b) Krawan and Bekasi Stations

1 Electric Current Convertor Facility (Depot) at Krawan Station

In accordance with electrification plan, a sector between Bekasi and Cikampek is envisaged to be operational in 1988. Power supply for this sector, direct current (d.c.) for the sector between Bekasi and Krawan and alternating current (a.c.) for the sector between Krawan and Cikampek will be used respectively. Installation of the current convertor therefore will be needed because d.c. and a.c. operated locomotives will be exchanged at Krawan Station.

Provision of the current convertor facility (depot) is a temporary step until such time that the a.c. electrified track is laid because a.c. operated trains are envisaged to originate from Manggarai station after completion of a double track between Manggarai and Krawan in 1994.

It is therefore recommended to make adequate alignment plans to avoid future modification.

2 Provision of Spurs to Freight Line at Bekasi Station

In the Jakarta area, there is another plan to construct Cibinang Freight Line. This line is to be an a.c. electrified line across the North Line adjacent to Bekasi station and links Cibinang with Tanjung Priok Gudang.

For connection to the North Line, it is recommended to connect at Bekasi station which is the nearest station in the vicinity whereby direct freight train operations for Tanjung Priok Gudang yard hauled by a.c. locomotive would be feasible. Spurs to link the North Line with Cibinang freight line should therefore be provided.

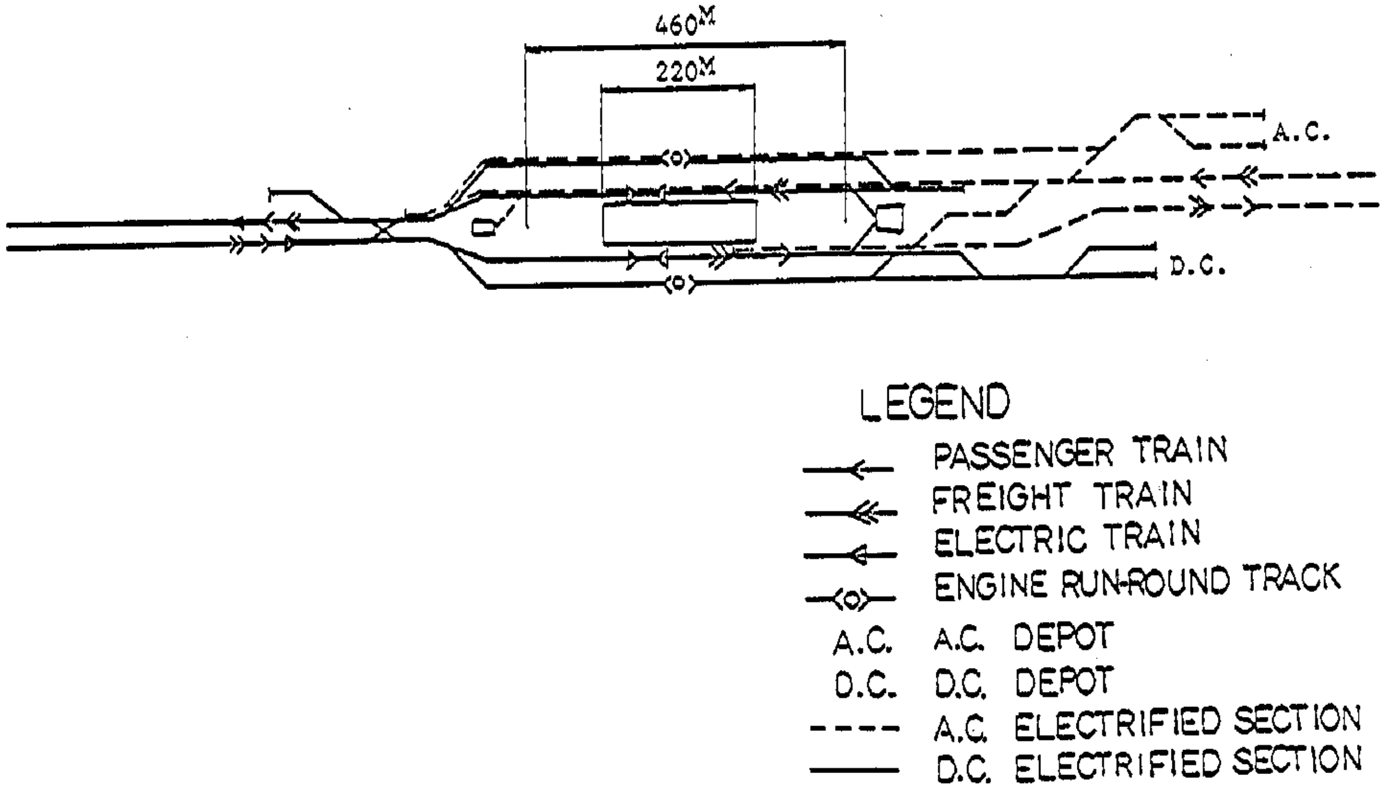


Fig. 7.2.5 Wiring Diagram for Electric Current Convertor Facility (Depot) at Krawang Station

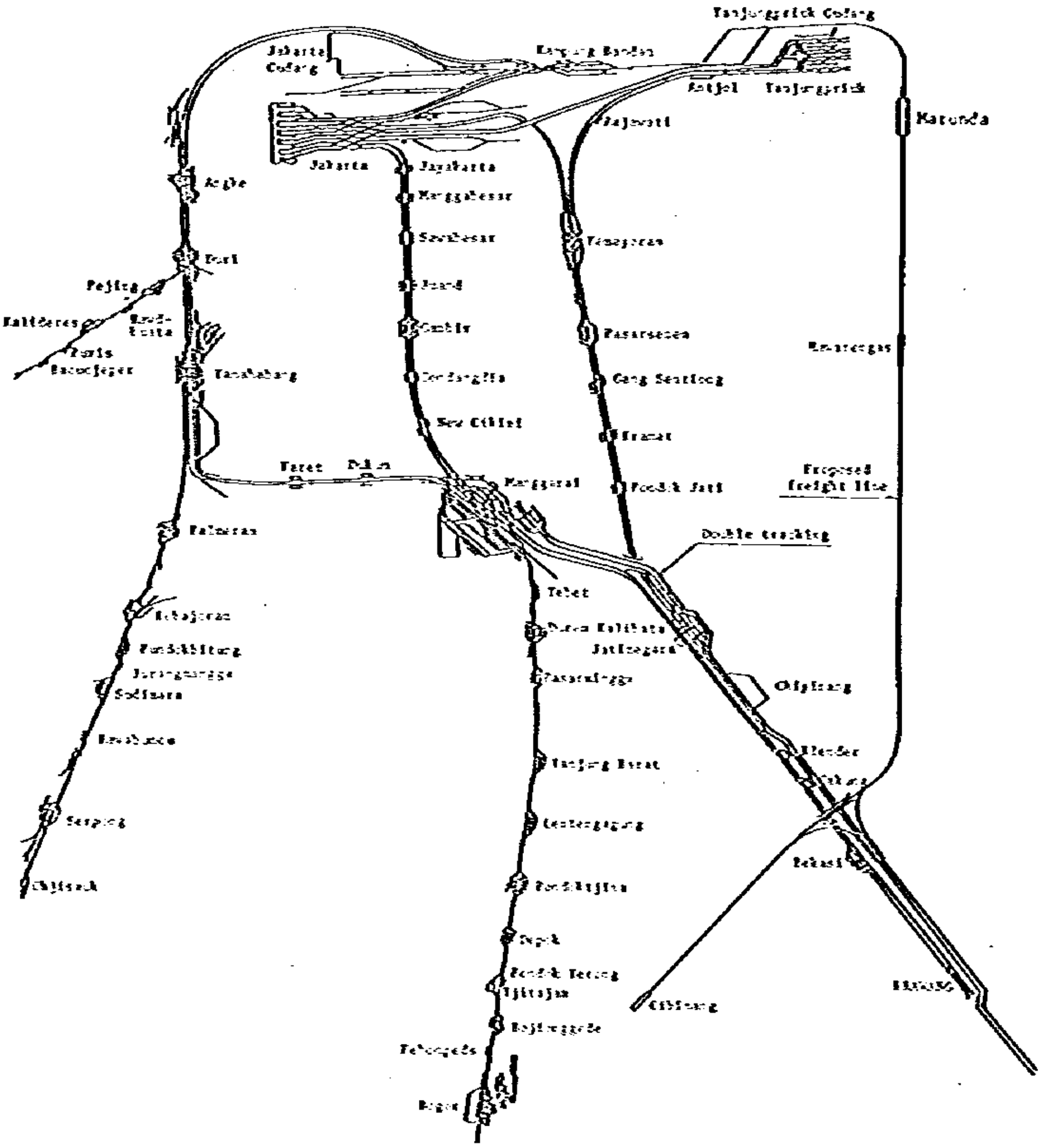


Fig. 7.2.6 Railway Layout in Electrification Area

c) Special express train shuttle-point station

At the stations of Bandung, Yogyakarta, Surabaya Kota, Solo Palapan and Semarang which will be used as departure and arrival points of special express trains, the extension of the effective length, the elevation of platforms, the construction of overbridges and other equipment expansion is necessary because of the great number of trains and the increase in number of passengers handled (Figs. 7.2.6, 7 and 8).

d) Other stations

The effective length at most existing branch and intermediate stations is, respectively, 300m and 200m. To cope with an electrified transportation plan, respective effective lengths of 460m and 220m are necessary for freight trains and passenger trains. As for passing loops for freight trains, this effective length will be secured at one in every five stations because of the small number of freight trains. Other stations are available for pass-by of passenger trains. (Figs. 7.2.10 and 11)

The station improvement plan is consolidated in Table 7.2.2, based on what has been described above.

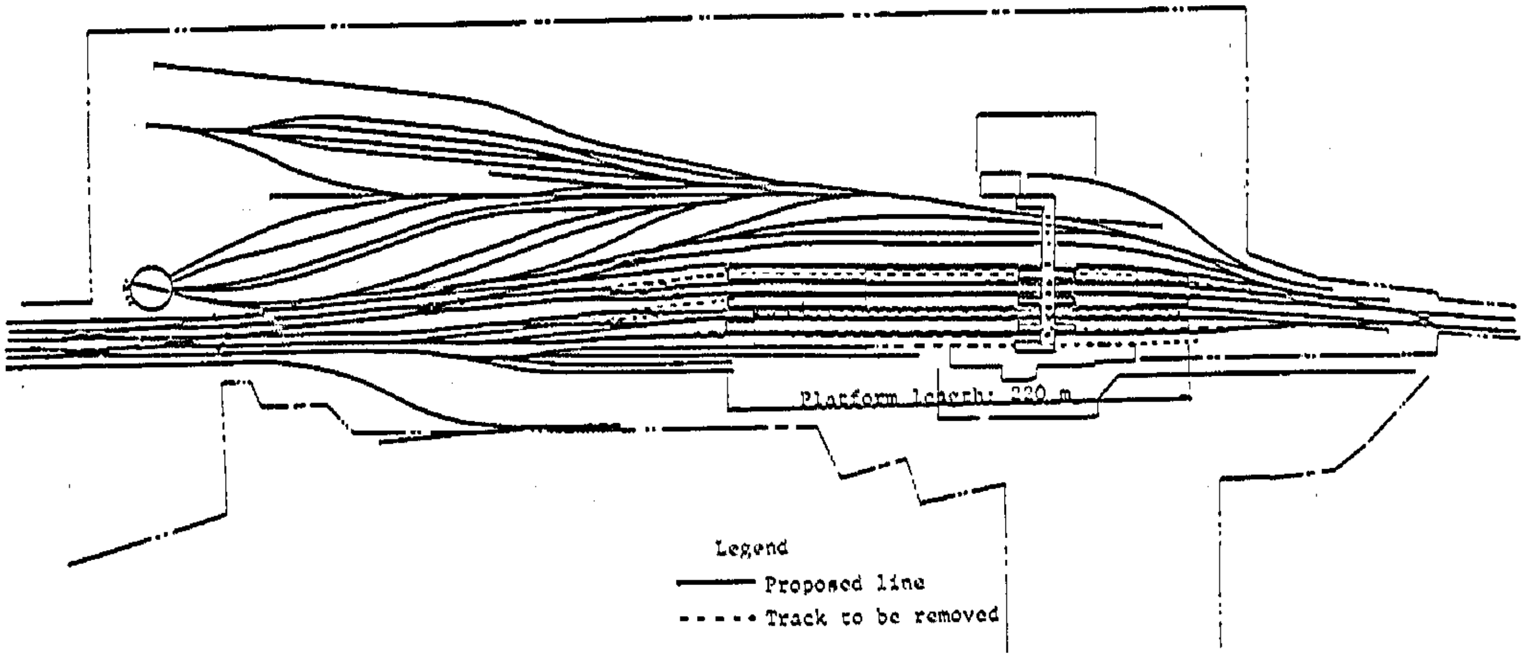


Fig. 7.2.7 Sketch of Bandung Station Yard Track Layout Improvement Plan

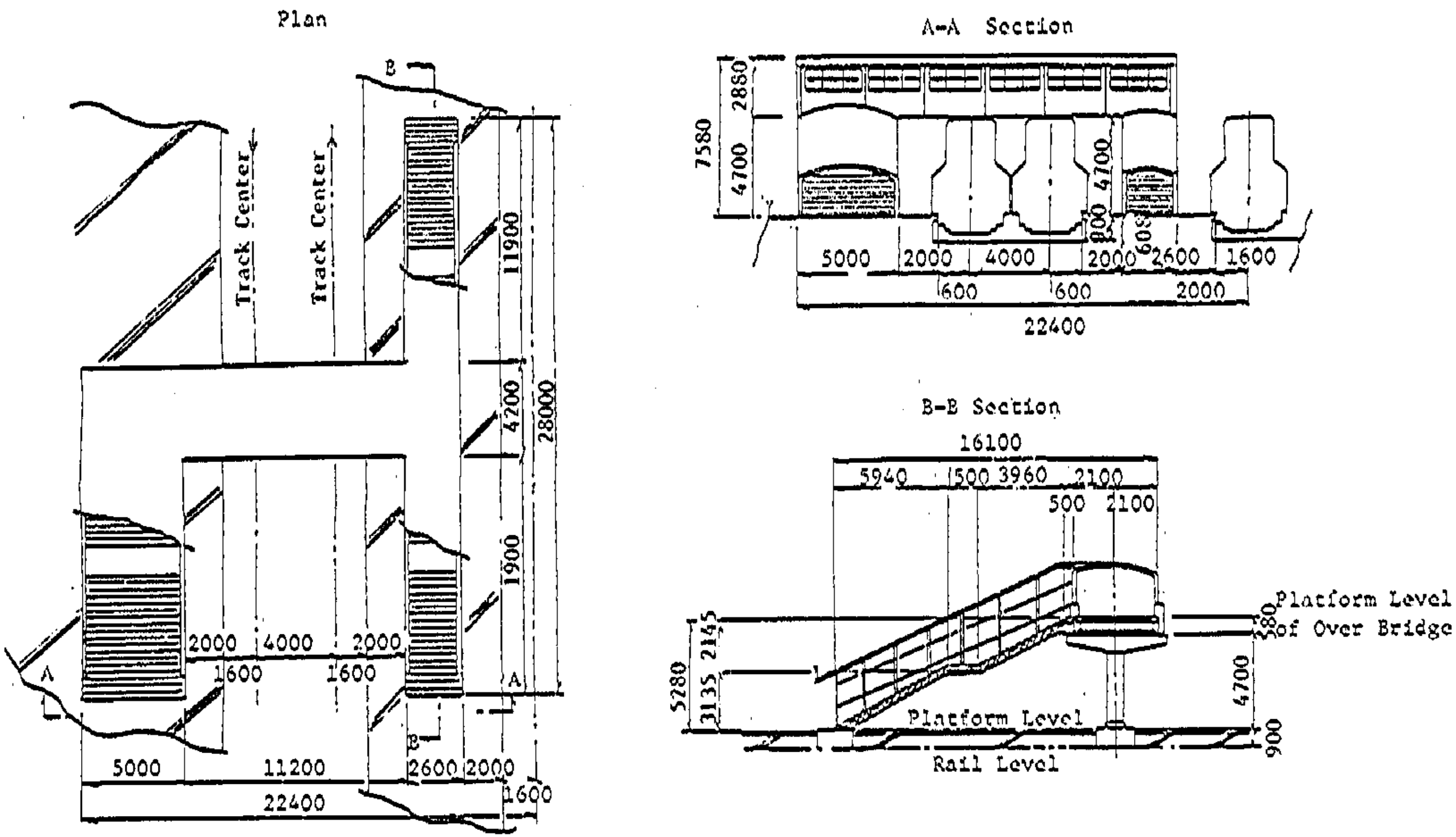
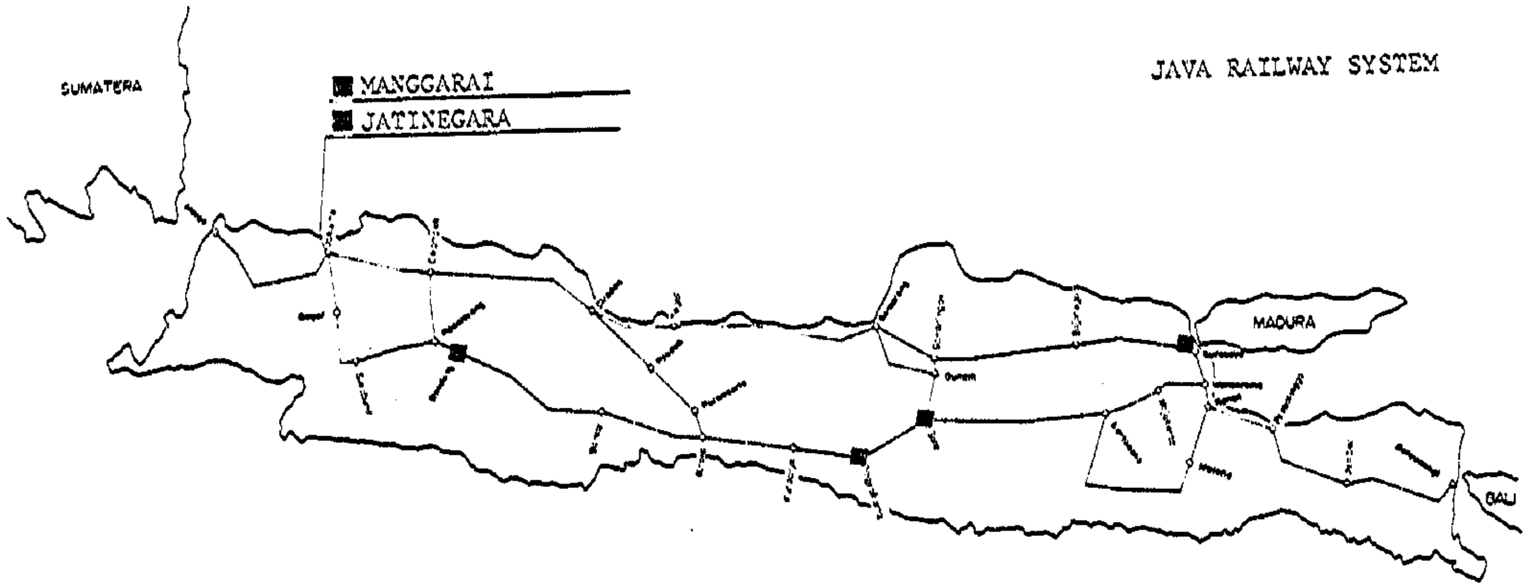


Fig. 7.2.8 Overbridge Model

JAVA RAILWAY SYSTEM



Legend

■ Station with proposed elevated platform and overbridge

Fig. 7.2.9 Stations with Proposed Overbridges

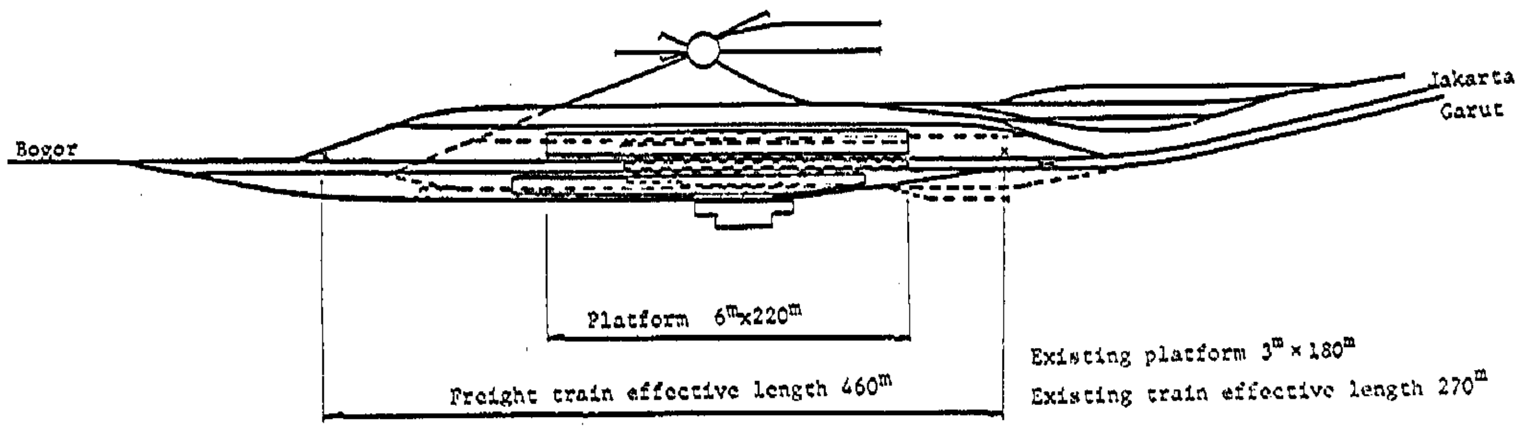


Fig. 7.2.10 Cibatu Station Yard Track Layout Plan
(B type effective length extension plan)

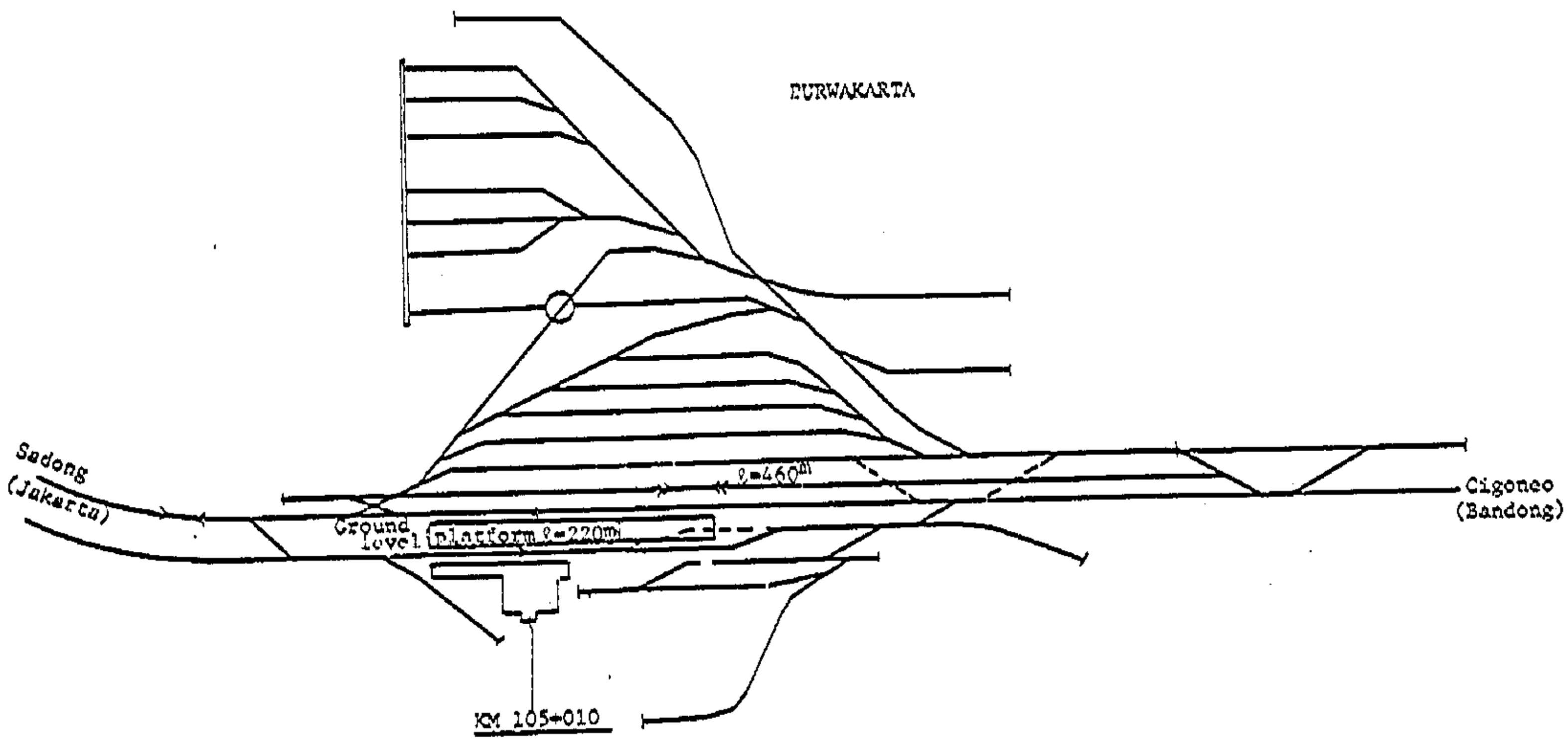


Fig. 7.2.11 Extension of Effective Length for Intermediate Stations (C type)

Table 7.2.2 Table on Station Improvement Plan

Year to be opened for business	Section	A	B	C	D	E	Total
1994	MANGGARAI ~ KRAWANG	⊙ MANGGRAI ⊙ JATINEGARA ⊙ BEKASI ⊙ KRAWANG					4
1988	BEKASI~CIREBON		CIKAMPEK CIREBON	3	16	4	26
1989	CIKAMPEK~ KIARAKONDONG	BANDUNG	PADALARANG	3	14	3	22
1991	CIREBON ~YOGYAKARTA	YOGYAKARTA	PRUPUK PURWOKERTO KROYA KUTOAOROTO	8	32	11	56
1992	YOGYAKARTA ~SOLOPALAPAN	SOLOPALAPAN		2	9		12
1995	SOLOPALAPAN ~SURABAYAKOTA	SURABAYAKOTA	MADIUN KERTOSONO TARIK WONOKROMO SURABAYAGUBENG	5	26	3	40
1996	WONOKUROMO ~PROBOLINGGO		SIDOARJO BANGIL PROBOLINGGO	2	7	4	16
1998	MERAK ~TANAHABANG		MERAK KRENCENG RANGKSBETUNG PARUNGPANUANG	2	13	5	24

Year to be opened for business	Section	A	B	C	D	E	Total
2003	BOGOR~SUKABUMI		BOGOR SUKABUMI	1	7	3	13
2003	KIARAKONDONG~KROYA		CIBATU BANJAR MAOS	4	23	18	48
2003	CIREBON~ SEMARANGTAWANG	SEMARANG	TEGRL PEKRLONGRN	4	21	15	43
2003	SEMARANGTAWANG ~SURABAYA PASARTURI		SURABAYAPASARTURI GAMBRINGAN CEPU BABAT	5	27	26	62
2003	BRUMBUNG ~ SOLOBALAPAN			2	8	5	15
2003	PROBOLINGGO~JEMBER		KLAKAH	2	9	4	16
2008	SUKABUMI~PADLARANG			2	10	4	16
2008	KERTOSONO~MALANG ~BANGIL		MALANG	5	24	3	33
2008	JEMBER~BANYUWANGI		BANYUWANGI KALISAT	2	11	5	20

GRAND TOTAL

Year to be opened for business	⊙	A	B	C	D	E	Total
1989 ∿ 1994	4	1	3	6	30	7	51
1991 ∿ 1998		3	16	19	87	23	148
2003		1	12	18	95	71	197
2008		0	3	9	45	12	69
Total	4	5	34	52	257	113	465

⊙ is a station for which for special reasons improvement is planned.

A station: Extension of effective length (to cope with freight transportation), elevation of platforms, strengthening of sheds and tracks and construction of overbridges are proposed.

B station: Extension of effective length at junction station to cope with freight transportation (ℓ=460 m).

C station: Extension of effective length at intermediate stations to cope with freight transportation (ℓ=460 m).

D station: Passing loop for passenger trains.

E station: Single track station.

7.2.2 Freight Equipment

(1) Future Freight Volume

The volume of railway freight handled in 1981 averaged about 25,000 t/day. It is estimated from the aforementioned demand forecast that this will increase to 29,000 tons in 1989, 61,000 tons in 1994 and 80,000 tons in 2002, the increase rate being 1.2 times, 2.4 times and 3.2 times, respectively. (Table 7.2.3)

In 2002, the volume of freight handled will be large in the Jakarta Area (10,000 t/day), Kroya Area (10,000 t/day) and Surabaya Area (17,000 t/day). In other areas, it will be very small at less than 4,000 t/day.

Quantities handled in the three areas, by item, are as indicated in Table 7.2.4. In each area, sugar, petroleum products, fertilizer and cement together represent more than 94% of the total volume handled.

The increase rate of the volume handled for 2002 is 1.6 times for Jakarta, 4.2 times for Surabaya and 6.18 times for Kroya. Separately by outgoing and incoming freight, the volume of outgoing freight is much greater than the volume of incoming freight. This indicates that much is shipped inland from these three areas which are important port areas and form foreign and domestic import and export bases. (Fig. 7.2.12)

Table 7.2.3 Tonnage of Freight Handled, by Year and by Area (Total of Outgoing and Incoming Freight)

Unit: 100 t

By area	1989	1994	2002	Daily amount in 2002
1 Merek	691	4,432	4,535	12
2 Rankaspitung	532	4,060	5,162	14
3 Jakarta	25,682	31,796	37,414	103
4 Cikampek	10,569	13,306	17,531	48
5 Sukabumi	798	875	10,757	29
6 Bandung	9,334	10,227	7,328	20
7 Cirebon	6,194	8,258	8,485	23
8 Tasikumalaya	1,926	2,303	8,579	24
9 Kroya	5,858	25,014	34,705	95
10 Pekalongan	3,399	3,260	5,696	16
11 Kebumen	388	4,544	5,760	16
12 Semarang	5,506	7,353	13,133	36
13 Purwodadi	587	889	2,356	6
14 Yogayakarta	2,038	10,247	9,199	25
15 Solo	3,922	11,102	10,139	28
16 Madiun	3,063	7,303	6,934	19
17 Bojonegoro	875	1,100	8,205	22
18 Surabaya	14,751	45,327	61,780	169
19 Kertosono	2,450	8,192	6,979	19
20 Tulungagung	468	3,473	3,601	10
21 Bangil	304	2,877	3,732	10
22 Malang	2,233	4,680	8,816	24
23 Probolinggo	1,119	4,691	3,121	9
24 Jember	1,616	4,592	4,517	12
25 Banyuwangi	1,227	2,954	3,444	9
Total	105,483	222,855	291,908	800
Daily average	289	611	800	

Remarks

Train speed: 100 km/h

Table 7.2.4 Past Volumes of Freight Handled in Main Areas
(Total of Outgoing and Incoming Freight)

100 t

Item	JAKARTA				SURABAYA				KROYA			
	1981	1989	1994	2002	1981	1989	1994	2002	1981	1989	1994	2002
Rice	95	257	270	253	78	144	257	327	95	155	321	303
Maize	551	983	914	878	320	431	462	473	0	26	92	57
A. Sugar	110	172	186	210	24	33	126	123	9	22	81	69
Salt	116	168	160	175	29	99	148	149	5	6	27	18
Paper	9	61	80	54	1	3	13	17	0	4	10	4
Iron and steel	80	427	607	761	57	219	324	487	21	87	129	180
B. Petroleum products	1,376	10,900	13,305	16,445	4,325	6,056	17,934	22,560	750	1,211	12,411	16,527
C. Fertilizer	34	888	1,502	2,491	2,120	4,336	13,493	20,722	1,063	2,134	3,812	6,853
D. Cement	261	11,828	14,773	16,147	1,707	3,431	12,570	16,921	1,101	2,214	8,131	10,692
Total	2,632	25,686	31,796	37,414	8,661	14,751	45,327	61,780	3,044	5,858	25,014	34,705
Ratio	1.00	9.76	12.08	14.22	1.00	1.70	5.23	7.13	1.00	1.92	8.22	11.40
Exclusive line freight tonnage E = A+B+C+D	1,781	23,788	29,766	35,293	8,176	13,856	44,123	60,326	2,923	5,581	24,435	34,141
Exclusive line freight ratio	68%	93%	94%	94%	94%	94%	97%	98%	96%	95%	98%	98%

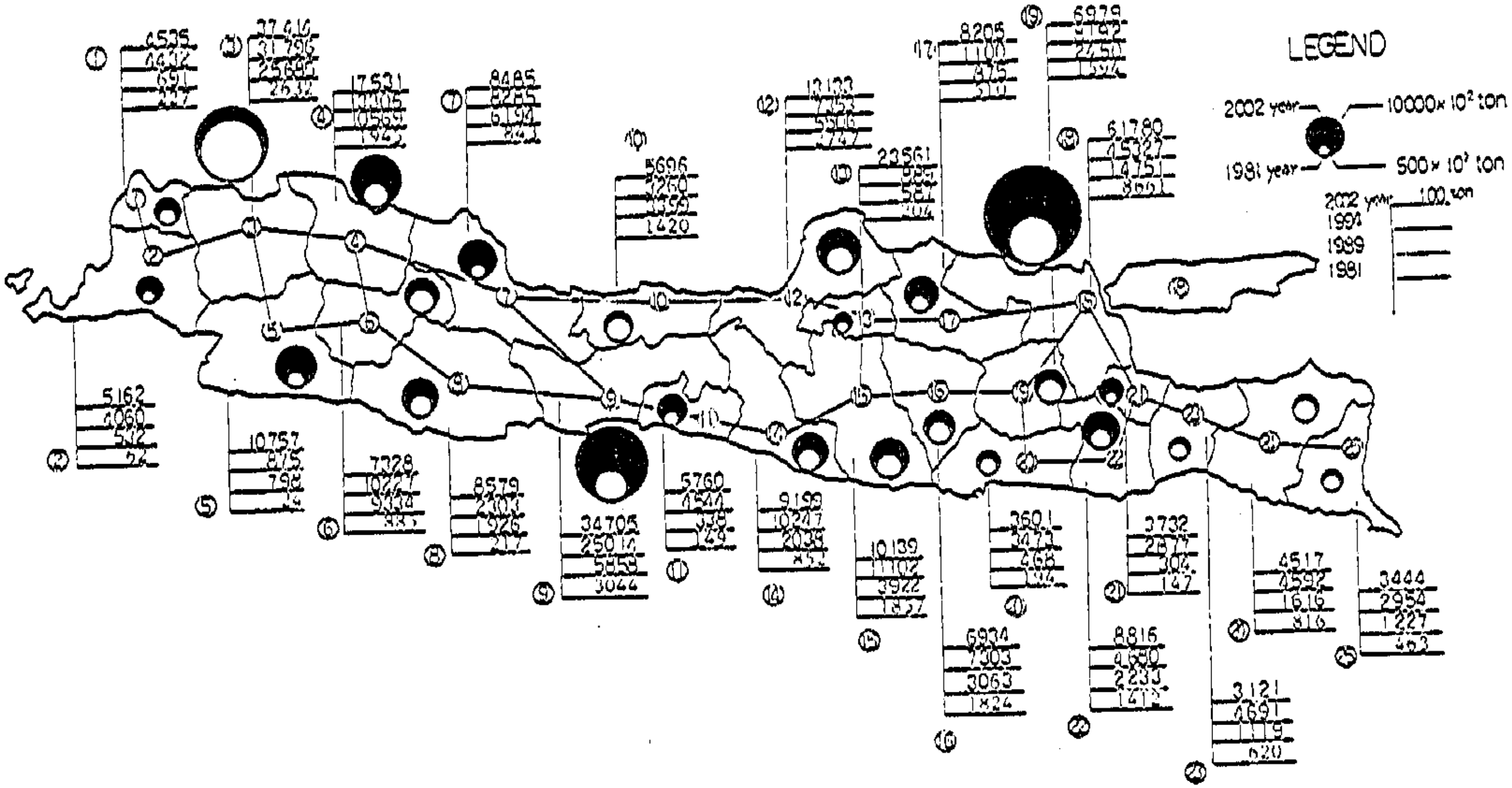


Fig. 7.2.12 Survey on Freight Handled, by Year and by Area

(2) Freight base improvement

The forecast total of loaded and unloaded railway freight for the 25 areas of the entire island for 2002 is 29,191,000 tons. The threee areas of Jakarta, Kroya and Surabaya which exceed the rest of the 25 areas in quantity of freight handled are estimated to handle 13,390,000 tons or 46% of the total.

These three areas, with important ports and adjacent manufacturing areas, are bases for the shipping of freight inland while other areas are places for freight arrival and consumption.

In these other areas, arriving freight is received by widely scattered stations and so the volume handled by each station is small. It will, therefore, be possible to generally cope by making effective use of present freight equipment.

It is considered that freight transportation throughout Java can only be smoothed if freight facilities in the three areas with large quantities of outgoing railway freight are improved.

a) Jakarta Area

The volume of railway freight handled will increase 14.2 times from 263,000 tons in 1981 to 3,741,000 tons in 2002. The total of the four main items (sugar, petroleum products, fertilizer and cement) is 3,529,000 tons or 94% of all that will be handled. The area can cope with freight handling in 2002 if it is completely equipped to handle these four items. The major item is petroleum products which will amount to 1,645,000 tons or 12 times the 1981 level of 138,000. Petroleum products are now brought to the Pretamina Oil Base by an exclusive line form Tandjung Priok Gudang and loaded by modern automatic loaders there. This equipment will have to be greatly expanded by 2002 and the number loading tracks will also have to be increased.

The handling of fertilizer will increase 83 times from 3,000 tons in 1981 to 249,000 tons in 2002. The exclusive line from Tandjung Priok Gudang is connected to the freight handling ground. The loading equipment will have to be greatly expanded by 2002.

The handling of cement will increase 62 times from 26,000 tons in 1981 to 1,615,000 tons in 2002. Since it is not able to cope with the future traffic demand under the existing facilities at Tanahabang Station, a separate study will be required on the modernized freight handling facilities.

These mass items of freight are mainly handled by direct base-to-base transportation and this transportation capacity will be increased by the increased 1,000-ton traction. To achieve this, the train length and the effective length on arrival and departure lines will have to be increased.

In addition, rice, corn, salt, paper, and steel traffic will increase 2.5 times from 85,000 tons in 1981 to 212,000 in 2002. The Jakarta Gudang which is a major freight depot will be able to cope with the traffic growth anticipated in 2002 provided that repairs and maintenance are properly made to the existing facilities as the sufficient loading/unloading facilities and go-downs are available at present.

b) Kroya Area

The volume of railway freight handled will increase 11.4 times from 304,000 tons in 1981 to 3,471,000 tons in 2002.

The four main items (sugar, petroleum products, fertilizer and cement) will total 3,414,000 tons or 98% of the entire freight volume in 2002.

Petroleum products will increase 5.2 times from 433,000 tons in 1981 to 2,256,000 tons in 2002, fertilizer will increase 6.5 times from 106,000 tons to 685,000 tons and cement will increase 9.7 times from 110,000 tons to 1,069,000 tons.

Petroleum products are handled at the Pertamina Oil Base of Maos and the cargo handling equipment there will also have to be expanded by the year 2002.

For fertilizer, the cargo handling equipment at the fertilizer plant of Cilacap-Pelasuhan will have to be expanded.

For cement, the cargo handling equipment at the cement mill of Karang Talun will also have to be expanded.

With the expansion of this cargo handling equipment, the number of related loading tracks will also have to be increased.

Furthermore, the effective length on arrival and departure lines will have to be extended so as to be able to handle direct base-to-base transportation.

c) Surabaya Area

The volume of railway freight handled will increase 7.1 times from 866,000 tons in 1981 to 6,178,000 tons in 2002.

In 2002, the four main items (sugar, petroleum products, fertilizer and cement) will total 6,033,000 tons or 98% of the entire freight volume.

The mass item of petroleum products, will increase 5.2 times from 433,000 tons in 1981 to 2,256,000 tons in 2002, fertilizer will increase 6.5 times from 106,000 tons to 685,000 tons and cement will increase 6.3 times from 171,000 tons to 1,069,000 tons.

Petroleum products are handled at the Pertamina Oil Base in the Bantang Yard and the cargo handling equipment there will have to be drastically expanded by 2002.

For fertilizer, equipment at the fertilizer bagging plant of Kalimas will have to be expanded. For cement, the cement loading equipment at Indro is likely to be expanded.

With the expansion of this cargo handling equipment, related loading tracks will also have to be increased.

Furthermore, the effective length of arrival and departure lines will have to be extended so as to be able to handle direct base-to-base transportation.

In planning the improvement of freight bases for these three areas, it is necessary to plan with a view to coordination after careful research has been made on each individual area because different areas have different city plans and different conditions for environment improvement.

Furthermore, detailed separate study is necessary because these bases will be improved accordingly at the cost of shippers as the freight volume gradually increases with the development of the economy.

(3) Consolidation of Freight Stations

At present, railway freight transportation is proving to be highly economical in the field of regular-shape and massive goods transportation and is used to transport petroleum products, fertilizer, cement, molasses, etc.

In the future, railway freight transportation will increases if measures aimed to improve transportation services, such the speeding up achieved through electrification and the direct transportation at types of commodity are initiated.

However, since station cargo handling equipment is outdated, it cannot cope with the increased freight volume because of its limited handling capacity even if the transportation capacity and the vehicles are improved.

The increased freight volume can only be completely handled by the additional provision of modern cargo handling equipment and trucks. Hence, the necessity to expand the loading/unloading facilities at freight stations, construction of additional warehouses by types of commodity and silos and securing of truck routes.

To expedite the delivery of goods, it is desirable to operate direct base-to-base freight trains. Allocating small-load vehicles to sporadic freight stations is a waste of both labor and time. To solve this problem, it is advisable to consolidate small freight stations into a modern merged freight station to be provided at a suitable site through either construction or improvement.

The number of freight trains operated in the 25 areas of Java Island may be tentatively estimated to total 175 in 2002 (see Table 7.2.6). The number of freight trains is large in the freight originating areas of Surabaya (37), Jakarta (23) and Kroya (21), followed by the freight receiving areas of Cicampek (10), Semarang (8), Sukabumi (7) and Solo (6).

The consolidation of freight stations requires a freight volume sufficient to make the operation of direct base-to-base trains necessary. The following is a study of the number of operated trains with regard to the above-mentioned four freight receiving stations (Table 7.2.5).

Table 7.2.5 Survey on Base-to-Base Freight Volume, Etc.

Name of area		JAKARTA	SURABAYA	KROYA	Others	Total
CIKAMPEK	A	9,240	2,193	4	6,094	17,531
	B	27	6	-	18	50
	C	6	1	-	3	10
SEMARANG	A	954	5,725	2,882	3,572	13,133
	B	3	17	8	10	38
	C	1	4	2	2	8
SUKABUMI	A	8,372	2,193	33	159	10,757
	B	24	6	-	0	31
	C	5	1	-	0	6
SOLO	A	337	63	5,876	3,863	10,139
	B	1	-	17	11	29
	C	-	-	4	2	6

A: Freight volume in 2002 (Total of loaded and unloaded freight) (100 t/year)

B: Daily volume handled A × 1.05 × 1/365
Volume of nine items handled × 1.05 = total volume handled

C: B × 1/4.8 480 t ... Per-train freight load
Number of freight trains.

Table 7.2.6 Tonnage of Freight Handled, by Year and by Area (Total of Outgoing and Incoming Freight) per day

Unit: 100 t/day
No. of trains

Area	1989	1994	2002	No. of freight trains 1989	1994	2002
1 Merek	2	13	13	0.4	2.7	2.7
2 Rankaspitung	2	12	15	0.4	2.5	3.1
3 Jakarta	74	91	108	15.4	19.0	22.5
4 Cikampek	30	38	50	6.3	7.9	10.4
5 Sukabumi	2	3	31	0.4	0.6	6.5
6 Bandung	27	29	21	5.6	6.0	4.4
7 Cirebon	18	24	24	3.8	5.0	5.0
8 Tasikumalaya	6	7	25	1.3	1.5	5.2
9 Kroya	17	72	100	3.5	1.5	20.8
10 Pekalongan	10	9	16	2.1	1.9	3.3
11 Kebumen	1	13	17	0.2	2.7	3.5
12 Semarang	16	21	38	3.3	4.4	7.9
13 Purwodadi	2	3	7	0.4	0.6	1.5
14 Yogyakarta	6	29	26	1.3	6.0	5.4
15 Solo	11	32	29	2.3	6.7	6.0
16 Madiun	9	21	20	1.9	4.4	4.2
17 Bojonegoro	3	3	24	0.6	0.6	5.0
18 Surabaya	42	130	178	8.75	27.1	37.1
19 Kertosono	7	24	20	1.5	5.0	4.2
20 Tulungagung	1	10	10	0.2	2.1	2.1
21 Bangil	1	8	11	0.2	1.7	2.3
22 Malang	6	13	25	1.3	2.7	5.2
23 Probolinggo	3	13	9	0.6	2.7	1.9
24 Jember	5	13	13	1.0	2.7	2.7
25 Banyuwangi	4	8	10	0.8	1.7	2.1
Total	305	639	840	63.5	133.1	175.0

Remarks: The daily tonnage of loaded and unloaded freight was calculated as being the demand forecast freight tonnage (9 items) × 1.05 (total freight volume) × 1/365 days. Assuming that a train is composed of 32 loaded cars + 19 empty cars = 51 cars, the per-train freight load is 32 cars × 15 t ≒ 480 t. This was used as the basis of calculation of the number of freight trains for each area.

The figure for Cikampek comprises 6 freight trains from Jakarta and 1 freight train from Surabaya because of the availability of equivalent freight sources and 3 freight trains from other areas.

Similarly, the figure for Seramang comprises 4 from Surabaya, 2 from Kroya and 2 from other areas, the figure for Sukabumi comprises 5 from Jakarta, 1 from Surabaya and 1 from other areas and the figure for Solo comprises 4 from Kroya and 2 from other areas.

Assuming that the one freight station will be in each area, the stations to be merged will be as follows:

Cikampek: Krawang, Purwakarta, Pegadan, Baru
Semarang: Kendal, Semarang Poncol, Semarang-Gudang, Demak, Kudus, Pati
Sukabumi: Cianjur
Solo : Klaten, Purwosari, Hasaran, Sukoharjo, Pasarnguter, Wonogiri

This will make the efficient operation of 24 direct trains possible.

To cope with future increases of freight transportation, the transportation system must be improved by increasing the transportation capacity and by expanding the transportation network. The consolidation of freight stations has been mentioned as a way to improve the transportation system but, in planning this, a detailed separate study is necessary.

7.2.3 Freight-Car Yards

Java Island has freight-car yards in the Jakarta Area and in the Surabaya Area.

(1) Future Plan for Jakarta Area

The freight-car yard of Jakarta Area is located at Cipinang and can disassemble or form 600 cars a day. It handles station order formation in the Jakarta Area and sorting and formation for Bandung, Cikampek, Jatibarang, Semarang and Kalimas stations.

In the future planning of freight transporting routes in the Jakarta Area, the Cipinang freight line will run north to south from the vicinity of Bekasi of the northern line to connect in the north with Tandjung Priok Gudang and with Cipinang Area in the south.

With this, the operation of freight trains via the eastern line will end as freight trains will be routed through the new line. Freight to and from Tandjung Prinok Gudang, a station with outgoing mass freight, and Jakarta Gudang with much arriving freight will be handled via the new line. In this case, the handling of freight trains will be inconvenienced by the shuttle operation necessary to use the new freight line since Cipinang is on the west side of Bakasi.

Meanwhile, Tandjung Priok Gudang is a port wharf freight-car sorting station with 17 sorting tracks and is hardly used now due to the decrease of port cargo using railway transportation. To make the most of this station in the limited local space, it must be used as a freight-car yard with restored yard functions. This is possible provided that its lead tracks are improved.

When it ceases to function as a freight-car yard it is desirable for the Cipinang Yard to be used as a vehicle base for trains starting from Hanggarai which will become departure station for medium- and long-distance trains after the electrification of trunk lines. Cipinang is only about 4 km from Hanggarai and has a space of 120,000 m^2. So, it can keep 350 cars and incorporate equipment for car inspection and repairs.

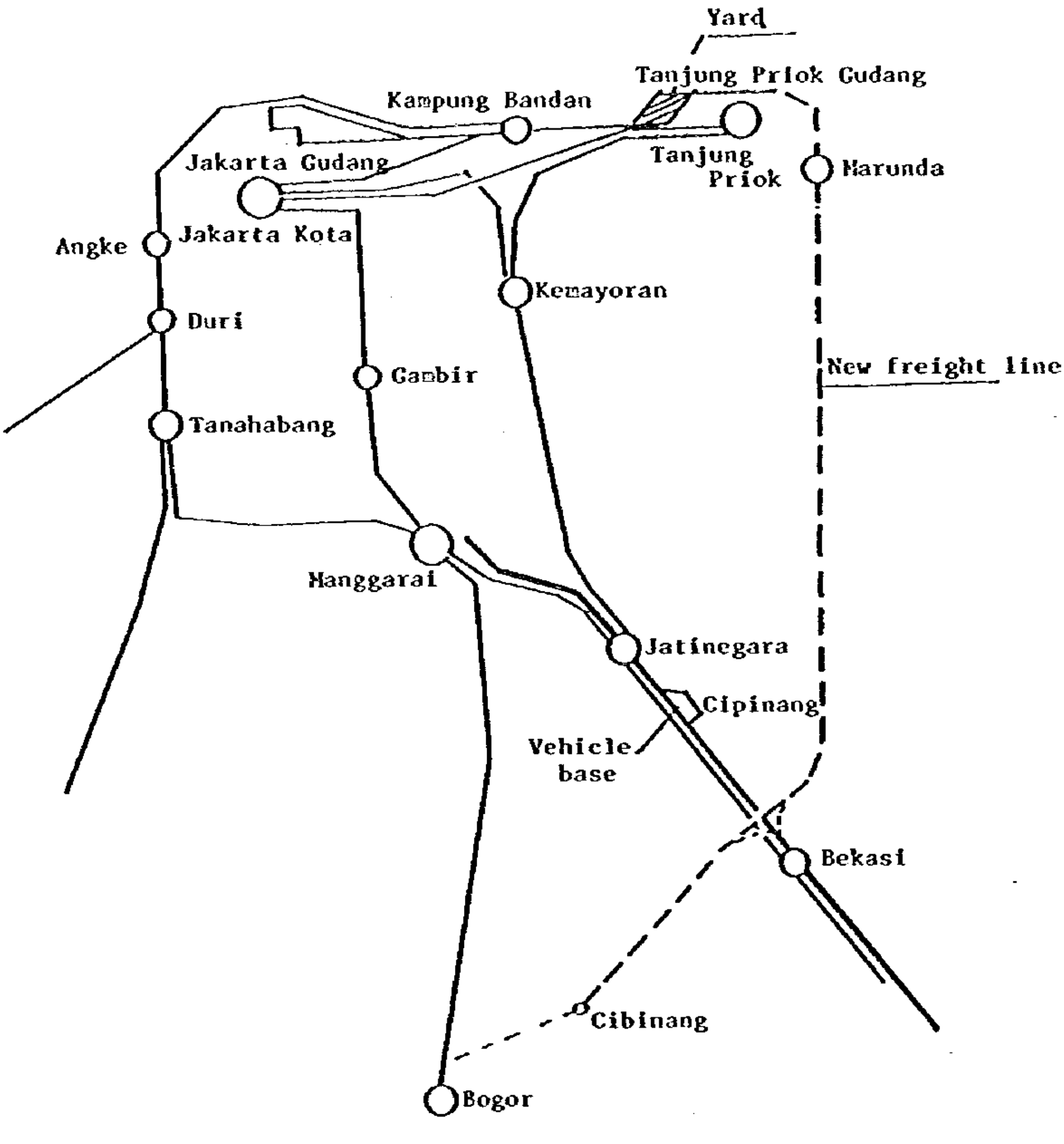


Fig. 7.2.13 Map Showing Arrangement of Yard and Vehicle Base in the Jakarta Area

(2) Study of Tandjung Priok Gudang Yard

The following is tentative calculation of the number of freight cars to be handled at the Tandjung Priok Gudang Yard in 2002:

The number of freight cars operated between Jakarta Area and other areas is 957 and the number of freight cars operated east to west across the Jakarta Area is 108. So, the number of freight cars handled by the yard is 1,065. According to forecasts, by direction, 248 are in the direction of Merak, 274 are in the direction of Sukabumi 165 are in the direction of Bandung, 35 are in the direction of Yogyakarta and 451 are in the direction of Surabaya. (Tables 7.2.7, 8, 9 and 10)

For the freight volume by commodities in Jakarta Area, 301 cars are for petroleum products, 295 cars are for cement and 45 are for fertilizer. Because of these mass commodities, there is the possibility of operating direct freight trains by area and by commodity. If 70% of petroleum products and cement are handled by direct proceeding freight trains, 417 cars will be outside the scape of this yard. So, the number of freight cars to be sorted and formed at the yard will be about 1,065 ∿ 417 = 648.

Thus, the Tandjung Priok Gudang Yard will be able to handle the number of freight cars in its charge in 2002 because its handling capacity is 700 cars. However, the yrad has many problems concerning marine container handling of port cargoes, closing of elevated line crossings and the connection method with the Cipinang freight line and so requires separate study and research.

Table 7.2.7 Number of Freight Cars in Jakarta Area, by Commodity

× 100 t, number of car

Item	Petroleum products	Fertilizer	Cement	Others	Total
Tonnage handled: a	16,445	2,491	16,147	2,331	37,414
Daily average tonnage: b = a × 1/365	45.1	6.8	44.2	6.4	102.5
Number of freight cars: c = b × 1/15 t	301	45	295	43	684

Table 7.2.8 Volume of Freight Cars Handled at Tandjung Priok Gudang Yard

Freight Volume, by Direction (Jakarta Area vs. 24 areas)

A.D. 2002 × 100 t

Name of area	Tonnage handled
Direction of Merak	
Merak	3,874
Pankasbitung	3,950
Total	7,824
Direction of Sukabumi	
Sukabumi	8,372
Total	8,372
Direction of Yogyakarta	
Kroya	267
Kebumen	20
Yogyakarta	178
Solo	337
Madiun	175
Kertosono	135
Tulungagung	116
Total	1,228

Name of area	Tonnage handled
Direction of Surabaya	
Cikampek	9,240
Cirebon	713
Pekalongan	435
Semarang	954
Purwodadi	66
Bojonegoro	75
Surabaya	1,328
Bangil	8
Malang	53
Probolinggo	185
Jember	216
Banyuwangi	248
Total	13,521
Direction of Bandung	
Bandung	4,971
Tasikmaraya	1,498
Total	6,469

Table 7.2.9 Volume of Freight Passing through Tandjung Priok Gudang Yard

Unit: 100 t/day

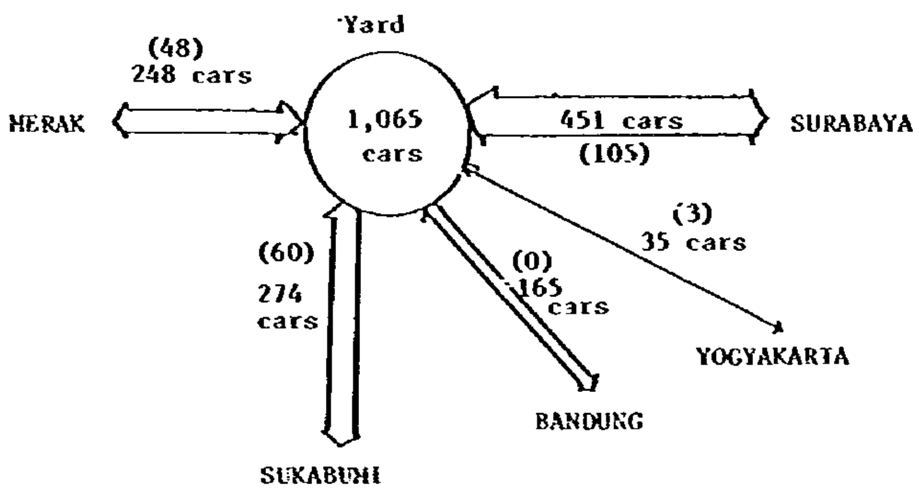
ZONE	Merak	Rankaspitung	Sukabumi	Total
1 Merak	-	-	5	5
2 Rankaspitung	-	-	5	5
3 Jakarta	-	-	-	-
4 Cikampek	479	1,090	2,193	3,762
5 Sukabumi	5	5	-	10
6 Bandung	3	4	7	14
7 Cirebon	4	0	3	7
8 Tasikumalaya	5	3	1	9
9 Kroya	5	5	33	43
10 Pekalongan	1	1	1	3
11 Kebumen	1	1	3	5
12 Semarang	9	17	5	31
13 Purwodadi	1	0	1	2
14 Yogyakarta	4	1	4	9
15 Solo	9	1	5	15
16 Madiun	4	1	4	9
17 Bojonegoro	2	15	3	20
18 Surabaya	79	40	63	182
19 Kertosono	4	2	6	12
20 Tulungagung	6	2	8	16
21 Bangil	1	1	1	3
22 Malang	5	2	4	11
23 Probolinggo	4	3	5	12
24 Jember	16	7	15	38
25 Banyuwangi	11	8	12	31
Total	658	1,209	2,387	4,254

Table 7.2.10 Number of Cars Handled by Yard
(Tandjung Priuk Gudang)

By direction		Tonnage of freight handled: a	Daily average tonnage: b = a × 1/365	Number of loaded cars: b × 1/15t	Number of empty cars: c = b × 0.4	Total: d = b + c
		100t	100t	Cars	Cars	Cars
MERAK	①	7,824	21.4	143	57	200
	②	1,867	5.1	34	14	48
	Total	9,691	26.5	177	71	248
SUKABUMI	①	8,372	22.9	153	61	214
	②	2,387	6.5	43	17	60
	Total	10,759	29.4	196	77	274
BANDUNG		6,469	17.7	118	47	165
YOGYAKARTA		1,228	3.4	23	9	32
SURABAYA		13,521	37.0	247	99	346
Total		41,668	114,0	761	304	1,065

① is Jakarta Area freight. ② is freight passing through Jakarta Area

TANDJUNG PRIUK GUDANG



( ) is the number of freight cars passing through the yard.

Number of cars handled by the yard

(248 + 274 + 165 + 35 + 451) - (105 + 3) = 1,065 cars

(3) Prospects in Surabaya Area

Surabaya Area has two freight-car yards, one at Sidotopo Station and the other at Kalimas Station. The through operation of freight trains between the northern and southern lines in the Surabaya Area consists of leading the train to Kalimas from Surabaya Pasarturi, terminus of the northern line, by a shunting locomotive and bringing it to Sidotopo via the freight passage line. Where it is sorted and formed by direction at the Sidotopo yard and enters the southern line at Surabaya Gubeng after passing through the southern line freight track. For trains proceeding from the southern line to the northern line, the Kalimas yard takes charge of sorting and formation. (Fig. 7.2.14)

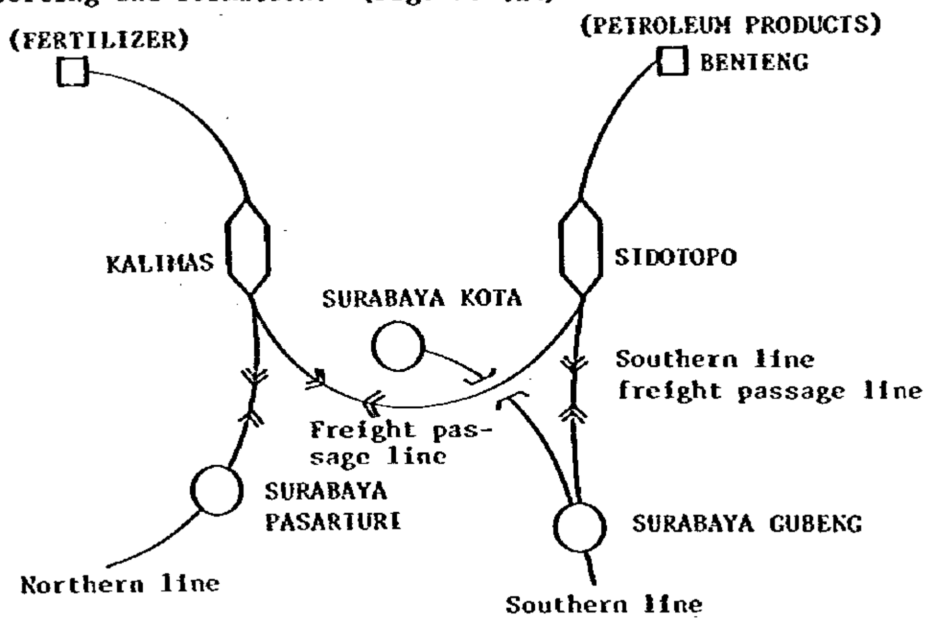


Fig. 7.2.14 Northern Line/Southern Line Connection System

Sidotopo has 19 sorting tracks and can sort an form 1,000 cars a day. It is responsible for the formation of freight trains bound for the southern line. Kalimas has nine sorting tracks and can sort and form 500 cars a day. It is in charge of forming freight trains bound for the northern line.

The number of freight cars to be handled by each yard will be 1,145 for the Sidotopo yard and 500 for the Kalimas yard, calculated from the freight volume forecasted for 2002 (Table 7.2.12, 13 and 14).

Classified by commodity, 412 cars will be for petroleum products, 379 for fertilizer and 309 for cement, these being mass commodities (Table 7.2.11). Assuming that 770 cars or 70% of this number will be operated as direct proceeding freight trains, the number of freight cars to be sorted at the yards will be 1,645 - 700 = 875.

Table 7.2.11 Volume of Freight Handled, by Commodity

Item	Petroleum products	Fertilizer	Cement	Others	Total
Annual volume handled: a	100 tons 22,560	100 tons 20,722	100 tons 16,921	100 tons 1,577	100 tons 67,780
Daily average volume handled: b = a × 1/365	61.8	56.8	46.4	4.3	169.3
Number of loaded cars: c = b × 1/15	412	379	309	29	1,129
Place of freight origination	BENIENG	KALIMAS	INDRO		

It is considered, therefore, that the yards of Sidotopo and Kalimas, with hardly anything more than their present facilities, can cope with the situation for the year 2002 because they can fully display their sorting and forming capacities if shunting locomotives are suitably disposed.

Table 7.2.12 Volume of Freight Handled, by Destination

2002 × 100 t

Sidotopo Yard		Kalimas Yard	
Name of area	Tonnage of freight handled	Name of area	Tonnage of freight handled
BANYUWANGI	2,360	BOJONEGORO	7,202
JEMBER	3,835	PURWODADI	1,289
PROBOL	2,693	SEMARANG	5,725
BANGIL	3,663	PEKALONGAN	1,444
MALAG	8,450	CIREBON	1,110
TULUNGAGUNG	3,078	CIKAMPEK	59
KERTOSONO	6,564	JAKARTA	1,328
MADIUN	5,851	RANKASBITUNG	40
SOLO	3,523	MERAK	79
YOGYAKARTA	2,210		
KEBUMEN	47		
KROYA	515		
TASIKUMARAYA	437		
BANDUNG	214		
SUKABUMI	63		
Total	43,503	Total	18,277

Table 7.2.13 Volume of Freight Passing Through Surabaya Area

2002 × 100 t

Name of yard	BANGIL	MALAG	PROBOL	JEMBER	BANYU WANGI	TOTAL
JAKARTA	5	53	185	216	240	702
CIREBON	17	67	18	67	144	313
PEKALONGAN	4	24	7	27	85	147
SEMARANG	3	16	4	28	51	102
PURWODADI	1	3	1	3	10	18
BOJONEGORO	2	5	1	3	11	22
Total	35	168	216	344	541	1,304

Table 7.2.14 Number of Freight Cars Handled, by Yard

2002

Name of yard	By type	Annual tonnage of freight handled	Daily average volume of freight: A	Number of loaded cars: B = A x 1/15 t	Number of empty cars: C = B x 0.4	Total: D = B + C	Total
		1000 t	1000 t	Cars	Cars	Cars	Cars
SIDOTOPO	Leaving or arriving at Surabaya	4,350	11.9	795	318	1,113	1,145
	Passing	130	0.4	23	9	32	
KALIMAS	Leaving or arriving at Surabaya	1,828	5.0	334	134	468	500
	Passing	130	0.4	23	9	32	

CHAPTER 8 ROLLING STOCK PLAN

CHAPTER 8 ROLLING STOCK PLAN

This project is intended for promoting electrification for furtherance of modernization through investigation of the main railway lines extending for 2500 km in Java Island in the Republic of Indonesia.

In planning electrification of the main railway lines, the present as well as future conditions of transport, reliability and maintenance will be considered, and upon such consideration, optimum locomotives for the Indonesian State Railway will be examined.

8.1 Fundamentals of Electrification Plan

8.1.1 Electrification Systems

In the world, various systems are employed for electrification. Largely, they are divided into DC and AC systems. The DC systems use 600 ∿ 3000V, and the AC systems use 15kV ∿ 25kV and, as a special case, 50kV, with 16-2/3Hz, 25Hz or commercial frequency.

These systems have advantages as well as disadvantages. Here, electrification is already made in the suburban area of Jakarta under DC 1500V. But, from what was found out up to the present, it would be advisable to advance the examination along the line of using commercial frequency of 50Hz and standard voltage of 25kV for the future electrification over the whole country.

8.1.2 Fundamental Conditions for Electric Locomotive

1) Electrification system
2) Maximum traction load weight
3) Maximum operating speed
4) Rolling stock gauge
5) Axle load

With the foregoing taken as principal conditions, the following conditions were taken into consideration for examination, that is,

6) Environmental condition;
7) Accelerating;
8) Braking;

9) Multiple unit control; and

10) Other conditions.

8.1.3 Fundamental Performance of Electric Locomotive

Assuming the transport demand and other various conditions at the time of electrification and also that the so-called South Line, North Line and Bandung Line would be the most important lines for electrification of the main lines in Java, and further assuming the type, load and speed of the unit train in consideration of the character of the respective lines, the optimum electric locomotive for electrification of the main lines in Java would be determined through simulation of the running according to the characteristics of a locomotive assumed for the respective line conditions.

8.2 Electric Locomotive Plan

8.2.1 Axle Load and Axle Arrangement

The National Railway of the Republic of Indonesia has it in plan to increase the allowable axle load from the present 15t to 18t or 20t along with progress of the improvement of the tracks. The number of axles of the electric locomotive is related to the required adhesion coefficient, axle load and tare weight. For the electric locomotive adapted for the present electrification plan, an axle load of 15t/axle is planned. To embody this, the following two types are conceivable:

6 Axles,	Weight 90t	Axle-arrangement,	B_o-B_o-B_o, or C_o-C_o;
4 Axles,	" 60t	"	, B_o-B_o,

In the case of 4 axles, special consideration is required for design in order to keep the total weight of the AC locomotive within 60t. As an example of special axle arrangement, JNR employes a B_o-2-B_o system in some district. This system is adapted for changing the axle load and its reduction.

Such axle arrangements will be discussed in detail later in "Simulation."

8.2.2 Lines for Electrification

From the transport volume and other conditions, the following were taken as the lines to be electrified first among the main lines of 2500km for electrification in Java, and thus the rolling stock plan was advanced.

(1) Jakarta-Surabaya (North Line)

(2) Jakarta-Surabaya (South Line)

(3) Jakarta-Bandung (Bandung Line)

The line conditions are:

(1) Jakarta-Surabaya (North Line) runs along the coast line and is generally level with the gradient less than 5 ‰ ;

(2) Jakarta-Surabaya (South Line) has a gradient of middle class present existing between Prupuk and Purwokerto where it transverses the mountaineous district in middle part of Java; and

(3) Jakarta-Bandung Line has a number of grade of 15 ∿ 16 ‰ and curves of a radius of 200m between Purwakarta and Padalarang extending for 56km among the total extension of 173km, and in this respect, it is different greatly from (1) and (2).

8.2.3 Pattern of Transportation Form, and Train Type and Load Weight

The State Railways of the Republic of Indonesia has the passenger transport made mainly with medium and long distance trains with a considerable length between the stopping stations, and trains are operated in a composition of 8 ∿ 10 cars, although some has the composition fixed. Thus, for the load of the passenger car train, 400t was taken.

Freight transport is made of relatively bulkey ones mainly. Then, considering the transport unit of a train and crossing at station a load of about 1000 tons was considered to be adequate for a train.

8.2.4 Maximum Operating Speeds

With consideration given to the future transportation and renewal of track, signalling and cars, the maximum speed of operation by type of trains is set as below.

Passenger car train	100km/h ∿ 120km/h
Freight car train	75km/h

8.3 Rolling Stock Gauge

For the Indonesian State Railways starting AC electrification from now, determination of the structure gauge and rolling stock gauge for the lines designed AC electrification section is an important matter governing the future development.

The rolling stock gauge for the AC electrification lines is determined depending on how the gauge for the pantograph is set with the current rolling stock gauge in the non-electrification section taken as a base. In Fig. 8.3.1 is shown the current rolling stock gauge on the main track designed for electrification, and in Fig. 8.3.2 is shown that in the section already DC electrified.

The height from the fitting surface on the roof to the top of the pantograph in folded position is considered to be 700 mm as the maximum (including insulators). For the roof height, it is desirable to secure about 3600mm above the rail surface for both EL and EC (Jakarta suburban electric cars being of the same value). Therefore, the pantograph height in folded position in the rolling stock gauge is ideally 4300mm above the rail surface (this value being the same with that of JNR).

However, where said height is not secured due to restriction from, say, tunnel cross-section, it has to be reduced. The reducible limit is, in principle, the maximum height (=3820mm) of the current rolling stock gauge, and if reduced further, the required isolating distance between the top of the current passenger car or the like and the trolley wire is not secured.

In the critical case of 3820mm, even if a pantograph having a very low height in folded position (about 550mm including insulators) is used, the roof height is about 3250mm so that the ceiling height over the floor is about 1700mm in the case of EL or 1900mm in the case of EC, such value presenting a difficulty practically. Therefore, a minimum of 4000mm should be secured for the height with the pantograph in folded position. The height will be determined specifically with the possibility of repairing the tunnel to be taken into consideration.

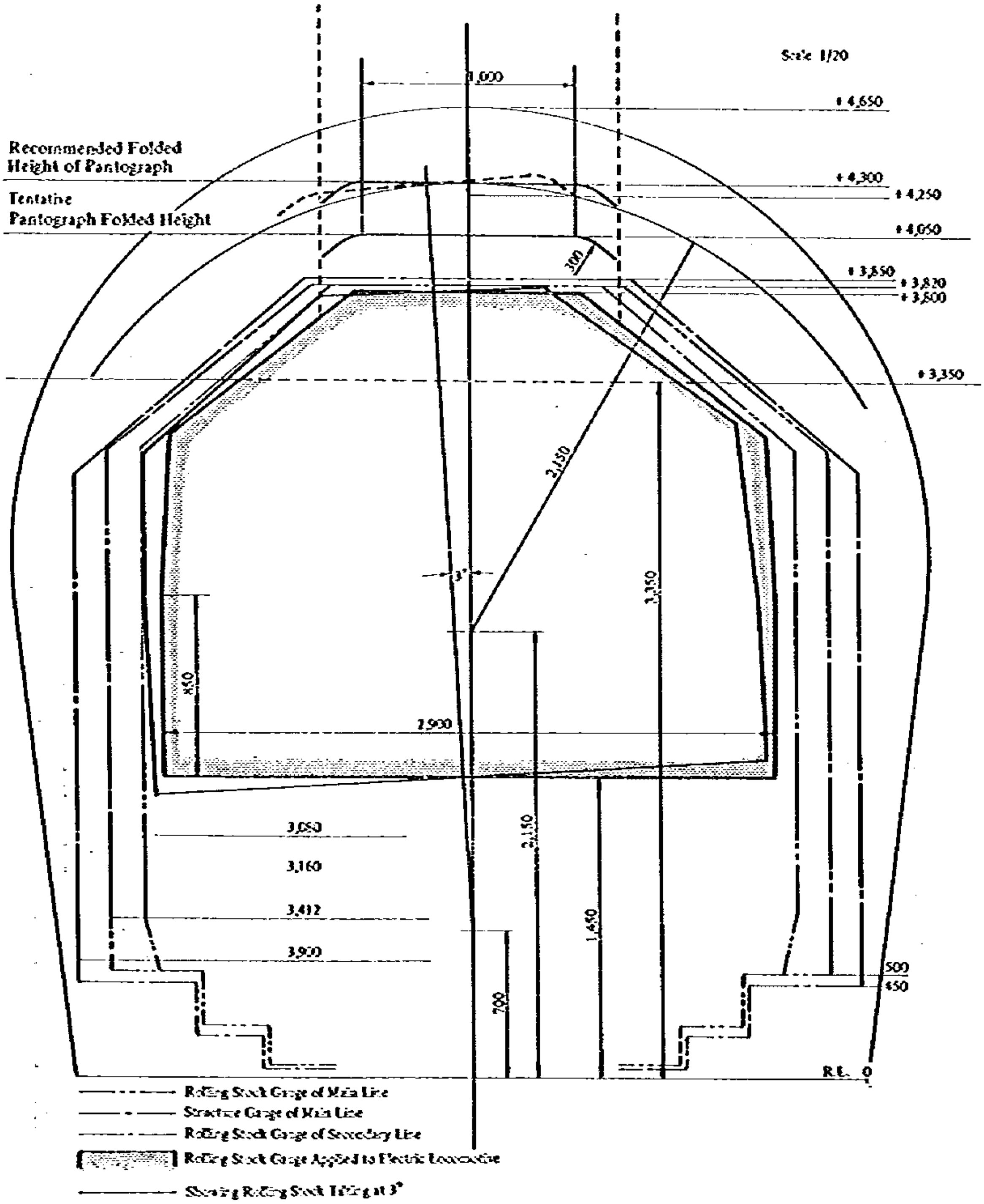


Fig. 8.3.1 Rolling Stock Gauge AC25kV Electrification of Main Lines in JAVA

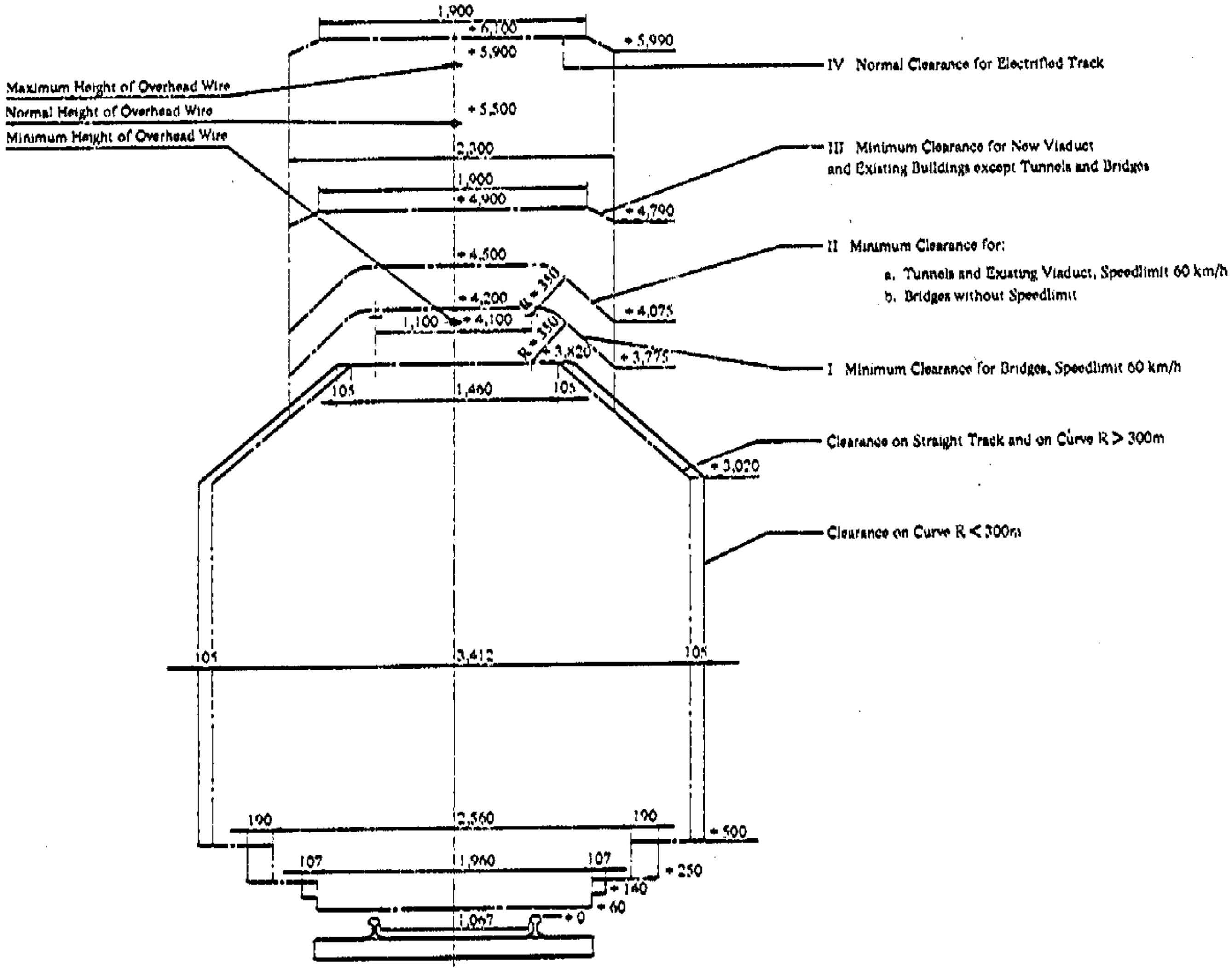


Fig. 8.3.2 Indonesian National State Rolling Stock Gauge for DC-Electrified Line

It should be added that the sections in which such a low gauge is to be employed are limited, so that it is desirable to determine the height at the advisable value of 4300mm in the general rules concerning the railway structure and apply a reduced height (for example, 4050mm) to special sections tentatively and, at the same time, plan to revise it at the time of improving the tunnel etc. in the future.

8.4 Performance Plan

In planning the performance of the electric locomotive introduced upon electrification of the main railway lines in Java Island, the following fundamental conditions are set for said three lines first, then the performance and ratings of an economic and optimum standard locomotive are determined through repetition of train operating simulations.

(1)	Track conditions:	Kilometerage, grade, curve, speed limit and axle load limit
(2)	Load conditions:	Train weight, locomotive weight and running resistance
(3)	Operating conditions:	Schedules time, stop stations, marginal time and conditions for starting along upgrade

8.4.1 Train Weight

The number of composing cars and weight of the train are determined in consideration of the capacity of facilities such as tracks and stations, performance of locomotive, track capacity and schedule speed as related to the transport demand.

Among the objective three lines, the North line is a level section with the steepest gradient at 5 ‰ so that if the facilities are equipped well, it permits operation of a very long freight train of several thousands tons with ease. But, the present equipment capacity is 1000 tons maximum. The South line includes a slope of 13 ‰ over a mountain (including a part of 16 ‰ but in a short section of some 200m so that it may not be taken into consideration) so that the maximum weight of the train is determined by such section. But, in view of the present facilities, the examination is made for maximum 1000 tons. The Bandung line includes a succession of 15 ∿ 16 ‰ slopes and sharp curves of a radius of 200m, while the weight of cargo transport is not high so that the weight up to about 600 tons which a standard locomotive is able to pull is tractable by a standard locomotive will be considered.

The weight of the passenger car train has the arrival time (schedule speed) as a great factor for determination, and the examination will be made for 400 tons which is the same with the current train weight.

8.4.2 Train Resistance

The train resistance is comprised of the running resistance, starting resistance, grade resistance and curve resistance.

(1) The starting resistance varies with locomotive or training composing car and also with the type of axle bearing. In JNR, the values shown in the table below are employed, and they are assumed to decrease linearly with increasing speed up to 10km/h.

Table 8.4.1 Kg/ton

Type of car	Plane bearing	Roller bearing
Electric locomotive	8	5
Passenger or freight car	6	4

(2) For calculation of the running resistance, a formula obtained experimentally is used, and it differs from country to country. In the present calculation, JNR's formula was used for the electric locomotive, and PJKA's resistance formulas used for the passenger and freight cars.

Electric locomotive	$(1.72 + 0.0084V)\ W + 0.0369V^2$	kg
Passenger car	$2.5 + 0.00025V^2$	kg/t
Freight car	$2.5 + 0.0005V^2$	kg/t

(Note) W: Locomotive weight (ton)

V: Speed (km/h)

(3) Slope resistance is given, if the slope angle is θ, by

$$r = 1,000 \sin\theta \doteqdot 1,000 \cdot \frac{S}{1000} = S$$

Thus, the slope resistance (kg/t) is expressed in the same value with the slope S ($^{0}/_{00}$), and it has (+) affixed for up-grade or (-) for down-grade.

(4) The curve resistance includes various factors such as curve radius, tread form, cant and slack of the track, etc. and is complicated. Here, the value used in JNR, or 600/R (kg/t), was employed.

(5) The train resistance is calculated as the sum of the foregoing resistances.

8.5 How to Determine the Locomotive Specifications

When the track, load and operating conditions are established as stated above, ratings and other specifications of the locomotive would be determined in consideration of the technical procedures and economy. Further, upon such specifications, train operating simulation in the objective lines will be carried out repeatedly for optimization.

8.5.1 Reted Tractife Effort

This is one of the basic specifications concerned with the train hauling ability of the locomotive and temperature rise and required capacity of the equipment.

So far as the hauling ability of the locomotive is based on the adhesive capacity, the rated tractive effort and adhesive capacity are deeply related to each other. As a general yardstick, a locomotive of good adhesive performance (AC locomotive, etc. falling in this category) has about 25 percent of its adhesive weight as a rated tractive effort, while a locomotive inferior in adhesive performance (such as DC locomotive of resistance control system) has the tractive effort rated at about 20 percent. Starting from such a standard value, the optimum value for the respective lines is chosen. However, the foregoing is not applicable to the locomotives designed exclusively for passenger car train.

The rated tractive effort thus chosen is optimized through examination of the results of simulation upon the data obtained of the temperature rise, etc. from the grade in the line, train weight, frequency of stopage, etc. In the case of the Indonesian State Railways, between Purpuk and Patugran on the South Line presents the most severe condition among the objective lines so that the rated tractive effort of the locomotive is determined from the load condition in this line.

8.5.2 Rated Speed

The rated speed is concerned with the obtainable balancing speed and maximum speed. But, unless it is considered in relation to the control system, it tends to become a meaningless figure or induce misunderstanding.

As a control system of this locomotive, a combination of voltage control and field control is most reasonable.

For the voltage control, a thyristor phase control (cascade converter) is employed as it is distinguished in the control performance and is adapted for reducing the size as well as weight of the equipment. Further, as the locomotive is designed in dual purposes for passenger and freight trains running along flat and grade lines, a field weakening control is employed for multiple application. The minimum field is chosen at a value insuring a sufficient high speed performance.

With the field weakening control of a wide range employed, the traction motor should have the voltage rating chosen at the maximum value (In the nominal trolley wire voltage) of the DC voltage at the rated current and the corresponding speed taken as the rated speed.

8.5.3 Rated Output

The rated output is determined from the foregoing rated tractive effort (ton) and rated speed (km/h).

$$\text{Rated output} = (\text{Rated tractive effort}) \times (\text{Rated speed}) \times \frac{1}{0.367} \ (\text{kw})$$

But, because of restriction in the weight and dimensions of the locomotive, the hardware aspect of the locomotive such as if the locomotive of such output and performance is really manufacturable or what is the reliability or maintenability should be fully examined before the rated output is determined finally.

8.5.4 Adhesive Performance

The maximum tractive effort is determined by the adhesive performance. The adhesive performance is dependent on the following three factors.

1) Adhesive coefficient and method of increasing it.
2) Effective use of the adhesive coefficient.
3) Readhesion.

From the current practical level, sanding is available for (i), continuous control and weight transfer compensation for axles for (ii), and forced readhesion by self-readhesivity of the locomotive and slip detection for (iii). Anyway, the adhesive performance of the locomotive is the cumulative effect of these three factors.

With respect to evaluation of the adhesive performance, it must be exercised carefully as there is a problem which is apt to cause misunderstanding. That is, it is the adhesive capacity at the time of starting a train over the starting resistance or the adhesive capacity when the speed is zero and that at the time of accelerating the train that has moved out or adhesive capacity in the medium speed range. The adhesive coefficient itself tends to decrease gradually with increasing speed, while the relationship in value between the starting resistance and the grade resistance is apt to change depending on the degree of the slope. Then, which one of the foregoing two adhesive capacities is subject to severer condition is variable from case to case. In general, in the start at a gentle slope, the adhesion at zero speed is severe, and at a steep slope, the adhesion in the medium speed range is severe.

In terms of the adhesive coefficient, about 40 percent at the zero speed start or about 30 percent in the medium speed range is expectable of the present high performance AC locomotives. The present high performance AC locomotives ensure adhesive coefficients of about 40 percent at the zero speed start and about 30 percent in the medium speed range. With DC locomotives, they are about 25 and

20 percent respectively. Then, with a 1000 tons load tracted, the adhesion in the medium speed range is subject to slightly severer condition between Prupuk and Patugran in the South Line. If it is conditioned to start on a 13 ‰ slope in this section, not 1000 tons but about 900 tons is appropriate.

8.5.5 High Speed Performance

The high speed performance should be given by the weak field and be chosen so that a load of 400 tons of passenger cars is balanced at about 120km/h in a level line.

For the allowable maximum speed of the locomotive, 110 ∿ 120km/h will be taken for examination, with future improvement of the tracks taken into consideration.

8.6 Train Operating Simulation

Computer simulation of the operation was made with input of the line conditions of the objective three lines, performance curves of the locomotive and classification by passenger and freight cars. The output was comprised of the speed, time, kilometerage, RMS (Root Mean Square) current of traction motor and power consumption.

8.6.1 Locomotive Performance Specification

Assuming the following types of locomotive, Table 8.611, the results of simulation were compared and evaluated with one another. Performance curves of these locomotives are shown in Figures 8.6.1∿5. In conclusion, D-3 was optimum, as described later.

Table 8.6.1

Type	D-1	D-2	D-3	F-1	F-2
Axle Arrangement	B_o-B_o			B_o-B_o-B_o	
Tare Weight (ton)	60			90	
Cont. Ratings:					
Output (kW)	1,600	1,600	1,800	2,400	2,400
Tractive effort (kg)	14,000	12,000	13,700	21,000	18,200
Speed (km/h)	41	48	49	41	47
Traction Motor	400kW-900V-480A		450kW-900V-540A	400kW-900V-480A	
Min. Field (%)	60		50	60	

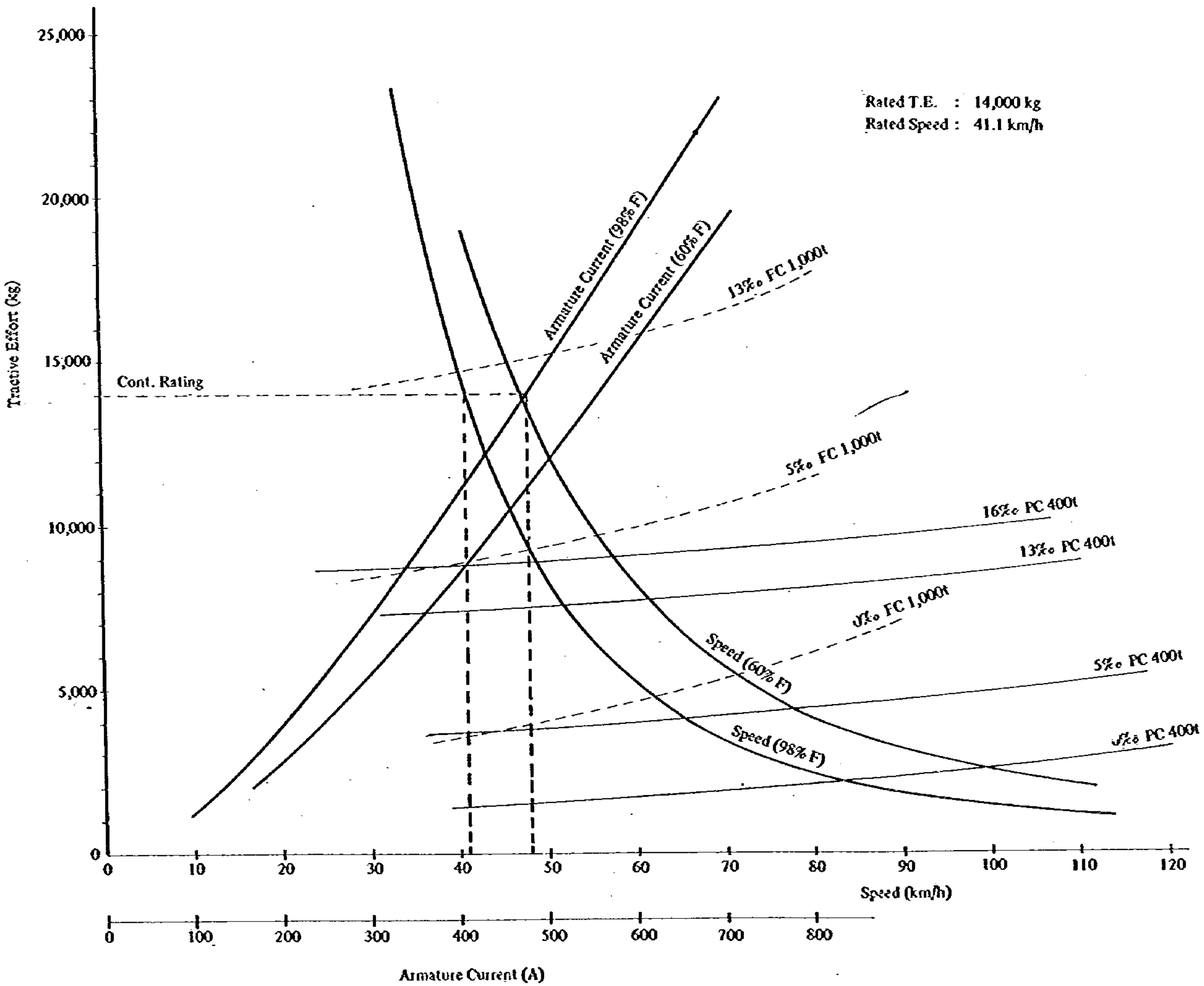


Fig. 8.6.1 Performance of Locomotive Type D-1

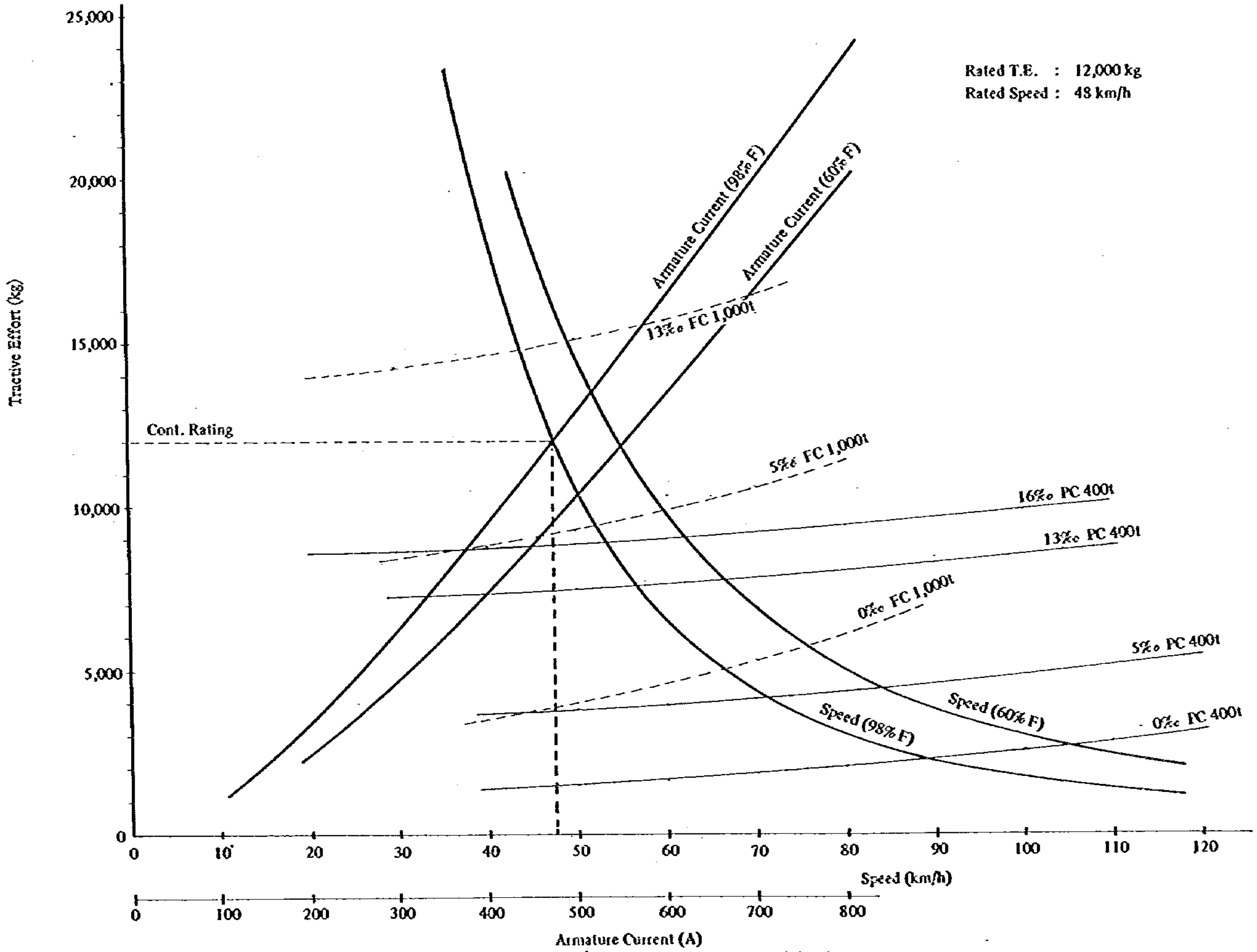


Fig. 8.6.2 Performance of Locomotive Type D-2

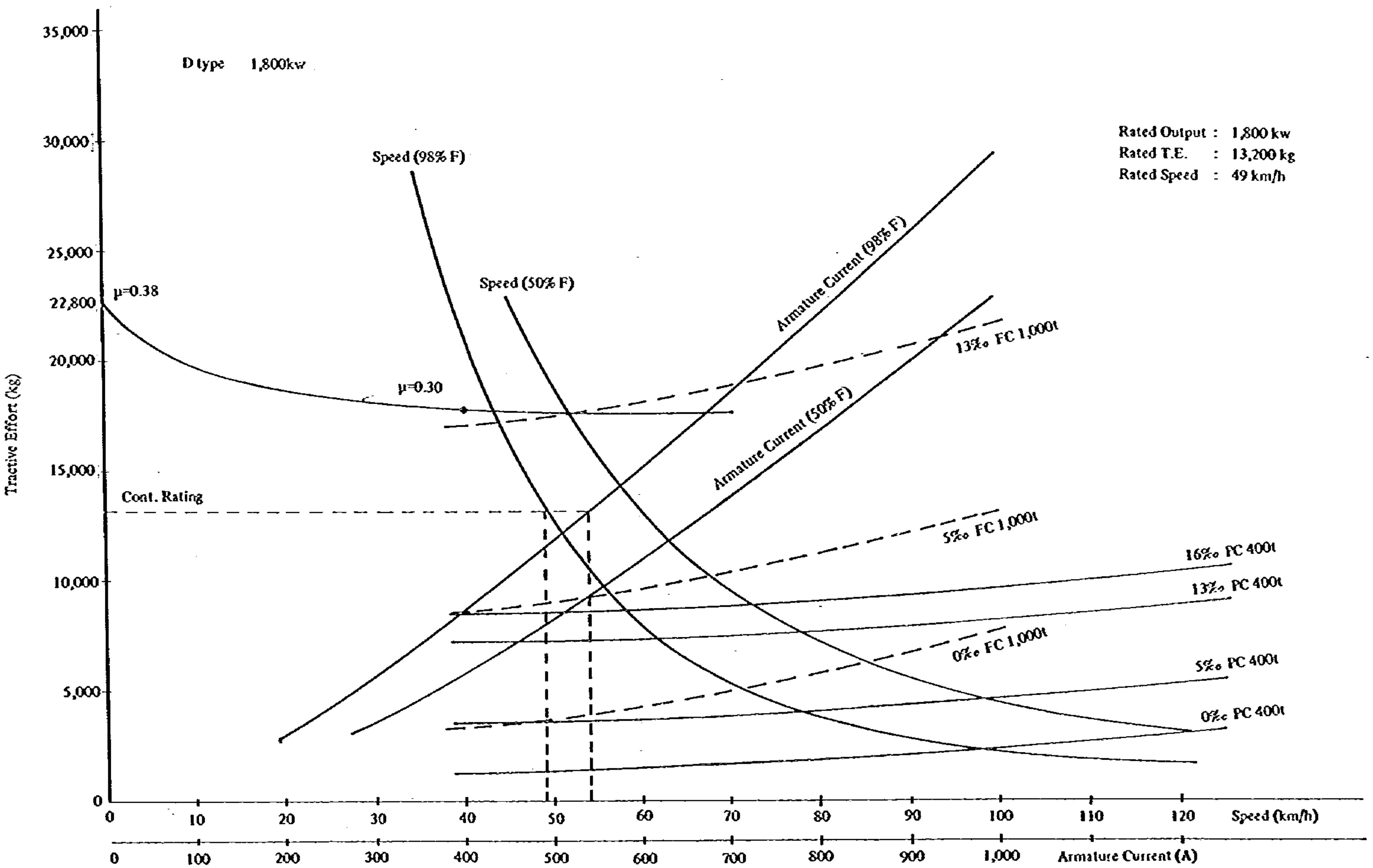


Fig. 8.6.3 Performance of Locomotive Type D-3

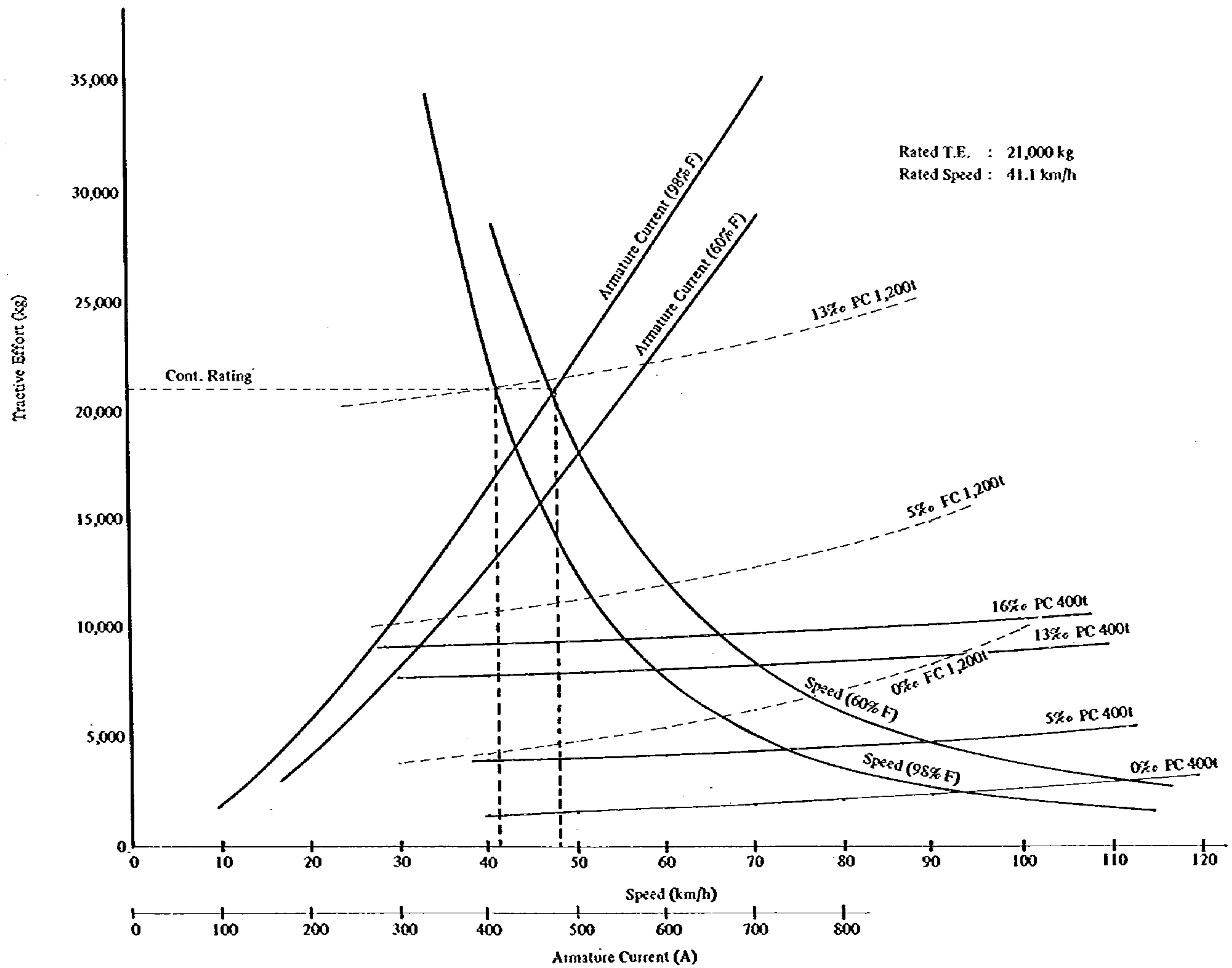


Fig. 8.6.4 Performance of Locomotive Type F-1

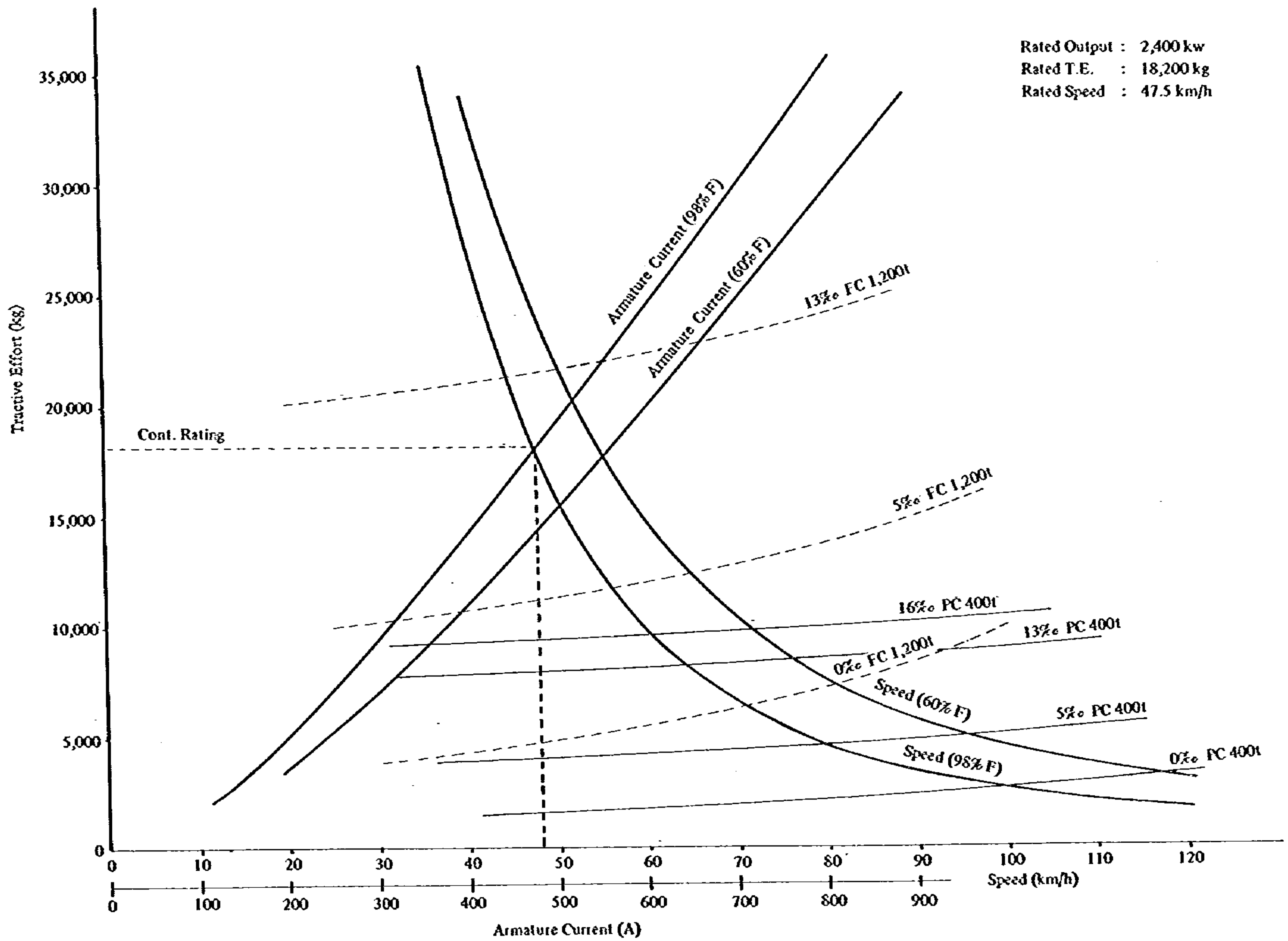


Fig. 8.6.5 Performance of Locomotive Type F-2

8.6.2 Running Simulation

Simulation of train running by an electronic computer will be described below.

Procedure 1. Read-in of track conditions

In Procedure 1, the necessary track conditions for simulation are read-into the computer. From the track conditions, the train resistance and speed limit for each kilometer are obtainable. That is, the train resistance is obtained as the sum of the resistance along the grade and that, along the curve, and the speed limit is determined by the minimum value among the speed limits set forth for the down grade, curve, particular section, turnout, etc.

Procedure 2. Determination of train parameters

In Procedure 2, the train parameters shown below are determined.

(1) Powering characteristics (including the current limiting value and control system).
(2) Braking characteristics.
(3) Number of tractive units and number of trailers.
(4) Car weight.
(5) Allowable maximum speed of train (V_M).
(6) Deceleration by brake (β).
(7) Train length (L).
(8) Running resistance of train (R).

Procedure 3. Setting of running conditions

In Procedure 3, the conditions such as shown below for running trains are set.

(1) Allowable maximum speed of the running section (V_L).
(2) Allowable maximum speed at curve (V_C).
(3) Allowable maximum speed at grade (V_G).
(4) Turnout passing speed limit (V_P).
(5) Other speed limits (Slow-down, signal, etc). (V_S).
(6) Repowering speed width (V_{RP}).
(7) Minimum coasting time (T_C).

Procedure 4. Plotting the speed limit curve

In Procedure 4, the allowable maximum speed ($V_{max}(S)$) at each point of the track along which the train runs are obtained (Fig. 8.6.6). Vmax(S) is the maximum speed allowed for the train at each point and is defined by the for formula

$$Vmax(S) = min(V_L(S), V_C(S), V_G(S), V_P(S), V_S(S), V_M) \quad ...... (1)$$

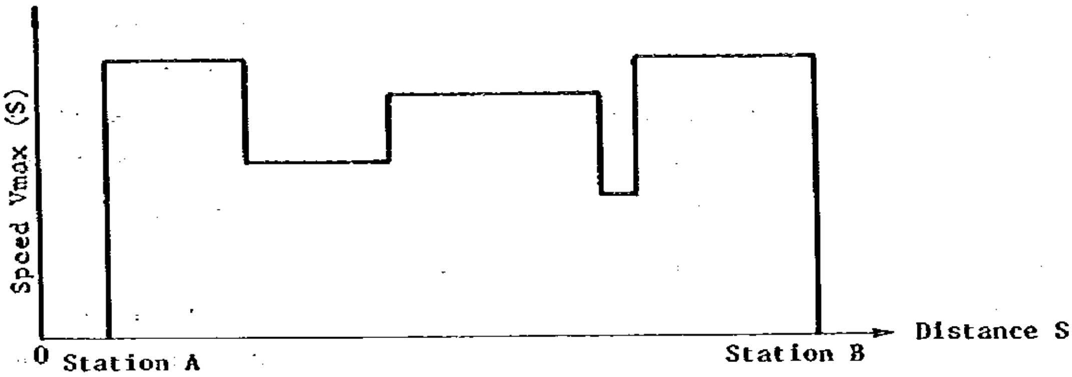


Fig. 8.6.6 Speed Limit Curve Plotting

Procedure 5. Correction of train length

When a train runs, any part of the train must not exceed the maximum speed limit for the track on which the train is present. Therefore, in Procedure 5, the speed limit curve prepared in Procedure 4 is corrected with the train length taken into consideration.

An example is shown in Fig. 8.6.7. The corrected curve is obtainable by connecting the allowable maximum speeds of the forefront part of the train at the respective points.

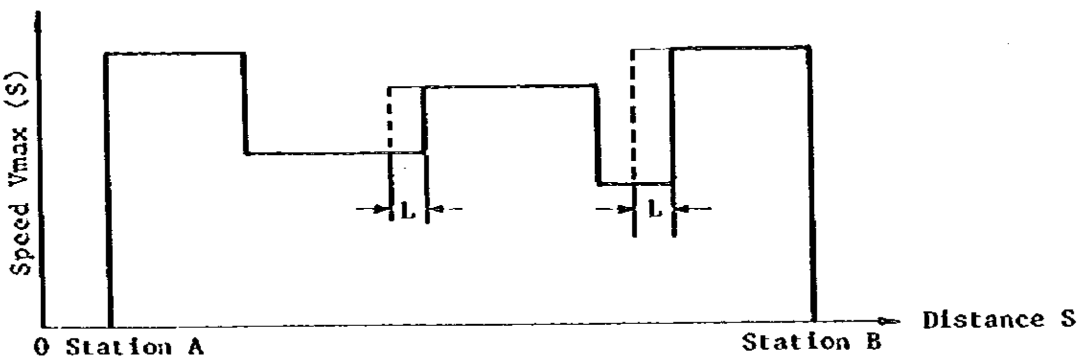


Fig. 8.6.7 Correction for Train Length

Procedure 6. Plotting the reversing curve

In procedure 6, the reversing curve is prepared from the curve prepared in Procedure 5. The reversing curve is that which is obtain from the set deceleration through braking and by the train resistance at the respective point. For the purpose of simulation, the train does not exceed the speed $V_B(S)$ shown by this curve in any case. In the simulation, when a train which is powering or coasting reaches the train speed $V_B(S)$, it runs thereafter with the brake applied until the speed comes below $V_B(S)$.

Fig. 8.6.8 illustrates a reversing curve obtained from Fig. 8.6.7.

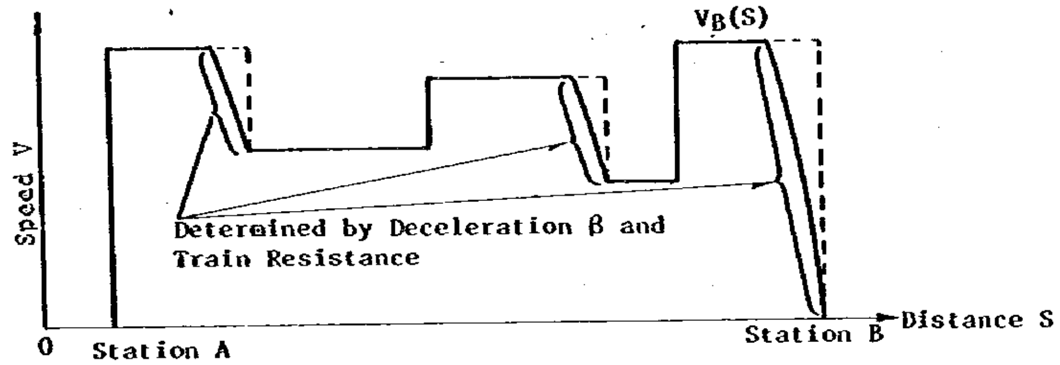


Fig. 8.6.8 Reversing Curves

Procedure 7. Run calculation

In Procedure 7, the train is run on the program using the reversing curve obtained in Procedure 6 and according to the powering and braking characteristics, and the speed, traction motor current, power consumption and time at the respective points are calculated. Basic formulas for calculation are shown in formulas 2, 3 and 4

$$F(V) - R(V,W) = W\alpha(V) \quad \ldots\ldots (2)$$

$$V = \int \alpha(V)dt \quad \ldots\ldots (3)$$

$$S = \int V dt \quad \ldots\ldots (4)$$

where F(V) : Tractive force at speed V;

R(V,W): Train resistance at speed V and car weight W;

α(V) : Acceleration at speed V; and

S : Running distance.

Such factors as RMS current, power consumption and required time which are important for determination of the equipment capacity are obtainable by integrating the train speed, traction motor current, etc. at the respective points.
A running curve obtained by running calculation and a flow chart of calculation are shown in Fig. 8.6.9 and Fig. 8.6.10 respectively.

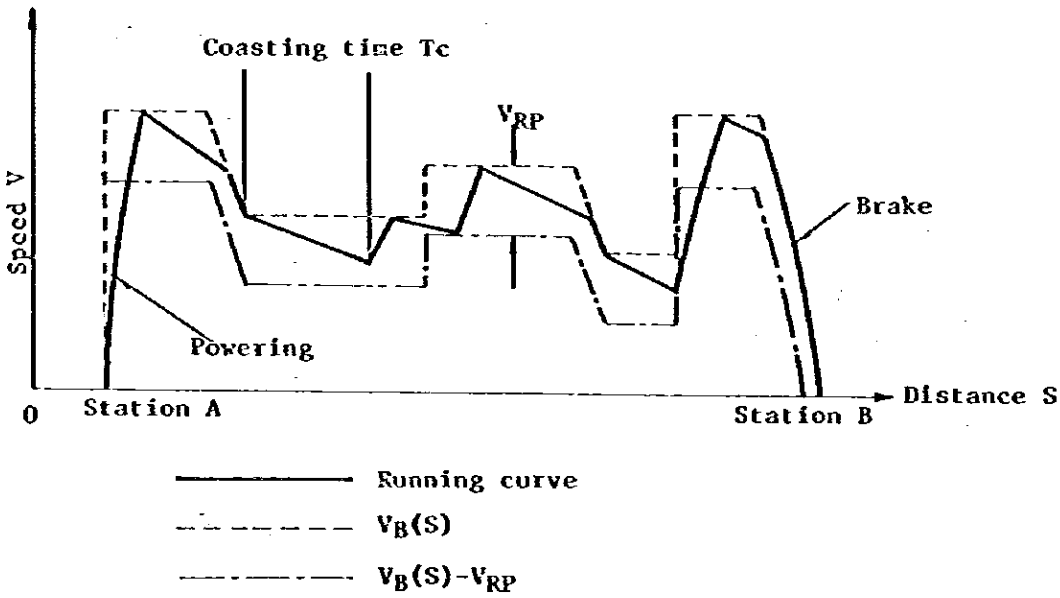


Fig. 8.6.9 Running Curve

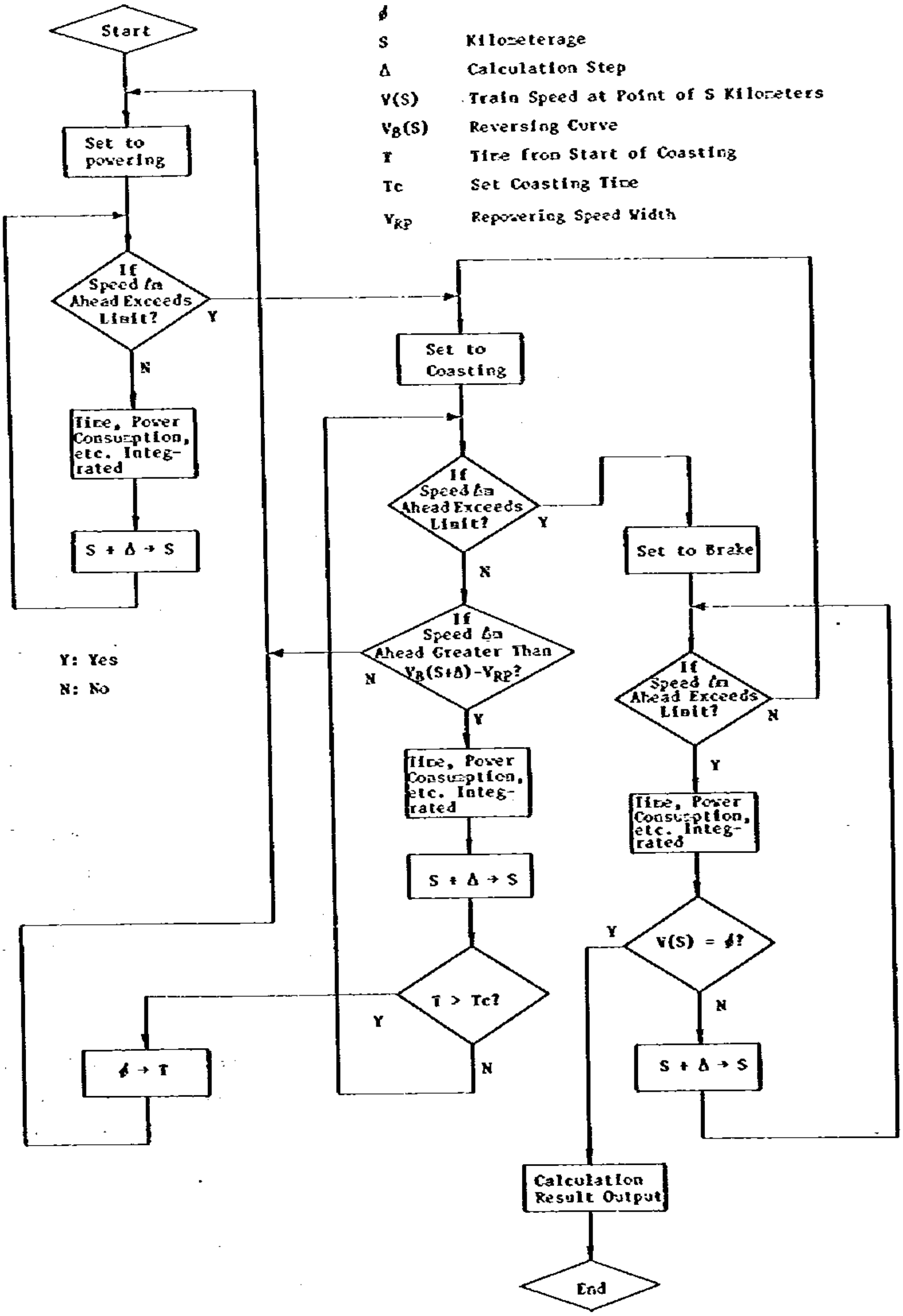


Fig. 8.6.10 Flow Chart

8.6.3 Operating Conditions for Simulation

(1) Maximum speed:

Passenger 120km/h

Freight 75km/h

(2) Speed limit on curves:

$V = 4.3 \sqrt{R}$; R: radium of curve (m)

Speed limit on turnouts, restrained speed etc.

: Not considered

(3) Speed limit on down-grade:

Not considered.

(4) Method of operation for the limited speed:

Operated at -2km/h of the limit value.

8.7 Recapitulation

8.7.1 Simulation Results and Consideration

The results of simulation are shown in Table 8.7.1. First, Cases IV and V are with the 90 tons, 6-axle locomotive, and the locomotive capacity as seen from the RMS current is too much marginal at about 60 percent (ratio to the continuous rating) for the freight train as heavy as 1200 tons, while the operating time is not so much reduced. It may be considered that the 6-axle locomotive is not suitable.

In the case of the 4-axle locomotive, it is necessary to note the load condition particularly at the section with steep gradient between Prupuk and Bumiayu. (The up-grade slope continues over Bumiayu to a point somewhat beyond Patugran but when the RMS current is taken, it is greater up to Bumiayu. The whole section of Prupuk-Patuguran has a height difference of 304m and a line length of 33km so that the grade is equivalent to 9.2 ‰ .)

The operating time of the freight train in this section is within 30 minutes so that if the RMS current is within 115 ∿ 120 percent of the continuous rating, the temperature rise is within the limit and poses no practical problem. In this respect, the D-2 locomotive has a difficulty for practical use, and D-1 or D-3 becomes a candidate. On the other hand, when the operating time is taken, D-1 is considerably low in the mean speed as compared with the others, and in this respect, D-3 is advantageous. If it is taken as a condition to start on the 13 ‰ slope between Purpuk and Rurwokerto, 900t rather than 100t is

Table 8.7.1

CASE	I - 1	I - 2	II - 1	II - 2	III - 1	III - 2	III - 3	IV - 1	IV - 2	V - 1	V - 2
Locomotive	D - 1	D - 1	D - 2	D - 2	D - 3	D - 3	D - 3	F - 1	F - 1	F - 2	F - 2
Hauled train	PC 400ton	FC 1000ton	PC 400ton	FC 1000ton	PC 400ton	PC 400ton	FC 1000ton	PC 400ton	FC 1200ton	PC 400ton	FC 1200ton
Max. speed	110 km/h	75 km/h	110 km/h	75 km/h	110 km/h	120 km/h	75 km/h	110 km/h	75 km/h	110 km/h	75 km/h
NORTH LINE: (723.45 km)											
Operating time	7°-56'-56"	10°-49'-38"	7°-39'-44"	10°-35'-45"	7°-21'-41"	7°-08'-52"	10°-25'-40"	7°-19'-17"	10°-19'-10"	7°-13'-42"	10°-15'-23"
RMS Curr. (Amps.)	211.2 A	313.2 A	239.4 A	348.7 A	284.0 A	297.5 A	381.4 A	177.8 A	272.0 A	193.8 A	290.9 A
(ratio)	44.0 %	65.3 %	50.0 %	72.7 %	52.6 %	55.1 %	70.6 %	37.1 %	56.7 %	40.4 %	60.6 %
Power consumption	6010 kwh	12264 kwh	6398 kwh	12692 kwh	6835 kwh	7215 kwh	12927 kwh	6834 kwh	15051 kwh	7038.8 kwh	15298 kwh
SOUTH LINE: (829.31 km)											
Operating time	9°-02'-14"	12°-42'-26"	8°-39'-9"	12°-19'-51"	8°-20'-59"	7°-45'-42"	12°-05'-50"	8°-28'-24"	12°-14'-43"	8°-21'-58"	12°-08'-13"
RMS Curr. (Amps.)	214.2 A	325.0 A	239.7 A	363.0 A	280.9 A	301.1 A	390.6 A	183.4 A	288.0 A	198.7 A	307.4 A
(ratio)	44.6 %	67.7 %	49.9 %	75.6 %	52.0 %	55.8 %	72.3 %	38.2 %	60.0 %	41.4 %	64.1 %
Power consumption	6966 kwh	14004 kwh	7325 kwh	14582 kwh	7713 kwh	8205 kwh	14903 kwh	7981 kwh	17617 kwh	8171 kwh	17920 kwh
PRUPUK-BUMIAYU:											
RMS Curr. (Amps.)	345.8 A	539.1 A	385.2 A	608.5 A	446.9 A	446.7 A	625.8 A	278.4 A	519.8 A	309.6 A	535.0 A
(ratio)	72.0 %	112.3 %	80.3 %	126.8 %	82.8 %	82.7 %	115.9 %	58.0 %	108.3 %	64.5 %	111.6 %
BANDUNG LINE: (173.73 km)											
Operating time			2°-11'-59" (non-stop)		2°-07'-36" (non-stop)	2°-05'-50" (non-stop)		2°-14'-57" (non-stop)		2°-13'-10"	
RMS Curr. (Amps.)			335.3 A		382.4 A	387.7 A		260.7 A		287.1 A	
(ratio)			69.9 %		70.8 %	71.8 %		54.3 %		59.8 %	
Power consumption			2439 kwh		2522 kwh	2573 kwh		2696 kwh		2758 kwh	

Note: Station dwelling time is excluded in each case

adequate. (Running simulation of D-3 locomotive is illustrated in Figs. 8.7.1∿8.7.8 and their attached.)

8.7.2 Supplements Concerning D-3 Type Locomotive

Specifications of the D-3 type Locomotive are listed again in the following.

Electric system	:	25kV, 50Hz
Axle arrangement	:	$B_o - B_o$
Tare weight	:	60 tons (Axle load: 15 tons)
Continuous ratings	:	Output 1800kW
		Tractive effort 13,200kg
		Rated speed 49km/h
Control system	:	Thyristor continuous phase control, and Field control (Minimum field, 50%).
Traction motor continuous rating	:	450kW-900V-540A-1070rpm
Driving wheel diameter	:	1120mm (1080mm for calculation)
Gear ratio	:	16:71 = 1:4.44
Power transmission	:	Nose suspension with axle roller

This locomotive specification is of very high level in view of the weight, output and performance and is realizable only through positive application of high level techniques in the whole system design and individual equipment design. At the same time, thorough examination is necessary in the aspects of the failure rate or reliability and maintenability. If the rated output only is noted, it is possible to propose greater nominal value nominally greater output is practicable. But, when various important factors such as those cited above are considered, this specification is recommended as the optimum one for the Indonesian State Railways.

If DC locomotives have a performance approximately equivalent to those of the D-3 type, they should have 6-axles drive.

8.7.3 Running Curve by Simulation and Data

The results of simulation of running by D-3 type AC locomotive of passenger and freight trains along the North, South and Bandung Lines are shown in Figs. 8.7.1 through 8.7.8 and appended data. The Fig. 8.7.9 is an image sketch of D-3 type locomotive.

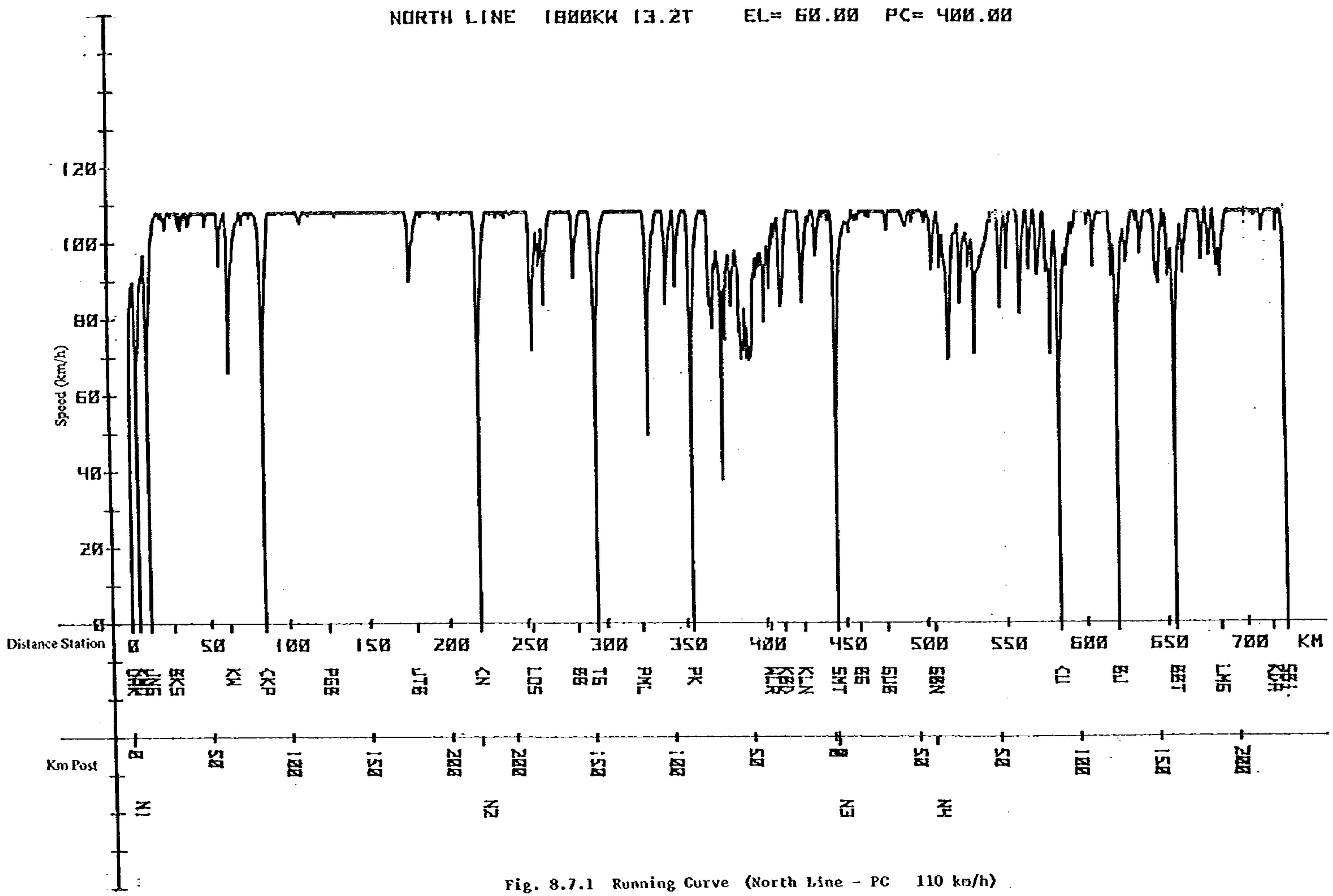


Fig. 8.7.1 Running Curve (North Line - PC 110 km/h)

```
NORTH LINE  1800
kN 13.2T
L=            60.00
PC=          400.00
Prate=      1800.00
Frate=        13.20
Vrate=        49.06
Irate=       540.00
Vm= 110   Vd=     2
Iac= 630A   16210
α= 1.08   β= 1.50

 * Jak
D(km)          4.71
T(s)         270.69
E(kWh)        69.06
RMS(A)       399.11
              73.91
 * Kmo
D(km)          7.04
T(s)         366.64
E(kWh)       106.39
RMS(A)       392.25
              72.64
 * Jng
D(km)         14.80
T(s)         562.94
E(kWh)       189.65
RMS(A)       361.78
              67.00
 | Bks
D(km)         35.78
T(s)        1209.63
E(kWh)       285.91
RMS(A)       242.91
              44.96
 | Ku
D(km)         21.68
T(s)         801.02
E(kWh)       226.98
RMS(A)       289.48
              53.61
 * Cke
D(km)         40.25
T(s)        1415.85
E(kWh)       375.59
RMS(A)       283.40
              52.48

 | Pgb
D(km)         54.86
T(s)        1847.30
E(kWh)       430.93
RMS(A)       228.61
              42.34
 | Jtb
D(km)         40.05
T(s)        1378.87
E(kWh)       324.65
RMS(A)       236.76
              43.84
 * Cn
D(km)         33.10
T(s)        1178.75
E(kWh)       333.24
RMS(A)       300.32
              55.61
 | Los
D(km)         28.70
T(s)        1026.99
E(kWh)       262.40
RMS(A)       268.67
              49.75
 | Bb
D(km)         12.20
T(s)         455.34
E(kWh)        94.91
RMS(A)       232.44
              43.04
 * Tg
D(km)         28.10
T(s)        1010.78
E(kWh)       298.24
RMS(A)       311.94
              57.77
 | Pal
D(km)         31.90
T(s)        1184.08
E(kWh)       307.18
RMS(A)       283.35
              52.47
 * Pk
D(km)         49.10
T(s)        2066.60
E(kWh)       518.89
RMS(A)       315.98
              58.50

 | Mlr
D(km)          8.80
T(s)         326.63
E(kWh)        75.35
RMS(A)       263.50
              48.80
 | Kbd
D(km)         12.00
T(s)         416.64
E(kWh)        96.12
RMS(A)       242.25
              44.86
 | Kln
D(km)         20.40
T(s)         743.36
E(kWh)       176.67
RMS(A)       255.71
              47.35
 * Smt
D(km)         14.60
T(s)         558.68
E(kWh)       196.74
RMS(A)       377.56
              69.92
 | Bg
D(km)         16.90
T(s)         566.04
E(kWh)       135.60
RMS(A)       238.54
              44.17
 | Gub
D(km)         29.41
T(s)         994.93
E(kWh)       275.38
RMS(A)       267.49
              49.54
 | Gbn
D(km)         78.50
T(s)        2935.30
E(kWh)       748.36
RMS(A)       281.52
              52.13
 * Cu
D(km)         36.15
T(s)        1358.32
E(kWh)       332.17
RMS(A)       289.37
              53.68

 * Bj
D(km)         35.72
T(s)        1355.53
E(kWh)       346.47
RMS(A)       298.35
              55.25
 * Bbt
D(km)         28.20
T(s)        1045.26
E(kWh)       265.39
RMS(A)       311.43
              57.67
 | Lns
D(km)         32.37
T(s)        1097.78
E(kWh)       286.38
RMS(A)       256.84
              47.56
 | Kdo
D(km)          8.63
T(s)         326.56
E(kWh)        56.49
RMS(A)       207.15
              38.36
 * Sbi

---TOTAL---
D(km)        723.45
T(s)       26500.32
E(kWh)      6834.66
RMS(A)       284.03
              52.60
```

(Note)

L	:	Locomotive weight (ton)
PC	:	Passenger car weight (ton)
P rate	:	Rated output (KW)
F rate	:	Rated traction force (ton)
V rate	:	Rated speed (km/h)
I rate	:	Rated current (A)
Vm	:	Maximum speed
Vd	:	Speed compensation value
Iao	:	Current limiting value (A)
α	:	Acceleration (km/h/sec)
β	:	Deceleration (km/h/sec)

Fig. 8.7.1 Attach

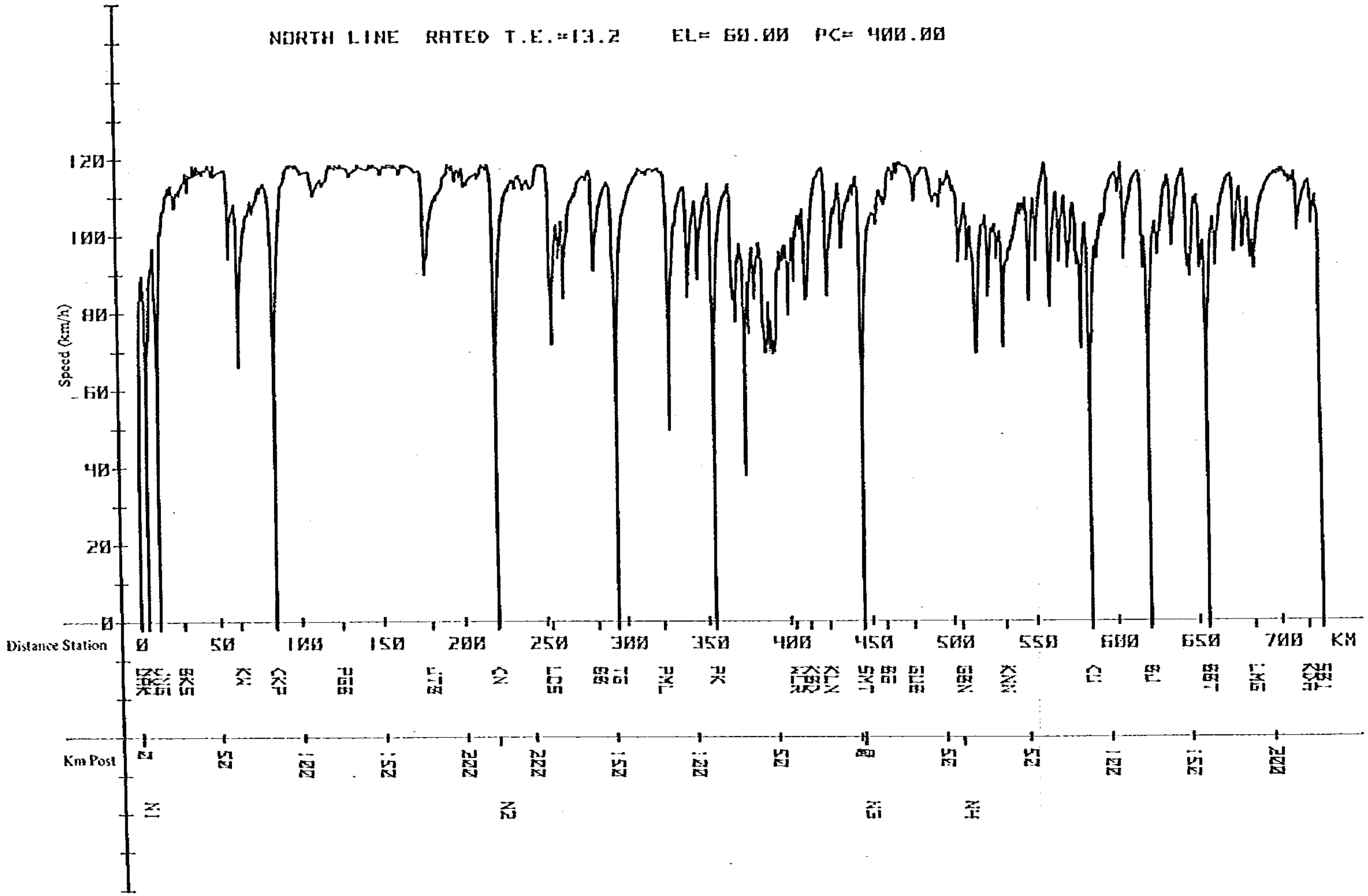


Fig. 8.7.2 Running Curve (North Line - PC 120 km/h)

```
NORTH LINE   RATE
D T.E.=13.21
L=            60.00
PC=          400.00
Prate=      1800.00
Frate=        13.20
Vrate=        19.06
Irate=       510.99
Vm= 120   Vd=     2
Iac= 630A   16210
α= 1.06   β= 1.50

 * Jak
D(km)          4.71
T(s)         270.69
E(kWh)        69.06
RMS(A)       399.11
              73.91

 * Kno
D(km)          7.04
T(s)         366.64
E(kWh)       106.39
RMS(A)       392.25
              72.64

 * Jng
D(km)         14.90
T(s)         553.70
E(kWh)       195.95
RMS(A)       370.23
              68.56

 ↓ Bks
D(km)         35.79
T(s)        1135.21
E(kWh)       310.96
RMS(A)       261.64
              48.45

 ↓ Ku
D(km)         21.60
T(s)         789.67
E(kWh)       232.40
RMS(A)       295.60
              54.74

 * Ckp
D(km)         40.25
T(s)        1336.27
E(kWh)       410.54
RMS(A)       307.19
              56.89
```

```
 ↓ Pab
D(km)         54.86
T(s)        1708.73
E(kWh)       466.77
RMS(A)       254.98
              47.22

 ↓ Jtb
D(km)         40.05
T(s)        1304.74
E(kWh)       354.78
RMS(A)       260.37
              48.22

 * Cn
D(km)         33.10
T(s)        1128.00
E(kWh)       356.65
RMS(A)       320.61
              59.37

 ↓ Los
D(km)         28.70
T(s)        1006.53
E(kWh)       276.22
RMS(A)       281.72
              52.17

 ↓ Jb
D(km)         12.20
T(s)         447.78
E(kWh)       101.00
RMS(A)       246.50
              45.65

 * Tg
D(km)         28.10
T(s)         967.11
E(kWh)       320.89
RMS(A)       333.37
              61.74

 ↓ Pal
D(km)         31.93
T(s)        1167.70
E(kWh)       316.46
RMS(A)       291.26
              53.94

 * Pk
D(km)         49.10
T(s)        2061.71
E(kWh)       524.90
RMS(A)       318.08
              58.90
```

```
 ↓ Mlr
D(km)          8.80
T(s)         326.63
E(kWh)        75.35
RMS(A)       263.50
              48.80

 ↓ Kbd
D(km)         12.00
T(s)         401.87
E(kWh)       108.45
RMS(A)       271.91
              50.35

 ↓ Kln
D(km)         20.40
T(s)         732.76
E(kWh)       190.75
RMS(A)       270.84
              50.16

 * Snt
D(km)         14.00
T(s)         556.14
E(kWh)       200.04
RMS(A)       381.03
              70.56

 ↓ Bg
D(km)         16.90
T(s)         527.39
E(kWh)       154.46
RMS(A)       266.91
              49.43

 ↓ Gub
D(km)         29.41
T(s)         946.62
E(kWh)       281.37
RMS(A)       275.58
              51.03

 ↓ Gbn
D(km)         26.50
T(s)        1008.45
E(kWh)       267.12
RMS(A)       295.14
              54.66

 ↓ Knn
D(km)         52.10
T(s)        1915.01
E(kWh)       500.02
RMS(A)       282.20
              52.26
```

```
 * Cu
D(km)         36.15
T(s)        1325.93
E(kWh)       355.76
RMS(A)       304.32
              56.36

 * Bj
D(km)         35.72
T(s)        1334.74
E(kWh)       369.11
RMS(A)       309.60
              57.33

 * Bbt
D(km)         28.20
T(s)        1031.53
E(kWh)       300.59
RMS(A)       322.75
              59.77

 ↓ Lns
D(km)         32.37
T(s)        1058.[illegible]
E(kWh)       30[illegible].1[illegible]
RMS(A)       2[illegible].44
              [illegible]1.41

 ↓ Kdo
D(km)          9.63
T(s)         321.30
E(kWh)        58.75
RMS(A)       219.62
              40.67

 * Sbi

---TOTAL---
D(km)        722.45
T(s)       25731.08
E(kWh)      7214.94
RMS(A)       297.45
              55.08
```

Fig. 8.7.2 Attach

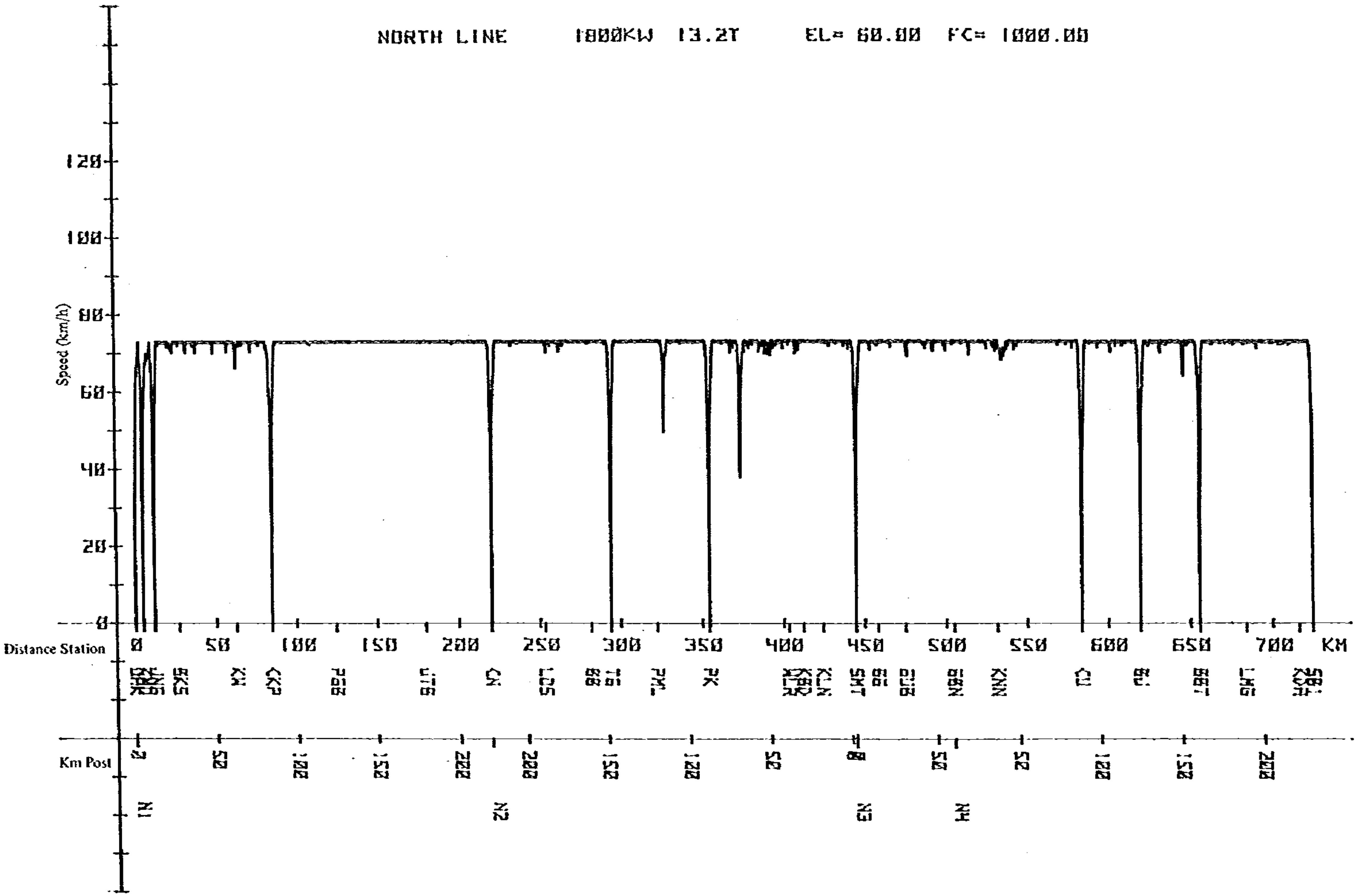


Fig. 8.7.3 Running Curve (North Line - FC 75 km/h)

NORTH LINE 1
800kW 13.2T

L=	60.00
FC=	1000.00
Prate=	1800.00
Frate=	13.20
Vrate=	49.06
Irate=	540.00
Vm= 75	Vd= 2
Iac= 650A	16890
α= 0.44	β= 0.70

* Jak

D(km)	4.71
T(s)	374.69
E(kWh)	122.05
RMS(A)	504.31
	93.39

* Kmo

D(km)	7.04
T(s)	502.07
E(kWh)	193.79
RMS(A)	519.40
	96.18

* Jng

D(km)	14.80
T(s)	821.12
E(kWh)	325.05
RMS(A)	464.91
	86.09

↓ Bks

D(km)	35.78
T(s)	1775.29
E(kWh)	593.52
RMS(A)	356.00
	65.93

↓ Ku

D(km)	21.68
T(s)	1135.34
E(kWh)	426.75
RMS(A)	400.47
	74.16

* Ckp

D(km)	40.25
T(s)	2082.60
E(kWh)	689.34
RMS(A)	370.90
	68.68

↓ Pgb

D(km)	54.86
T(s)	2715.13
E(kWh)	871.69
RMS(A)	325.86
	60.34

↓ Jtb

D(km)	40.05
T(s)	2035.64
E(kWh)	641.25
RMS(A)	333.54
	61.77

* Cn

D(km)	33.10
T(s)	1729.27
E(kWh)	626.75
RMS(A)	396.96
	73.51

↓ Lcs

D(km)	28.70
T(s)	1423.53
E(kWh)	503.15
RMS(A)	369.58
	68.44

↓ Bb

D(km)	12.20
T(s)	656.62
E(kWh)	193.83
RMS(A)	326.62
	60.49

* Ts

D(km)	28.10
T(s)	1482.77
E(kWh)	544.09
RMS(A)	397.16
	73.55

↓ Fal

D(km)	31.90
T(s)	1651.30
E(kWh)	538.10
RMS(A)	360.13
	66.69

* Pk

D(km)	49.10
T(s)	2582.11
E(kWh)	1007.10
RMS(A)	435.34
	80.62

↓ Hlr

D(km)	8.80
T(s)	437.34
E(kWh)	160.32
RMS(A)	393.37
	72.85

↓ Kbd

D(km)	12.00
T(s)	593.80
E(kWh)	170.52
RMS(A)	290.02
	53.71

↓ Kln

D(km)	20.40
T(s)	1065.48
E(kWh)	317.33
RMS(A)	333.98
	61.85

* Smt

D(km)	14.00
T(s)	739.87
E(kWh)	354.75
RMS(A)	532.39
	93.04

↓ Bg

D(km)	16.90
T(s)	837.19
E(kWh)	259.85
RMS(A)	315.78
	54.03

↓ Gub

D(km)	29.41
T(s)	1462.77
E(kWh)	594.39
RMS(A)	417.17
	77.25

↓ Gbn

D(km)	26.50
T(s)	1316.32
E(kWh)	505.99
RMS(A)	396.62
	73.45

↓ Knn

D(km)	52.10
T(s)	2643.86
E(kWh)	301.80
RMS(A)	333.45
	61.75

* Cu

D(km)	36.15
T(s)	1938.68
E(kWh)	623.99
RMS(A)	384.55
	71.21

* Bj

D(km)	35.72
T(s)	1918.38
E(kWh)	656.50
RMS(A)	401.32
	74.32

* Bbt

D(km)	28.20
T(s)	1482.32
E(kWh)	511.72
RMS(A)	394.66
	73.09

↓ Lrg

D(km)	32.37
T(s)	1603.12
E(kWh)	562.32
RMS(A)	362.19
	67.07

↓ Kda

D(km)	8.63
T(s)	480.05
E(kWh)	121.46
RMS(A)	293.21
	54.30

* Sbi

---TOTAL---

D(km)	723.45
T(s)	37539.65
E(kWh)	12926.62
RMS(A)	381.41
	70.63

Fig. 8.7.3 Attach

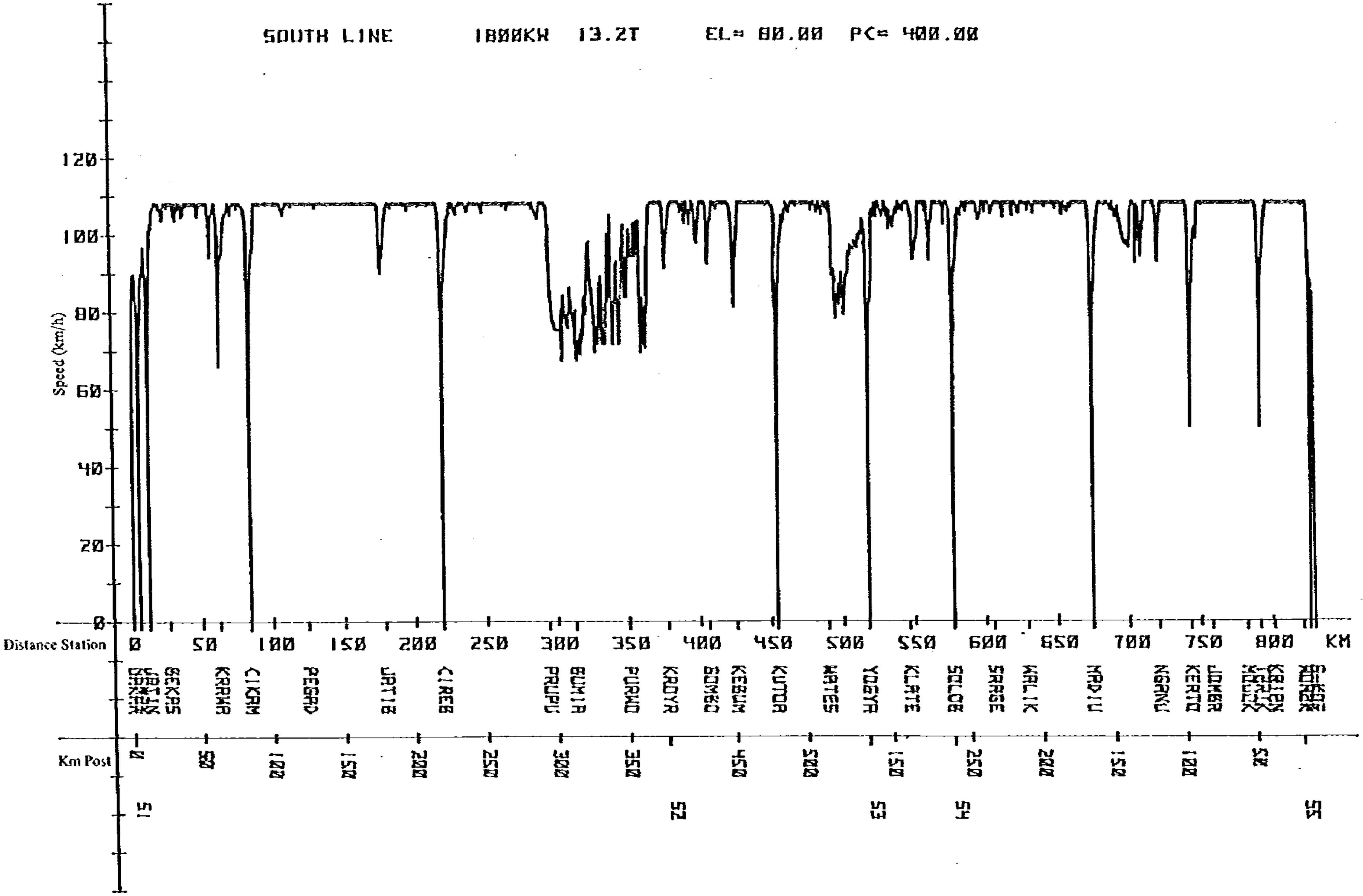


Fig. 8.7.4 Running Curve (South Line - PC 110 km/h)

```
SOUTH LINE
1800kW  13.21
L=          60.00
PC=        400.00
Prate=    1800.00
Frate=      13.20
Vrate=      49.06
Irate=     540.00
Va= 110  Vd=    2
Iac= 630A  16210
α= 1.08  β= 1.50

 * JAKAR
D(km)        4.71
T(s)       270.60
E(kWh)      69.06
RMS(A)     399.11
            73.91

 * KEMAY
D(km)        7.04
T(s)       366.64
E(kWh)     106.39
RMS(A)     392.25
            72.64

 * JATIN
D(km)       14.80
T(s)       562.94
E(kWh)     189.05
RMS(A)     361.78
            67.00

 ↓ BEKAS
D(km)       35.78
T(s)      1209.63
E(kWh)     285.91
RMS(A)     242.91
            44.98

 ↓ KRAWA
D(km)       21.68
T(s)       801.02
E(kWh)     226.98
RMS(A)     289.48
            53.61

 * CIKAN
D(km)       40.25
T(s)      1415.85
E(kWh)     375.59
RMS(A)     283.40
            52.48

 ↓ PEGAD
D(km)       54.86
T(s)      1847.30
E(kWh)     430.93
RMS(A)     228.61
            42.34

 ↓ JATIB
D(km)       40.05
T(s)      1378.87
E(kWh)     324.65
RMS(A)     236.76
            43.84

 * CIREB
D(km)       74.77
T(s)      2579.59
E(kWh)     734.49
RMS(A)     283.10
            52.43

 ↓ PRUPU
D(km)       18.62
T(s)       844.64
E(kWh)     384.34
RMS(A)     446.90
            82.76

 ↓ BUMIA
D(km)       37.29
T(s)      1675.25
E(kWh)     332.90
RMS(A)     291.88
            54.05

 ↓ PURWO
D(km)       27.17
T(s)      1024.75
E(kWh)     183.46
RMS(A)     233.27
            43.20

 ↓ KROYA
D(km)       28.85
T(s)       983.22
E(kWh)     244.21
RMS(A)     253.48
            46.94

 ↓ GOMBO
D(km)       19.46
T(s)       675.61
E(kWh)     177.97
RMS(A)     266.77
            49.40

 ↓ KEBUM
D(km)       28.13
T(s)       982.07
E(kWh)     225.61
RMS(A)     233.82
            43.30

 * KUTOA
D(km)       35.63
T(s)      1265.54
E(kWh)     362.25
RMS(A)     305.19
            56.52

 ↓ WATES
D(km)       28.01
T(s)      1115.59
E(kWh)     328.83
RMS(A)     313.90
            58.13

 * YOGYA
D(km)       28.58
T(s)      1037.47
E(kWh)     309.91
RMS(A)     323.31
            59.87

 ↓ KLATE
D(km)       30.59
T(s)      1085.58
E(kWh)     201.29
RMS(A)     221.54
            41.03

 * SOLOB
D(km)       28.95
T(s)      1047.02
E(kWh)     291.22
RMS(A)     310.50
            57.50

 ↓ SRAGE
D(km)       23.57
T(s)       791.19
E(kWh)     184.84
RMS(A)     240.02
            44.45

 ↓ WALIK
D(km)       44.44
T(s)      1526.63
E(kWh)     342.13
RMS(A)     232.96
            43.14

 * MADIU
D(km)       46.91
T(s)      1687.29
E(kWh)     459.27
RMS(A)     296.57
            54.92

 ↓ NGANJ
D(km)       21.36
T(s)       755.39
E(kWh)     171.76
RMS(A)     232.50
            43.06

 ↓ KERTO
D(km)       15.39
T(s)       550.39
E(kWh)     172.13
RMS(A)     311.93
            57.77

 ↓ JOMBA
D(km)       24.14
T(s)       806.39
E(kWh)     173.14
RMS(A)     215.34
            39.88

 ↓ MOJOK
D(km)        9.70
T(s)       346.87
E(kWh)      73.15
RMS(A)     249.84
            46.27

 ↓ TARIK
D(km)        9.33
T(s)       334.42
E(kWh)     108.53
RMS(A)     315.18
            58.37

 ↓ KRIAN
D(km)       20.36
T(s)       700.33
E(kWh)     168.71
RMS(A)     232.67
            43.09

 ↓ MONOK
D(km)        4.41
T(s)       183.63
E(kWh)      20.58
RMS(A)     159.68
            29.39

 * S-GUB
D(km)        3.18
T(s)       206.10
E(kWh)      53.48
RMS(A)     423.96
            78.51

 * S-KOT

---TOTAL---
D(km)      829.31
T(s)     30957.71
E(kWh)    7712.79
RMS(A)     280.90
            52.02
```

Fig. 8.7.4 Attach

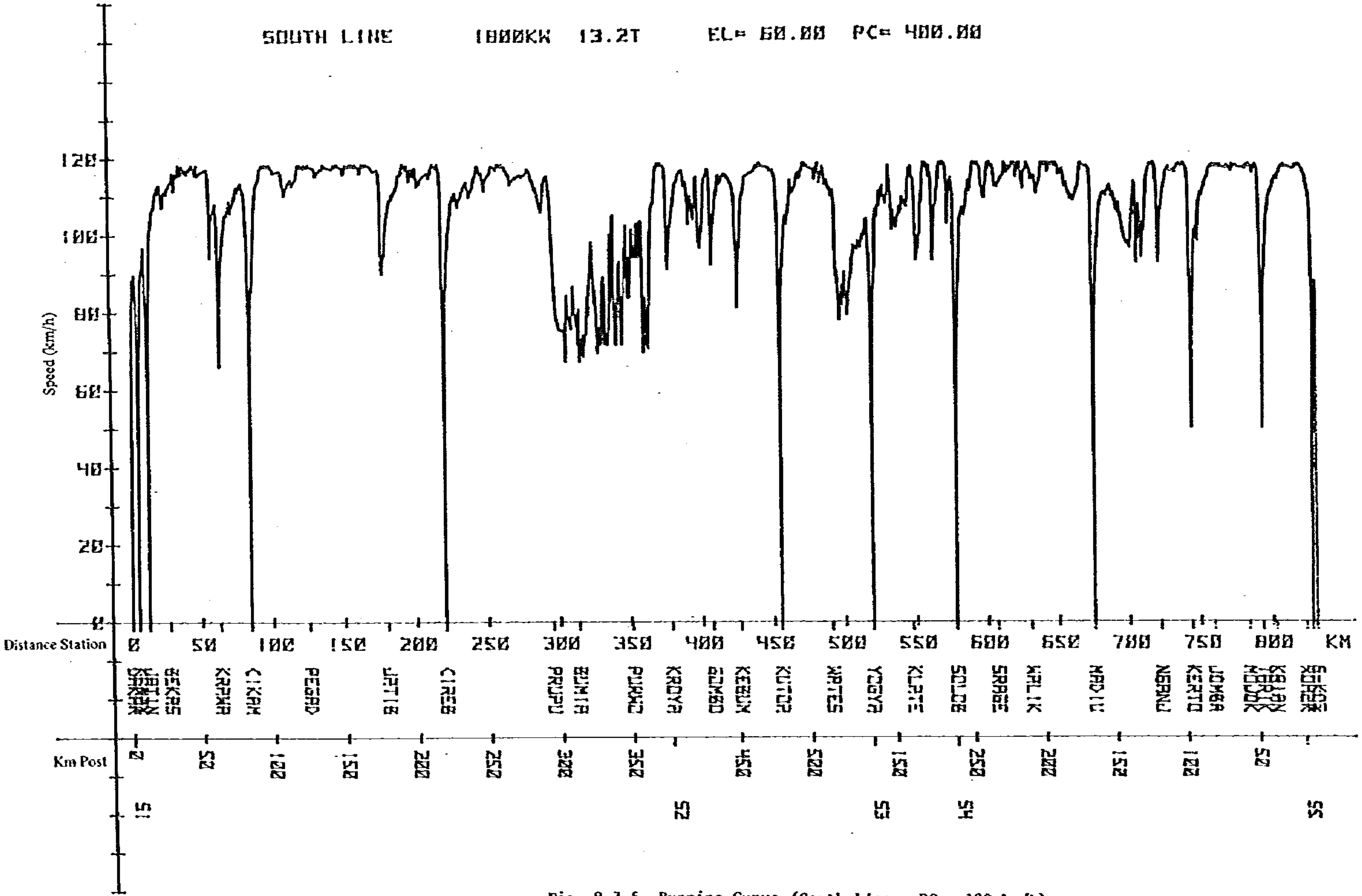


Fig. 8.7.5 Running Curve (South Line - PC 120 km/h)

SOUTH LINE
1800KW 13.21
L= 60.00
PC= 400.00
Prate= 1800.00
Frate= 13.20
Vrate= 49.06
Irate= 540.00
Vm= 120 Vd= 2
Ioc= 630A 16210
α= 1.08 β= 1.50

Station	D(km)	T(s)	E(kWh)	RMS(A)	
* JAKAR	4.71	270.69	69.06	399.11	73.91
* KEMAY	7.04	366.64	106.39	392.25	72.64
* JATIN	14.80	553.70	195.95	370.23	68.56
I BEKAS	35.78	1135.24	310.96	261.64	48.45
I KRAWA	21.68	789.67	232.40	295.60	54.74
* CIKAM	10.25	1336.27	410.54	307.15	56.83
I PEGAD	54.86	1708.73	466.77	254.98	47.22
I JATIB	40.05	1304.74	354.78	260.37	48.22
* CIREB	74.77	2457.50	768.82	299.57	55.48
I PRUPU	18.62	843.81	384.39	446.67	82.72
I BUMIA	37.39	1675.25	332.90	291.88	54.05
I PURWO	27.17	1002.52	198.47	247.15	45.77
I KROYA	28.85	952.40	266.54	273.14	50.58
I GOMBO	19.46	652.52	187.74	279.93	51.84
I KEBUM	28.13	925.79	247.41	258.51	47.87
* KUTOA	35.63	1204.23	335.90	319.65	59.19
I WATES	28.01	1112.15	337.22	313.57	58.07
* YOGYA	28.58	1019.45	326.38	331.55	61.40
I KLATE	30.59	1038.05	236.97	245.99	45.55
* SOLOB	28.95	1000.50	312.72	325.75	60.32
I SRAGE	23.57	734.49	204.69	260.09	48.16
I WALIK	14.44	1433.43	337.14	249.63	46.23
* MADIU	46.91	1653.33	484.67	307.45	56.94
I NGANJ	21.96	711.95	193.08	264.75	49.03
I KERTO	15.39	535.26	188.75	334.25	61.90
I JOMBA	24.14	739.64	193.16	244.44	45.27
I MOJOK	9.70	324.13	77.00	269.10	49.83
I TARIK	9.32	329.58	116.99	331.58	61.40
I KRIAN	20.97	645.84	187.36	263.74	48.84
I WONOK	4.41	178.35	16.11	150.52	27.87
* S-GUB	3.17	205.73	53.31	423.99	78.52
* S-KOT					

---TOTAL---

D(km)	829.30
T(s)	27941.58
E(kWh)	8204.57
RMS(A)	301.09
	55.76

Fig. 8.7.5 Attach

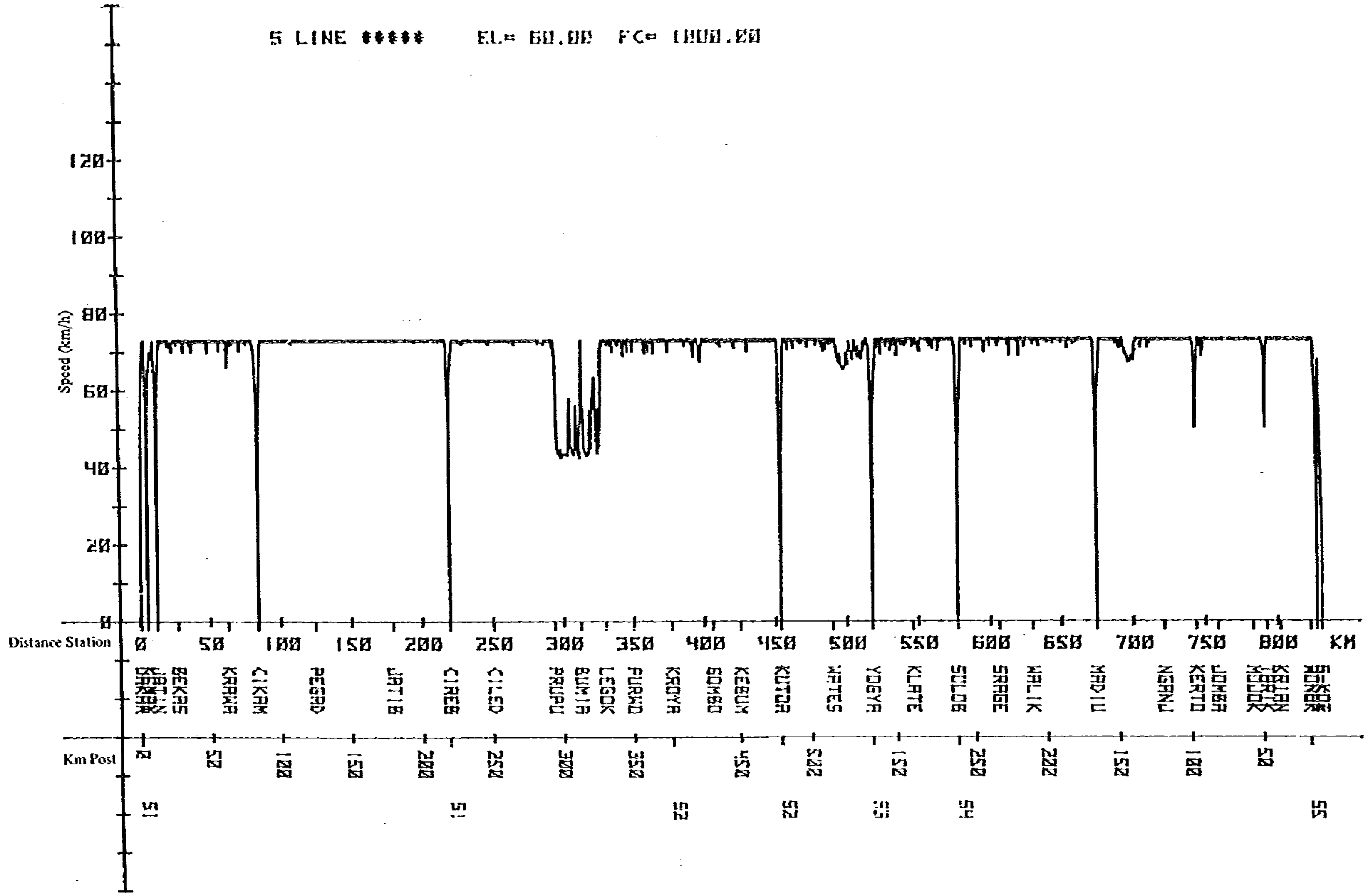


Fig. 8.7.6 Running Curve (South Line - FC 75 km/h)

```
S LINE *****
L=            60.00
FC=         1000.00
Prate=      1800.00
Frate=        13.20
Vrate=        49.06
Irate=       540.00
Vn=  75   Vd=    2
Iac= 650A   16890
α= 0.44   β= 0.70

 * JAKAR
D(km)          4.71
T(s)         374.69
E(kWh)       122.05
RMS(A)       504.31
              93.39

 * KEMAY
D(km)          7.04
T(s)         502.07
E(kWh)       193.79
RMS(A)       519.40
              96.18

 * JATIN
D(km)         14.99
T(s)         921.12
E(kWh)       325.95
RMS(A)       464.91
              86.09

 I BEKAS
D(km)         35.78
T(s)        1775.29
E(kWh)       593.52
RMS(A)       356.00
              65.93

 I KRAWA
D(km)         21.68
T(s)        1135.34
E(kWh)       426.75
RMS(A)       400.47
              74.16

 * CIKAM
D(km)         40.25
T(s)        2082.69
E(kWh)       689.34
RMS(A)       370.90
              68.68

 I PEGAD
D(km)         54.86
T(s)        2715.13
E(kWh)       871.69
RMS(A)       325.86
              60.34

 I JATIB
D(km)         40.05
T(s)        2035.64
E(kWh)       641.25
RMS(A)       333.54
              61.77

 * CIREB.

---TOTAL---
D(km)        219.17
T(s)       11441.88
E(kWh)      3863.45
RMS(A)       375.88
              69.61

S LINE *****
L=            60.00
FC=         1000.00
Prate=      1800.00
Frate=        13.20
Vrate=        49.06
Irate=       540.00
Vn=  75   Vd=    2
Iac= 700A   18586
α= 0.49   β= 0.70

 * CIREB
D(km)         31.85
T(s)        1659.63
E(kWh)       662.80
RMS(A)       431.02
              79.82

 I CILED
D(km)         42.92
T(s)        2126.67
E(kWh)       783.03
RMS(A)       370.67
              68.64

 I PRUPU
D(km)         18.62
T(s)        1438.88
E(kWh)       894.17
RMS(A)       625.80
             115.89

 I BUMIA
D(km)         17.96
T(s)        1215.42
E(kWh)       577.15
RMS(A)       514.34
              95.25

 I LEGOK
D(km)         19.43
T(s)         967.33
E(kWh)         9.92
RMS(A)        72.78
              13.48

 I PURMO
D(km)         27.17
T(s)        1352.46
E(kWh)       279.01
RMS(A)       294.84
              54.60

 I KROYA
D(km)         28.85
T(s)        1439.02
E(kWh)       492.33
RMS(A)       373.79
              69.22

 I GOMBO
D(km)         19.47
T(s)         964.98
E(kWh)       345.96
RMS(A)       369.61
              68.45

 I KEBUM
D(km)         28.12
T(s)        1445.21
E(kWh)       432.61
RMS(A)       322.38
              59.70

 * KUTOA

---TOTAL---
D(km)        234.39
T(s)       12609.60
E(kWh)      4476.97
RMS(A)       407.25
              75.42

L=            60.00
FC=         1000.00
Prate=      1800.00
Frate=        13.20
Vrate=        49.06
Irate=       540.00
Vn=  75   Vd=    2
Iac= 650A   16890
α= 0.44   β= 0.70

 * KUTOA
D(km)         35.63
T(s)        1858.24
E(kWh)       677.91
RMS(A)       414.46
              76.75

 I WATES
D(km)         28.01
T(s)        1501.56
E(kWh)       755.51
RMS(A)       515.43
              95.45

 * YOGYA
D(km)         28.53
T(s)        1519.05
E(kWh)       590.35
RMS(A)       448.46
              83.05

 I KLATE
D(km)         30.53
T(s)        1571.33
E(kWh)       389.85
RMS(A)       322.41
              59.71

 * SOLOB
D(km)         28.95
T(s)        1511.61
E(kWh)       530.05
RMS(A)       415.93
              77.03

 I SRAGE
D(km)         23.55
T(s)        1172.22
E(kWh)       364.55
RMS(A)       354.51
              65.65

 I WALIK
D(km)         44.45
T(s)        2259.25
E(kWh)       689.95
RMS(A)       343.01
              63.52

 * MADIU
D(km)         46.91
T(s)        2438.91
E(kWh)       946.90
RMS(A)       410.87
              76.09

 I NGANJ
D(km)         21.95
T(s)        1093.97
E(kWh)       316.60
RMS(A)       300.78
              55.70

 I KERTO
D(km)         15.39
T(s)         780.22
E(kWh)       292.95
RMS(A)       406.52
              75.28

 I JOMBA
D(km)         24.14
T(s)        1194.22
E(kWh)       236.93
RMS(A)       229.39
              55.44

 I MOJOL
D(km)          9.70
T(s)         493.81
E(kWh)       149.38
RMS(A)       338.48
              62.68

 I TARIK
D(km)          3.33
T(s)         467.10
E(kWh)       170.19
RMS(A)       377.52
              69.91

 I KRIAN
D(km)         20.97
T(s)        1037.76
E(kWh)       337.96
RMS(A)       330.26
              61.16

 I MONOK
D(km)          4.40
T(s)         270.10
E(kWh)        43.43
RMS(A)       219.32
              40.61

 * S-GUB
D(km)          3.18
T(s)         299.25
E(kWh)        80.50
RMS(A)       491.09
              90.94

 * S-KOT

---TOTAL---
D(km)        375.75
T(s)       19498.62
E(kWh)      6563.06
RMS(A)       387.98
              71.85

 * JAKARTA
D(km)        219.17
T(s)       11441.88
E(kWh)      3863.45
RMS(A)       375.88
              69.61
 * CIREBON
D(km)        234.39
T(s)       12609.60
E(kWh)      1476.97
RMS(A)       407.25
              75.42
 * KUTOARJO
D(km)        375.75
T(s)       19498.62
E(kWh)      6563.06
RMS(A)       387.98
              71.85
 * SURABAYAKOTA

---TOTAL---
D(km)        829.31
T(s)       43550.10
E(kWh)     14903.48
RMS(A)       390.56
              72.33
```

Fig. 8.7.6 Attach

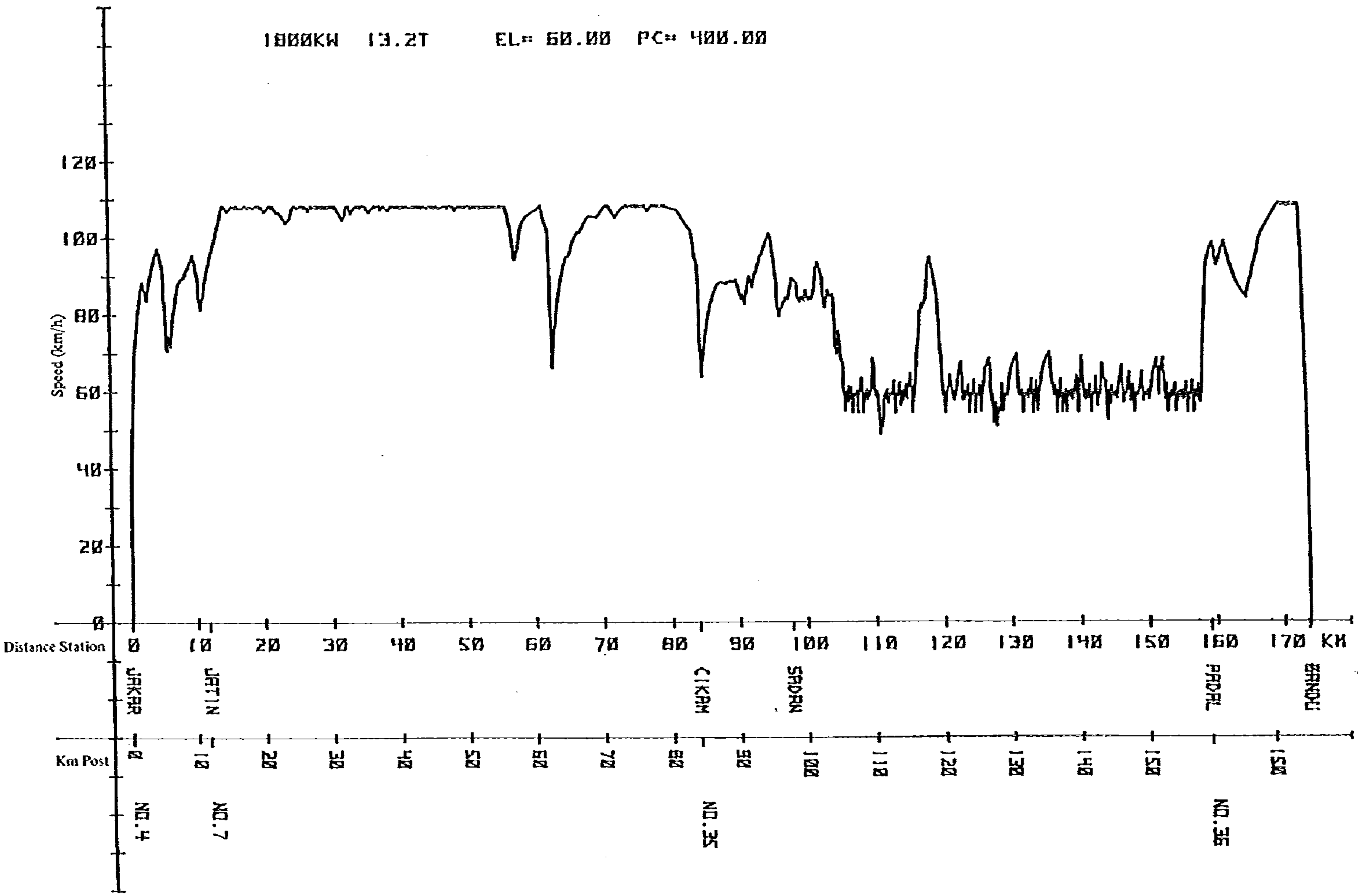


Fig. 8.7.7 Running Curve (Bandung Line - PC 110 km/h)

```
1800kW  13.21
L=            60.00
PC=          400.00
Prate=      1800.00
Frate=        13.20
Vrate=        49.06
Irate=       540.00
Vn= 110   Vd=     2
Iac= 630A   16210
α= 1.08   β= 1.50

 * JAKAR
D(km)         11.75
T(s)         532.65
E(kWh)       168.34
RMS(A)       387.13
              71.69
 ↓ JATIN
D(km)         72.26
T(s)        2478.63
E(kWh)       668.68
RMS(A)       268.33
              49.69
 ↓ CIKAM
D(km)         13.77
T(s)         576.16
E(kWh)       185.68
RMS(A)       349.77
              64.77
 ↓ SADAN
D(km)         61.29
T(s)        3493.22
E(kWh)      1345.13
RMS(A)       460.45
              85.27
 ↓ PADAL
D(km)         14.66
T(s)         575.40
E(kWh)       154.36
RMS(A)       294.51
              54.54
 * BANDU

---TOTAL---
D(km)        173.73
T(s)        7656.07
E(kWh)      2522.19
RMS(A)       382.36
              70.81
```

Fig. 8.7.7 Attach

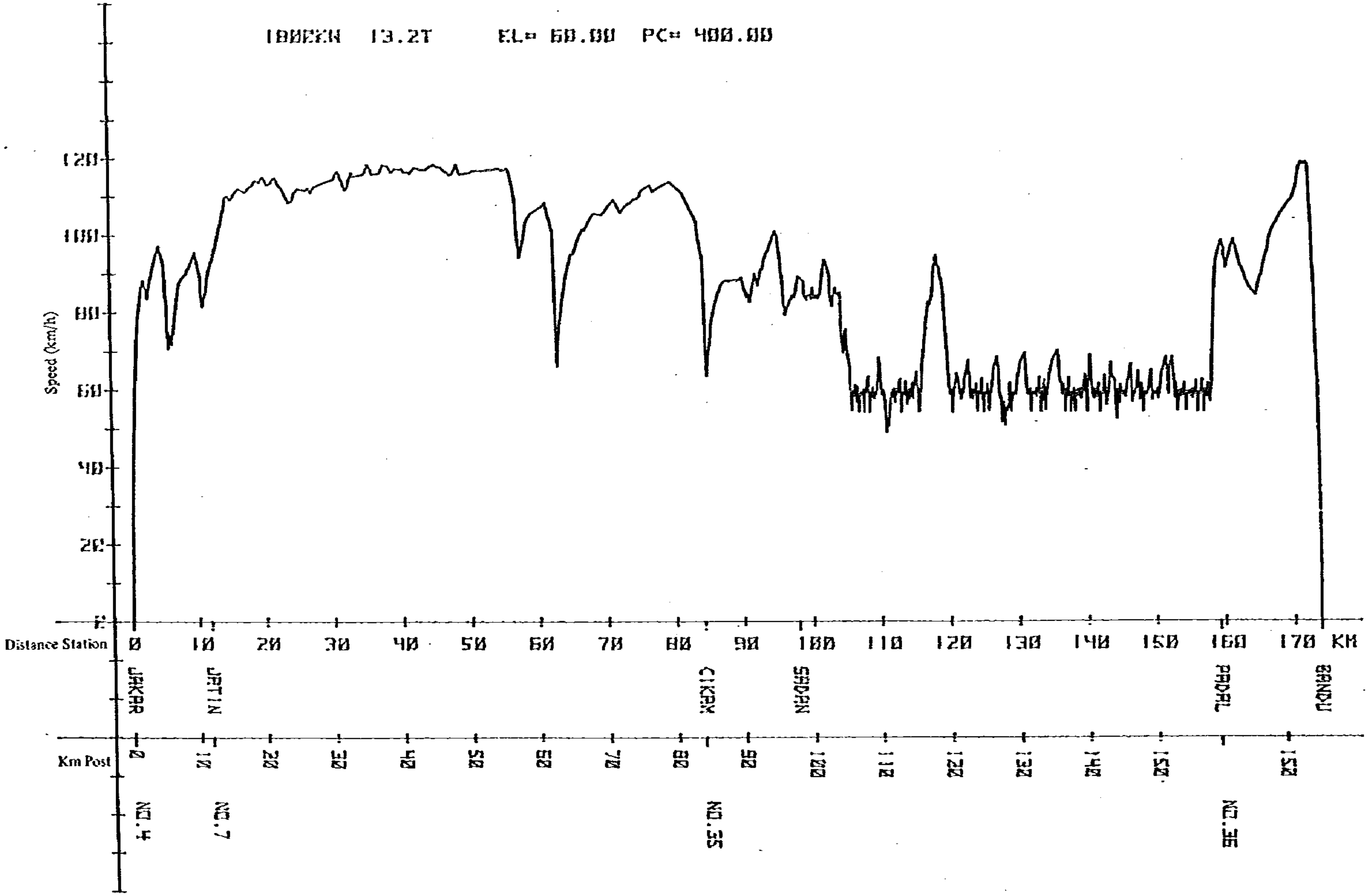


Fig. 8.7.8 Running Curve (Bandung Line - PC 120 km/h)

```
1800kW   13.2T
L=           60.00
PC=         400.00
Prate=     1800.00
Frate=       13.20
Vrate=       49.06
Irate=      540.00
Vn= 120   Vd=    2
Iac= 630A  16210
α= 1.08   β= 1.50

 * JAKAR
D(km) ·      11.75
T(s)        532.65
E(kWh)      168.34
RMS(A)      387.13
             71.69
 ↓ JATIN
D(km)        72.26
T(s)       2377.68
E(kWh)      708.60
RMS(A)      283.19
             52.44
 ↓ CIKAN
D(km)        13.77
T(s)        576.15
E(kWh)      185.68
RMS(A)      349.77
             64.77
 ↓ SADAN
D(km)        61.29
T(s)       3493.22
E(kWh)     1345.13
RMS(A)      460.45
             85.27
 ↓ PADAL
D(km)        14.66
T(s)        570.14
E(kWh)      165.71
RMS(A)      305.42
             56.56
 * BANDU

---TOTAL---
D(km)       173.73
T(s)       7549.85
E(kWh)     2573.46
RMS(A)      387.69
             71.80
```

Fig. 8.7.8 Attach

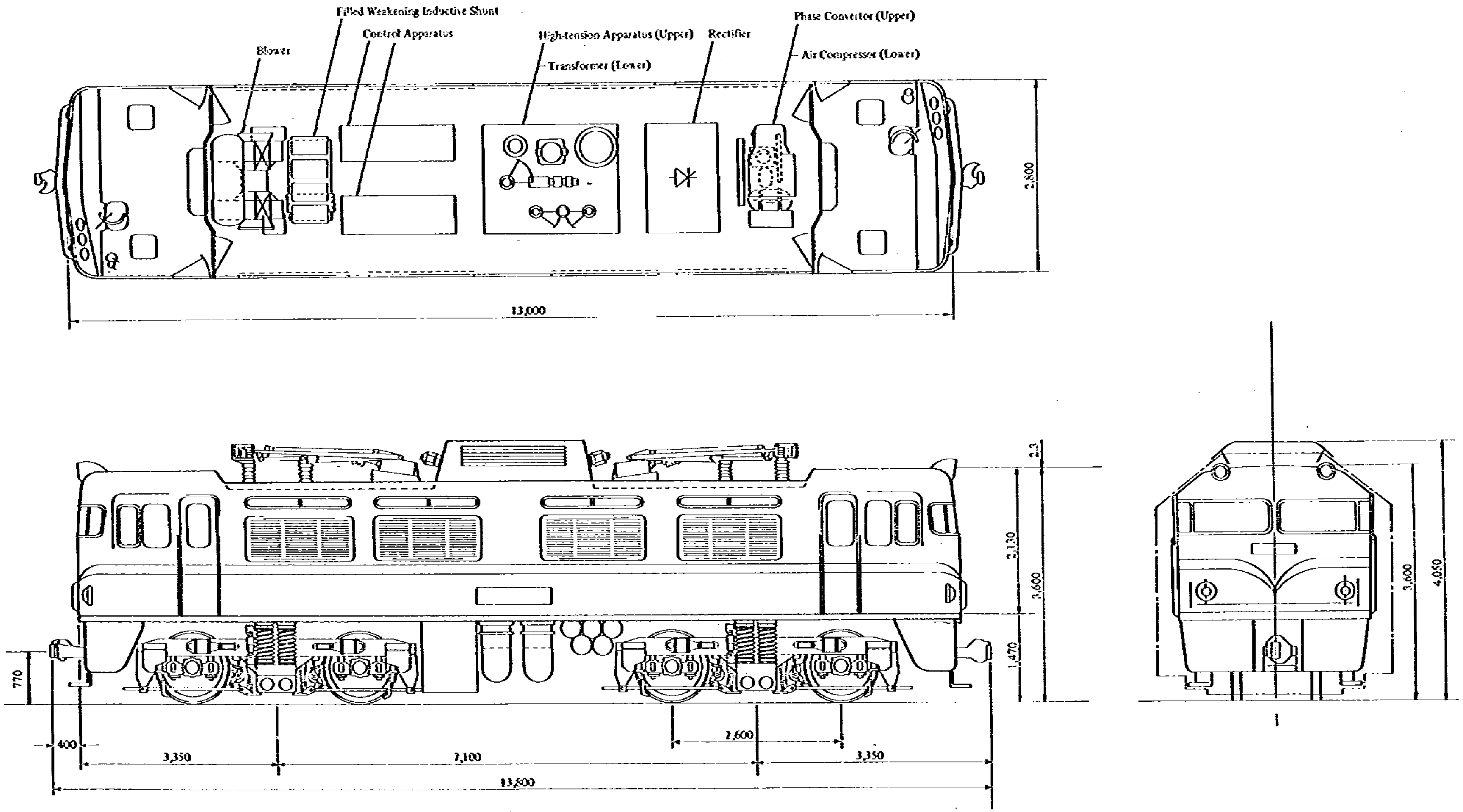


Fig. 8.7.9 D-3 Type Image Sketch

CHAPTER 9 ROLLING STOCK WORKSHOP AND ROLLING STOCK DEPOT

CHAPTER 9 ROLLING STOCK WORKSHOP AND ROLLING STOCK DEPOT

9.1 Rolling Stock Workshop

As the railway transport capacity is improved by electrification, the rolling stock changes greatly in quality as well as quantity. It is necessary then to improve the rooling stock workshop so that it will be able to cope with these changes. Passenger cars in particular will be greatly increased and will exceed the current repair capacity of the workshop soon after electrification begins. Therefore, it is required to note the changes in the transport of passengers after electrification so that measures to improve workshop capacity will be taken in time.

As for locomotives, when electrification of the main lines is completed, there should be about 19 DC electric locomotives and about 256 AC electric locomotives. The big diesel locomotives for the main lines will all be replaced by electric locomotives so that remaining diesel locomotives will be the small type used in local sections and for shunting. Consequently, the repair work load for diesel locomotives will greatly decrease, while repairing electric locomotives, not presently done, will increase sharply. Thus, the current locomotive repair work system has to be greatly changed.

The following are the results of an study of the promblem concerning repair of electric locomotives. First, the basic specifications for repair of the electric locomotives and the workshop capacity based on these specifications are set forth. Then, the possibility of converting the existing workshops and selection of such workshops, and a general equipment plan, etc. for both cases of converting the existing workshops and constructing new workshops, are studied.

9.1.1 Basic Specifications for Electric Locomotive Repairing at Workshop

(1) Inspection system

Electric locomotives are subject to wear, rust, etc. and their performance and functions deteriorate gradually with use. Thus after use for some time, it is necessary to check the locomotive, do any necessary repairs, and restore to the initial condition. Electric locomotives will assume all of the railway transport along the main lines on Java Island, so high reliability is required. A preventive maintenance system is thus employed to perform inspection and repairing at a predetermined cycle.

For the types, details, cycles and places of inspections, it is considered appropriate, when the quality of the recent electric locomotives and the experience with similar locomotives in the Japanese National Railways are taken into consideration, that they should be determined as shown in Table 9.1.1.

Table 9.1.1 Types, Details and Cycles of Inspection, and Places of Inspection (Standard)

Types and Details of Inspection			Cycles of Inspection		Places of Inspection
Types		Details	Period	Running Distance	
Periodic inspection	General Inspection	Total inspection with the respective parts dismantled at a predetermined cycle.	Within 60 months	Within 800,000km	workshop
	Principal equipment inspection	Inspection upon disassembly of main parts such as traction motors, trucks power transmissions, running gears, brake equipment, controllers, auxiliary motor, etc. at a predetermined cycle.	Within 30 months	Within 400,000km	workshop
	Bogie inspection	Inspection made of main parts, such as traction motors, trucks power transmissions, running gears, brake equipment, etc, at a predetermined cycle.	Within 15 months	Within 200,000km	Depot
	Monthly Inspection	Inspection made of the conditions and functions of main parts at a predetermined cycle.	Within 60 days	Within 25,000km	Depot
Daily inspection	Daily Inspection	Inspection made externally, depending on the condition of use of the locomotives, of the conditions and functions of main parts prior to operation.	Within 48 hours	Express, within 2000km; and Local, within 1000km	Depot
Occasional inspection	Extra-ordinary inspection	Inspection made of part or whole of the locomotive, as required.	Occasional		Workshop Depot

At the initial stage of electrification, it will be realistic to tentatively reduce the inspection periods as it is required to grasp the scope of changes related to the use of electric locomotives and also to give due consideration to immature inspection and repair techniques. It will be necessary to see if such a tentative system is required and, if required, what items are to be included. For reference, an example of such a tentative system is shown in Table 9.1.2

Table 9.1.2 Types and Cycles of Inspection, and Places of Inspection (Tentative)

Type and details of inspection			Cycles of inspection		Places of inspection
Types		Details	Period	Running distance	
Periodic inspection	General Inspection	Same as Table 9.1.1.	Within 48 months	Within 480,000km	Workshop
	Principal equipment inspection	Same as above	Within 24 months	Within 240,000km	Workshop
	Yearly inspection	Inspection made to the respective parts of traction motors, power transmissions, running gears, brake equipment, meters, etc. upon partial disassembly.	Within 12 months	Within 120,000km	Depot
	Monthly inspection	Same as Table 9.1.1.	Within 30 days	Within 12,000km	Depot
Daily inspection	Daily inspection	Same as above	Within 48 hours	Within 1,200km	Depot
Occasional inspection	Extraordinary inspection	Same as above	As required		Workshop depot

(2) Scope of work at the workshop

The major work to be executed at the workshop with respect to inspection and reapir of locomotives will be as follows.

a. General inspection and principal equipment inspection.
b. Inspection and reapiring on exceptional basis.
c. Repair and management of spare parts.
d. Management of purchase parts.
e. Supply of locomotive parts to depots.
f. Maintenance of workshop facilities, and management of measuring instruments.
g. Investigation of locomotive failures and corrective measures.

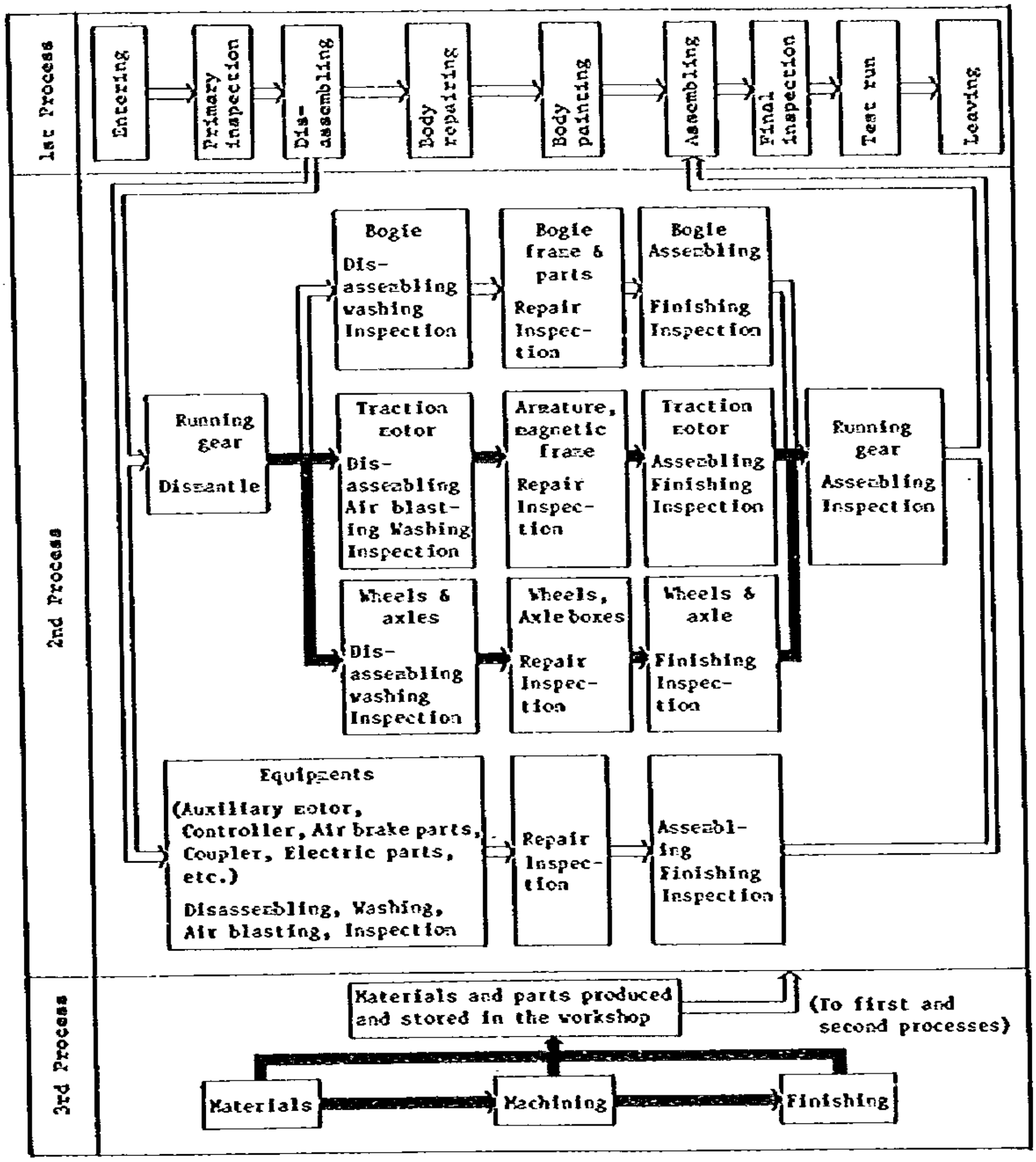
(3) Work System

In order to carry out locomotive reapir work at the workshop reasonably and efficiently, a basic work system was determined as below.

a. Periodic inspections be made according to a predetermined schedule.
b. Test runs be made of the locomotives subject to periodic inspection and extraordinary inspection of the main parts such as running gears, controllers, brake equipments, etc. or modifications.
c. The locomotive reapiring process is classified in to three steps as shown in Table 9.1.3 and Fig. 9.1.1, and each step is managed independently. By this, the process can be reduced and stabilized and the work standardized.

Table 9.1.3 Inspection and Repairing Process

Processes	Details
1st Process	Process of inspecting and repairing the locomotive body and equipment mounted on the body.
2nd Process	Process of inspecting and repairing the equipment taken off the body.
3rd Process	Process of manufacturing parts and materials required in the first and second processes.



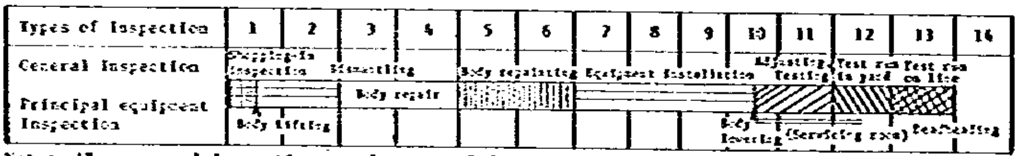
Note: ➡ indicates the flow not directly affected by the first process.
In the second process, recirculated spare parts are to be used.

Fig. 9.1.1 Basic Flow Chart in the Inspection and Repair Process

(4) Standard process

The locomotive repairing process is determined by how deteriorated the locomotive is, the number of locomotives to be reapired a year and the number of work days, technical level and number of the workers, equipment used for inspection and repairing and acquisition of the required materials. However, it is very important for the management of the workshop to determine a reasonably logical process with the foregoing conditions taken into consideration, and thus plan and execute the direct and indirect work with reference to the above process as a standard, and examine the results of execution.

Fig. 9.1.2 illustrates a standard process at the time of completion of electrification of the main lines, and it is prepared on the basis of the foregoing conditions. It is therefore, necessary to study this process further, including establishment of a standard process for the initial stage and medium stage of electrification and so on as electrification progresses.



Note: When several locomotives, under general inspection and under principal equipment inspection, are inspected simultaneously, two methods are available: one is to change the process for each type of inspection with emphasis placed on levelling the workers; and the other is to avoid overlapping of the process of dismantling and mantling works and to simplify progress management, thus carring out the work in one and the same process. The chart gives an example of the latter.

Fig. 9.1.2 Standard Process (Example)

9.1.2 Equipment Scale and Capacity of Electric Locomotive Workshop

(1) Scale and capacity of workshop

The number of electric locomotives at the time of completion of electrification of the main lines is estimated to be about 19 DC electric locomotives and about 256 AC electric locomotives, for a total of about 275. When planning the workshop facilities, it is necessary that the facilities have a capacity sufficient to withstand an increase in locomotives in the near future. Thus, the workshop scale was set for a 10 percent increase of the foregoing number, or 300 locomotives, and the facilities capacity was planned to cope with this scale.

In such a case, the number of locomotives to be inspected will be as shown in the following table (in the case of the standard inspection system).

Table 9.1.4 Number of Locomotives to be Inspected (for Equipment Planning)

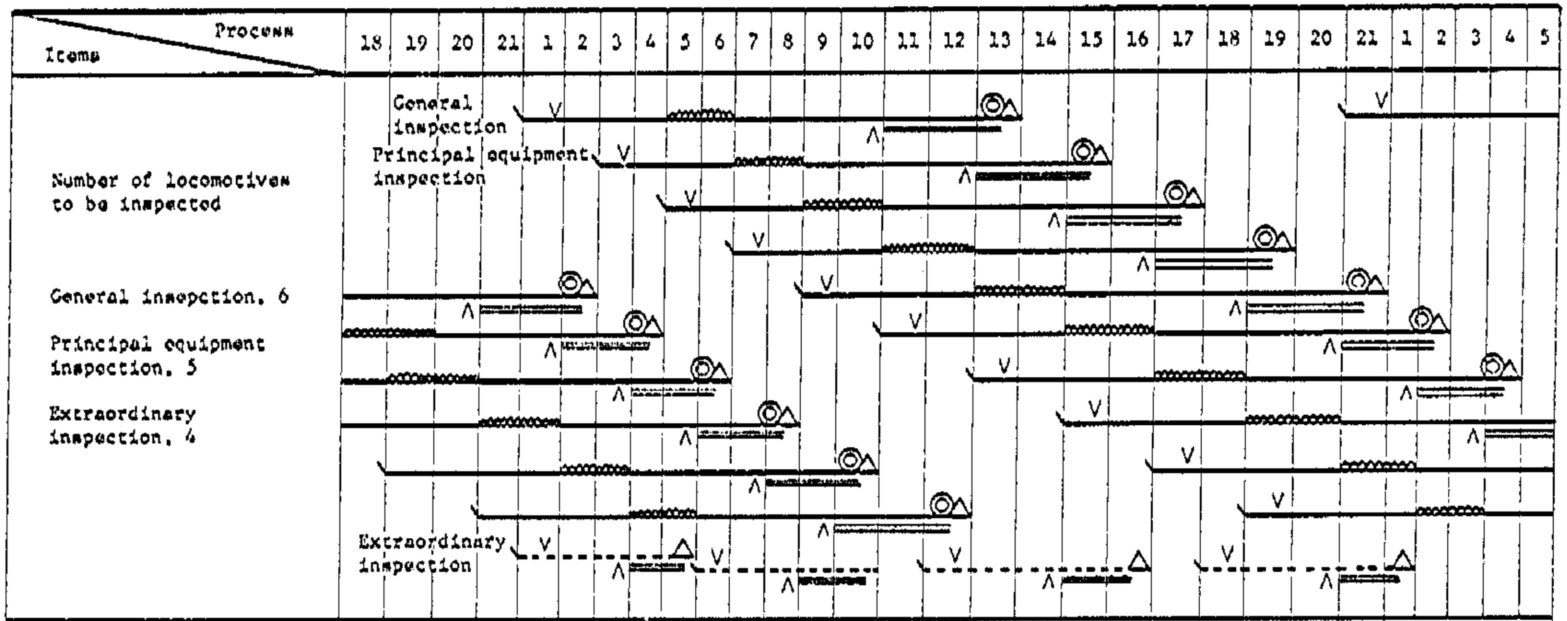
Types of Inspection	Yearly	Monthly	Remarks
General inspection	66	6	Cycle at 60 months and shop-in fluctuation at 10%
Principal equipment inspection	66	5	Cycle at 30 months and shop-in fluctuation at 10%
Extraordinary inspections	45	4	15% of the locomotives to be taken care of
Total	177	15	

Note: The number of locomotives of extraordinary inspection is considered to be about 5 percent normally. But in this case it was assumed to be 15 percent to take the worst condition into consideration.

(2) Inspection plan and the amount of principal equipment present simultaneously in the workshop

The monthly shop-in and -out plan, based on the number of locomotives to be inspected and the standard process described in the preceding paragraph and having the work loads and workers levelled by the shop, is shown in Fig. 9.1.3.

The number of locomotives shopped-in simultaneously by day and by the main shop, as calculated from the drawing, is shown in the lower



Number of locomotives shopped in simultaneously

Items		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Shop-in		2		1		1	1	1		1		1	1	1		1		1	1	1		1
Body lifting and lowering shop	Body lifting	2		1		1	1	1		1		1	1	1		1		1	1	1		1
	Body lowering	1		2		1		1	1	1	1		1		2		1		1		2	
Body dismantling shop		5	5	5	4	3	5	5	5	4	4	4	4	5	5	4	4	3	4	4	4	3
Repainting shop		1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Servicing room		1	2	1	3	2	2	1	2	2	3	1	2	2	1	3	2	2	1	2	1	3
Bogie shop		3	5	4	4	3	5	4	5	4	4	4	5	5	5	4	5	4	5	5	5	4

Legend: V Body lifting; Λ Body lowering; ~~~~ Body repainting; ═══ Servicing room; ◎ Test run on line; △ Deadheading

Fig. 9.1.3 Monthly Shop-in and -out Simulation part of the drawing. This indicates the basic capacity which each shop should have and serves as the basic value for equipment design. The maximum number of locomotives shopped-in simultaneously by the main shop according to the drawing, is shown in the following table.

Table 9.1.5 Simultaneous Maximum Number by Main Shops

Shops	Maximum number of simultaneous shop-in	Shops	Maximum number of simultaneous shop-in
Body lifting shop	3	Servicing room	3
Dismantling, mantling & body shop	4	Bogie shop	Equivalent to 5 locomotives
Body blowing and cleaning shop	1	Parts shop	Equivalent to 5 locomotives
Body repainting shop	1		

9.1.3 Site of the Electric Locomotive Workshop

(1) Basic conditions for selection of the site

When the site of a rolling stock workshop is chosen, it is considered appropriate to study the site emphasizing the following items (as in the case of enterprises in general).

a. Relationship between the sources of materials and the forwarding sites
   - a) Materials
   - b) Suppliers
   - c) Customers and markets
   - d) Transport methods (railway, truck, waterway, airway)
   - e) Means of transportation

b. Other relationships
   - a) Labor supply capacity and wages
   - b) Technical and staff personnel supply capacity
   - c) Electric power, water, gas and fuel oil supply capacities and prices
   - d) Local services - Local traffic, communication, banks, commerce and services, police, fire fighting, sewage disposal and garbage collection
   - e) Relations to Government - Taxes, degree of freedom, restrictions and laws

c. Environment
   - a) General - climate, attitudes of the government and local communities, neighborhood and appearance
   - b) Dwelling houses, hospitals and health and sanitation
   - c) Schools and education, recreation.
   - d) City planning and roads

d. Investments
   - a) Land
   - b) Reclamation
   - c) Building, construction, loans

e. Extent of profit
   - a) Operation cost
   - b) Economy and recovery

As described in the foregoing, these items are those common to enterprises in general, and when the item "a, a)-c)" is read as rolling stock depot, all of the foregoing items are applicable to the selection of the site of a rolling stock workshop.

(2) Conversion of existing workshops

Where the steam locomotives are replaced by diesel or electric locomotives and passenger cars by diesel or electric railcars through railway modernization, it is customary to improve the existing workshops and use them for repair of the new types of rolling stock. This method has many advantages. Compared with the case of limiting or abolishing an existing workshop and constructing a new workshop, the amount of investment can be saved and that many of the inspecting and rapairing techniques of the old type rolling stock are applicable to the new type rolling stock, so that by merely cultivating the techniqes particularly required by the new type rolling stock, it is possible to shift to the new operation easily and in a short period. Thus, to check in the repair of the electric locomotives introduced under this project from such a point of view, the existing five workshops were investigated. The general conditions and adaptability to repair of electric locomotives of the workshops are shown below.

a. Manggarai workshop

a) General

This workshop is assuming a variety of work, including repair of all passenger cars, diesel railcars and electric railcars for Java Island, production of sheet springs, coil springs, tools and manual tools for Java and Sumatra and concentrates production of cast iron and steel, brass castings and bronze castings for the other workshops.

Dismantling and body repair work on passenger cars is made in shops separate from those of the diesel and electric railcars, and all of the shops except the latter are arranged in parallel in a large main building. All of the main work objects such as the bodies, bogies and wheel sets are allowed to move over a traverser, but because of improper layout, work is inefficient. All of the shops except the diesel and electric railcar shop and the air brake valve shop are obsolete and deteriorated, and the work environment is poor. For machinery equipment, a set of machines for various purposes is installed, but the machines are old, obsolete and are cause inefficient work along with the improper layout and poor work environment.

In the JABOTABEK project now in progress, this workshop is designed for repair of electric railcars, and an improvement for such purpose is being planned.

b) Conversion to electric locomotive workshop

This workshop is adjacent to Manggarai Station, which is located close to the stations in Jakarta City where the number and variety of trains are the greatest and the trains start and terminate. It is thus located at the ideal position as a repair workshop for rolling stock. Presently, it has a land area of about 140,000m^2, which will satisfy the facility scale of the electric locomotive workshop set previously and is suitably shaped. Therefore, as a site of the electric locomotive workshop, it is optimal.

In the case of converting this workshop to an electric locomotive workshop, the existing work facilities are scarcely reusable for the reasons stated in the preceding paragraph, and a new shop will have to be constructed with a greater part of the existing facilities removed. Such drastic measures of reconstruction may be made, but the current land area of 140,000m^2 is much to small for installation of the repair facilities of the existing passenger cars along with the electric locomotives, much less for construction of the repair facilities for the electric railcars which will increase so greatly under the JABOTABEK project. Accordingly, if this workshop is to be converted to an electric locomotive workshop, a passenger car workshop and a concentrated production shop for parts will have to be constructed on new land, all of the current work of the Manggarai workshop transferred to them, and almost all of the existing major facilities be removed before an electric locomotive workshop can be constructed. Then, substantially, all of the electric locomotive workshop, passenger car workshop and concentrated production shops have to be constructed. The investment becomes then enormous.

From the foregoing, the problem of whether or not this workshop is convertible to an electric locomotive workshop becomes the problem of choosing what kind of rolling stock workshop should be built in order to make the best use of this excellent location. Here, the conclusion will be apparent whether the electric locomotives and freight cars distributed throughout the country should be taken or passenger cars, or, more particularly, the electric railcar concentrated in the urban area.

b. Yogyakarta Workshop

a) General

This workshop is designed exclusively for repair of diesel locomotives and is taking care of all diesel locomotives in Java.

This workshop employs the flow system as its basic mode of work, and a locomotive taken in from one end of the main building is shopped out of the other end after repair. Repair work on bogie and main equipment of the diesel locomotive forms a similar flow process. The work is laid out orderly in the main building.

The main building has sufficient space in height as well as the pillar clearance to repair locomotives. It has a number of overhead traveling cranes and is a strong building. It is well maintained generally, except the floor surface, and the aging of steel was not observed.

The mechanical equipment is old and obsolete generally, is particularly so in the wheel set machining equipment, and work which cannot be done at this workshop is entrusted to the Manggarai and other workshops.

There is no other workshop where the basic flow process is so reasonably and logically arranged and where the building has such space and strength, and in these respects, this workshop may be the most excellent.

However, at the time of the investigation, the workshop had the following problems.

(a) The bogie shop and wheel set shop are separated across the dismantling shop so that they are not well linked. Moreover, both shops are limited in space.

(b) A stationary repair system is emplyed for the body so that the parts and materials are spread around the body. As the result, sufficient work space is not secured around the body. Also, there is no passage secured for carriage of the repair parts and materials or movement of the workers. Here, the shortcoming of the narrow and long workshop accruing from the flow process system of one-way traffic becomes evident. This phenomenon is particularly noticeable when the work lags due to delay in acquisition of parts, and a similar phenomenon is occurring in the other shops.

(c) The flow of the repair work on rolling stock is shown in Fig. 9.1.1. The equipment taken out of the body repair line are successively repaired in their respective repair lines, and the equipment that has been repaired is mounted on the body as required in the flow of repair of the body to complete the repair work of the rolling stock. The layout of the principal work of this workshop faithfully reflects the foregoing basic work flow. Here, what is to be noted is that the production speed is different between the main line and the respective branch lines, and between the branch lines generally. Actually, this appears as a delay of parts at the branching points along the main line or the starting and terminal points of the branch lines, and when the transit between the main and branch lines is not smooth, both main and branch lines have trouble. In this respect, the present situation of this workshop should be studied and improved in many points. Specifically, the carrying-in and -out system, temporary storage places and storage system need improvement.

(d) One of the functions of rolling stock repair work is to inspect and measure a number of parts and, upon the result of such inspection and measurement, determine whether to repair for reuse or to replace. The cleaning and washing work of car parts precedes the inspection and measurement work, and whether it is made properly or not has a great influence on the accuracy of inspection and measurement. This workshop is the locomotive workshop and is loaded heavily in this work. Then, so long as the work is removing rust, mud and oil by manually and manual washing in a light oil pan as at present, such should be studied and improved from the aspect of accurate inspection of car parts as well as work environment.

b) Conversion to electric locomotive warkshop

This workshop is located between the two big cities Jakarta and Surabaya, and is adjacent to the Yogyakarta Station which has and will have a large variety of trains and is included in the section of early electrification. Thus, it is favorably located next to the Manggarai Workshop for rolling stock. It has a land area of about 128,000m^2, which is satisfactory for the facilities scale previously set for the electric locomotive workshop, and the shape of the land is also good. Thus, it is suitable as a site for an electric locomotive workshop.

This workshop is a special workshop for diesel locomotives and thus needs great changes with the progress of electrification. That is, at the time of completion of electrification of the main lines the big locomotives on the main lines will all be replaced by electric locomotives, and only small diesel locomotives left on the local sections and for shunting. The repair work on diesel locomotives will thus decrease greatly and the greater part of the facilities and workers here will become redundant.

This workshop has a distinguished form and structure not seen in the other shops, and has a large capacity, as has been described with respect to the flow of the locomotive repair work and the present condition of the main building accommodating this work.

It may be converted to an electric locomotive workshop promising good performance merely by taking measures to improve the problems pointed out in the preceding paragraph as well as some shortages in equipment capacity in order to repair both small desel locomotives and electric locomotives.

When this workshop is viewed from the point of rolling stock repair technology, it has experience accumulated over long years for the diesel locomotives of both electric and hydraulic systems, and is the only one workshop having experience and techniques in the large power rolling stock. Moreover, electric locomotive repair techniques are similar in many ways to diesel locomotive repair techniques, so that by acquiring the special techniques required for electric locomotives, this workshop can be quickly converted to one having high reliability.

Furthermore, from the aspect of management of the workshop, the electric locomotives will increase with the progress of electrification, while diesel locomotives will decrease gradually, so that it is possible to promote the conversion reasonably and economically in both fields of worker operations and facilities.

In view of the foregoing, this workshop is favorably located and almost all of the existing facilities can be used effectively. Furthermore, it is distinguished in its locomotive techniques so far accumulated, the ease of instilling new techniques, the high reliability of the repaired locomotives, the possibility of economic operation of workers as well as facilities in the transition period, and in many other important aspects. This workshop is optimally qualified to be electric locomotive workshop.

c. Surabaya Gubeng Workshop

a) General

This workshop is special workshop for repairing freight cars. It will assumes the repair of all freight cars in the Java Island together with the Tegal Workshop and also the production of long rails for the Eastern District. The land area is about 100,000m^2, of rectangular shape, and about 1/3 is used by the long rail manufacturing shops and about 2/3 by the freight car repair shops which have body shops arranged on each side of the land and the other shops therebetween.

These two body shops are used for specific purposes respectively depending on the difference in the car structure and repairing process, that is, one for the freight cars with roller bearings and the other for those with plain bearings., and each shop is composed of two parallel buildings and an intermediate traverser. Each body shop has a width of 35m, accommodating two small cars per line or one in the case of a large car. The total number of lines of body shops is 72, a capacity equivalent to 144 small cars. But, the building is constructed of small-sized steel, precluding the installation of overhead traveling cranes so that efficient works are hardly practicable.

The bogies have no specific shop, and they are repaired along with the bodies in the body shops. The wheel set workshop is installed at the deepest part of the land next to the body workshop for freight cars with palin bearings. It is provided with all sorts of equipment from corrective machining of the tread to change of the wheel and axle, but they are old and obsolete, and the productive efficiency is by no means high.

Throughout the shops, the facilities are maintained well, and careful consideration is extended to management and progress as well as to the improvement of works. However, the following fundamental problems are involved.

(a) The line arrangement in the yard is not made properly for the body shops so that the flow of works is not smooth.

(b) Long yard lines are provided, but the number of lines are very small so that the line length usable effectively as the car repair shop is very short. In this sense, the line capacity is in great shortage.

(c) The work layout is not good between the respective body shops, between the body shops and the bogie shop or the wheel set shop, resulting in generation of the carriage loss and inefficiency in operation of the facilities or workers.

(d) The main building for the freight cars and other buildings are of small-sized steel and are greatly short of the strength so that the overhead traveling cranes can hardly be installed.

Among the foregoing, (a) through (c) are the problems of the basic layout may be produced from the positional and configurational restrictions of the land. But, it will be necessary to study them thoroughly in order to enhance the efficiency or improve the productive efficiency of this workshop greatly in the future.

b) Conversion to electric locomotive workshop

This workshop is located in the Surabaya area where a number of various trains start and teminate. Thus, it is located at an ideal place as a rolling stock workshop. However, because of a real shortage and improper shape of the land as described above, it is hardly converted into an efficient electric locomotive workshop. Furthermore, if it is assumed that the workshop is converted into an electric locomotive workshop, what is usable is the land only. Then, a freight car workshop and a long rail manufacturing shop will have to be constructed on new land, and all of the current works of the workshop be transferred. Then, all of the existing facilities are to be removed before an electric locomotive workshop is constructed. The investment will be enormous.

In view of the foregoing, this workshop should be utilized as a shop for the type of cars having modernization and conversion of the works made gradually with the existing facilities and current techniques utilized.

d. Tegal Workshop

a) General

This workshop is special workshop for repair of freight cars or, specifically, hand brake freight cars and the tank cars in the Middle and Western Districts. The land is about 50,000m^2, of rectangular shape, with three shop-in/out lines disposed at the central part and the shops arranged on the left and right sides of the lines.

The body shop is divided into three buildings, one for bogie freight cars and two for four-wheeled freight cars, and the intake and output of freight cars are made through a traverser. The buildings are made of small-sized steels which are small in the strength so that overhead traveling cranes cannot be installed.

The bogies have no exclusive shop and are repaired along with the bodies in the bogie freight car building. The wheel set shop is installed at the deepest part of the land, included in the general machining shop.

The equipment of the workshop is old but is maintained well, and as the freight car repair works are carried out carefully, this workshop is well managed.

The problems of this shop as seen from the point of view of the equipment are as set forth below and are the same as those of the Surabaya Gubeng Workshop described above.

(a) The yard lines serve only as through tracks for shopping-in and shopping-out, and as the storage track, small capacity lines are istalled outside the yard. Therefore, when the number of freight cars to be repaired increases in the future, the line capacity will fall short of that required.

(b) The work layout is not proper, with the body shop divided and located inadequately to the related shops.

(c) The body shop and other main buildings are made of small-sized steels and are in shortage in the strength, precluding installation of overhead traveling cranes.

These are fundamental problems. Therefore, in order to enhance the capacity or improve the productive efficiency of the shop greatly hereafter, it will be necessary to study them thoroughly for improvement.

b) Conversion to electric locomotive workshop

As described previously, the shop's land is limited greatly so that it is not practicable to convert the workshop to an electric locomotive workshop.

e. Semarang Workshop

a) General

This workshop started as a railcar repair shop. But, now, it has ceased such works and is engaged mainly in the manufacturing of steel sleepers and other track articles and repairing of axle boxes, wheel and other car parts and that of the freight car track scale and other scales.

The buildings in the shop and their layout take the form of car repair shop, but they are made of small-sized steel of, wooden frame and short of strength and are generally deteriorated. The mechanical equipment nothing worth particular note, and as a whole, this workshop has not the form suited to a rolling stock workshop. Therefore, if it is to be used as a rolling stock workshop hereafter, drastic improvements are required.

b) Conversion of electric locomotive workshop

This workshop is located in Semarang, a nucleus city in the middle part of the Java Island. But, when seen from the viewpoint of railway transport, the number of trains is not great as compared with the other districts, and under the present plan, the electrification is scheduled in the later stage. Accordingly, the location is inferior to the workshop at Manggarai, Yogyakarta and Surabaya described above.

The land area of this workshop is about 120,000m^2 which is adequate as an electric locomotive workshop specified previously, and the land form is propriety. However, this workshop and the adjacent yard are very poor in drainage, and the workshop land is lower than the adjacent land so it has rain water flowing in from the surrounding area in the rainy season, and the land is reportedly submerged for about 50cm normally. Therefore, if the land of this workshop is used, submersion preventive measures are required.

As typical methods of preventing submersion, improvement of the drain equipment over the whole area, raising the workshop land including the necessary parts of the adjacent station yard, and drainage by drain pumps may be utilized. Among these, the drain pump method must have an embankment constructed to prevent inflow if the plan is to be made to allow inflow from adjacent land, and it is apparent, even if the draining of rain water in the workshop only is intended, that the method will involve much difficulties technically and financially. Furthermore, in the event of a failure of the drainage, the loss which this workshop receives extends over all of the mechanical equipment including the electric locomotives shopped in, and the expense and the period required for restoration are enormous. Consequently, the method involving such fatal risks should not be employed.

Improving the draining facilites of the whole area in which the shop is located, will be a wide ranging and large scale project to by undertaken by the local government. In this case it is necessary for PJKA to inquire to, or negotiate with, the local government about the policy and the will for disbursement of the funds of the local government.

Raising the land of the workshop yard and the related parts of the adjacent yard involves less technical difficulty and is free from the danger of submersion in the future so that it is the easiest and safest measure and has only the economic problems left to be resolved. Obviously, the construction cost will be much higher than for the case of improving and converting the Yogyakarta workshop described above. Also, it is doubtful if such method is more economical than the case purchasing a new land and constructing a new workshop (Appendix 9.1).

f. Results of study

The results of study of the respective workshops are shown in Table 9.1.6. As seen, it is optimum, in all respects, to convert the Yogyakarta Workshop to an electric locomotive shop.

Table 9.1.6. Aptitude for Conversion of Existing Workshops

Workshops	Location	Land		Availability of Existing Facilities		Scale of Investment for Conversion	Existing Techniques Conversion Effects		Overall Assessment
		Area	Shape and Geographical Features	Reusable Extent	Substitute Facilities Required or Not		When Existing Personnel Convertible	When Existing Personnel Relocated to Substitute Facilities	
Manggarai	◎	○	○	×	Required ×	Large ×	○	×	×
Yogyakarta	○	○	○	◎	Not ○	Small ◎	◎	—	◎
Surabaya Gubeng	○	△	△	×	Required ×	Large ×	○	×	×
Tegal	△	×	△	—	—	—	—	—	×
Semarang	△	○	△	×	Not ○	Medium △	△	—	△

Note: ◎ Best ○ Good △ Not Good × Bad

(3) Choice

While the aptitude of the existing workshops for conversion has been studied in the preceding section, the items of study are applicable to the case of constructing a new workshop on a new land, Accordingly, when the plan of constructing a new workshop on a new land is added to Table 9.1.6 for comparison, the plan requiring a large amount of investment and involving technical and economical losses in the case of recruiting a number of workers, training them and assigning them, and is obviously inferior to the plan of converting the Yogyakarta Workshop.

Furthermore, according to the results of study in the preceding section, conversion of the Yogyakarta Workshop is entirely free from problems and, moreover, has many advantages in the light of PJKA management and is, therefore, an ideal plan. Thus, the Yogyakarta Workshop should be chosen for an electiric locomotive workshop.

9.1.4. Approximate Facility Plan of the Electric Locomotive Workshop

(1) Principle of the plan

When the improvement of the Yogyakarta Workshop is set forward, the following points should be taken into consideration.

a. The objects of the repair work are two types of locomotives, electric and small diesel, and they are different from each other in both work and repair process. Therefore, in planning the repair facility, it should be considered that whatever facilities which are commonly usable are used in common as much as is practicable and that the facility capacity has the flexibility to withstand against changing work load of repair.

b. The basic problems under the present condition should be improved as much as practicable so that there will develop a well balanced and highly efficient workshop as a whole.

c. Efforts be made for improvement of the work environment along with improvement of the repairing accuracy and that of work efficiency.

(2) Outline of the facility plan

An improvement plan according to the principles in the preceding paragraph is shown in Fig. 9.1.4. The main items are generally as follows.

a. With a new body shop installed adjacent to the existing body shop, the dismantling, mantling and body repair works of the electric and diesel locomotives are transferred. The works are made according to a flow system, and necessary machines are installed.

b. A shop-in inspection room and a servicing room are provided before and after the body shop, and necessary measuring instruments are installed for grasping the locomotive conditions.

c. The old body workshop is used as a shop for the bogies, wheel sets, traction motors and electric equipments, with necessary machines installed. Presently, repairing of the diesel locomotives extends over a very long period. Then, upon further study, part of the old body workshop is used as a diesel locomotive body shop, if required.

d. Along with the relocation of the bogies and wheel sets shop, the air brake valve shop, maching shop and other shops will be relocated, improved and arranged reasonably.

e. The management office and warehouse standing in the way of the newly constructed body shop will be built newly at a place presenting no hazard. For the new location, it is necessary to study and discuss the details to determine an optimum place. The capacity of the warehouse should be such that the necessary quantity for maintenance of the diesel and electric locomotives can be stored.

f. As the cleaning and washing accuracy is improved for higher efficiency and as various machines are increased, boilers, air compressors and power receiving and distributing equipment are installed newly or increased, while for higher efficiency of the carriage works, the numbers of forklifts and other carriage machines are increased.

The quantities of the principal machines according to the foregoing equipment plan are as shown in Tables 9.1.7 and 9.1.8.

Table 9.1.7 Increase or Decrease of Building Areas (Rough Stimation)

Items		Approximate Area (m^2)	Remarks
New Installation	Body shop	5,100	
	Management office	2,400	Two storied building considered
	Warehouse	2,400	
	Miscellaneous	2,900	Shop-in inspection room, servicing room, power testing room, etc.
	Total	12.800	
Removal	Management office, warehouse, electric machine workshop, etc.	5,000	
Balance		7,800	

(3) Approximate construction cost

The construction cost required of the plan is estimated approximately as below.

Total construction cost	25,160	millions	Rp.
(Breakdown)			
Buildings	4,049	"	"
Machines	18,927	"	"
Others	2,184	"	"

Table 9.1.8 Major Mechanical Equipment

Shops	Major Mechanical Equipment
Body shop	Overhead traveling crane, underfloor equipment attaching/detaching device, body blowing and cleaning device, body repainting device, high place work scaffolding.
Bogie shop	Bogie carrier, washing device, magnetic flaw detecter, painting device.
Wheel set shop	Washing device, ultrasonic flaw detecter, wheel lathe, axle lathe, wheel boring machine, tyre boring machine, wheel cneter lathe, axile grinding machine, wheel set press, tyre heating furnace, tyre tightener.
Traction motor shop	Cleaning device, amature lathe, armature testing device, revolution testing machine, dynamic balance tester, drying furnace, auxilialy motor tester.
Electric machine shop	The number of relay testing device, electromagnetic valve testing machine, jumper coupler testing machine, speed meter testing machine, dielectric strength testing machine, cleaning device.
Air brake shop	Air brake valve testing machines, washing device, painting device.
Parts shop	Washing device, magnetic flaw detecter, testing machines.
Servicing room	Dielectric strength testing machine, circuit testing machine, high place work scaffolding
Others	Boiler, air compressor, power receiving and distributing equipment, drain water treatment device. Bridge crane, forklift, parts storing equipment.

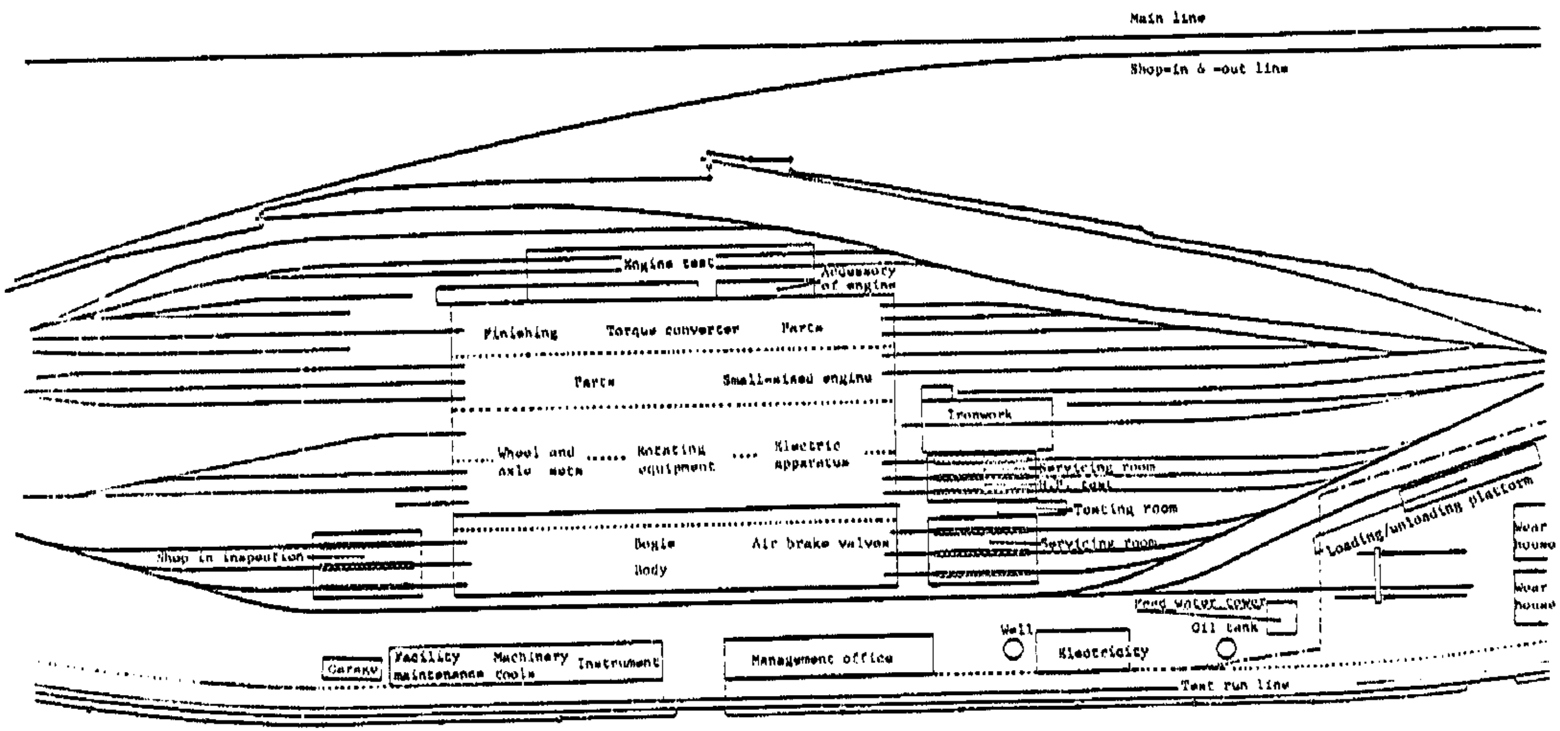


Fig. 9.1.4 Yogyakarta Workshop Improvement Plan Diagram

9.2 Rolling Stock Depot

9.2.1 Location of Depot

It is desirable for the position of a depot with reference to the station and the freight yard to be decided in consideration of the following conditions:

(1) It must be set up near the station and the freight yard to minimize losses of crew time and the deadheading of cars.

(2) In the moving of cars to a depot or from a depot, wasteful turnround shunting and hinderance by main-track trains and other yard work must be held to the minimum.

(3) If the place of car storage for inspection and/or repair is far from the station and losses in crew time are heavy, the crew base only must be near the station.

9.2.2 Functions of Depots

A depot must perform work concerning the receiving, formation, servicing, inspection and repair of cars, and work concerning crew, such as the rostering, training, guidance, roll calling and resting of crew as well as functioning as a field agency for management.

To meet these requirements, the following work is done by the depot:

(1) Work concerning cars: Yard work, maintenance, inspection and repair, operational and technical control of cars, etc.

(2) Work concerning crew: Operation planning, rostering of crew, guidance and training, rest, etc.

(3) Work concerning management as field agency: Clerical work, planning, control, supplies, etc.

9.2.3 Rolling Stock Inspection at Depots

(1) Electric locomotives

The following inspection is conducted at the depot:

1) Daily check: Inspection carried out from the outside according to a certain cycle prior to the use of a locomotive with respect to

the supplementary replacement of expendables and the condition and action of pantograph, running gear, brakes, coupling and other gear.

2) Monthly check: Inspection carried out according to the state of use of locomotives and by a certain cycle with respect to the installed conditions of pantograph, electric equipment, rotary machine, running gear, brakes, coupling and other gear.

3) Bogie truck check: Inspection of details carried out according to the state of use of locomotives and by a certain cycle after detaching specific main devices including the traction motor, running gear, brakes and instruments or dismantling specific main parts.

An example of inspection cycle is as follows:

Type of inspection	km type	Number-of-days type
Regular inspection	25,000 km	60 days
Bogie truck check	200,000	15 months
Partial overhaul	400,000	30 months
Overhaul	800,000	60 months

Whether the km type or the number-of-days type is the used depends on which limit of km or number of days comes first, but electric locomotives to be used in Java Island fall in the km category.

The depot handles the daily check, monthly check and bogie truck check while the workshop handles partial overhaul and overhaul. It is economical for the regular inspection and bogie truck check to be concentrated at certain depots, if possible, because of the limited number of cars inspected and the necessity of equipment and personnel. Daily check is, of course, to be conducted at depots but it is also convenient to do it at places where a certain number of cars are stabled.

(2) Other car types

Since Indonesia is already experienced in the inspection of diesel locomotives, passenger cars and freight cars, inspection of these will be carried out in the future in general accordance with the present Indonesian inspection system. At present, no regular inspection of freight cars is handled by depots but after electrification the monthly check of freight cars as well as passenger cars should be handled by depots because of the increase of train running speed and the equipping of freight cars with brakes.

9.2.4 Depot Equipment

(1) Track arrangement at depots

1) Work flow

There are three types of major work performed during the period when a car enters the depot until it leaves: storage, daily inspection, and servicing (including car cleaning) and inspection/repair. The flow of this work is indicated in Fig. 9.2.1.

Track groups at a depot are divided into three types of work: car-holding sidings, servicing track group and inspection/repair track group. It is important for these track groups to be efficiently arranged in accordance with the flow of a series of work: (arriving)→ (servicing-inspection/repair)→ (storage).

2) Example of electric locomotive depot

Since locomotives are normally operated singly, the obstacle time due to main track crossing for moving in/out is short and drivers' cabin can be quickly changed. Thus, these restrictions are less severe than at a passenger car depot; however, conflict with other work including shunting will also increase. Therefore, the following considerations are necessary:

a. Serial moving in/out is possible from the station of train departure of arrival.

b. To avoid conflict with other work at a yard, etc.,

- An exclusive locomotive moving track should be provided: or
- Grade separation from the main track is necessary.

Fig. 9.2.4 ∿ Fig. 9.2.7 show examples of layout at locomotive depots. Fig. 9.2.2 is an example where an receiving track group and an inspection/repair track group are arranged in parallel while Fig. 9.2.3 and Fig. 9.2.4 are examples where they are arranged in series. Fig. 9.2.5 is an example of zebra arrangement of receiving tracks high in work efficiency and convenient for automatic yard work.

3) Examples of passenger car and electric railcar depot

Since passenger cars or electric cars are used as train set, the obstacle time in main track crossing is long when cars are shunted to depot or from depot and the change of driver's cabin at the turn-round point or the work for pushing operations take time. It is important to be able to eliminate these conditions as much as possible.

Fig. 9.2.6 and Fig. 9.2.7 show examples of depots. Fig. 9.2.7 is a case where car shunting between track groups is linear and is without unnecessary switch-back work. Thus, it is suitable for depots handling the composition of long train sets.

4) Example of freight car depots

A freight car depot is provided in a yard or a freight station from which it receives cars for inspection/repair. A freight car depot is often provided adjacently to sorting tracks so as to minimize the movement of cars for inspection/repair in the terminal area and avoid hindering yard work as much as possible.

Fig. 9.2.8 shows an example of freight car depots.

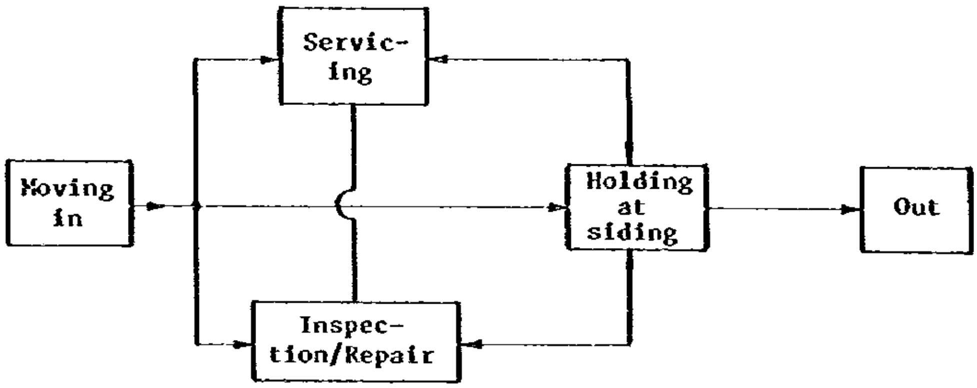


Fig. 9.2.1 Flow of Work at Depot

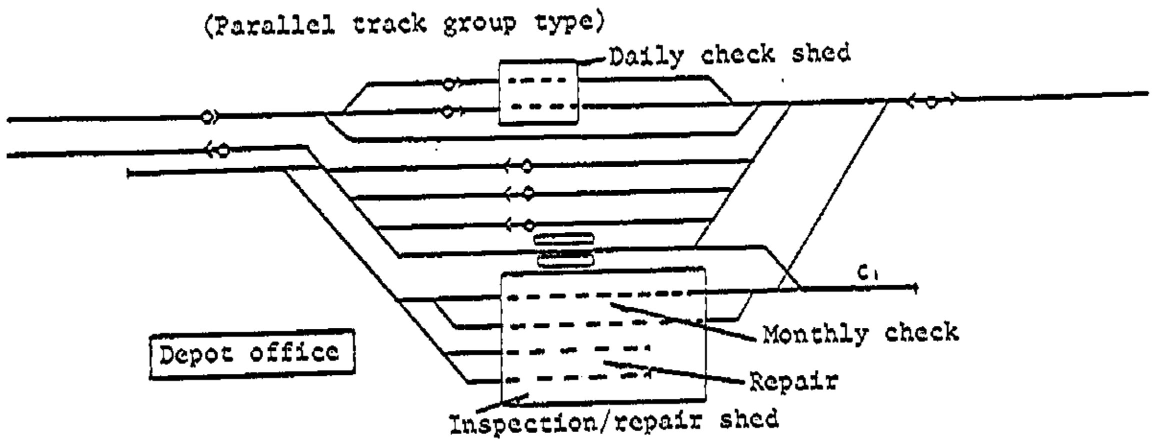


Fig. 9.2.2 An Example of Electric Locomotive Depot (1)

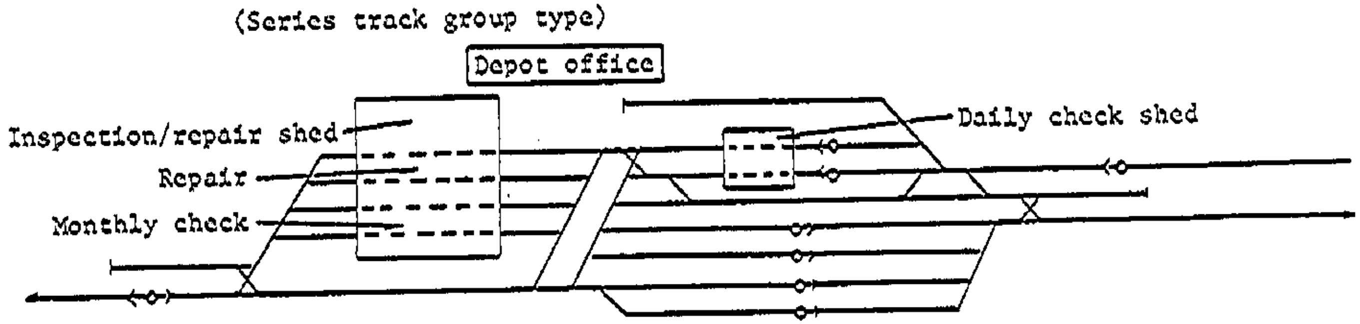


Fig. 9.2.3 An Example of Electric Locomotive Depot (2)

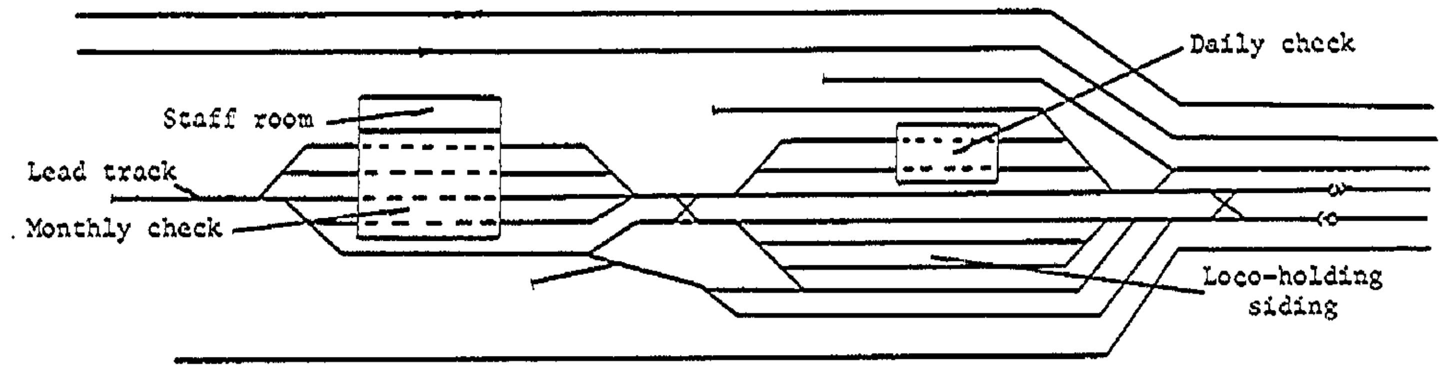


Fig. 9.2.4 An Example of Electric Locomotive Depot (3)

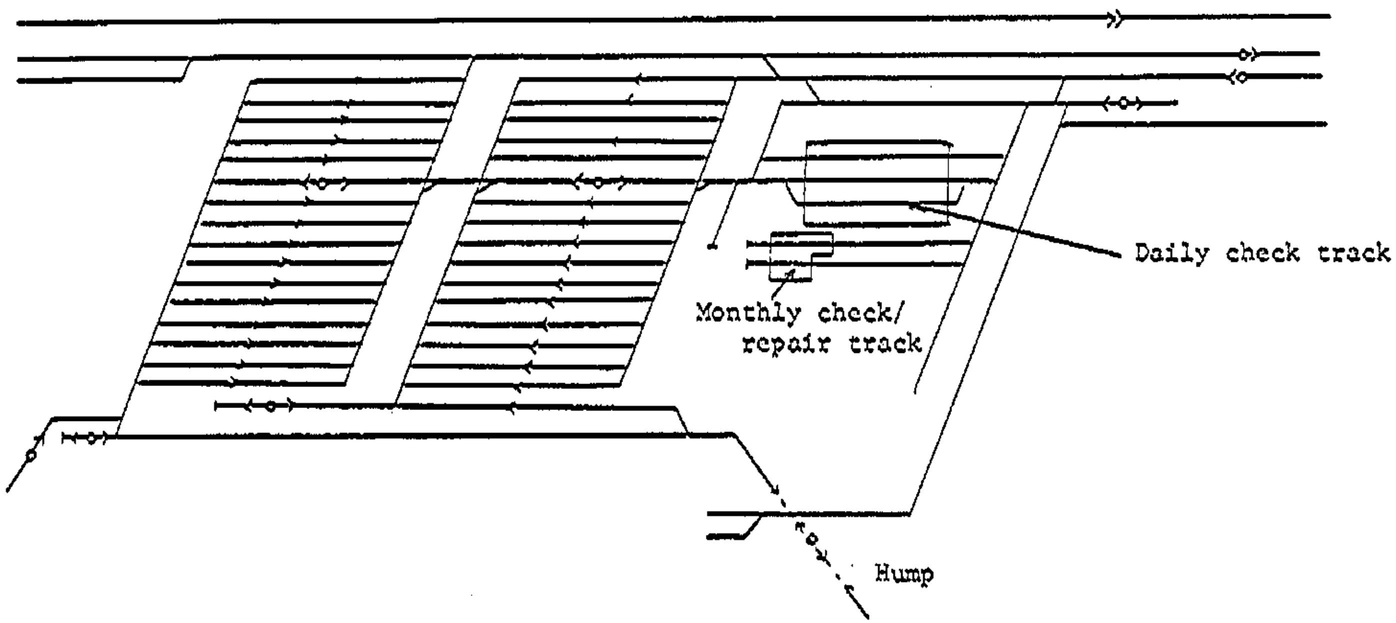


Fig. 9.2.5 An Example of Electric Locomotive Depot (4)

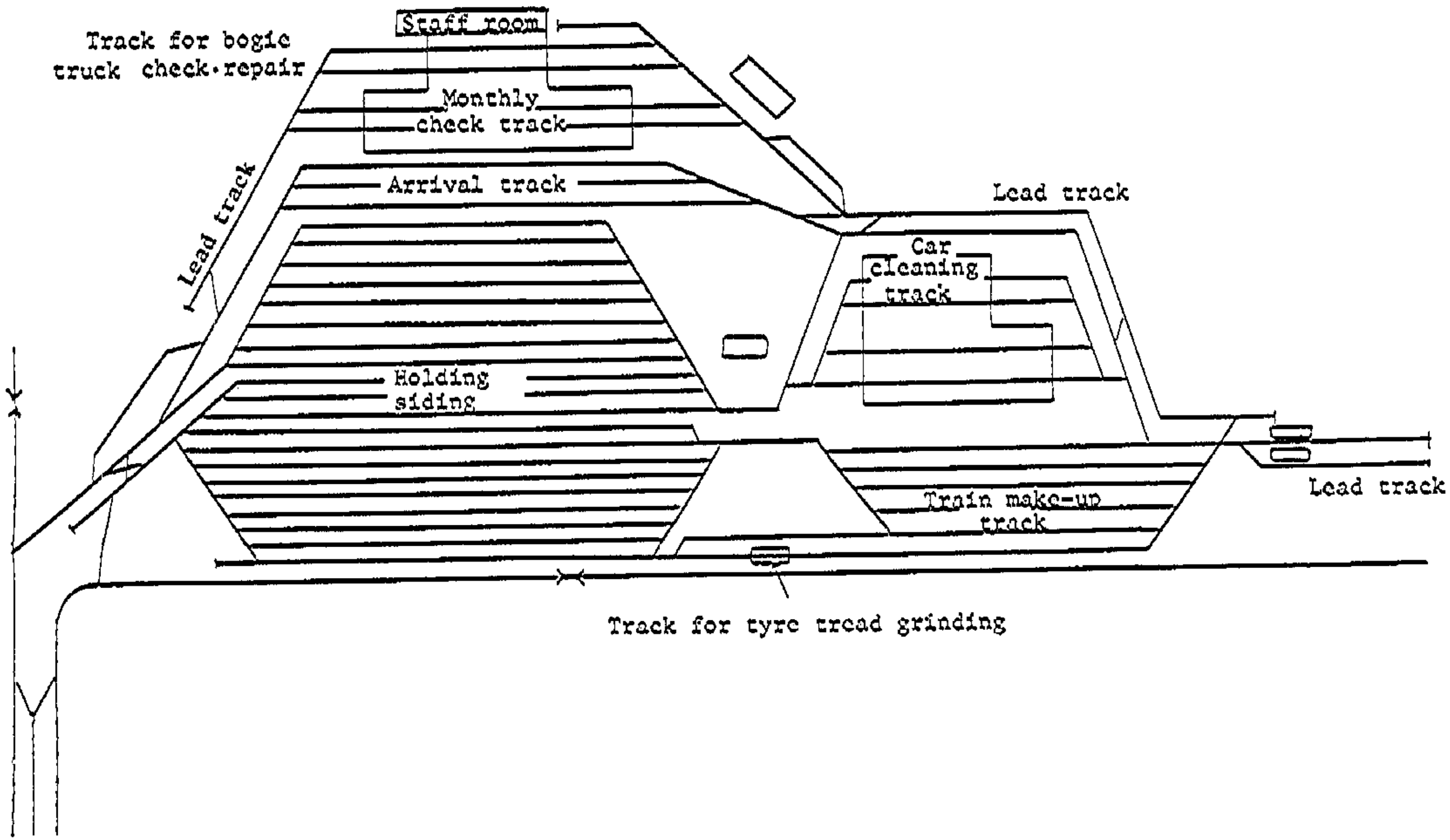


Fig. 9.2.6 An Example of Passenger Car, Electric · Car Depot (1)

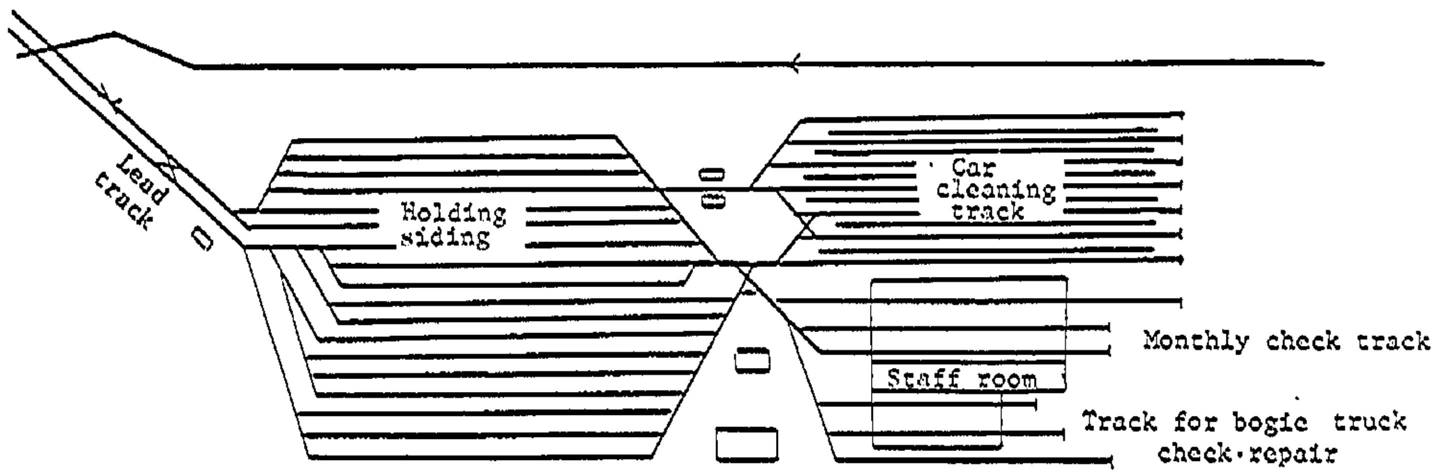


Fig. 9.2.7 An Example of Passenger Car, Electric Car Depot (2)

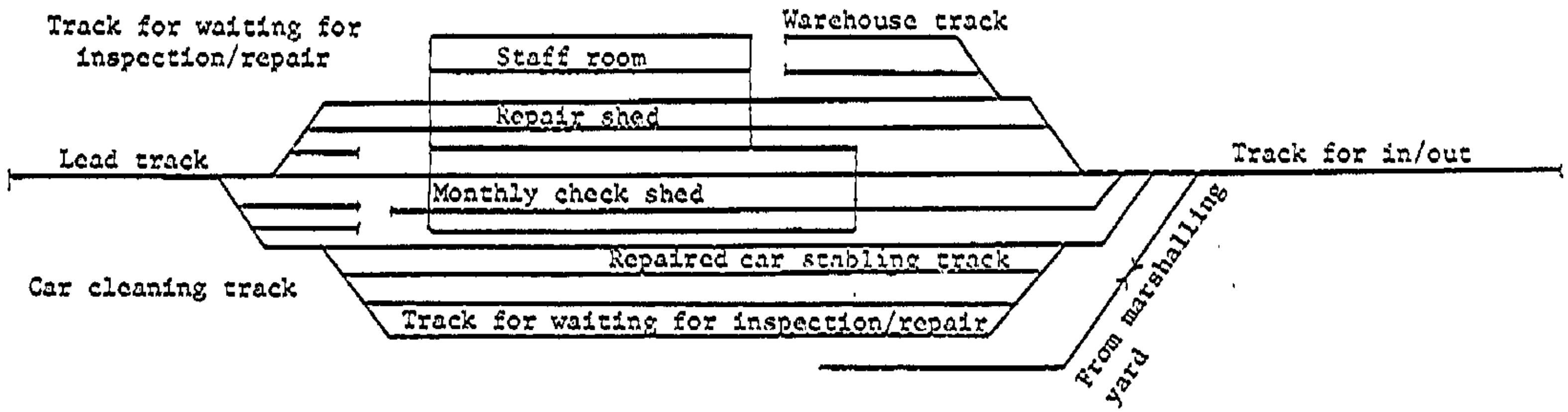


Fig. 9.2.8 An Example of Freight Car Depot

(2) Inspection/cleaning equipment

Table 9.2.1 shows necessary depot equipment by type of vehicle and by type of inspection.

Mechanical equipment necessary for inspection and repair work includes: overhead crane, lifting jack, monorail crane, turntable, woodworking lathe, parts cleaner, filter cleaner, universal machine tool, drilling machine, grinding machine, electric generator tester, silicon rectifier, pressure tester, dust arrester and electric welder.

Also, car washing and cleaning equipment and train sewage disposing equipment are necessary, particularly at electric car and passenger car depots.

Table 9.2.1 Facilities by Type of Inspection and Accessory Equipment

Name of facilities	Daily check		Monthly check		Bogie truck check	
	EL	EC,PC	EL	EC,PC	EL	EC,PC
Daily check track	O	O				
Monthly check track			O	O		
Bogie truck check track					O	O
Repair track					O	O
Inspection shed	O	O	O	O	O	O
Inspection pit	O	O	O	O	O	O
Trolley wire disconnecting switch	O	O	O	O		
Rooftop check stand	O	O	O	O		
Power equipment (AC,DC)	O	O	O	O	O	O
Compressed air pipe	O	O	O	O	O	O
Water supply equipment		O		O		
Secondary wiring for electric welding			O	O	O	O
Parts dismantling workshop, etc.					O	O

9.2.5 Provision of Electric Locomotive Depots, by Stage of Electrification

(1) Depot and stabling siding

Electrified sections will grow yearly from the time the electrified Jakarta-Cirebon section is opened for business in 1988 until all the main lines are electrified in 2008. Electric locomotive depots should be provided at both ends of an electrified section to make the use of locomotives easier and also at stations where transportation volume slumps. After electrification, the present diesel locomotive depots will be used as electric locomotive depots, though diesel locomotives for branch line sections and for shunting will be left there. The sites of former steam locomotive depots which are now unused can be used to provide stabling sidings for electric locomotives.

In view of these conditions, new electric locomotive depots and stabling sidings will have to be installed at the places indicated in Table 9.2.2 as electrification progresses.

(2) Inspection equipment, by depot

The daily check, monthly check and bogie truck check are performed at depots but it is more economical in terms of equipment and personnel to concentrate the monthly and bogie truck checks on as few depots as possible. Table 9.2.3 shows inspection equipment, by depot, prepared according to this idea. A large depot is necessary for Jakarta and its vicinity where many trains leave and arrive. If Manggarai is to be a terminal for long-distance trains, the Cipinang yard seems to be most suitable as the position of its depot.

(3) Depots for other kind of vehicles

As mentioned in [3.2.5 Number of Passenger Cars and Freight Cars], about 2,500 passenger cars and about 3,900 freight cars will be required in year 2008. It is desirable to locate passenger car depots near electric locomotive depots shown in Table 9.2.2. Considering from [Fig. 3.2.2(10) Train Operation Routes and Number of Trains], freight yard will be necessary at Jakarta, Surabaya, Bandung, Solo and Kroya, but present freight yards have enough capacity as shown in [CHAPTER 7 STATIONS].

Table 9.2.2 Electric Locomotive Depots and Stabling Siding, by Year of Electrification

Year	Number of electric locomotives		Depot and number of locomotives assigned		Stabling places of electric locomotive		Remarks
	DC	AC	DC	AC	DC	AC	
1988	14	25	Thb (14)	Cn (25)	Kw (6)	Kw, Ckp (12)(3)	(1) Figure in ( ) under depot name is number of locomotives assigned.
1989	14	37	Thb (14)	Cn, Bd (20)(17)	Kw (6)	Kw, Ckp (16) (1)	
1991	16	57	Thb (16)	Cn, Bd, Yk, Kya (25) (18) (11) (3)	Kw (7)	Kw, Ckp, Km (21) (1) (1)	
1992	16	65	Thb (16)	Cn, Bd, Yk, Kya (28)(18) (14) (5)	Kw (7)	Kw, Slo, Km, Ckp (23)(12) (1) (1)	(2) Figure in ( ) under location is stabling siding capacity.
1994	16	92	Thb (16)	Jak, Cn, Bd, Yk, Kya (19) (18) (30)(18)(7)	Mer, Rk (6) (1)	Slo, Km, Ckp (16) (1) (1)	
1995	16	127	Thb (16)	Jak, Cn, Bd, Yk, Sb, Kya, Kts (25)(16)(32)(14)(26) (9) (5)	Mer, Rk (1) (1)	Slo, Km, Mn, Ckp (12) (1) (2) (1)	
1996	16	138	Thb (16)	Jak, Cn, Bd, Yk, Sb, Kya, Kts (28)(16)(34)(15)(34) (6) (5)	Mer, Rk (6) (1)	Slo, Km, Mn, Pro, Bg, Ckp (12) (1) (2) (4) (1) (2)	
2003	19	237	Thb (19)	Jak, Cn, Bd, Yk, Sb, Jr, Sm, Kya, Kts (67)(16)(33)(23)(59)(11)(23)(6)(6)	Mer, Rk (7) (1)	Slo, Km, Mn, Pro, Bg, Tsm, (15)(1)(1)(1) (1)(3) Ckp, Pk, Gbn, Bj, Si (3) (4) (1) (1) (5)	
2008	19	256	Thb (19)	Jak, Cn, Bd, Yk, Sb, Jr, Sm (60) (16) (33) (23) (70) (11) (23) Kya, Kts (6) (14)	Mer, Rk (7) (1)	Slo, Pro, Bw, Pk, Ckp, (18) (1) (5) (4) (3) Km, Mn, Bg, Gbn, Bj, Si, (1) (1) (2) (1) (1) (4) Tsm, Ml, Ta (3) (3) (1)	

Table 9.2.3 Places Electric Locomotive Inspection is Performed

Year	Up to bogie truck check for DC EL	Places inspection of AC EL is performed		
		Up to bogie truck check	Up to month-ly check	Daily check only
1988	Thb	-	Cn	-
1989	Thb	Bd	Cn	-
1991	Thb	Bd, Yk	Cn	Kya
1992	Thb	Bd, Yk	Cn	Kya, Slo
1994	Thb	Bd, Yk	Jak, Cn	Kya, Slo
1995	Thb	Bd, Yk, Sb	Jak, Cn	Kya, Slo
1996	Thb	Bd, Yk, Sb	Jak, Cn	Kya, Slo
2003	Thb	Jak, Bd, Yk, Sb, Sm	Cn, Jr	Kya, Slo
2008	Thb	Jak, Bd, Yk, Sb, Sm	Cn, Jr	Kya, Slo, Kts

CHAPTER 10 ECONOMIC ANALYSIS, FINANCIAL EVALUATION, EFFECTS OF ELECTRIFICATION, EDUCATION AND TRAINING OF PERSONNEL

CHAPTER 10 ECONOMIC ANALYSIS, FINANCIAL EVALUATION, EFFECTS OF ELECTRIFICATION, EDUCATION AND TRAINING OF PERSONNEL

10.1 Economic Analysis

10.1.1 Methodology

1. "With/without" analysis

This analysis compares the case when the project has been executed (with the project) with the one when it has not (without the project). The main items of analysis are as follows.

(1) Items of analysis

1) Investment

Time and amount of investment in ground facilities (power supply, electrification, civil works, signals, telecommunications, workshop & depot), and in vehicles (electric locomotives, diesel locomotives, passenger cars and freight cars/buses and trucks).

2) Maintenance and operating costs

Personnel costs, maintenance costs, replacement costs, and energy costs required for maintaining and operating the ground facilities and vehicles.

3) Benefits

Various kinds of benefits occur when the project has been executed, compared to when the project has not been executed.

2. Increment analysis

The master plan is designed to attain large-scale improvement and modernization of conventional lines. Therefore, the facilities and the railway traffic demand in the project area contain not only the portions belonging to this project but also those already existing.

This analysis views the project as an addition, or increment, to the existing rail transport system. The object of the analysis is to evaluate and watch the incremental benefits obtained from the project alone, while disregarding existing rail system and its current demand. We shall call this increment analysis in this report.

10.1.2 Traffic Volume

In the above mentioned analysis of the cases, the basic item among all the items of analysis was future traffic volume. The future traffic volume includes the following two volumes.

1. Ordinary traffic volume

   Railway traffic volume increasing naturally in the future irrespective of project execution.

2. Converted traffic volume

   Traffic volume converted from road traffic to railways as a result of execution of the project. The traffic volume to be carried by railways when the project is executed consists of (1) ordinary traffic volume + (2) converted traffic volume. But when the project is not executed, (1) ordinary traffic volume is carried by railways and (2) converted traffic volume is carried by roads. These traffic volumes after the year 2002 are assumed to be constant in those cases when the project has been executed and when it has not.

10.1.3 Preconditions

The following preconditions are assumed in the economic analysis.

1. Exchange rate (rate at the time of the survey in July, 1982)

   ¥260 = US$1 = RP660

2. Inflation

   It is unreasonably difficult to forecast inflation for a 30 year period (the project life), and a mistaken forecast may considerably distort economic evaluation. Therefore, this matter is excluded from the analysis.

10.1.4 Economic Cost Estimation

Based on the above preconditions, costs were calculated for the respective items of analysis as follows:

1. Difference in the amount of investment

The construction cost (financial) calculated was adjusted as follows, in order to estimate the economic cost.

1) Tax and subsidy adjustment

① Foreign currency portion

No adjustment was required, since import duties were excluded when the financial cost was calculated.

② Local currency portion (materials and equipment)

The tax to be paid by the producers (mean, 20%) and the total of MPO and PPN (mean, 4.5%) were so estimated and subtracted from the financial cost.

2) Reuse of retired assets

Of those assets to be retired when the project is executed, diesel locomotives were excluded from the analysis at this time, though it is surmised that they may be diverted to other sections.

3) Times of investment

The amount of investment for each respective section is collectively appropriated to the year prior to the opening of the new facilities. The detailed schedule is entrusted to the F/S of each district.

4) Reinvestment

To secure the same base for calculating the amounts of investment in the cases when the project has been executed and when it has not, the same asset values were assumed to be reinvested in the respective years following the life expectancy shown in Table 10.1.4.

5) Appropriation of the salvage value

The set project life of 30 years is the period for analysis and the railway facilities will continue to be operated thereafter. Therefore, all the unamortized balance of the invested capital at the final year of the project was appropriated as the salvage value.

Based on the above preconditions, the amounts of investment in the cases with and without the project were calculated as follows.

(1) The case "with the project"

The execution of this project will remarkably increase the railway traffic volume, but on the other hand, the following enormous amounts of investment are required for ground facilities and rolling stock in order to meet the demand (electric locomotives, diesel locomotives, passenger cars and freight cars).

Table 10.1.1 Investment of "With the Project" (Railway)

(In million RP)

Kind of construction \ Period of construction	I (∿1988)	II (1989∿1997)	III (1998∿)	Total
Electrification	45,839	112,483	207,060	365,382
Signals & telecom	16,341	33,171	53,739	103,251
Civil work	22,466	118,344	49,102	189,912
Workshop	24,086	86,314	104,068	214,468
Rolling stock	78,969	453,366	141,039	673,374
Land	1,089	27,176	1,617	29,882
Total	188,790	830,854	556,625	1,576,269

Note 1:

Economic Prices of Rolling Stock

(In million RP)

Kind	Economic Price
DC locomotive	787
AC locomotive	812
Diesel locomotive	609
Passenger car	178
Freight car	25

(2) The case "without the project"

If this project is not executed, the traffic volume which can be carried by railways is only the ordinary traffic volume, and the volume corresponding to the converted traffic volume is carried by roads. Therefore, the investment also must be considered in the two categories of railways and roads, as follows.

1) Railways

The investment in ground facilities and rolling stock (diesel locomotives, passenger cars, freight cars) etc., required for carrying the demand (ordinary traffic volume) that naturally increases in the future, is as follows:

Table 10.1.2 Investment of "Without the Project" (Railway)

(In million RP)

Kind of construction \ Period construction	I (∿1988)	II (1989∿1997)	III (1998∿)	Total
Signals & telecom	7,979	24,695	18,848	51,522
Civil work	0	13,938	20,243	34,181
Workshop	0	41,103	22,248	63,351
Rolling stock	16,621	141,179	117,781	275,581
Land	0	325	346	671
Total	24,600	221,240	179,466	425,306

2) Roads

Investment must be made in vehicles (buses and trucks) for carrying the volume that corresponds to converted traffic volume.

Table 10.1.3 Investment of "Without the Project" (Road)

Vehicles \ Period	I (∿1988)	II (1989∿1997)	III (1998∿)	Total
Bus, Truck	9,247	340,349	1,151,861	1,501,457

① For public transport of passengers on roads, compared with railways, buses (with a capacity of 36 persons at a loading rate of 70%)(Note 1) were assumed, and automobiles, taxis, etc.were excluded from the analysis. For cargo, trucks (with a capacity of 5 tons at a mean loading rate of 70%) (Note 1) were assumed.

② Prices of rolling stock

(In RP)

	Typical Type	Economic Price (Note 2)
Bus	36-person capacity	29,656,000
Truck	5t	16,147,200

③ The life expectancy of a bus was assumed to be 7, and that of a truck was 8 years (Note 3).

Notes 1 and 2: Sources ... Pelayanan Peningkatan Jalan Proyek Studi Kelayakan Jalan, Laporan Khusus by Bina Marga in Maret 1981, and interviews with carriers.

Note 3: PPD and interviews with carriers

2. Difference of maintenance and operating costs

(1) Maintenance cost difference

1) Railways

For estimating the maintenance and replacement cost of railway facilities, the JNR method was used for lack of a suitable alternative.

① Maintenance cost of depreciated assets
= Maintenance rate (Note 1) × Total of unamortized depreciated assets

② Maintenance cost of replacement assets
= 0.95/life expectancy × Maintenance rate (Note 1) × Total of replacement assets

③ Replacement cost of replacement assets
= 0.95/life expectancy × Total of replacement assets

Note 1: The maintenance rates of the various assets are shown in Table 10.1.4.

Table 10.1.4 Maintenance Rates and Life Expectancy of Assets

		Maintenance Rate	Life Expectancy	Type of Assets (Note 2)
Civil work	Foundation	0.0004	57	Depreciated assets
	Road bridge, via-duct, bridge	0.0027	50	"
	Tunnel	0.0004	35	"
	Platform	0.0041	32	"
	Overbridge	0.0051	32	"
	(RC)Station building, station installations	0.0067	45	"
	(RC)Building, car shed	0.0057	45	"
	Rail track	0.15	41	Replacement assets
Signals and telecommunication	Crossing safety	0.0292	12	Depreciated assets
	Signal installations	0.0210	20	"
	Telecommunications devices	0.0312	9	"
	Signal line	0.035	35	Replacement assets
	Telecommunications line	0.12	35	"
	Track circuit	0.035	19	"
Power supply and electrification	Substation devices	0.0008	20	Depreciated assets
	Electric car line	0.013	45	Replacement assets
	Transmission line	0.013	31	Depreciated assets
Work-shop	Mechanical equipment	0.03	12	"
	Electric equipment	0.057	35	"
Rolling stock	Electric locomotive	0.0102	30	"
	Diesel locomotive	0.02503	20	"
	Passenger car	0.00508	30	"
	Freight car	0.0147	30	"

Note 2: A depreciated asset refers to an asset depreciated every year and reinvested after the lapse of the life expectancy. A replacement asset refers to an asset replaced at a certain rate every year, being continuously renewed.

2) Roads

In the case "without the project", the maintenance cost of the buses and trucks that would carry the converted traffic volume should be considered, in addition to the maintenance and replacement costs of the railway facilities used to carry the ordinary traffic volume.

Table 10.1.5 Annual Maintenance Costs per Bus and Truck

Item	Economic price (RP)
Annual maintenace cost per bus (Note 1)	2,965,600
Annual maintenance cost per truck (Note 1)	1,614,720

Note 1: According to information from PPD and interviews with carriers.

(2) Operating cost difference

1) Railways

Personnel costs differ between the cases "with the project" and "without the project", (i.e. train crew, workshop workers, inspectors and repairmen in the depot, etc.), due to the large difference in traffic volume. In the case "with the project", electricworkers are then required. With regard to the energy cost, this is for electricity in the case "with the project" but is for diesel oil in the case "without the project".

2) Roads

There will be additional personnel and energy costs in the operation of additional buses and trucks.

Table 10.1.6 Personnel Costs for Operation (per Bus and Truck)

	Number of Persons	Time Value
BUS driver	1	545^{RP}
conductor	2	300×2^{RP}
TRUCK driver	1	545^{RP}
assistant	1	164

Note: Source ... Pelayanan Peningkatan Jalan Proyek Studi Kelayakan Jalan, Laporan Khusus by Bina Marga in Maret 1981

Table 10.1.7 Fuel Cost of Buses and Trucks

(In RP)

	Market Price	Economic Price
Diesel oil	85	113.3 (Note 1)
Engine oil	1164	931 (Note 2)

Note 1: Directorate Oil Revenue, Ministry of Finance

Note 2: Mean actual cost of PPD

10.1.5 Benefit Estimation

The benefits given to the parties concerned were expressed quantitatively for the cases "with the project" and "without the project".

Although there is a railroad operation benefit in the railroad, the largest benefit is the saving of time through faster transport.

1. Time saving benefit

By executing this project, speeds can be expected to increase remarkably. This must be considered in both categories of passengers and cargo.

(1) Passenger time value

1) Procedure of calculation

① Estimation of traffic means by income classes

This estimation was made based on the Cost of Living Survey, 1977/1978, in Jakarta, Surabaya, Semarang, Bandung and Yogyakarta, and the following preconditions:

Preconditions:

- Means of transportation used by families were assumed to be approximately as follows, in the order of household income:
  1. Automobiles (including taxis)
  2. Public transport (railways and buses)
  3. Others

  This analysis covered only the class using the public transport.
- To determine the trend of Java as a whole, the average incomes in the above 5 major cities were weighted with overall population ratios in order to calculate the mean income of the families using public transport.
- The users considered included not only income earners but also their families.

The monthly income after taxis per family member using public transport was as follows:

Table 10.1.8

(In RP)

Transportation means used	Mean monthly income of a family	Mean number of members of a family	Monthly income per member of a family
Public transport	94,089	5.3551	17,570

② Estimation of passengers' time-value

The passengers' time-value was estimated based on the following preconditions:

Preconditions:

- Income per hour

= Monthly income per passenger ÷ (Mean monthly working hours × Non-working time adjusting value)

- Mean working hours per week (average of all the males and females of Indonesia)(Note 1) = 37.2 hours

  Mean working hours per year = 37.2 hours × 52 weeks
  = 1,934.4 hours

  Mean working hours per month = 1,934.4 hours ÷ 12 months
  = 161.2 hours

- Working time ratio = Working hours ÷ Active hours
  = 37.2 ÷ (12 hours × 7 days) = 0.44

- The time-value of the non-working time is 1/4 of the time-value of the working time (Note 2).

  Hence, the non-working time adjusting value is
  0.44 + 0.56 × 0.25 = 0.58

Table 10.1.9

	Time Ratio	Time Value
Working time	0.44	1
Non working time	0.56	0.25

- To convert the time-value per capita in 1977 into the time-value of 1982,the C.P.I. (Consumer Price Index) was used. With the value in 1977 as 100, C.P.I. (1982) = 192.2.

  Note 1: Source ... Population of Indonesia
  Note 2: Data of the World Bank

2) Passengers' time-value

From the above, the time-value of a user of public transport was calculated as 121 RP/hr.

(2) Freight time-value

If goods arrive at the destination sooner, the consignor can thereby save the financial cost of the goods.

Composition rates of cargoes by commodity item of the railways of Java and the prices per ton are as follows:

Table 10.1.10

Commodity Item	Rate of Total Cargo	Price/ton (RP)
Rice	1.6%	256,900
Maize	4.1%	137,330
Petrorium products	40.0%	401,224
Cement	15.9%	73,250
Fertilizer	23.6%	74,000
Molasses	3.1%	557,000
Salt	1.0%	39,000
Sugar	0.8%	560,000
Steel	0.5%	2,087,500
Others	9.4%	255,970
Total and mean	100.0%	255,977

The formula for calculating the saved interest is as follows: Saved interest per ton = Mean cargo value/ton × interest rate per hour × Saved time.

If general short-term interest rates of 18.5% are prevailing at the time the survey is applied, the time-value of cargo per ton is 24.5 RP/ton.

2. Cost saving benefit

As described in 10.1.4 "Difference of maintenance and operating costs", the difference in the maintenace and operating costs between the cases "with the project" and "without the project" was calculated and this difference was taken as the cost saving benefit. The explanation is omitted here.

10.1.6 Evaluation

1. EIRR

In this analysis, comprehensive evaluation is made in reference to EIRR. The EIRR is an excellent index which allows the respective evaluation items in the cases "with the project" and "without the project" to be evaluated on the same basis, in terms of currency values, and adjusts the differences of values between business years by discount rates, as already described. Based on the description made so far, the main features of the project are enumerated below:

1) 1,122,700 million RP in time saving benefits

2) 2,093,200 million RP in cost saving benefits

(Of which, 611,900 million RP were energy saving benefits)

Especially, the fuel saving can be said to be in accordance with the energy saving policy of Indonesia. The EIRR of the master plan calculated on the above basis is 24.3%, thus exceeding the 13% of the evaluation standard of a railway project in Indonesia.

Though not considered in the analysis at this time, other conceivable benefits include regional development, accident reduction, etc. Also, in the case "Without the project", additional investment in roads is expected to be required. This will be examined in detail in the F/S stage in the future.

2. Sensitivity analysis

All the estimations made in this analysis were made on forecast values with allowances, but they were treated as firm values. In this paragraph, a sensitivity analysis was made assuming more pessimistic values for the construction costs and traffic volumes in order to test the evaluation. The results are shown in the following table.

Table 10.1.11

	Case 1	Case 2	Case 3
Traffic volume	-20%	-30%	-
Construction cost	+10%	+20%	+30%
EIRR	20.6%	17.9%	17.4%

The results show that even with a decrease of 30% in traffic volume and a 20% cost overrun or with a 30% cost overrun in extreme cases, EIRR will be 17.9% and 17.4% respectively, indicating that project is sufficiently feasible to satisfy the sensitivity analysis.

10.2 Financial Evaluation

10.2.1 Purpose and Preconditions

1. Purpose of financial evaluation

All the investments made in railway installations, rolling stock, etc., are made by the government, and these facilities are managed by the PJKA. In principle, the PJKA must cover business expenses within the range of business income but actually every year the business expenses of the PJKA have exceeded its business income, showing deficits in the stage of operating income. Thus, they have been granted government subsidies. Furthermore, the fares are not set to cover the business expenses and the interest to be paid by the PJKA to the government as rent on assets. The PJKA is not required to operate to gain commercial profit, but is expected to make income and expenditures balance as much as possible.

From this viewpoint, the purpose of the financial evaluation made here is not only to calculate the financial internal rate of return but also to examine the following:

(1) To examine whether a government subsidy is required, based on the income and expenditure plan of the PJKA concerned with this master plan.

(2) To examine the burden of debt involved in the procurement of funds required for executing the master plan, and the surplus power of repayment of the debt on a cash flow projection.

2. Preconditions for examining the cash flow projection

The increment of demand involved in the increase of transport capacity by the execution of the master plan was estimated, and the income and expenditure and the burden of debt ascribable to the extended portion were examined. Based on this so-called "increment method", a cash flow projection was prepared for financial evaluation. The project life, conversion rates of RP/US$/Yen and the treatment of the inflation factor were in accordance with the economic analysis. Since the PJKA is a governmental organ, the customs duties were not assumed to be incurred, as in the case of the economic analysis. Items different from the economic analysis are that an average 24.5% was added as a tax component in the local currency portion of the invested amount, and that a subsidy component was reduced for diesel oil in the fuel cost. According to the fund procurement plan, three cases of Base Case, Case 1 and Case 2 were established to examine the cash flow in these respective cases.

10.2.2 Items in the Cash Flow Table

1. Items related to the income and expenditure of PJKA.

(1) Operating income

Based on the profit and loss statement (passenger income and freight income) of the PJKA in 1981/82 and the gross transport volume (gross person km, and gross ton km) in 1981/82, a passenger fare of 5.4 RP/person km and a freight fare of 16.0 RP/ton km were applied and assumed to remain constant during the project period. The income after 2002 was assumed to be constant.

(2) Operating expenses

The business expenses were the total of the operating expenses including the maintenance expenses, personnel expenses, and energy expenses of rolling stock and ground installations, plus depreciation expenses. Depreciation expenses were calculated by applying the above depreciation rates of JNR to the depreciated assets.

(3) Operating profit and net profit

The balance remaining after subtracting business expenses from business income is the operating profit. Furthermore, the amount obtained by subtracting the "interest on total assets" to be paid by the PJKA to the government from the operating profit is the net profit. This corresponds to the "profit after tax" of private companies. According to the agreement between the Minister of Finance and the Minister of Communications (Article 11 of the Joint Decree of the Minister of Finance and the Minister of Communications issued on 30th March, 1979), it seems agreed in principle that 3% of the fixed assets should be paid to the government as an "interest", but actually this interest has not been paid, since a deficit has been recorded in operating profit every year. The base for calculation of interest is not clear, but here this interest has been obtained by subtracting the depreciation expenses every year from the total amount of fixed assets and then multiplying the result by 3%.

2. Investment and fund procurement plans

(1) Investment plan

The investment plan (Table 10.1.1) used for the economic analysis was used. The investment plan by foreign currency and local currency after financial price adjustment is as shown below (Table 10.2.1). For the respective installations, the same amounts were assumed to be reinvested after the lapse of the depreciation period. Of the total amount of investment, the local currency portion accounts for about 25%, and the foreign currency portion for about 75%.

(2) Fund procurement plan

It was presumed that the investment and related fund procurement would be undertaken by the government. Of funding, the foreign currency portion would be borrowed from overseas countries, while the local currency portion would be from the national budget or borrowed in rupiah currency in Indonesia. According to the cash flow projection of the master plan, a large surplus is expected to be recorded by the project in the initial business year, which could be used as investment funds (viz., by decreasing the loans payable). However, because the analysis adopts the "increment method" and because this project is only a part of the entire organization of the PJKA, which would probably absorb this surplus in its overall deficit, it is realistic to assume the procurement of outside investment funds will be 100% until the business results of the PJKA show an amount in the black.

The following fund procurement conditions for foreign and local currency were assumed.

1) Loans from overseas countries

① Average conditions were set in reference to the conditions of the public loans (including IBRD and ADB) from overseas countries:

Interest: 6.0% p.a.

Period: 27 years (incl. 7 years as grace period)

Method of repayment: Equal yearly installments for 20 years

Table 10.2.1 The Amounts of Investment "With the Project"

(In million RP)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
INVESTMENT	51694	144769	72132	170457	75783	55979	160635	128761	42567	22255	105128	26761	26792	45938	26454
FOREIGN TOTAL	30075	113979	72132	112802	65591	55979	69277	69108	36020	26173	69336	26761	26764	44274	26454
LOCAL TOTAL	21619	30790		57655	10192		91358	59653	6547	152	35524		28	1664	
ELECTRIFICATION	35218	11535		33657	4787		12074	27558	11552		24228				
FOREIGN CURRENCY	22193	7426		20309	2716		7199	17659	7635		15437				
LOCAL CURRENCY	13025	4109		13349	2071		4875	11559	4517		8819				
SIGNALS & TELECOM	14349	3872		12727	2261		5563	8887	1676	2339	4591		283	120	
FOREIGN CURRENCY	7219	1135		2763	671		3263	2075	734	2165	1371		255	108	
LOCAL CURRENCY	7130	2737		5964	1590		2655	6812	943	152	3218		28	12	
CIVIL WORK	1586	23772		17178	9688		71087	23352	1757	59	2243	74			
FOREIGN CURRENCY	664	7553		5959	3438		20069	9631	752	59	933	74			
LOCAL CURRENCY	922	15012		11215	6250		51018	13951	1005		1349				
WORKSHOP & DEPOT		25159		46861							46882			18928	
FOREIGN CURRENCY		18577		24745							24766			17276	
LOCAL CURRENCY		6581		22116							22116			1652	
ROLLING STOCK		78769	72132	59224	55776	55979	55831	59613	27499	25875	26587	26687	26559	26570	26454
FOREIGN CURRENCY		78769	72132	59224	55776	55979	55831	59613	27499	25875	26587	26687	26559	26570	26454
LAND	342	1181		1037	271		32818	1291	85		459				
LOCAL CURRENCY	342	1131		1037	271		32818	1291	85		459				

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
INVESTMENT	245508	1071	117	2344	577	93267	5587	22520	13787	2533	19265	6971	37620	5109	310	1,641,599
FOREIGN TOTAL	149933	984	106	2176	464	52242	4712	21568	11455	2220	17556	6125	34357	4302	257	1,196,890
LOCAL TOTAL	95575	87	11	168	113	41047	875	952	2333	313	1739	846	3263	793	53	444,709
ELECTRIFICATION	115219					69152	4733		11955	1353		4012	11263	4176		375,732
FOREIGN CURRENCY	69849					49285	4063		10196	1235		3276	9531	3597		242,025
LOCAL CURRENCY	45361					19867	672		1759	118		735	1732	577		133,707
SIGNALS & TELECOM	31457	418	117	2344	577	13701	654	120	1716	1160	358	2659	3957	924	310	117,298
FOREIGN CURRENCY	6555	331	106	2176	464	5265	359	110	1210	965	280	1651	3369	705	257	46,079
LOCAL CURRENCY	24792	87	11	168	113	8655	295	10	504	195	78	268	557	219	53	71,219
CIVIL WORK	35734	653				18593										211,637
FOREIGN CURRENCY	11659	653				6931										68,375
LOCAL CURRENCY	24074					11672										143,262
WORKSHOP & DEPOT	22459							22459			18928		22459			223,930
FOREIGN CURRENCY	21459							21459			17276		21459			167,037
LOCAL CURRENCY	942							942			1652		942			56,943
ROLLING STOCK	34459															673,374
FOREIGN CURRENCY	34459															673,374
LAND	1459					733										39,578
LOCAL CURRENCY	1409					733										39,578

② Average conditions were set in reference to the conditions of public assistance between two countries (excluding IBRD and ADB):

Interest: 3.0% p.a.

Period: 30 years (incl. 10 years as grace period)

Method of repayment: Equal yearly installments for 20 years

2) Local currency funds

① Conditions were set, in reference to the financing conditions for loans of more than one year given by national banks to governmental organs. The interest is lower than those in general markets.

Interest: 13.5% p.a.

Period: 10 years (incl. 4 years as grace period)

Method of repayment: Equal yearly installments for 6 years

② Government budget

In this case, the payment of interest and the repayment of capital are not required.

Based on the above fund procurement conditions, three cases were set by combining the foreign currency and local currency funds. The case surmised to be most general as a fund procurement plan is called the Base Case, as shown in the following table together with the other two cases.

Table 10.2.2. Fund Procurement Plan

	Foreign Currency	Local Currency
Base Case	6.0% 27 yrs. incl. 7 yrs. grace period	Government budget
Case 1	3.0% 30 yrs. incl. 10 yrs. grace period	Government budget
Case 2	6.0% 27 yrs. incl. 7 yrs. grace period	13.5% 10 yrs. incl. 4 yrs. grace period

It is assumed that the entire amount required for the business year concerned is procured at the beginning of the business year and that each year's loan is independent, respectively.

10.2.3 Profit of the PJKA

Since the operating income and expenditure and the net profit shown in the cash flow projection indicate that a profit will be recorded from the initial business year, no government subsidy whatsoever is required throughout the period. However, what should be noted in the above income and expenditure plan is that the cash flow was prepared based on the "increment method", without considering the existing portion. Furthermore, the regions considered in the master plan are only part of the entire organization of the PJKA, and this too, must be noted in evaluating the estimated income and expenditure. However, from the above estimation of income and expenditure, the execution of the master plan can be said to greatly contribute to the enhancement of the business of the PJKA. (In the cash flow projection, the income after 2002 was assumed to be constant.)

10.2.4 Cash Flow Analysis

1. Base case

The details of the Base Case are shown in Appendix 10.2.1 and it is summarized in Table 10.2.3.

The net cash flow in the Base Case keeps showing positive values throughout the period of the master plan. In short, this means that there is no problem in the debt service (repayment of the principal + interest). Therefore, as far as the master plan is concerned, it is not necessary to raise the fare or freight charge or to take any other measures if the assumed demand is constant. However, it must be noted that this discussion on the hike of the fare or freight charge is based on the prices of 1982, and does not include the inflation factor.

Table 10.2.3 Cash Flow of Base Case

(In million RP)

	1987∿1988	1989∿1997	1998∿2016	Total
Revenue	39,156 (19,578)	1,142,902 (126,989)	4,283,536 (225,449)	5,465,594 (182,186)
Operating profit	28,638 (14,319)	765,324 (85,036)	2,754,659 (144,982)	3,548,621 (118,287)
Net profit	24,016 (12,008)	634,215 (70,468)	2,425,870 (127,677)	3,084,101 (102,803)
Investment	196,263 (98.132)	868,719 (96.524)	576,617 (30,348)	1,641,599 (54,720)
Debt service	1,804 (902)	282,216 (31,357)	1,555,795 (81,884)	1,839,815 (61,327)
Net cash flow	30,744 (15,372)	663,478 (73,720)	1,903,471 (100,183)	2,597,693 (86,590)

2. In Case 1, since a low interest fund (so-called concessional loan was assumed for the loan from overseas countries, the net cash flow is further improved. Even if the burden of debt is largest in Case 2, the net cash flow keeps showing positive values throughout the period.

3. Conclusion

Based on the examination made above, the execution of the master plan is judged to be sufficient in project viability with FIRR of 16.3%.

Though it is possible to cover some of the investment funds with the net profits of the project and to procure funds through ordinary commercial loans, it is realistic to procure 100% of the investment funds from outside the PJKA and to cover the local currency portion (25%) of the investment completely by the government budget and the foreign currency portion by low interest long-term funds until the point when the overall results of PJKA show a profit, as the "increment method" is adopted here.