5.2.2 Premises of the Modernisation Plan

The modernisation plan is developed based on the assumptions below. The modernisation will cover the rolling stock inspection and repair works, machining and other processes, and related auxiliary equipments.

(1) Estimation of rolling stock to be repaired

The Jamalpur Workshop is responsible for periodical overhaul (POH) of all steam and diesel locomotive assigned to the Eastern Railway. The number of diesel locomotives to be inspected can be determined based on the number of diesel locomotives assigned to the Eastern Railway in 2000. The POH period for diesel locomotives is governed by both the number of years in service and the running-kilometers. In the study, the number of years in service is used as a basis of estimation as this is what is actually used for deciding turning-in schedule. The number of POH per year can also be estimated by using the ratio of the number of locomotives assigned in the past years to the number of locomotives inspected in corresponding years, but this is inaccurate because many of the locomotives was added relatively recently and their POH period are relatively long, (five to six years).

The number of diesel locomotives which will be inspected in 2000 is estimated as follows:

Main line 103 locomotives (9 per month on average)
Shunting 30 locomotives (3 per month on average)

Those for each year from 1987 to 1999 period are estimated by a simple linear interpolation because no reliable method is available. The number of steam locomotives to be repaired at the workshop up to 1995 (after which no inspection will be carried out except for the parts supplied to outstation) is estimated based on the figures proposed by the Railway Board. The estimation assumes that the outstation supply work will continue until 1997.

The rolling stock inspection plan for Jamalpur Workshop is shown in Table 5.2.3.

Table 5.2.3 Locomotive Inspection Plan at Jamalpur Workshop

Classification and type \ Year			80	85	86	90	91	92	93	94	95	96	97	98	99	2000
Diesel locomotive	Number to be assigned	Main line	179	221	227	339	367	395	424	452	480	508	536	564	592	620
		Shunting	74	97	120	129	131	133	135	137	139	141	144	146	148	150
		Total	253	318	347	468	498	528	559	589	619	649	680	710	740	770
	Number to be inspected	Main line	0	17	39	57	62	66	71	76	80	85	89	94	98	103
		Shunting	9	27	31	26	26	27	27	27	28	28	29	29	30	30
		Total	9	44	70	83	88	93	98	103	108	113	118	123	128	133
Steam locomotive	Number to be assigned		966	727	653	450	350	300	250	200	150	100	50	0	0	0
	Number to be inspected		212	209	226	120	96	72	48	12	0	0	0	0	0	0
(Reference)	Total number to be inspected		221	253	296	203	184	165	146	115	(24) 108	(29) 113	(34) 118	(38) 123	(43) 128	(48) 133

Note: (1) The number of locomotives assigned in the year 2000 is an estimate based on the rolling stock plan, and the number of inspected locomotives for the same year is obtained from the inspection period.

(2) The number of locomotives assigned and inspected after 1990 is obtained by linear interpolation between 1986 and 2000.

(3) The number of inspections for steam locomotives is based on the estimates by the Railway Board and the number of locomotives assigned is based on the Japanese estimates.

(4) (   ) separately indicates electric locomotives.

The work loads due to accident and other special repairs are not considered here due to difficulty of estimation. But when estimating the facility size, they are calculated by multiplying a fluctuation factor of 1.2.

(2) Cycle time

The modernisation plan has the major objective of reducing the cycle time and increasing the POH capacity. For this reason, the planned cycle time after various improvements which are mentioned later is adopted as a basis for estimating the facility size. The cycle time for each locomotive type is shown in Table 5.2.4.

Table 5.2.4 Cycle Time by Type of Locomotives

Type	Planned cycle time	Present cycle time (Reference)
WDM2	16 (10)	25 (21)
WDS4	16 (12)	25 (21)

Note: 1. Shown in actual working days.
2. Numbers in ( ) designate the number of days in the main building.

(3) Basic rationale for drawing up the improvement plan

The facility improvement plan is developed based on an analysis of present work procedure and on items which seem essential in reducing the cycle time and improving the quality and reliability of locomotives. Types and requirements for equipment and machinery need to be determined according to inspection and repair requirements. The scope of mechanisation and its level was determined from the machines commonly used in Japan which have given satisfactory results.

Several improvement plans were developed as alternatives. These were compared and evaluated fairly and objectively to select the optimum plan. Basic requirements which need to be considered in developing the improvement plans are given below.

1) Body related works

a) The present critical path in the body-related works is the stripping and assembling at the in-coming and outgoing pits and various tests and adjustments. Fundamental improvement should be made by reducing the present three tracks to two, which would increase space to be used as a temporary placement for the large number of parts generated from the stripping, as well as for various transport equipment.(Fig. 5.2.3)

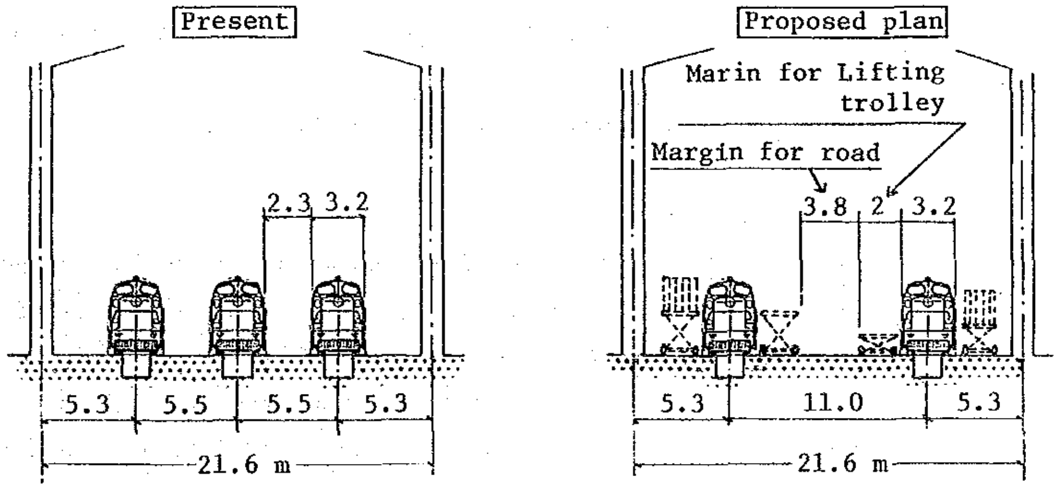


Fig. 5.2.3 Cross Sectional Views of Present Body Shop and Proposed Plan

b) To improve the work efficiency at the in-coming and out-going pits, a lifting trolley and a lifting platform vehicle should be provided.

c) Work space for the main and small hoods should be provided, at a rate of 0.8 of actual car body per locomotive.

d) The hood and body chassis should be painted with electrostatic spray painting equipment, instead of manual painting as done at present.

e) Body cleaning work, except the engine room and underfloor, should be done outside the body shop in the in-coming inspection shed. Chasis cleaning for engine room and underfloor should be done in the body shop, cleaning section. Also, a steam cleaner should be provided.

f) As an EOT crane is heavily used for stripping and assembling diesel locomotives, a long and narrow layout causing long waiting hours for body movement should be avoided.

g) To reduce the cycle time at the out-going pit, the engine, bogie, and other major parts should be individually tested before being installed on the body.

h) Adjustment and other additional work after the trial run should be done at the final adjustment shed where the extension of the building is planned.

i) In-coming and out-going line should be increased for DL use.

2) Bogie-related works

a) Washing the bogie in the Bosch tank takes many hours and constitutes a bottleneck in the cycle time. An injection washing device should be provided.

b) As cracks in the bogie frame frequently occur and they require many hours of welding repair, a surface plate for measuring distortion and a manipulator to facilitate welding work in flat position should be provided.

c) The bogie should be stripped and assembled in the bogie shop, rather than at the in-coming and out-going pits to reduce their work loads.

d) Rotating test equipment should be provided to check heat generated in wheels and plain bearings for suspension of traction motor after the bogie assembly.

e) The bogie shop, where many works are done generating a relatively large amount of dust, should be separated from the engine shop.

f) The shop areas should be considered by including EL use.
g) Necessary number of spare bogies should be equipped.

3) Engine related works
   a) Washing devices for the engine and other parts should be provided to reduce the cycle time.
   b) A manipulator and a lifting type platform should be provided to improve the efficiency of disassembling and assembling the engine for both types of locomotives.
   c) Testing device to individually test the assembly of engine and generator should be provided, instead of the present test procedure after installation on the actual car body, which takes around four days.
   d) The minimum required number of complete engine and generator sets should be provided as spare parts.
   e) Washing and other equipments should be capable of use for both engine types.
   f) Consideration should be made to include 4000 HP DL engines, which will be serviced and inspected in the future.

4) Traction motor and generator works
   a) Air blast and washing devices, dielectric test equipments, and mica cutting device should be provided in addition to tester and other equipments currently available to reduce the present cycle time of 10 days.
   b) A power source for no-load rotating test of the traction motor should be provided to streamline the process.
   c) Heavy repair shop in which re-coiling and other heavy repair can be done, should be provided separately from light repair shops.
   d) Facilities for light repairs of rotating machines should be arranged in a same location as much as possible to facilitate the sharing of repair devices by various shops.
   e) The shop areas should be considered by including EL use.

5) Wheel set works

a) The present wheel shop is long and narrow, providing little service path and requiring even the wheels to be transported by crane. The layout should be completely revised to improve work efficiency.

b) A rail or wheel traverser should be used to transport the wheels, minimising the use of the crane for this purpose.

c) The whole system should be reviewed and improved so as not to place semifinished wheels and axles for a long time in the work place.

d) The roller bearing shop should be provided with necessary equipment.

e) The axial direction incidence type ultrasonic flaw detector is to be introduced.

f) Easy disposal of chips generated in wheel profiling and other machine works should be taken into consideration.

g) Efficiency in handling wheels to and from the shed should be increased by means of layout improvement.

h) The shop areas should be considered by including EL use.

i) Parts material space for heavy repair of wheels and axles should be secured.

6) Other parts related works

a) Equipments to individually test major parts before loading to the car body should be provided to minimise the time for adjustment after installation on the car body.

b) The layout of the parts shops which are currently divided into small rooms should be revised because some are having difficulties for installation of planned test equipment.

7) Other general items

a) Service paths and floors in the shops should be paved to ensure smooth traffic, and forklifts and trailers should be added.

b) Pneumatic and electric tools should be provided as far as possible to increase the efficiency of basic works such as bolt tightening and so on. For this purpose, the building should be provided with air pipes, electrical wiring, and outlets.

c) Spare parts and material storage spaces of adequate size should be provided at each work place to ensure accurate inventory control all the time.

d) Each shop should be arranged with the view to minimise the distances for transporting materials and parts.

e) The design should consider possible inspection and repair of electric locomotives in the future.

f) An example of improvement plan for adjacent stores depot will also be considered.

The anticipated reduction of working hours in each task and the activity network after the improvements recommended above are presented in Tables 5.2.5 and 5.2.6 and Fig. 5.2.4. Overall, the cycle time for DWM2 locomotives is expected to decrease from 25 days to 16 days, and that for WDS4 locomotives also from 25 to 16 days.

Table 5.2.5 Analysis of Present Car Body Works and Improvement Plan for WEDM2 (1/6)

Activity No.	Present			Proposed plan		Remarks
	Work content	Working hour	Float hour	Improvement plan	Working hour	
1 - 2	In-coming inspection	* 2	0	Fixed platform and pit lighting	* 1.5	① In-coming inspection shed
2 - 3	Removing small hood	0.5	(1) 1.5		0.5	
2 - 4	Removing pipe stage 1, exp. pipe line, and pipe line on hood	* 4	0	Lifting platform vehicle and lifting trolley	* 3	①
2 - 5	Draining lube oil, fuel oil, and water	4	—		4	
2 - 6	Uncoupling elec. equipment	14	(2) 25		14	
2 - 7	Uncoupling of TM cables and booster	8	—		8	
2 - 8	Uncoupling truck pins, brackets, cattle guards, buffers and components	8	—		8	
2 - 9	Removing air brake and parts	32	(3) 29	Brake parts washing device	25	③
2 - 10	Removing battery stage 1	2	—		2	
3 - 11	Removing air maze filter	1	(1)		1	

Table 5.2.5 (2/6)

Activity No.	Present			Proposed plan		Remarks
	Work content	Working hour	Float hour	Improvement plan	Working hour	
3 - 43	Inspecting, repairing small hood	8	(4) 136.5		8	
6 - 39	Inspecting, repairing electrical parts	80	(2)	Various testing devices Addition of spare parts	60	③
11 - 12	Removing main hood	2	(1)	Lifting platform and lifting trolley	1	②
12 - 13	Uncoupling of expressor and power pack	4	(1)	- ditto -	3	②
13 - 14	Removing expressor	2	—		2	
9 - 36	Inspecting/repairing/ testing brake parts	48	(3)	Brake parts washing device	36	③ Including addition of spare parts
12 - 37	Inspecting reparing/ painting main hood	48	(5) 57.5		48	
4 - 15	Uncoupling pipe stage II, lube oil, fuel oil and cooling water pipes	* 3	0	Lifting trolley	* 2	①
15 - 17	Uncoupling pipe stage III, cooler and radiator fan	* 4	0	- ditto -	* 3	①
13 - 17	Removing power pack	2	(1)		2	

Table 5.2.5 (3/6)

Activity No.	Present			Proposed plan		Remarks
	Work content	Working hour	Float hour	Improvement plan	Working hour	
17 - 18	Removing power pack and sending to the shop	4	—		4	
17 - 19	Lifting	* 2	0		* 2	
19 - 20	Removing filter and fan in the radiator room	4	(6) 38		4	
20 - 21	Removing radiator	4	(6)		4	
19 - 22	Transporting car body to cleaning area	* 3	0		* 3	
22 - 23	Cleaning car body	24	(7) 52	Underframe washing device (steam cleaner)	24	
22 - 24	Disconnecting wiring on the body	8	55 (8)		8	
24 - 25	Maintaining tank	4	(8)		4	
25 - 26	Painting body and tank (manual)	4	(8)		4	
26 - 27	Wiring body (main circuit)	16	(8)		16	
22 - 39	Replacing control cables	56	47 (9)	Setting up of wiring preparation shop	56	
22 - 28	Cleaning and modifying fuel tank	32	52 (10)		32	

Table 5.2.5 (4/6)

Activity No.	Present			Proposed plan		Remarks
	Work content	Working hour	Float hour	Improvement plan	Working hour	
22 - 29	Removing bogie, wheel set, traction motor	* 8	0		* 8	
29 - 30	Sending wheels	* 1	0		* 1	
30 - 31	Sending traction generator	* 6	0		* 6	
31 - 32	Stripping and cleaning bogie soaking	24	(11) 18	Bogie washing device, bogie painting device	* 14	②
31 - 33A	Inspecting and repairing bogie	* 48	0	Enlargement of shop, fixture for welding	10	① Including addition of spare bogie
33A - 34	Assembling brake ccy	* 4	0		* 4	
32 - 33	Ultrasonic testing of bogie (parts)	1	(11)		* 1	
33 - 33A	Identifying damaged parts	1	(11)		* 1	
34 - 35	Assembling bogie (including wheel set and traction motor)	* 24	0		* 24	
23 - 27	Painting (car body)	8	(7)		8	
27 - 35	Moving car body to the assembly line	3	(7)		3	

Table 5.2.5 (5/6)

Activity No.	Present			Proposed plan		Remarks
	Work content	Working hour	Float hour	Improvement plan	Working hour	
49 - 36	Mounting power pack on car body	2	—		2	
35 - 36	Lowering	* 4	0		* 4	
36 - 37	Mounting expressor	* 2	0	Lifting platform vehicle, lifting trolley	* 1.5	①
37 - 38	Adjusting coupling between expressor and power pack	* 6	0	- ditto -	* 5	①
38 - 39	Mounting main hood	* 6	0	- ditto -	* 4	①
39 - 40	Coupling cooling water pipes and supplying water	* 4	0	Water filler	* 3	①
40 - 41	Injecting lube oil and oiling	* 4	0	Oil filler (fuel, lubricant)	* 3	①
41 - 42	Cranking power pack	* 8	0	Power pack performance testing device Addition of spare units	0	① Change into spare parts system
42 - 43	Test operating power pack	* 8	0		0	①
43 - 44	Load test (grid resistance)	* 8	0		0	①
44 - 45	Adjustment and modification	* 8	0		0	①

Table 5.2.5 (6/6)

Activity No.	Present			Proposed plan		Remarks
	Work content	Working hour	Float hour	Improvement plan	Working hour	
45 - 46	Load test (water resistance: maintenance room)	* 8	0		* 8	① ⇩
46 - 47	Trial run on main line	* 12	0		* 12	
47 - 48	Adjustment and modification	* 8	0		* 8	Work outside the main building
48 - 49	Touch-up painting, adjustment, deadheading	* 8	0		* 8	
	Total critical path	203 hrs (25. days)			130 hrs (16.3 days)	

Note: 1. The asterisk shows the critical path. 2. Figures in ( ) designate a group the same float time is applied.
3. Number in ○ in remarks indicate a sequence of improving the critical path.
4. ▭ indicates items designed to improve accuracy, etc.

Table 5.2.6 Analysis of Present Car Body Works and Improvement Plan for WDS4 (1/4)

Activity No.	Present			Proposed plan		Remarks
	Work content	Working hour	Float hour	Improvement plan	Working hour	
1 - 2	In-coming inspection	* 2	0	Fixed platform pit lighting	* 1.5	① In-coming inspection shop
2 - 3	Draining lube oil, fuel oil transmission oil, and cooling water	* 6	0	Oil drainage facility	* 4	① Including tank for old oil
3 - 4	Cleaning car body	* 4	0	Underframe washing device (steam cleaner)	* 2	①
4 - 5	Uncoupling side rod, cattle guards, and brake lever	* 4	0		* 4	
5 - 6	Removing wheels, moving car body, and sending wheels	* 2	0		* 2	
6 - 7	Uncoupling pipes and V belts	3	—		3	
6 - 8	Removing electrical wiring	2	—		2	
6 - 9	Removing main and small hoods and roof of operator cab	4	—		4	
6 - 10	Removing battery	1	—		1	

Table 5.2.6 (2/4)

Activity No.	Present			Proposed plan		Remarks
	Work content	Working hour	Float hour	Improvement plan	Working hour	
6 - 11	Removing equipment, instruments brake parts in operator cab	8	—		8	
6 - 12	Removing lube oil, fuel oil, cooling water pipes, and pumps	8	—		8	
6 - 15	Removing cardon shaft	* 4	0	Lifting trolley	3	①
15 - 14	Removing jack shaft	* 4	0	- ditto -	3	①
14 - 13	Removing parts	* 4	0	- ditto -	3	①
13 - 16	Removing power pack	4	—		4	
13 - 17	Removing transmission and operation equipment	* 4	0		4	
6 - 18	Removing compressor, exhauster, and belt fan	3	(1) 41		3	
18 - 19	Repairing the above	24	(1) 41	Providing compressor and and exhauster test equipment	24	
6 - 20	Machining and repairing car body, engine base and basic brake devices	64	(2) 8	Lifting trolley	* 56	②

Table 5.2.6 (3/4)

Activity No.	Present			Proposal plan		Remarks
	Work content	Working hour	Float hour	Improvements plan	Working hours	
20 - 21	Painting car body	4	(2) 8	Electrostatic painting device	* 3	②
16 - 21	Repairing power pack	—	—	Providing engine test equipment and adding spare parts	—	Including washing device
17 - 24	Repairing transmission and operation equipment	* 48	0	Injection washing device, adding spare parts for transmission, reverser	10	①
24 - 25	Testing the same above	* 8	0	Flushing device for transmission, reverser	6	①
25 - 21	Mounting transmission and operation equipment on body	* 4	0		4	
21 - 27	Mounting power pack on body	4	(3) 2		4	
21 - 28	Mounting belt fan and accessories	8	(4) 6		8	
27 - 28	Replacing lube oil fuel, cooling oil pipes and pumps	8	(3) 2		8	
21 - 30	Mounting compressor exhauster and oil pump	* 6	0	Lifting trolley	* 5	①

Table 5.2.6 (4/4)

Activity No.	Present			Proposal plan		Remarks
	Work content	Working hour	Float hour	Improvements plan	Working hours	
30 - 31	Mounting equipment instruments and brake parts on operator cab	* 8	0	Lifting trolley	* 7	①
34 - 35	Mounting battery and starter motor	* 4	0	"	* 3	①
31 - 32	Mounting main and small hoods and operator cab roof	* 8	0	"	* 7	①
32 - 34	Assembling cables and pipes	* 8	0		* 8	
35 - 40	Injecting lube oil, test operating power pack, load testing and adjustment	* 70	0	Providing oiling equipment and adding power pack spare parts.	* 28	① Outside main building, 36 hrs. (both)
	Total critical path	198 hrs (24.8 days)			130.5 hrs (16.3 days)	

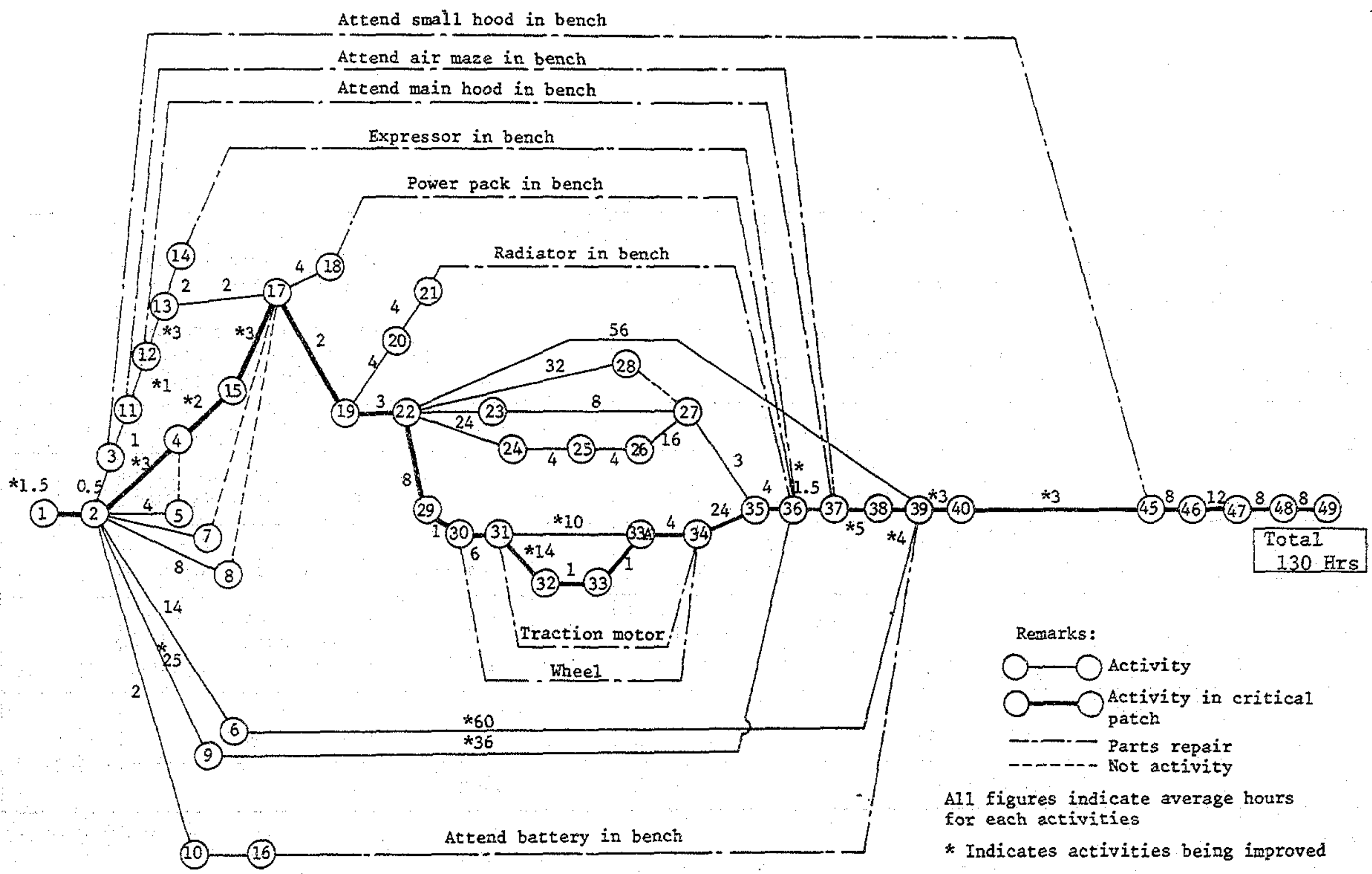


Fig. 5.2.4 Network Flow for Periodical Overhaul (WDM2) IMPROVED

(4) Comparison of each alternative

As to the DL related shops, comparisons were made from various points of view like the basic elements described in the premises of the plan; the maximum use of existing facilities and the relations between facilities for the future EL purposes. The comparisons were made by setting up three plans, and we come to the conclusion that Plan 1 is the best, as shown in the Table 5.2.7. Therefore, the modernisation plan has been drawn up based on Plan 1. The alternatives are shown in Figs. 5.2.5 to 5.2.7.

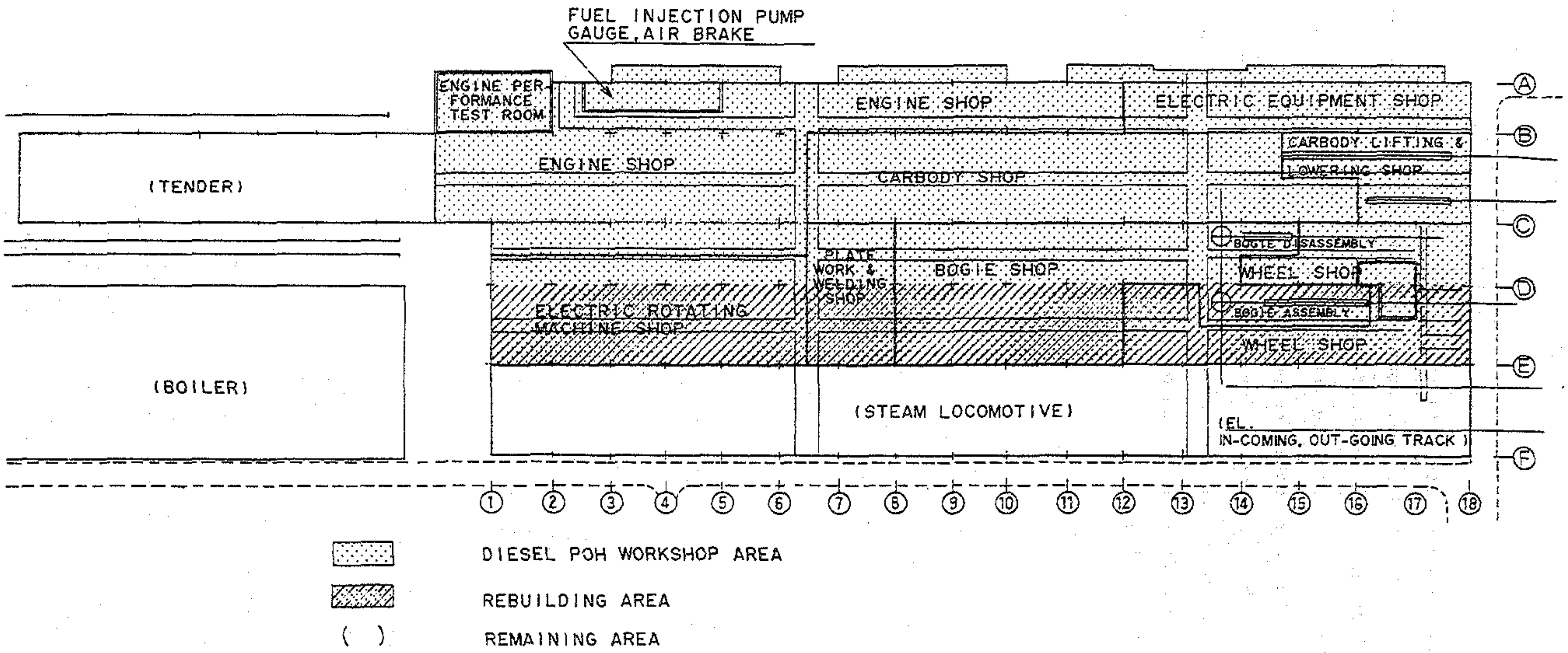
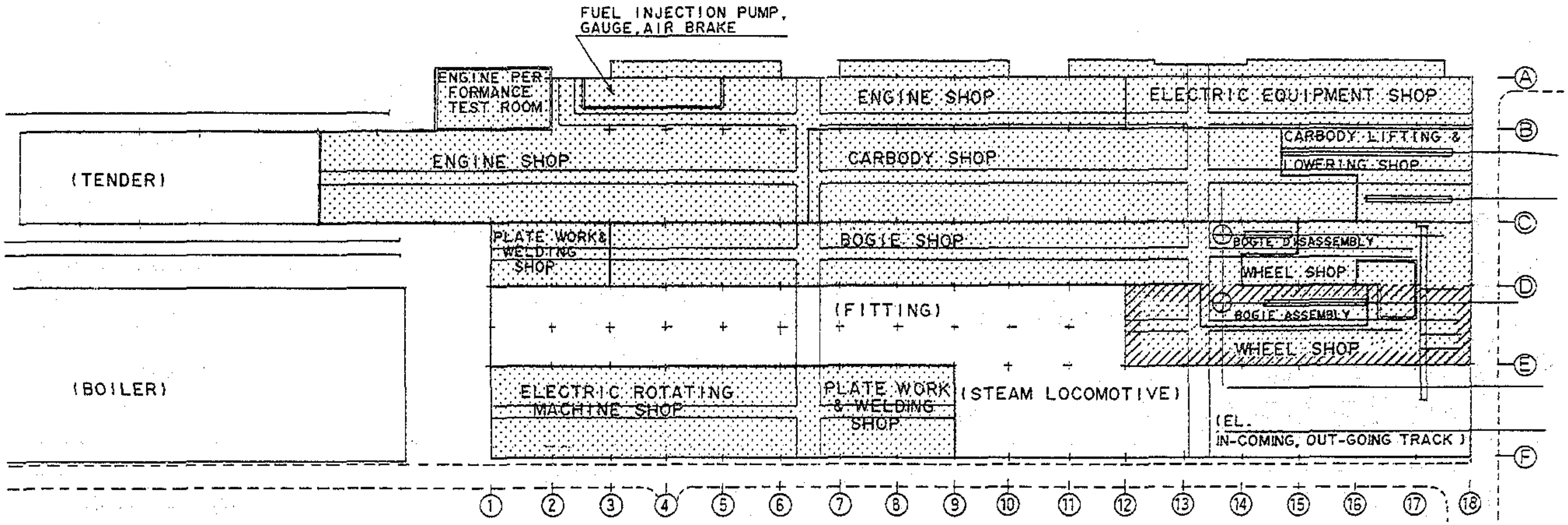


Fig. 5.2.5 Workshop Layout Plan (Plan 1)



DIESEL POH-WORKSHOP AREA

REBUILDING AREA

( ) REMAINING AREA

Fig. 5.2.6 Workshop Layout Plan (Plan 2)

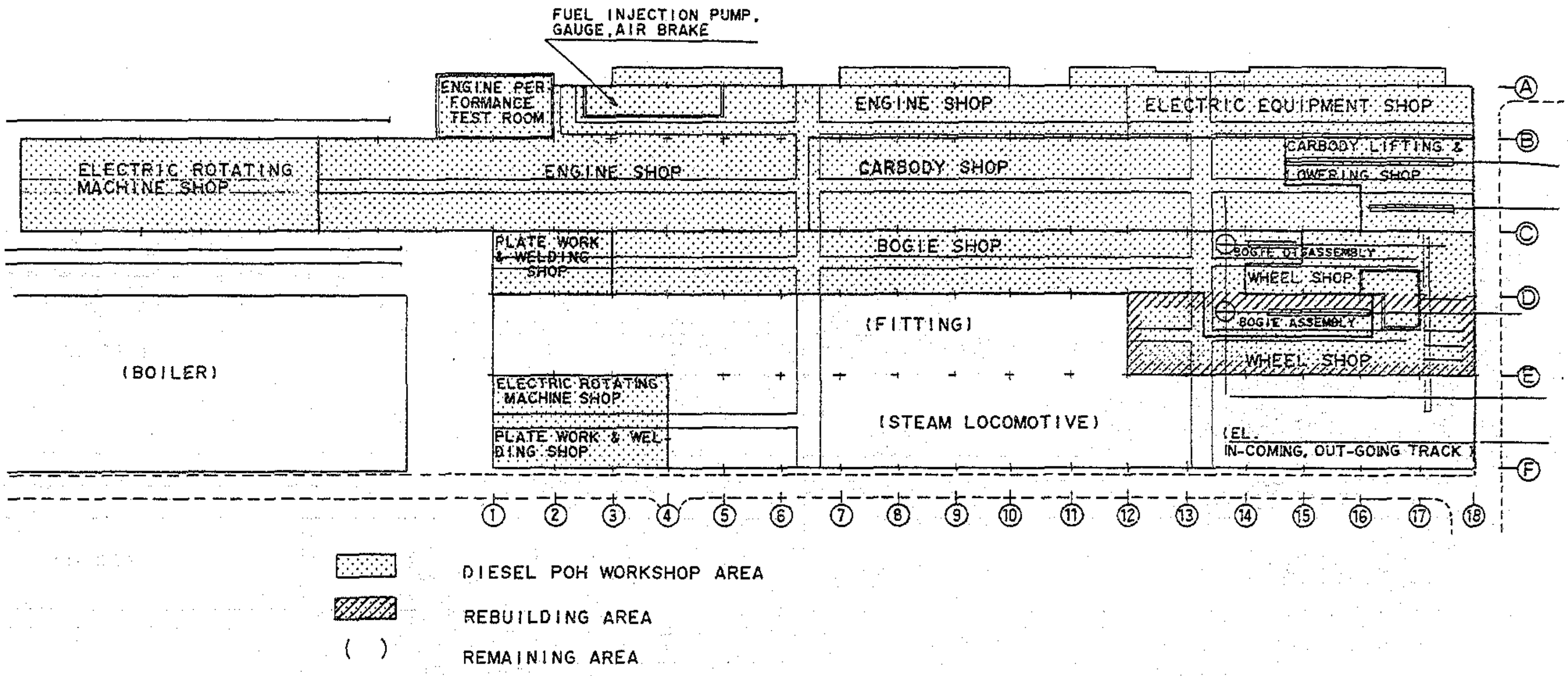


Fig. 5.2.7 Workshop Layout Plan (Plan 3)

Table 5.2.7 Comparison of Each Plan

Item		Plan 1	Plan 2	Plan 3
Facilities to be modified		Overall modification of the fitting shop	Partial modification of the fitting shop	Partial modification of the fitting shop
Area to be modified (estimated) (m^2)		4400	1600	1600
Transporting parts	Car body	o	o	o
	Engine	o	o	o
	Electric rotating machine	Traction generator o Traction motor o	Traction generator △ Traction motor △	Traction generator △ Traction motor x
	Bogie	o	△	△
Relationship with the steam locomotive repair work		No disturbance o	Conflict between the electric rotating machine repair work and the boiler transportation x	Same as left x
Adaptability to electric locomotive repair work	Bogie	o	△	△
	Wheel set	o	o	o
	Electric rotating machine	o	△	x
Adaptability to future diversification		o	△	x
Evaluation		o	x	x

Legend: o: satisfactory △: not quite satisfactory x: unsatisfactory

5.2.3 Drawing up the Facility Improvement Plan for Diesel Locomotives

On the basis of the study of the present state of the Workshop and the premise of modernisation plan mentioned before, the plan for the scale of rolling stock maintenance facilities, layout of work areas, and layout of plant and machinery is drawn up for this Workshop.

In addition, inspection/repair requirements for electric locomotive which may be introduced in future are taken into consideration in this plan.

(1) Scale of Facilities

In this plan, the following facilities will have the following holding capacity at one time. (Refer to the Clause 1.1.2 in the Vol. II)

1) In-coming Inspection Shop		1 locomotive
2) Final Adjustment Shop	(1 loco/line, 2 loco/line)	3 locomotives
3) Carbody Lifting/Lowering Shop	(Lifting line)	1 loco length
	(Lowering line)	2 loco length
4) Carbody Shop	(carbody repair area)	6 locomotives
	(chassis cleaning area)	1 locomotive
5) Engine Shop	(engine repair area)	6 engines
	(performance test room)	3 engines
6) Bogie Shop		Correspond to 6 (2) locomotives
7) Electric Rotating Machine Shop	(traction generator)	Correspond to 4 locomotives
	(traction motor)	Correspond to 3 (2) locomotives

Figures in ( ) shows number of electric locomotives separately.

(2) Overall Layout Plan

The layout plan of the Workshop Building, In-coming Inspection Shop, Final Adjustment Shop, and so on, is shown in Fig. 5.2.8.

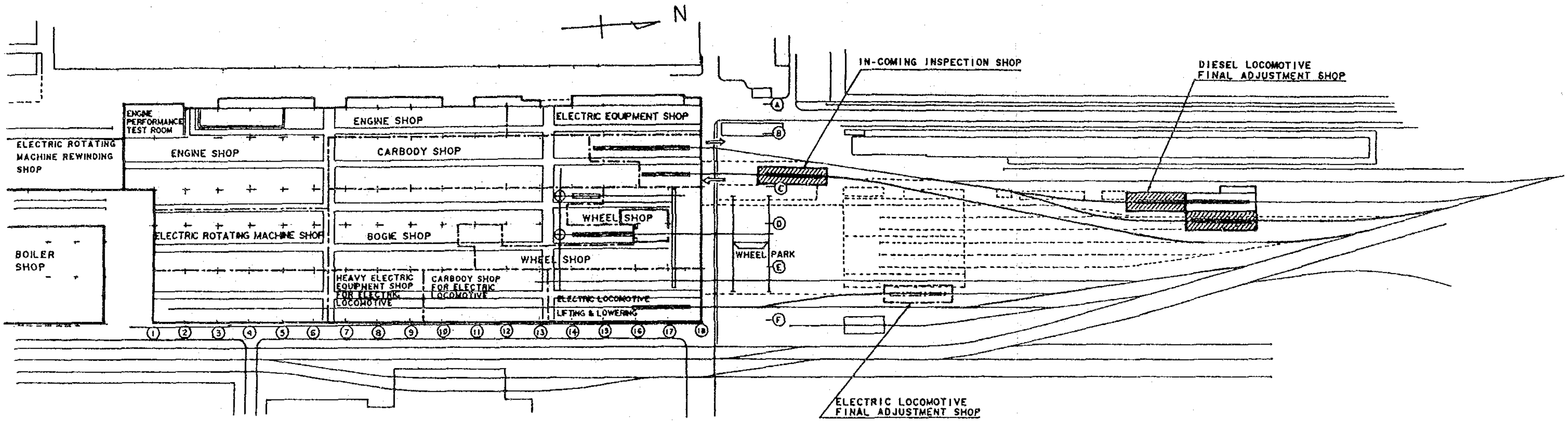


Fig. 5. 2. 8 LAYOUT PLAN OF DIESEL POH FACILITY

In-coming Inspection Shop is arranged outside of the Main Building at the location of present carbody cleaning pit. Final adjustment Shop is an enlargement of the present Shop. The track layout between the Workshop Building to these two shops is changed so that the movement of locomotive in and out of the Workshop Building will not interfere each other, and also so that the repaired locomotive can enter into the Final Adjustment Shop from the Workshop Building directly without switch back.

The track line to be used for in-coming and out-going of wheel set supplied to outstation is planned to use a line laid at the Fitting Shop side of the present Erecting Shop, along with the wheel park outside.

Further, the Electric Locomotive Final Adjustment Shop for POH of electric locomotive in future is shown in the Vol. III Fig. 1-2.

The layout plan of various shops in the Workshop Building is as follows.

That is, Carbody Lifting/Lowering Shop, Carbody Repair Shop, and Engine Shop are arranged in series in the bay of Diesel POH Shop (High).

As for the three shops of Bogie Shop, Wheel Shop, and Electric Rotating Machine Shop, the present Fitting Shop bay will be rebuilt so as to be able to install EOT crane in its whole length (about 4,400 m^2), and together with the present Wheel Shop bay, the space of these two bays are divided into 3 sections and these 3 shops are arranged here in the order from the north end of the Building, Wheel Shop, Bogie Shop, and Electric Rotating Machine Shop as shown in the Vol. III Fig. 1-2.

Further, in the present Diesel POH Shop (Low), the Shop for engine accessories and Electric Equipment Shop are arranged.

The above-mentioned layout plan has the following rationality.

1) Each Shop is arranged with the Carbody Shop as the centre so as to keep good relationship between each other.
2) The route for transporting parts between the Shops is short and simple, and there is no interference between each route.
3) While continuing repair work of steam locomotive, relocation of shops can be made with least disturbance on the repair work.

4) As the Bogie Shop, Wheel Shop, and Electric Rotating Machine Shop are located adjacent to the Erecting Shop which will be converted to the Electric Locomotive Carbody Lifting/Lowering Shop, Carbody Shop, and Shop for repairing transformer and other large sized electric parts, so as to enable changes in the shops such as extension or common use of shops in future without extra additional works.

(3) Plan of Each Shop

1) In-coming Inspection Shop and Final Adjustment Shop (Refer to Clause 1.1.2. (1) in Vol. II)

In-coming Inspection Shop having the capacity to hold one locomotive is to be provided newly at the location of the present carbody cleaning pit.

The Final Adjustment Shop in which test and final adjustment of locomotive is carried out will be extended to have a capacity to hold 3 locomotives at one time from the present capacity of holding one locomotive, providing 2 lines, one for two locomotives and one for one locomotive.

2) Carbody Lifting/Lowering Shop and Carbody Shop

The pit will be made up of two tracks and the carbody repair area of two lines as to widen the space between carbodies to allow the usage of mobile platform and carrier in this space to increase work efficiency.

Electro-static painting equipment is adopted for the painting of carbody and consequently specific carbody painting shop will not be provided. (Refer to the Clause 1.1.2. (2) in the Vol. II)

3) Engine Shop

The repair of engine and its accessories for both WDM2 and WDS4 can be carried out in the same working block in the Engine Shop and also repair facilities are arranged so that they can be used commonly. But machines and equipment used for repair of special parts of WDM2 are located in one work block so that the work can be carried out in the block area.

The repair work of fuel injection pump, gauge and instrument (including other than those of the engine) is to be carried out in a dust-proof enclosed room.
The Engine Performance Test Room will be provided independently where the performance test of 2 power-packs for WDM2 and of 1 engine for WDS4 can be carried out at the same time after assembling of the engines.
In order to utilise repair facilities commonly for the repair work of traction generator and of traction motor, the traction generator is repaired in the Electric Rotating Machine Shop. (Refer to the Clause 1.1.2. (3) in the Vol. II)

4) Bogie Shop, Wheel Shop, and Electric Rotating Machine Shop (Refer to the Clauses 1.1.2. (4), (5), (6) in the Vol. II)
The place where assembling and disassembling of the bogie is carried out is taken as a base point in determining the arrangement of Bogie Shop, Wheel Shop, and Electric Rotating Machine Shop. That is, the bogie disassembling work area is provided in the present Wheel Shop adjacent to the Carbody Lifting/Lowering Shop and the bogie assembling work area is provided in the present Fitting Shop which will be rebuilt in future.
Bogie sent to the Bogie Shop from the Carbody Lifting/ Lowering Shop is disassembled at the bogie disassembling work area, and bogie frame and its accessories are sent to the Bogie Shop, and traction motor is sent to the Electric Rotating Machine Shop.
In the Bogie Shop and Electric Rotating Machine Shop which are arranged at the location of present Wheel Shop and Fitting Shop which will be rebuilt in future, bogie frame and traction motor are repaired with the repairing machines and equipment laid along the flow line of repair work, and they are assembled with wheel sets and after that they are sent to the Bogie Shop and completed as the bogie. The bogie is transferred to the Carbody Lifting/Lowering Shop.

Further, the work areas for repairing suspension bearing of traction motor, side rod of WDS4, etc., are provided in a part of the Bogie Shop which is located adjacent to the Wheel Shop.
In the Wheel Shop, the wheel set repair line, from the bogie disassembling area to the bogie assembling area, is arranged with track and traverser in a reasonable way to decrease labour for transfer of wheel set in the repair work.
Inspection of roller bearing is to be carried out in the room of dust-proof construction, and heavy repair of wheel set such as replacement of tyre and so on is to be carried out at the place near the wheel set repair line.

5) Electric Equipment Shop

The Electric Equipment Shop is arranged at the north side of the present Diesel POH Shop (Low) adjacent to the Carbody Shop.
The aim of this plan is to concentrate the repair work in this shop and the repairing facilities can be utilised commonly in the repair work of electric equipment stripped from the carbody and engine. (Refer to the Clause 1.1.2. (7) in the Vol. II)

6) Facilities Related to EL

For the POH of EL which will be executed in future, Carbody Shop and Heavy Electric Equipment Shop for EL are arranged at the present Erecting Shop, as this space can be utilised wholly.
Final Adjustment Shop for EL is provided at the location of the present SL Painting Shop, separate from that of DL.
Repairing facilities for bogie, wheel set, traction motor are planned so as to cater for the amount of repair work of 4 EL in a month.
The Electrical Equipment Shop is arranged near the Electric Rotating Machine Shop so as to carry out the same work at one place.
Judging only from the space for carbody repair, the Carbody Shop will have sufficient capacity for 4 EL, and further it is considered that it can sufficiently cater for the increase in the number of electric locomotives.

(4) Store House

It is very important to establish the whole system of material management to execute smooth repair work of rolling stock and shorten the time schedule of the work.

Improvement of the storehouse is a part of this, but setting up a plan for improvement of the storehouse is difficult unless the whole system is revised and improved at the same time.

Therefore, this time, only a sample plan for improvement of the storehouse has been proposed. (Refer to the Clause 1.1.2. (8) in the Vol. II)

(5) Material Transport System in Workshop

1) Transport 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.

The materials handled are large parts of SL, and considerable time is required for loading and unloading these materials on the lorry.

To raise the efficiency of transport, a change is made so that the parts of DL, which will increase in accordance with the increase in the number of POH of DL in future, are put on the pallets and moved between shops by forklift truck. (Refer to the Clause 1.1.2. (9) in the Vol. II)

2) Transport by Wagon

Raw material for casting (pig-iron, scrap, cokes, limestone, etc.) casting products, spring, etc. are transported by wagon to and from the outside of the Workshop. These can be transported by lorry, but the volume of these are very large, so it is better to transport these by wagon which has a larger capacity than lorry.

In order to decrease the detention time of wagon and also number of wagons staying in the Workshop, improvement of loading and unloading facilities for raw material and products of brake block casting is proposed.

3) Scrap disposal system

With the inspection/repair of locomotives, a huge amount of scraps is generated. Proper and efficient disposition of these scraps is extremely important to make use of shop area and execute efficient repair of locomotives.

Especially at Jamalpur Workshop, a lot of heavy repair of wheelsets is done, leaving scrapped tyres, discs and axles on shop floors as the result of re-tyring, re-axling work. This extremely hampers transporting work.

Accordingly, the workshop needs to enhance the efficiency of wheelset repair work. For this purpose, it is most desirable to install the wheel park with enough space outside equipped with overhead crane from the view point of effective use of shop floor. With this taken into account, the outdoor wheel park will be arranged and the scrap will be transported daily between wheel shop and wheel park by rail cart with floor appx. 4 m in length and 2 m in width or by foklift truck using pallet.

Besides, the wheel park may be utilised as temporary storage place for various raw materials, completed wheelsets and wheelsets from outsation.

(6) Building, Track, and Other Facilities

Improvement plan of building, track, passage, and so on in accordance with the new shop layout plan is as follows.

1) Building

The existing building such as Diesel POH Shop (High and Low), Wheel Shop and so on, are to be utilised as far as possible, but construction of new building, extension, and rebuilding of the following are planned. (Refer to the Clause 1.1.2 (11) in the Vol. II)

(a) To be newly built

a) In-coming Inspection Shop (for one locomotive)

b) Engine Performance Test Room (for 3 engines)

(b) To be extended

a) Final Adjustment Shop (for 2 locomotives)

b) Present Wheel Shop and a part of Fitting Shop in the Main Building

(c) To be rebuilt

All of the present Fitting Shop and a part of the present Wheel Shop in the Main Building

The work for repairing injection pump of engine and instrument in the Engine Shop and the work for repairing roller bearing in the Wheel Shop are planned to be carried out in the room to be constructed isolated from the general work area.

The building area corresponding to the facilities for the Diesel locomotive POH is shown in Table 5.2.8.

Table 5.2.8 List of Building Area

Unit m^2

Name	Total Area	Existing Now	Newly Built	Extended	Rebuilt
In-coming Inspection Shop	240		240		
Final Adjustment Shop	680	240		440	
Main Building	16,385	11,363	412	232	4,378
Total	17,305	11,603	652	672	4,378

2) Track

Track layout around the In-coming Inspection Shop and Final Adjustment Shop in connection with the Main Building is changed in the new plan. (Refer to the Clause 1.1.2 (10) in the Vol. II)

In accordance with this change, in-coming and out-going operations of diesel locomotives will be smoothly carried out without interference between them. (Refer to the Vol. III Fig. 1-13)

In the Main Building, tracks for transfer of bogies and wheel sets and also tracks used for pool of wheel sets are newly provided.

All of the existing tracks except tracks of carbody lifting and lowering line are removed.

3) Other Facilities

(a) Inspection Pit

In the Final Adjustment Shop, existing inspection pit is extended for a length of one locomotive and a pit for a length of one locomotive is newly provided.

Inspection pit at the carbody lifting and lowering lines in the Main Building will be modified.

(b) Pits for Bogie Diassembling and Assembling

In the Bogie Shop of the Main Building, a pit for disassembling bogies (requirements for one locomotive) and a pit for assembling bogies (requirements for two locomotives) are provided newly.

(c) Pavement of Floor and Security of Passage

It is planned to reconstruct the pavement of the floor of the work area in the Main Building, and to secure adequate passage. As a consequence, transport of materials and goods by forklift truck and other carrier can be made smoothly and rapidly.

(d) Passage in the Workshop Premises and Drainage System

It is planned to adjust and arrange the passages and ditches for drainage around the Main Building, In-coming Inspection Shop, and Final Adjustment Shop.

(e) Others

It is planned to completely equip with illumination and lighting system the buildings newly built, extended, and rebuilt, and other facilities such as inspection pits and work pits.

(7) Machinery

In this modernisation plan to convert steam locomotive workshop to diesel locomotive workshop, the accented point of improvement of repair facilities is on the installation of new machines for testing and repairing diesel locomotives and their components to secure the proper function and performance of diesel locomotives after POH, and in addition to this, it is considered to install machines suitable for the modernised workshop to improve the work efficiency.

Also, in selecting new machines, utilisation of the existing machines and equipment has been considered as far as possible.

As a result of this planning, the number of machines to be newly installed, and to be replaced are as shown in the following Table 5.2.9. (Refer to the Clause 1.1.3. in the Vol. II)

Table 5.2.9 Number of Machines

Work Area	Total	Details	
		Newly installed	Replaced
In-coming Inspection Shop	2	2	
Final Adjustment Shop	3	3	
Carbody Lifting/Lowering Shop, Carbody Shop	31	31	
Engine Shop	37	37	
Bogie Shop	10	10	
Wheel Shop	22	18	4
Electric Rotating Machine Shop	12	12	
Electrical Equipment Shop	14	14	
Brake parts repair area	4	4	
Diesel Component Shop	3		3
Others	3	3	
Total	141	134	7

5.2.4 Stage-wise Shop Arrangement Conversion Plan for Modernisation of Diesel Locomotive Inspection/Repair Facilities

To convert the existing shop arrangement as shown in Fig. 5.2.9 while keeping the POH of steam locomotives into the future shop arrangement as shown in the Vol. III Fig. 1-2, the conversion of shop arrangement should be carried out step by step in accordance with the future decrease in number of POH of steam locomotives. The year-wise number of POH of steam locomotives is as shown in Table 5.2.10.

Table 5.2.10 Year-wise Number of POH of Steam Locomotives

Year	1982	1983	1984	1985	1986	1990	1991	1992	1993	1994	1995	2000
POH	182	192	195	209	226	120	96	72	48	12	0	0

From the above, it will be most desirable to commence conversion of shop arrangement from year 1990; in this year the number of POH will decrease considerably. However, the number of POH of steam locomotives at this time will be ten locomotives per month. So, the existing tender shop will be shifted into erecting shop, but it is very difficult to relocate the machines exclusive for steam locomotive repair in the wheel shop and fitting shop into other shops at the same time. The number of machines to be retained in the wheel shop and fitting shop in year 1990 will be 25 machines in the wheel shop and 40 machines in the fitting shop. That is, in the First Stage, the wheel shop and fitting shop exclusive for steam locomotive repair will be arranged in the southern part of the existing wheel shop and fitting shop as shown in Fig. 5.2.10. The details of relocation of machines is described in another volume of report.

The shops related to the repair of chassis and hood, wheel and bogie will be arranged closely to the final shop arrangement plan except installation of machines to be newly introduced.

It will be desirable to commence the second stage shop arrangement conversion in year 1993; in this year the number of POH of steam locomotive will be only 4 locomotives per month. The number of machines to be retained in the wheel shop and fitting shop is estimated as 15 machines in the wheel shop and 25 machines in the fitting shop. These machines should desirably be moved into the marginal floor space inside the boiler shop at this time. The second stage shop arrangement is as shown in Fig. 5.2.11.

The conversion of electric rotating machine shop, engine performance test room and final adjustment of shop arrangement of each shop will be carried out after conversion of the wheel shop and fitting shop exclusive for steam locomotive repair into the boiler shop.

The final stage shop arrangement will be the stage for shop arrangement and adjustment for reception of future POH of electric locomotives. The final stage shop arrangement is as shown in Fig. 5.2.12.

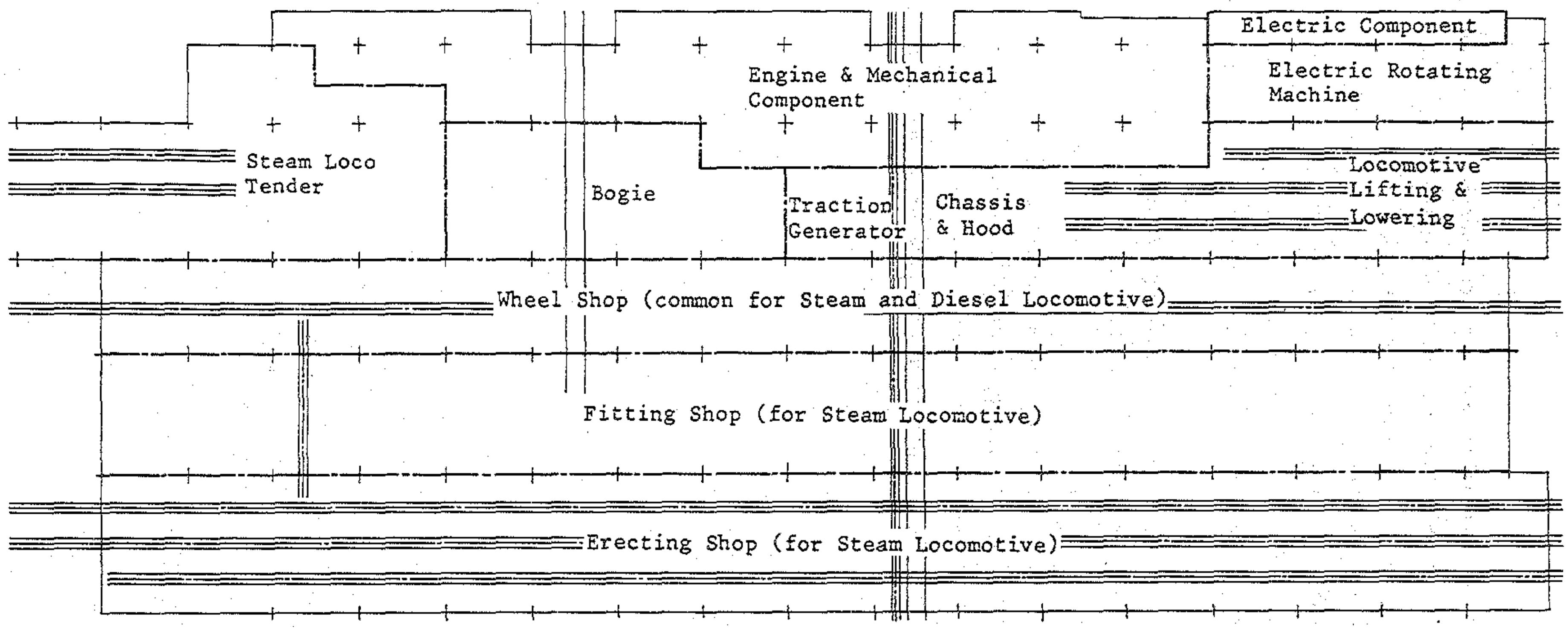


Fig. 5.2.9 Existing Shop Arrangement

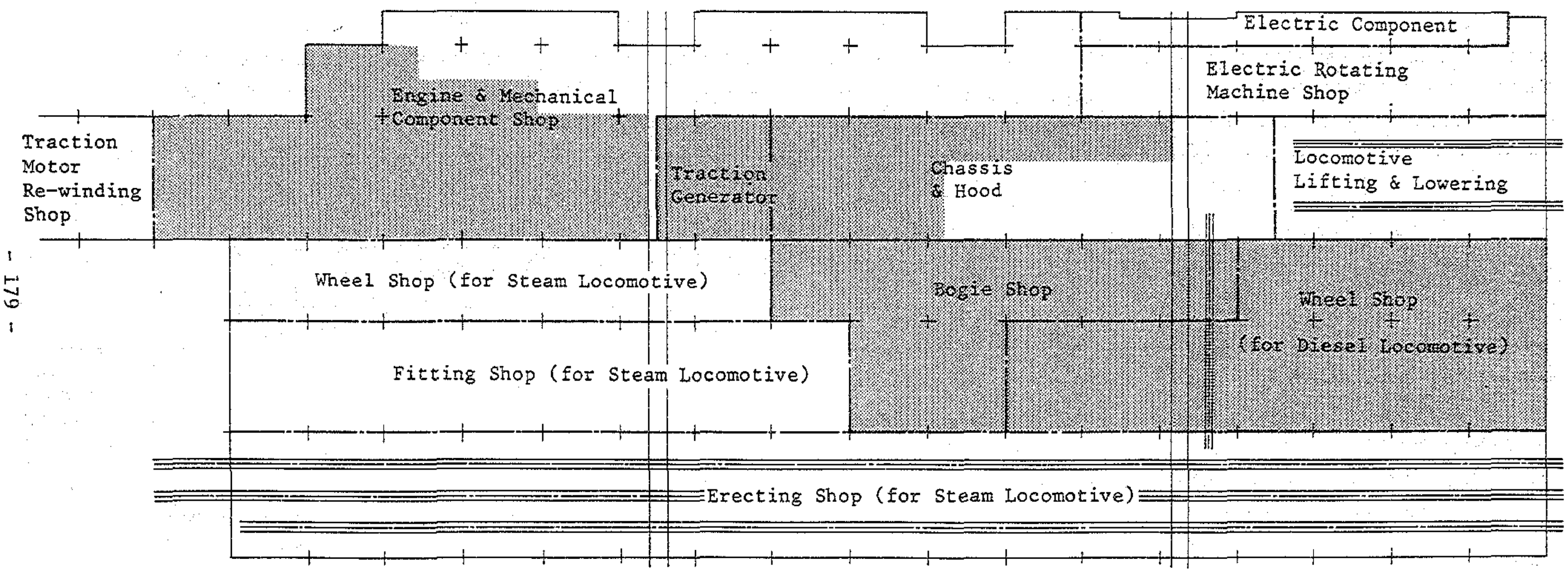


Fig. 5.2.10 First Stage Shop Arrangement

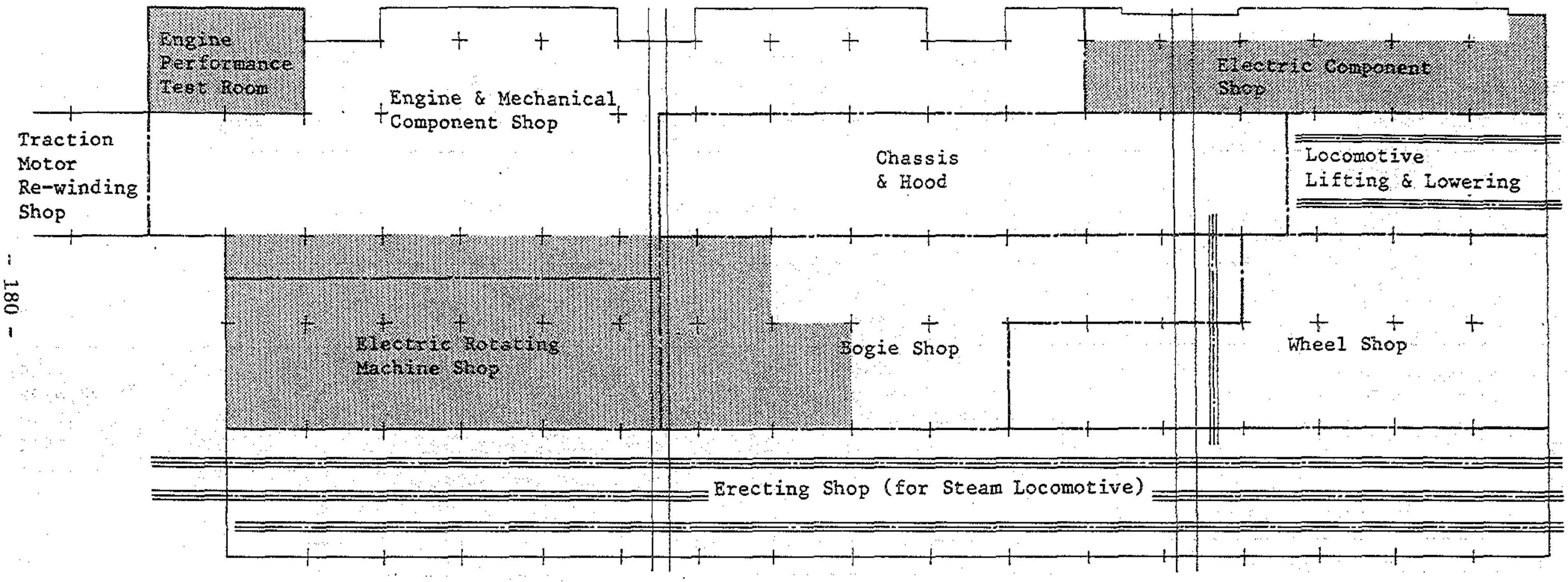


Fig. 5.2.11 Second Stage Shop Arrangement

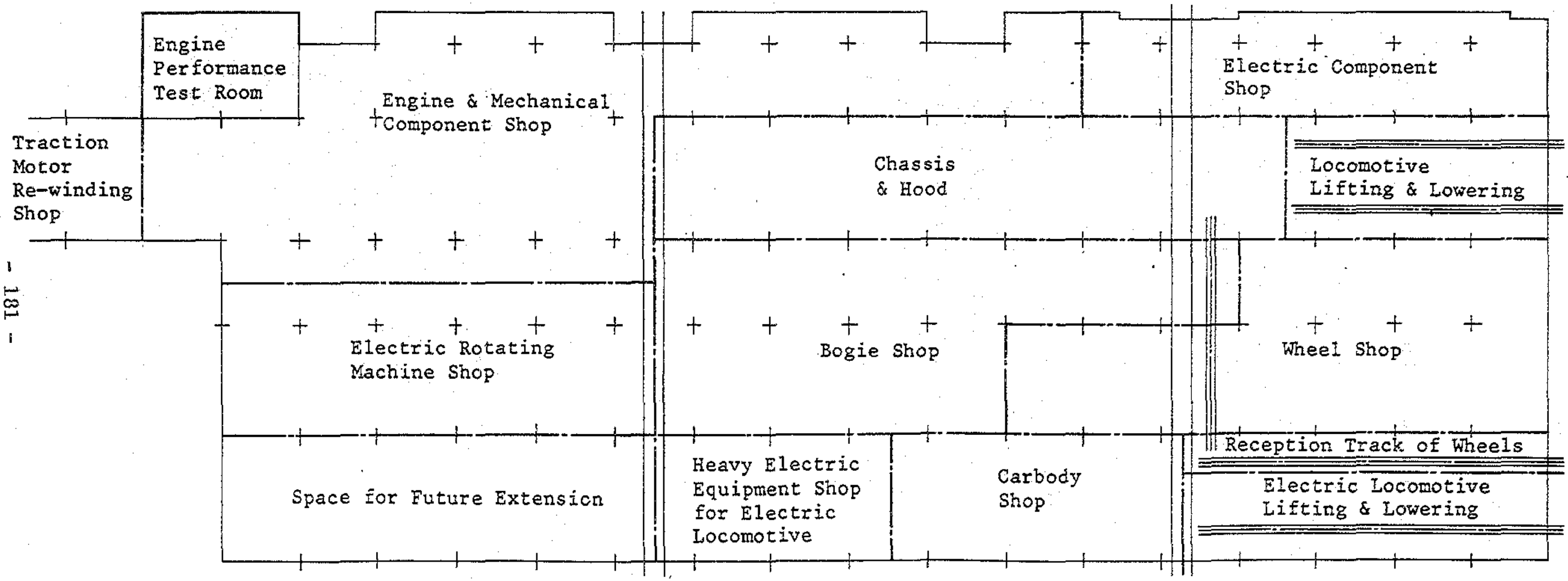


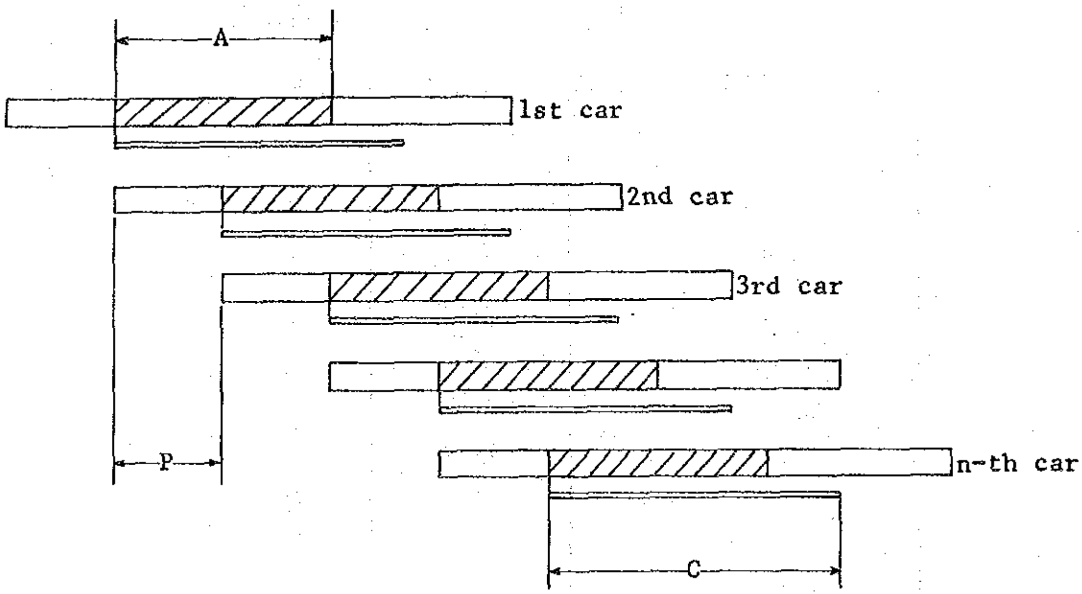
Fig. 5.2.12 Final Stage Shop Arrangement

5.2.5 Spare Parts Enhancement Plan

Shortening rolling stock cycle time requires not only shortening car body inspection/repair time, but also introduction of a unit exchange spare parts system, by which complete parts such as engines and wheels are stored in ready-to-use condition. These parts are taken out of storage and mounted on car bodies at the time needed. What follows is a description of the optimum quantity together with the corresponding cost of each of the parts to be stored.

(1) Concept of estimating the optimum storage quantities

Estimates of the optimum storage quantities of spare parts are based on three factors. One is the number of cars to be inspected by type of car. Another is the number of allowed days between removal of parts and mounting of parts onto the car body. Still another is the number of days needed to inspect and repair those parts.



Example

Rolling stock cycle time

Parts cycle time

A: the days between removal and mounting of parts from and onto the car body (allowed time);

P: In-coming interval of cars of the same type to the shop; and

C: The days needed to inspect and repair parts.

Then we get an optimum storage quantity of a given spare part using the following relations:

$$A > C \quad \ldots\ldots \text{ 0 piece}$$

$$A \leqq C < A + P \quad \ldots\ldots \text{ 1 piece}$$

$$A + P \leqq C < A + 2P \quad \ldots\ldots \text{ 2 pieces}$$

$$\vdots$$

$$A + (n-1)P \leqq C < A + nP \quad \ldots\ldots \text{ n pieces}$$

As a result, (C-A)/P is the formula by which to estimate the quantity. Where the cycle time of the same type cars vary significantly due to heavy repairs like corrosion treatment and so forth, the allowed time will be calculated using the cycle time for light repair so as to be on the safe side. The in-coming interval (P) takes into account a 20 percent fluctuation rate, and the days needed to inspect and repair parts (C) allows for a 10 percent delay.

If the heavy repair of parts occurs at each periodic overhaul (POH), the applicable spare parts will be out of stock during the additional days for the heavy repairs.

So additional parts for the predicted heavy repair are also proposed in addition to the usual spare parts (see Table 5.2.12 and 5.2.13)

(2) Contents of the spare parts enhancement plan

Table 5.2.11 shows those spare parts together with their cost which will be provided at the Jamalpur workshop during the period of plant investment

Table 5.2.11 Spare Parts Enhancement Plan

Type of car	Parts name	Q'ty of spare parts required	Q'ty of spare parts currently stored	Q'ty of spare parts to be added	Costs (in thousand RS.)
WDM2	Power pack (complete)	4	1	3	12,000
	Traction generator	3	0	3	2,210
	Supercharger	1	0	1	240
	Expressor	1	1	0	0
	Bogie (complete)	3	2	1	2,500
	Wheel set	6	0	6	540
	Traction motor	20	6	14	6,240
	Exciter	1	0	1	160
	Others	-	-	-	5,000
	(Total)				(28,890)
WDS4	Engine	1	0	1	2,000
	Transmission	1	0	1	280
	Wheel set	1	0	1	80
	Others	-	-	-	2,000
	(Total)				(4,360)
			Grand total		33,250

Table 5.2.12 Breakup of Estimates of Spare Parts to be Stored at the Jamalpur Workshop

Type of car	No. of cars inspected/ repaired with P and P'	Parts name	Cycle time C	Cycle time C'	Allowed time A	Estimation formula (C'-A)/P'	Q'ty of spare parts required in units of cars	Q'ty of spare parts required: Light repairs	Heavy repairs	Total	Q'ty of spare parts currently stored	Q'ty of spare parts to be added	Costs (in thousand Rs.)
WDM2	103 nos/Yr	Power pack (complete)	14.0	15.4	7.0	3.5	4	4	-	4	1	3	12,000
	P = 2.9	* Traction generator	8.0	8.8	6.5	0.96	1	1	2	3	0	3	2,210
	P' = 2.4	Supercharger	6.0	6.6	6.0	0.25	1	1	-	1	0	1	240
		Expressor	8.0	8.8	8.0	0.33	1	1	-	1	1	0	0
		* Bogie (complete)	8.0	8.8	8.0	0.33	1	2	1	3	2	1	2,500
		* Wheel set	2.5	3.0	5.0	-0.8	0	0	6	6	0	6	540
		* Traction motor	6.0	6.6	6.0	0.25	1	6	14	20	6	14	6,240
		Exciter	5.0	5.5	5.5	0	1	1	-	1	0	1	160
		Others											5,000
		Total											28,890
WDS4	30 nos/Yr	Engine	12.0	13.2	6.0	0.88	1	1	-	1	0	1	2,000
		Transmission	8.0	8.8	5.5	0.4	1	1	-	1	0	1	280
	P = 9.8	Compressor	6.0	6.6	7.5	-0.1	0	0	-	0	1	0	0
	P' = 8.2	Exhauster	5.0	5.5	7.5	-0.2	0	0	-	0	1	0	0
		* Wheel set	3.5	4.2	5.5	-0.16	0	0	1	1	0	1	80
		Reverser	4.0	4.4	7.0	-0.3	0	0	-	0	0	0	0
		Others											2,000
		Total											4,360

Note 1: P' and C' incorporate allowances for fluctuations.

2: The quantities of spare parts required in units of cars were obtained as follows.
- Parts for 1 car, if $0 \leq (C'-A)/P' < 1$
- Parts for 2 cars, if $1 \leq (C'-A)/P' < 2$

3: Asterisked (*) items in the table are the spare parts of which additional ones were estimated separately to provide for heavy repairs.

Table 5.2.13 Breakup of Estimates of Spare Parts to be Provided for Heavy Repairs at the Jamalpur Workshop

Type of car	Parts name	Occurrence rate of heavy repairs	Q'ty of parts inspected/ repaired		No. of days for repairs			Q'ty of spare parts for heavy repairs (A) x (B)
			Annually	Per day (A)	Heavy repairs	Light repairs	Add'l days (B)	
WDM2	Traction generator	-	*19	0.08	33	8.8	24.2	2
WDM2	Traction motor	-	*160	0.65	27.5	6.6	20.9	14
WDM2	Bogie	25%	52	0.21	12.1	8.8	3.3	1
WDM2	Wheel set	90%	550	2.24	5.0	2.8	2.2	6
WDS4	Wheel set	60%	55	0.22	6.1	3.9	2.2	1

Note 1: Occurence rate of heavy repairs are the rates to the quantities of all parts inspected/repaired.

2: The quantities of spare parts inspected/repaired per day allow for a 20 percent fluctuation rate in each.

3: The numbers of repair days allow for a 10 percent delay each.

4: For asterisked (*) items, half of the quantities predicted to undergo inspection/repairs are excluded as it involves those for depots.

5.2.6 Current State of Rolling Stock POH Techniques and Improvement Measures

(1) Defects of Diesel Locomotive found at POH

Table 5.2.14 shows the main defects of diesel locomotives discovered at POH.

Table 5.2.14 Main Defects Discovered at POH

Component	Description
Engine	Flaw, deformation, and wear of engine block, crankshaft, supercharger, and other components.
Bogie	Flaw of bogie frame. Flaw, deformation, and wear of bogie parts.
Axle bearing	Burn, flaw and axle journal flaw.
Electrical parts	Control equipment defects. Wire defect and wear.
Others	Exhauster defects and compressor defects.

(2) Skilled Worker Training

In Japan, when repair of diesel locomotives started, repairmen of steam locomotive were assigned to repair diesel locomotives, and for this transfer, a thorough transfer training was conducted. Training aids, documents, photographs, slides, charts, and various models were wrked out for this purpose spending a great deal of time and expenses. Sufficient time was spent for lectures and practices to bring up skilled workers and supervisors.

Now, it is time for the Jamalpur to change from steam locomotives to diesel locomotive, and the workers' re-education and transfer training must be established as a top priority. Even in the current state, in spite of the fact that many workers are assigned to each work, work efficiency is not so high. Its cause may be attributed to the shortage of skilled workers.

(3) Reduction of POH maintenance cost and quality improvement measures. Table 5.2.2 shows the required man-hours and material cost spent at POH in Jamalpur workshop along with those in Japan.

Table 5.2.15 Average Man-Hour and Material Cost

Type of loco.	Main line		Shunting	
	WDM2	DD51	WDS4B	DE10
Average man-hour (M.H.)	20,500	4,192	13,500	3,208
Material cost (Rs.)	361,517	492,991	207,636	429,145

Repair cycle time of Indian Railway (both main line and shunting) is 25 days and very long compared with Japan (8 ∿ 10 days). That is why so many man-hours as shown in the above table are required. Considering the increasing number of locomotives, the measures shown below must be taken to shorten the cycle time, and to improve quality.

1) Parts stripping and assembling work
   Parts repair is performed generally in the following procedure.

(1) Removal from car body → (2) External cleaning →

(3) Disassembling → (4) Parts cleaning →

(5) Inspection → (6) Repair → (7) Finish cleaning →

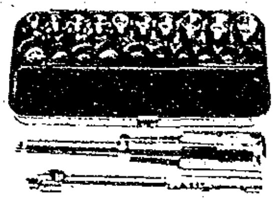
(8) Assembling → (9) Individual adjustment →

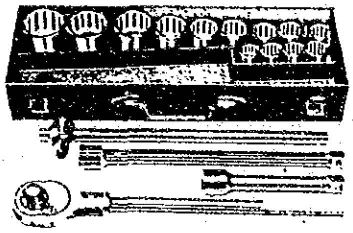
(10) Painting → (11) Installation to car body

Since steps (1), (3), (8) and (11) are usually manual work, long time is required. Measures for improving efficiency are as follows:

a) Efficiency promotion of going up and down of person and parts by providing platform.
b) Mechanisation of parts transfer
c) Efficiency promotion of stripping and assembling work by providing toos to workers.
d) Provision of high efficiency tools as shown in Fig. 5.2.13. (Efficiency Promotion)

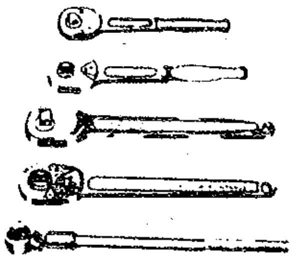
Socket Wrench Set

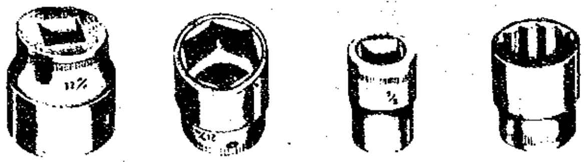




Ratchet Handle

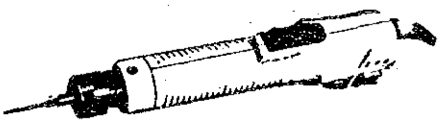
Sockets for Socket Wrenches



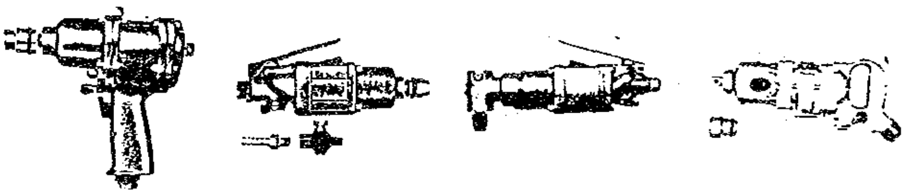


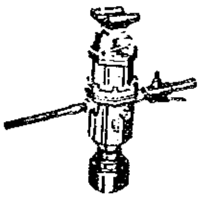
Electric Screwdriver

Electric Screwdriver



Air Impact Wrench





Automatic Screwdriver

Fig. 5.2.13 High Efficiency Tools

2) Parts cleaning work

Since diesel locomotive has many elements deteriorating or contaminating the car body and parts, such as lubricating oil, fuel oil, transmission oil, lubricating oil for supercharger, gear oil, and cooling water, compared with other types of locomotive, and the power pack causing vibration in the car body, there are many damages and deteriorations, and wear in the sliding parts, etc. Accordingly, cleaning work is very important for the parts inspection and improving parts quality.

Table 5.2.16 shows the current cleaning work conducted at Jamalpur Workshop.

Table 5.2.16 Summary of Cleaning Work at Jamalpur Workshop

Parts	Cleaning Method	Problem(s)
Bogie frame, cylinder head, piston, valve, and other parts having carbon sludge deposits	Soaking in chemicals	Requires many hours. Poor cleaning. Requires water cleaning. Requires careful control of density and temperature.
Engine and its parts, transmission, traction motor bearing	Manual cleaning by old lubricant or small amount of cleaning oil.	Requires many hours. Requires many workers. Requires a cleaning tank which can remove dust properly.
Body underframe, body exterior, tank, and radiator	Washing by running water.	Poor cleaning.
Others. wheel set etc.	Wiping by dry cloth or no cleaning.	Little cleaning.

Problem is that each method is inadequate in cleaning effect and long time is required. To assure high precision of inspection and repair, cleaning method suitable for individual part must be employed. (Quality improvement and efficiency promotion)

3) Inspection and measurement work

It has been noted that inspection and measurement are thoroughly performed routinely. Accuracy of diesel parts, however, is very high, and many must have an accuracy of the order of 1/100 mm or 1/1000 mm.

Particularly, for the inspection of the bogie frame requiring measurement of strain condition and for the inspection of the rotary shaft such as crankshaft and camshaft requiring measurement of bending condition, the surface plate matching the size must be provided.

Various nondestructive tests, such as ultrasonic test for the axle, magnetic particle test for engine parts, color check for brake rigging parts, etc. are performed, however, for parts that went into trouble frequently or parts having possibility of serious trouble, must be inspected by higher performance flaw detection method or flaw detector. Table 5.2.17 shows examples of nondestructive test in Japan.

Table 5.2.17 Examples of Nondestructive Test

Types	Parts tested
Ultrasonic	Axle, Tortion bar, Armature shaft of traction, Motor.
Magnetic particle	Crank shaft, Cam shaft, Connecting rod, Coupler, Braking rod, Axle, Gear, Bogie frame.
Fluorescent	Piston, Plain bearing.
Colour check	Cylinder block, Cylinder head, Impeller of super charger.
X-ray	Welded parts

4) Individual test equipment for parts

The purpose of POH is to restore each part of the rolling stock to specified design performance and design function through the inspection and repair, and to restore the rolling stock to the condition of new manufacture. Accordingly, if any equipment whose performance/function is specified as a single body is subjected to precheck before mounting on the rolling stock to make it trouble-free, correction after mounting can be eliminated. This is very effective for shortening the cycle time.

As test equipment, Jamalpur Workshop has the governor test stand, nozzle tester, panel plate tester, contactors test bench, etc. In addition, however, individual test equipment for the power pack, fuel injection pump, compressor, exhauster, speedometer, gauges, relays, etc. should be provided. (Quality improvement and efficiency promotion)

5) Stripping and assembly of engine component parts

Engine component parts are characterised by high accuracy and heavy weight, and slight dent, scar, etc. tend to cause damage. Accordingly, removal/installation of the cylinder head, piston, cylinder liner, crankshaft, camshaft, etc. must be done very carefully, hence operation takes time. For the stripping and assembling of these parts, using the manipulator that can turn the engine as desired can facilitate the operation greatly, and possibility of inflicting damage can be reduced. (Quality improvement and efficiency promotion)

6) Accuracy of cylinder head

Portions withstanding explosion pressure between the cyliner head and piston are the cylinder head seat surface, cylinder gasket, cylinder liner flange, cylinder head valve and valve seat. Accordingly, seat surface contact has a serious effect on the engine output, and causes blow-by. These seat surfaces are polished with jig, however, using equipment of higher accuracy is recommended. (Quality improvement)

7) Inspection of crankshaft and camshaft

When the engine generates high output, the crankshaft and camshaft are subjected to the largest bending stress that causes cracks. For these two shafts, inspection of bending condition and magnetic particle test must be performed. (Quality improvement)

8) Bearing inspection/repair work

As is evident from the accident statistics, the problem on POH at the workshop and depot is that bearing failure is very frequently occurring. Bearings are subjected to the largest load and are used under very severe condition in terms of accuracy. For this reason, the bearing is very susceptible to dust.

For the bearing work in the Jamalpur Workshop, the following recommendations are made.

a) Provision of shop having dust-proof structure.
b) Provision of cleaning equipment.
c) Axle fit control. Combination control.
d) Close inspection of bearing parts at a bright location using magnifying glass.
e) Thorough cleaning of axle journal before bearing installation.
f) Injection of clean grease with grease gun, etc. as much as specified.
g) Careful installation/removel without forcing.
h) Immediate assembling to the axle after grease injection. When storing is required, store in the dust-proof storage area, etc. (Quality imprvoement)

9) Oil/grease control (cleaning oil, fill-up grease, oiling)

Cleaning work is important, however, if contaminated oil is used, cleaning would not only be ineffective but also would cause trouble. Normal control is such that cleaning is performed using clean oil, dust is completely removed, and clean oil/grease is filled or supplied. All work using oil/grease must be rechecked. (Quality improvement)

10) Repair of bogie frame

In the bogie frame, flaw tends to occur at the corner portion of the side frame and axle guide. In addition, the location is such that dust tends to collect, and cleaning is particularly important. Currently, cleaning is performed by "soaking in chemical" method. This method is poor in cleaning effect and requires long cleaning time. Cleaning equipment of better cleaning efficiency is needed.

Though repair of the bogie frame is performed by being placed on trestle, unless perfect gouging and welding are performed, serious accident may occur, such as bogie frame breakage while running. For a complete repair, the manipulator which allows the bogie frame to turn any desired angle is required. The bogie frame tends to generate strain due to its structure, and welded one is worse still. To improve repair accuracy, measurement and strain correction must be performed with a secure surface plate provided. (Quality improvement and efficiency promotion)

11) High-speed rotary body balance test

When the parts that rotates at a high speed is repaired, it is often the case that the bearing is broken or rotary body itself is broken due to rotary body imbalance. When high-speed rotary elements, such as the armature of motors, impeller or blower of supercharger, etc. are repaired, dynamic balance check must be performed. (Quality improvement)

12) Piping leak countermeasures

Troubles due to piping leak and correction thereof are frequent, with resultant large man-hours. In Japan, the screw part of piping is wrapped with seal tape to prevent leak generation. (Efficiency promotion)

13) Preparation work for cable replacement

Cable replacement is performed every two POH. Cable is replaced in other cases also. When bundles of new cable are brought in to the car body area, it not only hinders other works but also leads to low work efficiency. When the preparation work area is marked off and cable is half processed, workload at the car body area will be reduced to 1/2, and time can be shortened. In the case of local rubber covering failure aside from total cable degradation (since rubber is less resistant to oil, such case is frequent at portions exposed to oil splashing), defective part alone should be replaced (partial patching). (Efficiency promotion)

14) Quality control measures

What is important in the locomotive repair work is to restore to new manufacture condition or the condition within repair limit whatever the condition of individual locomotive may be at the time of in-coming. In the parts shop, multiple workers are performing the same work. Accordingly, the same work must be done to the same result regardless of the worker.

To accomplish it, the Jamalpur workshop needs to work out its own work standard. The work standard is a document containing such information as work procedure, machine, jig, and tool to be used, and repair limit. Based on this standard, workers are trained to assure thorough understanding. Important information (main work procedure and repair limit) should be posted in the work place as a means to bring up workers.

On the other hand, the workshop must arrange for the acquisition of unreparable parts, grasp the stock conditions at all times, and be ready to issue as required. Otherwise, lack of parts will make locomotive repair impossible, or defective locomotive must be used unrepaired. (Quality improvement)

5.3 Modernisation of Laminated Spring Manufacturing and Repairing Facilities

5.3.1 Existing State and Problems of Laminated Spring Manufacturing/ Repairing Works and Facilities

Jamalpur workshop manufactures/repairs the laminated springs for wagons, steam locomotives, diesel locomotives, rail cranes and others. The amount of annual production is shown in Table 5.3.1; in 1985, 10,000 laminated springs were repaired and 400 laminated springs were manufactured.

The machine layout in the work section is shown in Fig. 5.3.1, and the block diagram of the work flow is shown in Fig. 5.3.2. The disposition of workers is shown in Table 5.3.2.

The breakage of laminated spring as shown in Table 3.2.24, accounts for 36% (the greatest) of all wagon troubles in Indian Railways. Details of breakage of laminated spring are shown in Table 5.3.3. Main breakages of spring are spring leaf snapped-off and cracks in the buckle. The former accounts for 80% of all breakages. Furthermore, most of the snapped-off occurs on the top spring leaf, especially around eye roll.

As shown on these breakage's statistics, it seems that a major cause disturbing the smooth operation of goods trains is the laminated spring breakages.

The existing state of repair works and breakages of the laminated springs has been mentioned above, and some improvements of these works are necessary as shown below.

(1) To reduce the manual operation

1) Laminated springs are being formed manually and that induces repetitive heating and leads to the risk of ill forming.

2) Works to insert leaf-set into the buckle and works for debuckling are also being done manually. In order to save labour to reduce cost and to assure safety, some improvements of works are necessary.

(2) To remove the inadequate control of temperature

Temperature in quenching and tempering is controlled based on the worker's experience without using pyrometers or other temperature measuring instruments. Also, there is no temperature control measure for the quenching bath.

Uniform quality can be maintained if such artificial errors are eliminated.

(3) To change the shop layout

In order to avoid the waste of time and energy and excessive labour in carrying the laminated springs and leaves, the shop layout change is necessary. Improvement of quality and work safety can be expected by changing the layout.

(4) To improve the method and equipment for carrying spring leaves and springs from machine to machine, from machine to work section and carrying them into and out of the shop.

(5) To put into practice measures to reduce friction between spring leaves and prevent their corrosion.

(6) To change the method of measuring hardness

The Shore hardness tester is being used, but in order to control hardness adequately, the Brinell hardness tester should be used.

(7) To take measures to improve fatigue strength, such as shot peening.

(8) To do adequately cleaning and appearance test for spring leaves when the spring leaves are inspected visually; in order to detect defects, sufficient cleaning is necessary.

(9) To review and rearrange the operation standard for repair work

IR maintains appropriate Standard Specifications (serial No. R66-81) on manufacturing and the Indian Railways Maintenance Manual For Wagons on repairing, but an appropriate operation standard (all work process shown more concretely) should be established based on their specification & manual and all workers instructed to follow it thoroughly.

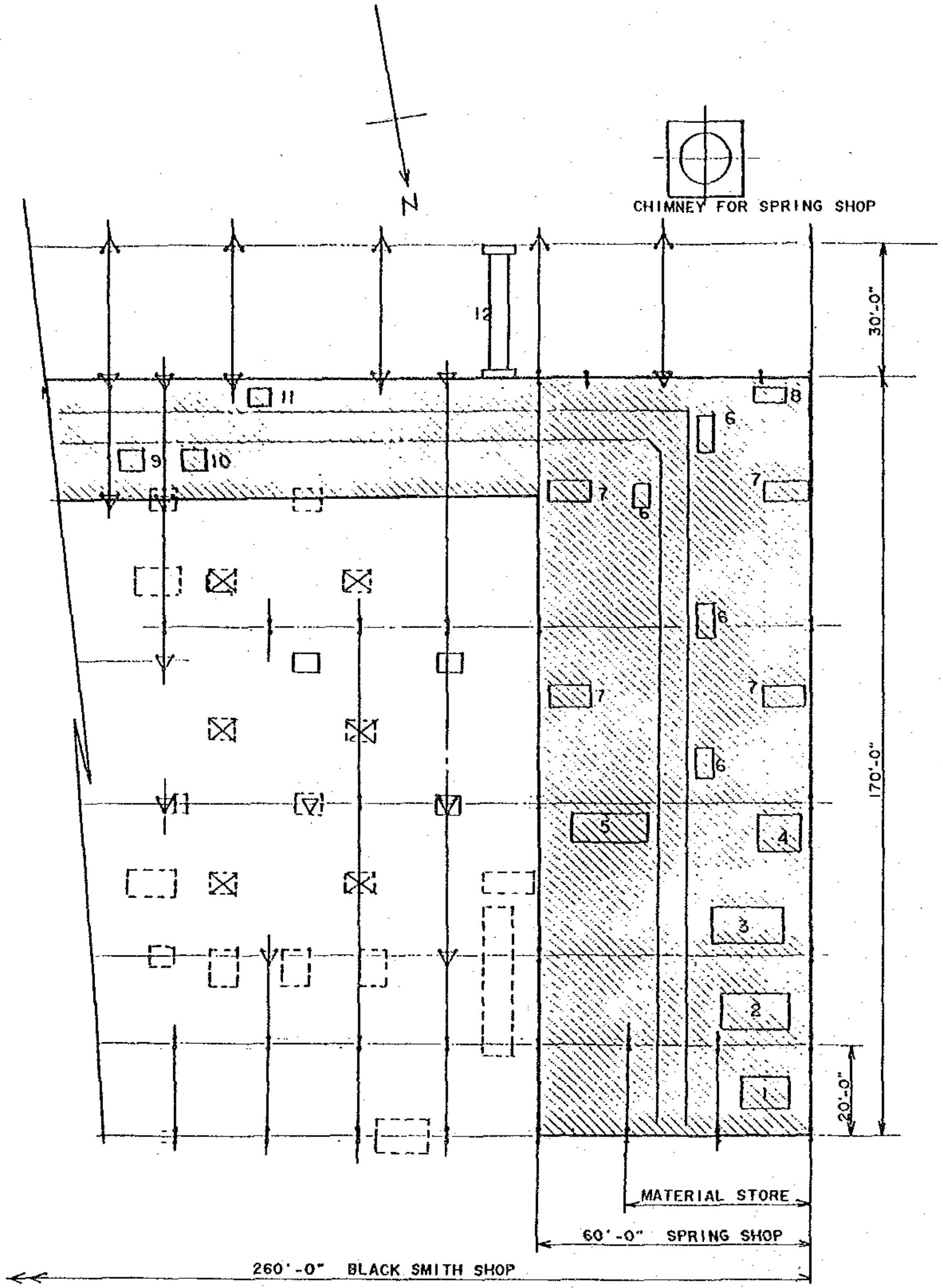
(10) To improve the method of transportation of laminated springs between the workshop and car depots

At present, the laminated springs are transported on wagons between the workshop and car depots as bulk cargo. Saving labour, improving work efficiency, and preventing accidents and damages during transportation can expected by using pallets.

Table 5.3.1 Manufacture and Repair of Laminated Springs from 1981 to 1985

JMP W/S

Name of spring	Kind of car	1981		1982		1983		1984		1985	
		Mfd.	Repaired	Mfd.	Repaired	Mfd.	Repaired	Mfd.	Repaired	Mfd.	Repaired
Front Bogie	WP	5	285	46	189	58	188	7	216	20	149
Hind Truck	WP	7	175	1	118	2	129	x	79	3	116
Front Truck	WG	41	368	39	278	28	299	43	231	20	273
Hind Truck	WG	10	330	3	357	56	375	23	270	27	325
Coupled	WP/WG	101	1922	113	1737	118	1667	22	1587	62	1720
Tender	WP/WG	63	1327	74	1060	42	727	15	689	20	860
Coupled	N.G.Locos	30	74	66	104	146	73	40	48	24	44
Coupled	WDS4B (Diesel)	x	61	x	105	18	207	36	197	17	207
Carrying	Rail Cranes	92	236	53	175	73	131	82	81	45	66
Carrying	Tower Car	x	x	x	x	4	x	50	x	43	x
Carrying	Box/CRT Wagons	x	3041	x	4310	84	4640	6	6116	114	6321
Total		349	7981	395	8433	621	8436	324	9514	395	10081



NO.	N A M E
1	BUCKLING PRESS FURNACE
2	HYDRAULIC SPRING BUCKLING PRESS
3	HYDRAULIC SPRING BUCKLING PRESS
4	BUCKLING PRESS FURNACE
5	SPRING TESTING MACHINE
6	SURFACE TABLE
7	FURNACES
8	OIL QUENCHING TANK
9	EYE ROLLING MACHINE
10	FURNACE
11	SHEARING MACHINE
12	OVERHEAD CRANE

Fig.5.3.1. SPRING SHOP LAYOUT (EXISTENT)

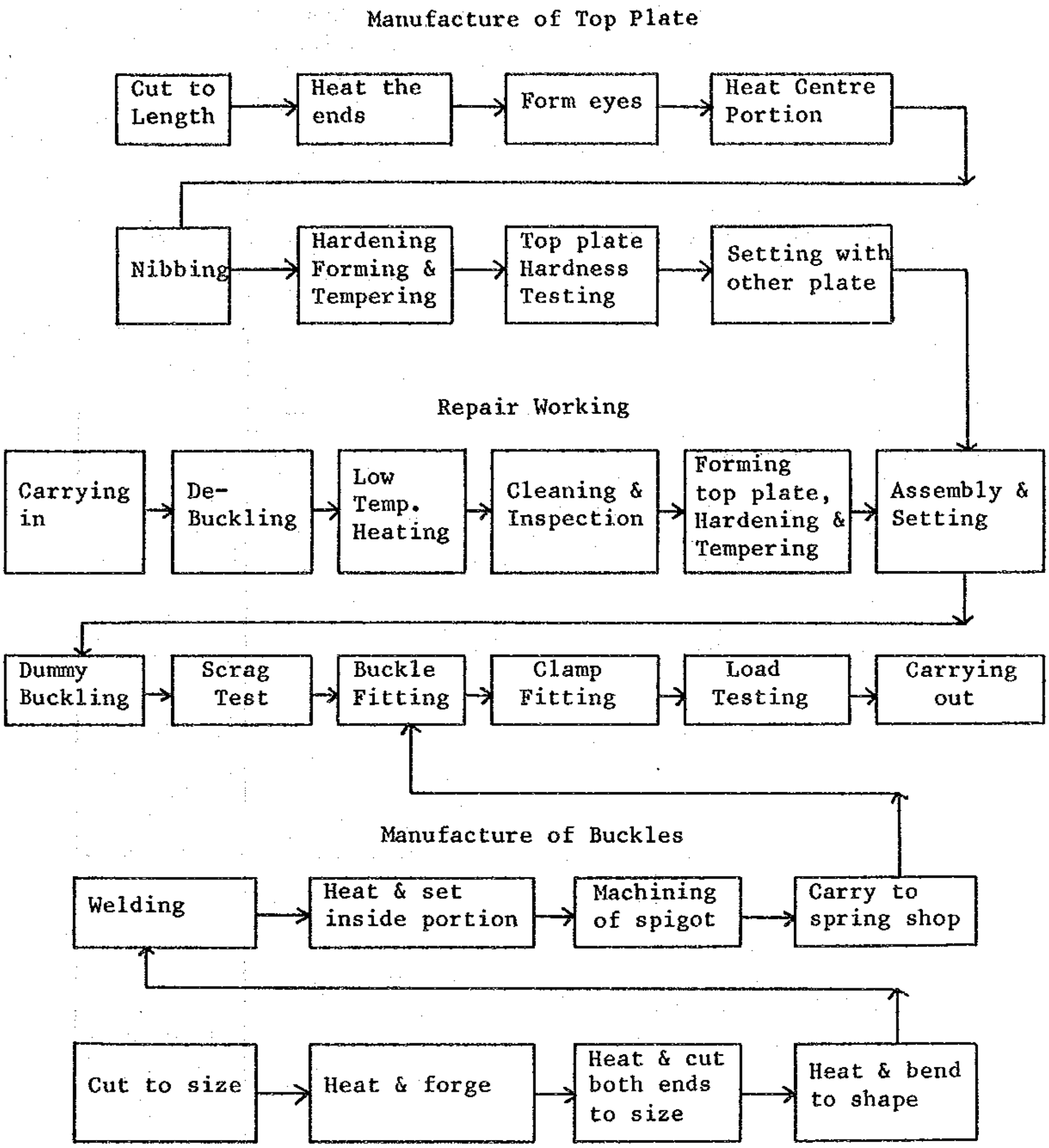


Fig. 5.3.2 Block Diagram of Work Flow for Repair and Manufacture of Laminated Spring (Existent)

Table 5.3.2 Assignment of Workers for Manufacturing and Repair of Laminated Spring

1. Manufacture of top plates	
Cut to length	2
Heat the ends, form eyes	4
Heat centre portion	4
Nibbing	4
	(14)
2. Repair working	
Debuckling, Low temperature heating, Cleaning & Inspection, Forming top plate Hardening & Tempering, Assembling & Setting	42
Dummy buckling	
Scragging test	10
Buckle fitting	12
Clamp fitting	4
Load testing	5
Carrying in & out	10
	(83)
3. Manufacture of buckles	
Cut to size	2
Heat & Forge, Both ends cut, Bend to shape, Set inside portion	12
Welding, Machining	Other shop
	(14)
Total	111

Table 5.3.3 Details of Spring Breakages

Month	No. of spring received for repairs			Broken top plate		Broken other plates		Broken buckles	
	BOX	CRT	Total	BOX	CRT	BOX	CRT	BOX	CRT
Mar/86	535	115	650	530	71	75	115	149	37
Apr/86	505	155	660	505	111	91	151	160	52
May/86	532	129	661	532	103	107	123	161	48
Jun/86	474	186	660	474	143	71	186	148	66
Jul/86	520	140	660	514	94	77	140	150	53
Aug/86	510	155	665	510	95	80	147	150	45
Sep/86	505	160	665	505	100	83	156	155	53
Oct/86	412	128	540	412	90	74	120	137	50
Nov/86	453	147	600	453	87	66	143	156	47
Dec/86	500	165	665	500	130	78	160	163	48
Jan/87	505	160	665	505	103	91	160	161	60
Feb/87	480	120	600	472	90	77	117	144	45
Total			7691	7129		2688		2438	

5.3.2 Premises of Modernisation Plan for Laminated Spring Manufacturing and Repairing

The problems on the present laminated spring manufacturing/repairing works are pointed out in clause 5.3.1, and the premises of modernisation to resolve these problems and to repair/manufacture good quality laminated spring effectively, cheaply and safely are described below.

(1) Number of laminated springs to be manufactured/repaired

The number of laminated springs to be repaired at Jamalpur Workshop in the year 2000 is estimated at 10,000 springs including springs for locomotives (WDS4B and WDM2) and wagons (BOX and CRT) but excluding those currently manufactured for steam locomotives (WP and WG). The basis for calculation is shown in the Vol. II Table 1.2.1. The number of spring leaves to be manufactured is assumed at 60,000 leaves/year. This number is calculated as follows.

The number of top leaf and second leaf for replacement in accordance with design change of laminated spring.

2 leaves x 10,000 = 20,000 ... Jamalpur Workshop

40,000 ... Other workshops

Total 60,000 leaves

(2) Capacity for repair/manufacture of laminated spring

1) Repair of springs

working condition .... single shift work

working rate is 85%

required capacity of facility ... 10,000 ÷ 0.85

= 11,760 springs/annum

2) Manufacture of spring leaves

working condition .... double shift work

working rate is 85%

required capacity of facility ... 60,000 ÷ 0.85 ÷ 2

= 35,300 leaves/annum

3) Heat treatment of leaves to be repaired

working condition ...... double shift work

working rate is 85%

number of leaves to be heat treated ... 23,500 leaves/annum/shift

The top and second leaves are to be manufactured in accordance with design change of laminated spring. Accordingly, the capacity of facility for re-heat treatment of spring leaves is assumed as 23,500 leaves/annum, assuming that the number of leaves to be re-heated is one half of number of leaves repaired.

number of spring leaves to be repaired

10,000 springs x (10 - 2) = 80,000 leaves/annum

number of spring leaves to be re-heated

80,000 leaves/annum ÷ 2 ÷ 0.85 ÷ 2 = 23,500 leaves/annum/shift

4) In case the re-heat treatment is carried out in the new spring leaves manufacturing line, necessary capacity of heat treatment facility in single shift work is calculated as below.

35,300 leaves/annum + 23,500 leaves/annum = 58,800 leaves/annum

5) Capacity of existing quenching furnace

working condition ..... single shift work

working rate is 85%

The capacity of existing quenching furnace is calculated in Vol. II and estimated as follows. The capacity is estimated to be sufficient for future work load.

(167,265 ~ 111,510) x 0.85 = 142,200 ~ 94,800 leaves/annum/shift

(3) Plan for improving the quality of laminated spring, saving labour in manufacture and repair work and improving work efficiency

1) To eliminate artificial errors and ensure uniform quality of laminated spring, the furnace used in heat treatment should be equipped with temperature regulator and automatic spring leaf feeding devices.

2) To improve accuracy of detecting flaws in the spring leaf, the spring leaves should be cleaned completely. For this purpose, a magnetic flaw detector for flaw detection and a washing machine for cleaning work of spring leaves should be introduced.

3) To test the hardness by the Brinell hardness tester, and supporting instruments should be used to improve the measuring accuracy and the measuring efficiency.

4) To minimise decarburisation of spring leaves, a low-temperature heating furnace and other measures to permit low-temperature processing below tempering temperature should be provided.

5) To reduce friction between spring leaves and prevent corrosion, anticorrosive lubricators and anticorrosive baking and drying oven should be introduced.

6) To mechanise laminated spring debuckling, forming of spring leaves, assembling of laminated springs, adjustment of camber of laminated springs and dummy buckling.

7) To change the present manual handling of laminated springs and spring leaves into mechanised handling system such by conveyor and/or mono-rail crane.

(4) Work process

The laminated spring manufacturing and repair process should be divided into the following three works, each of which is conducted as shown in Fig. 5.3.3.

Non-debuckling repair
Debuckling repair
Spring leaf manufacture

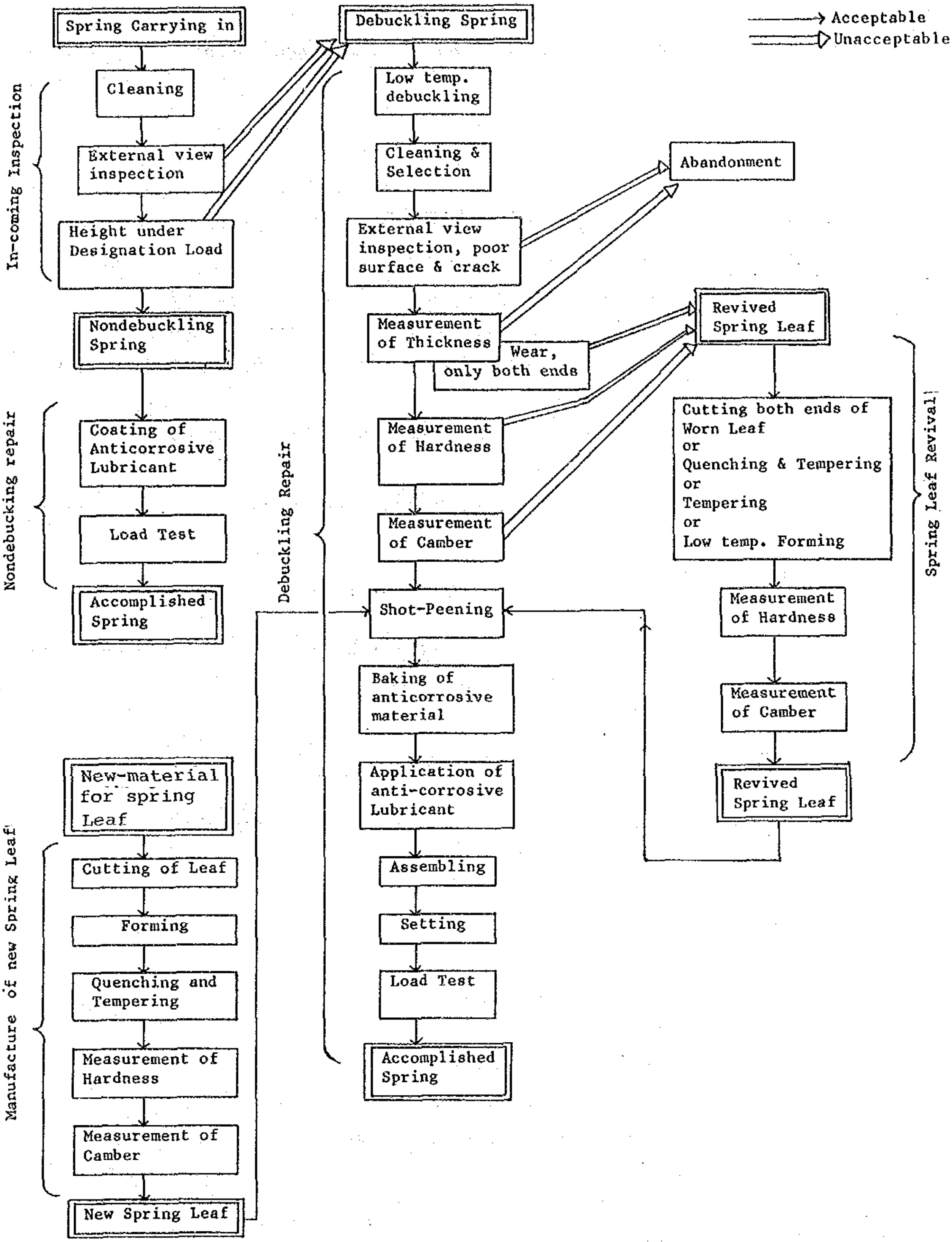


Fig. 5.3.3 Flow Chart of Manufacture and Repair of Laminated Springs (Proposed)

5.3.3 Drawing up of Modernisation Plan for Laminated Spring Manufacturing and Repairing Facilities

Based on the work modernisation plan proposed in the previous sections, the undermentioned laminated spring manufacturing and repairing facilities will be planned for improvement of laminated spring quality, labour saving and work efficiency. However, the modernisation plan for laminated spring manufacturing/repairing facilities has already been established in the Workshop and some parts of the plan are now in progress. Accordingly, the parts of the plan already progressing will be incorporated in our modernisation plan.

The work-wise machines to be introduced will be as follows.

(1) Cleaning of laminated spring, in-coming inspection

Washing machine
Spring load tester

(2) Flaw detection of spring leaves, measuring spring camber and hardness

Magnetic flaw detector
Spring camber tester
Brinell hardness tester

(3) Coating and baking of anticorrosive agent and lubricant

Spring leaf lubricating machine
Greasing machine
Baking and drying oven

(4) Spring leaf forming and heat treatment

Spring leaf forming machine
Low temperature heating furnace
High temperature heating furnace
Spring leaf cambering and quenching equipment
Tempering furnace

(5) Spring leaf peening

Shot blasting machine

(6) Dummy buckling, buckling, setting and camber correcting of spring leaves

Buckle assembling machine
Buckling machine
Scragging machine
Buckle heating furnace
Camber correcting machine

(7) Spring debuckling

Buckle heater
Debuckling machine

(8) Eye rolling

Spring leaf heating furnace
Eye rolling machine

(9) Cutting and nibbing

Spring leaf cropping machine
Hydraulic press

(10) Carrying of spring leaves and completed laminated springs

Roller conveyor
Jib crane
Mono-rail crane
Manipulator

(11) Completion test

Spring load tester

These major plants and machines are listed in the Vol. II Table 1.2.2. And the general shop layout is shown in the Vol. III Fig. 1-15.

Some existing machines are unsuitable for work flow, so it is expected that these machines will be changed to new machines designed as suitable for work flow by IR, in future.