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THE FEASIBILITY STUDY

ON

MODERNISATION OF ROLLING STOCK WORKSHOP

IN

INDIA

VOL. II

(BASICS OF FACILITY PLANNING)

FINAL REPORT

DECEMBER 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)

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In the cource of planning the rolling stock inspection and repair plan, modernisation of repair and manufacture of laminated springs, and modernisation of brake block casting which are described in the Report, various investigation and calculation data, etc., were accumulated. This Appendix has been made collecting these data in a booklet form.

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CHAPTER 1 JUMALPUR WORKSHOP

CHAPTER 1 JUMALPUR WORKSHOP

1.1 Diesel Locomotive Inspection/Repair Facility

1.1.1 Basic Conditions for Facility Planning

(1) Assumption of Number of Rolling Stock to be Repaired

Number of each kind of rolling stock to be repaird is shown in Table 1.1.1. This facility plan was made on the basis of number of rolling stock repaired in the year 2000.

Table 1.1.1 Transition of Number of Rolling Stock to be Repaired

Type of locomotives	Item	1986	1990	1995	2000
SL	Assigned number of SL	653	450	150	0
	Number of SL for POH	226	120	0	0
DL (WDM2)	Assigned number of DL	227	339	480	620
	Number of DL for POH	39	57	80	103
DL (WDS4)	Assigned number of DL	120	129	139	150
	Number of DL for POH	31	26	28	30
EL	Assigned number of EL				
	Number of EL for POH			24	48

(2) Cycle Time and Standard Schedule

The POH cycle time for diesel locomotive used in this plan is as shown below.

WDM2	16 days
WDS4	16 days

Work schedule of repair is shown in Fig. 1.1.1.

(3) Number of Rolling Stock to be Repaired and Number of Rolling Stock Staying concurrently in the Workshop

Number of rolling stock staying in the workshop concurrently is as shown on Table 1.1.2.

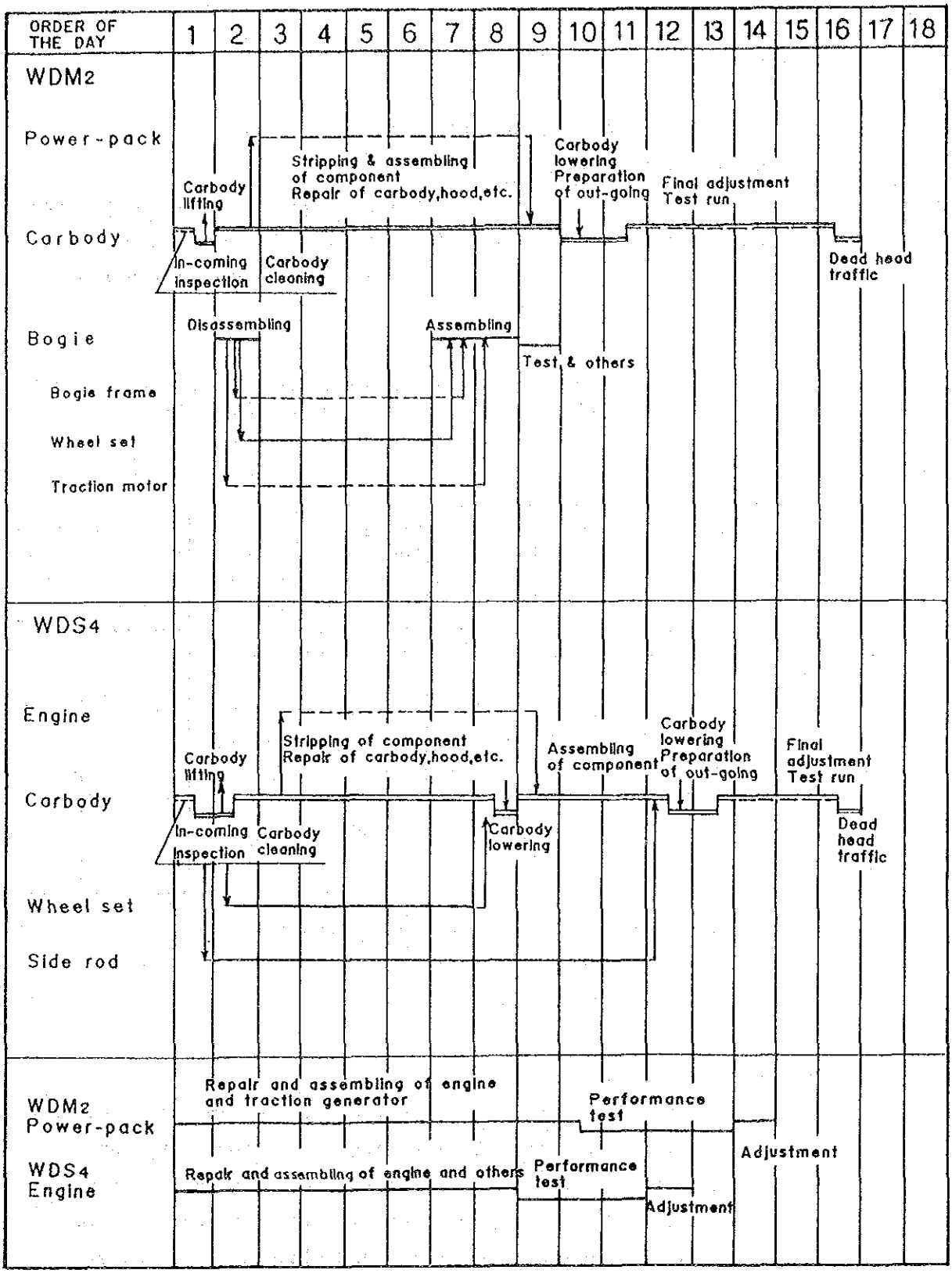
Table 1.1.2 Number of Rolling Stock to be Repaired and Staying in the Workshop concurrently

Type of locomotives	Number of Rolling Stock to be Repaired in a Year	Cycle time for POH			Number of Rolling Stock Staying concurrently		
		Main Shop	Other Shop	Total	Main Shop	Other Shop	Total
WDM2	103	10	6	16	4.2	2.5	6.7
WDS4	30	12	4	16	1.5	0.5	2.0
Total	133				5.7	3.0	8.7
(EL)	(48)	(11)	(5)	(16)	(2.2)	(1)	(3.2)

Note 1. Number of Rolling Stock Staying in the Workshop includes a 20% margin in the number of rolling stock to be repaired.

$$\text{Number of rolling stock staying} = \left(\text{No. of rolling stock repaired} \times \text{cycle time} \div \text{Total working days in a year}\right) \times 1.2$$

2. As for the EL, it is out of scope of this plan, but, for reference in planning the scale of Bogie Shop, cycle time of EL is calculated according to that of WDM2, and shown in ( ).
3. Total working days in a year is assumed to be 295.
4. In calculating the quantity of carbody and parts staying in each shop or work area shown in 1.1.2, the formula described in Note 1 is used.



Note: ═══ shows that carbody stays in the Main Building.

═ ═ ═ shows that carbody stays at other place of the Main Building.

– – – – shows that the spare parts system is used in repair.

Fig. 1.1.1 STANDARD TIME SCHEDULE OF POH OF DIESEL LOCOMOTIVE

1.1.2 Facility Improvement Plan

(1) In-coming Inspection Shop and Final Adjustment Shop

1) Capacity of Facilities

Both WDM2 and WDS4 stay at In-coming inspection shop for 0.5 days and at Final Adjustment shop for 5 days for WDM2 and 3 days for WDS4, so the average number of locomotives staying concurrently is as shown on Table 1.1.3.

Table 1.1.3 Number of Locomotives to be Repaired and Staying concurrently in the Workshop

Shop	WDM2			WDS4			Total No. of Loco. staying concurrently
	No. of Loco. to be repaired in a year	No. of days in the shop	No. of Loco. staying concurrently	No. of Loco. to be repaired in a year	No. of days in the shop	No. of Loco. staying concurrently	
In-coming Inspection shop	103	0.5	0.2	30	0.5	0.1	0.3
Final Adjustment Shed	103	5	2.1	30	3	0.4	2.5

Therefore, the capacity of the facilities is,

In-coming Inspection Shop	1 Locomotive
Final Adjustment Shop	3 Locomotives

2) Plan of Facilities

It is planned that new building capable of holding one locomotive will be constructed for the In-coming Inspection Shop, and provided with the platform and oil reservoir for the fuel oil extracted from the coming-in locomotive to increase the work efficiency of in-coming inspection and cleaning of carbody.

As for Final Adjustment Shop, it is planned to reform the existing building to have 2 lines: one line can hold 2 locomotives and another line can hold one locomotive. The existing test apparatus of power pack is used as it is.

(2) Carbody Lifting/Lowering Shop

1) Capacity of Facilities

From the standard schedule of WDM2 and WDS4 in the Main Building (Refer to Fig. 1.1.1), the average number of locomotive staying concurrently in each shop is as shown on Table 1.1.4.

Table 1.1.4 Number of Locomotives Staying and Repaired in the Shops

Shop	WDM2			WDS4			Total No. of Loco. staying concurrently
	No. of Loco. to be repaired in a year	No. of days in the shop	No. of Loco. staying concurrently	No. of Loco. to be repaired in a year	No. of days in the shop	No. of Loco. staying concurrently	
Carbody Lifting Shop	103	0.5	0.2	30	1	0.1	0.3
Carbody Shop	103	8	3.4	30	9.5	1.2	4.6
Carbody Lowering Shop	103	1.5	0.6	30	1.5	0.2	0.8

Therefore, the capacity of these shops is as below:

Carbody Lifting Shop — 1 Loco (1 Loco/Line)

Carbody Lowering Shop — 2 Loco (2 Loco/Line) (including preparation area for lowering)

Carbody Shop

Carbody repair area — 6 Loco (WDM2: 4, WDS4: 2)

Chassis cleaning area — 1 Loco

For the Carbody Shop, carbody repair area for each kind of locomotive and chassis cleaning area were taken into consideration, and for the Carbody Lowering Shop, the area for placement of completed bogies and wheels was taken into consideration.

2) Plan of Facilities (Refer to the Vol. III Fig. 1-2)

The carbody lifting, carbody repair, and carbody lowering work areas are arranged in series in the present Diesel POH Shop and also utilise the existing 60 ton EOT crane effectively for the efficient transport of carbody.

Among the existing 3 lines in the north end of Diesel POH Shop (High) used for in-coming/out-going lines, one line laid in the middle of these is removed and the other two lines are used for carbody lifting and lowering lines. Carbody lifting line will have a length of one locomotive and carbody lowering line will have a two locomotive length and both lines will have pit.

Carbody Shop will be located south side of Carbody Lifting/ Lowering Shop, and in the Shop carbody repair area and hood repair area are arranged.

Six carbodies will be arranged in two rows and there will be sufficient space to use lifting platform vehicle.

Chassis cleaning area is provided at a separate place because it is necessary to consider the drainage of cleaning water on the floor of work area.

Generally, it is most common that the painting of carbody including hood is carried out in a room separate from the carbody repair shop in its nature, but in this plan, in consideration of the volume of painting work, electro-static painting equipment is adopted in order to avoid dispersion of paint mist and also to secure uniformity of paint coat. So there will not be provided a special painting room.

(3) Engine Shop

The repair work of power-pack for WDM2 and engine for WDS4 will adopt the unit exchange spare parts system in which spare engine is repaired beforehand. Then, required days for repair of these will be as follows.

Power-pack for WDM2	14 days
Engine for WDS4	12 days

According to this, average number of engines staying concurrently in the shop is as shown on the Table 1.1.5.

Table 1.1.5 Number of Engine Repaired and Staying in the Shop

Shop	WDM2			WDS4			Total No. of Engine staying concurrently
	No. of Engine to be repaired in a year	No. of days in the shop	No. of Engine staying concurrently	No. of Engine to be repaired in a year	No. of days in the shop	No. of Engine staying concurrently	
Shop	103	10.5	4.4	30	9	1.1	5.5
Test Room	103	3.5	1.5	30	3	0.4	1.9

Then the capacity of the Shop is as follows:

Engine Shop 6 engines

Engine Performance Test Room 3 engines (WDM2: 2, WDS4: 1)

2) Plan of Facilities (Refer to the Vol. III Fig. 1-4)

The repair work of engine and its accessories, both for WDM2 and WDS4, will be carried out at the same block of work area which is provided in the present Diesel POH Shop (High) south side of Carbody Shop and in the Diesel POH Shop (Low) adjacent to this in order that the facilities can be used commonly.

Main repair work of engine will be carried out in the present Diesel POH Shop (High), and in this shop, each work area for cleaning, disassembling, repair, and assembling is arranged in a flow line and transfer of engine and its accessories between each work area will be done by EOT crane and carrier.

In each work area, machines for repair work, engine rotating device (manipulator), jib crane and so on are provided to secure efficient work process.

However, the repair of torque convertor, reverser, etc., which are particular equipment of WDS4, is to be carried out at a part of the present Wheel Shop adjacent to the Engine Shop, after these equipment are washed in the main work area of the Engine Shop. In the present Diesel POH Shop (Low), work area for repair of engine accessories such as instrument, radiator, fan, etc., and work area for pre-arrangement of pipe work are provided. As it is preferable to repair fuel injection pump, gauge and instrument (including those other than for engine), etc., in a room of dust-proof structure, a room separate from the other work area is provided.

Test room for the performance test of completed engine is built separately at the location connected to the main engine repair area. In this Test Room, 2 power-packs for WDM2 and 1 engine for WDS4 will be able to be tested at the same time.

The EOT crane to be provided in each of this Test Room and the present Diesel POH Shop (High), will have 40 ton capacity, in consideration of large engine in future.

The traction generator will be sent to the Electric Rotating Machine Shop and be repaired there because the machines for repair of traction motor can be used commonly for the repair of traction generator.

After the repair is finished the traction generator will be sent back to the Engine Shop and assembled to the engine. Same procedure will be applied for the auxiliary generator.

The area to place the preliminarily repaired engine for spare is arranged in a corner of the Engine Shop. In this area, four power-packs for WDM2 and one engine for WDS4 can be placed.

(4) Bogie Shop

1) Capacity of Facilities

The repair work for bogie of WDM2 requires eight days. (Refer to the Fig. 1.1.1)

In these days, one day for disassembling and 3 days for assembling and rotating test are required.

It is estimated that 5 days are required for the light repair of bogie frame, but 25% of coming-in bogies for POH have the deficiency of crack in bogie frame, and it is estimated that 8 days are required for the heavy repair of bogie frame consisting of welding of crack on the frame.

Therefore, the unit exchange spare parts system is adopted in the repair of bogie frame both in heavy and light repair. For this unit exchange system, two bogies for light repair and one bogie (one bogie for EL) for heavy repair are required as spares.

According to the above, average number of locomotives staying concurrently is shown on the Table 1.1.6.

Table 1.1.6 Number of Bogies Repaired in a Year and Staying Concurrently in the Workshop

Shop		WDM2			EL			Total No. of Loco. staying concurrently
		No. of Loco. to be repaired in a year	No. of days in the shop	No. of Loco. staying concurrently	No. of Loco. to be repaired in a year	No. of days in the shop	No. of Loco. staying concurrently	
Disassembling Area		103	1	0.4	48	1	0.2	0.6
Assembling Area		103	3	1.3	48	3	0.6	1.9
Bogie Frame Repair Area		103	-	2.5	48	-	1.1	3.6
-do-	Light repair	77	5	1.6	36	5	0.7	2.3
(Break up)	Heavy repair	26	8	0.9	12	8	0.4	1.3

From these, the capacities of each area in the Bogie Shop are,

Bogie Disassembling Area	1 Locomotive
Bogie Frame Repair Area	3 (2) Locomotives
Bogie Assembling Area	2 Locomotives

Figures in ( ) shows the number of EL exclusively.

2) Plan of Facilities (Refer to the Vol. III Fig. 1-4)

The cleaning and repair of bogie frame and equaliser which are transported from the bogie disassembling area by the EOT crane will be carried out at the specified place in the present Wheel Shop and the Rebuilt Building. Parts attached to these will follow the same procedure.

After the repair work, bogie frame and so on will be transferred to the Rebuilt Building through painting booth, and preliminary work for assembling will be done there and transported by EOT crane to the bogie assembling area and lowered on the wheelset arranged here and set together.

Traction motor will be set on the bogie and then the bogie will be tested on the bogie rotating test apparatus located on the extension line of Bogie Shop. No load driving test will be carried out on the bogie. After the test, bogie will be sent out as a completed bogie.

As the repairs of suspension bearing of traction motor, side rod and its bearing for WDS4, and axle box are closely related to the repair of wheelset, and the work areas of these equipment are located in a corner of Bogie Shop adjacent to the Wheel Shop. Further, X-ray test apparatus with protection facilities is arranged near the place where the welding work for crack of bogie frame is carried out.

As for the springs, unit exchange system is adopted and the placing area of spare springs sent from the spring repair shop will be considered in the planning of layout.

The placing area for four spare bogie frames for unit exchange system is arranged in a corner of the Shop.

(5) Wheel Shop

1) Capacity of Facilities

The repair work of wheelset in the Wheel Shop consists of repair of wheelset of locomotive POH, repair of wheelset supplied to outstation, and repair of wheelset of crane car and so on.

As for the repair of wheelset, the amount of heavy repair such as replacement of axle, wheel, and tyre is much larger than that of light repair consisting only of turning of wheel tread. Then, number of wheel set to be repaired in the year 2000 for each kind of locomotive and others is calculated according to the assumption from the present state and it is shown on the Table 1.1.7.

Table 1.1.7 Work Volume of Wheelset Repair in the year 2000

		DL		EL	Others	Total
		WDM2	WDS4			
Assigned Loco. No.		620	150			770
Loco. No. for POH		103	30	48		181
No. of Wheelset to be Repaired	POH	618	90	288	120	1,116
	Required from outstation	595	26	280	400	1,301
No. of Wheelset Manufactured					150	150
Total number of wheelsets repaired/mfd.		1,213	116	568	670	2,567

Note 1. Percentage of number of wheelsets required for repair from the outstation in whole number of wheelsets of assigned locomotives is 16% for WDM2 and 5.8% for WDS4. Number of wheelsets of EL required from outstation is calculated with the rate of number of wheelsets for POH and outstation for WDM2.

2. Numbers of wheelsets in columns POH and Manufactured in Others are for the wheelsets of crane car and tower car.
Number of wheelsets required from outstation is of carriage and wagon.

3. These numbers show the number of wheelsets.

Number of wheelsets to be repaired in the Workshop is as shown on the Table 1.1.8.

Table 1.1.8 Number of Wheelsets to be Repaired and Staying Concurrently

Kinds of Repair		Number of Wheel Sets to be Repaired in a year	Staying Days of Wheelsets in the Shop			Number of Wheelsets Staying in the Shop concurrently		
			A	B	C	D	E	F
Light repair	DL (WDM2)	122	5	2.5	2.5	2.6	1.3	1.3
	DL (WDS4)	44	5.5	3.5	2	1	0.6	0.4
	EL	61	5	2.5	2.5	1.2	0.6	0.6
	Others	493	4	0.8	3.2	8	1.6	6.4
	Total	720				12.8	4.1	8.7
Heavy repair	DL (WDM2)	1,091	5	4.5	0.5	22.2	20	2.2
	DL (WDS4)	72	5.5	5.5	0	1.6	1.6	0
	EL	507	5	4.5	0.5	10.3	9.3	1
	Others	177	4	2.1	1.9	2.9	1.5	1.4
	Total	1,847				37	32.4	4.6
Total	DL (WDM2)	1,213				24.8	21.3	3.5
	DL (WDS4)	116				2.6	2.2	0.4
	EL	568				11.5	9.9	1.6
	Others	670				10.9	3.1	7.8
	Total	2,567				49.8	36.5	13.3

(Note) A: Total staying days of wheelsets in the Shop.

B: Actual days required for repair.

C: Staying days of unrepaired and repaired wheelsets (excluding those under repair) in the Shop.

D: Total number of wheelsets staying concurrently.

E: Number of wheelsets under repair concurrently.

F: Number of unrepaired and repaired wheelsets (excluding those under repair) staying concurrently.

In consequence of this, 37 wheelsets under repair (4 for light, 33 for heavy repair) and 13 sets not under repair, totally 50 wheelsets in average per day will be staying in the Wheel Shop in the year 2000.

Therefore, planning of capacity of repair facilities was made based upon the number of wheelsets mentioned above.

In this plan, unit exchange spare parts system with pre-repaired wheelsets will be adopted in the heavy repair of wheelset for DL (WDM2) and EL.

It is considered to arrange space for placing 10 spare wheelsets for the unit exchange system.

2) Plan of Facilities

In the Wheel Shop, repairing line was planned between bogie disassembling area and assembling area where common works for all wheelsets such as flaw detection, turning of wheel tread and journal of axle, etc. are carried out, and further machines for heavy repair and necessary stabling line of wheelset was arranged effectively. (Refer to the Vol. III Fig. 1-6.)

In this repairing line, machines and work areas are so arranged to minimize transfer distance of wheelsets between them and also they are arranged in accordance with the execution order of the repair work. Tracks and wheelset traverser are arranged in connection with these machines for ease of transfer of wheelset.

Wheel sets for POH of WDM2 and EL are sent to the repairing line, after they are stripped from the bogie in the bogie disassembling area.

After finishing the repair work, the wheelsets are sent to the bogie assembling area.

Inspection and repair work of roller bearing is carried out in the room of dust-proof structure to be provided in the above-mentioned wheelset repairing line, and also attachment of roller bearing to the wheelset after finishing repair work is carried out in this room.

This wheelset repairing line will also be used for repair of wheelset for POH of WDS4 and others, of wheelset sent from outstation, whether it is light or heavy repair, but turning of crank pin will be carried out at the Bogie Shop by transferring it to the Shop by EOT crane as mentioned in (4).

For the heavy repair of wheelset such as replacement of wheels and so on, necessary machines are arranged near and outside of the repairing line of wheelset for the convenience of mutual communication.

A track in the present steam locomotive POH shop is used for the in-coming and out-going line of wheelsets requested from outstations to be repaired.

At the same time, wheel park was planned outside so as to place the finished wheelset for outstation, as well as various scraps generated from re-tyring, re-axling process.

(6) Electric Rotating Machine Shop

1) Capacity of Facilities

The plan of the repair facilities in this shop was planned on the assumption that all the repair works of rotating machine necessary for the POH of locomotive are of light repair.

For this assumption following matters are considered.

(a) It cannot be considered that the heavy repair will occur in a constant rate in the POH of coming-in locomotive.

(b) It is necessary to consider that there is a possibility that the repair work of electric rotating machine in POH of coming-in locomotive will be continuously of light repair.

For the repair of traction motor and traction generator, unit exchange spare parts system is adopted and days for repair are as follows:

Traction generator	8 days
Traction motor	6 days

From these, average number of locomotives staying concurrently is as shown on Table 1.1.9.

Table 1.1.9 Number of Electric Rotating Machines Staying Concurrently (In terms of locomotives)

Item	WDM2			EL			Total No. of Loco. staying concurrently
	No. of Loco. to be repaired in a year	Staying days in the shop	No. of Loco. staying concurrently	No. of Loco. to be repaired in a year	Staying days in the shop	No. of Loco. staying concurrently	
Traction Generator	103	8	3.4	-	-	-	3.4
Traction motor	103	6	2.5	48	6	1.2	3.7

Therefore, capacity of the facilities is as follows:

Traction generator	4 locomotives
Traction motor	3 (2) locomotives

Figure in ( ) shows the number of EL exclusively.
These are applied to the auxiliary electric rotating machine correspondingly.
Further to say, facilities for heavy repair of electric rotating machine was set out of scope because it will be executed in other work area which is planned in other plan.

2) Plan of Facilities (Refer to the Vol. III Fig. 1-4)
Layout of machinery required for repair work of traction generator is planned so as to enable all the repair works in a series of disassembling, repair, and assembling in the same one Shop.
In a corner of the repair area of traction generator, air blowing equipment is provided and traction generator will be cleaned with air blowing before and after disassembling. Traction motor transferred from the bogie disassembling area by carrier or EOT crane will also be cleaned with air blast here. Traction motor will be transferred to the rebuilt building after the cleaning by air blow and in each of the exclusive repair area of magnet frame, armature, and other parts, repair work will be executed effectively. Then the motor will be assembled in the motor assembling area and after test the traction motor will be stored at a specified place. Transfer of the traction motor to the bogie assembling area will be done by carrier or EOT crane.
Facilities for repair of auxiliary rotating machine corresponds to that of the traction motor. Further, storage area for spare of traction generators, and traction motors for each requirement of locomotives (WDM2, EL) is arranged in a corner of the Shop.

(7) Electric Equipment Shop

Electric Equipment Shop is arranged in a part of Diesel POH Shop (Low) adjacent to the Carbody Shop. Among the various kinds of electric equipment attached to the locomotive body and the engine, control device, relay, contactor, etc., which can be detached from the locomotive body and the engine are repaired in this Shop. Test machines and equipment suitable for the repair of the electric equipment will be installed in this Shop. As the parts and equipment dealt with here are relatively small and light, transfer of these to the Carbody Shop and Engine Shop will be done by carrier.

(8) Store House

For the improvement plan of store house, only a sample was proposed at this time (Refer to the Vol. III Fig. 1-11), but the basic concept of the improvement plan is as follows:

1) To improve the material management system, it is essential to improve the whole system including inventory management, demand forecasting, and procurement control.
2) In planning this, it will be effective to introduce automatic mechanical stocker to make use of vertical space to utilise the limited area of store house effectively and to enable efficient materials handling work in and out of the store house.
3) In introducing automatic mechanical stocker, parts and materials to be stored in this should be classified in 3 classes as follows, and middle weight and light weight class material will be stored in a high storied rack.

Heavy material:	Its weight is over 1 ton or its one side length is over 1.5 m.
Middle weight material:	Not belongs to the others.
Light weight material:	Small material which can be handled by a man easily.

4) In storing middle weight and light weight material in the stocker, the following procedure will be applied.

Middle weight material: It will be arranged on the wooden pallet (about 1 m x 1.4 m, 1 ton) and this pallet will be stored on the rack of mechanical stocker by automatically operated stacker crane with fork.

Light weight material: It will be stored manually on the rack of mechanical stocker which is arranged vertically in 10 - 20 stages, and a man who gets on and operates the manually operated stacker crane will put on or pick up the material from the rack.

5) Accordingly, almost all the material will be stored in the mechanical stocker and in this case material will go in and out through one place, making it necessary to provide considerable area for issuing and receiving of material.

6) Further, in order to cope with the fluctuation in the amount of material entering the stocker, flat storage area for heavy material should be provided adjacent to the mechanical stocker.

7) For the efficient operation of the stacker crane, it is necessary to have a conversion programme for the retrieval of addresses of stored material easily and computer should be introduced for this system.

8) The number of stacker crane and the arrangement of the racks will be influenced by the number of stored material and store area as well as by the frequency of issuing and receiving of material in a day, so it is necessary to grasp them sufficiently.

(9) Material Transport System in the Workshop

1) Improvement of Transport System of Rolling Stock Parts

Transport of rolling stock parts between shops is now being done by lorries and loading and unloading on the lorry rely on a forklift truck.

In order to increase efficiency of transport, it will be so changed that the following parts for DL, except especially large parts, are put on a pallet and transported between shops by forklift truck.

Parts	Shops
Laminated spring	Smithy Shop
Suspension bearing for traction motor	Brass Foundry Shop
Pipe, Radiator	Copper Smith Shop
Other diesel engine parts	Diesel Component Shop, Machine Shop, Welding Shop, etc.

For the above improvement, number of equipments assumed to be required is as follows:

	Quantity
Forklift truck (2 ton)	3
Wooden pallet	about 30

2) Improvement of Transport by Wagon

Parts and material being transported now by wagon from the outside of the Workshop to the shop are as follows:

Wagon	Parts and Material	No. of wagons in workshop
4-wheeler covered wagon 4-wheeler open wagon Tank wagon	iron scrap steel scrap pig-iron moulding sand cokes limestone fuel oil coal for boiler	120 wagons/day
4-wheeler covered wagon 4-wheeler open wagon	brake block and other castings laminated spring slag	30 wagons/day

Among these materials mentioned above, raw material for casting can be transported by lorry, but these are transported from various places in the country and the volume is very large, so it is better to transport these material by wagon which has a larger capacity than lorry.

Therefore, these material will be transported by wagon. In order to decrease the staying time of wagon and also the number of wagons staying in the Workshop, loading and unloading facilities of Brake block casting will be improved.

(11) Building and Track

1) Building

The buildings which are necessary to be built newly, to be extended and rebuilt are as follows. (As for the Workshop Building, refer to the Vol. III Fig. 1-12.)

(a) Newly Built

i) In-coming Inspection Shop

It is necessary to build newly a building with an area of 240 m^2 (8 m x 30 m) in which in-coming inspection and washing of exterior of locomotive is to be carried out. It should be equipped with platform so that the work will be carried out on it.

ii) Engine Performance Test Room

It is necessary to build newly at a separate place a building with an area of 412 m^2 (27.5 m x 15 m) in which the performance test of completed engine will be carried out. The building should have sound-arresting structure and be equipped with 40 ton EOT crane. Further, it should be provided with control room from where the test equipment will be controlled.

(b) Extension and Rebuilt

i) Final Adjustment Shop

It is necessary to extend the Final Adjustment Shop having now the capacity to hold one diesel locomotive to the extent of holding 3 locomotives.

It is most preferable to extend the shop so as to locate 3 lines in parallel and each line can hold one locomotive, but it cannot be realized from the circumstances of location of the Shop and site limitation, it is planned to extend one locomotive line to the south and locate another locomotive line in the east side.

Then the area of the extended portion of the building will be 200 m^2 (8 m x 25 m) to south and 240 m^2 (8 m x 30 m) to the east, totalling 440 m^2.

ii) The present Fitting Shop and Wheel Shop

The present Fitting Shop will be wholly rebuilt into one bay removing the intermediate row of columns and also extending the bay to the north end of Diesel POH Shop. The area of the rebuilt bay is 4,276 m^2 (18.89 m x 13.72 m x 16.5 column spacing) and area of extension is 130 m^2 (18.89 m x 13.72 m x 0.5 column spacing). In this rebuilt bay, 10 ton and 5 ton EOT crane will be provided. Further, the present Wheel Shop will be extended to the north and in relation to this, the north end of this Shop will be rebuilt accordingly. The area of extension is 102 m^2 (14.93 m x 13.72 m x 0.5 column spacing) and the area of rebuilt is 102 m^2 (14.93 m x 13.72 m x 0.5 column spacing).

2) Track

Future layout plan of tracks in this modernisation plan is as shown on the Fig. 5.2.8, but at the time when construction works will commence, steam locomotive POH will be still executed and SL Paint Shop must be retained somewhere. Then the track layout of transitional period is shown in the Vol. III Fig. 1-13.
Therefore, at the time when the steam locomotive POH will phased out, tracks becoming unnecessary will be removed and the layout of tracks at this time will be as shown in the Vol. III Fig. 1-14.

3) Other Facilities

a) Improvement of Floor and Arrangement of Passage in the Main Building

As a measure of improvement of working environment, floor in the Main Building will be wholly repaired. In addition, one passage in each bay of 3 m width will be arranged parallel to the longitudinal direction of the bay (2 m width in case of Wheel Shop), and two passages of 5 m width perpendicular to the above-mentioned passages will be also arranged, to secure the safety and speed up of transport of parts and material by forklift truck and other carrier.

b) Tracks in the Building and Pit

New tracks for in-coming and out-going of locomotive, for transfer of bogie, and for transfer and pool of wheelset in the Main Building will be provided. The tracks other than these will be removed to reduce the ruggedness of the floor.
For the work for locomotive underfloor, one pit of 40 m length and one pit of 20 m length will be provided in the Carbody Lifting/ Lowering Shop. In the Bogie Shop, one pit for bogie disassembling work of 12 m length and one pit for bogie assembling work of 24 m length will be provided, but side pit not so deep will be provided at each of these pits for the convenience of the work.
In each of the above pits, lighting equipment will be suitably provided.

1.1.3 Machinery Plan

The major machines to be installed in each Shop in this plan are shown on the Table 1.1.10.

The details of the classification of Newly installed, Replaced, and Reused machines are as follows.

A. Newly installed: to install machine newly

B. Replaced: to replace existing machine older than 15 years with new one

C. Reused: to use existing machine in its place or some other place after relocated.

In this table, the machine with O mark will be imported and the machine without O mark will be indigenously manufactured.

Table 1.1.10 List of Major Machines

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
In-coming Inspection Shop	Carbody washer	Steam jet cleaner, press.: 7 kg/cm^2	2	2		
	Shunting locomotive		1			1
	Others					
Final Adjustment Shop	Air brake tester	Compressor with air piping 10 kW	1	1		
	Oil supply equipment	for fuel oil and lubricant	1	1		
	Water supply equipment	for cooling water for engine	1	1		
	Water load box tester		1			1
	EOT Crane		2	2		
	Others					
Carbody Lifting/ Lowering Shop	Lifting platform vehicle	Battery type, self-propelled	6	6		
Carbody Shop	Chassis cleaner	Steam jet cleaner, press.: 7 kg/cm^2	2	2		
	Electro-static painting equipment	Electro-static, airless spray type	2	2		
	Forklift truck	Battery type, 1.5 t	3	3		
	Carrier	Battery type, with lifting table, 1 t	12	12		
	Trestle	4/loco. for 7 loco.	28	20		8
	Tractor	Tractive force 1 t (for transfer of bogie)	1	1		
	EOT Crane	60 t x 21 m	2			2
	EOT Crane	10 t x 21 m	1			1
	EOT Crane	8 t x 21 m	1			1
	Others					
Engine Shop	O Engine block washer	for cleaning inside and outside of engine block, passing through type, by injection of hot water and detergent alternately	1	1		

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
Engine Shop	○ Cylinder head cleaner	with oscillating apparatus	1	1		
	○ Soft blasting equipment	with glass beads	1	1		
	Rotating manipulator for engine	with working platform	6	4		2
	Valve seat grinder	for grinding valve seat on cylinder head	1	1		
	Valve grinder		1	1		
	○ Fuel injection pump tester		1	1		
	○ Fuel injection nozzle tester	Test for injection angle (spread), atomizing, etc.	1	1		
	○ Internal grinder	for grinding inner surface of big end of connecting rod	1	1		
	○ Parts washer	for engine parts, with oscillator	1	1		
	Radiator cleaner	cleaning inside (remove scale) and outside	1	1		
	Engine performance test apparatus	for running performance test with no load/load (for WDS4)	1	1		
	Power-pack performance test apparatus	for running performance test with no load/load (for WDM2)	2	2		
	Engine carrier	load 40 t, battery type, self propelled in performance test room	1	1		
	Oil flushing apparatus	cleaning with oil circulation	1	1		
	EOT Crane	40 t x 21 m	1	1		
	EOT Crane	40 t x 15 m	1	1		
	Honing machine	for cylinder liner	1	1		
	Magnetic flaw detector	Portable	1	1		
	Dynamic balancing machine	Max. weight 150 kg, (rotor for super charger)	1	1		
	○ Engine painting equipment	Painting booth, truck, airless spray	1	1		

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
Engine Shop	Expressor tester	for WDM2	1	1		
	Compressor tester	for WDS4	1	1		
	Exhauster tester	for WDS4	1	1		
	O Transmission driving tester	for transmission drive test and oil flushing	1	1		
	O Injection washer	Reciprocating feeding type for inside of transmission gear case	1	1		
	Jib crane	2 t x 6 m	6	6		
	Hydraulic press		1	1		
	Oil supply equipment	for engine performance test room	1	1		
	Water supply equipment	for engine performance test room	1	1		
	Vertical milling machine	for inside surface of small end of connecting rod	1			1
	Lapping machine		2			2
	Governer tester		1			1
	Nozzle grinding & lapping machine		1			1
	EOT Crane	10 t x 14 m	1			1
	EOT Crane	3 t x 12 m	1			1
	Others					
Bogie Shop	O Bogie washing equipment	for washing bogie frame, parts etc., return back type inject hot water and detergent alternately	1	1		
	O Bogie painting equipment	for painting bogie frame, parts, etc., passing through/return back dual type airless spray, transfer table	1	1		

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
Bogie Shop	Magnetic flaw detector	Portable	1	1		
	Arc welder	CO_2 gas arc welding, semi-automatic	1	1		
	O Bogie driving tester	for no load driving test of assembled bogie with jack and power source equipment	1	1		
	Bogie turn-table	electric motor driven, table dia. 5000 mm	2	2		
	Hydraulic press		1			1
	Bogie frame welding positioner	for welding bogie frame, rotary	1	1		
	O X-Ray inspection equipment	for testing welded part of bogie frame, portable	1	1		
	EOT Crane	10 t x 18 m	1	1		
	EOT Crane	10 t x 14 m	1			1
	EOT Crane	5 t x 14 m	1			1
	Cylindrical grinding machine	for crank pin	1			1
	Quartering machine		1			1
	Double headed vertical boring machine		1			1
	Double headed vertical boring/grinding machine		1			1
	Axle box planer		1			1
	Shaper		1			1
	Slotter		1			1
	Vertical milling machine		2			2
	Upright drilling machine		1			1
	Lathe	Suspension bearing bore finish	2			2

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
Bogie Shop	Radial drilling machine	Crank pin, side rod, bearing finishing	1			1
	Others					
Wheel Shop	○ Wheel press	Capacity 400 t	2		2	
	Tyre heating furnace	Induction heating	1	1		
	Induction heater for bearing inner race	Induction heating, for pull out of inner race, with 2 coils	1	1		
	○ Roller bearing washer	Pre and after cleaning of roller bearing, 2 booths	1	1		
	○ Ultrasonic flaw detector	axial direction incidence type, with axle rotating device	1	1		
	○ Wheel set traverser	wheelset holding type	1	1		
	EOT Crane	3 t x 14 m	1	1		
	EOT Crane	3 t x 18 m	1	1		
	Roller bearing cleaner	Booth and steam cleaner (for WDS4)	1	1		
	○ Roller bearing grease filler		1	1		
	○ Axle box setter	with hand lifter	2	2		
	Bearing setter	for conical roller bearing of WDM2	2	2		
	Oil bath for heating bearing inner race	Electric heater type (for press in inner race to axle)	1	1		
	○ Bearing outer race and axle box setting equipment	for press in outer race to axle box	1	1		
	Jib crane	3 x 6 m	3	3		
	Wheel lathe	1100 mm x 1676 mm with chip conveyer	2		1	1
	Vertical lathe	NC type	1			1

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
Wheel Shop	O Axle journal turning and burnishing lathe	1090 mm x 1676 mm	2		1	1
	Vertical lathe for tyre		1			1
	Tyre drilling machine		1			1
	Vertical turret lathe		1			1
	Axle turning lathe	exclusively used for finishing fitting part of axle with wheel	2			2
	Gantry crane	outdoor type	1			1
	Others					
Electric Rotating Machine Shop	Armature lathe	Swing over bed 1500 mm	1	1		
	O Commutator groove cutting machine	grooving and chamfering	1	1		
	Insulation tester	DC component, tan δ, (TM, TG)	1	1		
	O Traction motor driving test apparatus	no load test	1	1		
	O Traction motor driving test apparatus	Loading and high speed test	1	1		
	Terminal temperature rise tester	measurement of temperature at transition bar of field coil	1	1		
	Air blast cleaning apparatus for rotating machine	Booth and truck with turntable (TM, TG)	1	1		
	O Parts washer	with oscillator (for end plate etc.)	1	1		
	O Parts washer	Kerosene (for small parts)	1	1		
	Carrier	self-propelled with electric motor to transfer traction generator to other shop	1	1		

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
Electric Rotating Machine Shop	EOT Crane	5 t x 18 m	1	1		
	Heating oil bath	electric heater (for fitting pinion)	1	1		
	Drying oven		2			2
	Others					
Electric Equipment Shop	Pressure relay tester	Performance test (including pressure switch)	1	1		
	Temperature relay tester	Performance test	1	1		
	Electro-pneumatic valve tester	Performance test	1	1		
	Voltage regulator tester		1	1		
	Speedometer tester		1	1		
	Contactor tester		1	1		
	Engine control panel tester		1	1		
	Circuit breaker tester		1	1		
	Insulation resistance tester		1	1		
	Capacitor tester		1	1		
	Carrier	0.5 t battery type	2	2		
	Air blast cleaning apparatus	Booth and truck	1	1		
	O Parts washer	Kerosene (for small parts)	1	1		
	EOT Crane	5 t x 12 m	1			1
	Load regulator tester		1			1
	Others					
Brake Parts Work Area	O Control valve tester		1	1		
	O Parts washer		1	1		

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
Brake Parts Work Area	Pressure gauge tester		1	1		
	Carrier	0.5 t, battery type	1	1		
	Valve lapping machine		1			1
	Others					
Diesel Component Shop	○ Internal grinder	287 mm x 300 mm	1		1	
	○ Universal cylindrical grinder	130 mm x 200 mm	1		1	
	○ Horizontal milling machine	630 mm x 275 mm	1		1	
Others	Forklift truck	2t, battery type	3	3		

1.1.4 Stage-wise Shop Arrangement Conversion Plan

The outlines of the stage-wise shop arrangement conversion while continuing the steam locomotive POH into exclusive workshop for future POH of diesel locomotives and electric locomotives was described in the Vol. I report.

The details of facilities plan and shop layout plan are as described in paragraph 1.1.2. To accomplish smooth conversion of shop arrangement, the shifting and conversion works of machines and work areas for steam locomotives repair inside the existing Wheel Shop and Fitting Shop should be done step by step.

(1) Existing machines inside Wheel Shop and Fitting Shop

The existing machines inside Wheel Shop and Fitting Shop are listed in Table 1.1.11 and existing machine layout is shown in Fig. 1.1.2.

(2) Machines to be shifted or demolished in the first stage

Among the existing machines inside the Wheel Shop and the Fitting Shop, the machines to be shifted into the planned Bogie Shop and Wheel Shop exclusively used for diesel locomotive POH in the first stage (1990) are listed in Table 1.1.12. And the machines to be demolished as surplus at that time are listed in Table 1.1.13.

(3) Machines to be shifted in the second stage

At the time that the number of steam locomotive POH decreases to only four locomotives per month, all machines needed for work volume of that time should be shifted into the marginal floor space inside the Boiler Shop.

These machines are listed in Table 1.1.14.

Therefore, all other remaining machines will be taken away from the Workshop.

Table 1.1.11 Existing Machine List inside Wheel Shop and Fitting Shop

I. Wheel Shop No.	Name of Machine
2	Centre Lathe
3	Centre lathe
4	Double Wheel Grinder
6	Upright Drilling Machine
7	Radial Drilling Machine
8	Radial Drilling Machine
11	Axle Box Planer
12	Axle Box Planer
14	Horizontal Boring Machine
15	Horizontal Boring Machine
16	Horizontal Boring Machine
17	Wheel Lathe (for steam loco. driving wheel)
18	Wheel Lathe (for steam loco. driving wheel)
20	Wheel Lathe (for narrow gauge wheel)
21	Wheel Lathe
22	Slotting Machine
23	Wheel Centre Lathe
24	Radial Drilling Machine
25	Vertical Turret Lathe
26	Vertical Turning Lathe (for tyre of steam loco. driving wheel)
27	Wheel Fitting Press
29	Journal Lathe (for steam loco. driving wheel axle journal)
30	Centre Lathe
31	Tyre Turning Lathe
33	Face Lathe
34	Journal Lathe
35	AJTB Lathe
36	Quartering Machine
37	Tyre Turning Lathe (for steam loco. tyre)

I. Wheel Shop (cont.) No.	Name of Machine
38	Vertical Turret Lathe
39	Vertical Turret Lathe
40	Shaping Machine
41	Quartering Machine
42	Tyre Drilling Machine
43	Wheel Fitting Press
44	Axle lathe
45	Tyre Drilling Machine
46	Centre lathe
47	Centre Lathe
48	Axle Lathe
49	Vertical Milling Machine
50	Axle Lathe

II. Fitting Shop No.	Name of Machine
1	Belt Driven Centre Lathe
2	Belt Driven Centre Lathe
3	Centre Lathe
4	Centre Lathe
5	Grinding Machine
8	Centre Lathe
9	Centre Lathe
10	Radial Drilling Machine
11	Radial Drilling Machine
12	Grinding Machine
14	Belt Driven Upright Drilling Machine
15	Centre Lathe
17	Centre Lathe
18	Centre Lathe
21	Horizontal Internal Grinding Machine
22	Horizontal Internal Grinding Machine
23	Radial Drilling Machine
24	Cylindrical Grinding Machine
25	Radial Drilling Machine
26	Upright Drilling Machine
27	Slide Bar Grinding Machine
28	Radial Drilling Machine
29	Shaping Machine
30	Hack Sawing Machine
31	Grinding Machine
33	Vertical Boring Machine
34	Grinding Machine
35	Slotting Machine
37	Bench Drilling Machine
38	Shaping Machine
39	Double Head Shaping Machine
42	Cylindrical Grinding Machine
43	Radial Drilling Machine

II. Fitting Shop (cont.) No.	Name of Machine
44	Vertical Milling Machine (for key way)
45	Radial Drilling Machine
46	Precision Centre Lathe
47	Vertical Boring Machine
48	Double Wheel Grinding Machine
49	Shaping Machine
50	Double Head Vertical Boring Grinding Machine
51	Centre Lathe
52	Piston Rod Grinding Machine
53	Centre Lathe
55	Cross Head Planer
57	Centre Lathe
58	Centre Lathe
59	Centre Lathe
67	Vertical Boring Machine
75	Slotting Machine
76	Centre Lathe
77	Centre Lathe
79	Double Head Vertical Boring Grinding Machine
80	Double Head Vertical Boring Machine
81	Hydraulic Press
82	Double Head Vertical Boring Machine
83	Horizontal Boring Grinding Machine
84	Radial Drilling Machine
85	Hydraulic Press
86	Centre Lathe
87	Cylindrical Grinding Machine
88	Vertical Milling Machine
89	Double Wheel Grinding Machine
90	Centre Lathe
91	Radial Drilling Machine
92	Air Hammer

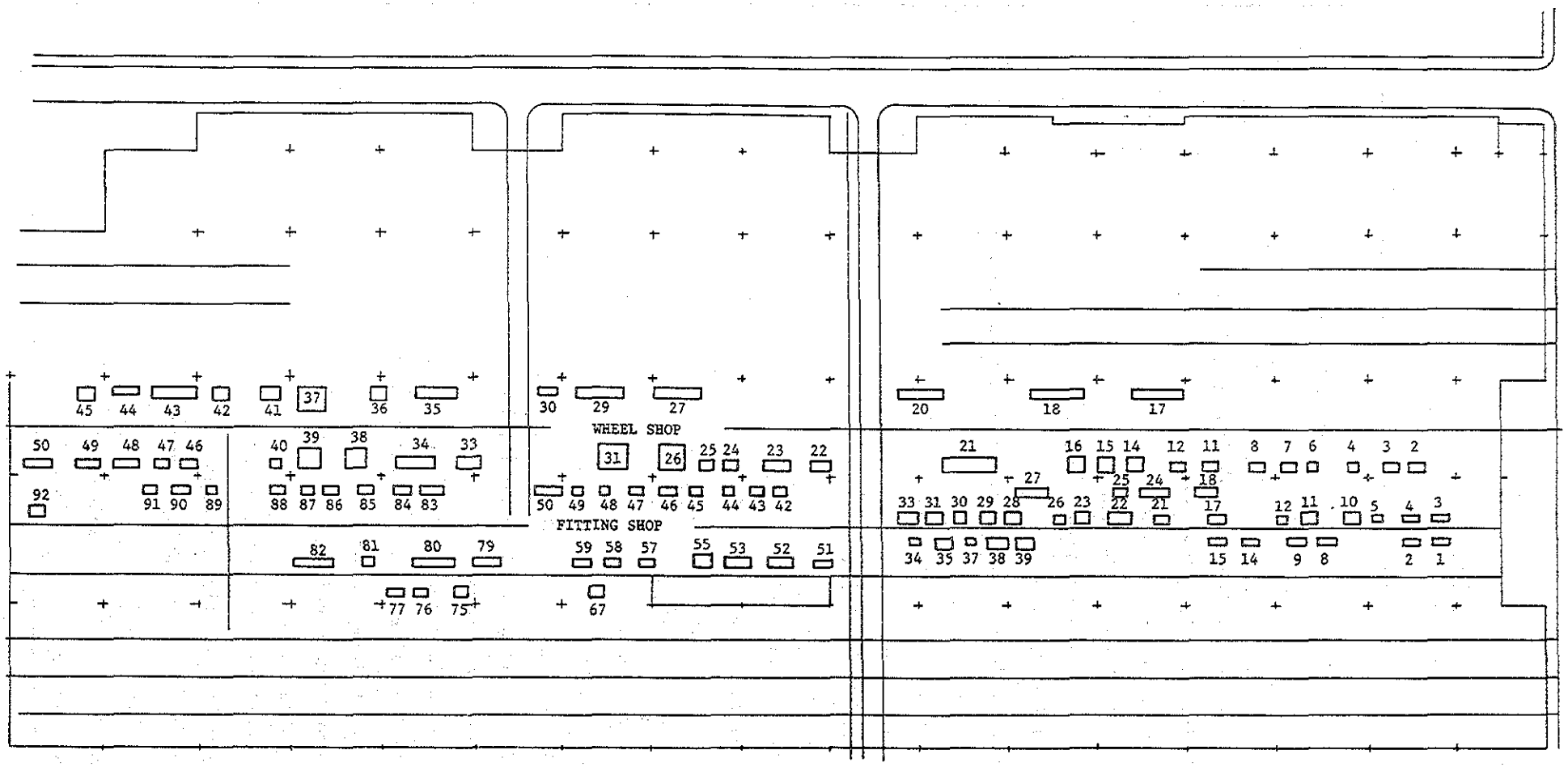


Fig. 1.1.2 Existing Layout of Machines Inside Wheel & Fitting Shop

Table 1.1.12 Machines to be Shifted to Diesel Locomotive Bogie and Wheel Shops in First Stage

I. Wheel Shop No.	Name of Machine
6	Upright Drilling Machine
7	Radial Drilling Machine
11	Axle Box Planer
21	Wheel Lathe
31	Tyre Turning Lathe
35	AJTB Lathe
36	Quartering Machine
39	Vertical turret Lathe
40	Shaping Machine
42	Tyre Drilling Machine
44	Axle Lathe
48	Axle Lathe
49	Vertical Milling Machine
II. Fitting Shop No.	**Name of Machine**
46	Precision Centre Lathe
75	Slotting Machine
79	Double Head Vertical Boring Grinding Machine
80	Double Head Vertical Boring Machine
81	Hydraulic Press
86	Centre Lathe
87	Cylindrical Grinding Machine
88	Vertical Milling Machine

Table 1.1.13 Machines to be Demolished in First Stage

I. Wheel Shop No.	Name of Machine
3	Centre Lathe
8	Radial Drilling Machine
14	Horizontal Boring Machine
18	Wheel Lathe
26	Vertical Turning Lathe
33	Face Lathe
38	Vertical Turret Lathe
46	Centre Lathe
II. Fitting Shop No.	**Name of Machine**
1	Belt Driven Centre Lathe
2	Belt Driven Centre Lathe
3	Centre Lathe
5	Grinding Machine
8	Centre Lathe
10	Radial Drilling Machine
14	Belt Driven Upright Drilling Machine
21	Horizontal Internal Grinding Machine
23	Radial Drilling Machine
34	Grinding Machine
37	Bench Drilling Machine
45	Radial Drilling Machine
57	Centre Lathe
67	Vertical Boring Machine
77	Centre Lathe

Table 1.1.14 Machines to be Shifted to Boiler Shop in Second Stage

I. Wheel Shop No.	Name of Machine
2	Centre Lathe
12	Axle Box Planer
15	Horizontal Boring Machine
17	Wheel Lathe
22	Slotting Machine
23	Wheel Centre Lathe
25	Vertical Turret Lathe
27	Wheel Fitting Press
29	Journal Lathe
37	Tyre Turning Lathe
41	Quartering Machine
45	Tyre Drilling Machine
II. Fitting Shop No.	**Name of Machine**
4	Centre Lathe
9	Centre Lathe
11	Radial Drilling Machine
12	Grinding Machine
15	Centre Lathe
18	Centre Lathe
22	Horizontal Internal Grinding Machine
24	Cylindrical Grinding Machine
25	Radial Drilling Machine
26	Upright Drilling Machine
27	Slide Bar Grinding Machine
29	Shaping Machine

II. Fitting Shop (cont.) No.	Name of Machine
30	Hack Sawing Machine
33	Vertical Boring Machine
42	Cylindrical Grinding Machine
44	Vertical Milling Machine
47	Vertical Boring Machine
50	Double Head Vertical Boring Grinding Machine
52	Piston Rod Grinding Machine
53	Centre Lathe
55	Cross Head Planer
82	Double Head Vertical Boring Machine
89	Double Wheel Grinding Machine
90	Centre Lathe
91	Radial Drilling Machine

1.2 Modernisation Plan for Laminated Spring Manufacturing and Repairing

1.2.1 Assumption of Number of Laminated Springs to be repaired in the year 2000

Estimated number of laminated springs to be Repaired in the Year 2000 was calculated as follows. Calculation is made as shown in Table 1.2.1 based on the number of cars owned by IR in 1985.

For wagons	9,500 unit/year
For locos	500 unit/year

1.2.2 Calculation of Capacity of Laminated Springs Hardening Furnace

Capacity of existing laminated springs hardening furnace was calculated as stated in page 44 and the result is as follows:

Running ratio is assumed to be 85% in one shift work.

142,175 - 94,784 leaves/year/shift

1.2.3 Major Plant & Machinery for Laminated Springs Manufacture/Repair

Name, quantity and major performance of major Plants & Machinery needed for laminated springs manufacture/repair are shown in Table 1.2.2.

1.3 Modernisation Plan for Brake Block Casting

1.3.1 Assumption for Brake Block Casting Requirements in the Year 2000

Casting amounts of brake block required in the year 2000 were calculated as shown below. Calculation is made as shown on Table 1.3.1 based on the number of cars owned by IR in '85.

For wagons	7,100 t/year
For coaches	4,600 t/year
For locos	1,700 t/year
Total	13,400 t/year

1.3.2 Major Plant & Machinery for Brake Block Casting

Name, quantity and major performance of major plants & machinery needed for brake block casting are shown in Table 1.3.2.

1.3.3 Comparison of Melting Work of Cupola and Induction Furnace

Comparison of melting work of cupola and induction furnace is shown in Table 1.3.3.

1.3.4 Comparison of Respective Pouring System

Comparison of respective pouring system is shown in Table 1.3.4.

Table 1.2.1 Estimated Number of Laminated Spring to be Repaired in the Year 2000

a. Wagon

	①	②	③	④	⑤	⑥	⑦
	Number of wagons owned by IR in 1985	Number of springs in 1985 in IR	Number of springs repaired at Jamalpur in 1985	③ / ②	Number of wagons owned by IR in 2000	Number of springs in 2000 in IR	⑥ x ④ Number of springs repaired at Jamalpur in 2000
8 wheeler	92,222	① x 8 737,776			238,800	⑤ x 8 1,910,400	
4 wheeler	193,876	① x 4 775,504			115,400	⑤ x 4 461,600	
Total	286,098	1,513,280	6,321	0.004	354,200	2,372,000	9,488

b. Loco

①	②	③	④	⑤
Number of locos assigned to Jamalpur in 1985	Number of springs repaired in 1985	② / ①	Number of locos assigned to Jamalpur in 2000	④ x ③
318	207	0.65	730	474

c. a + b = 9,962

Calculation of Capacity of Hardening Furnace

Assumed as: running ratio 85% in one shift work.

Length of furnace:	4,000 m/m
Pitch:	Leaf width + 30 = 150 m/m
Holding time in furnace:	20 - 30 min.
Actual working time in a day:	7 hrs.
No. of leaves in one charge:	4,000 m/m ÷ 150 m/m = 26.7 = 27 leaves
No. of charges in a day:	60 min. x 7 hr ÷ (20-30) m/m = 21-14 times
No. of leaves to be treated in a day:	27 leaves x (21-14) = 567-378 leaves
No. of leaves to be treated in a year:	(567-378 leaves) x 295 days = 167,265-111,510 leaves
Capacity of furnace:	(167,265-111,510 leaves) x 0.85 = 142,175-94,784 leaves

Table 1.2.2 List of Major Plants and Machnery Proposed in Laminated Spring Shop

(Newly Installing)

Description	No.	Major performance
1. Injection washing equipment	1	L 5500 x W 1400 x H 1600
2. Electromagnetic flaw detector	1	DC 4000 A
3. Electric heating furnace	1	300 kVA, Temp. 430°C
4. Spring forming m/c	2	Roller type Roller revolution 27 rpm
5. Anticorrosive coating & baking equipment	1	Overhead trolley conveyor 50 kg Baking furnace L 800 x W 1300 x H 700
6. Lubricator	1	Roller dia. 120 ϕ, 20 rpm
7. Monorail crane	4	0.5 t
8. Conveyor	1 set	Roller conveyor, Belt conveyor
9. Camber correcting m/c	1	Roller type
10. Buckle assembling m/c	1	Pneumatic type
11. Jib crane	1	0.5 t
12. Spring load tester	1	Max. load 40 t
13. Lubricant penetrating equipment	1	L 980 x W 1500 x H 860

(Relocation)

1. Spring debuckling m/c	1	Hydraulic, 110 t
2. Jib crane	2	1 t, 0.5 t
3. Scragging press	1	Horizontal type, Max. pressure 40 t

(Existent Installed)

Description	No.	Major performance
1. Spring load tester	1	Max. load 40 t
2. Brinell hardness tester	2	Testing height 13 - 300 mm
3. Shot blasting m/c	1	Max. projection 90 kg/min.
4. Spring buckling m/c	1	150 t
5. Eye rolling m/c	1	Eye rolling 23 - 29 ϕ
6. Nibbing press	1	100 t
7. Spring hardening furnace	1	Walking beam type, Temp. range 830 - 1050°C
8. Spring cambering & quenching m/c	1	Max. leaf dimension W 160 x L 1320 x T 18
9. Spring tempering furnace	1	Conveyor type, Temp. range 400 - 550°C
10. Spring leaf cropping m/c	1	Width 150 mm, Thickness 16 mm
11. Matching press	4	
12. Drilling m/c	1	

Note: All machines planned for the laminated spring shop are considered to use indigenously manufactured ones.

Table 1.3.1 Estimated Brake Block Casting Requirements in 2000

a. For wagons

	①	②	③	④	⑤
	Wagons owned by IR in 1985	Amount cast in 1985 (t)	② / ① (t)	Wagons owned by IR in 2000	③ x ④ (t)
8 wheeler	92,222	2,594.05	0.028	238,800	6,686
4 wheeler	193,876	889.15	0.004	115,400	462
				Total	7,148

b. For coaches

①	②	③	④	⑤
Coaches assigned to ER in 1985	Amount cast in 1985 (t)	② / ① (t)	Coaches assigned to ER in 2000	③ x ④ (t)
3,880	3624.07	0.934	4,900	4,576

c. For locomotives

	①	②	③	④	⑤
	Locomotives assigned to ER in 1985	Amount cast in 1985 (t)	② / ① (t)	Locomotives assigned to ER in 2000	③ x ④ (t)
WDM2	221	531.47	2.40	580	1,392
WDS4B	97	217.35	2.24	150	336
				Total	1,728

d. a + b + c = 13,452 t/year

Table 1.3.2 List of Major Plants and Machinery Proposed in Brake Block Casting Shop

Category	Description	No.	Major performance
Melting Equipment	○ Cupola	2	6 t/h, Hot air blast, water cooling
	○ Automatic material charger	1	Charging capacity 2.2 t, Bucket volume 0.8 m^3
	○ Fore hearth	1	3 t
	○ Cupola controller	1	Automatic controller for temp. & air capacity
	○ Hopper for coke & limestone	1	Coke 7 t, Limestone 3 t
	○ Slag disposer	1	
	○ Heat exchanger	1	Air capacity 1000 m^3/min, Hot blast temp. 400°C
Sand Molding Equipment	○ Molding machine	1	Jolt capacity 800 kg, Squeeze pressure 18 t
	○ Flask matching equipment	1	Semi-automatic traverser type, Lift 600 kg
	○ Weight removing equipment	1	Automatic traverser type, Lift 600 kg
	○ Flask sending out equipment	1	Automatic type, Cyl. dia 200 mm, Stroke 1440 mm
	○ Mold releasing device	1	Automatic type, Punch out pusher dia, 200 mm x 800 mm stroke
	○ Pattern changing equipment	1	Compressed air, Electric power type
Sand Conditioning Equipment	○ Sand carrying device	1	Capacity 7 m^3/h
	○ Sand storage	1	Used sand 10 m^3, New sand 3 m^3 Breaker screen
	○ Moisture controlling device	1	Moisture measuring unit, Sand temperature measuring unit
	○ Bond carrying equipment	1	Tank volume 91 m^3
	○ Bond storage	1	Hopper volume 0.7 m^3 x 1.03 m^3 x 1

Category	Description	No.	Major performance
Sand Conditioning Equipment	○ Mixer	2	31 rpm, 7 - 8 m^3/h
	○ Sand spreading machine	1	Treating capacity 7 m^3/h
Core Making Equipment	○ Shell core blowing machine	1	Cycle time 60 sec, Hopper 0.1 m^3 Blow head capacity 20 l
Product Processing Equipment	○ Weir breaker	1	Shake out type
	○ Shot blasting equipment	1	Drum type 0.6 m^3/batch
	○ Product finishing conveyor	1	0.8 - 24 m/min
	○ Dust collector	1	Air capacity 100 m^3/min
Material Handling Equipment	Yard crane	1	Capacity 3 t, Span 18 m, Run way 70 m
	Over head travelling crane	3	Capacity 3 t, Span 18 m
	Forklift truck	2	2 t, Rotary head type
	Shovel loader	2	1.5 t
	Lifting magnet	1	1.5 t
	Pallet	300	L 1000 x W 1000 x H 500, Made of steel
	Geared crane ladle	3	1 t
	Trolly ladle with lift	3	0.2 t
Metal Mold Casting Plant	○ Metal mold casting plant	2	Turn table type, metal pattern 8 x 2, Casting tact time 75 sec, Apron conveyor
	○ Die	32	
Other M/C & Instrument	Die sinking m/c	1	
	Press	3	200 t, 100 t, 60 t
	Automatic welder	1	
	○ Si-meter	1	For measuring carbon equivalent

Note: Machines marked with ○ are imported ones.

Table 1.3.3 Comparison of Melting Work of Cupola and Induction Furnace

Item	Cupola	Induction Furnace
Heat efficiency	30 - 40%	15 - 25 %
Pre-heating measure	In case of coke ratio is 9%, 300°C hot air is blasted.	Raw metal is pre-heated to 800°C (melting capacity is doubled.)
Application	Suitable for gray cast iron casting. Applicable to brake block casting.	Suitable for modular graphite cast iron casting.
Running cost	Low	High
Banking fire measure	After out of air blast, molten metal must be taken out from cupola, and fire must be banked. (Worker is not required)	For holding molten metal, electric power must be supplied all the night through and cooling water also must be circulated. (Worker is required)
Skillness	Necessary	Not necessary

Table 1.3.4 Comparison of Respective Pouring System

Item	Pouring by crane or monorail	Pouring by automatic carrying equipment	Pouring by automatic fixed point pouring equipment
Pouring	by ladle	by ladle	by Pouring Furnace
Temperature	Temperature drops with time.	Temperature drops with time.	Temperature rise is possible.
Pouring ladle handling	by Crane or monorail	by Monorail operated by electric signal	Fixed point
Pouring position	Travelling pouring (by overhead crane) Fixed point pouring (by monorail and two pouring ladles)	Fixed point pouring (Same as left)	Fixed point
Number of workers	2	1	1
Pouring operation	Manual pouring	Manual pouring	Pouring furnace is operated by compressed air cylinder
Volume of molten metal inside ladle	Adjustable	Adjustable	Constant volume
Electrical system	Same as ordinary crane	Operated by electric signal	Electric power must be supplied all the night through by inductor for maintaining temperature and cooling water must be circulated.
Work environment	Shift of workers is necessary, because of high temperature atmosphere	Same as left	Good
Plant cost	Low	High	High

CHAPTER 2 PERAMBUR WORKSHOP

CHAPTER 2 PERAMBUR WORKSHOP

2.1 Coach Inspection and Repair Facility

2.1.1 Basic Conditions for Facility Planning

(1) Estimation of the number of coaches to be inspected.

Table 2.1.1 shows the number of coaches to be inspected by type of coach. According to this table, the Phase I work will be planned for the year 1995 and the Phase II work for the year 2000.

Table 2.1.1 Number of Coaches to be Inspected by Type of Coach Over the Years

Item		Type of coach	Year			
			1986	1990	1995	2000
No. of coaches assigned		AC	86	161	256	350
		Ordinary	2585	3004	3527	4050
		Total	2671	3165	3783	4400
No. of coaches inspected	Total	AC	68	120	185	250
		Ordinary	2001	2386	2868	3350
		Total	2069	2506	3053	3600
	Perambur workshop	AC	68	120	185	250
		Ordinary	1724	2086	2268	2750
		Total	1792	2206	2453	3000
	Loco works	Ordinary	277	300	-	-
	Tirupati workshop	Ordinary	-	-	600	600

Note 1. The average turning-in ratio over the past years (No. of coaches inspected/No. of coaches assigned) were calculated as follows.

AC coach: 0.72

Ordinary coach: 0.72 + 0.11 (portion carried out at loco works) = 0.83

2. The figures for 1990 and 1995 were obtained by linear interpolation.

(2) Estimation of the number of coaches by type of repair

Table 2.1.2 shows the number of coaches requiring heavy repair (corrosion repair) and those requiring ordinary repair. For the calculations, in view of future introduction of anti-corrosive coaches, the corrosion rates are estimated at levels lower than at present.

Table 2.1.2 Estimation of the Number of Coaches by Type of Repair

Type of coach	Type of repair	Year			
		1986	1990	1995	2000
AC coach	Corrosion repair	18	30	50	60
	Ordinary repair	50	90	135	190
	Total	68	120	185	250
	(Corrosion rate)	(0.27)	(0.27)	(0.26)	(0.24)
Ordinary coach	Corrosion repair	(277) 771	(300) 835	685	690
	Ordinary repair	1230	1551	1583	2060
	Total	(277) 2001	(300) 2386	2268	2750
	(Corrosion rate)	(0.38)	(0.35)	(0.30)	(0.25)
Total	Corrosion repair	(277) 789	(300) 865	735	750
	Ordinary repair	1280	1641	1718	2250
	Total	(277) 2069	(300) 2506	2453	3000
	(Corrosion rate)	(0.38)	(0.35)	(0.30)	(0.25)

Note: Encircled figures indicate the number of coaches inspected at loco works (included in the figures directly right of them).

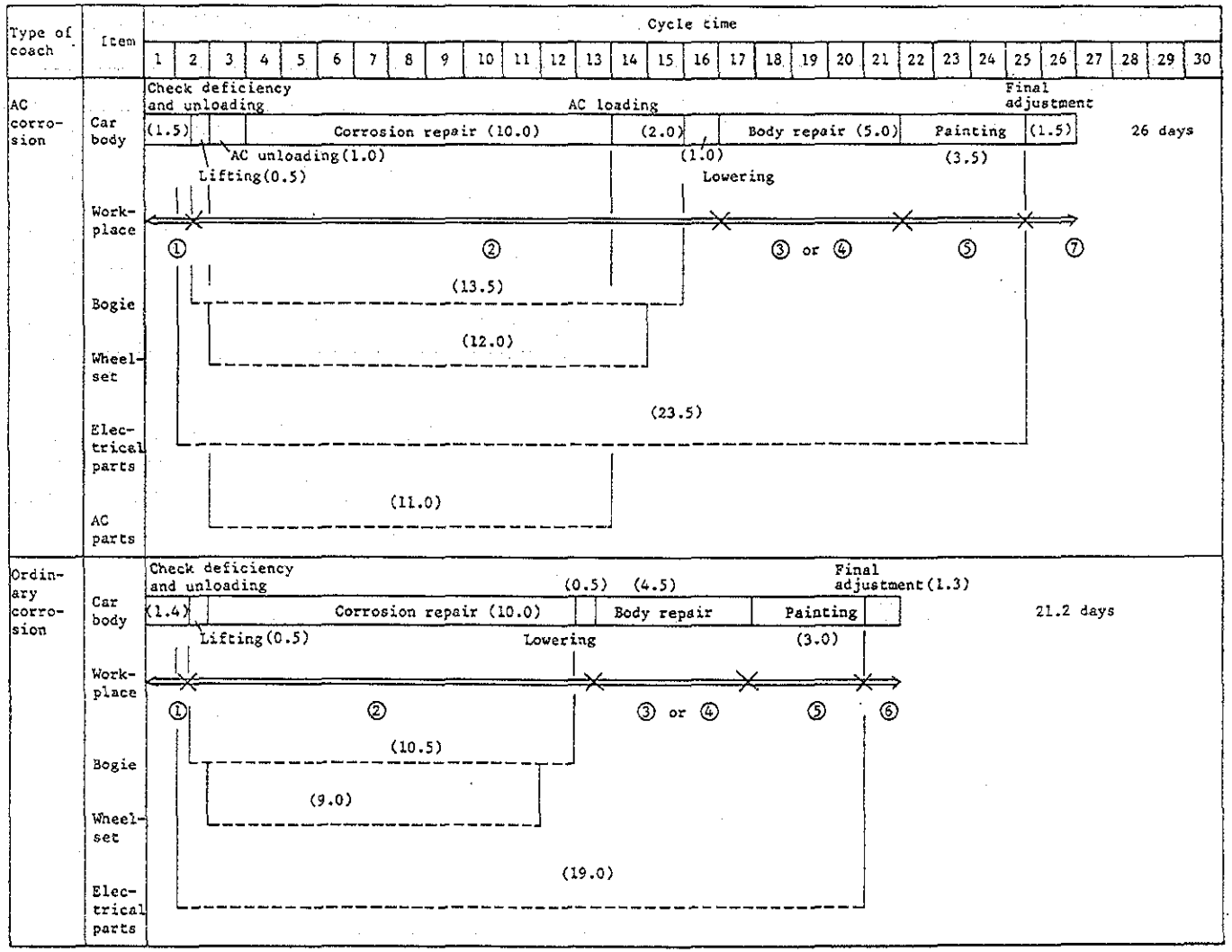
(3) Cycle time by type of coach and by type of repair

Table 2.1.3 shows the cycle time for repairing the coaches used in this report. It is planned that upon completion of the Phase I work, part of the car body repair work will be carried out at the same shop as at present (CR shop, CB shop). This requires cycle time longer than that at the completion of Phase II work by 0.5 day due mainly to delays from waiting for inspection/repair. Figures 2.1.1 and 2.1.2 show the relations between cycle time, work place, and process of major parts.

Table 2.1.3 Inspection/Repair Cycle Time by Type of Coach

Type of coach	Type of repair	Planned cycle time							
		Check deficiency and unloading	Lifting and lowering	Loading and unloading of AC parts	Corrosion repair	Body repair	Painting	Loading and adjustment	Total
AC coach	Corrosion	1.5	1.5	3.0	10.0	(5.0) 4.5	3.5	1.5	(26.0) 25.5
	Ordinary repair	1.4	1.5	3.0	-	3.5	2.5	1.5	13.4
Ordinary coach	Corrosion	1.4	1.0	-	10.0	(4.5) 4.0	3.0	1.3	(21.2) 20.7
	Ordinary repair	1.1	1.0	-	-	2.5	1.5	1.0	7.1

Note: 1. All duration figures are given as actual working days.
2. Numbers in parentheses indicate the days that apply to the Phase I work, as opposed to the Phase II work.



Legends: ① In-coming inspection shed, ② New car body shop, ③ Existing carriage repair shop (CR), ④ Existing carriage building shop (CB), ⑤ Painting shop, ⑥ Final adjustment shed, ⑦ AC final adjustment shed

* Numbers in parentheses indicate the days for repair. Figures for the bogies and other parts show the allowed days for each work.

Fig. 2.1.1 (1) Inspection/Repair Cycle Time and Work Place by Type of Coach (Phase I work plan)

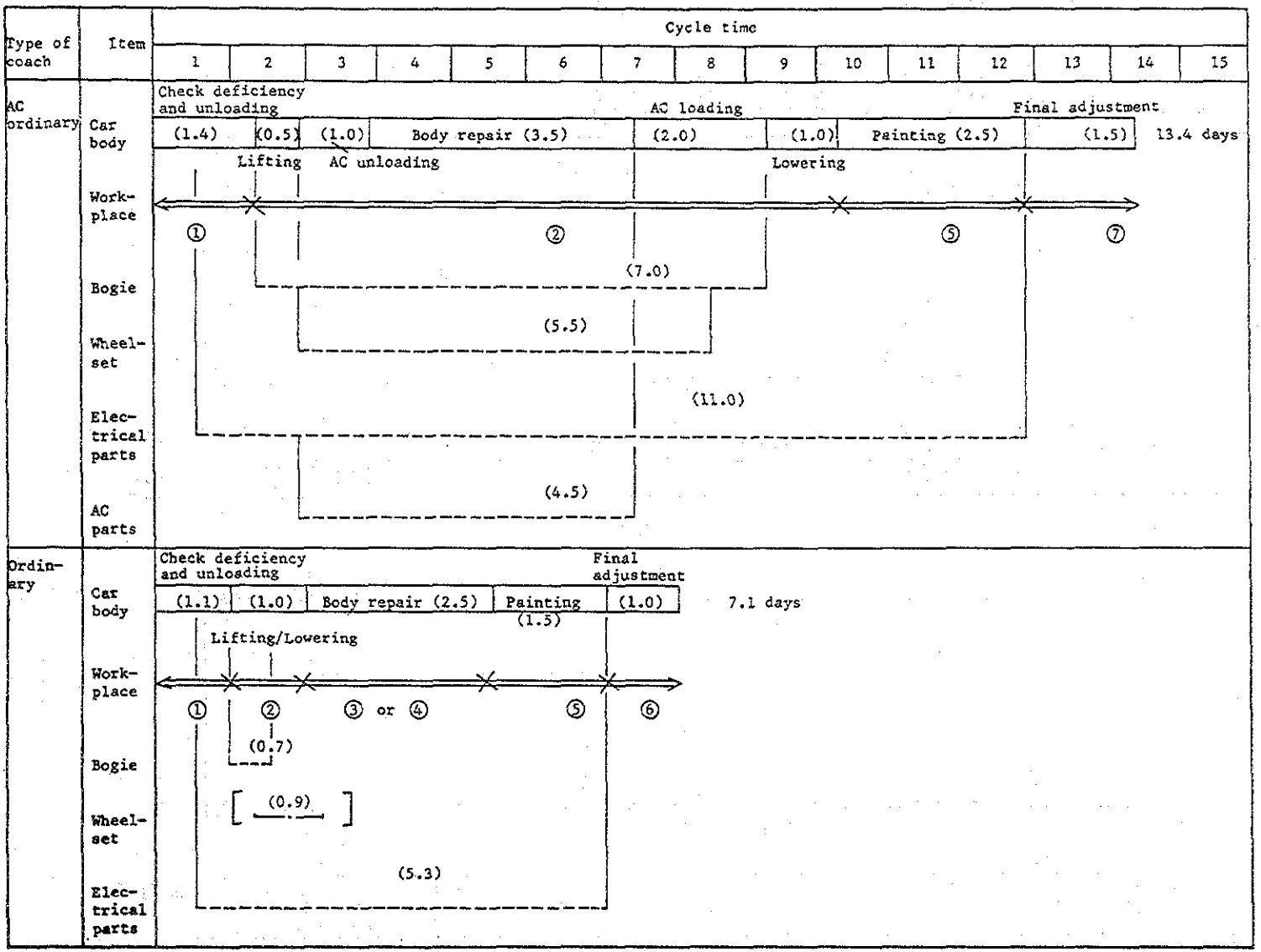
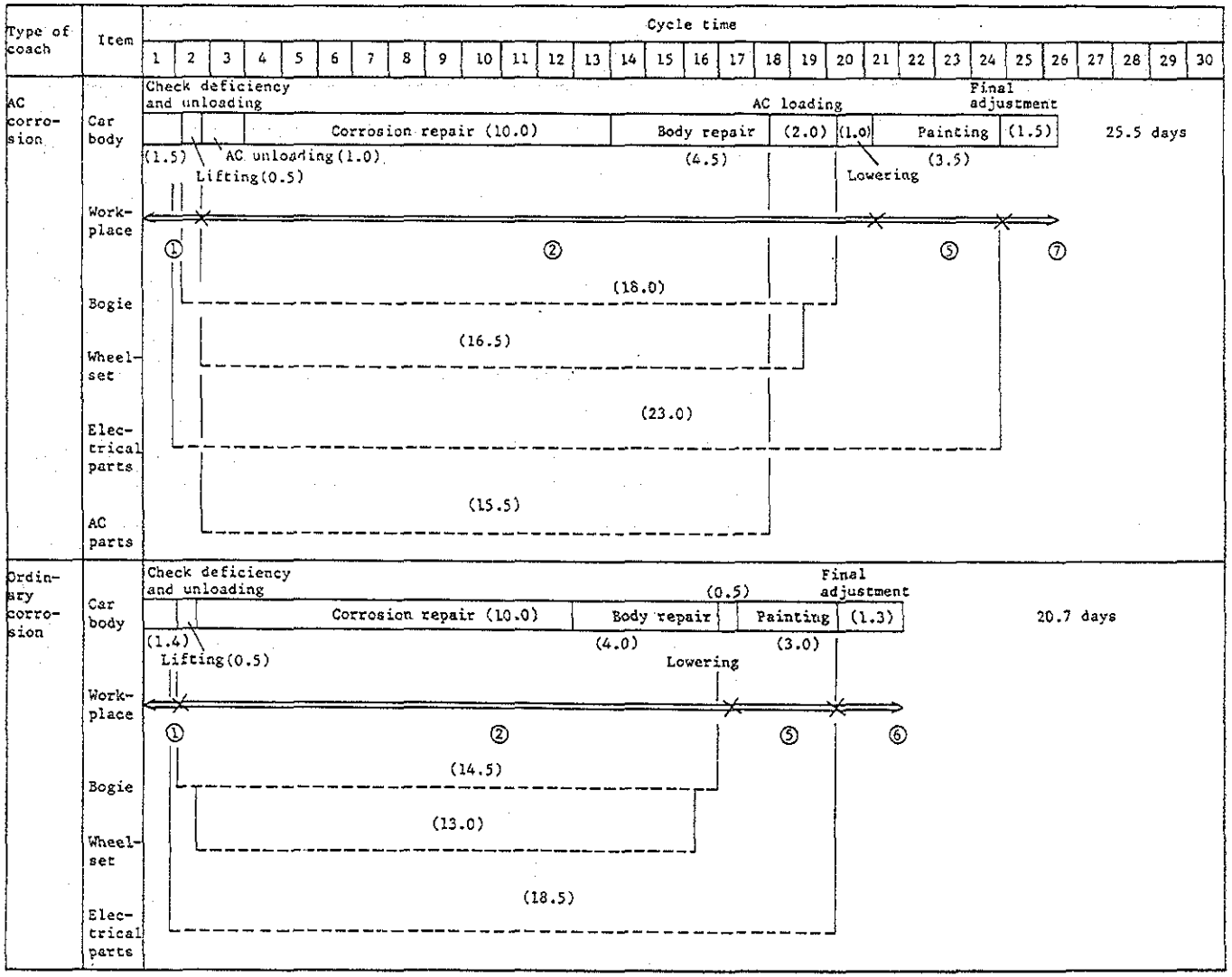


Fig. 2.1.1 (2) Inspection/Repair Cycle Time and Work Place by Type of Coach (Phase I work plan)



Legends: ① In-coming inspection shed, ② New car body shop, ③ Existing carriage repair shop (CR), ④ Existing carriage building shop (CB), ⑤ Painting shop, ⑥ Final adjustment shed, ⑦ AC final adjustment shed
* Numbers in parentheses indicate the days for repair. Figures for the bogies and other parts show the allowed days for each work.

Fig. 2.1.2 (1) Inspection/Repair Cycle Time and Work Place by Type of Coach (Phase II work plan)

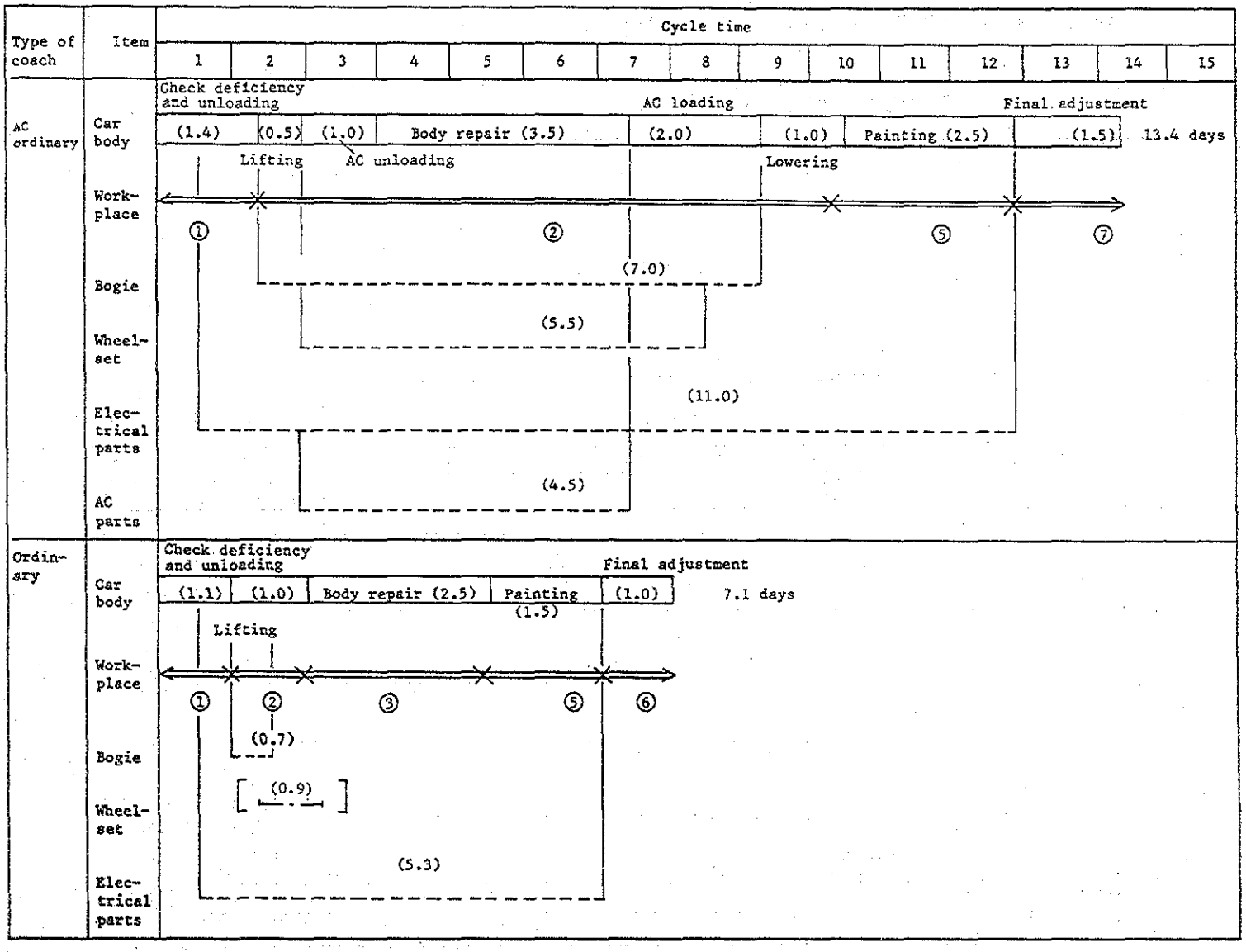


Fig. 2.1.2 (2) Inspection/Repair Cycle Time and Work Place by Type of Coach (Phase II work plan)

2.1.2 Facility Improvement Plan

(1) In-coming inspection shed

The work to be carried out in this shed will include inspection of coaches on their condition upon admission, unloading of general electrical parts (fans, lights, batteries, alternators, etc.), and uncoupling of brake rigging.

1) Scale of facility

Table 2.1.4 shows the proposed scale of the in-coming inspection shed.

Table 2.1.4 Proposed Scale of the In-coming Inspection Shed

Type of coach		Phase I			Phase II		
		No. of coaches inspected annually	Cycle time	No. of coaches staying concurrently	No. of coaches inspected annually	Cycle time	No. of coaches staying concurrently
AC	Corrosion	50	1.5	0.31	60	1.5	0.37
	Ordinary	135	1.4	0.78	190	1.4	1.10
Ordinary	Corrosion	685	1.4	3.95	690	1.4	3.98
	Ordinary	1,583	1.1	7.18	2,060	1.1	9.34
Total		2,453	-	12.2	3,000	-	14.8

Note 1: No. of coaches staying concurrently = No. of coaches inspected annually x cycle time x fluctuation rate (1.2)/No. of actual working days annually

2: Present scale of facility = 11 coaches x 1 track

2) Facility plan

(a) The parts and equipments under the coach floor will be unloaded using a forklift.

(b) The facility will be built with single pit structure to allow for ease of work under the coach floor. The rails and the floor surface will be positioned flush so as to facilitate forklift work.

(c) The removed electrical parts will be carried after being detached by forklift or by carrier to the adjacent electrical parts shop.

(d) With the above requirements taken into account, the present in-coming inspection shed is not adequate and should be demolished. The site after demolition of current shed will be used as a passage for transport purposes.

(e) A two-track layout will be adopted, with a track-to-track spacing of 7 meters.

(f) Eight coaches on 2 tracks (16 coaches in total) will be accommodated. The entire facility will be built during the Phase I period.

(2) Car body repair shop

The car body repair shop will consist of a new car body shop with cross-wise arrangement system, and the existing carriage repair shop and carriage building shop. At the end of the Phase II, only the first two shops will be used. The work to be performed at the new car body shop will include lifting and lowering of car bodies, replacing of bogies, unloading and loading of interior parts, repair of corrosion on body panels, and loading and unloading of AC components to and from AC coaches. The CR shop and CB shop will primarily be used for repairs on the carriage interior.

1) Scale of facility

Table 2.1.5 and 2.1.6 shows the proposed scale of the car body repair shop.

Table 2.1.5 Proposed Scale of the Car Body Repair Shop (Phase I plan)

Type of coach		No. of coaches inspected	Cycle time by work type and No. of coaches staying concurrently				
			Lifting and lowering	Unloading and loading of AC parts	Corrosion repair	Body repair	Total
AC	Corrosion	50	(1.5) 0.3	(3.0) 0.6	(10.0) 2.1	(5.0) *1.0	*1.0 3.0
	Ordinary	135	(1.5) 0.8	(3.0) 1.7	-	(3.5) 1.9	4.4
Ordinary	Corrosion	685	(1.0) 2.8	-	(10.0) 28.2	(4.5) *12.7	*12.7 31.0
	Ordinary	1,583	(1.0) 6.5	-	-	(2.5) *16.3	*16.3 6.5
Total		2,453	10.4	2.3	30.3	*30.0 1.9	*30.0 44.9

Note: Circled figures indicate the number of days. Asterisked (*) items apply to the CR and CB shops (listed separately).

Table 2.1.6 Proposed Scale of the Car Body Repair Shop (Phase II plan)

Type of coach		No. of coaches inspected	Cycle time by work type and No. of coaches staying concurrently				
			Lifting and lowering	Unloading and loading of AC parts	Corrosion repair	Body repair	Total
AC	Corrosion	60	(1.5) 0.4	(3.0) 0.7	(10.0) 2.5	(4.5) 1.1	4.7
	Ordinary	190	(1.5) 1.2	(3.0) 2.4	-	(3.5) 2.7	6.3
Ordinary	Corrosion	690	(1.0) 2.8	-	(10.0) 28.5	(4.0) 11.4	42.7
	Ordinary	2,060	(1.0) 8.5	-	-	(2.5) *21.2	*21.2 8.5
Total		3,000	12.9	3.1	31.0	*21.2 15.2	*21.2 62.2

Note: Asterisked (*) items apply to the CR shop (separately listed).

2) Facility plan

a) The new car body shop to be built will be of cross-wise arrangement system, with 4 coaches stayed on 1 track. The spacing between body centers will be 10 meters at the lifting/lowering section to allow for forklift/lorry work. The spacing will be 7.5 meters at the inspection/repair section to allow for the use of a lifting platform vehicle and for the storage of steel members.

b) Table 2.1.7 shows the proposed scope of work to be accomplished during the first and second phase.

Table 2.1.7 Improvement Plan for the Car Body Repair Shop

Category	Location	Phase I (to be matched for the year 1995)	Phase II (to be matched for the year 2000)
Proposed requirement of coaches	New car body shop Breakup: (lifting/ lowering section) (Inspection/repair section)	44 coaches (12 coaches) (32 coaches)	64 coaches (16 coaches) (48 coaches)
	CR shop CB shop	24 coaches 6 coahces	24 coaches -
	Total	74 coaches	88 coaches
Proposed improvement of shops	New car body shop	4 coaches x 4 lifting/ lowering tracks to be built; 4 coaches x 7 inspection/repair places to be built (One lifting/lowering track will be used as an inspection/repair section at this phase.)	4 coaches x 5 inspection/repair places to be added
	CR shop	To be added to accommodate 4 coaches x 1 track	-
	CB shop	-	To be converted into a trimming shop

c) At the new car body shop to be built, the column span will be 30 meters to accommodate 26-meter coaches that may be introduced in the future. The column span will provide the minimum physical requirements for the purpose.

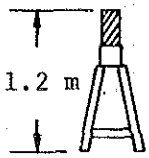
d) The overhead crane should be of a 50-ton capacity type to accommodate 26-meter coaches.

e) Because this new car body shop will be mainly used for corrosion repair, a buried surface plate (of H steel) will be installed in the car body inspection/repair area.

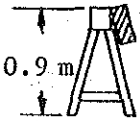
f) Because pneumatic and electric tools will be used, compressed air and 200 V outlets will be provided on each column and on the center floor for each car body. Each column will also be equipped with an MIG welding power supply.

g) 4 coaches on the south side of the new car body shop will be ued as an AC coach loading/unloading section. This requires setting up power supply equipment so that an underfloor equipment fitting/removing device may be installed.

h) The trestle at this location will have the following structure:



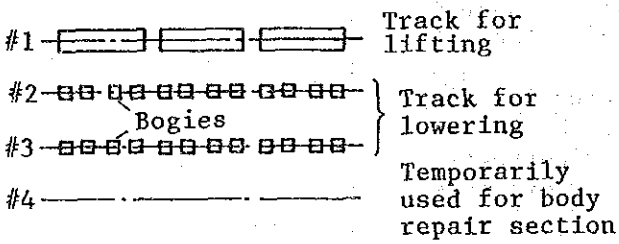
(When loading/ unloading underfloor equipments)



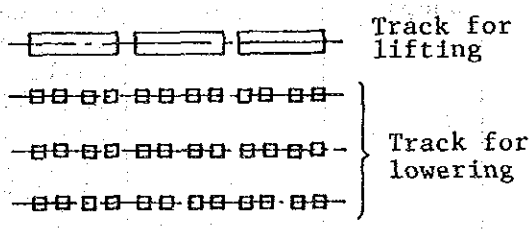
(When corrosion treatment)

i) The lifting and lowering tracks will be used as follows.

(Phase I)



(Phase II)



(Completed bogies for the day's work load will be allocated to the lowering track. When the bodies are lowered onto the bogies, the mattresses carried in by lorries will be carried into the coach interior.)

j) No pit will be set up inside the car body repair shop including the lifting/lowering section. This will maximise the use of transport and cargo handling facilities.

k) Coupling and uncoupling of brake rigging will be performed at the in-coming inspection shed and the final adjustment shed.

1) A lifting platform vehicle, underfloor equipment fitting/removing device, MIG (CO_2) welder, and mobile plasma-gas cutting device will be provided. In addition, scrap bins will be introduced at various points, along with forklifts that will carry these bins.

m) The entire shop floor inside the CR shop will be paved. All pits will be buried for ease in cargo handling work.

(3) Paint shop

The work to be performed at the paint shop will cover all the painting-related tasks including painting of body panels after completion of the body repair, puttying, old paint peeling, washing and lettering.

The present paint shop will be fully utilised. Improvement will be completed during the Phase I period.

1) Basic concept

a) The work procedure by type of repair is as follows:

Light painting	:	W-P-D-L
Ordinary painting	:	W-Puttying-UC-P_1-D_1-P_2-D_2-L
Heavy painting	:	Partial peeling-W-Puttying-UC-Putting-P_1-D_1-P_2-D_2-L
Completely new painting	:	Peeling-W-Puttying-Primer-Puttying-UC-P_1-D_1-P_2-D_2-Polishing-L

Note: In the listing above, P stands for painting, D for drying, L for lettering, W for washing and UC for undercoating. The underlined processes are carried out on the conveyor line facilities.

b) Double coated painting will be applied, as done at present.

c) Routine work steps including the transfer of coaches will be mechanised and carried out on a conveyor belt line.

(d) The composition of equipment on the conveyor belt line will be as follows.

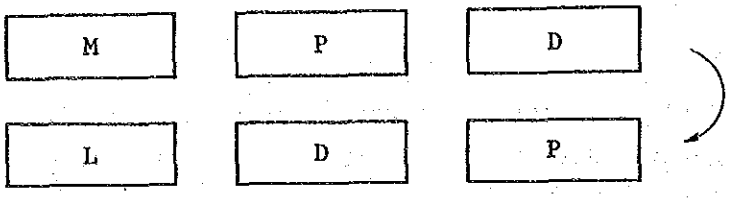
- One-colour coaches:

  M-P -D -P -D -L (M: masking)

- Two-colour coaches:

  M-P -D -P -D -M'-P '-D '-P' -D' -L

  With the above makeup taken into account, the equipment will be deployed as follows.



That is, one-colour coaches will undergo a 6-tact setup (M-P-D-P-D-L), and two-colour coaches a 12-tact setup (M-P-D-P-D-(L)-M-P-D-P-D-L).

2) Scale of facility

(a) Conveyor belt line equipment

Considering the tact time to be 50 minutes,

- No. of coaches painted per line (coaches/day) = 480 minutes/day ÷ 50 minutes = 9.6 coaches/day/line

  If the ratio of one-colour coaches to two-colour coaches is assumed to be same, then we get,

- No. of coaches painted (coaches/year; in terms of one-color type) = 1500 coaches + 1500 coaches x 2 = 4500 coaches/year
- No. of lines required = 4500 x 1.2 ÷ 291 days/year ÷ 9.6 coaches = 1.9 ≒ 2

  That is, 2 conveyor belt lines will have to be set up.

(b) Pre-paint treatment section

Table 2.1.8 shows the proposed scale of the pre-paint treatment section.

Table 2.1.8 Proposed Scale of the Pre-paint Treatment Section

Type of painting	Rate of occurrence	No. of coaches treated annually	Pretreatment cycle time (days)	No. of coaches staying concurrently
Light painting	10%	300	(-) 0.1	0.1
Ordinary painting	65%	1,950	(1.0) 0.7	5.6
Heavy painting	20%	600	(2.3) 1.8	4.5
Completely new painting	5%	150	(5.0) 3.6	2.2
Total	100%	3,000	-	12.4

Note: Figures in parentheses in the pretreatment cycle time indicate the current state. With this taken into account, the pre-paint treatment section will be designed to accommodate 15 coaches at a time.

3) Facility plan

a) Masking, painting, drying and lettering are all routine tasks and will be mechanised on a conveyor belt line. In this case, the tact time will be set at 50 minutes, i.e., 40 minutes of net tact time plus a 10 minutes allowance for coach transfer.

b) The existing paint shop building will be fully utilised.

c) Traversers ① and ② will be replaced with roofed types so as to be free from the effects of rain during the transfer of coaches through the painting process.
Also, a shed that is needed will be constructed.

d) Transfer film sheet (Decal comamia) will be used for lettering.

e) Inside the shop, coaches will be transferred using endless wire equipment along rail flange grooves.

(4) Final adjustment shed

The work to be carried out at the final adjustment shed will include loading of general electrical parts (excluding AC components), coupling of brake rigging, and final adjustment of various parts of each coach. AC coaches will be led into their exclusive shed adjacent to the deluxe shop for higher productivity.

1) Scale of facility

Table 2.1.9 shows the proposed scale of the final adjustment shed.

Table 2.1.9 Proposed Scale of the Final Adjustment Shed

Type of coach		Phase I			Phase II		
		No. of coaches inspected annually	Cycle time	No. of coaches staying concurrently	No. of coaches inspected annually	Cycle time	No. of coaches staying concurrently
AC coach		185	1.5	1.1	250	1.5	1.5
Ordinary coach	Corrosion	685	1.3	3.7	690	1.3	3.7
	Ordinary	1,583	1.0	6.5	2,060	1.0	8.5
	Total	2,268	-	10.2	2,750	-	12.2

(Scale of the existing facility)

- For ordinary coaches: 4 coaches x 4 tracks = 16 coaches
- For AC coaches : 1 coach

The existing final adjustment shed will be used unchanged for ordinary coaches. A new final adjustment shed for AC coaches will be set up to accommodate 2 coaches at the Phase I, and 3 coaches at the Phase II.

2) Facility plan

a) The panel plate shop located adjacent to the deluxe shop, as well as part of the carriage special repair shop, will be demolished to establish a final adjustment shed for AC coaches.

(b) The building will be built during the Phase I to accommodate 3 coaches. Testing equipment and tracks will be provided to accommodate 2 coaches during the Phase I and 1 more during the Phase II.

(c) The shed will adopt an all-pit structure for ease in adjusting equipment under the coach floor. The track-to-track spacing will be 7.5 meters to allow for forklift passage.

(d) Traverser ② will be extended by about 50 meters.

(e) After inspection, each AC coach will be transferred outside across traverser ②. This requires necessary track switching arrangements.

(5) Bogie shop

The bogie shop will be used to repair bogies and bogie-related accessories (brake riggings, brake cylinders, etc.). It will also be used to accommodate completed bogies temporarily. A coupler repair section and a coil spring section will also be established adjacent to the bogie shop.

1) Scale of facility

The scale of the bogie shop was determined on the basis of the estimates outlined in Table 2.1.10 - 2.1.13.

Table 2.1.10 Estimated Number of Bogies to be Accommodated in the Bogie Shop and the Lifting/Lowering Section

Stage of work	Type of coach	No. of coaches inspected	Same as on the left* (per day)	Cycle time between lifting and lowering	No. of coaches to accommodate bogies
Phase I	AC corrosion	50	0.2	13.5 Days	2.8 Coaches
	AC ordinary	135	0.6	7.0	3.9
	(AC total)	(185)	(0.8)	-	(6.7)
	Ordinary corrosion	685	2.8	10.5	29.7
	Ordinary	1,583	6.6	0.7	4.6
	(Ordinary total)	(2,268)	(9.4)	-	(34.3)
	Total	2,453	10.2	-	41.0 coaches
Phase II	AC corrosion	60	0.2	18.0 Days	4.5 Coaches
	AC ordinary	190	0.8	7.0	5.5
	(AC total)	(250)	(1.0)	-	(10.0)
	Ordinary corrosion	690	2.8	14.5	41.3
	Ordinary	2,060	8.5	0.7	5.9
	(Ordinary total)	(2,750)	(11.3)	-	(47.2)
	Total	3,000	12.4	-	57.2 coaches

Note: 20 percent fluctuation rate was taken into account for the column indicated *.

Table 2.1.11 Breakup of Locations that Accommodate Bogies

	Total	Lifting/lowering section*	Bogie shop	
			Under inspection/repair	Reserve**
Phase I	84 Bogies (For 42 coaches)	16 Bogies (For 8 coaches)	66 Bogies (For 33 coaches)	2 Bogies (For 1 coach)
Phase II	118 Bogies (For 59 coaches)	24 Bogies (For 12 coaches)	92 Bogies (For 46 coaches)	2 Bogies (For 1 coach)

* Calculated from the capacity of lifting/lowering section

** Calculated using Table 6.2.20, "Spare parts Calculations"

Table 2.1.12 Estimated Number of Bogies to be Placed by Location and by Facility inside the Bogie Shop

	Disassembly section	Washer	Repair section	Assembly section	Painting equipment	Adjustment section	Subtotal	Reserve and completed	Total
Cycle time (hrs)	2.5	0.5	3.0	2.0	0.5	4.0	12.5	-	-
Phase I	4 Bogies	1	4	3	1	6	19 Bogies	49 Bogies	68 Bogies
Phase II	4 Bogies	1	5	4	1	7	22 Bogies	72 Bogies	94 Bogies

Note 1: Calculation formula = No. of bogies coming-in per day x days required

A two-shift arrangement was assumed for the bogie shop (16 hrs/day)

2: The cycle time are averages (reduction of about 20% from the current figures).

Table 2.1.13 Areas of the Bogie Shop and Related Section to be Improved

	Bogie shop	Buffers and other parts section	Total
Phase I	Approx. 4,000 m2	Approx. 1,200 m2 (existing bogie components shop)	Approx. 5,200 m2
Phase II	Approx. 4,700 m2 (existing bogie shop + CR#5 ~ #10)	Same as above	Approx. 5,900 m2

2) Facility plan

(a) Because the number of bogies staying inside the proposed bogie shop is expected to be much greater than at present, all bogies will be repaired immediately upon coming-in and will be stored in ready-to-use condition.

(b) Completed bogies will be stacked in two tiers for storage.

(c) The bogie shop will operate in two shifts work and the car body shop usually in one shift. This requires allocating a place where bogies for a day's work load are to stay.

(d) Pneumatic wrenches will be used wherever possible on bogies for disassembly and assembly. This requires providing pneumatic piping outlets at strategic positions.

(e) A bogie frame manipulator will be set up in the bogie frame repair section.

(f) It is necessary to allocate an in-coming place for bogies for condemned coaches which will be sent back every month from the depots.

(g) A bogie washer, bogie painting booth, bogie setting press, etc. will be provided.

(h) Vacuum cylinder inspection/repair section etc. will be relocated into the ancillary repair shop during the Phase II period.

i) The process of inspection and repair on bogies will be carried out in the following sequence:

De-wheeling --> Washing --> Disassembly --> Repair --> Assembly --> Painting

--> Storage in ready-to-use condition --> Wheeling --> Adjustment --> Placed in car body lifting/lowering section

One day before lowering of car body

(6) Wheel shop

Heavy and light repairs on coach wheelsets and heavy repairs on wagon wheelsets will be carried out at the wheel shop in the same manner as at present. New manufacture of wheelsets for coaches and wagons will also be performed. Since the existing wheel shop has comparative surplus in its capacity, the improvements will be implemented during the Phase II period.

1) Scale of facility

Table 2.1.14 to 2.1.17 show the criteria by which the scale of the wheel shop was estimated.

Table 2.1.14 Estimated Number of Wheelsets to be Inspected and Repaired

(in pairs)

Type of repair	Type of rolling stock	1986		2000	
		Annually	Daily	Annually	Daily
Light repair	Coach	7,168		11,940	
	Wagon	–		–	
	Sub-total	7,168	30	11,940	49
Re-discing	Coach	1,472		2,460	
	Wagon	10		10	
	Sub-total	1,482	6	2,470	10
Re-tyring	Coach	520		870	
	Wagon	519		540	
	Sub-total	1,039	4	1,410	6
Re-axling	Coach	359		600	
	Wagon	741		780	
	Sub-total	1,100	5	1,380	6
New manufacture	Coach	165		260	
	Wagon	41		60	
	Sub-total	206	1	320	1
Total	Coach	9,684		16,130	
	Wagon	1,311		1,390	
	Sub-total	10,995	46	17,520	72
By bearing type	RB	9,980	41	16,780	69
	PB	1,015	5	740	3

(For more information, refer to Table 2.1.15)

Note: Daily estimates allow for in-coming fluctuation.

Table 2.1.15 Breack up of Wheel-Related Workload of Perambur

Type of rolling stock	Results in 1986						Estimates for 2000				
	No. of cars assigned	No. of cars inspected	Type of repair on wheel	Coefficient	No. of pairs inspected/ repaired annually	Per day	No. of cars assigned	No. of cars inspected	Type of repair on wheel	No. of pairs inspected/ repaired annually	Per day
Coach	2,761	1,792	Total No. of POH		7,168		4,400	3,000	Total No. of POH	12,000	
			Wheelsets to outstation *	22% of assigned axles	2,351				Wheelsets to outstation *	3,870	
			Total		9,519	39 pairs			Total	15,870	65 pairs
			Light repair		7,168	30			Light repair	11,940	49
			Re-discing	15.5% of inspected pairs	1,472	6			Re-discing	2,460	10
			Re-tyring	5.5% of inspected pairs	520	2			Re-tyring	870	4
			Re-axling	3.8% of inspected pairs	359	1			Re-axling	600	3
			New manufacture	1.5% of assigned axles	165	1			New manufacture	260	1
Wagon			Total No. of POH		10,762				Total No. of POH	10,880	
	4-wheeler wagons 13,494	4-wheeler wagons 3,387	Wheelsets to outstation *	4.1% of assigned axles	2,083		4-wheeler wagons 6,700	4-wheeler wagons 1,600	Wheelsets to outstation *	2,520	
			Total		12,845	49			Total	13,400	51
	8-wheeler wagons 6,009	8-wheeler wagons 997	Light repair		11,575	44	8-wheeler wagons 12,000	8-wheeler wagons 1,920	Light repair	12,070	46
			Re-discing	0.1% of inspected pairs	10	-			Re-discing	10	-
			Re-tyring	4% of inspected pairs	519	2			Re-tyring	540	2
			Re-axling	5.8% of inspected pairs	741	3			Re-axling	780	3
			New manufacture	0.1% of assigned axles	41	-			New manufacture	60	-

*: Wheelsets for EMU are included. Numbers of pairs per day include estimated fluctuation rates (20% for coaches, 10% for wagons).
The rate of roller bearings for 1986 was 98% for coaches and 37% for wagons; it is estimated at 98% for coaches and 70% for wagons in 2000.

Table 2.1.16 Estimated Number of Wheelsets to be Accommodated (Under inspection/repair)

Type of repair	No. of pairs per day	Bearing attention		Machining for heavy repair		Total
		Cycle time	No. of wheelsets accommo-dated	Cycle time	No. of wheelsets accommo-dated	
Light repair	49	0.6 Days	29.4 Pairs	-	-	29.4
Re-discing	10	0.4	4.0	0.8	8.0 Pairs	12.0
Re-tyring	6	0.4	2.4	0.9	5.4	7.8
Re-axling	6	0.4	2.4	1.3	7.8	10.2
New manu-facturing	1	0.2	0.2	2.1	2.1	2.3
Total	72	-	38.4 Pairs	-	23.3 Paris	61.7 Pairs

Note: The estimate on cycle time allow for a reduction of about 20 percent from the current state.

Table 2.1.17 Estimated Number of Wheelsets to be Stored at the Wheel Park

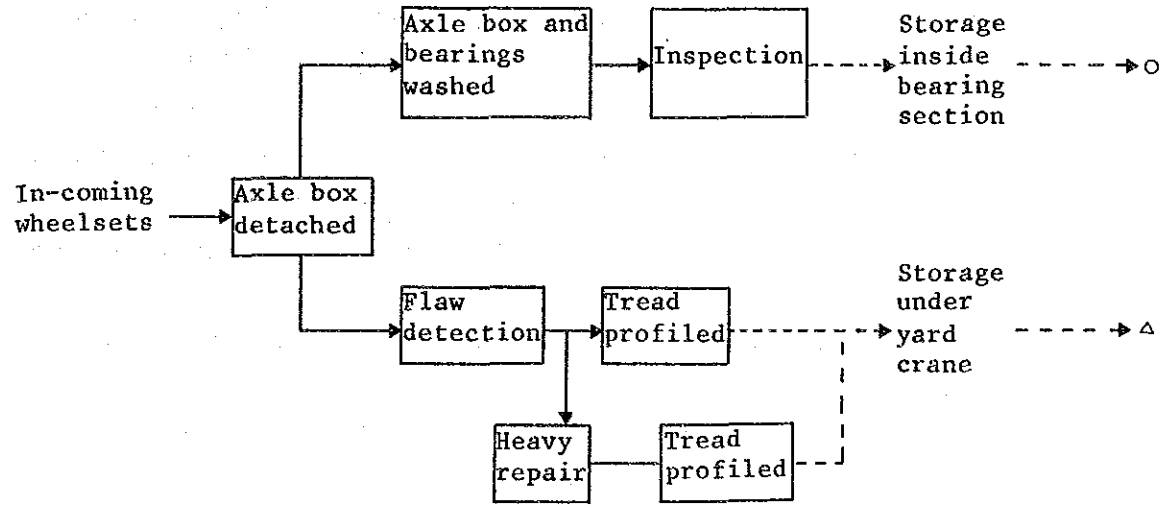
Type of car	No. of pairs per day	No. of days between in-coming and out-going	Average No. of days for inspection/ repair	No. of days for storage	No. of pairs stored at wheel park
AC corrosion	0.8	16.5 Days	0.9 Days	15.6 Days	12.5 Pairs
AC ordinary	3.2	5.5 Days		4.6	14.7
Ordinary corrosion	11.2	13.0 Days		12.1	135.5
Orinary	34.0	0.9 Days		0	0
Heavy repairs for wagon	5.7	1.4 Days	*	0	0
Wheelsets from out-station	17.1	1.4 Days	1.4 Days -	0	0
Spare wheels	-	-	-	-	**44
Total	72.0	-	-	-	206.7 pairs

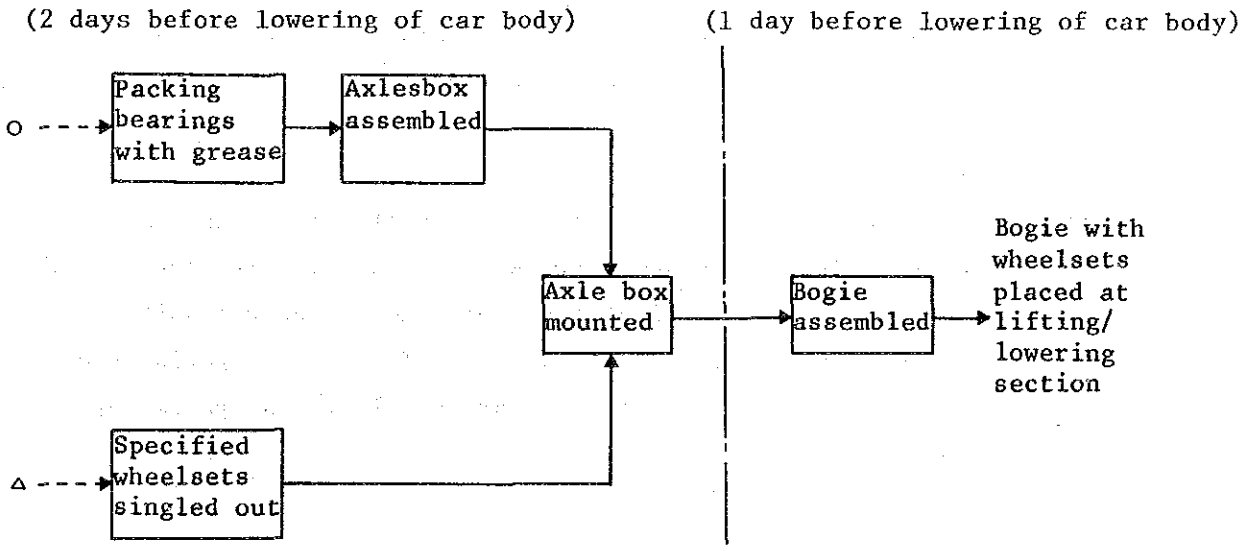
* Average numbers of days for heavy repairs only

** Calculated using Table 6.2.20, "Spare Parts Calculations"

2) Concept of wheel inspection/repair process

Wheelsets will be repaired immediately upon admission. Bearings will be stored after inspection. With their treading surfaces profiled, the wheelsets will be stored under a yard crane.
Two days before body lowering, wheelsets with matched tread diameters will be picked out for required coaches. After fitted with bearings, the wheelsets will be sent to the bogie shop.
One day before lowering, the bogie and wheelsets will be assembled at the bogie shop, then sent to the car body lifting/lowering section.





3) Facility plan

(a) Drastic improvements will be implemented to enable work on 72 pairs of wheelsets per day including the disassembling, washing, inspection, grease packing, assembly and mounting of bearings as well as flaw detection on axles.

(b) Wheel lathes will be divided into two groups: one for light repair and the other for heavy repair. These lathes will be optimally positioned in the work flow.

(c) The machining section will be located so that workpieces will have the shortest possible distance to travel to and from the location.

(d) As at present, the entire facility will operate in two shifts.

(e) The bearing removing/attaching section will be equipped with an overhead crane, impact wrench pneumatic piping, induction heating equipment for inner race removal, oil bath for inner race mounting, oscillating-type bearing washer, kerosene injection washer (with handling robot), grease packing device, bearing assembler, roller conveyor, and bearing inspection bench. The bearing inspection section will be located indoors and will have a dustproof structure.

(f) Axial direction incidence ultrasonic flaw detector will be provided.

(g) Major machines will be equipped with a chip conveyor.

(h) The wheel park will be provided with a yard crane.

(i) At the wheel park, wheelsets with their tread profiled will be stored, equipped with journal caps but without bearings.

(j) In addition to the above wheelsets, other components such as axle, tyre, disc will also be stored.

(7) Electrical parts repair shop

The electrical parts repair shop will consist of deluxe shop and train lighting shop. The deluxe shop will be used for inspection and repair of air conditioners, electrical appliances, control units and other electrical parts used for AC coaches. The train lighting shop will conduct inspection and repair of various electrical parts for ordinary coaches.

1) Scale of facility

Table 2.1.18 shows the proposed scale of the electrical parts repair shop

Table 2.1.18 Proposed Scale of the Electrical Parts Repair Shop

Category	Year	No. of coaches inspected	Average cycle time of parts	Q'ty of parts staying concurrently (in terms of coaches)	Existing area	Approximate area required	Extension area
AC Deluxe shop	1986/1987	68 coaches	3.2 Days	0.9 coaches	1,200m^2	1200 x (0.5+0.5x3.6) 2,760 m^2	1,560m^2
	2000/2001	250	3.1	3.2 (3.6)			
TLD shop	1986/1987	1,724	2.3	16.4	2,600m^2	2600 x (0.5+0.5x1.2) 2,860 m^2	260m^2
	2000/2001	2,750	1.7	19.3 (1.2)			
Total					3,800m	5,620 m^2	1,820m^2

Note 1: The figures in brackets in the column "Q'ty of parts staying concurrently" are multiplier factor to the current figures.

2: Approximate area required = existing area x (percentage of fixed area + percentage of variable area x multiplier factor)

(Breakup of the extension area of 1820 m^2)

- 1200 m^2: added portion of the body special repair shop adjacent to the deluxe shop
- 620 m^2: addition to the TLD shop

Buildings will be improved and extended during the Phase I except for an addition of TLD shop. Machinery will be introduced mainly during the Phase II.

2) Facility plan

(a) In order to shorten the cycle time for the final adjustment of AC coaches synthetic testing device for AC equipment will be provided to test the entire air conditioning system before loading coaches.

This is intended to enhance the system reliability. A testing room capable of enthalpy measurements will also be provided for this purpose.

(b) Washers and painting equipment for the parts will be installed. In addition, cargo handling equipment such as forklifts will also be provided.

(c) Necessary arrangements will be made to utilise pneumatic tools for disassembly and assembly of various parts.

(8) Ancillary repair shop

This shop will be set up to inspect, treat and repair body panels and other steel members of coaches, water tanks, vestibules, shock absorbers, doors, drain pipes and other parts. Table 2.1.19 shows the areas of the respective shops.

Table 2.1.19 Existing Areas of the Ancillary Repair Shop

No.	Shop name	Existing area	Remarks
1	Small panel plate section	840m2	Panel plate building
2	Electro plating section	350	Adjacent to the above section
3	Door, step section	840	Former Basic training center
4	Shock absorber section	250	Adjacent to the above section
5	Sheet metal section	660	Inside body special repair shop
6	Vestibule section	140	Adjacent to CB shop
7	Water tank, drain pipe section	820	Inside CB shop
8	Air brake section	0	Provision required in the future
9	Vacuum cylinder section etc.	450	Inside bogie shop
10	Total	4,350m2	

The sheet metal shop (No. 5 above) is being shifted to a site beside the existing panel plate building.

1) Scale of facility

Table 2.1.20 shows the proposed scale of the ancillary repair shop.

Table 2.1.20 Proposed Scale of the Ancillary Repair Shop

Year	No. of coaches inspected/ repaired	Multiplier factor	Approximate area required
1986/1987	1,792	1.0	4,350 m2
1995/1996	2,453	1.4	4,350x(0.5+0.5x1.4)= 5,200m2
2000/2001	3,000	1.7	4,350x(0.5+0.5x1.7)= 5,900m2 Air brake section 200m2 Total 6,100m2

2) Facility plan

a) The work on these miscellaneous parts is an important part of the inspection and repair of car bodies. This means that these shops should be located as close to the car body repair shop as possible. Thus, ancillary shop will comprehensively be set up around the existing panel plate building.
Part of bogie component shop such as vacuum cylinder section will also be relocated in this shop.

b) Construction is planned by year as follows.

(Year)	(Contents of work)
. 1988	Shifting and extending the sheet metal shop (carried out by the Indian side)
. Phase I	- Demolishing the small panel plate section and the electro plating section - Setting up extended shop at the same site
. Phase II	- Demolishing the shock absorber section at the former BTC - Setting up an extended shop at the same site - Relocating the vestibule section and other section from CB shop - Relocating part of the bogie component section

(9) Scrap disposal facility

The scrap from repair of coaches and wagons, especially from corrosion repair, are being left on the shop floor in large quantities. Their presence is hampering smooth execution of inspection/repair work. A scrap disposal facility is needed to improve the situation.

1) Estimating the quantities of scrap to be generated

Table 2.1.21 shows the estimated quantities of scrap that will be generated from now on.

Table 2.1.21 Estimated Quantities of Scrap to be Generated

Category	Parts name	Quantities in 1986 (tons/month)	Estimates for 1995		Estimates for 2000	
			Coefficient	(tons/month)	Coefficient	(tons/month)
Coach	Iron plate	40	① 735/497	60	⑥ 750/497	60
	Trough floor plate	30	①	45	⑥	45
	Heavy meltings	40	② 2450/1800	55	⑦ 3000/1800	65
	Light meltings	20	②	27	⑦	35
	Vacuum cylinder	10	②	15	⑦	17
	Vacuum reservoirs	5	②	7	⑦	8
	Other iron products	10	②	15	⑦	17
	Wood chips	30	1/2	15	0	0
	(Total for coaches)	(185)	-	(239)	-	(247)
Wagon	Iron plate	125	③ 1500/1800	105	⑧ 1400/1800	100
	Steel members	125	③	105	⑧	100
	Heavy meltings	75	④ 4000/4400	70	⑨ 3520/4400	60
	Light meltings	25	④	23	⑨	20
	Spring plates	60	④	55	⑨	50
	(Total for wagons)	(410)	-	(358)	-	(330)
Wheels	(Condemned wheelsets etc.)	(385)	⑤ 26000/22000	(455)	⑩ 29300/22000	(510)
Total		980	-	1,052	-	1,087

Note: The coefficients listed above are explained below.

①, ⑥: Rate of corroded coaches

②, ⑦: Rate of PHO coaches

③, ⑧: Rate of corroded wagons (in terms of 4 wheeler wagon)

④, ⑨: Rate of PHO wagons

⑤, ⑩: Rate of inspected/repaired wheelsets

2) Transporting the scraps

a) Condemned wheelsets

At present, all wheelsets are transported by forklift. The same method will also be used from now on.

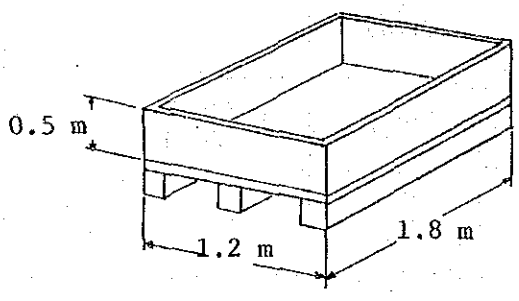
b) Ordinary scrap

Table 2.1.22 outlines how to handle ordinary scrap.

Table 2.1.22 How to handle Ordinary Scrap

Category	Handling method	Remarks
Location where scrap generates	- Scrap bins will be placed at appropriate points. - Scrap will be cut into small pieces before being placed in a scrap bin.	- Scrap bins will be grouped by scrap type. - Each piece of scrap should be small enough to be handled manually.
Transportation	Each scrap bin will be transported by forklift.	- Scrap will not be transferred from one bin to another.
Scrap yard	Scrap will be unloaded from their bins using a magnetic crane	Scrap bins will preferably be made of wood.

Scrap bin



Load capacity: about 1.5 tons

3) Requirements of scrap disposal facilities

a) Number of forklifts needed to transport scrap

(For wheel section)

	'86	'95	2000
Carrying capacity	385 Tons/month	455	510
No. of units required	6 units	7 units	8 units
	(6 units at present)		

(For ordinary scrap section)

	'86	'95	2000
Carrying capacity	595 Tons/month	597	577
No. of trips for transport *	660 Trips/month	663	641
No. of trips for transport **	26 Trips/day	27	26
No. of units required	3	3	3
	(0 units at present)		

*: The average carrying load per trip was assumed to be 1.5 tons x 0.6.

**: The actual working days per month is set at 25.

b) Number of magnetic cranes required at the scrap yard

One magnetic crane will be provided for No. 1 scrap yard and another for the No. 2 yard (a 3-ton crane truck each)

2.1.3 Machinery Plan

Table 2.1.23 lists the names of major machines considered needed for inspection/repair of coaches under this project. In this table, machines are grouped by the following symbols:

A (newly installed): Machines in this group are to be installed new.

B (replaced): Machines in this group are 15 years old or more and to be replaced with new ones.

C (re-used): Machines in this group are to be used where they are or relocated somewhere else.

Notice that in this table, the machines whose names are prefixed with a circle are imports, and unmarked machines are products made indigenously.

Table 2.1.23 List of Major Machines

Shop	Description	Major performance	Q'ty Phase I	Q'ty Phase II	Details A	Details B	Details C
In-coming Inspection Shop	Carrier	1t trailer	10		10		
	Forklift truck	1.5t with engine	3		3		
	○ Car mover	Rail cum road type	1		1		
	Others						
Carbody Shop	Surface traverser	① and ②	2				2
	EOT crane	25t crab trolleyx2 span: about 28m	4		4		
	○ Car mover	It is also used for transferring bogie	2		2		
		Rail cum road type					
	○ Lifting platform vehicle	Dimension of platform: about 900Wx1500Lmm, Max. height: about 4000mm	10	6	16		
	Arc welder	CO_2 gas arc welding, semi-automatic	30	5	35		
	Plasma gas cutting device	with battery type self-propelled truck	15	2	17		
	Trestle	Height: 0.9m	35	15	50		
	○ Under-floor equipment setting and removing device	1t, battery driven, with hydraulic unit	8	4	12		
	Forklift truck	Table lift: about 1000mm	5	3	8		
	Compressed air piping		1	1	1		
	Oxygen gas piping		1	1	1		
	Others						
Paint Shop	○ Carbody painting apparatus	Automatic type with booth	4		4		
	○ Lifting platform vehicle		30		30		
	○ Paint drying apparatus	booth type, hot air	4		4		

Shop	Description	Major performance	Q'ty Phase		Details		
			I	II	A	B	C
Paint Shop	○ Carbody mover	rail cum road type	1		1		
	Carbody transfer device	for painting, drive with endless wire	10		10		
	○ Carbody polishing & cleaning apparatus	with traversing equipment	1		1		
	○ Lifting platform	length: 24m, motor driven	4		4		
	Surface traverser	60t, girder length about 22m with winch, covered with roof	2			2	
	Others						
Final Adjustment Shed	Vacuum brake test apparatus	including vacuum plant	2		1		1
	○ Car mover	rail cum road type	1		1		
	Motor for testing generator		2	1	2		1
	Others						
Bogie Shop	○ Bogie washer	injection cleaning with hot water and detergent, length of conveyor: about 22mm	1		1		
	Hydraulic press	50t	1		1		
	Magnetic flaw detector	portable	1		1		
	○ Bogie painting booth	including truck with turntable and spraying equipment	1		1		
	Bogie traverser	motor driven type	2		2		
	Bogie welding positioner	bogie frame manipulator	2		2		
	Bogie setting press		2		1		1
	Forklift truck	1t	4		4		
	Compressed air piping		1		1		

Shop	Description	Major performance	Q'ty Phase		Details		
			I	II	A	B	C
Bogie Shop	Oxygen gas piping		1		1		
	Others						
Wheel and Tyre Shop	EOT crane	Outdoor 5t		3	3		
	Wheel lathe	1100mm x 1676, with chip conveyor		4		2	2
	Vertical borer	For tyre boring		3		1	2
	O Axle turning lathe	CNC		2	1		1
	Wheel press			2			2
	Tyre heater	Low frequency induction heating		1		1	
	Oil bath for heating inner race of bearing	Electric heater		1	1		
	Bearing inner race pull-out equipment	Induction heating, with 2 sets of induction coil		2	2		
	O Bearing cleaner	Injection cleaning with kerosene, with handling robot		2	2		
	O Ultrasonic flaw detector	Automatic axial direction incidence type, with wheel set rotating apparatus		2	2		
	O Axle box and Bearing cleaner	Cleaning by oscillating		2	2		
	O Bearing grease filler	Automatic		1	1		
	O Bearing and axle box setting machine			1	1		
	Conveyor	Roller conveyor		1	1		
	Journal grinding machine			2			2
	Tyre lip rolling machine			1			1
	Axle grinding machine			2	1		1

Shop	Description	Major performance	Q'ty Phase		Details		
			I	II	A	B	C
Wheel and Tyre Shop	AJTB lathe			2			2
	Vertical lathe	for hub boring		2			2
	Centre lathe			3		1	2
	Crane for axle box setting and removing	EOT crane, 1t		2	2		
	Others						
Electric Component Shop	EOT crane	1t span: about 12m		1	1		
	Air blasting apparatus	for radiator and evaporator		1	1		
	Radiator cleaning apparatus	steam jet cleaner		1	1		
	○ Circuit breaker tester			1	1		
	○ Dielectric strength tester			1	1		
	Drying oven	Electric heater		2	2		
	Alternator tester			2	1		1
	○ Electric component cleaner	Injection cleaning with kerosene		1	1		
	Commutator mica under cutting machine	for small size electric motor and generator		1	1		
	○ Synthetic testing device	for AC equipment		1	1		
	Auxiliary motor no-load tester			2	1		1
	Alternator load tester			2	1		1
	○ Voltage regulator tester	for AC and ordinary		2	2		
	Carrier	Battery driven 1t		2	2		
	○ Compressor tester			2	1		1
	Others						

Note: AJTB lathe means axle journal turning & burnishing lathe

Shop	Description	Major performance	Q'ty Phase		Details		
			I	II	A	B	C
Brake Component Shop	○ Vacuum cylinder cleaning apparatus		1		1		
	Vacuum cylinder test apparatus		2		1	1	
	Others						
Trimming Shop	Carrier	Trailer for transport of seat cushion	10		10		
	Forklift truck	1t	3		3		
	Others						
Smithy Complex	Electric normalising machine		1		1		
	Draw bar testing machine		1		1		
	Buffer spindle screwing machine		1		1		
	Hydraulic buffer rivetter		1		1		
	Centre lathe		1		1		
	Pillar drilling machine		1		1		
	Load testing machine for coil springs		1		1		
	Others						
Others	Forklift truck	2t	5	1	6		
	Truck crane	3t crane, with lifting magnet	2		2		
	Lorry	6t	2		2		

2.2 Wagon Inspection and Repair Facility

2.2.1 Basic Conditions for Facility Planning

(1) Estimation of the number of wagons to be inspected

Table 2.2.1 shows the estimated number of wagons to be inspected by type of wagon. For wagon facilities, improvement will be implemented during the Phase I period.

Table 2.2.1 Estimated Number of Wagons to be Inspected by Type of Wagon over the Years

Item	Type of wagon	Year		
		1986	1990	2000
No. of wagons assigned	4 wheeler wagon	13,494	11,639	7,000
	8 wheeler wagon	6,009	7,721	12,000
	Total	19,503	19,360	19,000
No. of wagons inspected	4 wheeler wagon	3,387	2,876	1,600
	8 wheeler wagon	997	1,261	1,920
	Total	4,384	4,137	3,520

Note 1. The average turning-in ratio over the past years (No. of wagons inspected/No. of wagons assigned) was calculated as follows.

4 wheeler wagon: 0.23

8 wheeler wagon: 0.16

2. The figures for 1990 were obtained by linear interpolation.

(2) Estimation of the number of wagons to be inspected by type of repair

Table 2.2.2 shows the estimated number of wagons requiring corrosion repair (heavy repair) and those requiring ordinary repair.

For the estimates, a large number of corrosion-prone 4 wheeler wagons were assumed to be condemned from now on. Taking this factor into account, the corrosion rates for the future were estimated at levels lower than at present. 8 wheeler wagons with many years of service life left were expected to develop corrosion in the future. Thus, the corrosion rates for 8 wheeler wagons were set high.

Table 2.2.2 Estimated Number of Wagons to be Inspected by Type of Repair

Type of wagon	Type of repair	Year		
		1986	1990	2000
4 wheeler wagon	Corrosion	1,428	1,000	400
	Ordinary repair	1,959	1,876	1,200
	Total	3,387	2,876	1,600
	(Corrosion rate)	(0.42)	(0.35)	(0.25)
8 wheeler wagon	Corrosion	188	250	480
	Ordinary repair	809	1,011	1,440
	Total	997	1,261	1,920
	(Corrosion rate)	(0.19)	(0.20)	(0.25)
Total	Corrosion	1,616	1,250	880
	Ordinary repair	2,768	2,887	2,640
	Total	4,384	4,137	3,520
	(Corrosion rate)	(0.37)	(0.30)	(0.25)

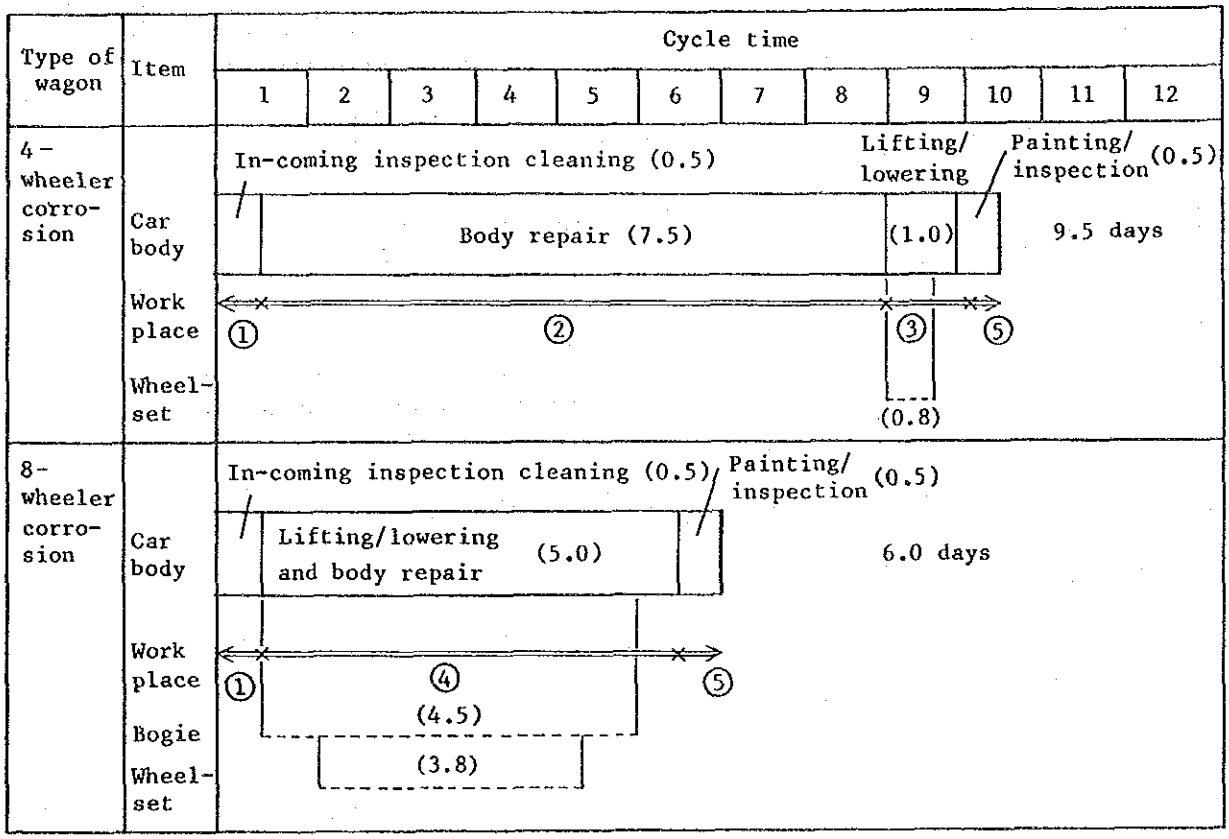
(3) Cycle time by type of wagon and by type of repair

Table 2.2.3 shows the cycle time adopted in this report for inspection/repair of wagons. A cleaning process was added because a new in-coming inspection and cleaning shed will be established. Figure 2.2.1 depicts the relations between cycle time, work place, and process of major components.

Table 2.2.3 Cycle Time for Inspection and Repair of Wagons by Type

Type of wagon	Type of repair	Planned cycle time				
		In-coming inspection, cleaning	Body repair	Lifting/ lowering	Painting/ inspection	Total
4 wheeler wagon	Corrosion	0.5	7.5	1.0	0.5	9.5
	Ordinary	0.5	1.7	1.0	0.5	3.7
8 wheeler wagon	Corrosion	0.5	5.0	Included in left-hand figures	0.5	6.0
	Ordinary	0.5	2.3	Included in left-hand figures	0.5	3.3

Note: All figures in the table are actual working days.



Legends: ① In-coming inspection and cleaning shed
② 4 wheeler/repair shop
③ 4 wheeler lifting/lowering shop
④ 8 wheeler/repair shop
⑤ Painting shop

Numbers in parentheses indicate the days for repair. The figures for the bogies and wheels show the allowed days for each work.

Fig. 2.2.1 (1) Inspection and Repair Cycle Time and Workplace by Type of Wagon

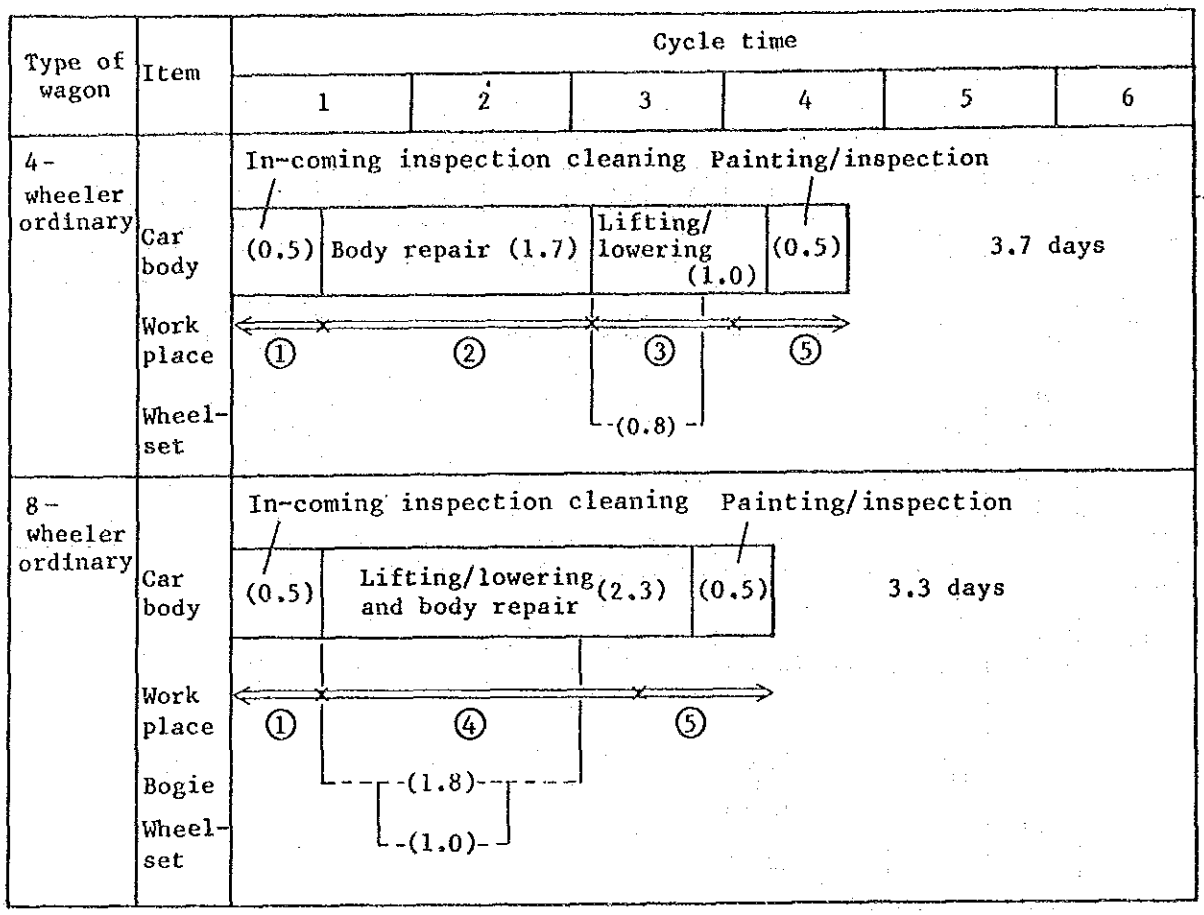


Fig. 2.2.1 (2) Inspection and Repair Cycle Time and Workplace by Type of Wagon

2.2.2 Facility Improvement Plan

(1) In-coming inspection and cleaning shed

Upon admission to this shed, each wagon will be inspected for its body panel condition and cleaned. The primary purpose of this is to minimise the amount of dirt in the body repair shop downstream. When inspected, each 4 wheeler wagon will be allocated to an appropriate track in the body repair shop depending on the degree of repair required.

1) Scale of facility

Table 2.2.4 shows the proposed scale of the in-coming inspection and cleaning shed.

Table 2.2.4 Proposed Scale of the In-coming Inspection and Cleaning Shed

Type of wagon	No. of wagons inspected annually	Cycle time	No. of wagons staying concurrently
4 wheeler wagon	1,600	0.5	4
8 wheeler wagon	1,920	0.5	4
Total	3,520	0.5	8

Note: No. of wagons staying concurrently = No. of wagons inspected annually x Cycle time x fluctuation rate (1.1)/actual working days.

2) Facility plan

a) No pit will be provided for the inspection and cleaning work. A fixed platform will be set up for roof inspection.

b) The track-to-track spacing will be 7.5 meters. Four 4 wheeler wagons will be kept to one track, and two 8 wheeler wagons to two tracks each. The shed will be designed for common use for 4 wheeler and 8 wheeler wagons.

c) No partition will be set up inside the building.

d) A surface traverser (maximum carrying length: 20 m; load capacity: about 50 tons) will be installed between the in-coming inspection and cleaning shed and the wagon repair shop.

e) The wagon will be moved by the shunting vehicle to and from the surface traverser.

(2) Wagon repair shop

The wagon repair shop will consist of the 4 wheeler wagon repair section, the 4 wheeler wagon lifting/lowering section, and the 8 wheeler wagon repair section. The work to be carried out here will include mounting and dismounting of couplers and other parts, repair of various car body portions, and replacement of wheelsets and bogies.

1) Scale of facility

Table 2.2.5 shows the proposed scale of the wagon repair shop.

Table 2.2.5 Proposed Scale of the Wagon Repair Shop

Type of wagon	Type of repair	No. of wagons inspected annually	Cycle time		No. of wagons staying concurrently	
			Body repair	Lifting/ lowering	Body repair section	Lifting/ lowering section
4 wheeler wagon	Corrosion	400	7.5	1.0	11.3	1.5
	Ordinary	1,200	1.7	1.0	7.7	4.5
	Total	1,600	-	-	19.0	6.0
8 wheeler wagon	Corrosion	480	5.0	-	9.1	-
	Ordinary	1,440	2.3	-	12.5	-
	Total	1,920	-	-	21.6	-

2) Facility plan

a) Around the centre of the wagon repair shop, an approximately 2 meter wide passage will be arranged to transport sheet metal and other parts. For this reason, 9 4-wheeler wagons and 6 8-wheeler wagons will be placed on one track each.

b) Because the wagon repair shop will have two tracks in one bay, the scale of the shop improvements will be as shown in Table 2.2.6.

Table 2.2.6 Proposed Scale of Improvements at the Wagon Repair Shop

Name of shop	Space required in terms of wagons	Scope of improvement	Remarks
4 wheeler wagon repair section	19	2 bays (4 tracks x 9 wagons)	The floor will be improved
4 wheeler wagon lifting/lowering section section	6	1 bay (2 tracks x 9 wagons)	The building will be reconstructed and the floor will be improved
8 wheeler wagon repair section	22	2 bays (4 tracks x 6 wagons)	The floor will be improved

c) The capacity to inspect and repair 4 wheeler wagons will drop because the 4 wheeler wagon lifting/lowering shop is being reconstructed. So the task will be entrusted to other workshops during this period.

d) The floor of the shop targeted for improvement will be paved. At the same time, the tracks will also be renovated.

e) Wagons will be moved by winch inside the 4 wheeler wagon repair section, as done at present.

f) Both the 4 wheeler and the 8 wheeler wagon sections will each be equipped with a lifting platform vehicle, CO_2 welder, mobile plasma-gas cutting device, and various carriers.

g) One of the bays for the current 4 wheeler wagon repair section will be converted to house a sheet metal shop (shifted from the current smithy shop) and a Coupler reclamation section (shifted from the current bogie shop).

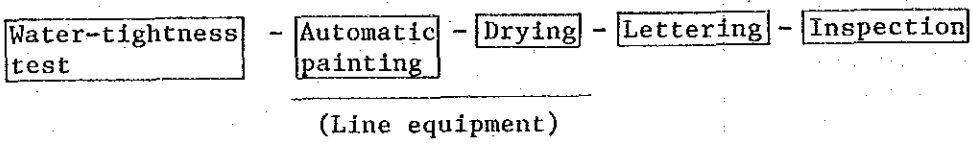
h) The 4 wheeler wagon lifting/lowering section will be equipped with a new 15-ton overhead crane, and the sheet metal shop with a 3-ton overhead crane.

(3) Painting/final adjustment shed

After repair, the body panels of each wagon will be painted and subjected to final adjustment. Before painting, the car body will be tested for water-tightness. Automatic painting equipment will be installed to deal with large quantities of wagons in a limited period of time. Some vehicles such as flat wagons and container wagons are difficult to paint automatically; they will be painted manually inside the current building, as done at present.

1) Basic concept

a) The work procedure will be as follows.



b) Automatic painting and drying alone will be implemented on a conveyor belt line.

c) Transfer film sheets will be used for lettering. One site will be used for both lettering and inspection.

d) The tact time for the conveyor belt line will be 40 minutes including the time for transport.

2) Scale of facility

a) Line equipment

o No. of wagons painted per line (wagons/day)

= 480 min./day ÷ 40 min. = 12 wagons/day/line

o No. of lines required

= 3520 x 1.1 ÷ 291 days/year ÷ 12 wagons = 1.1 ≒ 2 (approx.)

As calculated above, two lines will be installed.

b) Lettering/inspection section

A site that can accommodate a full day's work load (12 wagons) will be allocated to cope with unexpected delays.

c) The track-to-track spacing will be 7.5 meters. A painting/drying section will be 20 meters long for one wagon so that the shop can house up to the BCX type (about 16 meters in car length). For the lettering inspection section, weighted mean length for one wagon was considered to be 10 meters so that both 8 wheeler and 4 wheeler wagons will be commonly used (see sketch below).

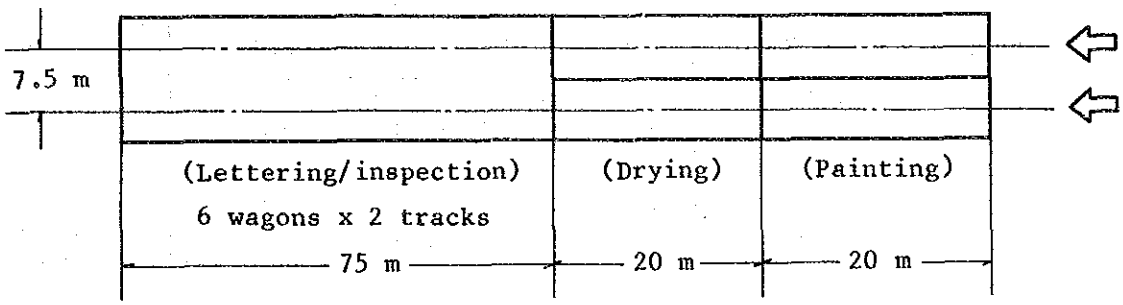


Fig. 2.2.2 General Arrangement of Painting/Inspection Shop

d) The lettering/inspection section will be equipped with a lifting platform vehicle (track type).

e) Wagons will be moved using an endless wire traction device inside the painting/final adjustment shed.

(4) Bogie shop

The bogie shop will be used to inspect and repair bogies and their accessories (brake riggings, etc.) as well as to store completed bogies temporarily.

1) Scale of facility

The scale of the bogie shop was proposed using the estimates shown in Table 2.2.7 to 2.2.9.

Table 2.2.7 Estimated Number of Bogies to be Accommodated in the Bogie Shop

Type of repair	No. of bogies inspected annually		No. of bogies per day	Days between lifting and lowering	No. of bogies accommodated
	No. of wagons	No. of bogies			
Corrosion	480	960	3.6	4.5	16.2
Ordinary	1,440	2,880	10.9	1.8	19.6
Bogies supplied to outstation	-	340	1.3	4.0	5.2
Total	1,920	4,180	15.8	-	41.0

Note: No. of bogies supplied to outstation
= No. of 8 wheeler wagons assigned x 2.8% (past result)

Table 2.2.8 Estimated Number of Bogies to be Placed by Location and by Type of Facility

Type of repair	No. of bogies per day	Disassembly section	Washing equipment	Repair section	Heavy repair section	Assembly section	Painting section	Completed	Spares	Total
(Cycle time: hrs.)		(5)	(0.5)	(8)	(32)	(5)	(1)	-	-	-
Ordinary	12.6	3.9	0.4	6.3	-	3.9	0.8	-	-	-
Heavy repair	3.2	1.0	0.1	-	6.4	1.0	0.2	-	-	-
Total	15.8	5	1	7	7	5	1	15	6 *	47

Note: 1. Calculation formula
= No. of bogies per day x cycle time
Calculation was based on a two-shift arrangement (16 hours/day).
2. The cycle time was reduced by about 20% from the current state.
3. The number of spare bogies (*) was calculated using Table 6.2.20, "Spare Parts Calculations".

Table 2.2.9 Areas of the Bogie Shop and Related Sections to be Improved

	Bogie shop	Bogie lifting/lowering section	Total
Approximate area	1,650 m^2	250 m^2	1900 m^2
Scope of improvement	Existing bogie shop, wheel place and CBC reclamation section	East side of traversers #13 and #14	-
Contents of work	Overall inspection/repair of bogies, and stocking of completed and spare bogies	De-wheeling and wheeling	-

Note: The wheel place will be shifted to an outdoor yard crane section and the CBC reclamation section to the wagon repair shop.

2) Facility plan

a) Each bogie will be repaired immediately upon admission. Completed bogies will be stored in ready-to-use condition. When completed, bogies from outstation should be returned to their respective wagon outstation as soon as possible.

b) Pneumatic piping will be installed so that impact wrenches may be used wherever possible on bogies for disassembly and assembly.

c) The heavy repair shop will be equipped with bogie frame manipulator (for 7 bogies).

d) A passing-through bogie washer, a bogie painting device, and a CO_2 semi-automatic welder etc. will be provided.

e) The following places will be relocated as indicated:

- Wheel place ——→ Outdoor yard crane section to the south
- CBC reclamation section ——→ Sheet metal shop inside the wagon shop
- Axle box inspection/repair shop ——→ Wheel shop

f) Enough space will be allocated to accommodate wagons carrying bogies supplied to outstation.

(5) Wheel shop

Light repair of wagon-related wheelsets will only be carried out at the wheel shop, as done at present.

1) Scale of facility

The scale of the wheel shop was proposed using the estimates shown in Tables 2.2.10 and 2.2.11.

Table 2.2.10 Estimated Number of Wheelsets to be Inspected/Repaired

Type of wagon	No. of wagons inspected annually	No. of wheelsets inspected annually	Same as on the left (light repair)	Pairs per day		
				Light repair	By bearing type	
					PB	RB
4 wheeler wagon	1,600	3,200	2,880	10.9	10.9	—
8 wheeler wagon (Corrosion)	480	1,920	1,730	6.5	—	6.5
8 wheeler wagon (Ordinary)	1,440	5,760	5,180	19.6	—	19.6
Wheel sets supplied to outstation	—	*(1) 2,520	2,280	8.6	2.6	6.0
Total	3,520	13,400	*(2) 12,070	45.6	*(3) 13.5	*(3) 32.1

Note: *(1) Rate of wheelsets supplied to outstation was assumed to be 4.1% of the number of axles of the wagons assigned.

*(2) The rate of light repair was assumed to be 90%.

*(3) The rate of roller bearings was assumed to be 70%.

Table 2.2.11 Estimated Number of Wheelsets to be Stored in the Wheel Shop

Type of wagon/ repair	No. of wheel pairs inspected annually	Per day	Under repair		Completed wheelsets		Total	
			No. of days	No. of wheelsets	No. of days	No. of wheelsets	No. of days	No. of wheelsets
4 wheeler wagon	2,880	10.9	*(1) 0.3	3.3	0.5	5.5	0.8	8.8
8 wheeler wagon (corrosion)	1,730	6.5		2.0	3.5	22.7	3.8	24.7
8 wheeler wagon (ordinary)	5,180	19.6		5.9	0.7	13.7	1.0	19.6
Wheelsets supplied to outstation	2,280	8.6		2.6	3.0	25.8	3.3	28.4
Spares	-	-	-	-	-	10.0	-	*(2) 10.0
Total	12,070	45.6	-	13.8	-	77.7	-	91.5

Note: *(1) These figures are averages in the planned cycle time (reduction of about 20% from the current figures).

*(2) Calculations were made by referring to Table 6.2.20, "Spare Parts Calculations".

In reality, more space will have to be allocated to handle in-coming and out-going of wheels requiring heavy repair.

2) Facility plan

(a) The planned facility will operate by two shifts work base, as at present.

(b) The bearing section will be equipped with an overhead crane, impact wrench pneumatic piping, induction heating equipment for inner race removal, oil bath for inner race fitting, oscillating-type bearing washer, kerosene injection washer (with handling robot), grease packing device, bearing assembler, roller conveyor, and bearing inspection bench. This section will have a dustproof structure.

(c) Axial direction incidence type axle flaw detecter will be provided.

(d) Wheel lathes will be equipped with a chip disposal device.

2.2.3 Machinery Plan

Table 2.2.12 lists the names of major machines considered needed for inspection/repair of wagons under this project. In this table, machines are grouped by the following symbols:

A (newly installed):	Machines in this group are to be installed new.
B (replaced):	Machines in this group are 15 years old or more and to be replaced with new ones.
C (re-used):	Machines in this group are to be used where they are or relocated somewhere else.

Notice that in this table, the machines whose names are prefixed with a circle are imports, and unmarked machines are products made indigenously.

Table 2.2.12 List of Major Machines

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
Common	○ Car mover	rail cum road type	1	1		
	Surface traverser	loading capacity about 50t max. loading length 20 m	1	1		
	○ Weigh bridge	electronic weigh bridge	1		1	
Wagon Repair Shop	EOT crane	15 t, span about 15 m, used for 4 wheeler carbody lifting and lowering section	1	1		
	○ Lifting platform vehicle	dimension of platform about 900Wx1500Lmm max. height about 4000mm	9	9		
	Arc welder	CO_2 gas arc welding, semi automatic	10	10		
	Plasma gas cutting device	with battery type self-propelled truck	5	5		
	Trestle	for 4 wheeler and 8 wheeler	30	30		
	Others					
Paint and Final Adjustment Shop	○ Carbody painting apparatus	painting booth and automatic painting equipment	2	2		
	○ Paint drying apparatus	drying booth and hot air blowing equipment	2	2		
	○ Lifting platform vehicle	dimension of platform: about 900Wx1500Lmm (rail type)	4	4		
	Carbody transfer device	for painting, drive with endless wire	4	4		
	Others					
Bogie Shop	○ Bogie washer	injection cleaning with hot water and detergent	1	1		
	○ Bogie painting booth	including truck with turntable and spraying equipment	1	1		
	Bogie welding positioner	Bogie frame manipulator	7	4	3	
	Arc welder	CO_2 gas arc welding, semi-automatic	1	1		

Shop	Description	Major performance	Q'ty	Details		
				A	B	C
Bogie Shop	Magnetic flaw detector	portable	1	1		
	Others					
Wheel Shop	EOT crane	2t, span about 15m	1	1		
	O Wheel lathe	passing through type	2		1	1
	AJTB lathe		1			1
	Bearing inner race pull-out equipment	induction heating, with 2 sets of induction coil	1	1		
	Oil bath for heating inner race of bearing	electric heating	1	1		
	O Axle box and bearing cleaner	washing by oscillating	1	1		
	O Bearing cleaner	injection cleaning with kerosene with handling robot	1	1		
	O Ultrasonic flaw detector	axial direction incidence type with wheelset rotating apparatus	1	1		
	O Bearing grease filler	automatic	1	1		
	O Bearing and axle box setting machine		1	1		
	Tyre Flange welding plant		1			1
	Others					
Others	EOT crane	3t, span about 15m for sheet metal section	1	1		

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