2.			400	U	Opening the vice
3.	Clamping work piece in vice	PP	800	PP	Clamping work piece in the vice
4.			400	TL	Take the file.
5.	Do the hand filling operation.	U	2000	U	Do the hand filling Operation.
6.			400	TL	Taking the micrometer
7.	Check the dimension	I	1600	I	Check the dimension
8.			400	U	Open the vice
9.	Remove the work piece	TL	400		

**Objectives:** It is very important technique in which micro motion study is performed at a rate of 1000 films/min.

#### Examination & Development:

1. To remove unnecessary/non-productive activities.
2. Use of combined work technique.
3. Reduction in delay by changing sequence of operations.
4. To simplify the work.

#### Installing & Maintaining: It is divided into four stages:

1. To change process approved by competent authority.
2. To develop favourable environment by briefing every one before implementation of new work technique.
3. Training of Workers & Supervisors before implementation of new technique.
4. Implementation at right time.

**Maintaining:** After implementing new technique if there is problems then should be sorted out as soon as possible.

Hence, where changes/improvements are made, the new techniques should be made as standard practice.

## **Work Measurement**

Work measurement techniques determine the time taken in completion of an activity according to a given method under given job conditions by an average worker.

### **Techniques of Work Measurement:**

1. Time Study
2. Work Sampling
3. Standard Time data
4. Analytical determination
5. Ratio Delay Study
6. Activity Sampling
7. PMTS (Pre-determined motion time standard)
8. Rated activity sampling

### **Objectives of Work Measurement:**

1. To analyse the activity with the view to improve the existing methods & to minimise the human effort.
2. To establish & standardise the working conditions for an efficient operation.
3. To control man, machine & labour utilization by assessing the plant capacity.
4. To balance the assignment of man & machine.
5. To determine the standard time to be used as a basis for wage incentive payment to the direct labour.
6. To improve the plant operating efficiency & thereby improving the productivity.

### **TIME STUDY:**

Time Study is a work measurement technique for recording the times & rate of working for the elements of a specified job carried out under specified conditions & for analysing the data so as to obtain the time necessary for carrying out the job at a defined level of performance.

### **Objectives:**

1. To find out standard time for incentive bonus schemes.
2. To help in find out labour cost as a part of Production cost.
3. To find out effectiveness of various techniques for the purpose of process improvement.
4. Helps in motion study.
5. Comparative assessment of machines, equipment & working conditions.
6. Comparative study of production & efficiency of workers.

### **Advantages of Time Study:**

1. By Time Study work & time can be measured, which helps in uniform work distribution.
2. Time Study helps to decide production time.
3. Time Study helps to decide standard time & standard work rate.
4. Exact labour cost may be calculated using measured time & work distribution.
5. Based on the best and approved evidence of the work of all workers, the prudent evaluation becomes simpler.
6. Easy assessment of efficiency of group working, machines, processes & productivity.

**Limitations:**

1. Cannot be used in all activities.
2. Costlier.
3. Workers usually oppose time study.

**Time Study Equipment:**

1. Stop Watch.
2. Time Study Board.
3. Time study forms along with pencil & rubber.
4. A Calculator.
5. Measuring instruments (Measuring tape, steel rule, micrometre, tachometer etc.)

**Steps involved in Work Measurement:**

1. Breaking down of job into logical parts called elements, such that each element has a distinct beginning & end and can be easily identified.
2. Determination of basic times for each element (through records/actual time study)
3. Assessment of the rate of working so that the time can be expressed in terms of normal time.
4. Estimation of allowances, which are necessary to compensate for accumulative fatigue, personal needs or anticipated delays.
5. Collection of data for machine times.
6. Calculation of the work content (standard time)

**Rating (Performance Rating):**

Rating is the process during which time study engineer compares the performance of operator under normal observation with the observer's own concept of normal performance. (It is also referred as efficiency of workers).

$$\text{Performance Rating} = \frac{\text{Observed Performance}}{\text{Normal Performance}} \times 100$$

**Normal Worker:**

Trained worker of average ability & who in a reliable supervision without motivation, without any physical/mental stress complete the assigned work at average speed.

**Rating Factors which are within worker's control are:-**

1. Variation due to his ability.
2. Variation due to his attitude.
3. Acceptable variations in the quality of Products.

**Factors outside worker's control are:-**

1. Variation in the quality of material.
2. Change in the efficiency of equipment.
3. Change in the environmental conditions of working.
4. Variation in mental attention owing to distractions.
5. Minor change in process or conditions of operations.

**Rating Scale:** The most common scale is 0- 100 scale. On this scale 100 is referred to as standard rating.

## Allowances

**Calculation of allowance:** Allowances are added in normal time to calculate standard time.

$$\text{Standard time} = \frac{\text{Normal time} + \text{allowance}}{(\text{Actual time} \times \text{Rating factor})}$$

### TYPES OF ALLOWANCES

**Fatigue Allowance:** To compensate the fatigue during the work. (3 times in a shift of 08hrs)

**Personal Allowance:** To cater for attention to personal needs.

$$\text{Rest allowance} = \text{Fatigue allowance} + \text{Personal allowance}$$

Rest allowance is divided into two parts

**Fixed allowance:** (Constant allowance) – This is personal allowance & fatigue during that time, when worker does not perform any activity & only present at work place.

**Variable Allowance:** To cater for fatigue during the work. Different for different work.

It depends upon:

1. Usual/unusual way of standing/sitting.
2. Use of muscle power
3. Working environment (Light/heat etc.)
4. Working capacity.
5. Noise.
6. Mental Work.

$$\text{Sustained Performance time} = \text{Normal time} + \text{Rest allowance}.$$

**Delay Allowance:**

- Not given for avoidable delay.
- Given for unavoidable delaye.g. Machine breakdown, Power Cut etc.

**Special Allowance:**

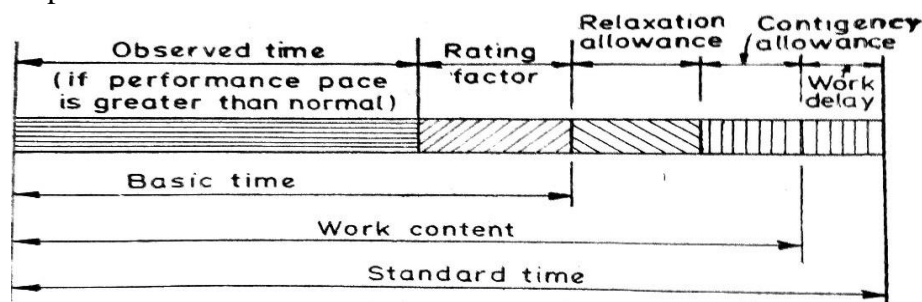
It is given to compensate for factors which are not the part of work, but important for smooth completion of work. It may be permanent/temporary.

**Contingency Allowance:**

It is a small allowance of time which may be included in Standard time to meet legitimate expected items of work/delays, the precise measurement of which is uneconomical because of their infrequent/irregular occurrence.

- It is commonly < 5%.
- Given only on recommendation of time study men.
- Eg. – Consultation with Supervisors, obtaining drawings, collecting tools, sharpening tools etc.

**Standard Time** = Normal Time + Fatigue allowance + Personal allowance + Process allowance + Special allowance.



**Policy Allowance:**

- Not come under work measurement.
- Management gives as special benefit to workers.
- Sometimes trade unions insist on certain allowances in order to inflate the performance level of workers. Generally when Incentive Schemes are in operation.

**Example:**

The Time study data on a job consisting total elemental time (observed time) = 1.47 min. If the worker's rating is 110% & 15% total allowances on normal time are to be given, find the std. time.

$$\begin{aligned}\text{Observed Time} &= 1.47 \text{ Min.} \\ \text{Rating Factor} &= 110\% \\ \\ \text{Normal time} &= \frac{1.47 \times 110}{100} = 1.617 = 1.62 \text{ Min.} \\ \text{Allowances @ 15\% on normal time} & \\ &= 1.62 \times 0.15 \\ &= 0.24 \\ \text{Standard Time} &= \text{Normal time} + \text{allowances} \\ &= 1.62 + 0.24 \\ &= 1.86 \text{ Min.}\end{aligned}$$

# WORK SAMPLING

## INTRODUCTION

- Work Sampling is a technique based on statistical direction principle.
- Random samples are taken out to find out proportion of production time & waste time.
- Work Sampling is a method of finding the percentage occurrence of a certain activity by statistical sampling & random observation.
- Work sampling involves intermittent sampling over a considerably long period. Basically it provides an estimation of the proportions of time devoted to a given particular activity over a certain period of time.

**Example:** If out of 100 observations 85 Observations are working and 15 observations are non-working then the % of working time is 85%. It indicates that in one day of 8 hour shift, Operator will be working for 408 minutes and non-working 72 minutes.

## Objectives of Work Sampling

1. To find out the actual working time & idle time (non-working time) of Workers.
2. To find out Standard time for any activity by estimating the allowances.

## Applications of Work Sampling

1. Estimation of unavoidable delay as a basis for establishing a delay. It helps to establish goals for Supervision.
2. It is very useful for analysis of non-repetitive/ irregular occurring activities, where no complete method & frequency description is available.
3. Used for time estimation in supervision, maintenance and inspection. (%age)
4. Estimation of percentage utilization of Machine tool, Cranes in heavy machine shop, fork trucks in a ware house. It will aid in economic analysis of equipment.
5. Estimation of standard time allowances to considerable accuracy.
6. Estimation of nature & extent of peak load variations n observable activity.

## METHODS OF WORK SAMPLING STUDY

### 1. Definition on stage

- a) Defining the problem.
  - Illustration of each measuring activity.
  - To get permission from concerned SSE in charge & explain the operator @ objectives of study to get his full co-operation.
- b) Find out factual Std. Error in form of percentage in previous time measurement.
- c) To explain with believable facts.
- d) Estimate the reduction in % delay.

### 2. Design stage

- a) No. of Observations.
- b) Design of Observation Sheet.
- c) No. of day & shift for study.
- d) No. of necessary observations, giving instructions after selection.
- e) To decide time & route for observation by observer.

### 3. Observation & Conclusion

- a) To observe and mark them.
- b) To summarize data at the end of day.

- c) To verify the accuracy observations at the end of study.
- d) Conclude after preparing final report & give recommendations if necessary.

### Advantages

1. There is no need for observation for a long period.
2. Single observer can carry out work sampling of multiple machines & operation, hence less difficulty & fatigue to observer.
3. Work sampling study can be stopped at any time & it does not affect the results.
4. Operator also prefers it instead of long term study.
5. Less time consuming.

### Disadvantages:

1. In group work study it is difficult to find out individual differences.
2. On Observer's presence Operators change the working methods, so result of work sampling has become less important.
3. Not economical for work sampling of widely spread machines & operators.
4. Time study is easy to understand to management & workers as compared with work sampling.
5. Sometimes observers do not follow the basic principles of work sampling, leading to unsatisfactory results.

**Example 1:** A work study is carried out in a machine shop for a period of 10 hours. Out of 250 observations, 40 observations are non-productive. Ratio of physical to machine work is 2: 1 & Performance rating considered is 1: 1. Total 600 nos. are produced during study period. Find out the standard time / piece if personal allowances are 10%.

$$\begin{aligned}
 \text{Idle time} &= \frac{\text{No. of inactive observations}}{\text{Total No. of observations}} \\
 &= \frac{40}{250} = 0.16 = 16\% \\
 \text{Inactive time of total hours.} &= 16\% \times 10 \text{ hours} = 1.6 \text{ hours} \\
 \text{➤ Productive Time} &= 10 - 1.6 \\
 &= 8.4 \text{ hours} = 504 \text{ min.} \\
 \text{Ratio of Physical/machine hours} &= 2.1 \\
 \text{Physical Time} &= \frac{2}{3} \times 504 = 336 \text{ min} \\
 \text{Machine Time} &= \frac{1}{3} \times 504 = 168 \text{ min} \\
 \text{Performance Rating} &= 1.1 \\
 \text{Normal time} &= \text{Machine time} + \text{Rating} \times \text{physical time.} \\
 &= 168 + (1.1 \times 336) = 537.6 \text{ min.} \\
 \text{➤ Standard time (for 600 pcs)} &= \text{Normal Time} + \text{Allowances} \\
 &= 537.6 + (10 \times 537.6) \times 10\% \\
 &= 591.36 \text{ min} \\
 \text{➤ Standard time/pc} &= \frac{591.36}{600} \\
 &= 0.986 \text{ min.} \\
 \text{➤ Standard time/pc} &= 0.986 \text{ min.}
 \end{aligned}$$

**Example 2:** A work sampling study on a long cycle operation records the following data:-

- Total time of study = 5 days
- Total No. of observations = 800
- Observations of Productive activity = 580
- Manually controlled elements = 190
- Total acceptable units produced = 2400 pcs.
- Average rating index = 12%
- Observations of unavoidable delay = 70

Calculate the standard time assuming the process was within control. No overtime was recorded & 8 hours shift/day was adopted.'

$$\text{Total time of study} = 5 \times 8 = 40 \text{ hours}$$

$$\text{Productive time \%} = \frac{580}{800} \times 100 = 72.5\%$$

$$\begin{aligned} \text{Productive time} &= 40 \times 0.725 \text{ hours} \\ \text{(for 2400 pcs)} &= 40 \times 0.725 \times 60 \text{ min} \\ &= 1728 \text{ min.} \end{aligned}$$

$$\text{Productive time /pc} = \frac{1728}{2400} = 0.72 \text{ min}$$

$$\text{Manually controlled elements} = 190 \text{ observations}$$

$$\begin{aligned} \text{Manually controlled time} &= \frac{190}{580} \times 0.72 \\ &= 0.235 \text{ min/pc} \end{aligned}$$

$$\text{Machine controlled time} = 0.72 - 0.235 = 0.485 \text{ min/pc}$$

$$\begin{aligned} \text{Basic time/unit (Normal)} &= (0.235 \times 1.2) + 0.485 \\ &= 0.767 \text{ min.} \end{aligned}$$

$$\text{Unavoidable delay time} = \frac{70}{800} \times 100 = 8.75\%$$

$$\begin{aligned} \text{➤ Allowances to be provided:} &= \frac{0.0875}{0.767} \times 100 \\ &= 11.34 = 12\% \end{aligned}$$

$$\text{➤ Standard time} = 0.767 + (0.12 \times 0.767) = 0.86 \text{ min.}$$

$$\text{Standard time} = 0.86 \text{ min.}$$



# JOB COSTING

It would ordinarily have been simple matter to analyse the total expenses of repairs and maintenance under the detailed Heads of Accounts under which the expenses of a railway are required to be shown in its Financial Accounts.

**Shop Costs:**The 'Shop' is the ultimate unit of workshop organisation (where it is not further divided into 'sections'). It is, therefore, the unit also for purposes of the initial accounts. The work carried out in each shop (or section of each shop) has to be accounted for initially before the accounts of the 'workshop' can be compiled. Even if the work on the same job has to be carried out in more than one shop, the expenditure thereon will stand analysed, shop by shop, for the reason that the initial accounts of each shop are maintained separately.

**Prime Cost:**The expenditure in a workshop stands analysed not only by shops (and divisions, such as the Yard, the Laboratory, etc.) but also by 'wages' and 'materials', as the initial records of these are maintained separately, hence it is total of material and labour cost only.

**Workshop Costing:** The extent to which expenditure incurred in a workshop (i.e. cost of jobs) should be further analysed depends very largely on the information that is required by the authorities controlling such expenditure. This will have to be determined by practical considerations and the actual needs of each railway administration.

- (1) Recording expenditure under the detailed and sub-detailed heads of accounts classification, whether Capital or Revenue.
- (2) identifying expenditure that has to be separately recorded for the reason, say, that it has to be billed for and recovered, whether recovery has to be made from another department or division of the railway or from outsiders

**The object of job costing system in Railway Workshops is:**

- (a) To compare the cost of similar articles manufactured from time to time in the workshops and finding out reasons for variations in cost and
- (b) To compare the cost of articles manufactured in the workshops with those manufactured on other railways or with the market price of similar articles.

It should meet the needs of the purpose in view if job costing is done to the extent indicated below:

- i) Cost of manufacture of each of the workshop manufactured stock items should be worked out in the first instance and the rates thus determined should be notified, and be done only once a year.
- ii) The wastages and defective costs are required to be allocated to the jobs concerned instead to on cost, and to take remedial steps to reduce this wasteful expenditure.
- iii) Every time the method of manufacture is changed, the cost of manufactures of the stock item involved should be worked out to arrive at the new rate under the changed method.

## Essential Features of Job Costing System

The essential features of job costing system is the estimating in advance of the time that should be spent and the materials that should be used and a systematic comparison of the results of actual performance with such estimates.

The institution of any detailed system of costing is, thus, contingent upon the initial fixation by suitably trained technical staff of standards of time and of materials for the items of work to be undertaken and for the prompt comparison of the standards.

### **Cost Sheet**

The cost should cover the whole field of record of productive activity. The entire progress of a production order in the way of consumption of material and the charging of labour and of on cost should be reflected on the cost sheet. The cost of each job should be ascertained through the cost sheet which should be opened by the production control at the time of issuing production documents. The cost sheet should be supplied to the job costing section by the WAO's Office.

### **Cost Cards**

- (i) From the information available in the Route Card and the Cost Sheet particulars of the manufacture of articles should be posted by the Job Costing Section in the Cost Cards. This card would enable the Workshop authorities to see if there is any improvement as successive orders pass through the Workshops. These cards should be used for fixing and revising prices of the Workshop manufactured articles.
- (ii) The variations in cost or man-hours per unit from work order to work order, if significant, should be immediately investigated with reference to the operations laid down in the Route Cards, vouchers for labour and material charges, man-hours and average rates for labour, the quantity, specifications and rates for material utilised, etc. If the investigators do not reveal the causes for variations which can be considered as reasonable, satisfactory clarification should be obtained from the Officer in-charge of workshops for further scrutiny.

**Final Costing:** As soon as a sub-work order has been completed and its completion has been notified by the production department by submitting the connected completed route card to the job costing section, and after the job costing section has satisfied itself that the expenditure booked on the cost sheet as well as the credit received from the stores department have been completely and correctly accounted for, the total expenditure incurred from the commencement of the job till its completion should be totalled up and the unit cost of manufacture worked out by dividing the total expenditure as appearing on the cost sheet by the number of articles delivered to the Stores Department for which the credit has been afforded by that department to the workshops. The unit rates so worked out should be approved of by the Workshop Accounts Officer and posted in the relevant cost card maintained in the job costing section.

### **Elements of Costing System in Workshop**

- i) Material Cost
- ii) Labour Cost
- iii) On Cost List of

**ON COSTS:** Expenditure which cannot be charged direct to the cost of articles manufactured or works done are termed "On Cost".

### **Types of On Cost:**

- 1. Proformaon Cost
- 2. General on Cost
- 3. Shop on cost

**1. PROFORMA ON COST:** Includes all on cost which is not included in cost of work done in Railway Workshops but which would be included in commercial costing. Items included in Performa On Cost are:

- (a) Share of expense for the Rolling Stock management in Zonal Headquarters Office and Establishment in Offices of Mechanical Department of Workshops.
- (b) General Superintendence of all Service Departments such as Financial, Personnel and Material Management etc. including Officers and Office Establishment of Security Department and Medical Services.
- (c) Contribution to Provident Fund in respect of non-pensionable staff.
- (d) Gratuity and Special contribution to PF in respect of non-pensionable staff.
- (e) Pension liabilities – Pensionable Staff.
- (f) Payment under Workmen's Compensation Act.
- (g) Depreciation of plant and buildings.
- (h) Repairs of M&P other than those charged to cost of manufacture and repairs to buildings, Yards etc.
- (i) Cost of materials used and labour expended on the maintenance of Electric lighting throughout the Workshop.

**2. GENERAL ON COST:** General On Cost denotes cost other than Proforma on cost, which is incurred in common with all the Shops or Departments in Workshop.

- a) Leave, sick, hurt and Holiday pay paid to workshop employees whose wages are not charged to shops i.e. Yard Establishments.
- b) Wages, Overtime etc. of staff such as Workshop apprentices, Tool Keepers not attached to Shops.
- c) Freight charges that cannot be directly allocated to jobs.
- d) Electrical power which is not possible to allocate to shops.
- e) Hydraulic and Pneumatic power and gas that cannot be allocated to shops.
- f) Working expenses of Crane and shunting engines, lorries, auto trucks, traversers etc. provided for use of the workshop when not chargeable to Shop on cost.
- g) Water charges that cannot be allocated to shops.
- g) Experimental work when not appropriately charged directly to job itself.
- h) Yard Lighting.

**3. SHOP ON COST:** Shop on cost includes all on cost incurred within accounting unit, such as a shop or a department or a section. Items included are:

- a) Wages, Overtime etc. of Workshop apprentices attached to shops, Charge men, Mistry's, unskilled labour except when employed as direct labour tally men, store men, Oilers, Shop Clerks etc.
- b) Shop scrap (credit) i.e. Scrap which cannot be allocated to job.
- c) Defective and spoilt work in the case of experimental work.
- d) Power charges whether electric, pneumatic, gas or Hydraulic which can be directly allocated to shops.
- e) Consumable stores for shop use viz oil for lubrication, sponge, emery / glass cloth, soap etc.
- f) Small tools for shop use.

## WORKSHOP MANUFACTURING SUSPENSE (WMS)

**INTRODUCTION:** WMC account is prepared every month by a Workshop account unit for expenditure made and work done by workshop for home/foreign railway division, board & private parties.

**Purpose of WMS Account:**

1. To calculate unit cost for each activity.
2. To control excess withdrawal of store.
3. To control irregular/wrong booking.
4. To increase out turn to know maximum utilization of labour (proper utilization of labour with regard to their out turn.
5. To minimize expenditure according to budget allotted.

**Contents of WMS A/c:**

It has two parts:-

- (i) Debit side
- (ii) Credit side

S.No.	Debit Side	S.No.	Credit Side
1.	Opening Expenditure	1.	Work done for capital (E.g. Manufacturing of ew coaches, wagon engines).
2.	Labour Salary	2.	Work done for development land.
3.	Material drawn from stores	3.	Work done for OLWR (Open line works revenue)
4.	Material purchased directly from market	4.	Mfg. Shop out turn
5.	Miscellaneous item (material taken from other division/Workshop)	5.	Repair Shop (Wagon) out turn
6.	Freight Charges	6.	Repair Shop (Carriage) out turn
7.	Shunting Charges	7.	Repair Shop (Engine) out turn
8.	Shop adjustment (Transfer of item on shop to another shop)	8.	Repair Shop (M&P) out turn
9.	Coal for Foundry purpose	9.	Work done for other Workshop
10.	Electric Charges	10.	Work done for RSP of Rly. Board
11.	Other Charges	11.	Return Store (DS-8) all types of serviceable & non-serviceable (DS-8)
		12.	Release material e.g. used empty tanks, used old rail lines etc.
		13.	Closing balance.

**Closing balance:** indicates that quantum of works pending. This closing balance will be the opening balance of next month.

**Review of WMS Balance:**

The purpose of review is to find out irregular booking, WIP, on cost rates, debits, awaiting of acceptance. This review is essential when there is  $\pm 3\%$  variation in debit & credit side.

**Review of Balance under "Workshop Manufacture Suspense Account"**

- 1) The balance under the 'Workshop Manufacture Suspense Account' should be reviewed monthly to see
- 2) that all the items are current and have been undertaken after the issue of a proper work order, under the sanction of a competent authority;
- 3) that the details consist of nothing else except labour, material and work on cost charges expended on unfinished jobs or completed jobs awaiting adjustment;
- 4) that there are no credit items in the detail of balance and if there are any such items, they are noted for immediate adjustment;
- 5) that in the case of jobs undertaken for outsiders, a sufficient deposit has been made, where such a deposit is required by rules, and on the first appearance of a work it is seen that an estimate is on record, containing the extra percentage charges required under the rules, and accepted by the party ordering the work; and
- 6) that there are no inefficient balances and the periodical adjustments in respect of "overcharges and undercharges" under the on cost, manufacture and repair work orders are carried out regularly as laid down in Chapter X and the outstanding are not allowed to accumulate.

The results of the review should be put up to the Financial Adviser and Chief Accounts Officer at least once a year.

# CORROSION REPAIR

**CAUSES OF CORROSION:** Corrosion due to cell formation as

- Galvanic cell
- Differential stress cell
- Differential temperature cell
- Differential concentration cell
- Differential aeration cell

Metals are readily attacked by most of the suitable chemicals; non-metals are attacked rarely of varying conditions.

**Classification of corrosion:** Corrosion can be classified on

Temperature basis

- High temperature corrosion
- Low temperature corrosion

Condition basis

- Wet corrosion or electrochemical
- Dry corrosion or oxidation corrosion

**Nomenclature of corrosion**

A)	Rust	Oxidation product of iron and steel
B)	Oxides	Oxidation product of non-ferrous metals
C)	Ageing	Oxidation product of non-metal
D)	Decay	Oxidation loss of weld deposition metals due to absorbed hydrogen or atmospheric oxygen.

Manifestation	Characteristics	Prevention
Uniform corrosion or General corrosion	More or less uniform attacks over the entire exposed surface with minimum variation in the depth of change	Protective coating and cathodic protection where natural resistance is marginal.
Bimetal corrosion or Galvanic corrosion.	When two or more dissimilar metals are electrically coupled and placed in electrolyte and results from the existence of a potential difference between the metals which cause a flow of current between them.	It can be minimized by keeping the anode large or avoided by electrically insulating the members of the couple with dielectric spacers provided this insulation is complete.

<b>Manifestation</b>	<b>Characteristics</b>	<b>Prevention</b>
Crevice corrosion	A type of corrosive attack associated with the confined spaces or crevices formed by certain mechanical configuration such as tapped joint, gasket interfaces and tubular sleeves. Both approximating surfaces need not be metal. It is also associated with the shielded areas caused by setting out of particular solids on a surface or under marine growth. It occurs in surface coated components due to oxygen deficiency. Excess of hydrogen ion stimulates corrosion.	<ol style="list-style-type: none"> <li>1. Eliminate crevice</li> <li>2. Design change</li> <li>3. Using non-permeable gasket or seals</li> <li>4. Materials with poor wet ability</li> <li>5. Periodic removal of sediments and debris from tank bottoms</li> <li>6. Insuring adequate adhesion of coating</li> </ol>
Pitting corrosion	A form of localised corrosion in which the attack is confined to numerous small cavities on the metal surface a true pit has a length/depth ratio equal or greater than one.	Correct selection of material with adequate pitting resistance.
Cavitation corrosion	It superficially resembles pitting, but the surface appears considerably rougher and has many closely spaced pits which are neat and orderly arrayed. It is due to plastic deformation and honey combing.	<ol style="list-style-type: none"> <li>1. Design change</li> <li>2. Cathodic protection</li> <li>3. Rubber and elastomeric material</li> <li>4. Proper choice of materials such as stainless steel in place of brass.</li> </ol>
Selective leaching or selective dissolution	When one element is preferentially dissolved from a solid solution, i.e. when a phase is selectively attacked in an alloy. Example dezincification of brass alloys.	It is intentional corrosion for property modification.
Erosion corrosion	It exemplified by an increase in the corrosion rate caused by relative motion between the surface and the environment. Surface exhibits severe weight loss and many scooped out, rounded areas appear like sculptured impression.	<ol style="list-style-type: none"> <li>1. Design modification</li> <li>2. More resistance materials</li> </ol>

Manifestation	Characteristics	Prevention
Fretting corrosion	Two metals in contact under load and having small relationship between them exhibit intense attack at the area of contact and is usually revealed by reddening of lube oil between them.	Proper colour matching
Inter-granular corrosion	Due to in homogeneous condition at the grain boundaries. This may be due to segregation mechanism or inter-granular precipitation.	Careful control of heat treating measures.
Exfoliation corrosion or lamellar corrosion	Is a special form of inter-granular attack, which primarily affects aluminium and magnesium alloys? It is directional and is characterized by attack of the elongated grain on a plane parallel to the rolled or extruded surface. This result in characteristic delimitation or stratification of the surface structure.	<ol style="list-style-type: none"> <li>1. Extended ageing cycles for all alloys</li> <li>2. Organic and sprayed metal coating</li> <li>3. Promoting equi-axed grain structure on the surface.</li> </ol>

#### **Causes of corrosion in Indian Railway coaches:**

- Water seepage through the flooring to the top of trough floor
- Leakage of water through lavatory flooring.
- Missing of commode chute and drain pipe.
- Defective water pipe fittings.
- Absence of surface preparation during replacement of commode and drain pipe.
- Habits of flushing the flooring with the water jet for cleaning.
- The conditions of air trapped in between trough floor and flooring due to climate change.
- Striking of flying ballast when the train is running.
- Design of window seal leaves the gap between the side panel to allow the rain water and water during washing of the coaches flow through the panel and to drain out at the bottom.
- Blockage of drain water by accumulated dust on top of trough floor and other areas of under-frame and panels.
- Improper welding of PVC flooring.
- Improper welding of sole bar box.
- Spreading of water from side filling.



**Areas prone to high rate of corrosion in passenger coaches are:**

- Trough floor: areas adjacent to lavatory, doorway, and luggage compartment in SLR and kitchen area of pantry car.
- Head stock: areas inner and outer head stock, stiffener, protection tube area, support tube area etc.
- Side wall bottom: area below lavatory and between body side pillars.
- Body pillars: bottom portion of pillar near doorway and lavatory area.
- Cross bearers: joint between sole bar and cross bearers.
- Body side door: bottom of door due to accumulation of dust.
- Battery boxes: corrosion due to acid action.
- Roof: ventilator and area around it.

**Vulnerable members and locations:**

- Tubular frame below lavatories and trough floor in bays adjoining lavatories in all types of coaches and under the luggage compartments of SLRs and parcel vans and kitchen area of pantry cars.
- Sole-bar, body pillars, turn-under in the bays under and adjoining lavatories in all types of coaches and in addition kitchen area of pantry cars.
- Sole bars, turn under and pillars above lifting pads.
- Sole bars and pillars behind the sliding door pockets of SLR's & parcel vans.
- Sole bars, pillars and turn-under at door corners.
- Side panels below window in non ac coaches and lower portion of body pillars.

**General instructions for inspection in workshops**

When coaches are received in the workshops for repairs they should be thoroughly inspected for locating corroded members by competent and trained staffs; that have thorough knowledge of integral coaches. Adequate instruments such as spiked hammer, torch etc should be provided to enable proper and through inspection being carried out. It is seen that these coaches generally require their first corrosion repair after 9-11 years. It is therefore essential to visually inspect all coaches irrespective of their age and if signs of corrosion are noticed, they should be subjected to through detailed inspection. For those post 1977 built coaches which are provided with sealed window sills and closed turn unders mandatory opening of side wall sheet for inspection is not necessary this should be done on condition basis only.

**Procedure for inspection of 'vulnerable' members and locations in workshops**

1. **Trough floor:** On coaches built since 1982, the trough floor and the under-frame members are provided with FRP tissue sandwiched in between layers of bituminous emulsion at the trough floor and these locations should be examined visually from below for signs of corrosion supplemented by tapping with a spiked hammer. If signs of corrosion are noticed, the trough floor should be replaced as described in Annexure IV. In case of replacement of trough floor below luggage compartment of SLRs, LR's etc and bays adjacent to the lavatories under doorways as also in case the whole trough floor in a coach has been replaced, FRP tissue should be laid over trough floor.

## **2. Sole bars, body pillars and turn under**

**Turn under with elongated holes:** The sole bars, body pillars and turn under in the bays under and adjoining lavatories should be examined visually from the below the coach and through the elongated holes in the turn under after removing accumulated dirt and cleaning the inside surfaces. A torch light may be used to facilitate inspection. The inside of sole bar above the trough floor, however, cannot be visually inspected. If incidence of corrosion is noticed in the bottom half of the sole bar, the through floor should be cut to a width of 300 mm and requisite length for examining the inside top half. If heavy corrosion is noticed, the side wall should be cut to a height of 500 mm from the bottom of the turn under covering sufficient length and all the exposed parts, after scraping and cleaning should then be examined to determine the extent of corrosion.

**Turn under without elongated holes:** coaches without elongated holes in the turn under, should be visually examined, supplemented by tapping with spiked hammer on the bottom of the turn under as well the lower half of the sole bar, from inside, if corrosion is suspected, a 100 mm dia hole in the bottom of turn under in the suspected area should be cut without damaging the pillar, for examining the inside. If signs of corrosion are noticed, sidewall up to height of 500 mm bottom same manner as described of turn under should be cut for thorough examination.

- 3. Sole bar, turn under and pillars above the lifting pads:** The above members should be examined visually. If signs of corrosion are noticed, the side wall sheet above the lifting pads should be cut to a height of 500 mm above the turn under and to length of half a metre on either side of the lifting pads and the structural members scraped cleaned and examined minutely to ascertain the extent of corrosion.
- 4. Head stock:** The inner head stock, the outer head stock and the stiffening immediately behind the buffers including stiffening tubes and the junction of sole bar at the head stock should be visually examined for incidence of corrosion. After removing the buffer assembly, the head stock should be carefully examined as corrosion has been primarily noticed at this location.
- 5. Pillars behind the sliding door pockets of SLRs & Parcel vans:** The pockets for sliding doors should be opened and the accumulated dust dislodged and thoroughly cleaned. If on visual examination, signs of corrosion are noticed the side wall sheet should be cut to a height of 500 mm above the turn under and to a distance of one meter on either side of the sliding door corners and the pillars thoroughly examined. The trough floor to a width of 300 mm from sole bar should also be removed and the sole bar thoroughly examined to ascertain the extent of corrosion.
- 6. Sole bars, pillars at door corners:** These members should be examined visually in the same manner. If corrosion is noticed, the turn under to a width of half a metre from the door corner should be cut and the accumulated dust dislodged. The structural members should be thoroughly scraped, cleaned and examined carefully to assess the extent of corrosion.

## **Procedure for inspection of ‘not so vulnerable’ members and location in workshops**

- 1. Trough floor:** The entire area of trough floor should be visually examined thoroughly from below, supplemented by tapping with a spiked hammer for signs of corrosion. In case corrosion is noticed, the affected and surrounding areas should be thoroughly scraped, cleaned and minutely inspected to assess the extent of corrosion.

**2. Sole bars, body pillars, turn under at location other than the vulnerable areas:**

**Turn under with elongated holes:** Visible portion of sole bars through the elongated holes and from the bottom of the under-frame should be examined. To facilitate inspection, the accumulated dust in the turn under should be dislodged through the elongated holes and structural members scraped to the extent possible. If corrosion is noticed, side wall side wall sheets in the area where the corrosion has been observed should be cut to a height of 500 mm from the bottom of turn under covering sufficient length for thorough examination and to facilitate subsequent attention.

**Turn under without elongate holes** - Coaches without elongated holes in the turn under should be visually examined, supplemented by tapping with a spiked hammer on the bottom of the turn under as well as the lower half of the sole bar from inside. If corrosion is suspected, a 100 mm dia hole in the suspected area should be cut without damaging the pillar, for examining the inside. If signs of corrosion are noticed, side wall up to a length of 500 mm from bottom of turn under should be cut for through examination.

- 3. End wall stanchions and end wall sheets:** The end stanchions should be inspected for corrosion by opening the interior panelling. If signs of corrosion are noticed, the end wall sheet may also be cut to the extent of corroded portion marked for attention.
- 4. Body side doors** - the interior of the body side door should be carefully inspected after removing the panelling.
- 5. Lavatory partition walls** - visible portions of the partition pillars at its junction with the floor should be examined for incidence of corrosion. If corrosion is noticed the flooring around the area should be removed for thorough examination.
- 6. Seat pillars and partition walls:** Square\round tubes at the junction of the floor should be visually examined for corrosion. If signs of corrosion are noticed, the flooring around the area should be removed for more detailed examination.
- 7. Side wall sheets** -Entire side wall should be visually examined for signs of corrosion.
- 8. Water tank ceiling construction-** This should be visually examined for signs of corrosion by removing the lavatory ceiling.
- 9. Vestibule Hoods:** The vestibule hood should be visually examined for signs of corrosion all round its joint with the end wall and any cracks on the hood particularly at corners under the vestibule suspension bracket.
- 10. Battery box frames:** The battery box frame should be visually examined for signs of corrosion.
- 11. Check list:** After completion of inspection of the entire coach shell, including members/Components, the members affected by corrosion should be distinctly marked to indicate the entire area affected by corrosion requiring repairs by replacement/modification, as the case may be. Appropriate items in the check list (RDSO Sketch Nos.760832 to76036) should be filled in, showing details of the members to be attended to for corrosion repairs.
- 12. Inspection at Sick lines:** With systematic inspection and repairs of these coaches for corrosion in the Railway workshops, it should be possible to ensure that coaches having extensive corrosion are not in service. When considered necessary, Railways may also organise inspection at primary coach maintenance depots to identify coaches with heavy corrosion for dispatched to Railway workshops.

## Corrosion repairs

### Material & treatment of components

It is essential to use low alloy high tensile corten type steel sheets and plates to IRS-M41-1974 for repairs of integral coaches. The thickness of steel sheets/plates to be used shall be as under:

S. No.	Description of components	Thickness of steel sheets & plates IRSM 41-Gr. I
1	Inner head stock- centre plate	10 mm
	Inner head stock- beam web plate	8 mm
2	Outer head stock	8 mm
3	Sole bar	5 mm
4	End wall stanchions cross bears above & below trough floor	4 mm
5	Turn under With elongated holes	4 mm
	Turn under Without elongated holes	2 mm
6	Floor side moulding	2 mm
7	Through floor body side pillars body side and end wall panels waist rail and light rail	2 mm
8	Roof sheet	1.6 mm

- All body shell replacement components less than 5 mm thickness used for corrosion repairs should be hot phosphate and applied with protective paints. Cold phosphate should be done body wall side panel areas where welding has been carried out on hot phosphate components.

Zinc rich primer should be used where spot welding is done. Components of 5 mm or more thickness should be grit blasted and immediately followed by application of red oxide zinc chromate primer.

- Welding electrodes and paints should be of the prescribed quality conforming to the relevant IS/ IRS specification. Where the corrosion noticed is of a very minor nature and has just started, there is no need to renew parts. The paint and rust should be thoroughly cleaned to reach the bare metal and the surface treated with two coats of primer. In addition under frame members should be given four coats of bituminous solution.
- Design improvements / modifications: Several design improvements/ modifications for eliminating/minimising corrosion have been issued by the RDSO/ICF from time to time. Brief details of these together with the action to be taken by the railways are given below:
- FRP tissue sandwiched between layers of bitumen

Since 1982 FRP tissue sandwiched between bituminous coats has been laid on trough floor, sidewall and body pillars up to waist rail height and the entire under frame as shown in RDSO sketch –91163.

On these post 1982 coaches, whenever corrosion repair is carried out on portion laid with FRP tissue, patch repair of the FRP tissue should also be done to the extent to which the original lining is removed for repairs to the corresponding parts.

- Trough floor: 13 mm dia. holes provided in the valleys of through floor for drainage of condensation were increased to 19 mm so as to allow quicker drainage. This modification may be incorporated in all coaches, if not already done, when ever trough floor is laid with FRP tissue, these holes should be pierced through.
- Stainless steel trough floor: use of austenitic stainless steel in place of corten type steel to IRSM-41 has been made in parcel vans, SLRs and pantry cars, where corrosion may become prominent due to carriage of perishables and where there is possibility of seepage of water to a large extent. Earlier ICF had turned out some SCN coaches also with austenitic stainless steel trough floor. Coaches provided with austenitic stainless steel trough floor should be repaired with equivalent material using special type of low heat input type electrodes. Now a decision has been taken to provide SS trough floor in all types of coaches through RSP.
- Sealing of window sills: To prevent seepage of water through the gap between the side wall and window sill, a modified arrangement as per RDSO sketch - 76014 has been introduced on all coaches which are being turned out by ICF from 1975 onwards. This modification has not eliminated the seepage of water and problem still persists. Further design modification is required to mitigate the problem.
- Lavatory pan with longer neck: The neck of the lavatory pan have been increased by 100 mm as shown in Drg.No.C/LF 1880 AIL-3 to avoid drain water from spilling over trough floor and connected members. It is essential that at the time of corrosion repairs in the lavatory area or renewal of magnesium oxy-chloride flooring composition in the lavatories, pans having shorter neck may be used only after welding an additional piece to the neck to bring it in conformity with Drg.No.C/LF-1880 AIL-3.
- Stainless steel inlay in lavatory instead of decolite flooring: In order to eliminate any leakage of water or chloride through the floor leading to corrosion of the underframe, ICF has started providing a stainless steel inlay in the lavatory with conventional lavatory pan duly supported as per Drg.No. ICF/SK-1-0-666 Alt. d. The stainless inlay is made from 1.6 mm steel sheet and has a skirting up to waist rail. The inlay is provided with a 20 mm slope for smooth flow of water towards lavatory pan. 2 mm thick PVC overlay is posted over the inlay. Some railways have tried the floor of polyurethane layer in the lavatories to prevent the leakage of water.
- PVC flooring over plywood: Till 1988, the standard flooring in lower class coaches has been timber floor boards with magnesium oxy-chloride and in first class coaches, corridor, doorways, gangways and lavatories were provided with timber floor boards with magnesium oxy-chloride flooring and compartment portion was provided with PVC pasted over plywood with timber flooring. In case of AC coaches, doorways, gangways and lavatories were provided with timber floor boards with magnesium oxy-chloride flooring and compartment portion was provided with PVC pasted over plywood and timber flooring board till 1982. In order to prevent seepage of water through decolite flooring to eliminate release of chloride ion leading to corrosion, flooring consisting of PVC over plywood has been introduced in all areas except lavatory since 1983 in AC coaches and since 1989 in second class coaches. Now the plywood has been replaced

with compreg board. Aluminium chequered sheets are laid over the PVC near door bays and lavatory bays to prevent the seepage of water.

- Battery box frames: To prevent corrosion battery box frames are now being hot galvanised before riveting aluminium sheets. This should be ensured during POH. In addition, to prevent acid from batteries coming in contact with battery boxes, the battery boxes should be fitted with FRP trays to ICF drg.No.GS-7-1-018 during POH. If and when battery boxes need renewal, the new battery box should be to Drg.No.GS-7-1-015.
- **PROCEDURE FOR CORROSION REPAIRS:** Detailed procedure for corrosion repairs of various members are given in the following table:-

S. No.	Part	Annexure	Reference Drawing
1	Stiffening of Sole bar	I	SK.78101, 78102, 78103 & 78096
2	Sole bar	II	SK.76018, 76019
3	Side wall sheet, body pillars & turn under	III	SK.76020, 76014
4	Trough Floor	IV	SK.76021 to 76024
5	Head stock	V	SK.76026
6	End walls and End wall stanchions	VI	SK.76027
7	Roof sheet around ventilators	VII	SK.76028, 91167
8	Body side doors	VIII	SK.76029
9	Seat pillars and partition walls	IX	SK.76030
10	Longitudinal partition walls in 1 class coaches	X	SK.76031
11	Procedure for lying of fibre glass tissue on coach shells	XI	SK.91163

- Wherever a portion of the sole bar is to be replaced during corrosion repair, the bottom portion of side wall pillars at this location should also simultaneously be replaced.
- Corrosion repairs are required to be carried out to the best standard of workmanship. Trained and experienced welders should be deputed for carrying out welding under careful supervision of qualified welding supervisors. Suitable arrangement should be made for dry storage of electrodes. Approved class B-2 electrodes suitable for vertical and overhead welding should only be used for corrosion repairs. Reference may be made in this connection to the approved brands of electrodes issued by RDSO. Procedure detailed in 'Code of Practice for painting of all metal coaches' should be followed for cleaning and painting of surfaces, which are attended to during corrosion repairs. Effective supervision and inspection should be introduced at all important stages of corrosion repairs.

### **Corrosion repair of sole bar**

At locations other than the lifting pads and bolster (Refer RDSO Sketch- 76018)

1. Support the coach body on bolster.
2. Support the coach body near the sole bar portion under replacement through the window opening on wooden struts.
3. Provide additional wooden supports on either side of the sole bar to be cut.
4. Cut off the side wall sheets and turn under to a height of 500 mm covering length of approximately 200 mm on either side of the sole bar to be replaced.
5. Cut off the trough floor, cross bearers and body side pillars at the locations where the sole bar portion is to be renewed. Ensure that cross bearers are not damaged.
6. Cut off the sole bar and grind the edges and prepare for a 'V' Butt joint.
7. Prepare a new sole bar and grind piece of the requisite length with edges suitable for a 'V' Butt joint.
8. Tack welds the new sole bar piece at both ends.
9. Check and ensure straightness of the sole bar and overall alignment.
10. Tack welds cross bearers, if any, to the new sole bar piece.
11. Weld both ends of the sole bar.
12. Weld cross bearers, support piece and trough floor.
13. Weld new body pillar part, sidewall sheet and turn under. All supporting components also require replacement whenever a part of sole bar is replaced for corrosion.

#### **Note:**

- If sole bar of length more than 2400 mm requires replacement, the same should be done in lengths not exceeding 2400 mm at each stage.
- If sole bars are to be replaced on both sides, the joints must be staggered and both ends should not be attended to simultaneously.
- If the sole bar at head stock location requires renewal, the sole bar to a distance of 300mm towards body bolster from the inner head stock should also be replaced.
- If the coach under repair has its under-frame and body pillars up to waist rail level pasted with FRP tissue, the portion of the FRP tissue damaged during corrosion repairs should be pasted with FRP tissue afresh.

Corrosion repairs of side wall sheets, body pillars & turn under (Refer RDSO Sketch – 76020 alt 1 & 76014)

#### **Renewal of sidewall sheets**

1. Support coach body at body bolsters.
2. Cut the sidewall sheet requiring replacement and grind the burnt edges.
3. Prepare a new side wall sheet with 5 mm dia. holes at appropriate locations for plug welding, to the side wall pillars when required and tack weld the same on all four sides.
4. Check the sidewall for straightness and ensure overall alignment.
5. Weld the side wall sheets on all four sides and plug weld the same to body side pillars, if the inside panelling and flooring have not been removed for any other purpose. In case the inside panelling and trough floor have been removed for some other purpose, side wall sheets may be welded with the body pillars from inside and plug welding avoided.
6. Grind flush the welded joints on all the four sides to obtain a smooth exterior finish.
7. In case pillars are renewed, FRP tissue to be re-laid.

### **Renewal of Body Pillars**

1. Support the coach body on the body bolsters.
2. Remove the inside panels, flooring and floor side mouldings to gain access to the body pillars.
3. Cut off the turn under and side wall sheet and sufficient height so as to fully expose the corroded body pillars.
4. Cut off alternate body pillars on the same side to a height of approximately 430 mm or 525 mm as the need may be exercising care to ensure that the sole bar is not damaged. Prepare the edge of pillar for 'V' butt-welding.
5. Clean the surface of the sole bar thoroughly of rust etc.
6. Tack welds the new body pillar part to the pillar and sole bar.
7. Check and ensure straightness and alignment of the body pillars.
8. Full weld the body pillar part to the pillar and sole bar.
9. Cut off the remaining body pillars and attend to them in like manner as indicated above.
10. Replace the body sidewall sheet as indicated above.
11. Clean and paint the inner surface of the replaced sidewall and body pillars.
12. Replace floor side moulding and relay flooring.
13. Replace inside panel.

### **Renewal of Turn Under**

1. Support coach body on the bolsters.
2. Cut off side wall sheet also to a height of 500 mm to the required length.
3. Clean the surface of the sole bar thoroughly of rust etc. to the bare metal and ensure there is no corrosion on the sole bar.
4. Prepare a new turn-under to the length required with edges prepared for a 'V' Butt joint and tack weld the same to the body pillars and bottom of the sole bar.
5. Check the turn under for straightness.
6. Weld intermittently the body pillars to the turn under.
7. Replace the sidewall sheets.

#### **Note:**

- Whenever longer length of side wall sheet or turn under is replaced the skin should be properly tensioned by spot heating before giving anti-corrosive treatment.
- The new turn under part should be compatible with the existing turn under on the coach viz.: -
  - a) For a coach with 5 mm thick turn under with elongated holes, the new part should also be of 5 mm thickness with elongated holes.
  - b) For a coach with 2 mm thick turn under, the new part should be of 2 mm thickness without holes and all other dimensions.

But let us remember the following:

- Stainless steel is stainless
- It is not the most corrosion-resistant material
- It is not specific alloy

Stainless steel is the generic name for a series more than thirty different alloys containing from 11.5% to 30% chromium and 0 to 22% nickel together with other alloy conditions.



Stainless steels have wide spread application in resisting corrosion, but they do not resist all corrosive. In fact under certain conditions such as chloride-containing mediums, stressed structure; stainless steels are less resistant than ordinary structural steel. Stainless steels are more susceptible to localised corrosion such as inter-granular corrosion, stress cracking and pitting attack than ordinary structural Steel.

### **Conclusions**

- Corrosion can be mitigated by avoiding perfunctory Welding, ameliorating surface preparation, and modification techniques, carrying out more corrosion prevention trials, deploying aluminium instead of mild steel and stainless steel, implementing advance corrosion technology through research and development. Chromic acid can be employed rather than using sulphuric acid in anodizing.
- Use of stainless steel is restricted due to
  - Financial implication
  - Inadequate manufacturers of stainless steel in India.
- Silica hybrid coatings can be taken up as a trial measure. Thus corrosion can be minimised through judicious selection of materials and through proper practices and maintenance. Although salt spray test gives a simulated environment.

# PAINTING

## GENERAL

After the coach body is fully repaired and the flooring work completed, it should be swept and cleaned of all dust, shavings, etc., before the coach is placed in the Paint shop for painting and polishing. The condition of the paint on the inside and outside surfaces should be examined to decide whether the old paint should be removed to the bare metal. Usually, extensive corrosion repair work necessitates removal of old paint to bare metal and complete repainting of the coach. If the condition of the paint so warrants or at every 5th POH of a coach, the paint should be completely removed to the bare metal and the coach repainted as per paint schedule 'A'. If the general condition of the paint is good, follow paint schedule 'C'. These paint schedules cover the exterior painting of coaches with synthetic enamel paint system. RDSO Sketch No: CSC- 1723 gives the exterior colour scheme of the coaches (Sketch no. CSC - 1723 has been made into two parts)

## PAINT SCHEDULE 'A'

- The entire surface should be applied with a suitable paint remover and the old paint scraped off. Thereafter, the coach surface shall be swabbed with petroleum hydrocarbon solvent to IS: 1745 to remove all traces of paint remover.
- After the surface dries up completely, it should be sand papered to make it slightly rough and a coat of red oxide zinc chromate primer to IS 2074 -92 to a DFT of 25 microns minimum should be applied by spray/brush immediately. Where facilities exist, the entire coach body should be sand blasted and the primer coat of red oxide zinc chromate should be applied by spray/brush immediately thereafter.
- After allowing adequate drying time for primer, the entire coach should be applied with the first coat of brushing filler to IS 110-83 by spray/brush to a DFT of 30 micron minimum.
  - (i) After hard drying of filler, apply the first coat of knifing stopper putty to IS: 5083-88 followed by spot putty application and wet rubbing.
  - (ii) After ensuring drying of water, apply necessary putty to get a uniform surface followed by wet rubbing.
  - (iii) After drying of water, apply second coat of filler to IS: 110-83 to a DFT of 30 microns minimum.
- The dry surface should be wet rubbed down with bone cuttle and silicon carbide water proof paper grade 120 and 220. It should then be allowed to dry.
- After ensuring that there is no trace of water on the surface, a coat of under coating to IS 8662-93 should be sprayed or applied by brush to a DFT of 25 microns minimum.
- The entire surface should again be rubbed down smooth with silicon carbide water proof paper grade 320 and after drying, a coat of enamel finishing to IS 8662-93 should be applied to a DFT of 20 microns minimum.
- After the first coat of finish enamel has dried completely, it should again be flattened with silicon carbide waterproof paper grade 400 and apply a second coat of synthetic finish enamel to IS 8662-93 to a DFT of 20 microns minimum.
- The door handles, if not chrome plated, should be painted with golden yellow to IS 8662-93. The footsteps, roof, etc., should be painted as per prescribed colour scheme.

- Standard lettering, as specified, should be done with golden yellow to IS8662-93. Similarly, all standard schedule charts, signs, etc., should be stencilled/ painted as prescribed.
- Finally, the window glasses, etc., should be cleaned well and all paint marks removed. Any damage to the paint should be touched up before the coach is turned out after POH.

### **PAINT SCHEDULE `C'**

- The portions where paint has flaked or is damaged should be scraped off of all the loose and damaged paint. The coach should then be washed thoroughly with soap and water and allowed to dry. Then a coat of red oxide zinc chromate primer to IS 2074-92 should be applied by brush at the places where metal surface is visible.
- After the primer dries up completely, it should be puttied and a coat of under -coating to IS 8662-93 should be applied at these portions.
- The complete coach shall thereafter be painted in the manner described in paragraphs 1202g to 1202k above.

### **INTERIOR PAINTING**

- Newly built coaches with laminated plastic panels require painting only on the steel mouldings. The mouldings should be cleaned in every POH and repainted with one coat of synthetic enamel to IS: 133-93 of appropriate colour. Sketch 90068 gives the interior colour scheme of coaches.
- If the condition of the paint on the mouldings has deteriorated or become thick, the complete paint should be removed by the paint remover. The moulding should then be washed thoroughly, allowed to dry and repainted with one coat Red-oxide zinc chromate primer to IS:2074 -92 followed by synthetic enamel to IS 133 -93 of appropriate colour.
- Aluminium window frames should not be painted, but should be thoroughly cleaned of all stains in position. If they are very dirty, they should be removed and cleaned with oxalic acid. FRP windows should be painted with polyurethane paints to RDSO specification no. M&C/ PCN/100/ 96 (Chapter IV).
- Laminated panels should be polished with silicon paste or similar suitable polish to restore luster and also to provide a protective coating.
- Coaches other than those fitted with laminated plastic panels should be cleaned with soap solution or suitable detergent and thereafter cleaned thoroughly with wet cloth so that all head stains, oily marks, etc., are completely removed. Then a single coat or, if required, a double coat of synthetic enamel to IS: 133 -93 should be applied by brush/spray.
- In case where the old paint has become thick due to repeated painting or where the paint has deteriorated or cracked, the wooden panel should be removed and replaced or reused after completely removing the old paint and repainting it.

### **PAINTING OF PARTS**

- The laminated plastic seats or moulded seats of synthetic materials require no painting. They should only be thoroughly cleaned with soap solution or suitable detergent.
- In case of seats made of wooden battens, the battens which have been replaced should be sand papered smooth and a coat of filler should be applied. Then, entire surface including old painted surface should be sand papered smooth and the seats should be repainted with a coat of enamel finishing of the prescribed colour to IS 133-93.

## MARKING OF COACHES TOGETHER WITH EXTERIOR

All lettering on coaches should be according to the sizes prescribed in the marking diagrams for the type of coach to which they pertain (refer RDSO drawing number CSC-970). Anti-telescopic coach end walls should be marked with yellow stripes as sketch no. 77356. Each should be marked with following details:

- a) Coach No., Owning Railway, and Mechanical code if any.
- b) Name of base station for primary maintenance.
- c) No. of compartments and seating capacity as prescribed for the type of coach.
- d) Notices for use of alarm signal, safety precautions etc. if separate notice plates for these are not placed.
- e) Transportation code applicable to the type of coach as per appendix 'B' of IRCA Conference Rule part IV.
- f) Carrying capacity of OCV's to the nearest tonnes up to one decimal place above actual capacity.
- g) Tare weights as recorded at the time of initial building or subsequent major modifications.
- h) A woman's figure head painted on illuminated panel of compartments permanently reserved for ladies.
- i) Return date showing the month and year in which the coach is required to be returned to the owning railway workshop for POH.
- j) A block as shown below to be stencilled on the left side of end panel

Schedules	Station code	Date
Disinfected		
Alarm chain periodical examination done		
Dash pot oil checked		
Side bearer oil level checked		
Overhead tank flushed		
Intermediate lifting		
DA valve examined		

**Note: Size of letters should be 10 mm and the block 350x250mm.**

- k) The capacity of the dynamo and light/fan loads to be stencilled on the end panels.
- l) The following legends should be stencilled on battery box covers to enable stencilling of necessary particulars against each.
  - Make
  - Type
  - Specific gravity (at full charge)
  - Corrected to temperature
  - Cell watered on
  - Cell examined on

## TOOLS AND PLANTS FOR PAINTING

### Types of brushes

- i. Round brushes nos. 1/0, 2/0, 3/0 & 4/0.
- ii. Flat brushes nos. 25 mm, 38 mm, 50 mm, 63 mm, 75 mm, 100 mm
- iii. Lettering brushes:
  - Flat brushes nos. 1 to 12
  - Round brushes nos. 1 to 12
- iv. Stencil brushes
- v. Cleaning brushes for LP sheets with soda ash

### Putty knife

- i. Pallet knife
- ii. Falling knife
- iii. Haking knife

### Scrapers

- i. Shave tukes
- ii. Triangular
- iii. Semi circular
- iv. Diagonal

### Abrasive papers

- i. Silicon carbide water proof paper grade nos. 120, 220, 320 & 400.

### Safety apparels

- i. Goggles
- ii. Helmet
- iii. Gum boots

### Painting spray gun with air compressor plant for painting.

### A SCHEDULE (NINE DAYS)

1 <sup>st</sup> Day	Remove old paint
2 <sup>nd</sup> Day	One coat of Red Oxide Zinc chromate primer.
3 <sup>rd</sup> Day	One coat of brush filler followed by spot putty to fill up holes/ dents where required.
4 <sup>th</sup> Day	Filler second coat (including spot putty where necessary)
5 <sup>th</sup> Day	Rub down with silicon carbide water proof paper Gr. 120 220
6 <sup>th</sup> Day	One coat of under coat
7 <sup>th</sup> Day	Flat with silicon Carbide water proof Paper Gr. 320. One coat of enamel finishing.
8 <sup>th</sup> Day	Flat with silicon Carbide water proof Paper Gr. 400 and apply a second coat of synthetic enamel finishing.
9 <sup>th</sup> Day	Lettering with Golden yellow and misc. work (cleaning window glasses etc.)

## POH PAINTING PROCEDURE "C" SCHEDULE

1 <sup>st</sup> Day	Cleaning with soap solution or any other cleaning solution and wash thoroughly with water touch up damaged portion with primer recommended under A schedule.
2 <sup>nd</sup> Day	Spot putty if necessary and one coat of under coat.
3 <sup>rd</sup> Day	Flat with silicon carbide water proof paper Gr. 120 & 220, and apply one coat of finishing enamel.
4 <sup>th</sup> Day	Flat with silicon carbide water proof Gr. 400 and apply a second coat of synthetic enamel finishing.
5 <sup>th</sup> Day	Lettering with golden yellow and miscellaneous work.

### SURFACE PREPARATION

Surface preparation is defined as the process of removing deleterious contaminants from the substrate to be coated with paints or metallic coatings or any other anti-corrosive protective system.

The word deleterious contaminants mean those contaminants whose presence on the substrate is undesirable or harmful for the performance of any anti corrosive system. They include dirt, dust, oil, grease, rust, mill scale, presence of ionic species viz. Chloride and sulphate ions, presence of heat treatment salts etc.

#### Objective of Surface Preparation

- To ensure a uniform substrate which is as close as possible to the theoretical model?
- To ensure complete removal of deleterious contaminants.
- To increase the surface area so that more reactive sites are available.
- To remove water soluble salts.

#### Effects of deleterious contaminants

Dirt and dust – affects adhesion

Oil and grease – affects adhesion, abrasion and hardness

Rust and mill scale – affects bonding leading to premature coating failure

Chloride and sulphate ions – being strong de-passivators

They hinder the passivation process provided by the inhibitive ions in the primer leading to under film deterioration of the substrate.

### CAMBERING

Cambering of coaches under frame is the process of forming a negative deflection of the under frame structure at the time of body shell assembly to nullify the effect of the actual deflection under loading condition of the coach while on rail.

#### Dimension of Cambering of Coaches

Type	End	Centre
ICF	6.0 mm	12.0 mm
EMU	12.0 mm	25.0 mm

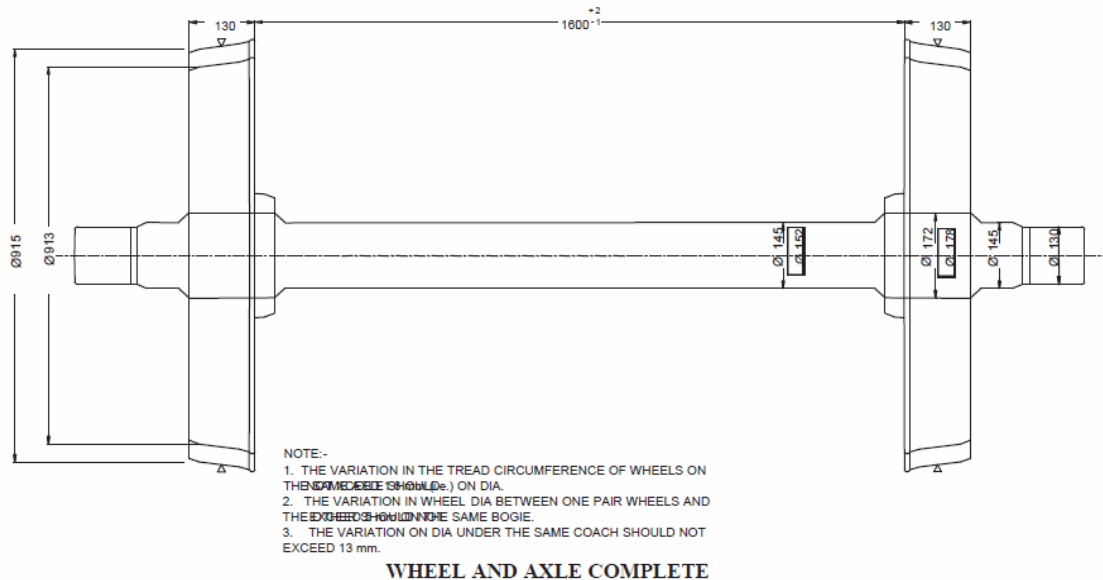
Possible methods of cambering of coaches

1. Thread method
2. Water level method
3. Rail level method
4. Optical method
5. Surface level method

# ROLLING GEAR (WHEEL AND AXLE)

## INTRODUCTION

The movement of rolling stock on the track is possible only with the help of wheels. The complete wheel set is shown in the figure with the assembly components. These assembly components are described in detail in the following



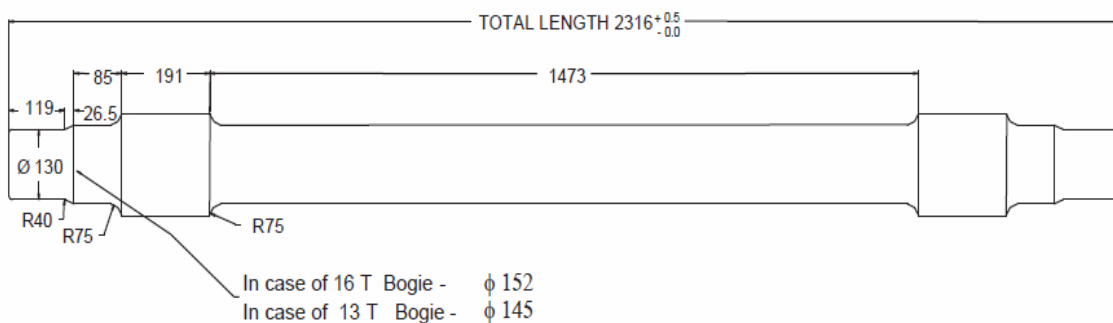
## Components of a wheel set

A wheel set is an assembly mainly of two components:

- Wheel discs(solid) on both sides of the axle
- An axle to hold these wheel discs in position

**Wheel disc solid:** The solid wheel disc is manufactured as per IRS Specification No. R - 19/ 93 Pt. II and drawing No. W/WL/1660.

**Axles:** An axle is a component of a wheel set to hold the wheel discs in position. The axle box is also mounted on the journal of the axle.



**Note:** - Rly. Bd. vide their letter no. 98/RSF/874/1/SAIL (P) dt. 8/10/1998 has decided that only 16.25t axles would be used for wheel set under 13t bogie also for new wheel sets. The existing wheel set in service may however continue till they are required to be changed.

**Axle boxes with roller bearings:** The axle boxes used on ICF coaches are with under mentioned spherical roller bearings.

**Spherical Roller Bearings No. 22326/C3:** These roller bearings are with 130 mm parallel bore on the inner ring and are directly shrunk on the axle journals.

## Maintenance Procedure in the Workshop

### Pre-inspection of wheels in the workshop

During pre-inspection of incoming wheels, the wheel-set is inspected for assessing the condition of the components. Following measurements are carried out on all the wheels, received in shop for repairs.

#### a) Measurement of a wheel gauge (distance between two wheels flanges on the same axle)

The distance between two wheel flanges on the same axle should be 1600 mm + 2/-1mm. This measurement should be taken at three locations apart with the help of an adjustable pi gauge. If wheel gauge is not within permissible limits, then the wheel disc(s) have to be pressed off and then pressed on.

#### b) Measurement of Wheel Diameter (Tread Diameter)/Wheel Flanges

The wheel diameter is measured with the help of a trammel gauge with a least count of 0.5mm. on both sides. However, a gauge with a least count of 0.1 mm. is recommended as the measurement of a diameter would be more accurate with this gauge.

The difference in tread diameter of the two wheels on the same axle should not exceed 0.5mm after tyre turning. There is no 'In service' limit for this variation and rejection shall be decided by tyre defect gauge

During last shop issue the wheel is to be turned to RDSO SK-91146. The profile is to be turned 1 mm above the condemning limit groove. The maximum diameter and last shop issue size for ICF type wheels are given below:

Type of wheel	New	Minimum shop issue
ICF solid	915	834

#### c) Inspection of wheel disc as per CMI-K003

The wheel should be inspected for rejectable defects in accordance with RDSO's instructions CMI-K003

#### d) Inspection of Wheel Flanges

The flanges on both sides of a wheel set are checked with the help of a profile gauge to measure the height and thickness of flanges. Accurate measurement of flange height and flange thickness is not possible with the profile gauge. It is, therefore, recommended to use a wheel profile gauge with which accurate measurement of flange height and flange thickness to the extent of 0.1 mm can be made.

After recording the diameters of wheels and wheel flange measurements, the wheel set is nominated for necessary repairs.

#### e) Inspection of axle

Axle journals should be thoroughly cleaned for inspection to detect flaws, pitting, ovality, taper, ridges etc. Each axle should be ultrasonically tested for detecting internal flaws and defects as per the code of procedure issued by RDSO. Axles found flawed, pitted or with under size journals should be replaced.

##### On ICF axle journal

- A taper should not exceed 0.015 /0.010 mm.
- Out of roundness (ovality) must not exceed 0.015 / 0.020 mm



## **CATEGORY OF WHEELS**

The wheels are categorised after pre-inspection as below:

### **Normal repair wheels**

If all the components are within the acceptable range of limits, these are taken directly for wheel profiling and servicing of roller bearings.

### **Wheels requiring replacement of an axle (RA wheels)**

The wheel is taken for replacement of an axle for the following:

- A bent axle,
- Dimensional deviations on a journal/ wheel seat
- Axle having groove marks in the middle due to rubbing of a pull rod,
- Dents, corrosion, pitting marks on the surface of the axle
- Axles found flawed in the ultrasonic flaw detection test

### **Wheels requiring replacement of solid discs (RD wheels)**

The wheel is taken for replacement of discs if found

- It is not possible to turn the wheel to the last shop issue size
- There is a reject able defect as per CMI-K003.

## **REPAIR PROCEDURES FOR DIFFERENT CATEGORIES OF WHEELS**

Detailed procedure for carrying out repairs to different categories of wheel sets are described below:

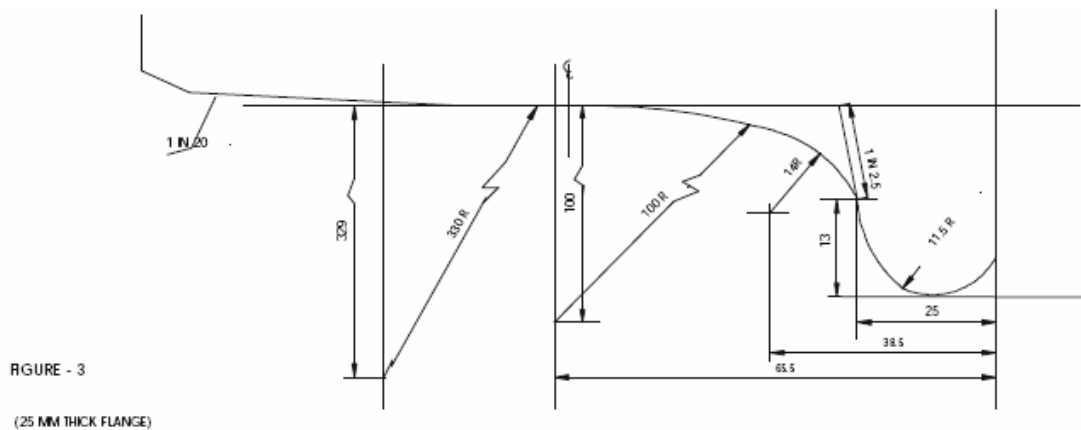
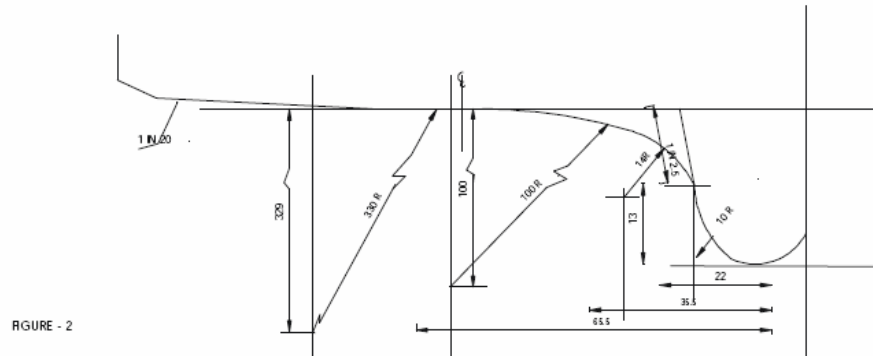
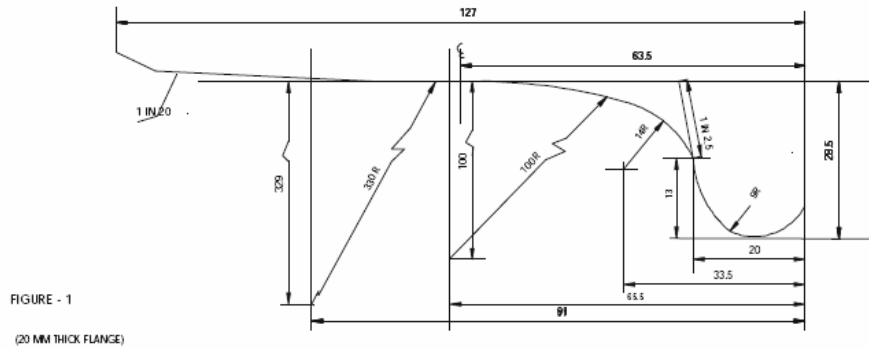
### **Normal Repair of Wheel sets**

Normal repair wheels are of two categories.

- a) With roller bearings mounted
- b) With roller bearings removed

### **The activities involved in Normal Repair Wheels are as follows:**

- Pre-inspection of incoming wheels.
- Drop axle boxes, clean and inspect axle boxes. If required, repair them.
- Carry out Ultrasonic Flaw detection test of axle.
- If required, dismount roller bearings from journals. (In any case dismount roller bearings in alternate POH)
- If the wheels are sent for re-profiling without dismounting roller bearings from the journals, special protective covers should be fitted on the bearings on either side of a wheel to avoid entry of chips / dust or damage to the bearing during machining.
- Machine wheel profiles to the prescribed dimensions. The wheel tread should be checked and machined to the worn wheel profile and machining standard N11 to IS: 3073.
- Clean roller bearing and assemble components in position, if not dismounted.
- Inspect roller bearing and assembly in position.
- Check radial clearance and confirm it to be within permissible limits.
- Pack fresh grease
- Mount cleaned and inspected axle boxes.
- Fit front cover with new sealing ring.



1. FIG. 3 SHOULD BE THE LAST INTERMEDIATE WHEEL PROFILE FOR THE WHEELS MEANT FOR THE COACHES TO RUN AT MAX. PKMPH AND ABOVE P2. ALL THE THREE INTERMEDIATE WORN WHEEL PROFILE (FIG. 1, 2 & 3) CAN BE USED FOR THE WHEELS FOR OTHER TYPES OF COACHES.

DEVELOPED BY:		INTERMEDIATE WORN WHEEL PROFILE FOR COACHING STOCK
SUPERSEDES:		
SCALE		
1:1	PART 9/92	
B.G. RDSO[C]		SKETCH-92082

## RA (Replacement of Axles) Wheels

The activities involved in replacement of an axle are as follows:

- **Pressing off a rejected axle from a wheel:** The wheel is taken on the wheel press for separating the rejected axle from the wheels.
- **Machining of new axles:** New axles should be machined to the correct drawing dimensions. Journal, journal fillets and shoulders should be finished smooth, concentric and without ridges, burrs or chatter marks.

- **Inspection of machined axles Dimensional checks :** A machined axle should be inspected for dimensional accuracy with the help of a micrometer with least count of 0.01 mm. Journal diameters should be measured at three points along the length of journals both on the vertical and horizontal axis. The ovality and taper must not exceed the limits prescribed in the drawing.
- **Surface finish checks :** Surface finish of the axle on journals, wheel seat and middle portions should be checked with the help of a surface finish tester and the prescribed limits are as below:

Axle Portions	Prescribed (RA) value for surface finish in microns
Journal Portion	0.8
Wheel Seat Portion	1.6
Middle Portion	3.2

- **Machining of serviceable wheel disc:** The serviceable wheel discs are re bored on the vertical boring machine. Care should be taken that the finished bore is straight, concentric to the tread of the wheel and has a smooth surface free from ridges, scores and chatter marks. A radius of 2.5 mm is provided on the hub to facilitate mounting. It must be made after the finishing cut.
- **Inspection of re-bored wheel disc**  
The re-bored wheel disc should be inspected with the help of an inside micro-meter to ensure consistent results. Each wheel bore must be checked at not less than three points in its length and on the different diameters at each of these points to ensure roundness and absence of tapers. The variation for any of these measurements must not exceed 0.05 mm.  
  
If any taper does exist, the small diameter must be outside ends of the hub (a reverse taper is not allowed). The surface finish of the bore should be within the permissible limits.
- **Machining of wheel seats for matching of wheel disc bores:** The wheel seat of the axle to be used for re-axling is machined to suit the bore of the wheel disc keeping interference allowance as specified. The bore of wheel disc and wheel seat on the axle should be maintained to the specified surface finish and diameters to achieve correct interference fit and pressing in pressure
- **Pressing on Wheel Discs on Axle:** Before pressing on operation, wheel seats on the axle and bore of the wheel centres should be cleaned to remove rust, grit, swarf, dirt etc. The wheel seat should be lubricated with a mixture of basic carbonate white lead and boiled linseed oil, in the proportion of 1.2 kg. of white lead paste to 1 litre of boiled linseed oil. The wheel and axle should be properly aligned on the wheel press. The wheel press should be equipped with a dial pressure gauge and pressure recording gauge with graphs to record mounting pressure diagrams for each assembly. Wheels should be mounted within the prescribed pressure limits. Wheels should be mounted (pressed in) carefully on the axle such that the wheel gauge distance is maintained. The axle end should be stamped with the shop code, date of mounting, pressing in pressure, axle no., cast no., cons. no. to enable identification of wheels. Care should be taken to ensure that wheel disc number is preserved. The wheel gauge should be checked by gauging at three or more equiangular points around the circumference.

## **RD (Replacement of solid discs) Wheels**

During pre-inspection, if it is found that tread diameters of the solid disc wheels cannot be issued at the last shop issue, the wheel is taken for replacement of discs.

### **The activities involved in replacement of discs:**

- **Dismounting of Axle boxes & Roller Bearings:** Axle boxes are dropped from the RD Wheel. The wheel is then taken for dismounting of roller bearings from journals.
- **Inspection of Axle journals/ Ultrasonic testing of the axle:** Journal diameters should be measured with an outside diameter to confirm to be within the permissible limits. The axle should be ultrasonically tested for flaw detection and should be flawless.
- **Pressing off rejected discs from a wheel:** The wheel is taken on the wheel press for separating the rejected discs from the wheels.
- **Boring (Machining) of new discs:** New discs are bored on the vertical boring machine. Care should be taken to ensure the finished bore is concentric to the tread of the wheel and has a smooth surface free from ridges, scores and chatter marks. The radius of 2.5 mm, which is provided on the wheel bore to facilitate mounting, should be made after the finishing cut. An inside micrometer should be used for measuring wheel bores to ensure consistent results. Each wheel bore must be checked at not less than three points in its length and on the different diameters at each of these points to ensure roundness and absence of tapers. The variation among any of these measurements must not exceed 0.05 mm. If any taper does exist, the small diameter must be at an outside end of the hub bore (reverse taper is not allowed).
- **Machining of wheel seats on an old axle for matching of wheel disc bores :** The wheel seats on the old axle (released from RD wheels) are machined to suit the bore of the wheel discs keeping interference allowance as prescribed. The bore and the wheel seat should be machined to the specified surface finish to achieve correct interference fit and pressing in pressure.
- **Pressing on Wheel on Axle**
  - ✓ Before pressing on operation, wheel seats on the axle and bore of the wheel should be carefully cleaned to remove rust, grit, swarf, dirt etc.
  - ✓ The wheel seat should be lubricated with a mixture of basic carbonate white lead and boiled linseed oil, in the proportion of 1.2 kg. of white lead paste to 1 litre of boiled linseed oil. The wheel and axle should be properly aligned on the wheel press.
  - ✓ The wheel press should be equipped with a dial pressure gauge and pressure recording gauge with graphs to record mounting pressure diagrams for each assembly.
  - ✓ Wheels should be mounted within the prescribed pressure limits. Pressing pressure should be 400 to 600 kg/mm of diameter of wheel seat. For ICF 16t axle with wheel seat diameter from 176mm to 178mm, the pressing pressure should be 71t to 108t.
  - ✓ Wheels should be mounted (pressed in) carefully on the axle such that the wheel gauge distance is maintained.
  - ✓ The axle end should be stamped with the shop code, date of mounting, pressing in pressure, axle no., cast no., cons. no. to enable identification of wheels.
  - ✓ The wheel gauge should be checked by gauging at three or more equiangular points around the circumference.

## **List of Tools and Plant**

- EOT crane 5 tonnes
- Wheel profiling lathe
- Axle journal turning and burnishing lathe
- Axle journal grinding machine for assembled wheel set.
- Hydraulic wheel press with facility for mounting pressure diagram
- Axle turning lathe
- Vertical turning lathe
- Axle centering machine
- Axle end drilling machine
- Axle grinder

## **AXLE BOX ASSEMBLY**

In passenger coaches of Indian Railway system, only single bearing type axle box arrangement is used. The inner ring of the bearing is provided with either a cylindrical bore (Direct Mounted type) or with a taper bore and withdrawal sleeve (Sleeve Mounted type). All new passenger coaches built by Indian Railways, use only direct mounted type spherical roller bearings. Therefore, practices related to the sleeve mounted bearings, have not been covered in this manual.

## **ROLLER BEARINGS**

### **1. Construction feature of Roller Bearings**

Spherical roller bearing consist of an outer ring having a continuous spherical raceway within which operate, two rows of barrel shaped rollers, which in turn are guided by an inner ring with two raceways separated by a centre rib. The spherical roller bearings have self-aligning properties and therefore can automatically adjust to any deviation in the centre line of the axle. Spherical roller bearings have a large capacity for radial loads, axle loads in either direction, and complex loads. They are suited for the applications such as railway rolling stocks where vibrations and shock loads are encountered. Roller Bearings are named according to the shape of rollers. Roller Bearings with spherical rollers are called as Spherical Roller Bearings.

Spherical Roller bearing no. 22326/C3 with 130 mm parallel bore on the inner ring is being used on ICF type coaches. They are directly shrunk fit on the axle journals.

These roller bearings need to be inspected periodically at a pre-defined schedule in the workshop in a Roller Bearing Maintenance Shop well equipped with all the facilities and proper lay out. The period of maintenance specified is as follows:

### **Periodicity of Inspection of Roller Bearing**

- All roller bearings should be cleaned, inspected and filled with fresh grease at every POH.
- All bearings should be dismantled every alternate POH or 2 lakh km whichever is earlier in the workshop for renewal of felt sealing ring and overhaul of the roller bearings.

### **Roller Bearing Maintenance in Shop**

Roller Bearing Maintenance Shop should be well equipped with all the tools, equipment and facilities for careful bearing handling. It should have proper workflow for easy maintenance of roller bearings. Clean surroundings and dust free atmosphere should be maintained in the shop. It should have adequate equipment and facilities for cleaning, handling, dismantling, dismantling, inspection, repair and storage of roller bearings.

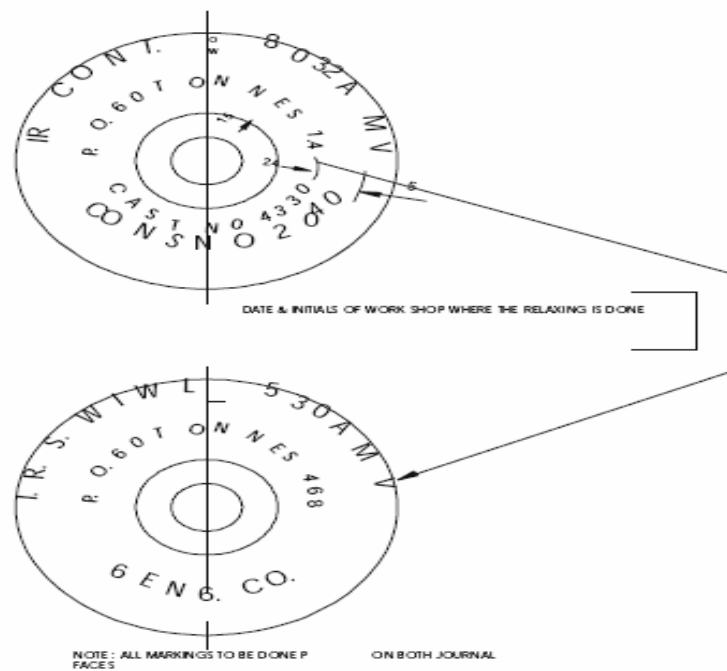
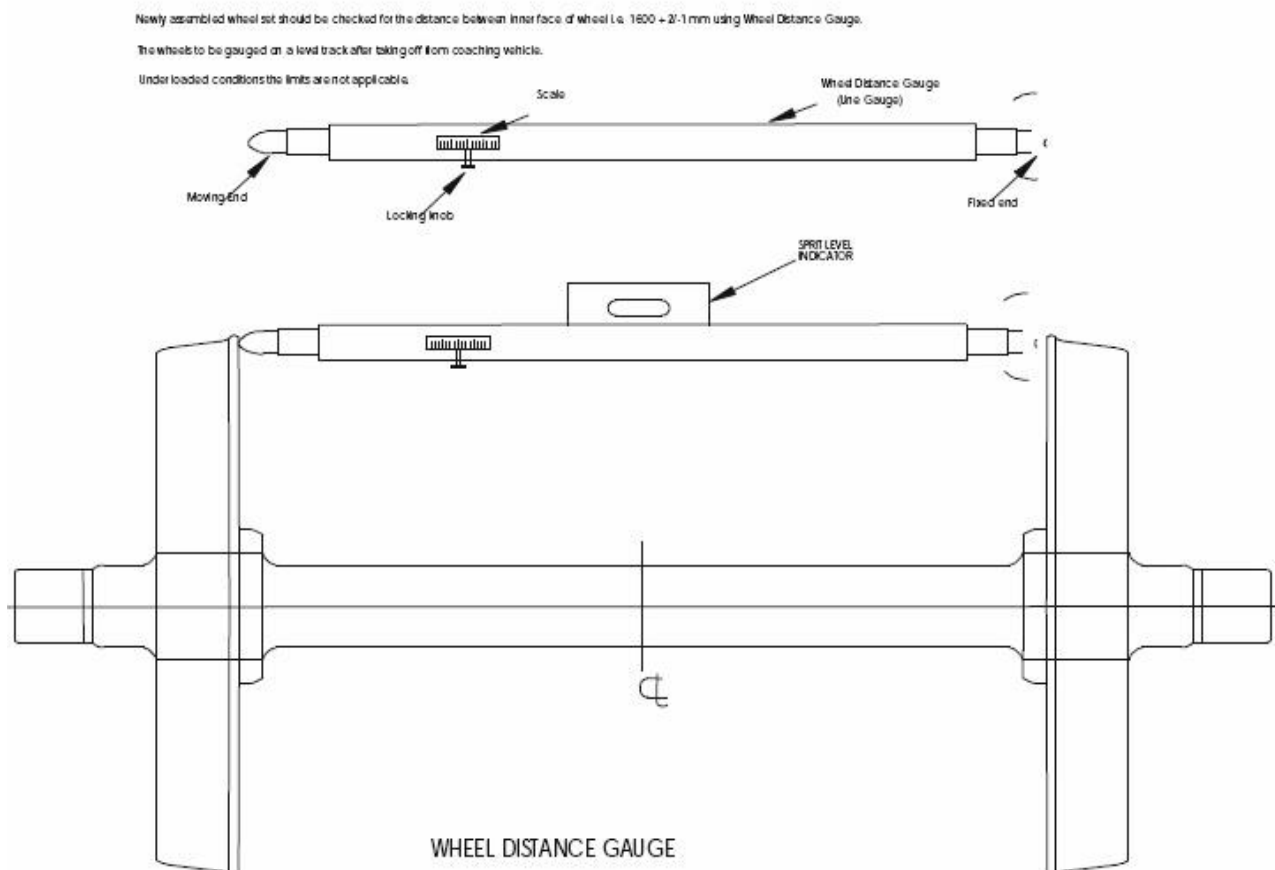
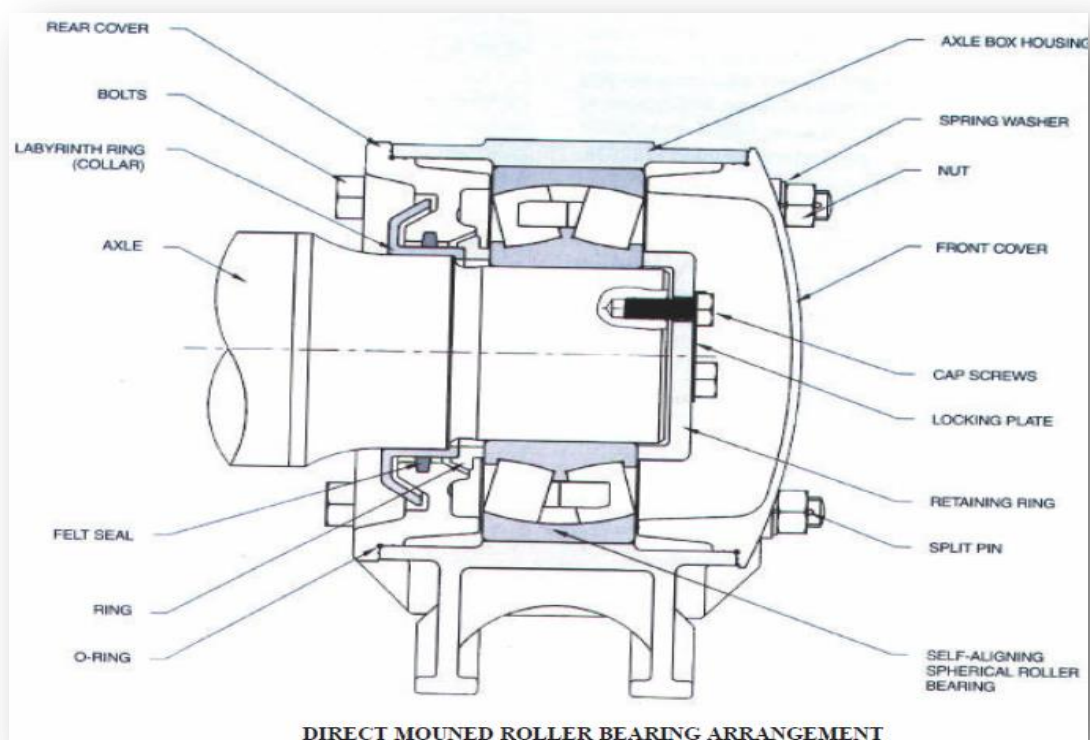


Fig. Stamping Shop Initials On Axles





S.NO	Nature of work	Equipment/ Facility Required
1.	Cleaning of Roller Bearing	Automatic RB cleaning equipment with 3stage cleaning of pre-wash, wash and water rinsing.
2.	Cleaning of Axle Boxes	Axle box cleaning plant with Bosch tank and spray jet cleaning in a close chamber
3.	Axle Box extraction	Axle Box extractor
4.	Dismounting of Spherical Roller Bearings -taper bore	Hydraulic dismounting Equipment – Withdrawal Nut
5.	Dismounting of Spherical Roller Bearings -straight bore	Hydraulic Dismounting equipment
6.	Mounting of Roller Bearings	Induction heater with de-magnetising device
7.	Securing of end locking bolts	Torque wrench and torque wrench tester
8.	Visual inspection of dismantled roller Bearings	Magnifying glass with light
9.	Measuring/checking of radial Clearance	Long feeler gauge set with number of leaves with different thickness
10.	Measurement of journal/ shoulder diameter	Outside micrometers
11.	Inspection of axle end tapped holes	Thread plug gauges for different size of tapped holes
12.	Inspection of locking bolts	Thread ring gauges for different sizes of Locking bolts
13.	Exact quantity of grease to be filled	Volumetric containers with different Sizes for different quantity of grease
14.	Identification of bearings, inspection details	Engraving / Etching machine

### Inspection of Roller Bearings in Mounted Position

Following procedure should be adopted for carrying out inspection of roller bearings in mounted position.

- Clean the exterior of axle box, front cover, and axle box housing.
- Remove axle box with the help of mechanical screw type puller, by taking care to protect axle centre with the use of pad not allowing the screw to rest on the axle centre. The end locking plate should be removed.
- Examine the grease for consistency, colour, contamination with water, foreign particles, etc.
- If the grease is in good condition, the bearing should not be dismantled, provided its felt sealing ring and rear cover does not require renewal.
- Remove old grease. Roller bearing and its components should be thoroughly washed and cleaned with kerosene and then petrol/white spirit.
- All components viz., rollers, cage, outer and inner rings (races), roller track of outer ring should be examined after swivelling the outer ring.
- Bearing should be rejected for the following defects:
  - Pitted or flaked roller tracks and rollers.
  - Cracked or deformed or badly worn out cage
  - Cracked inner or outer ring
  - Scored or damaged outer surface of the outer ring
  - Indentation or rings or rollers
  - Scoring of roller tracks or rollers
  - Rust/corrosion, damage or excessive fretting corrosion
  - Brinelling or false brinelling
  - Rings exhibiting deep straw or blue or purple colour indicating heat effect
  - Excessive or less radial clearance.

Radial clearance should be measured in a mounted position with a long feeler gauge simultaneously over both the rows of roller. The blades of the feeler gauge should be inserted between the outer ring and the unloaded rollers. While measuring the radial clearance, the rollers should not be allowed to roll over the blade. The acceptable range of radial clearance for bearing in mounted position on journal for different makes of roller bearings is given.

Bearing make	Radial clearance in mm
SKF	0.105 to 0.296 mm
FAG/NORMA	0.080 to 0.185 mm
NEI/NBC	0.080 to 0.190 mm

- After inspection, if bearing is found satisfactory for further service, the bearing may be cleaned further for re-assembly and greasing. Care should be taken that outer ring is aligned or turned back to its original position slowly. Jerky movement of outer ring can cause damage to rollers.
- Carry out detailed inspection of all other parts for wear, mechanical damage and any other defect, the locking plate should be fitted in position, the end locking bolts tightened with a torque wrench to a correct torque value as given below:

15 o 12 m kg. For M16 bolts.

15 o 16 m kg. For M20 bolts.



- Torque wrenches should be periodically checked for accuracy with torque wrench tester.
- Bend all tabs of locking plate against the sides of the bolt using adjustable rib joint plier.
- The date, the month, and the year of attention and workshop code should be punched on the locking plate in case of retaining ring and on the annular nut in case of annular nut type arrangement
- Fresh grease should be packed between the rollers and the space between rear cover and the roller bearing. Correct quantity of grease is filled in each axle box for which volumetric containers having unique shape and size are used to eliminate mistake by staff.
- A truncated cone of grease should be formed to in from of the bearing. The 'V' grooves in the rear cover should also be filled with fresh grease after thorough cleaning.
- The axle box housing, front cover and 'V' grooves on their faces should be thoroughly cleaned and checked for damages, distortion and trueness of dimensions. After filling the fresh grease in the grooves, the axle box housing should be carefully pushed on the bearing and the front cover tightened in position. The nuts of the axle box should be secured with the split pin. Month, year and workshop code should be stencilled on the front cover and the axle box sealed. The free rotation of the axle box should be checked by hand.

### **Lubrication**

- The quantity of grease filled per axle box  
SKF make bearing 2.00 kg  
Other makes bearings 1.75 kg
- Only lithium base grease of approved brands should be used

### **Guidelines for storage of Grease**

- 1) Grease drums should be stored in vertical position in a covered room.
- 2) Take all precautions to prevent contamination of grease due to dirt, moisture, dust foreign particles etc.
- 3) Always store grease in container with cover.
- 4) Never mix different types of grease.
- 5) Use only clean tools and container when handling the grease.

### **Inspection of other Roller Bearing Components**

The following components other than roller bearing should be inspected during roller bearing maintenance in the workshop.

- Axle end holes
- End locking plates
- End locking bolts
- Retaining Ring
- Collar
- Felt ring
- Rear and Front Cover
- Axle box housing

**Axle end hole:** The axle end holes should be checked with GO–NO GO thread plug gauge for correct size and thread condition. If any of the tapped hole is worn out, a helical thread insert could be fitted in that hole for using the same size of bolt. The practice of blocking of worn out holes and drilling a new hole 60° away from old ones reduces the probing are on axle face for ultrasonic testing.

**End locking plate:**End locking plates should be replaced every time its folds are opened to unscrew bolt.

**End locking bolt:** The end locking bolts should be of high tensile steel of reputed brand/ RDSO approved manufacturers. The condition of their threads should be checked with GO-NO GO thread ring gauges and worn out bolts replaced.

- The bolt head should be free from any damages and should have proper spanner grip. The length of the bolt should be less than that of tapped axle end holes. Bolts in service should not be reused unless they meet the above standards.
- Bolt while fitting should have no radial or axial play.

**Retaining ring:** The retaining ring should be cleaned and inspected for flatness and correct dimensions. The mating surfaces must be free from burr, sharp edge, rust or any other type of defect that will prevent proper seating with mating part.

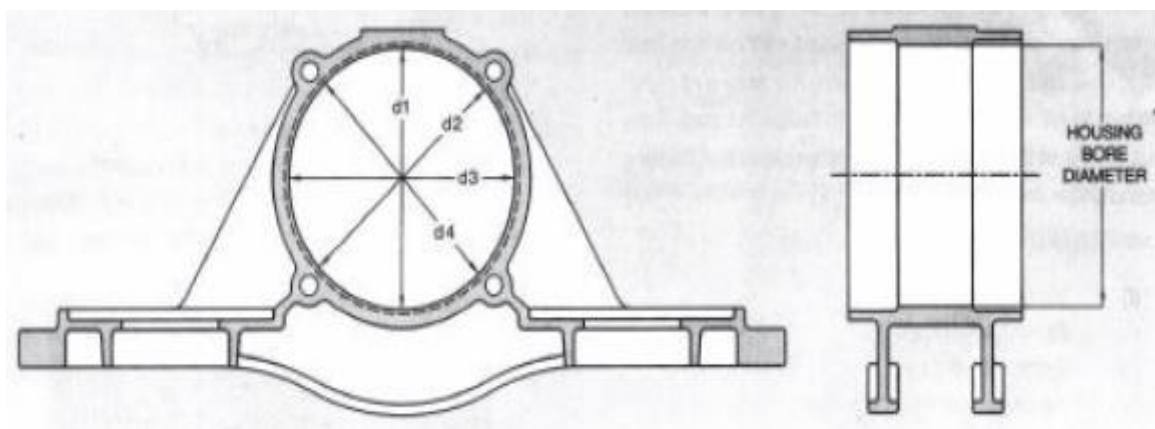
**Collar:** The collar should not be dismantled unless it is damaged or the interference fit with the axle is lost. Once dismantled, it should be invariably replaced.

**Felt ring:** Whenever the rear cover is removed from the roller bearing axle box, the felt ring should be replaced. New felt ring should be soaked in warm cylinder oil to IS-1589-60 type I Gr. 3 heated to 40 degree to 50oC for 30 minutes and smeared with the same grease as used in the axle box before fitting in the rear cover.

**Rear and front cover:** These covers should be cleaned and inspected for any crack, correct dimensions and concentricity of bolt holes. The height should be  $61 \pm 0.1$  mm in the as cast condition and may be checked with the help of a gauge. In case, the cover is worn out, it should be replaced. However the height of the shoulder from the face of both front cover and rear cover should be  $60 \pm 0.1$  mm (refer RDSO's letter no. MC/RB/General dtd. 24/27-3-2000).

**Axle box housing:** The axle boxes should be thoroughly cleaned in the axle box cleaning plant and inspected. Check for any mechanical damage or distortion. The housing should be free from score marks, excessive corrosion and any wear. The dimensions of the bore and width should be within specified tolerance limits. The axle box should be checked for distortion, particularly at the spring seat. Use cylindrical gauge fitted with dial indicator to check housing bore diameter at bearing seat. Check the bore at several places and it must be within specified tolerances. Housings not conforming to the limits or otherwise found unsatisfactory must be rejected.

Axle box faces should be even. The width of the box should be  $216 \pm 0.1$  mm between faces.

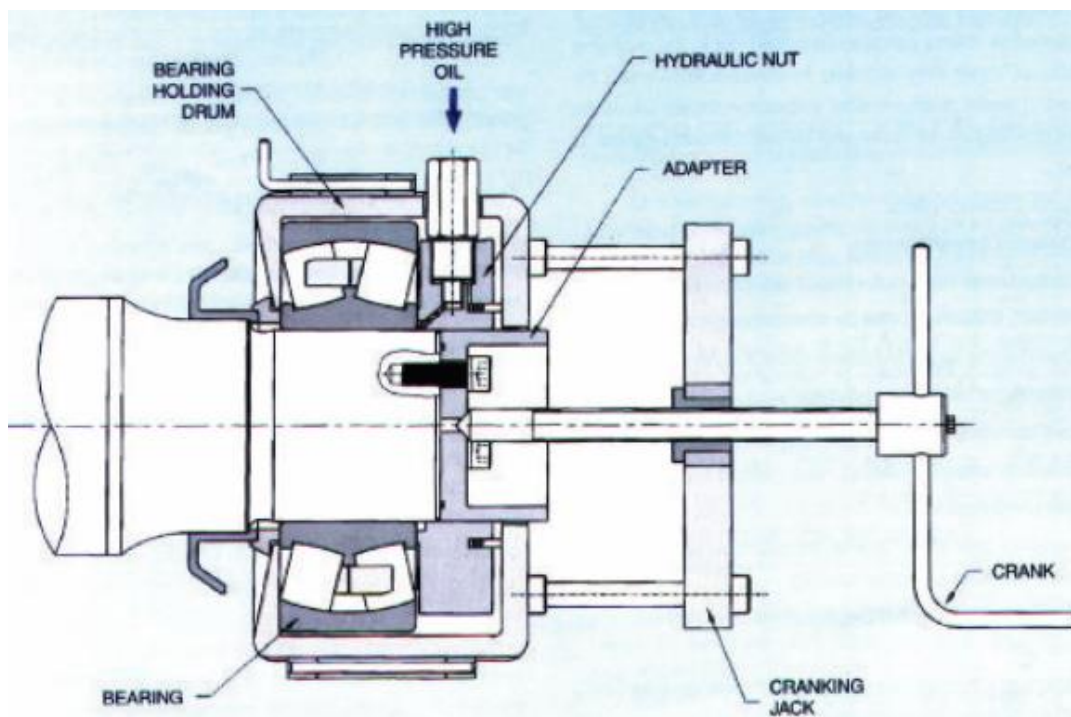


## MAINTENANCE WHEN BEARING IS DISMOUNTED

**Dismounting of bearing:** For dismounting roller bearings, special hydraulic dismounting equipment is used.

Following is the procedure for dismounting of roller bearing - Oil is injected between the journal and bore of the inner ring with high pressure, which expands inner ring resulting in breaking of interference. The bearing becomes loose on the journal and slides over it. The bearing is then removed from the journal and sent to the cleaning plant. Bearing after cleaning is thoroughly inspected for defects.

- All bearing components such as inner ring, outer ring, rollers, and cage are examined for cracks, damage and breakage. Roller (track of outer ring) is examined by swivelling the outer ring. Roller track of inner ring is examined by mechanically pulling out a few rollers from the cage.
- Inspection of roller bearings should be carried out under sufficient light, using magnifying glass. If the bearing is found free from all the defects mentioned above, the radial clearance is measured with proper feeler gauge and compared with the permissible limits prescribed by RDSO in the maintenance manual for different makes of roller bearings. If any of the components is found to be defective or radial clearance is not within prescribed limits, the bearing is rejected and discarded from service.



- Recommended limits of radial clearance for bearings in dismantled condition are as follows:

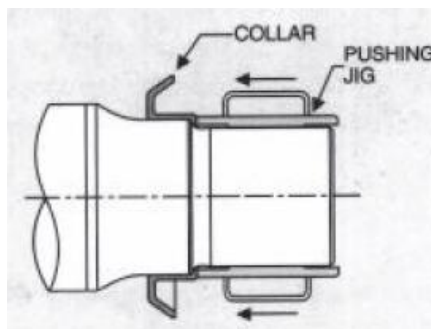
New bearings	0.145 to 0.190 mm
<b>Maximum permissible clearance for bearing in service</b>	
SKF make	0.33 mm
FAG/NORMA makes	0.270 mm
NBC makes	0.295mm

### **b. Mounting of spherical roller bearings and axle box components**

- Before mounting the bearings, it is checked that journal and shoulder diameters are within permissible limits as per respective drawing.
- End holes are checked for elongation with the help of thread plug gauge. If found beyond permissible limits, these should be attended by using stainless steel helical thread inserts of the same size to use the same size of bolt.
- Mounting and maintenance work must be done by qualified personnel as per laid down procedures. When all necessary preparation have been taken, proceed for bearing mounting in the manner described below .

### **Mounting of Labyrinth Ring (Collar)**

The labyrinth ring has an interference fit on the journal, and therefore requires heating for shrink fitting. Heat the labyrinth ring upto a temperature of 1000 C max. If several labyrinth rings are to be mounted a good method is to heat them in an oil bath. Oil bath should have a coarse wire mesh at bottom to allow sediments to settle below the part. Care should be taken that heating oil should be clean and heating time should be around 30 minutes.



Recommended grades of oil for heating are:

- i) Yantrol 150 (HPCL)
- ii) Servoline 150 (IOC)
- iii) Enklo 68 (HPCL)
- iv) Servosystem 68 (IOC)

Alternatively, an induction heater can also be used. Heating time should be between 5-7 minutes.

Clean the seating area of the axle, and push the heated labyrinth ring on the seating and hold it in position for few seconds when labyrinth ring has been cooled sufficiently to have a fairly firm fit on its seating, drive it home against the shoulder by tapping it with pushing jig, to avoid any possible gap. When tapping produces clear metallic sound, it shows that the part has seated correctly. After cooling, coat the labyrinth ring with grease of recommended brand to prevent any damage due to moisture, dirt or other foreign matter.

### **Mounting of Rear cover, Felt Seal & O-Ring (Collar)**

Wipe and clean the rear cover and insert 4 nos. bolts. Fill "V" grooves of rear cover with grease and fit rubber O-ring in its position.

Now soak the felt seal in warm cylinder oil (IS:1589 type 1 grade 3), heated to 40o C to 50° C for about 30 minutes. Smear the felt seal by hand with same grease as used in axle box and fit into the groove at rear cover. Always use new felt seal of specified quality.

Slide and push in the rear cover in position against the labyrinth ring along with bolts and rubber O-ring. Fill approximately 50% of sealing collar cavity with grease. Fill the space between rear cover and the neck of collar with grease and align.

### Mounting of Ring

Clean and wipe the ring. Ensure that faces are parallel, flat and free from burr, rust etc. Insert the ring in its position. Fill grease in the cavity in the rear cover up to the face of the ring.

### Mounting of Spherical Roller Bearing

New bearings should be taken out from original packing only just before mounting. The spherical roller bearings are coated with rust preventive oil prior to dispatch. There is no need to wash new bearings before installation.

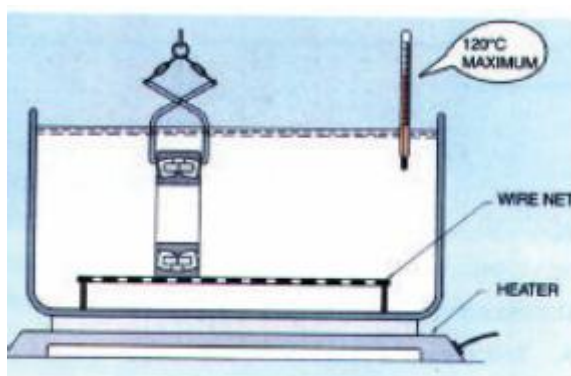
All direct mounted spherical roller bearing for passenger coach have interference fit with axle journal.

Therefore it requires heating and shrink fitting. Heating of bearings can be done either by using an oil bath or induction heater. Usually, temperature range of 100 to 120°C give sufficient expansion for easy sliding of bearing over journal. However, while heating by either of these methods, do ensure that temperature of bearing does not exceed 120°C.

### Oil bath method

The oil bath method has advantage of gradual and uniform heating of bearings. When several bearings are to be mounted, all can be put in oil bath simultaneously to save time.

The oil bath should be equipped with suitable arrangements for electrical heating, temperature controlling system (Auto cut-off) and thermometer. A wirenet should be provided at bottom, under which impurity can settle.



Oil used in oil bath should be fortified with anti-oxidation, anti-foaming additives. Recommended oils for this purpose are:

Oil	Supplier
Enklo 68	HPCL
Servosystem 68	IOC

Bearing should be suspended in heated oil by suitable hanger so that it can easily be lifted out. Heat the bearing for approximately 30 minutes to attain the temperature of 100°C to 120°C.

Induction heating is a quick, safe, energy saving and environment friendly process. In this system, bearing is short circuited to perform as a secondary winding whereas the core winding is at primary side. Bearing is placed around a yoke. Due to principle of induction current, bearing is heated due to its electrical resistance and attains the desired temperature.

The Induction heater should be equipped with:

1. Temperature and cycle time controllers
2. Auto demagnetizer
3. Temperature and cycle time indicator
4. Auto alarm to indicate completion of cycle

Heating time required in induction heating system largely depends upon the weight of the bearings. It is recommended to set the machine in such a way that it takes 5 to 7 minutes to attain the temperature of 1200 C maximum of bearing. Overheating (beyond 1200 C) or rapid heating may result in dimensional instability or change in material properties due to change in microstructure, which may initiate cracks in bearings races in due course.

Heated bearing should be handled with the help of hook, tong or asbestos gloves and mounted on the journal. Push the heated bearing on the axle. During mounting, installer must be careful to keep the bearing bore aligned with the axle to avoid the scoring marks. Bearing position must be corrected by giving light taps with plastic hammer. Keep the bearing pressed by hand towards rear cover side for new minutes, till it has acquired sufficient grip on its seat.

The stamp face of bearing should be kept towards outside so that stamping can be seen during inspection. The rest of the procedure is same as for Roller bearing maintenance in mounted condition.

#### **PRECAUTIONS FOR MAINTENANCE OF ROLLER BEARING**

During maintenance of Roller Bearing Axle Boxes, following precautions should be observed

- Only specified tools should be used for attention of roller bearings.
- Tools should be kept as clean as the bearing themselves
- Tools and bearings should be kept on dry surfaces
- Bearings should be handled carefully avoiding bruises to the bearings
- Bearings should not be dropped
- Only cotton cloth free from fluff should be used for cleaning of bearings.
- Cotton waste should never be used while cleaning and handling of bearings.

Spare bearings should be stored in a dry place. They should be opened only at the time of mounting so as to protect them from dust and moisture.



## ROLLER BEARING DEFECTS AND REMEDIAL MEASURES

Defect	Effect on Bearing	Remedial Measures
1. Felt ring perished	<ol style="list-style-type: none"> <li>Grease may ooze out from rear cover</li> <li>Dust and water may enter the axle box</li> </ol>	<p>Renew the felt ring every time the bearing is dismantled in workshop.</p> <p>Felt ring should be as per schedule of requirement laid down by RDSO.</p>
2. Rubber 'O' rings of cover perished	Dust and water may enter the axle box	Renew the rubber 'O' ring every time the bearing is attended in workshop. The material of the ring should conform to the specifications laid down by RDSO.
3. 'V' grooves on rear cover , front cover and axle box faces not filled with grease.	Dust and water may enter the axle box.	At the time of maintenance clean out the old grease and apply fresh grease.
4. Improper and/or excessive / inadequate grease.	Excessive temperature , seizing or complete failure of Roller Bearing.	<ol style="list-style-type: none"> <li>Use only approved brands of grease.</li> <li>Use specified quantity of grease.</li> </ol>
5. Bearing clearance not within prescribed limits.	Excessive wear of rollers and races leading to bearing failure.	Check bearing clearance during attention to roller bearing axle boxes in workshops and scrap bearings with clearances outside prescribed limits.
6. Fitment of substandard/ improper size end locking bolts/ screws.	Bolt may fail in service cause damage to front cover and bearings	Check the end locking bolts /screws and if worn/sub standard, replace
7. Improper locking of end locking screws.	Screw may get loose in service and cause damage to front cover and bearings	Follow correct procedure.
8. End locking screws not tightened properly.	End locking arrangement may fail.	Tighten screws with torque wrench at specified torque value.
9. Journal finish and Diameter not as prescribed in the drawing.	Bearing may become loose/inner ring cracks causing serious damage to the bearing leading to bearing failure.	Journal should be to the size , tolerance and finish shown on the relevant drawings.
10. Excessive or inadequate lateral clearance between axle box covers and bearings.	<ol style="list-style-type: none"> <li>Excessive clearance may damage roller bearings or covers.</li> <li>Inadequate clearance may result in gap between axle box housing and bearings.</li> </ol>	Maintain correct lateral clearance as indicated in the drawings.

### Roller Bearing Axle Boxes

A coach should invariably be detached from service for the following defects

- Hot axle box
- Damaged axle box
- Damaged front or rear cover
- Seized roller bearing
- Coach involved in accident, derailment, fire, flood etc.

Care should be taken not to keep a coach fitted with roller bearing stationary for a long time. Coaches grounded for a long time should be shunted up and down at regular intervals.

Coaches fitted with roller bearing should be checked to ensure that:-

- No wash basin drain hole /discharge pipe is directly above the axle box
- The front and rear covers of the axle boxes are not damaged, cracked or loose
- Clearance between axle box and wheel is such that the axle box does not bind against the wheel.
- Brake gear is properly adjusted to avoid possibility of brake binding

## ULTRASONIC TESTING OF AXLES

All incoming wheel sets are tested for flaw detection test of axles in the shop before sending them to service.

Following techniques are adopted to test the axles.

- Far end scanning
- Trace delay
- Near end low angle scanning
- High angle scanning

**Far end scanning technique:** This technique is used to detect fatigue crack, manufacturing defects, blow holes etc. In this technique, normal probe of 1 MHz to 2.5 MHz having 10 mm. and 20 mm. in size are generally used. By this technique, full length of the axle specimen is covered for test.

**Trace delay technique:** In this technique, the specimen is tested part by part with normal probe.

**Near and low angle scanning:** In this technique, the area which cannot be tested by far end scanning i.e. raised portion or shadow zone (wheel seat) is tested by low angle. In this technique, angular probe of 2.5 MHz having angle of 10°, 12.5°, 15°, & 17.5° are generally used.

**High angle scanning:** This technique is a confirmation test of low angle scanning. This test is carried out on the body of the specimen. In this technique, high angular probe of 37°, 60°, & 70° are generally used. All tested axles are stamped on the inner face of the hub with following details: UT.O 1.201. MM/YY/XXXX

Legend:

UT: Ultrasonic test

01: Code for Railway (This code changes from RLY to RLY)

02: Code for type of work shop (this code also changes for type of work shop)

01: Code for place of workshop (this code also changes for place of workshop)

MM/YY: Month and year of testing

XXXX: Initial of person testing the axle.



## GENERAL REQUIREMENT FOR ULTRASONIC TESTING OF AXLES

(as per RDSOs Compendium on Ultra Sonic Testing)

The general requirements prior to ultrasonic testing of axle are surface preparation, selection of coolant, care and checking of probe.

### 1. SURFACE PREPARATION

Surface preparation of the areas where the probe is to be applied is necessary for maximum transmission of ultrasonic energy in the test specimen. It is essential that the surface should be clear of loose paint, dirt and loose scale. Ultrasonic testing of an axle is carried out from axle ends journals and from body.

**Axle end:** Ultrasonic testing of an axle by far-end and near end low angle scanning is carried out from the axle ends. The end faces are usually stamped with cast Nos. and other identification numbers and this process displaces the surface material into raised areas thereby resulting in an inadequate acoustic coupling. The raised areas must, therefore, be removed by filing, or by using emery cloth, while cleaning of the end faces, care must be taken not to allow filing debris, dirt and grit to enter the axle box or roller bearings. The end faces should be cleaned by cotton cloth soaked in kerosene oil. All the precautions as mentioned in maintenance schedule for disassembly of the axle box covers and end face fitment should be strictly observed.

**Axle Journals:** When using the high angle scanning techniques on axle journals the surface must be made free of dirt, grit using cotton cloth soaked in kerosene oil.

**Axle Body:** When using the high angle scanning techniques on axle body, loose paint, rust and scale must be removed and the surface must be free from dirt and grit. Some axle body surfaces may have machining marks and these may cause some loss of ultrasonic energy but there should not be any difficulty from this source unless the machining is rough. In such cases or in case where axle body is in forged condition it is advisable to use adequate quantity of grease as coupling media. Where it has been necessary to remove protective paint, the surface should be repainted as per relevant specimen or as recommended in maintenance schedule before the axle is put into service.

### 2. CHOICE OF COUPLANT

The choice of coolant depends on the condition of probing surface. The following coolant may be used for ultrasonic testing of axles.

1.	Lubricant grease as recommended for particular type of bearings in order to avoid any chances of contamination.	For far-end scanning near end low angle scanning for all types of axles fitted with roller bearing.
2.	Lubricant grease grade 2 or 3 to IS 507-1967.	For high angle scanning of all types of axles.

### 3. CARE AND CHECKING OF PROBES

**Inspection and checking of probes:** The inspection and checking of the probes must be carried out periodically.

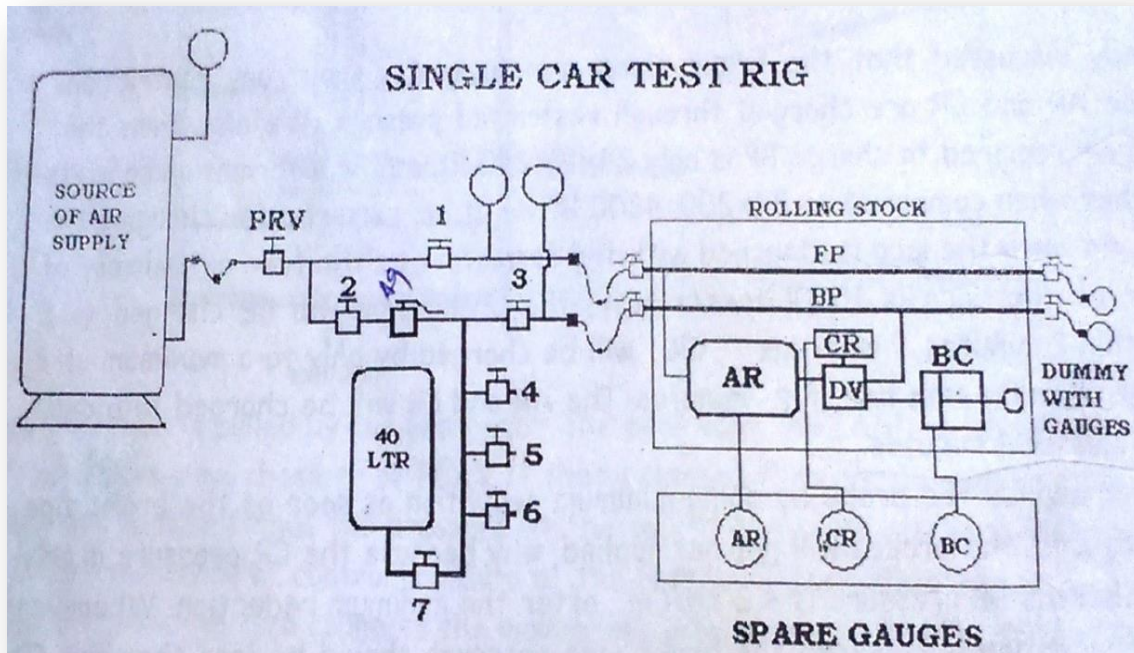
**Low angle wedges:** All the low angle Perspex wedges should be regularly checked at 6 months interval for the correctness of angle of refraction in steel. Any changes in the angle of Perspex wedges will seriously impair the test results.

**High angle wedges:** All high angle Perspex wedges should be regularly checked at 6 months interval. The operator must ensure that the angle of refraction in steel not been affected by wear. Any change in the angle of wedges will seriously impair the test results.

#### **CARE AND CLEANING OF PROBES**

- Probes should be handled very carefully. The probes should be carefully packed in cotton. U-foam etc, in order to avoid any damage during transportation from one place to another. In any circumstances no attempt should be made to open the probes by the operator as the crystal used inside the probe is very brittle. If any probe shows loss of sensitivity, it should be sent for repair to maintenance cell or to the suppliers.
- The probes and probe cable should be cleaned daily after completion of the work and characteristics of probe should be checked at regular interval. The probes should never dismantle in any way for cleaning but it should be thoroughly wiped over with clean cloth. At no time the probes should be immersed in the liquid paraffin.

# SINGLE TEST CAR RIG



## PROCEDURES

### 1. LEAKAGE IN FP AND BP

- Charge the system fully.
- Close the cock No. 1 and 3.
- Observe the pressure drop in FP and BP for three minutes. The leakage rate in the FP and BP should not be more than

0.2 Kg/cm <sup>2</sup> in one minute in FP
--

0.2 Kg/cm <sup>2</sup> in one minute in BP for coaching stock
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0.1 Kg/cm <sup>2</sup> in one minute in BP for goods stock
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### 2. BC FILLING TIME

- Charge the system fully.
- Bring the A-9 valve to full service application position.
- Observe BC pressure.
- The BC pressure should reach to 3.6 kg/cm<sup>2</sup> within

3 to 5 sec for coaching stock
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18 to 30 sec for goods stock
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- Observe the max. pressure it should be 3.8 kg/cm<sup>2</sup>

### 3. BC RELEASING TIME

- Bring the A-9 valve to release position.
- Observe the BC pressure.
- The BC should drop from 3.8 kg/cm<sup>2</sup> to 0.4 kg/cm<sup>2</sup> within

15 to 20 sec. for coaching stock
----------------------------------

35 to 60 sec for goods stock
------------------------------

### 4. SENSITIVITY TEST

- Open the cock no. 7 and charge the system fully.
- Close the cock no. 2 and open the cock no. 4.
- Wait for 6 sec and close the cock no. 4 (this will reduce the BP pressure by 0.6 kg/cm<sup>2</sup> in 6 sec automatically).
- Observe the Brake Cylinder. The brake should be in applied condition.

### 5. INSENSITIVITY TEST

- Open the cock no. 7 and charge the system fully.
- Close the cock no. 2 and open the cock no. 5.
- Wait for 60 sec and close the cock no. 5 (This will reduce the BP pressure 0.3kg/cm<sup>2</sup> in 60 sec automatically).
- Observe the Brake Cylinder. The brake should not be in applied conditions.
- Observe the BP and CR pressure. Both should be at 4.7 kg/cm<sup>2</sup>.

### 6. EMERGENCY APPLICATION TEST

- Open the cock No. 7 and charge the system fully.
- Close the cock No. 2 and open the cock No. 6.
- Observe the Brake Cylinder pressure. The maximum BC should be 3.8 Kg/cm<sup>2</sup>.

### 7. PISTON STROKE

After the emergency or full service application measure the full piston stroke. It should be within

90 ± 10mm for coaching stock
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85 ± 10mm for goods stock-Empty
---------------------------------

130 ± 10mm for goods stock-Load
---------------------------------

32mm for BMBC
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### 8. LEAKAGE IN BC

- After the emergency brake application observe the leakage in the Brake Cylinder.
- The leakage in BC should not be more than 0.1 Kg/cm<sup>2</sup> in 5 minutes.

### 9. GRADUATED APPLICATION TEST

- Charge the system fully.
- Reduce the BP pressure in steps through A-9 valve.
- Observe the BC pressure. The pressure should increase in steps.

For Example

BP	BC
5.0	0
4.5	1.25
4.2	2.0
4.0	2.5
3.8	3.0
3.5	3.8

#### 10. GRADUATED RELEASE TEST

- Increase the BP pressure in steps through A-9 valve.
- Observe the BC pressure. The pressure should decrease in steps.

For Example

BP	BC
3.5	3.8
3.8	3.0
4.0	2.5
4.2	2.0
4.5	1.25
5.0	0

#### 11. WORKING OF PEAS

- Charge the system fully.
- Pull the alarm chain from inside the coach.
- Observe the BP pressure and BC.
- BP pressure should drop and brake should apply.
- Reset the PEASD.
- Observe the BP pressure and BC.
- BP pressure should reach to 5 Kg/cm<sup>2</sup> and brake also should release.

#### 12. WORKING OF GEV (GUARD EMERGENCY VALVE)

- Charge the system fully.
- Operate the GEV handle.
- Observe the BP pressure and BC.
- BP pressure should drop and brake should apply.
- Bring back the GEV to normal position.
- Observe the BP pressure and BC.
- BP pressure should reach to 5 Kg/cm<sup>2</sup> and brake also should release.

#### 13. MANUAL RELEASE TEST

- Disconnect the test rig from the rolling stock.
- Pull the release valve handle.
- Observe the CR pressure and BC.
- The CR pressure should drop to 0 Kg/cm<sup>2</sup> and brake should release without any jerks.

# MAINTENANCE SCHEDULES OF LHB COACHES

## General

The following maintenance schedules are to be carried out.

### Coaching Depot Schedule

- Schedule D1 : Every Trip/Weekly
- Schedule D2 : Monthly  $\pm$  3 days
- Schedule D3 : Half Yearly  $\pm$  15 days

### Shop Schedule

- Shop Schedule I : 18 months/ 6 lakh Kms whichever is earlier
- Shop Schedule II : 36 months/ 12 lakh Kms whichever is earlier
- Shop Schedule III : 72 months/ 24 lakh Kms whichever is earlier

The details of activities to be carried out during these schedules are given below and a summarized checklist is given in Annexure 12.5.

## SCHEDULE D1 (EVERY TRIP/WEEKLY)

The following items shall be attended during schedule D1.

### Bogie Frame and Bolster Assembly

- Perform a visual check on longitudinal beams, cross beams & bolster for cracks, damages and corrosion.
- Perform a visual check on brake supports, damper supports, traction centre supports and anti-roll bar supports for cracks, damages and corrosion.
- Check bogie bolster sub-assembly and brackets for cracks, damages and corrosion.

### Brake Equipments

- Check functionality of Air Brake equipment and Hand brake equipment. Check flexes ball cable arrangement for proper working.
- Perform a visual check on Brake cylinders/ brake levers and Hand brake equipment for damage, cracks and corrosion.
- Perform a functional test on pneumatic brake system. Make sure that no leaks are present.
- Check operation of passenger emergency valve & pull box.
- Perform a visual check on hoses for cracks/damages.
- Visually inspect steel piping for cracks/ damages/ ballast hitting and leakages, Repair/ replace as necessary.
- Perform a visual check on brake discs for damage/wear/broken ribs. Verify absence of axial movement along the axle.

**Note:** For attending Brake Discs with broken ribs, please refer to M/S Knorr Bremse's letter no. kbi/m&s/lhb/ser. Dt. 31.08.2007.

### Axle Bearing Instruments

- Perform a visual check on all grounding cables & WSP equipment cables for breaks/ damages.
- Visually check equipment for absence of damages, cracks, and corrosion marks.
- Check functioning of WSP equipment. Verify that the signal arrives correctly to the diagnostic equipment.

**Primary & Secondary Suspension**

- Visually check springs for cracks, damages, corrosion or foreign objects presence.
- Check miner pads for cracks, damages and ageing.
- Visually check safety cables for damages, cracks and corrosion.

**Primary/Secondary/Yaw dampers**

- Perform a visual check on dampers for damage, cracks and oil leaks.
- Perform a visual check on all fixings for loosening and/or missing components.
- Perform a visual check on rubber elements for cracks and ageing.

**Bearings**

- Carry out bearing feeling for detection of hot bearing.
- Check bearings for grease leakage.

**Wheel & Axle**

- Perform a visual check on wheels for cracks, damages and tyre defects.
- Check by wheel profile gauge, the wheel flange thickness and profile.
- Check axle for cracks and signs of corrosion, if any.

**Note:** please refer to RDSO CMI – K 003 (Guidelines for interpretation of wheel defects) and ‘Maintenance Manual for ICF design BG coaches’ for details.

**Control Arm**

- Perform a visual check on all fixings for loosening and / or missing components.
- Visually check control arm parts for damages, cracks or corrosion marks.
- Inspect the rubber joint until it is visible for cracks, damages and ageing.

**Anti-Roll bar Assembly**

- Visual check on Anti roll bar, links and brackets for cracks, damages and corrosion.
- Perform a visual check on rubber joints for cracks, damage and ageing.
- Visually inspect for grease oozing out of anti-roll bar bearings, which may result in bearing failure.
- Perform visual check on all fixings for loosening/missing fittings.

**Traction Centre**

- Perform a visual check on the traction centre lever and on the rods for cracks, damages and corrosion.
- The assembly should be free to move, and not blocked by any foreign objects.
- Perform a visual check on all fixings for loosening.
- Perform a visual check on rubber joints for cracks/damages.

**Rotation Limiter**

- Perform a visual check of rotation limiter- components.

**Rubber and Rubber/Metal Bonded Parts**

- Perform a visual check on rubber and rubber/metal bonded parts for cracks, damages and ageing.

**SCHEDULE D2 (MONTHLY)**

Perform all the items of schedule D1. In addition to this perform the activities-as given below.

**Bogie Frame**

- Wash the bogie frame thoroughly with water jet in washing line, making sure that water is not directed towards pneumatic / electrical connections and axle bearings.

**Brake Equipment**

- Verify that the clearance between each pad and disc surface is 1-1.5 mm.
- Check wear of brake pads/ brake discs. If groove depth is reached, it is necessary to replace the discs.
- Lubricate the brake levers, fixings and all moving parts using prescribed grease (Autol Top 2000 spray).

**Axle Bearing Instruments**

- Inspect the Earthing equipment for wear of slip assembly / carbon bars.
- Monthly / Quarterly inspection of WSP equipment to be carried out as per schedule given by OEM.

**Wheel & Axle**

- Check treads diameter and wear of wheel profile. If necessary, perform re-profiling.

**Pins and Bushes**

- Lubricate all pins and bushes.

**SCHEDULE D3 (HALF YEARLY)**

Perform all the activities of schedule D2. In addition to this, perform the activities, as given below

**Bogie Frame**

- Examine the bogie frame for corrosion / damages, especially at critical locations.
- Carry out paint touch up with high built epoxy primer and paint as per RCF specifications MDTs – 166.

**Wheel & Axle**

- Check wheels offset on axle (1600 mm $\pm$  1 mm)

**Control Arm**

- Renew protection treatment with Tectyl / Cortec VC 1368 on the rubber joint on visible areas.

**Axle Bearing Instruments**

- Replace all carbon brushes on earthing devices.

**SHOP SCHEDULE-I (18 MONTHS)**

The following activities shall be carried out in Shop Schedule-I.

**Brake Equipment**

- Perform function test of the Air Brake system components:
  - Distributor valve
  - Check valve
  - Isolating cocks/angle cocks
  - Filters, indicators, test fittings.
  - Emergency brake valve & pull box
  - Brake cylinders
  - WSP Equipment
- Brake gear pins and other bogie pins must be examined for wear and re-greasing. Replace, if necessary.



- Examine BP/FP couplings and hoses. Replace, if necessary.
- Examine the Brake callipers and Brake pads for wear and damages. Replace, if necessary.
- Check the functioning of hand brake equipment. Replace the defective components.
- Examine the brake discs to detect any thermal or fatigue cracks. Replace, if necessary. Brake disc bolts should be checked for tightness.

#### **Axle Box Instruments**

- Overhaul the grounding equipment. Check spring mechanism for self-regulation. Replace carbon bar and slip assembly. Replace all worn parts.
- Carry out overhauling and testing of WSP equipment as per OEM's instructions.

#### **Primary/Secondary Suspension**

- Attention to springs during Shop Schedules shall be as given under Para 11.
- Examine the condition of lift stop pin and safety cables. Replace, if necessary.
- Check lower and upper centering discs for corrosion, wear, damage and cracks. Replace, if necessary.
- Examine the condition of rubber and rubber/metal bonded parts for damage, cracks and ageing. (Miner pads, rubber springs etc.). Replace, if necessary.

#### **Dampers**

- Check dampers for correct functionality, absence of deformations and oil leakages. Replace fixings/fasteners, if necessary.
- Damper should be tested during Shop Sch.-I and Shop Sch.-II (or early in case of oil leakages) as per parameters given in RCF drawings, read along with FIAT specification no. 17.560.100. Dampers should be replaced during Shop Sch.-III (6years).

<b>Damper</b>	<b>RCF Drg. No.</b>	<b>PL No.</b>
Primary Vertical Damper	LW 05102	00920083
Secondary Vertical Damper	LW 05101	00920060
Secondary Lateral Damper	LW 05100	00920058
Yaw Damper	LW 05103	00920071

#### **Bearings**

- Rotate the bearing assembly to detect any abnormal condition. Check the bearing mounted end play. If end play is beyond permissible limit or if any roughness is detected while rotating the bearing, dismount the bearing and send for reconditioning.

#### **NOTE:**

- ✓ Bearing reconditioning is to be carried out whenever bearing is removed from axle due to wheel-shelling / bearing failure.
- ✓ If new bearing or reconditioned bearing is fitted, a metal identification tag with the mounting date shall be crimped to the brake disc near the bearing.
- ✓ If the wheel sets are sent for re-profiling without dismounting bearings, lubricate the lathe centres with heavy grease.
- ✓ For reconditioning of bearings, please refer to OEM's instructions.

### **Wheels and Axle**

- Perform wheel profiling and wheel balancing (for Speed  $\geq$  130 Km/h). Refer to RCF specn.no. MDTS – 168 for balancing procedure.
- Perform a general overhaul of the axle, remove signs of corrosion, renew corrosion protection and repaint the axle.
- Check wear of wheels, if necessary, replace them.
- Perform an ultrasonic test on the wheel and axle to verify absence of internal cracks and damages.

### **Control Arm**

- Perform a general overhaul of the control arm: remove signs of corrosion, renew corrosion protection and repaint the components.
- Check wear limit of control arm bore as follows; (Ref: RCF's letter no. MD44121 Dt: 13.08.08)
- If the control arm bearing surface reaches a diameter of 230.5 mm (i.e. wears out by more than 0.5 mm), the control arm should be considered worn out and rejected.
- In case, the dia. is between 230.5 mm and 230.312 mm, the control arm maybe re-machined by providing a cut of 0.3 to 0.5 mm on the face of control arm. (This machining operation should not be carried out more than once).
- In case, the diameter is less than 230.312 mm, the control arm may be reused without re-machining.
- The control arm mating surface with bearing should be coated with "Blasol- 135" solution, to prevent corrosion.
- Examine the rubber joint for cracks/damage and ageing. Replace, if necessary.

### **Bogie Frame and Bogie Bolster**

- Examine the bogie frame and bolster for cracks, damages and corrosion. Check all the welded joints with dye penetration. If cracks are found, hold the bogie frame in a suitable manipulator, and rectify.
- Corroded bogie frames should be attended as follows:-
- Cleaning/washing of bogie frames.
- De-scaling/rust removal with rust converter to IS: 13515
- Touch-up with high build epoxy primer and paint as per RCF's specification no. MDTS 166 (Rev.2) and MDTS 094.

### **NOTE:**

Small pitting holes up to a maximum depth of 3 mm may be permitted on the frame, provided these are a) Staggered and non-continuous b) Are not concentrated on the bottom bend portion of the side frame.(Ref: RCF's letter no. MD 44121 dt. 17.09.09)

### **Anti-Roll Bar Assembly**

- Perform a general overhaul of the anti-roll bar. Remove signs of corrosion, renew corrosion protection and repaint the anti-roll bar and the links
- Examine the condition of the brackets: remove signs of corrosion, renew corrosion protection and repaint the block.
- Replace fixings, rubber joints and sealing, on condition basis.
- Replace anti roll bar bearings, if necessary.

**Traction Centre**

- Perform a general overhaul of the traction centre components (Traction lever, Traction Rods). Remove signs of corrosion, renew corrosion protection and repaint the components.
- Replace the rubber bush and the rubber joints, if necessary.

**Rotation Limiter**

- Check condition of the steel roll and pin for wear/damages. Replace, if necessary.

**Rubber and Rubber/Metal Bonded Parts**

- Examine the Rubber and Rubber/Metal Bonded parts for ageing / damages/failure of bonding. Replace, if necessary.

**Bogie Pins**

- Examine brake gear pins and other bogie pins for wear/ damages.
- Replace the pins with hard chrome plated pins as per RCF drawings.

**NOTE:**

RDSO has issued a check sheet for Bogie inspection of LHB coaches during SS-I & SS-II, vide letter no. SV.FIAT dated 14.03.2006. Further, western Railway has also issued a checklist for maintenance of LHB coaches in workshops, vide letter no. M442/19/4 (LHB) dated 23.11.2006, which may be referred by shops.

**CBC**

- Attend the Tight lock CBC as given in RDSO's CMI no. RDSO/2006/CG/CMI -01

**Under Frame & Running Gear**

- Inspect trough floor- for corrosion and damage
- Inspect water tank frame- for corrosion and damage
- Inspect air brake module frame- for corrosion and damage
- Inspect air brake pipe lines- for corrosion and damage
- Inspect water system pipe line- for corrosion and damage
- Inspect emergency battery box frame- for corrosion, fixation bolt
- Inspect head stock for corrosion, damage
- Inspect sole bar for corrosion, damage.
- Inspect Gusset plate for corrosion, damage
- Inspect cross member for corrosion, damage

**Water Supply**

- Water tank tightening bolts- for tightness
- Water level Indicator - damage, leakage, working
- Rubber hose connection -replace of all rubber hose connection
- Drain cock protection cover - damage, availability
- Water inlet cover - provided
- Water tank sensor & its bracket -damage, broken

**Roof**

- Roof sheet- inspect for corrosion, damage, cracks
- Ventilator- inspect for corrosion, damage, deficiency of louvers
- Roof leakage- conduct leakage test

**Exterior- Coach Body**

- Window glasses, cracked, moist, opaque

- Window glasses rubber profiles
- Entrance doors outside rubber gaskets
- Destination board cover with locking arrangement, function of lock
- Entrance hand rails (body handles)- for tightness, condition of plating, cleanliness
- Footsteps – for corrosion, damage, fixation, tightness
- Ventilation grills of generator cars – for corrosion, damage, deficiency

#### **Entrance Door (Main Door)**

- Entrance door glass for cracked, moist, opaque, fixing with frame.
- Locking mechanism including locking cam top & locking pin bottom, universal lock, pad lock arrangement for working condition, damage, worn out, lubrication
- Locking handles for working condition
- Hand safe gasket for damage, worn-out
- Barrel Bolt(locking arrangement) for well positioned
- Entrance door, flap complete, panel, FRP cover, arm cylinder -Remove door flap in SS-II and fill up the gap by extending floor.
- Door stopper (All types)- Condition, deficiency
- Door Assembly -Proper alignment & working.

#### **Luggage Door**

- Top & Bottom Sliding Mechanism including guide rail, rollers, bearings, holding brackets, for working condition, worn, damaged
- Locking mechanism, for working condition
- Key locking arrangement, for working condition
- Rubber gasket, for damaged, worn out
- Door Flap Elements viz. Inner & outer locking handle, louvers, etc., for bent, broken or external damage.

#### **Interior- Passenger Area**

- Upholstery-condition of cushioning, Rexene, levelling.
- Curtains (partition & window)-torn, stains
- Upper berth fenders- fixation, tightness
- PVC - aisle area-worn out, shabby look, torn.
- Snack table- cracks, damaged, shabby look, cleanliness
- Compartment mirror - dusty, cracked, de-silvering
- Magazine pocket
- Bottle holder
- Coat hooks
- Berth holder
- Luggage racks, luggage ropes
- Carpet (I class) - torn, stains, cleaned, dust free (replace if required)
- Locks of ceiling panels - working condition, lubrication
- Emergency window - working condition, availability of handles & instruction stickers.
- ICV pull Box
- All mandatory instructions stickers - availability in good condition

#### **Saloon Sliding Doors**

- Nylon wire rope -damaged, worn out
- S S wire rope- damaged, worn out

- Top mechanism including pneumatic cylinder - working condition, smooth working
- Guide shaft - lubrication by suitable lubricant.
- Locking mechanism - working condition
- Key locking arrangement - working condition
- Hand safe gasket - damaged, worn out
- Glass, glass film & rubber profiles - cleanliness, dusty, cracked
- Grill & grill rubber profiles
- Door flap elements viz. inner & outer locking handle, locking pin, moldings, rivets etc. - bent, broken or external damage

#### **Doorway & Gangway Area**

- Mirror (outside) - dusty, cracked.
- Wash basin/ FRP embedding- stainless steel or FRP (painted)
- Tap (gravity or auto sensor) - for working condition, leakage
- Dust bin with fire extinguisher stand - stainless steel or FRP(painted)
- Floor area (anti slip PVC or aluminium chequered plate) - worn-out, shabby look, tear off.
- Cup boards for linen and catering items - working condition, broken, damaged, availability of all fittings i.e. hinge, locks, stoppers etc.
- Attendant berth/seat - damaged, torn, broken, condition & securing of holding brackets
- Square key locks of ceiling panels - working condition, lubrication
- Levelling of ceiling panels
- Mouldings, vestibule door cover, soap dish, securing brackets of fire extinguishers

#### **Electrical Panel door**

- Door elements like glass, glass gasket, door frame moulding, side & middle hinges, key locking arrangements- damaged, alignment, working condition

#### **CDTS Panel Door**

- Locking arrangement, hinges - working condition, lubrication

#### **Lavatory Area**

- Mirror (inside) - cracked, poor silver plating
- Wash basin - stainless steel or FRP painted, clean
- Tap (gravity tap / luxury tap) - working condition, leakage
- Soap dispenser - working condition, leakage
- Paper roller - loose, deficient
- Hopper window glass - condition of rubber, glass, operation of upper glass, locking arrangement of upper glass
- Dust bin - stainless steel or FRP(painted)
- Tube light column & its fittings -crack, broken, damaged
- 30 litre water tank - crack, broken, damaged, leakage, clean as per procedure given in RCF Manual
- Pipes, fittings, filters, timers (after opening ceiling panel) - crack, broken, damaged, leakage, clean as per procedure given in RCF Manual
- Painting of FRP panels.

#### **Lavatory Door (Toilet Door)**

- Guide roller channel - fixation, tightness, lubrication
- Guide roller channel - lubrication by suitable lubricant.

- Pivot (top) for fixation, tightness
- Pivot (bottom) for fixation, tightness
- Top roller for fixation, tightness, and lubrication.
- Middle hinges gasket for damaged, worn out
- Hand safe gasket for damaged, worn out
- Bottom grill for damaged, bent
- Barrel bolt (locking arrangement) including arrangement for toilet occupation indication., for working condition
- Provision of extra handles (inside) & existing handles & turn-over latches -damaged, missing.
- Coat hook - damaged, missing
- Door flap elements for bent, broken or external damage

#### **Vestibule Sliding Door & Gang Bridge**

- Nylon belt for damaged, worn out.
- Nylon/ steel wire rope for damaged, worn out
- Top mechanism including pneumatic cylinder for working condition, damage, defective
- Guide shaft - lubrication by suitable lubricant.
- Locking mechanism for working condition
- Key locking arrangement for working condition
- Male & Female hand safe gasket for damaged, worn out
- Glass & glass frame for cracked, opaque
- Door flap elements viz. inner & outer locking handle, locking pin, moldings, rivets etc. for bent, broken or external damage
- Gangway bridge (vestibule foot) plate including roller, channel, spring, fasteners for damaged, working mechanism / condition
- Vestibule foot plate pin for wear, damage
- Vestibule foot plate split pin for wear, damage.
- Vestibule Rubber for crack, damage.

#### **SHOP SCHEDULE-II (36 MONTHS)**

In addition to the activities listed under Shop Schedule-I, the following activities shall be carried out in Shop Schedule-II.

#### **Brake Equipment**

- Perform *overhauling* and function test of the brake system components:
- Distributor valve
- Check valve
- Isolating cocks/angle cocks
- Filters, indicators, test fittings.
- Emergency brake valve & pull box
- Brake cylinders
- WSP equipment
- Replace brake gear pins and other bogie pins/bushes.
- Replace Air Brake Hoses

**Bogie Frame and Bogie Bolster**

- Check the dimensional and geometrical tolerances of bogie frame as per FIAT drg. No. 1267505. Rectify/replace as necessary.
- The complete bogie frame should be cleaned (with scrapping/shot blasting) and painted with high built epoxy primer and paint as per RCF specification no. MDTs 166 (Rev.2) and MDTs – 094, with a minimum DFT of 200 microns.

**NOTE:** Small pitting holes up to a maximum depth of 3 mm may be permitted on the frame, provided these are a) staggered and non-continuous b) Are not concentrated on the bottom bend portion of the side frame.

**Bearings**

- Dismount the Bearings and send for inspection/reconditioning.

**Anti-Roll Bar Assembly**

- Perform overhaul of the anti-roll bar. Repair/replace the defective/worn out components.
- Replace all rubber joints, sealing and anti-roll bar bearings.

**Traction Centre**

- Perform a general overhaul of the traction lever.
- Replace the rubber bush and the rubber joints.

**Rubber and Rubber / Metal Bonded Parts**

- Replace all the rubber and rubber/metal bonded parts as must change item.

**Under Frame & Running Gear**

- Inspect head stock for corrosion, damage
- Inspect sole bar for corrosion, damage.
- Inspect Gusset plate for corrosion, damage
- Inspect cross member for corrosion, damage

**Water Supply**

- Water tank and water supply pipe line- cleaning as per procedure given in RCF maintenance manual.
- Pressure testing

**Exterior- Coach Body**

- Condition of exterior paint for peeling off, loss of gloss, scratches
- Exterior body check for corrosion, damage

**Entrance Door (Main Door)**

- Pivot (top) for working condition
- Pivot (bottom) for working condition

Complete overhauling of main doors/Vestibules doors/sliding doors and Lavatory doors.

**Interior- Passenger Area**

- FRP panels including ceiling panels for cracks, damaged, condition of paint, shabby look (clean by soap water), and follow repair guidelines circulated by RCF.
- PVC (inside the compartment) for worn out, shabby look, torn
- Ladder - condition, painting.
- Non upgraded PVC flooring should be replaced.

**Electrical Panel door**

- Switch board doors - Replace FRP doors by better FRP.

**CDTS Panel Door**

- CDTS panel door - Replace FRP doors by better design FRP.

**Lavatory Area**

- FRP panels (Ref. RCF guidelines) - cracks, damaged, condition of paint, shabby look (clean by soap water) apply putty & paint the FRP panels

**Furnishings**

- 100% replacement of Rexene.
- 100% replacement of carpets of Exec. Chair car, thereafter, carpet is to be provided in Aisle portion only as per extant instructions.

**SHOP SCHEDULE-III (72 MONTHS)**

In addition to the activities listed under Shop Sch.-I and Shop Sch-II, the following activities shall be carried out in Shop Sch-III.

**Dampers**

- Replace all dampers during Shop Schedule-III.

**CBC**

- Dismount the CBC from coach, disassembled and overhauled as given in RDSO's CMI no. RDSO/2006/CG/CMI-01

**Interior- Passenger Area**

- Replacement of up graded specification PVC flooring.

**MUST CHANGE ITEMS DURING SHOP SCHEDULE –II**

List of must change items during Shop Schedule –II is enclosed as Annexure “12.6”

**1. TOOL AND EQUIPMENTS**

Tools and equipment for maintenance of FIAT bogie are given as Annexure “12.7” and Tools and equipment for Depot maintenance and traveling TXR are given in Annexure 12.8.

**2. RUBBER AND WEAR PARTS**

The major rubber and wear parts of FIAT bogie are:

- Rubber bush for traction centre
- Rubber joint for control arm
- Elastic joint for traction rods
- Joints for anti-roll bar
- Longitudinal bump stops
- Lateral bump stops
- Rubber disc and bump stop for primary suspension
- Rubber ring and rubber spring for secondary suspension
- Examine all rubber and wear parts for external condition, cracks, detachment between rubber & metal, and permanent set during shop schedule-I. Replace, if necessary.



### 3. PRIMARY & SECONDARY SPRINGS

The primary & secondary suspension springs used in various LHB coaches are given as follows:-

#### Primary Suspension Springs

Coach type	INNER (Drg. No.)	OUTER (Drg. No. )
AC-Chair car 1 <sup>st</sup> & 2 <sup>nd</sup>	1267412	1267411
ACCN/EOG	1277143	1267411
ACCW/EOG	1267412	1267411
FAC/EOG	1267412	1267411
Hot buffet car	1267412	1267411
Power Car	1277143	1277142

#### Secondary Suspension Springs

Coach type	INNER (Drg. No.)		OUTER (Drg. No. )	
AC-Chair car 1 <sup>st</sup> & 2 <sup>nd</sup>	1269513		1269514	
ACCN/EOG	1269513		1268836	
ACCW/EOG	1269513		1269514	
FAC/EOG	1269513		1269514	
Hot buffet car	1269513		1269514	
Power Car	Side 1	Side 2	Side 1	Side 2
	1277145	1268837	1277146	1268836

#### Coupling and Installation Instruction for Flexi Coil Secondary Springs

Please refer to FIAT-SIG technical specification No. 17.471, part document 101, and version 01 for coupling and installation instructions of flexi coil secondary springs.

#### Colour Coding of springs for Identification

For identification of springs to be used in different types of LHB Coaches, middle coil of the primary & secondary springs to be painted with compatible paint of springs indifferent colours indicated against each group as shown below:

(Ref: RCF's letter no. MD 23151 dt. 23.11.2002)

Primary Springs		Secondary Springs		Paint colour to be painted on middle coil
Inner	Outer	Inner	Outer	
1267412	1267411	1269513	1269514	Green
1277143	1277142	1268837	1268836	Yellow
-----	----	1277145	1277146	Blue
LG01101	LG01100	LG05100	LG05101	Black

The paint should be compatible with the paint of spring as specified in clause 8.3 of specification no. 17.248.100 version 05.

**Maintenance of springs**

Primary & secondary springs are protected against corrosion by a paint coating. This surface protection should remain undamaged, otherwise there can be local corrosion attack, resulting in spring failures.

**Trip Schedule (D1)**

Carry out visual inspection of springs for damages, corrosion, cracks or broken springs.

**Monthly Schedule (D2)**

Same as Trip schedule.

**Half Yearly Schedule (D3)**

Same as Trip schedule

**Shop Schedule I, II (18 Months/36 Months)**

- Clean the primary/ secondary springs thoroughly (with suitable detergent water jet) in disassembled condition.
- Inspect visually for any cracks, damages, corrosion and breakage.
- Any damage to coating may be repaired by primer and high build epoxy paint to RCF specification.
- If rust is visible, de-rust with the steel brush, and repair the coating as given above.
- In case of corrosion –pitting, cracks or breakage, replace the spring.

**Shop Schedule – III (72 Months)**

In addition to activities given under Shop Schedule –I, carry out the following-

- Testing of springs for free height (permanent set)
- Testing of spring for load/deflection characteristics as given in drawings and specification no. 17.248.100.
- Replace the spring, if free height/deflection is beyond permissible limits.

## PNEUMATIC SUSPENSION

It uses the properties of air for the cushioning effect (springiness). It is a proven technology on Indian Railways and is being used on EMUs for last many years. Now these have been introduced in mainline coaches with ICF bogies because it is technically superior in many ways.

- Provide better ride quality for passengers Ride index with air springs is 2.72 against 3.37 in steel coil springs (lower the ride index better the ride quality)
- Maintain constant buffer height even with dense crush load on the coaches •
- Improved reliability and less maintenance
- Isolation of structure borne noises
- Maintain one natural frequency at all speeds which reduces vibrations and in turn reduces passenger fatigue

To start with, these springs are being provided on hybrid coaches of Duronto rakes which have stainless steel body and conventional ICF bogies. Trials of air springs on high speed FIAT bogies of stainless steel coaches have also been completed with satisfactory results and in due course, all coaches will be provided with air springs.

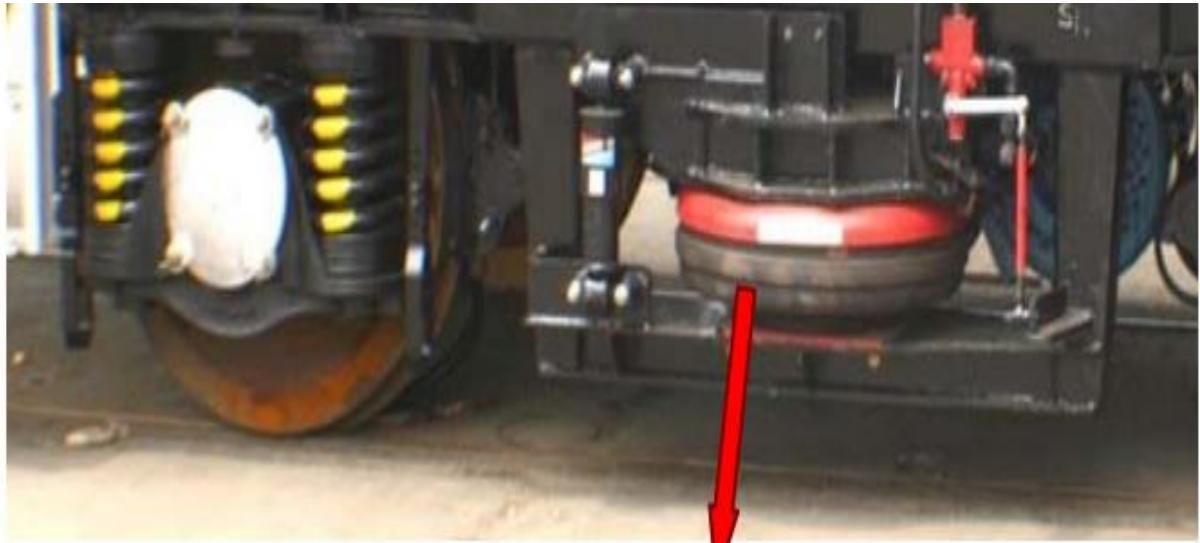
### Working principle of air springs

Air springs are basically pressurized air chambers made up of rubber bellows which maintain constant height under varying loads. The height of the air springs is controlled continuously by adjusting the air pressure in the bellows with the help of a load leveling device connected between the bogie frame and the base plate of air springs. The air springs replace only the secondary suspension, whereas primary suspension continues to use steel coil springs. An auxiliary air reservoir of 150 liters capacity is provided below each coach who is fed from feed pipe through a non-return valve. Maintains 7 bar pressure in loco compressor and air springs operate at a limiting pressure of 6kg/cm<sup>2</sup>.



### **Safety of operations**

The C&W staff at nominated passing staff should vigilantly see that all the bellows are in inflated condition. This can also be checked by seeing that the levelling valve lever is in horizontal position.



**Leveling Valve Lever**

The In case of heavy leakage or deflated air defective bogie is to be isolated with the help of isolation valves and driver should observe a speed restriction of 60 Kmph upto terminal point for maintenance. The air springs have inbuilt emergency rubber springs for safety with which train can work at a maximum speed of 60 Kmph up to a distance of 1000 kms.

# WHEEL SLIDE PROTECTION

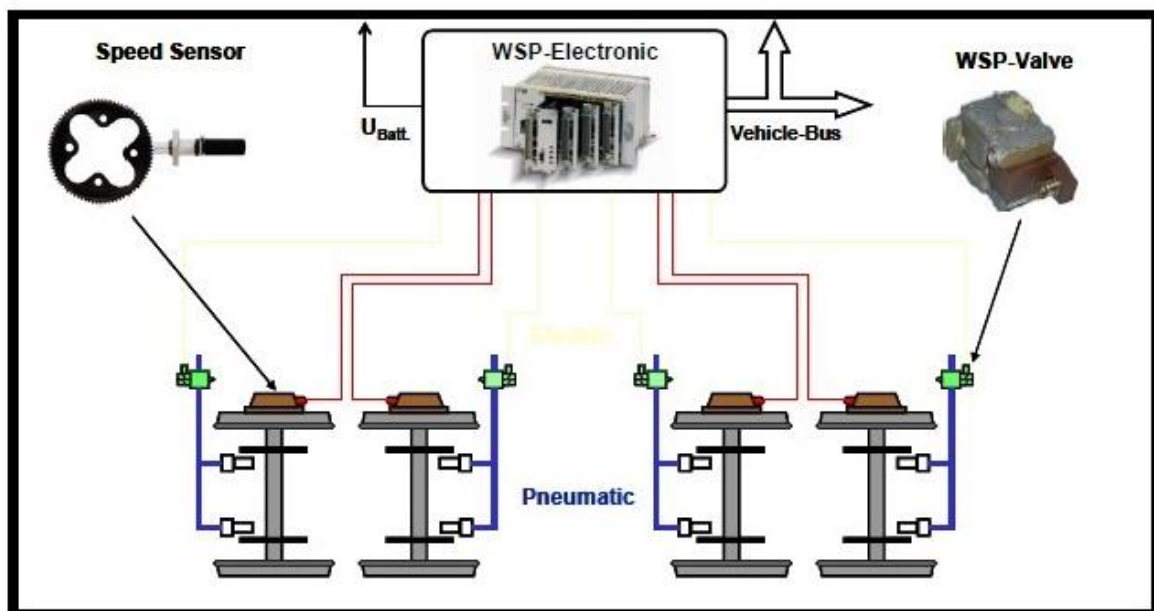
## INTRODUCTION

LHB coaches have been introduced in services on some of the premier trains on Indian Railways with state of art features. One of the important feature provided in these coaches are WHEEL SLIDE PROTECTION DEVICE (WSP).

Initially, coaches turned out by production units were having two types of WSP's namely supplied by (a) M/s Knorr Bremse India limited & (b) M/s SAB WABCO India ltd. During initial supplies Parrizi type processor was received with M/s Knorr Bremse air brake system whereas Sab Wabco with its own. During further developments, railways started using processors manufactured by M/s Knorr Bremse with its own air brake system & in the meantime, M/s Faiveley has taken over M/s Sab Wabco. Therefore, presently railways are having three types of processors (WSP's) in service:

- M/s Knorr Bremse India Ltd.
- M/s Knorr Parrizi India Ltd.
- M/s Faiveley India Ltd. (earlier known as M/s Sab Wabco)

After introduction in services, it is noticed that, performance of WSP specifically Knorr Parrizi system was not up to the mark & even firm was not able to give service support due to poor response from the OEM. In view of above, Parrizi type WSP are being replaced with Knorr Bremse system. Presently, railway is having mainly two types of WSP System. WSP control unit is a combination of various electronic cards. This unit is housed in electrical control panel units. This unit is connected by means of various cables through various equipment



## Working Principle

During the course of brake application, there are possibilities of skidding/sliding/locking of individual axle. In these cases adhesion between the rails & wheels plays vital role. Above situations are likely to cause damage to wheel sets with increased braking distance. The main purpose of using the WSPs is to utilize the available adhesion. The WSPs provided in the system avoids wheel sliding, also cuts the maintenance

cost. Speed sensors, the part of the system detect the speed of the wheel & sends signal to the processor unit.

The processor unit evaluates the received signal from speed sensor of the vehicle & generates signals enabling the dump valve/antiskid valves to control the brake cylinder pressure in case of any locking/skidding. The control on the brake cylinder pressure is instantaneous to the wheel to rail adhesion, keeping the wheels within their optimum range of skidding.

The WSP has some of the major parts.

- Speed Sensor.
- Phonic wheel.
- Microprocessor.
- Dump valves.
- Pressure switch.

# WAGON

## Introduction

For ensuring optimum performance of wagon fleet, it is necessary that:

- Preventive maintenance is given timely to avoid occurrence of defects.
- Defects are attended effectively and well in time so that the wagons remain fit for traffic use till the next schedule falls due.
- Detention during examination and repairs is kept to minimum.
- Frequent failures of similar nature are studied and necessary modifications/ design changes are effected to eliminate the cause of such failure.

While proper maintenance plays a vital role in ensuring effectiveness of the rolling stock, an equally crucial role is played by proper handling and careful operation of the wagon fleet so as to minimize the incidences of damage and subsequent need for repairs. Care must be taken to avoid bumping of wagons having CBC Knuckles in closed position. Proper release of brakes must be ensured. Cleaning of wagon interiors after unloading of corrosive, hygroscopic or other harmful consignments is necessary by unloading party and to be ensured by the commercial staff. Place free end of hose pipes on dummy carriers and couplings on suspension hooks.

## Main Parts of Wagon

- Under frame
- Body
- Bogie
- Brake gear arrangement
- CBC Assembly

## Under frame

The type and size of a particular under frame is intimately related to the type and design of a wagon, as it constitutes the main load bearing sub-assembly for the vehicle. The overall dimensions and design of this structure take into account the quantum and pattern of loading on the vehicles as well as the track considerations. This in turn determines the permissible wheel base and whether a four wheeler or a bogie wagon would be required for the purpose of carrying the required load. Accordingly, while designing an under frame, the loading per meter is also taken into account as this is to be permitted by the type of track available. The buffing and impact loads also govern the strength of the under frame and the shunting speeds permitted for the marshalling of the goods stock. In the case of bogie wagons, the load transfer to the bogie frame is by means of pivot arrangement and thus the bogie frame is by means of pivot arrangement and thus the bogie frame also assumes an equally important function.

## General Construction of BG Wagon under frame

The main members of a typical conventional BG wagon under frame are as under:

i.	Sole bars	ii.	Head Stock	iii.	Longitudinal channels
iv.	Cross bars	v.	Diagonal channels	vi.	Floor
vii.	Crib angle	viii.	End angle	ix.	Gusset plates
x.	Centre pivot	xi.	Transom		

The main under frame of a vehicle generally consists of two outer longitudinal members viz. Sole bars and the two head stocks which are strengthened by two middle longitudinal and various cross members. The diagonals and gusset plates protect the under frame against diagonal deflection and help in absorbing and distributing the buffing loads over different members. As already mentioned, the gusset plates and knees are provided at critical locations to impart additional strength to the joints. The whole structure is so designed that various loads are uniformly distributed and no single member has to bear excessive load than designed for.

Various rolled sections are used for the under frame members. Channel sections are generally used for headstock and sole bars for facilitating fitment of axle guards and buffers and Z-Sections are used for centre sills. Welding is generally used for joining the under frame members. But in earlier wagons, riveting had been used for joining these members. In the case of bogie wagons, the under frame has comparatively stronger cross members, known as bolsters. For fitting the upper centre pivot casting, which rests on the bogie pivot?

The under frame and all its members are necessarily to be true and square and these should conform to the manufacturing tolerances. All under frames are given an initial camber at the time of manufacture so that under actual loading conditions, these do not sag.

The under frame is main load bearing member in the vehicle which is not only subjected to static loads but also dynamic impacts owing to the unevenness in the track. In addition to this, it has to successfully withstand heavy buffing impacts during the course of marshalling as well as heavy jerks have to be sustained by the draw gear at the time of starting of goods trains. Hence in order to ensure safe and smooth running of vehicles, the maintenance of under frame has to be done very carefully.

It is therefore the duty of all supervisors both in workshops and divisions, to ensure that a thorough inspection of under frame is carried out at the time of POH. Other major repairs and all defects and deficiencies that come to notice must be given meticulous and thorough attention. The defects and deficiencies generally noticed together with recommended repair practices have been carried out.

### **Repair Procedure:**

**Cleaning and De-Rusting of the underframe:** The cleaning of the under frame and its fittings can be carried out after the wagon is placed on the trestles. Both the de-rusting and cleaning of under frame and its fittings can be carried out simultaneously. The members of the under frame are de-rusted by scrubbing and hammering so that it can be checked if any members are by heavily corroded or deformed requiring rectification. Badly bent members, which cannot be kept in service, are marked specially for replacement/application of suitable strengthening pieces. In case head stock pressings are badly damaged, these should be preferably replaced. It is also a good practice to keep stock of some spare head stock pressings to expedite the replacement and the damaged ones can then be brought into re-use after repairs in the blacksmith shops.

**Inspection of underframe:** At the time of POH, the under frame is to be inspected in respect of following points specially, as the under frame is the most important sub assembly of the wagon which imparts necessary rigidity to the wagon body as a whole.

- **Cracks:** The under frame is also inspected for any cracks. In case of a horizontal crack, it is drilled at both ends and the cracked portion gauged out and welded. In case of vertical cracks, patching strengthens the cracked portion.



- **Welding:** All welding joints are thoroughly clean and inspected properly.
- **Rivets:** All the rivets especially those of axle guard, scroll irons, head stock and knees joining the main members are checked for looseness. Ensure that these are not broken. All slack/broken rivets are to be replaced by sound ones at the time of POH but now a day's mostly rivet joints are replaced by welding joints.

### **Alignment of under frame**

The under frame is inspected for its proper alignment and any deflection of its members either in the form of sagging or buckling should be attended to or rectified. Since the alignment of the under frame has a very important role to play in guiding the wheels to run properly.

### **Repairs to Head Stock:**

- Slightly bent members or portions of them as the case may be, are heated in position by hack's burner and straightened by means of straightening devices or by applying blows with sledgehammer. For carrying out this repair, the buffer assembly is stripped off and if necessary, the floor plate which is riveted/welding to the head stock is gas cut and rivets punched out to facilitate the proper straightening of the bent portion.
- Stripping the heavily bent/damaged members and getting them straightened and aligned in the smith shop.
- All the under frame members are to be inspected as per IRCA Part III.

### **Repairs to Sole Bars:**

Sole bars are made from ISMC-250x9.0 web channel of copper bearing mild steel for all bogie wagons except on BOXNCR wagons where the channel is of IRSM-41 corten steel. Generally, damage to sole bar occurs at locations adjacent to head stock. It is repaired in the following methods:

- a. Cutting of entire sole bar portion and grafting a new portion prepared out of channel of the same section. Such type of replacement is always supported with double flanged U shaped sole bar patch, not less than 10mm thick and a back plate is to be also provided.
- b. Cracks at flanges and web are given proper repairs by electric welding as per instructions contained in IRCA part III rulebook and issued by authorities from time to time. Cracks extending up to webs are duly support with plain or flanged patch as the case may be.
- c. Slightly bent sole bars are, however, repaired by local heating and straightening. If the flanges are only bent, the same are straightened by a jawed crow bar.
- d. The patching has to confirm to IRCA part III rule no. 2.11.3.
- e. No patch shall be less than 10mm thick. Every patch shall be riveted to sole bar web and flange.
- f. The outer patch shall cover the full depth of the web and full width of crank flange, top & bottom of the sole bar.
- g. The inner patch shall cover full depth of the channel and shall be of the same length as per the outer patch to the extent possible.
- h. Where inner and outer patches cannot be fitted due to the presence of other fittings on the sole bar, only the outer or inner patch may be fitted. The thickness of the patch plate in such cases shall not be less than 10mm for metre gauge and 14mm for broad gauge wagons.

- i. The cracks in mild steel sole bar flange may be repaired by welding.
- j. Existing rivet holes shall be utilised for patch rivets.
- k. Additional rivets shall be of diameter not less than 16mm at a pitch of not more than 90mm.
- l. The length of the sole bar patch plate should not be less than 508 mm.
- m. Experience shows that on BG, the under frame of open wagon gets damaged more often than covered wagon because heavier loads are generally carried in open wagons. This also leads to higher incidence of damage during shunting in case of uneven loading or when the consignment is not secured properly inside the wagon.
- n. Generally pitting/corrosion on sole bar occur at doorways on open wagons. The provision of protection plates to sole bars at these locations, 3.15 mm thick copper bearing mild steel protection sheet is to be welded around the web below the door opening area if the thickness of the web has not been reduced by more than 2mm whereas by 5mm copper bearing mild steel plate if the reduction in the web thickness is more than 2mm but less than 5mm as the web thickness of the sole bar of ISMC 250x82 is 9mm, it concludes that any sole bar web found to be less than 4mm should be replaced.

# WAGON BODY

## INTRODUCTION

The superstructure attached to the under frame of wagon is called wagon body. It consists of body side and ends with their supporting structures such as stanchions, copings, roof structures, carlines; roof sheets in the case of covered wagons; hoppers and their supporting members in case of hopper wagons; tank barrels, cladding, if any, and supporting saddles in the case of tank wagons. Doors, door fittings, louvers for ventilation and various fittings such as cleats, handles, hooks, footsteps, hand brake wheel and ladders also form part of the body.

### General construction of Open Wagon

**Sides :** Sides are made up of side panels and side stanchions, which are attached to the under frame by crib angles, riveting strips or welding and side stanchions, they include top copings, intermediate copings if any, doors, door fittings, hand holds, tarpaulin cleats and label holder.

**Ends:** Ends are similar in construction to sides in that they consist of end panels, end stanchions, top copings and in some cases end shut stiffener, ventilator and intermediate coping. Attachment to the under frame is by means of end floor angles and through the stanchions. Corner stanchions connect the ends with the sides. Open wagons have reinforcing angles at each end together with reinforcing gussets and corner pressings at the corner.

**Doors:** Each side of the wagon is provided with door for manual unloading. The doors are hinged at the bottom with locking arrangement by chainless cotter at the top. In BOXN wagons two extra locking bolts per door have also been provided to avoid slipping of chainless cotter during tipping of wagon.

### General Construction of covered wagon

**Sides:** Sides are made up of side panels and side stanchions, which are attached to the under frame by crib angles, riveting strip/ Welding strips. They include top copings, doors, door fittings, and label holders, rain protection angles above swing doors, door striking plates and anti-bleeding device below the flap doors. Cattle wagons are also fitted with side louvers, breast bar fittings and wainscot boards.

**Ends:** Ends are similar in construction to sides in that they consist of end panels, end stanchions, top copings and in some cases intermediate coping. Attachment to the under frame is by means of end floor angles and through the stanchions. Covered wagons are provided with ventilators at the upper end of body ends. Corner stanchions connect the ends with the sides. Ends of cattle wagons include wainscot boards.

**Roof:** Roofs of covered wagons consist of roof sheets and carlines. Roof sheet are much thinner than the sheets used for the body sides and end panels.

**Door:** Each side of the wagon is provided with door for manual unloading. The doors consist of swing doors at the top with label holder hinged to the angles on the sides and flap doors at the bottom, hinged at the bottom with Anti bleeding device.

### Nature of Repairs required in Wagon Body

Apart from wagons involved in accidents or other serious mishaps, attention is normally necessitated because of the following defects:-

- Corrosion of panels, floor plates and roof sheets.

- Puncturing of panels due to improper loading, inadequately secured consignments or deliberate tampering.
- Bulging of ends due to shifting of loads.
- Tearing of panels, fracture of stanchions and shearing of rivets due to severe impacts, and shifting of loads.
- Corrosion of end floor angles and crib angles.
- Bulging of side usually occur after a prolonged period in service.
- Slackening of rivets due to the combined effect of ageing, corrosion wear and tear.
- Weakening of welded joints due to loss of weld metal by corrosion, wear and tear.
- Wearing out of door hinges.
- Damage to door fittings because of wear and tear or mishandling.
- Distortion of doors mainly because of mishandling.
- Failure of welded joints.
- Distortion or cracking of stanchions and other structural members because of abnormal loads, e.g., those due to defective clamping on tipplers.
- Wear or tear or breakage of miscellaneous fittings, such as ladders, label holder etc.

### **Corrosion in Wagon Body**

The corrosion of wagon floor and roof plates results from:

- Water logging in crevices and overlaps. This is accentuated if cleaning is neglected, since the accumulated dust and refuse retain moisture for a prolonged period.
- Contact of panels with residues from corrosive consignments e.g., salt, fertilizers etc.
- Spillage of corrosive fluids due to defective packing or rough handling.
- Escape of corrosive vapours from the consignment.
- Inadequate protection from weathering because of poor painting or inadequate surface preparation.
- The current practice is to paint only the exterior of the wagon body and not the interior, except for inside panels up to a height of 230 mm from floor, rivet seams and in the case of covered wagons, the swing and flap doors and the roof. The interior is left largely unpainted because paints have hitherto not been available which could withstand the constant scrubbing action of the consignment against the wagon walls. It is nevertheless a fact that most of the time corrosion originates from the interior of a wagon rather than the exterior.

### **Anti-corrosive Measures**

- The most important anti corrosive measure to be taken in day to day working is to ensure that the wagon is kept thoroughly clean and receives special attention in this respect after it has transported a corrosive or hygroscopic commodity.
- The second important step to prevent corrosion is to ensure that cleaning, surface preparation and painting are carried out with due thoroughness. The correct procedure to be followed in major maintenance schedules as per rule book IRCA part III. The procedure to be adopted at the time of minor repairs should come as close to this as practicable.
- While attending to miscellaneous repairs, panel patching or welding; it is important to ensure that surfaces in contact are well fitted to avoid water pockets. Due care is to be taken to clean and paint the affected surfaces to prevent corrosion by electrochemical action.

**Steps to prevent corrosion in wagons:**

- 1) For plates <4mm thickness, hot phosphating should be done. Then apply primer coat.
- 2) For plates >4mm short blasting should be done. Then apply primer coat to avoid rusting.
- 3) Thoroughly clean the weld affected area & coat with primer followed by red oxide.
- 4) Before painting follow the RDSO pamphlet no. 72 instructions.
- 5) Before welding thoroughly clean the welding surface to remove grease/ dirt to ensure good quality welding.
- 6) After welding, welding area with ½” more surrounding should be sand blasted followed by primer coating. Sand blasting relieves the thermal stresses produced during welding.

**Repairs to Bulged Ends**

If there are no serious damages to wagon ends other than bulging, the bulges can be effectively removed without dismantling. If two wagons with bulged ends are coupled together and a hydraulic jack is applied between them at the bulges, suitable packing being interposed between the jack and the wagon body. This method is particularly effective in dealing with dread-naught ends.

**Repairs to Body Structural Members (Stanchions, Carlines and Copings)**

Damages to these members are usually due to rough handling, heavy shunting impact or shifting of loads due to improper packing/stacking of the consignments. At first these components bulge out, but later even the rivets holding them to the under frame/superstructure members break out. It should be ensured that the bulging of these components does not cause infringements with the maximum moving dimensions of 1929mm. Bulging of these components by more than 25mm should be rectified. These components should be straightened without dismantling by pulling into correct position with the help of a chain and screw coupling or stripped and straightened either cold or by heating, as required and then riveted in position. Spot heating and cooling to straighten the stanchions can rectify bulging of all welded ends.

In certain cases, these components may have developed cracks, or may have broken in pieces. Such of these components should be repaired by welding both the pieces and applying a stiffener angle prepared by bending a 6mm plate in the shape of an angle with its outer faces sitting flush in the inner profile of the member to be patched and welding it all round to the member. Elongated holes in these components should be filled up by welding and refilled.

**Repairs to Doors and Door Fittings**

The main defects arising in doors are:-

- Distortion due to wedging or other mishandling.
- Jamming of hinges
- Excessive clearances in hinges
- Inadequate overlap between flaps and door leaves
- Gaping of doors at the stanchions
- Distortion or breakage of tower bolts
- Breakage of hinges and
- Damage to gravity cotters, hooks and hasps

Damaged doors covered wagons are responsible for a very large proportion of claims due to wetting or pilferage of consignments. Warpage of flap doors is often responsible for jamming of flap door hinges. Special care must therefore, be taken in attending to doors.

Distorted or bulged doors must be taken down and straightened to ensure proper fit. Worn out hinges are responsible for sagging or gaping doors and inadequate overlap. Such hinges must be replaced with new or reconditioned ones.

Bent door stanchions and depressed crib angles must be straightened to ensure free functioning of doors and prevent gaping. Corroded crib angles must be cut out and replaced. Graphite grease should be introduced in all hinges, sliding cotters and other working parts.

After repairs, doors must sit flush against striking plates with adequate overlap between leaves and without gaping at the stanchions or crib angles. Anti-bleeding devices and rain protection angles should also be checked and rectified where necessary.

In the case of hopper wagons, it should be ensured that when the doors are closed, no gap is left between the chute plate and frame, and that the operating gear works freely and is in good condition.

### **Water Tightening of Wagon**

Covered wagons must be kept watertight at all times. Covered wagons must be tested for water tightness at the time of leaving the workshop after POH or other repairs. All empty covered wagons attended to in sickliness, should also be tested for leaks, and made watertight by applying sealing compound. Before the onset of the monsoon season, a special drive should be instituted and sealing compound must be applied at all points of covered wagon bodies, which are likely to leak particularly peripheries of riveted patches other overlaps and small holes.

Before the application of sealing compound, mechanical defects such as bulged panels severely distorted body structural members, gaping joints, loose rivets and other corroded areas must be attended to. It should be ensured that the surfaces are clean and dry before sealing compound is applied. An attempt must not be made to fill up large gashes or other openings with sealing compound. Holes more than 6 mm in diameter should be filled by rivets. Irregular openings and cuts with more than 25 mm length and 3 mm width should be repaired by patching or welding after a wagon has been made watertight, it should be marked "WT" with station code and date on the left-hand bottom corner of both sides.

### **Cleaning, Surface preparation and Painting**

The correct sequences and procedure for cleaning, preparation of metal surfaces to be painted.

#### **Preparation of surface before painting**

- The purpose of cleaning is to remove dirt, oil, grease, rust and other contaminants, which would prevent the paint film from adhering to the metal or would provide a nucleus for commencement of corrosion.
- Cleaning by hammering, chiselling or scraping is unsatisfactory and should not be resorted to. The surface cleaning may be done by vigorously scrubbing with a stiff brush. All welded parts and adjacent surfaces should be thoroughly cleaned to remove residual alkaline flux.
- A coat of priming paint should be applied immediately after the surface has been cleaned and dried. A delay of more than 4 hours may result in development of fresh rust on the surface. A second coat of primer must be given when the first coat is dry.

Painting must be done under cover in a shed or shop. The painted surfaces must remain under cover until the paint is dry.

- Panel patches and riveting strips must be cleaned, as prescribed above, and given two coats of primer before storage of fitment.
- After completion of all repairs a final coat of finishing paint should be given to all painted surfaces.
- When the paint film is only partially damaged, it should be touched up with one coat of primer and then given the finishing coat.
- Surface, which will become inaccessible after assembly must be given complete painting before assembly.

#### **Important Precautions to be taken while carrying out welding**

Welding entails the risk of fire if combustible materials are present near the area being welded. To prevent such accidents, the following precautions must be taken:

##### **Loaded Wagons:**

It should be ensured that the content is not inflammable. Should the contents be inflammable they must be transhipped before welding is attempted. Tank wagons should never be welded when loaded.

##### **Empty wagons**

It should first be ensured that no portion of an inflammable consignment packing material or tonnage is present in the area to be welded.

Empty tank wagons should be given welding repairs only in depots specially equipped for this purpose and only after thorough steam cleaning and testing to ensure that there are not inflammable/explosive vapours left.

##### **Wagons fitted with roller bearing**

No welding should be attempted without effectively earthing the member or component to be welded. Neglect in taking this precaution will result in passage of the return current through the roller bearing, which may suffer severe damage leading to premature failure.

## BRAKE GEAR COMPONENTS

Details of components & assemblies used in various types of brake rigging arrangements are given below.

- |   |                                   |
|---|-----------------------------------|
| 1. End Pull Rod                         | 12. Long Pull Rod                 |
| 2. Equalizing Lever                     | 13. Control Rod With Head         |
| 3. Push Rod                             | 14. Horizontal Lever              |
| 4. Brake Beam                           | 15. Empty tie Rod with Sleeve Nut |
| 5. Brake Head Assembly                  | 16. Loaded Tie Rod                |
| 6. Brake Beam Hanger                    | 17. Empty Load Device             |
| 7. Brake Block                          | 18. Hand Brake Pull Rod           |
| 8. Brake Shoe Key                       | 19. Hand Brake Arrangement        |
| 9. Brake Wear Plate                     | 20. Slack Adjuster                |
| 10. Brake Gear Pins , Washers , Cotters | 21. BMBS assembly                 |
| 11. Short Pull Rod                      | 22. AMPD                          |

### Air Brake System

Types (On the basis of release)

- 1) Direct Release ABS
- 2) Graduated Release ABS

On the basis of No. of pipes.

- 1) Single pipe
- 2) Twin pipe

Single & graduated release. ABS consists of following components.

- |                                     |  |
|-------------------------------------|--|
| 1. Distributor Valve DV             | 7. Cut off Angle cock                          |
| 2. Common Pipe Bracket With CR      | 8. Air Brake Hose (Ø32mm for BP)               |
| 3. Auxiliary Reservoir 100 Litres   | 9. Brake Pipe (Ø32mm)                          |
| 4. 3 Way Centrifugal Dirt Collector | 10. Branch Pipe BP to Brake Equipment (Ø32mm ) |
| 5. Isolating Cock                   | 11. Guard Emergency Valve                      |
| 6. Brake Cylinder (ø355 mm dia )    | 12. Pressure gauges for BP                     |

### Sub-Assemblies of Air Brake:

#### Common pipe bracket:

- Common pipe bracket to fix to base frame permanently.
- The Distributor valve along with intermediate piece (sand witch) which houses the isolating cock is mounted on one face of the common pipe bracket.
- The control reservoir is mounted on the other face of the common pipe bracket.



- The common pipe bracket has been evolved with the purpose of making it suitable for use with a make of DV adopted on Indian Railways.
- It is a sturdy casting with internal air passages, matching the intermediate piece mounting face with accurately profiled air cavities & flanged ports leading to appropriate ports of DV.

#### **Intermediate piece: (Sand witch piece)**

- It serves the purpose of blanking all the other ports on the common pipe bracket from front face other than required for a particular make of DV.
- Intermediate piece is mounted on the common pipe bracket face with a common gasket & DV is fastened to the intermediate piece. Isolating cock for DV, which is housed in the intermediate piece, is for isolating the DV in case of malfunctioning/ for disconnecting the BP pressure.
- IC on intermediate piece has venting arrangement.

#### **Brake pipe hose**

In order to connect two successive wagons, the brake pipes (BP) installed on the under frame are fitted with flexible hoses. (BP hoses)

#### **Brake pipe coupling**

- To connect subsequent wagons, the hoses of BP are screwed to coupling hose nipple by means for SS “Bend it” type clips.
- The coupling is specially designed in the form of palm end coupling.
- For easy identification the couplings are engraved with letter BP & coupling heads are printed green.

#### **Cut off angle cock**

- Cut off angle cocks are provided on the ABS to facilitate coupling & uncoupling of air hoses (i.e. BP)
- When the handle of the cut off angle cock is placed in closed position it cuts off the passage of compressed air, thereby facilitating coupling & uncoupling action.
- The cut off angle cock consists of two parts viz cap & body which are secured together by bolts.
- The cap & body together hold firmly the steel ball inside it, which is seated on rubber seat.
- The ball has a special profile with the provision of a groove at the bottom portion for venting the air to atmosphere.

#### **Brake cylinder**

- On every wagon fitted with ABS one brake cylinder is provided for actuating the brake rigging for the application & release of brakes.
- During application stage the brake cylinder receives pneumatic pressure from auxiliary reservoir after being regulated by the DV.
- There after brake cylinder develops mechanical brake power by outward movement of it is piston assembly.
- To transmit this power to the brake shoe the push rod of the piston assembly is connected to the brake shoe through a system of levers to amplify & transmit the brake power.

- The cylinder body is made out of CI & carries the mounting bracket, air inlet connection ribs & flange.
- The piston is of CI having a groove in which piston packing is seated.
- The piston packing seats the air flow from the pressure side to the other side & is guided by a wear ring.

#### **Dirt collector:**

- It protects the DV & AR by trapping the dust & foreign matters from compressed air before it enters into the DV & AR.
- This action is achieved by centrifugal action.
- The air entering the dirt collector from BP is guided through suitably shaped passage in dirt collector body to produce centrifugal flow.
- The air is filtered through additional filter assembly.
- The dirt contained in the air descends down & gets deposited in the dirt chamber.

#### **Auxiliary Reservoir:**

- It is actually a pressure vessel & its function is to feed dry compressed air to the Brake cylinder for application of brakes.
- AR is a cylindrical vessel made of sheet metal with flanges provided on both ends for pipe connections.
- One end of AR is connected to BP through DV.
- AR is charged through BP through DV upto 5 kg/cm<sup>2</sup>.
- AR has drain plug at bottom to remove moisture/ condensate.

#### **Slack Adjuster: (Brake Regulator)**

- It is a device provided in the brake rigging for automatic adjustment of clearance/ slack between brake blocks & wheels.
- It is fitted into brake rigging as a part of mechanical pull rod.
- The slack adjuster is double acting & rapid working. (i.e. it quickly adjusts too large/ too small clearance to a predetermined value known as (A) dimension).
- The slack adjuster maintains this (A) dimension throughout its operation.
- The slack adjuster, type IRSA 800 used on wagons is composed of following parts.
  - (a) Adjuster spindle with screw thread of quick pitch (non self locking).
  - (b) Traction unit containing adjuster nut, adjuster tube & adjuster ear etc.
  - (c) Leader nut unit containing leader nut & barrel etc.
  - (d) Control rod with head.

#### **Distributor Valve:**

- DV is the most important component of Air Brake System ( Heart of ABS).
- It's function is to distribute compressed air received from brake pipe to AR & CR.
- In addition to this it also sense drop & rise in BP pressure for brake application & release respect.
- It is connected to BP through branch pipe.
- Various other components connected to DV are AR, BC & CR.

#### **Designs of DV are in use on wagons**

- 1) C3W type DV
- 2) KE type DV

At present KE type DV is used in new wagons.

### **Sub assemblies of KE type DV**

- The KE type DV consists of following main subassemblies.
  - a) Three pressure valve
  - b) U controller
  - c) R charger.
  - d) Choke cover
  - e) Minimum pressure limiter
  - f) Maximum pressure limiter
  - g) A controller
  - h) Quick release valve

### **Air brake Hose coupling:**

- To connect BP & FP air brake hose coupling is used.
- BP coupling hose's coupling head are exact reverse in design to same of FP.
- BP is marked with "BP" & green colour whereas FP with white colour.

# BOGIE MOUNTED BRAKE SYSTEM (BMBS)

## INTRODUCTION

In the air brake system, a lot of developments have taken place such as bogie mounted Air brake system, Twin pipe air brake system, Automatic load sensing device etc. Recently, Bogie mounted Brake System (BMBS) has been introduced for freight stock. The details and maintenance of BMBS are given below:

## DESCRIPTION OF BMBS

The Bogie Mounted Brake system (BMBS) equipment consists of a transversely mounted pneumatic Brake Cylinder with a self-contained, double acting slack adjuster, two brake beams, and two bell crank levers and interconnecting push rods. The hand brake arrangement is available as a mechanical model with two flexible handbrake cables. The pneumatic Brake Cylinder is 10" in diameter for application with high friction brake shoe (K type) on CASNUB type bogies. The system consists of a unique design with two pneumatic Brake Cylinder (one per bogie) to deliver reliable braking performance and is light in weight. It fits into CASNUB bogie and uses 58 mm thick brake shoes.

Brake cylinder contains an integral double acting slack adjuster, which provides optimum braking force and minimizes shoe & wheel wear. The design is with high strength and minimum brake beam deflection.

## WORKING DESCRIPTION OF BMBS

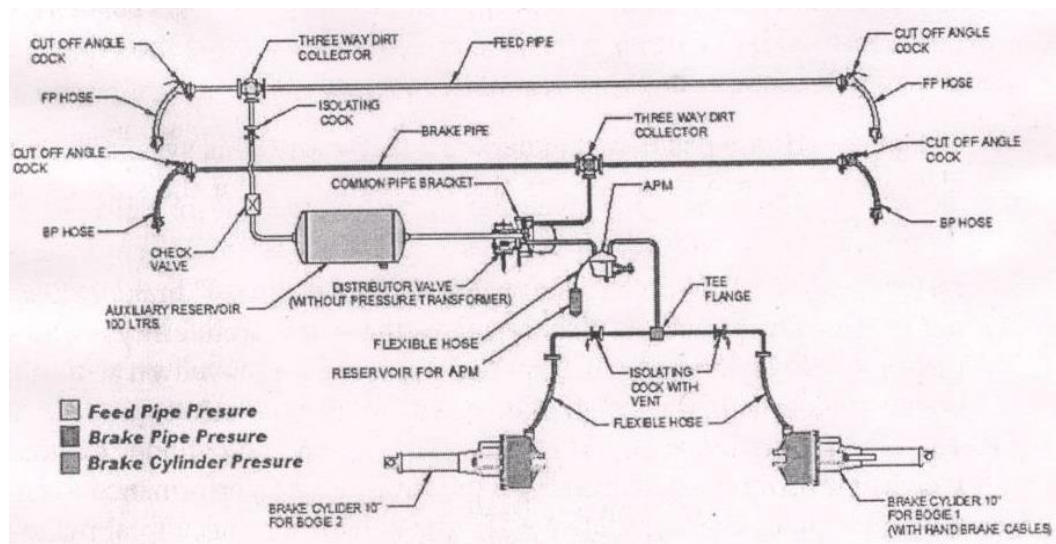
During application, the air is introduced into the brake cylinder, which forces out the piston along the ram assembly. The brake cylinder is floating in nature, as result the brake cylinder extends equally on both the sides. This extension of brake cylinder causes the rotation of the bell crank levers on their pivot (which is on primary brake beam) and forces the push rod to move towards the secondary beam. This movement causes the secondary brake beam to move towards the wheels and apply force on the wheels. Simultaneously a reaction force is developed which causes the primary brake beam (along with levers and brake cylinder) to move towards the wheels. The primary brake beam continues to move until it touches the wheels and apply force on the wheels.

When the brakes are released, the air from the brake cylinder is exhausted to the atmosphere through the Distributor valve. The return spring inside the brake cylinder pushes the piston along with the ram assembly back to its original position. The bell crank levers rotate back, causing the beams to move back to their earlier positions. The brake cylinder is equipped with a double acting slack adjuster. If there is any wear (Brake Shoe/Wheel) or any slackness in the structure, it will be automatically compensated by the built in slack adjuster which pays out to fill the gap.

## SALIENT FEATURES

**More Safety:** Two nos. of 10" brake cylinders with inbuilt double acting slack adjuster have been used per wagon. Along with this an automatic load-sensing device has been used for two stages braking (empty / loaded). This delivers optimum braking performance and hence increases safety parameters.

**Reliability :** Instead of one 14" cylinder, two 10" cylinders have been provided per wagon (one per bogie)., This increases the system reliability as in case of failure of one cylinder the wagon can be moved on another cylinder with the isolation of failed cylinder.



## ADVANTAGES OF BMBS

1. Low Maintenance cost
  2. Low Fitment cost
  3. Low Pay load cost
  4. Easy Retro fitment
  5. Simplified Hand Braking Installation
  6. Replaceable Brake Heads
  7. Integral Double Acting Slack Adjuster
  8. Patented Beam Design
  9. Under Bolster Design
- BMBS is reduces bending loads in the beams, enabling the use of lighter structure with no sacrifice in the performance. The brake cylinder is mounted parallel to the brake beams and transfers forces through the bell cranks. This parallelogram design improves the efficiency and aligns the braking forces with the wheels, which reduces the shoe and wheel wear.
  - The system delivers optimum braking performance while minimizing weight.
  - The system can be easily fitted on any IR standard CASNUB bogie without making any modifications. This is a drop in fit system and does not require any special tools and training for installation/assembly.
  - To achieve uniform wheel loading, the loads are applied to the ends of the brake beam instead of centre.
  - The system uses IR standard 58 mm thick K type brake blocks.
  - A replaceable brake head design permits the reuse of the beam in the event that the brake heads gets damaged. Replacement of the brake head is quickly accomplished by removal of only one pin.
  - The push rods are positioned under the bolster. With this system the track clearance has been increased, as there is nothing under the spring plank of the bogie.
  - Instead of one 14" cylinder, the system uses 2 nos. of 10" brake cylinders per wagon, one per bogie. This increases the system reliability as in case of failure of one brake cylinder, the wagon can be moved on with other brake cylinder with the isolation of failed brake cylinder.

- The integral double acting slack adjuster of the brake cylinder maintains a constant piston stroke resulting in uniform brake performance even as the brake shoes and wheels wear. The slack adjuster has a total make-up capacity of 500 mm, which will compensate for total combination of shoe wear, wheel wear and clearance.
- Re-screwing of slack adjuster is automatic and can be done from the side of the wagon by a pry bar.
- All cylinders are equipped with an automatic piston stroke indicator.
- The hand brake systems uses two steel hand brake cables pulled through standard hand brake rigging as a means to apply the hand brakes. The cables provide a flexible and lightweight interface to the hand brake actuator.
- Simplified installation and even shoe wear helps extend the turn round time between wagon maintenance intervals.
- The system also has an automatic pressure modular (APM) device (EL-60 valve) for two stage braking (empty / loaded). It is fitted between wagon under frame and the bogie side frame.

## APM Device (EL-60 valve)

APM device is interposed between bogie side frame of CASNUB bogie and the under frame of the wagon. It is fitted for achieving 2-stage load braking with automatic changeover of brake power. Only one APM is required per wagon. It restricts the brake cylinder pressure coming from the Distributor valve to  $2.2 \pm 0.25$  kg/cm<sup>2</sup> in empty condition of the wagon and allows the brake cylinder pressure of  $3.8 \pm 0.1$  kg/cm<sup>2</sup> in loaded condition of the wagon. The sensor arm of the APM device comes down for sensing only during the brake application.

The complete movement of the sensor point is 104 mm. The first 80 mm of the sensor point is for the loaded zone and the balance is for the empty zone. The deflection of the bogie from tare to changeover weight is added to 80 mm to arrive at the total movement of the sensor point to be adjusted on the wagon. The gap between the sensor point and the bogie is to be measured at the point it touches the top surface of the side frame. Also ensure that the sensor point touches in the middle of the side frame.

It has an indicator to show the empty or loaded position. Whenever the indication is "ON" i.e., it is showing the orange colour, it is indicating the empty condition with brake cylinder pressure of  $2.2 \pm 0.25$  kg/cm<sup>2</sup>. When there is no indication in the indicator, it is loaded condition with  $3.8 \pm 0.1$  kg/cm<sup>2</sup> going to the brake cylinder. It has a quick connect socket to connect the gauge to the check the pressure through the pressure gauge.



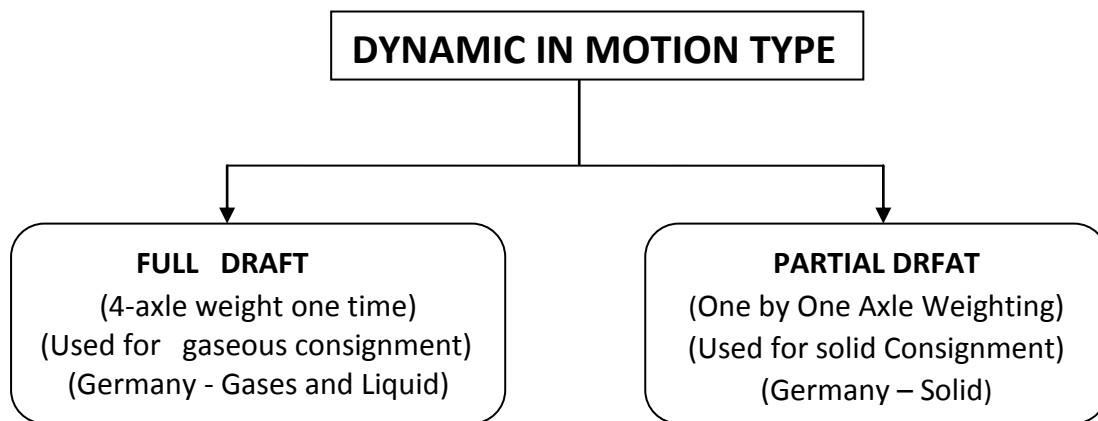
# WEIGH BRIDGE

## It is of two types

1. Static weighing bridge
2. Dynamic weighing bridge

## WEIGHMENT

It may be defined as a mechanical process by which one can measure the weight of any item. Whenever we weigh any item be it in motion or static or if it is being weighed on different machines its weight will remain same i.e. whatever be the way of weighing weight will remain the same.



**Full Draft:** - The whole wagon is being weighed together.

**Partial Draft:** - In this axle by axle weighing is done. Generally static weighing bridge is more accurate than dynamic ones.

**EIMWB** -(Electronic In motion Weigh Bridge) In Indian Railway weighing is done at 15 kmph.

## BASIC COMPONENT OF WEIGH BRIDGE

1. Weigh zone / Weigh rails
2. Junction Box
3. Digitalized / Control panel / Analogue to Digital Converter
4. Weighing PC / Software printer
5. Power Quality Improver, stabilizers, UPS, Surge protection
6. CPU, 7 Digitizer, Track switch. Lamp post

## FACTS REGARDING USE OF WEIGH BRIDGE

1. Reference Wagon
2. Scale interval
3. Accuracy classes
4. Maximum permissible

## CALIBRATION

It means to correct or adjust the graduations of something that measures, in comparison to a certain standard. E.g. calibration of a pressure gauge.

## Factors affecting calibration

1. Selection of Gauge
2. Allowances of measurement
3. Duration of calibration

### Factors affecting Weighment

1. Calibration
2. Preciseness
3. Accuracy
4. Least count

### RF WAGON

It is that wagon whose weight is known and which is being used to test IN MOTION WEIGH BRIDGE. In other words it is that weight which is being used to test and improve Weigh Bridge.

### SCALE INTERVAL

It is the least count between the two graduations on the weighing scale. It is also known IMB's scale interval in other words. In Indian Railway IMB's scale interval for 120 ton is 100 kg.

### ACCURACY CLASSES OF MEASUREMENT AND MAXIMUM PERMISSIBLE ERROR

Accuracy Class	Percentage of single wagon or total train as appropriate	
	During Verification	During Inspection
0.2	$\pm 0.10\%$	$\pm 0.20\%$
0.5	$\pm 0.25\%$	$\pm 0.50\%$
1	$\pm 0.50\%$	$\pm 1.00\%$
2	$\pm 1.00\%$	$\pm 2.00\%$

### BACK LOAD TEST

Run 75% train over the weighing instrument than stop the train and reverse the train & than check the reading both as same or not. It called back load test or anti roll trade test.

### LOAD CELL

It is an electronic device which is classified under force transducer. It converts force or weight into electronic signal.

Its advantage is that it is not mechanized. It maintains accuracy of 0.03% to 0.025%. A strain gauge is attached to load cell. When no load goes into weighing zone then in wheat stone bridge the strain gauge provides equal resistance and when load comes in weighing zone then bridge generates signal in mV.

This bridge circuit also send electronic signal to CPU which is according to the load on strain gauge. The strain gauge measures shear stress.

### Function of DIO Card

It senses the signal from track, switches and send out put to lamp post and alarm.

### Function of OP Card:-

It provides power through switches, contents lamp post & track switches.

### Function of OPTO Card

It provides isolation of track. Switch inputs and outputs to lamp post.



# **SWING MOTION BOGIE**

## **INTRODUCTION**

CASNUB bogie as freight track is introduced in Indian Railways in the year 1981 under BOXN Wagon. Before this, it was tested in 1972 under BOI wagon. Since then CASNUB types bogies are used as freight track in Indian Railways for enhancement of speed, improve mention pay to tare ratio and low maintenance.

A contract between M/s ASF KEYSTONE Inc. USA and Indian Railways has been made to supply of track friendly bogie with transfer of technology. This is a two axle three piece cast steel bogie. The bogie is designed in such a manner that pivoting at two place to provide swing motion feature. The side frame, Bolster and transom are design for 32.5 t axel load. They will apply 25 t axle load bogies its capacity can be elevated to 32.5 t axle load by changing its spring nest of suspension.

## **SALIENT FEATURE OF SWING MOTION BOGIE**

- Two axle three pieces cast steel bogie.
- Swing motion feature.
- Maximum swing of bolster 32mm in two stages.
- Speed 110 KMPH.
- Pivoted surface between the pedestal and adopter.
- Pivoted surface between the spring seal and rocker assembly.
- Bogie Mounted brake system.
- Spring loaded constant contact side bearers.
- Wheel base 1880 mm.
- Journal centre 2248 mm.
- Diameter of wheel 965 mm (new) & 920 mm (old).
- Bottom of centre pivot height from rail level 635.7 mm.
- Height of Side Bearer from rail level 774.3 mm
- Bogie Stiffness 715.16 kg/mm.

## **AXLE AND BEARING**

- Type of Bearing AAR Std. class “M” 7’ x9”
- Axle Aar M 101 Grade F
- Journal size 165.2 mm Dia.
- Journal Centre 2248 mm
- Adapter a type Class M

## **WHEEL**

- Diameter of the wheel 965 mm.
- Condemning diameter 920 mm.
- Wheel profile WWP.
- Rim thickness 127 mm.
- Flange thickness 28.5mm.
- Condemning size of flange thickness 23.8 mm.

## **SWING MOTION MECHANISM**

- Swing motion bogie design has two stage lateral suspensions.
- Pivoting surface between the pedestal and the adopter.
- Pivoting surface between the spring sheet and the rocker assembly.
- In this arrangement the wheel gets decoupled from the mass of the wagon and van flange heats the rail, the mass behind the contact is the mass of the wheel and not the mass of whole wagon.
- Lateral force between wheel and rail also wheel and rail wear get reduce considerably.
- Point of application of lateral forces is lowered from the height of conventional bolster gives to the height of spring sheet, reducing the wheel uploading considerably.

## **ADVANTAGES OF SWING MOTION BOGIE**

- Improves Curving Performance.
- Improves Ride Quality.
- High speed Stability and Axle-to-Rail alignment.
- Reduces Rolling resistance.
- It provides a longer bogie and rail life.
- Excellent wheel load equalizing ability.
- Increase Velocity.
- Reduce Wheel Wear.
- Prevent Hunting.
- Reduce Track wear.
- Reduce Component wear.

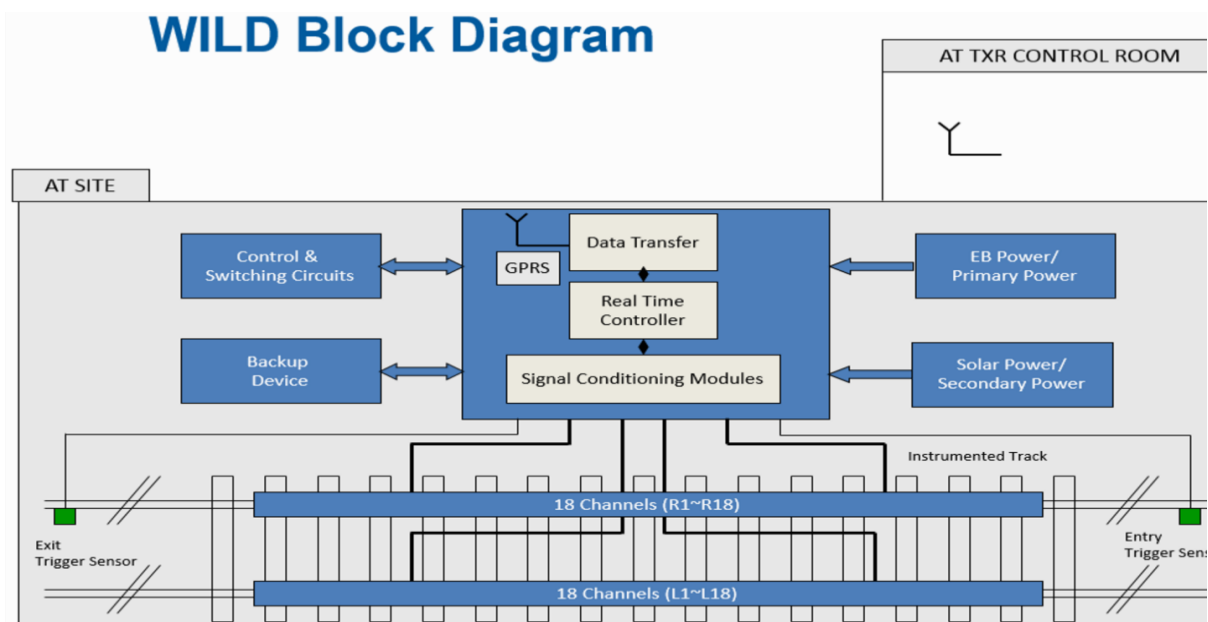
# WHEEL IMPACT LOAD DETECTOR (WILD)

## REQUIREMENT OF WILD

- Defective rolling stock produce high impact loads.
- These loads over a prolonged period of time leads to Rail/Wagon failure, wheel bearing failure etc.
- WILD measures the impact load independent of the cause.
- WILD system assists the railway engineer to attend to the defective rolling stock immediately.
- Reduces Service Failures and Unplanned Maintenance Cost of Rolling Stocks & Tracks.
- WILD is used to catch the defects in the early stage and thereby protecting Rail Infrastructure & avoids Catastrophic Failures.

## DEFECTS THAT CAN CAUSE HIGH IMPACT LOAD

- Uneven loading
- Coil spring weak
- Shell Tread
- Friction liner broken
- Snubber spring broken
- Axle box canting
- PU/CC/EM Pad Shifted/Pressed/Perished
- CC housing broken
- S/Bearer roof/Friction Liner welding open
- Bolster tilted one side
- Defect in suspension
- Broken spring
- Skid mark, etc



## **MEASURING CONCEPT OF WILD**

- WILD uses instrumented rails.
- The spaces between sleepers are instrumented using strain gauges and any load that appears in the effective zone is considered.
- Various such measuring zones are formed along the track.
- The maximum load measured in the entire instrumented portion is treated as the impact load.
- As wheel rolls over the rail various portions of the wheel fall in the effective zone and dead zone (sleepers).
- As a result various diameters of wheel have different coverage.
- The instrumented portions can be determined and prepositioned to give best coverage for the wheels of interest.
- Once installed the system's wheel coverage pattern does not change.

## NEW DESIGN WAGON

- BOXNHL
- BOXNEL

RDSO has designed a new open wagon type BOXNHL (HL stands for higher load) of 22.9.T axle load.

- This is the first all stainless steel open wagon.
- It was designed by RDSO in year 2006.
- Railway board has placed orders for procurement of 4280 BOXNHL wagons in Nov.07.
- First prototype BOXNHL wagon was manufactured & tested in Sept.08.
- This wagon has following main features compared to BOXN wagon.
- Increased pay to tare ratio- 3.45 (v/s 2.5 of existing BOXN (CC))
- Increased rake throughout (22.25% increase over rake of BOXN(CC))
- Corrosion resistant (Body & under frame of stainless steel to IRS:M-44)
- Brake system, brake rigging & brake cylinder different from BOXN.
- Slack adjuster of 750 mm capacity compared to 600 mm in existing wagon.
- Length 250mm more & width 50 mm more compared to existing BOXN wagon.
- Coupler & draft gears procured from AAR approved sources.
- Bogie having flat centre pivot & 'K' type CBB.
- Lock bolting (instead of riveting).
- PU Paint (instead of alkyd paint).

### Main Parameters

S No	Parameters	BOXNHL	BOXNHS/BOXN
1	Tare weight (design) in tones	20.6 t	23.2 t
2	Payload in tones	71 t	58.08 t (cc)
3	Gross weight (tones)	91.6 t	81.28 t
4	Axle load	22.9 t	20.32 t
5	Volumetric capacity (without heap loading)	61.05 m <sup>3</sup>	56.29 m <sup>3</sup>
6	Length over buffers	10963 mm	10713 mm
7	Length over headstock	10034mm	9784 mm
8	Overall width	3250 mm	3200 mm
9	Inside width	3022 mm	2950 mm
10	Overall, height	3301 mm	3225 mm (at corner 3233 mm)
11	Inside height	2028 mm	1950 mm
12	Number of wagon in 636 meters length.	58	59

## Super structure

S N	Parameters	BOXNHL	BOXN /BOXNHS
1	Centre sill	Fabricated from 'z' section @ ends (IS:2062 2006 E 410Cu) & CRF section at middle (IRSM44)	Std 'z' section (IS:2062-2006 E 250 cu)
2	Stingers (Longitudinal)	CRF (IRSM44) channel section 100x51x4mm	ISMC 100x50x4.7mm (IS:2062-2006 E250 Cu)
3	Cross stringer (Cross members)	Fabricated sec. of IRSM 44	Fabricated section of IS:2062-2006 E 250 Cu.
4	Sole bar	CRF (IRSM44) channel sc. 204x76x6mm	ISMC 250x82x9mm (IS:2062:2006 E 250 Cu)
5	Head stock	Fabricated from IRSM 44 steel	Fabricated IS:2062-2006 E 250 Cu.
6	Side stanchions	Fabricated from IRSM 44 steel	Fabricated IS:2062-2006 E 250 Cu.
7	Side body sheet	4mm thickIRSM 44	5 mm thick IS:2062-2006 E 250 Cu.
8	Middle copings (lower & upper)	Fabricated of CRF angle Sec (IRSM 44) 71 x40x4 mm & Plate 4 mm thick. (IRSM 44)	ISMC 100x50x4.7mm IS:2062-2006 E 250 Cu.
9	Side top coping	Fabricated box section of CRF (IRSM44) channel 110x75x7mm plate (IRSM 44)	Fabricated box section of ISMC 125 & Plate 6 <sup>th</sup> of IS:2062-2006 E 250 Cu.
10	Doorway stiffening cross bar	Fabricated box section of CRF (IRSM44) channel sec. 145x36x4 with 4mm plate. (IRSM 44)	Fabricated of pressed channel sec. 145x34x6 with 6mm Plate of IS:2062-2006 E 250 Cu.
11	Door	Fabricated of CRF (IRSM44) channel sec. 48x36x4 with 4mm plate. (IRSM 44)	Fabricated of pressing and Plate of IS:2062-2006 E 250 Cu.
12	Corner stanchion	IRSM 44 angle sec. 110x110x8	100x100x10 IS:2062-2006 E 250 Cu.
13	End Stanchions	CRF Hat sec (IRSM 44) 200x125x4	ISMC 150 with 6.5 web of IS:2062-2006 E 250 Cu.
14	End top coping	Fabrication from 2 CRF channel sec. 170x75x4 thick (IRSM 44)	ISMC 150 with 6.5 web of IS:2062-2006 E 250 Cu.
15	End body sheet	4 mm thick IRSM 44	5 mm thick sheet of IS:2062-2006 E 250 Cu.
16	Floor plate	4 mm thick IRSM 44	6mm thick of IS:2062-2006 E 250 Cu..
17	Bolster	Fabricated box section (IRSM 44)	Fabricated box section of IS:2062-2006 E 250 Cu.

## Air brake system

S No	Parameters	BOXNHL	BOXN /BOXNHS
1	Total brake block force (in empty condition)	9343 kgs.	18900 kgs.
2	Total brake block force (in loaded condition)	18955 kgs.	33642 kgs.
3	Brake percentage	44.9% (E) 20.7% (L)	86.5% (E) 41.4% (L)
4	Brake cylinder diameter	355 mm	300 mm
5	Slack adjuster	IRSA 750	IRSA 600
6	Length of slack adjuster (in fully extended condition)	2615 mm	2315 mm
7	Length of control rod	1405 mm	1255 mm
8	‘e’ dimension	515-585 mm	550-600 mm
9	Auxiliary reservoir	75 litres	100 litres
10	Empty load box	S x = 25	Sx = 10
11	Long pull rod	1536 mm	1518 mm
12	Short pull rod	758 mm	870 mm
13	Empty tie rod	891 mm	880 mm
14	Loaded tie rod	928 mm	916 mm
15	Length of slot (straight portion) in loaded tie rod.	62 mm	40mm
16	Horizontal lever distance of empty tie rod bole from bole connecting with brake cylinder	810 mm	335 mm
17	Horizontal lever distance of loaded tie rod bole from bole connecting with brake cylinder.	458 mm	458 mm

## Bogie

It is having CASNUB 22 HS bogie fit for 22.9 t axle load.

S No	Parameters	BOXNHL	BOXN /BOXNHS
1	Brake beam	With brake head for ‘k’ type CBB	With brake head for type CBB
2	Brake block	‘k’ type	‘L’ type
3	Centre pivot	Flat pivot	Spherical pivot

## Coupler and Draft Gear

S No	Parameters	BOXNHL	BOXN /BOXNHS
1	Coupler specification	WD-66-BD-06	48-BD-08
2	Draft Gear specification	WD-66-BD-06	49-BD-08

Item	Name of manufacturer	Model	Marking code
Coupler	ASF-Keystone, USA	E/F	K
Coupler	Mc Conway & Torley USA	E/F	M
Draft Gear	Wabtec USA	MK-325	X
Draft Gear	ASF-Keystone, USA	F325G	B
Draft Gear	Miner	SL7C	L

### Cutting & Welding

Superstructure of wagons is made of IRSM44 to IRSM44.

### Precautions during cutting & welding of Superstructure

**Cutting:** Use only plasma cutting. Do not use oxyacetylene cutting.

### Welding:

Material to be joined	Welding consumables to be used								
	MMAW as per IRS M-28.27		MIG/MAG welding filler wires as per IRS M-46-03				Wire & flux for SAW as per IRSM-39-01		
	IRS Class	AWS code	IRS Class	AWS code	Type of wire	Shield Gas	Wire Grade	Flux Grade	Flux Type
IRS:M44 IRS:M44	Class M2	E 19.9 LR26	Class VI	ER 308L	Solid wire	Argon 5% O <sub>2</sub>	-	-	-
IRS:M44 IS:2062 E410Cu	Class D	E8018 W2	Class IV	ER 81TIW/80-S-G	Solid wire Cu coke flux wire	Argon 1-5% O <sub>2</sub>	-	-	-
IS:2062 E410Cu IS:2062 E410 Cu	Class C1	E63 BD 126	Class III	ER 9ITI-D1 ER 90.S-D2	Cu Coke Flux/solid wire	100% CO <sub>2</sub> With 99.5% purity.	W4	F4	Granular

### Painting

Painting Parameters	BOXN HL	BOXN/ BOXNHS
Etch primer	IS: 5666-70; EPOXY zinc phosphate to RDSO spec. no. M&C/PCN/102/2005	IS:102-1962
Finishing paint	PU based Firozi colour to RDSO spec. No. M&C/PCN/109/88	To RDSO spec. no. M&C/PCN/122-06



## **BOXN-EL**

BOXN-EL wagon running of 25 Ton Axle load wagons on IR. The RDSO have developed the 25 ton axle load wagons BOY-25, BOXN-25, BOBRN-25, BOBSN-25 wagons for the running on dedicated freight corridor & on same important selected upgraded freight routes.

The upgraded wagon codes will be as under

- BOXN-EL
- BOY-EL

For extreme loading purpose the improvement have been made in existing wagons & in CASNUB 22 NLB bogies areas under the up gradation have been done by selected Railway Workshop.

- The CASNUB 22 NLB bogie has been upgraded to 25 Ton axle load nomenclature as CASNUB 22 NLC bogies.
- 4 additional coil springs to be provided in the 22 NLB bogies already upgraded +8+2T loading.
- The final spring combination of 22 NLC bogies shall be 14 outer, 14 inner & 4 snubber springs/bogie.
- Fitment of additional spring required modification in spring plank & bogie bolster.
- AAR approved grease in CTRB.
- Wheel dia- Minimum 950 mm
- Wheel seat dia- Minimum 211 mm
- Existing brake beam to be replaced with cast steel brake beam at the earliest but not later than next POH/ROH.

### **Criteria for selection of Wagons for up gradation to 25 Ton axle load.**

- The general condition of wagon should be sound & effect of corrosion should be minimum.
- The wagons should have all modification advised by RDSO & fitted with components as per latest instruction.
- The condition of under frame members, side walls, stanchions, top coping etc should be sound.
- The upgraded wagons should be fitted with high capacity draft gear preferably RF 361/SL 76. The draft gear should not be loose in the pocket. The back stops & striker castings should not be loose. AAR HT, CBC should not be fitted with reclaimed knuckles if draft gear is loose it requires replacement to parent unwanted impact loads on coupler & under frame.
- The wagons should have wheels without sprang holes.

### **Special/ other conditions for use of upgraded (wagons):**

- The wagons shall be used in nominated sections only (stencilled on the wagon)
- The wagon shall not be allowed to get mixed with other wagons.
- Wagons to be printed with changed code (BOXNEL, BOYEL etc.)
- Axle boxes provided with imported grease to AAR spec. no. M 942 to be painted white.

- The bogie frame to be painted with signal red bands on both sides for upgraded suspension.
- No overloading beyond 25 ton axle load including all tolerances.
- CME of Railway to certify track worthiness & safety of rolling stock before initiating movement.
- The loading shall be restricted to iron ore, Manganese, copper, zinc & other ores with similar density.
- The End “Panel hatched area” should be painted with olive green colour.

**Maintenance requirement of up graded wagons (BOXN-EL, BOY-EL,)**

1. POH every 3 years.
2. ROH every 12 months – Must change items in ROH - EM Pad, side bearer, wedge block, all pins & bushes, coupler, yoke, yoke pin & knuckle & knuckle joint.

**Intensive Examination:**

1. Check draft gear for looseness in the packet replace if necessary.
2. Special attention to bogie & it's components to detect damage/ crack.
3. CTRB to be checked for overheating any damage/ oozing out grease.

**25 Ton axle load operation:** Mostly will run on dedicated freight corridor.

## Standard Measurement of Wagon

S.NO.	Type of wagon/ Description	Length over Hd. Stock	Length over buffer/ couplers	Length inside	Width inside/overall	Height inside/from rail	Bogie Centres	Journal Centres	Wheel Dia On tread	Nominal max. axle load	Tare	Pay Load	Ratio pay Load /Tare	Gross Load	No. of wagons per rake	Throughput per rake t	Loading Density/ t	Cubic Capacity	Speed	Type of Coupler	Type of Bearing.
		mm	mm	mm	mm	mm	mm	mm	mm	t	t	t	t	t	no	t	t	Cum	kmph		
1	O OPEN	5944	7214	5934	2845/3055	1600/2836	3504	2235	1090	16.3	10.31	22.19	2.152	32.5	86	1908	4.5	27	75	SC	PB
2	BOXC/OPEN COAL	12800	13729	12790	2852/3136	1880/3161	8800	2240	1000	20.32	25	56.28	2.251	81.28	45	2532	5.925	68.58	75	CBC(T)	CRB
3	BOXN/BOXNHS	9784	10713	9784	2950/3200	1950/3233	6524	2260	1000	20.32	23.2	58.08	2.503	81.28	58	3368	7.59	56.3	75/100	CBC	CTRB
4	BOXNHA	9784	10713	9784	2950/3200	2175/3450	6524	2260	1000	22.1	23.17	65.23	2.81	88.4	58	3783	8.25	62.8	100	CBC	CTRB
5	BOXN(LW)	9784	10713	9784	3022/3250	1990/3263	6524	2260	1000	20.32	20.41	60.87	2.08	81.28	58	3530	7.59	58.84	65	CBC	CTRB
6	BOXNAL	9784	10713	9784	3022/3250	2066/3341	6524	2260	1000	20.32	18.26	63.02	3.45	81.28	58	3655	7.59	61.09	---	CBC	CTRB
7	BOXNHL	10034	10963	10034	3022/3250	2028/3301	6690	2260	1000	22.9	20.8	70.8	3.4	91.6	58	4106	8.35	61.05	80	CBC	CTRB
8	BOXN25	9784	10713	9784	2957/3135	2333/3606	6524	2260	1000	20.32	22.8	58.48	2.564	81.28	53	4466	9.33	67.5	75/100	CBC	CTRB
9	BOI/OPENGONDOLA	10700	11629	10690	2850/3100	1050/2331	6700	2240	1000	20.32	22.8	58.48	2.564	81.28	53	3099	7	32	75	CBC	CRB
10	BOY/IR BOY/IRON ORE Spl	11000	11929	10990	2924/3134	1175/2450	7330	2260	1000	22.9	20.71	70.89	3.422	91.6	52	3686	7.678	37.8	65	CBC	CTRB
11	BOY25	9784	10713	9784	2907/3135	1334/2607	6524	2260	1000	25	21	79	3.76	100	58	4582	9.33	37.94	75/100	CBC	CTRB
12	CR/COVERED	7162	8432	7162	2946/3081	2445/3746	4572	2235	1090	16.3	10.77	21.73	2.017	32.5	74	1608	3.85	51.4	75	SC	PB
13	CRT/COVERED	7890	8822	7890	2946/3081	2675/3977	4900	2240	1000	20.32	13.1	27.54	2.102	40.64	70	1927	4.61	61.9	75	CBC	CRB
14	CMR/CATTLE/MILLIT ARY	7162	8432	7162	2946/3081	2445/3746	4572	2235	1090	16.3	11.23	21.27	1.894	32.5	74	1573	3.85	51.4	75	SC	PB
15	CE/COVERED EXPLOSIVE	5943	7213	5772	2672/2978	2295/3746	3505	2235	1090	16.3	11.38	21.12	1.855	32.5	86	1816	4.51	32.7	75	SC	PB
16	BCX MK.-II/ Cov. Bogie Special	14500	15782	14494	2944/3199	2446/3792	10000	2240	1000	20.32	28.5	52.78	1.851	81.28	39	2058	5.15	104	75	CBC(T)	CRB
17	BCN/COVERED BOGBIE	14500	15429	14494	2944/3100	2446/3787	10000	2260	1000	20.32	27.2	54.08	1.988	81.28	40	2163	5.268	104	80/75	CBC	CTRB
18	BCNA/BCNAHS	13521	14450	13515	2944/3200	2677/4014	9500	2260	1000	20.32	24.55	56.73	2.31	81.28	43	2439	5.625	103.4	75/100	CBC	CTRB
19	BCNHL	10034	10963	10034	3345/3450	2980/4305	7153	2260	1000	22.9	20.8	70.8	3.4	91.6	58	4106	8.35	92.54	80	CBC	CTRB
20	BOBY/BOBYN	10718	12000	9000	2863/3189	1781/3050	7470	2260	1000	20.32	27.04	54.24	2.005	81.28	52	2820	6.77	40.3	75	CBC(T)	CTRB
21	BOBX/HOPPER	10668	11938	7672	2910/3050	-2819	7112	2260	915	22.9	25.15	66.45	2.642	91.6	52	3455	7.67	26.9	56	SC	PB
22	BOBS MK.-II	10668	11597	9296	2743/3020	- /3304	7112	2260	1000	22.9	30.4	61.2	2.013	91.6	53	3243	7.9	34	70	CBC *	CTRB
23	BOBSN25	9784	10713	9784	2925/3199	1941/3213	6524	2260	1000	25	28	72	2.57	100	58	4176	9.33	34.63	75/100	CBC	CTRB



## Standard Measurement of Wagon

24	BOBR	10671	11600	8732	3340/3500	2461/3735	7571	2260	1000	20.32	26	55.28	2.126	81.28	53	2929	7	57.2	80	CBC	CTRB
25	BOBRN	9671	10600	9327	3340/3500	2466/3735	6790	2260	1000	20.32	25.6	55.68	2.175	81.28	59	3285	7.67	56.78	65	CBC	CTRB
26	BOBRNAL	9671	10600	9327	3316/3500	2466/3735	6790	2260	1000	20.32	22.4	58.88	2.62	81.28	58	3414	7.67	56.6	--	CBC	CTRB
27	BOBRN25	9784	10713	9422	3460/3500	2756/4205	6903	2260	1000	25	24.4	75.6	3.1	100	58	4437	9.33	66.68	75/100	CBC	CTRB
28	TO/OIL TANK	7010	8280	6156	2362	- /4108	4572	2235	1090	16.3	13.9	18.61	1.338	32.51	75	1395	3.93	25.65	75	SC	PB
29	TORX/OIL TANK	7010	8280	6156	2362	- /3975	4572	2235	1090	16.3	12.1	20.4	1.685	32.5	75	1530	3.93	26.04	75	SC	CRB
30	TP/PETROL TANK	7010	8280	6156	2362	- /4024	4572	2235	1090	16.3	12.85	17.53	1.364	30.48	75	1314	3.68	25.65	75	SC	PB
31	TPR/PETROL TANK	7010	8280	6766	2362	- /3990	4572	2235	1090	16.3	11.84	20.66	1.744	32.5	75	1549	3.921	28.64	75	SC	CRB
32	TPGL/LQD.PET.GAS	8382	9652	8000	2000	- /3978	4877	2235	1090	16.3	20.66	11.84	0.573	32.5	64	757	3.37	24.1	75	SC	CRB
33	TPGLR/LQD.PET.GAS	8382	9652	8350	2300	- /4125	4878	2235	1090	16.3	18.2	14.3	0.78	32.5	64	915	3.37	33.1	75	SC	CRB
34	BTALN/AMMONIA	16600	17529	16325	2200	- /4265	11570	2240	1000	20.32	49.13	32.13	0.65	81.26	35	1124	4.63	60.66	65	CBC	CRB
35	BTPN	11491	12420	11434	2850	- /4265	8391	2260	1000	20.32	27	54.28	2.01	81.28	50	2714	6.54	70.4	75	CBC	CTRB
36	BTPGLN	18000	18929	17994	2400	2400/4285	12970	2260	1000	20.32	41.6	37.6	0.9	79.2	33	1240	4.19	79.48	75	CBC	CTRB
37	BVG/BRAKE VAN GOODS	5943	7213	-	- /3200	2396/3755	3505	2235	1090	16.3	10.77	-	-	10.77	-	0	1.5	-	75	SC	PB
38	BVGT/BRAKE VAN GOODS	5944	7226	-	- /3197	2447/3735.6	3505	2235	1090	16.3	-	-	-	-	-	0	-	-	75	CBC(T)	PB
39	BVZC/BRAKE VAN GOODS	8540	9469	-	- /3200	2448/3894	5400	2240	1000	20.32	13.803	-	-	13.803	-	0	1.48	-	75	CBC	CRB
40	BVZI	13540	14469	-	- /3200	- /3894	9026	2159	915	5.875	23.5	-	-	23.5	43	0	1.624	-	100	CBC	SRB
41	BOST	12800	13729	12800	2850/3100	1805/3080	8800	2260	1000	20.32	25.5	55.78	2.18	81.28	45	2510	5.92	65.84	80/75	CBC	CTRB
42	BFNS	13716	14645	13716	2845/3045	- /2785	9144	2260	1000	20.32	23.629	57.651	2.43	81.28	42	2421	5.55	-	100	CBC	CTRB
43	BRH/RAIL HEAVY	13716	14986	13716	2845	-	9144	2240	1000	20.32	24.38	56.9	2.333	81.28	41	2332	5.42	-	75	CBC(T)	CRB
44	BRNA/BRNAHS	13716	14645	13716	2845	-	9144	2260	1000	20.32	23.543	57.74	2.45	81.28	42	2425	5.55	-	75/100	CBC	CTRB
45	BRN25	13716	14645	13716	2930/3130	1274	9144	2260	1000	25	23.5	76.5	3.25	100	42	3210	9.33	-	75/100	CBC	CTRB
46	BLCA	13625	14566	-	2200 max	1009	9675	2260	840	20.32	19.1	61	3.19	80.1	42	2562	5.5	-	100	CBC/ SDB	CTRB
47	BLCB	12212	13165	-	2200 max	1009	8812	2260	840	20.32	18	61	3.39	79	47	2867	6	-	100	SDB	CTRB
48	Cement/Flyash	9784	10713	10085	3129/3245	- /4165	6684	2260	1000	22.13/1	22	66.5/	3.02/	88.5/	58	3857/	0.95/	70	75/100	CBC	CTRB
										7.25		47.11	2.14	69.11		2732	0.67				

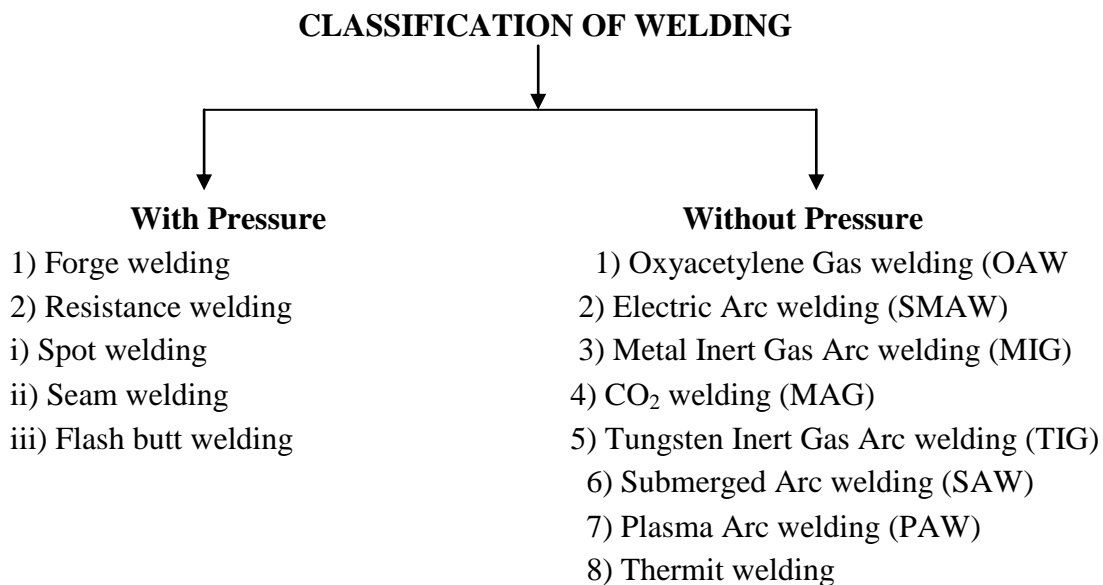
# WELDING

## INTRODUCTION

Welding is the process of joining two pieces of metals by application of heat. Heat may be developed in several ways. Along with this application of heat, pressure is also applied in order to have better action of joining. For additional strength, sometimes filler material is also used.

In welding without the application of pressure the metals are brought to fluid state & joined by some filler material. This is the most rapid & easiest way of fabrication & assembly of metal parts. The research carried out in this field has given various ways & method to weld practically all metals.

A device has also been found out to weld dissimilar metals. One beauty of welding on comparison to other process of joining metals is that by this process we can have more than 100-% strength of joint & it is very easy process.



**Plastic welding:** In this process, the pieces of metals to be joined are heated up to the plastic state & then forced together by external pressure without the addition of filler material. Forge welding, resistance welding & Thermit welding with pressure are examples of this class.

**Fusion welding:** In this case, the metal at the joint is heated to a molten state & allowed to solidify in this case filler material is used during welding process. This includes gas welding, arc welding & Thermit welding.

### Advantages of welding:

- A good weld is as strong as a base metal.
- General welding equipment is not very costly.
- Portable welding equipment are available.
- Welding permits considerable freedom in design.
- A large number of metals/ alloys with similar & dissimilar can be joined by welding.
- Welding can join work pieces through spots, as continuous pressure tight seams, end to end & in number of other configurations
- Welding can be machined.

**Disadvantages of welding:**

- Welding creates harmful radiation (light) fumes spatters.
- Welding results in residual stresses & distortion of the work pieces.
- Jigs & fixtures are generally required to hold & position the parts to be welded.
- Edge preparation of the work pieces is generally required before welding them.
- A skilled welder is a must to produce a good welding job.
- Welding heat produces metallurgical changes.
- Welded joints, for many reasons, needs stress relief heat treatment.

**CO<sub>2</sub> WELDING**

CO<sub>2</sub> (carbon - dioxide), MAG (Metal - active gas) welding is a variations of the standard MIG process.

- In MIG process generally argon, helium/ their mixtures are used for shielding the molten weld pool, whereas in CO<sub>2</sub> welding process, CO<sub>2</sub> is used as shielding gas.
- CO<sub>2</sub> being an active gas, this process is known as MAG process.
- CO<sub>2</sub> welding is used for the welding of carbon & low alloy sheets
- It produces deeper penetration than argon/ argon mixtures with slightly more spatter.
- CO<sub>2</sub> has become widely popular for arc shielding or the welding of sheets.
- CO<sub>2</sub> is basically a semi automatic process in which the arc length & the feeding of the electrode wire into the arc is automatically controlled.
- Less skilled welder is required in compare to TIG & SMAW process.
- CO<sub>2</sub> welding may also be used in mechanized & automatic forms where productivity is to be increased & consistent quality in welded object is demanded.

**Welding equipment**

- A D.C. power source & controls.
- A wire feeder which contain of DC motor. Speed reducing gear box, 2/4 roll drive, gas solenoid valve, potentiometer.
- Welding gun
- Shielding gas.
- Gas pressure regulator.
- Flow meter.
- Control cables.
- Welding cables.
- Hoses for gas & water.
- Gas pre heater.
- Welding helmet
- Gloves.
- Apron.
- Anti-spatter silicon spray etc.

## **Welding procedure**

1. Correct edge preparation & joint fit up.
2. Joint surfaces to be cleaned of rust, scale, grease or any other foreign matter.
3. Assembling the welding equipment & setting the welding parameters.
4. Selecting correct nozzle gun size.
5. Setting electrode extension on the basis whether short circuiting or spray type welding is to be done.
6. Passing on the CO<sub>2</sub> gas supply to remove air from the hoses & then setting CO<sub>2</sub> flow rate as per base metal & joint design.
7. It is easy to weld in the down hand position.
8. Fillet, vertical, horizontal & overhead welds also be made by using CO<sub>2</sub> welding.
9. After the weld is complete, the end crater should be file.

## **Advantages**

- Higher welding speeds.
- Better & deep joint penetration with good head control & little tendency to undercut as compared to argon.
- Sound weld deposits which can be made consistently.
- Lower associated cost as CO<sub>2</sub> is relatively inexpensive.
- Despite the O<sub>2</sub> in CO<sub>2</sub> porosity is not an issue when a suitably deoxidized wire (electrode) & reasonably short arc are used.
- Good mechanical properties of weld metal.

## **Disadvantages**

- High impact properties in weld metal can't be achieved.
- CO<sub>2</sub> produces a rather harsh arc.
- Spatter is expensive unless a very short, uniform arc length is maintained, keeping the tip of electrode below the surface of the work, properly adjusting the power supply inductance setting also minimizes spatter.

## **TIG (TUNGSTEN INERT GAS ARC WELDING)**

- The energy necessary for melting the metal is supplied by an electric arc struck between Tungsten / Tungsten alloy electrode & the work piece under an inert/ slightly reducing atmosphere.
- SS is always welded in DCEN (Direct current Electrode negative) or DCSP (Direct current straight polarity) mode.
- In these conditions, it is the work piece that is struck by the electrons enhancing penetration, while the electrode, which is generally made from thoriated tungsten, undergoes very little wear.
- Filler wire is used in the form of bare rods or coiled wire for automatic welding.
- The inert gas flow which protects the arc zone from the ambient air enables a very stable arc to be maintained.
- Depending on the base material, shielding gases consists of mixtures of Argon (Ar), Helium (He) & Hydrogen (H<sub>2</sub>)

## **TIG Apparatus**

**Power source:** Depending on current

- DC generator for DC welding.
- AC transformer for AC welding.

**Shielding Gas:** Argon/ Helium Protects the arc zone from ambient air at high temp.

**Coolant pump:** Current above 100 Amps. Is used during welding. Due to which welding gun becomes heated. Coolant pump circulate water coolant for cooling of gun.

**Welding Torch:** Holds tungsten electrode.

**Foot switch (optional)**

**Filler Metal.**

## **Advantages**

- Excellent metallurgical quality, with a precise control of penetration & weld shape in all positions.
- No slags.
- Spatter is absent.
- A concentrated heat source leading to narrow fusion zone.
- No flux is required, oxidation residues are eliminated.
- Very low electrode wear.
- Sound & pore free welds.

## **Applications**

- Aluminium & its alloys.
- Brass & its alloys.
- Stainless steel.
- CI, carbon steel etc.



## COST ECONOMY IN WELDING PROCESS

All industries involved in welding process should do welding cost estimation before actual start of welding. During welding progress also evaluation of cost analysis is done.

### Cause for Welding cost Estimation:

- Comparison of other manufacturing/ fabricating methods with welding.
- To collect the data related to job bidding.
- To collect information to decide design.
- To evaluate proposed changes in the procedure.
- Compare the economic advantages of completing welding processes.

### Main components of Welding Processes:

#### Welding cost:

**Direct :** (A) Consumable electrode (B) Labour

- Flux
- Shielding gas
- Electricity

**Indirect:** Overheads, Plant costs, Depreciation maintenance, Operator training, Technical supervision.

### Factors involved welding cost

- Time for preparing base plate edges by gas cutting, shearing grinding etc.
- Time for assembly.
- Time for weld tack up.
- Time for positioning.
- Time for welding.
- Time required for electrode locating & changes the setting.
- Time spend in personal work.
- Time for cleaning (slag removal)
- Time for the removal of assembly.
- Time for stress relieving.
- Cost of electrodes.
- Cost of shielding materials.
- Cost of electric power.
- Overhead cost.

It is observed that time is spend in following works other than welding e.g. Assembling positioning tacking etc. A Basic factor in cost formulae that must be determined accurately in order to make sound evaluation of cost is operating factor.

$$\text{Operating factor (\%)} = \frac{\text{Arc time}}{\text{Total time}} \times 100, \text{ Here total time} = \text{arc time} + \text{Down time}$$

### Basic costing procedure

Total welding cost: = Labour & overhead cost + welding consumable cost + power cost

Labour & Overhead costs / job:

$$= \frac{(\text{Total meters of weld}) \times (\text{Labour \& Overhead charge/hr.})}{(\text{Welding speed m/hr.}) \times (\text{Operating factor})}$$

**Welding consumable cost**

$$= (\text{Electrode consumption/meter of weld} \times \text{Total Mtrs of weld} \times \text{Electrode price}) \\ + (\text{Shielding material used/ kg of electrode} \times \text{Total kg. of electrode consumed} \times \text{shielding material price})$$

$$\text{Power cost} = \frac{V.I. \times T}{1000} \times \frac{1}{60} \times \frac{\text{Rate per unit}}{E}$$

Where V = Voltage (Volts)

I = Current (Amps)

T = Welding time (Min)

E = Efficiency of welding m/c. (0.6 for welding transformer)

= (0.25 for welding generator)

**Example**

Calculate the total cost of manual flux shielded metal arc welding using the data given below:

Weld length	=	2 metres
Welding speed	=	12m/hr.
Operating factor	=	30%
Labour & overhead charges per hr	=	Rs. 100
Electrode consumption	=	0.35 kg/metre
Electrode price	=	Rs. 20 per kg.
Arc voltage	=	22 volts
Arc current	=	200 A,ps.
E	=	0.6
Rate per kWhr	=	Rs. 8/-

Solution:

(i) Labour and overhead costs =  $\frac{(\text{Total mtrs of weld}) \times (\text{Labour \& Overhead charge/hr.})}{(\text{Welding speed M/hr.}) \times (\text{Operating factor})}$

$$= \frac{2 \times 100}{12 \times 0.3} = \text{Rs. 55.55}$$

(ii) **Welding consumable cost:**

$$= (\text{Electrode consumption/meter of weld} \times \text{Total mtrs of weld} \times \text{Electrode price}) \\ 0.35 \times 2 \times 40 = \text{Rs. 28/-}$$

(iii) Power Cost

$$= \frac{V.I. \times T}{1000} \times \frac{1}{60} \times \frac{\text{Rate per unit}}{E} \\ \frac{22 \times 200 \times 1 \times 10 \times 8}{1000 \times 0.6 \times 60} = \text{Rs. 9.8/-}$$

Adding (i), (ii) & (iii), the total welding cost = 55.55 + 28 + 9.80 = Rs .93.35/-

## **ELECTRICAL ASPECTS IN WELDING EQUIPMENT**

- Arc welding machines should be of good quality.
- Arc welding machine should work satisfactorily in following conditions:
  - (a) Coastal area
  - (b) Dust, smoke, fumes & Gaseous atmosphere.
  - (c) Excessive shocks/ Vibrations.
  - (d) Steam/ corrosive atmosphere.
- All welding machines should be inspected at regular intervals & always maintain safe working conditions.
- All welding machines should be weather protected if to be used in open atmosphere.
- If moisture is trapped in welding equipments then use only after drying.
- Do proper earthing of arc welding m/c.
- Use proper terminal for power line connection in arc welding machines.

### **Arc welding equipments:**

#### **Electrode Holders**

- Holder should be properly connected to welding lead.
- It should be of proper rating to avoid heating of holder during welding.
- Holder should have protective shield / disc to protect the welder from heat of arc.
- All metallic / current carrying parts should be insulated (including jaw).
- Never dip hot electrode holder in water because residual moisture can cause shock.

#### **Welding cables:**

- Welding cable should be flexible & insulated.
- Its current carrying capacity should be more than requirement.
- Cable should be joint free/ maintenance free.
- Cable connected to holder should not be less than 3 mtr.
- Welding cables should always be free from grease, oil & moisture to avoid premature failure.

#### **Earthing:**

- Proper earthing of welding m/c should be done.

## **C.M.T. LAB**

### **INTRODUCTION**

- CMT lab has very important contribution in quality & reliability of railway components.
- It tests the quality & chemical composition of spare parts used in coaches & goods and other stock.
- It also undertakes failure analysis of components.
- Central CMT lab for WR & NWR is situated in Ajmer.

### **Different Testing and Investigations in CMT Lab:**

#### **Failure investigation Lab:**

- Chemical & metallurgical investigation is done of failed components of rolling stock.
- Remedial measures are also suggested to avoid future failures.

#### **Fuel & Lubricant oil lab:**

- Quality testing of fuel oil, axle oil, furnace oil, furnace oil & lubricants.

#### **Water Testing Lab:**

- Testing of parameters of water quality eg. Hardness, TDS, PH, COD, BOD etc.

#### **Chemical & Mechanical testing lab:**

- Testing of physical, chemical & metallurgical properties of ferrous & nonferrous metals.

#### **Environmental lab:**

- Testing of environmental pollution in workshop & surrounding.
- Testing of chemical, metallurgical, physical, thermal & other properties of metals, paint, grease, water fuel oil, lubricants, electrical cable, transformer oil etc.
- Hence this lab play active role in safe running of Railways by failure analysis.

#### **Ultrasonic & NDT Lab:**

- This lab undertakes ultrasonic testing & other NDT of safety items such as wheel & axles etc.
- Sound freq. exceeding 20000 Hz is called ultrasonic. (Audible range: 20– 20000 Hz).
- Ultrasonic waves can travel through materials of several metric thicknesses, but when it meets boundary of air it reflect back. (Ultrasonic waves cannot travel through air).
- Defects like cracks porosities, blow holes, lamination have a thin column of air, and hence ultrasonic waves reflects when it meets them.
- Materials having piezoelectric effects are used as probes to generate ultrasonic waves in the material under test. Frequency of order of 2.5 MHz is used as ultrasonic frequency.

#### **X-ray Test lab**

- Using this method internal defect can easily be identified eg. Crack slag, weld cavity,
- Penetration & fusion etc.
- X-ray after passing metal expose the photographic film at other end & make image.
- Due to less density of weld metal, the image on film is dark which shows the defect.

## Indian Railway Conference Association(IRCA)

IRCA gives out the rule for standard & condemning sizes of various components used on a rolling stock and also gives guidelines for maintenance of rolling stock in workshops & in open lines.

- The rule books issued for the C&W department. are.  
Part III: For wagon stock.  
Part IV: For coaching stock.
- IRCA, part III & Part IV contains 4 chapters.

Chapter	Details
I	Definitions.
II	Workshop repair practice.
III	Maintenance practice in open line.
IV	Rejection rules.

### Chief Neutral Train Examiner.(C.N.TXR)

- It is a central body formed to control the objectives of quality control. It works as third eye.
- HQ – Works under Director Rly. Board & do not work under local authorities.
- Reference for Quality Standard:  
For wagons: IRCA Part III 2000  
For coaches: IRCA Part IV 2000
- Main objective is to maintain quality of rolling stock maintenance for it's safe working.

After repair of rolling stock in workshop e.g. POH/ NPOH every stock should be offered to CNTXR staff for pre inspection. After pre inspection CNTXR gives some booking for repair as per IRCA rule book. Then workshop staff attended bookings of pre inspection and same stock offered for final inspection to CNTXR. Again CNTXR checked rolling stock if he satisfied with repair quality as per IRCA rule book then he gives a fit certificate for particular coach/wagon. After getting fit certificate workshop staff dispatch the same coach/wagon to traffic. As per Railway board guidelines after repair in workshop no coach or wagon should be sent to traffic without getting fit certificate from CNTXR.