The cooling capacities of the airconditioning system in the powerhouse, service building and workers shift rooms are considered to be about 230,000 kcal/h, 300,000 kcal/h and 90,000 kcal/h, respectively.

4-7-2 Transmission Line, Substation and Communication System

1) Basic Idea for the Design of the Interconnecting Power System

The interconnecting system between unified power system and Ayun Musa Power Station should satisfy the following operating conditions.

a. The local load in Sinai Peninsula will not be so much in early 1990s. So, the most part of output of Ayun Musa PS should be sent to the unified power system with high reliability and good stable condition.

b. The interconnecting transmission system should be capable to send the final output of the power station.

c. Three new thermal power stations, Abu Sultan PS (600 MW), Ataka PS (600 MW), and Ayun Musa PS (1,200 MW), will be constructed in Canal Area upto 1990. The interconnecting transmission system should be effective for the reliability of these power stations' operation.

d. A failure of any 220 kV transmission line which interconnect Canal area to the main part of unified power system, does not affect the stability and reliability of transmitting the output of these power stations.

Actually, Abu Sultan PS is interconnected to unified power system with three 220 kV transmission lines, for Abu Zaabal via 10 Ramadan, for Delta area via Manayef and for Cairo East via Suez. And Ataka PS is interconnected to unified power system with three transmission lines, for Katamia near Cairo, for Cairo South via Sokhna and for Cairo East via Suez.

So Ayun Musa PS should be interconnected to unified power system with two or more transmission routes.

2) Study of Alternative Interconnecting Plans

Many alternative plans for the interconnection between Ayun Musa and the unified system were discussed by concerned engineers and JICA Team. Preliminary study of interconnecting system was scheduled to study only the following four (4) plans. (See Table 4-27)

The following conditions were considered in the study.

i) The capacity of Ayun Musa PS

1st stage ... 600 MW

2nd stage ... 1,200 MW

ii) The reliability of interconnecting system

The routes of interconnecting transmission line should be two or more.

If one route of interconnecting transmission lines is out of order, the remained routes should transmit the whole output of Ayun Musa PS.

Preliminary Study Plans

Case A: Stage 1 Interconnecting lines between Ayun Musa PS and New Suez SS ... 220 kV four bundle conductor line two (2) lines π branch from existing Cairo East Suez 220 kV line to New Suez SS.

Stage 2 New Suez-Katamia SS 500 kV two lines

Case B: Stage 1 Interconnecting lines between Ayun Musa PS and New Suez SS ... 220 kV bundle (2) conductors four lines π branch from existing Cairo East-Suez 220 kV lines to New Suez SS

Stage 2 Same to Case A.

Case C: Stage

Case C: Stage 1 Interconnecting line between Ayun Musa PS and Manayef SS, Suez SS ... 220 kV bundle (2) conductors two (2) circuits, each

Stage 2 Additional 220 kV two circuits between Ayun Musa PS and Manayef SS

500 kV interconnecting line between Abu Zaabal and Manayef SS

Case D: Stage 1 Interconnecting line between Ayun Musa PS and Katamia SS 500 kV two lines

Stage 2 New Suez Substation for interconnecting canal area to 500 kV system

a. Study of Construction Cost

Construction cost of alternative plans is shown in Table 4-28.

Case A is most cheapest one, and next is Case B. Case C and Case D are about 20% higher than Case A.

The reason of expensive cost for Case D is that it needs the construction of 140 km length of 500 kV line and Ayun Musa PS's 500 kV switch yard.

And the reason of expensive cost for Case C is that it needs to construct two routes of canal crossing cable lines.

b. Construction Period

Case A, B and C will need about 22 months for construction of Stage 1, but Case D 36 months.

c. Reliability of Transmission Line

500 kV line has most reliable for accident. Next is Case C and Case B.

d. Stability of Generator

Alternative plans have no remarkable difference on stability of generators at Ayun Musa PS in an emergency case which one interconnecting transmission line is tripped out.

e. Normal Operating Condition

Alternative plans have no remarkable difference on load flow in transmission lines and voltage at substations in normal condition and emergency conditions. But, the load flow on Manayef-Abu Sultan line in Case A and B becomes larger than Case D and E in Stage 1.

In Stage 2, the load flow of above mentioned Section in Case A and B becomes to exceed more than 600 MW. (See Fig. 4-23, Fig. 4-24)

f. Short Circuit GVA at Station's Busbar

In all loop of 220 kV system, the short circuit GVA around Suez area in Case D is lower than others. The reason is that Ayun Musa PS is interconnected directly to Cairo Area. 220 kV alternative plans are similar condition for short circuit GVA at station busbar. (See Fig. 4-25, Fig. 4-26)

g. Maintenance

Cleaning of insulators should be done every two or three months for transmission lines which run through desert areas for the protection of salt pollution.

So Case D needs more days of stopping line for the maintenance of lines.

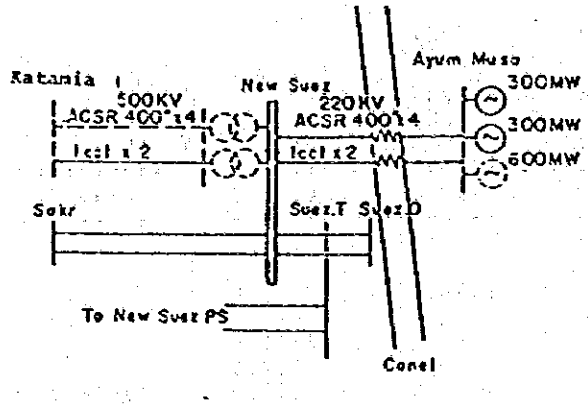
Conclusion of Preliminary Study

Case B and Case D are selected for the candidated plans for the interconnection line system of Ayun Musa PS.

More detailed study about the short circuit GVA in Stage 2 should be done and then final plan will be selected.

Table 4-27 Out line of Alternative Plans

Case A



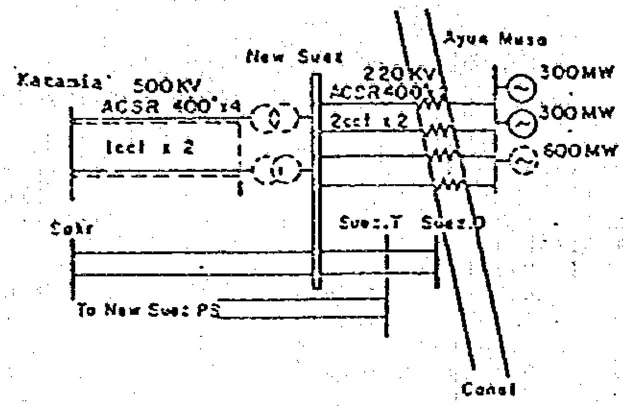
Stage 1 (big line)

1. Ayun Musa 300MW x 2
2. New Suez 220KV Switch Yard
3. Ayun Musa -------- New Suez S.Y.
   220 KV T/L 2 circuit

Stage 2 (dot line)

1. Ayun Musa 600MW x 1addition
2. New Suez S.Y. 500KV Uprate
3. New Suez - Katamia 500 KV T/L

Case B



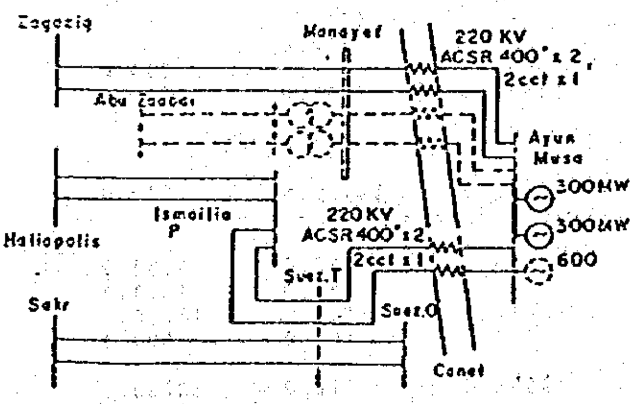
Stage 1 (big line)

1. Ayun Musa 300 MW x 2
2. New Suez 220KV Switch Yard
3. Ayun Musa - Mew Suez S.Y.
   220 KV T/L 4 circuit

Stage 2 (dot line)

1. Ayun Musa 600 MW x 1 addition
2. New Suez S.Y. 500 KV Uprate
3. New Suez - Katamia 500 KV T/L

Case C



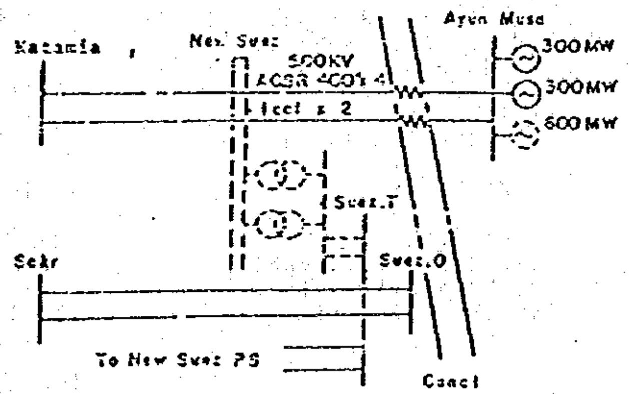
Stage 1 (big line)

1. Ayun Musa 300 MW x 2
2. Ayun Musa ----- Suez T.S.
   Ayun Musa ----- Manayef T.S.
   220 KV 2 circuit, each
3. Suez T.S. Manayef T.S. Incoming Facility

Stage 2 (dot line)

1. Ayun Musa 600 MW x 1addition
2. Manayef T.S. 500KV Uprate
3. Ayun Musa ---- Manayef 220 KV
   2 circuit addition
4. Manayef ---- Abu Zaabal 500KV
   T/L

Case D



Stage 1 (big line)

1. Ayun Musa 300 MW x 2
2. Ayun Musa - Katamia
   500KV T/L 2circuit

Stage 2 (dot line)

1. Ayun Musa 600 MW x 1 addition
2. New Suez T.S. 500KV
3. New Suez ---- Suez T.S. 220KV
   Tie line

Table 4-28

CONSTRUCTION COST of ALTERNATIVE PLANS

UNIT : 10^6 YEN

I T E M S	Case A	Case B	Case C	Case D
* STAGE 1.				
1. Overhead T/L				
A.Musa -- N.Suez	3165.2	3034.0	-	-
A.Musa -- A.Zaabal	-	-	-	20436.0
A.Musa -- Manayef	-	-	3552.0	-
A.Musa -- Suez SS	-	-	1554.0	-
Subtotal	3165.2	3034.0	5106.0	20436.0
2. Cable				
Suez Canal Crossing	3856.0	4510.0	6375.0	4854.0
T/L Total	7021.2	7544.0	11481.0	25290.0
3. Substation				
A.Musa P.S.	1723.0	2468.0	2468.0	6710.0
New Suez SS	2707.0	3152.0	-	-
Manayef SS	-	-	390.0	-
Suez SS	-	-	390.0	-
Others	151.0	193.0	137.0	304.0
SS total	4581.0	5813.0	3385.0	7014.0
4. Stage 1. Grand Total	11602.2	13357.0	14866.0	32304.0
* STAGE 2.				
1. Overhead T/L				
New Suez--A.Zaabal(500kV)	14410.0	14410.0	-	-
Manayef SS--A.Zaabal(500kV)	-	-	14410.0	-
A.Musa PS -- Manayef SS	-	-	3552.0	-
New Suez SS -- Suez SS	-	-	-	200.0
Subtotal	14410.0	14410.0	17962.0	200.0
2. Cable				
Suez Canal Crossing	-	-	1197.5	-
T/L Total	14410.0	14410.0	19159.5	200.0
3. Substation				
A.Musa PS additional	585.0	585.0	585.0	3158.0
220 kV additional	-	-	383.0	1321.0
500 kV SS facility	18810.0	18810.0	18810.0	18810.0
Others	500.0	500.0	500.0	500.0
SS total	19895.0	19895.0	20278.0	23789.0
4. Stage 2. Grand Total	34305.0	34305.0	39437.5	23989.0
T O T A L (Stage 1. + Stage 2.)	45907.2	47662.0	54303.5	56293.0

Fig. 4-23 Load Flow in 1989 (Peak) Case L-89-I

Conditions : i) All Loop
ii) A.Musa – N.Suez 220KV T/L

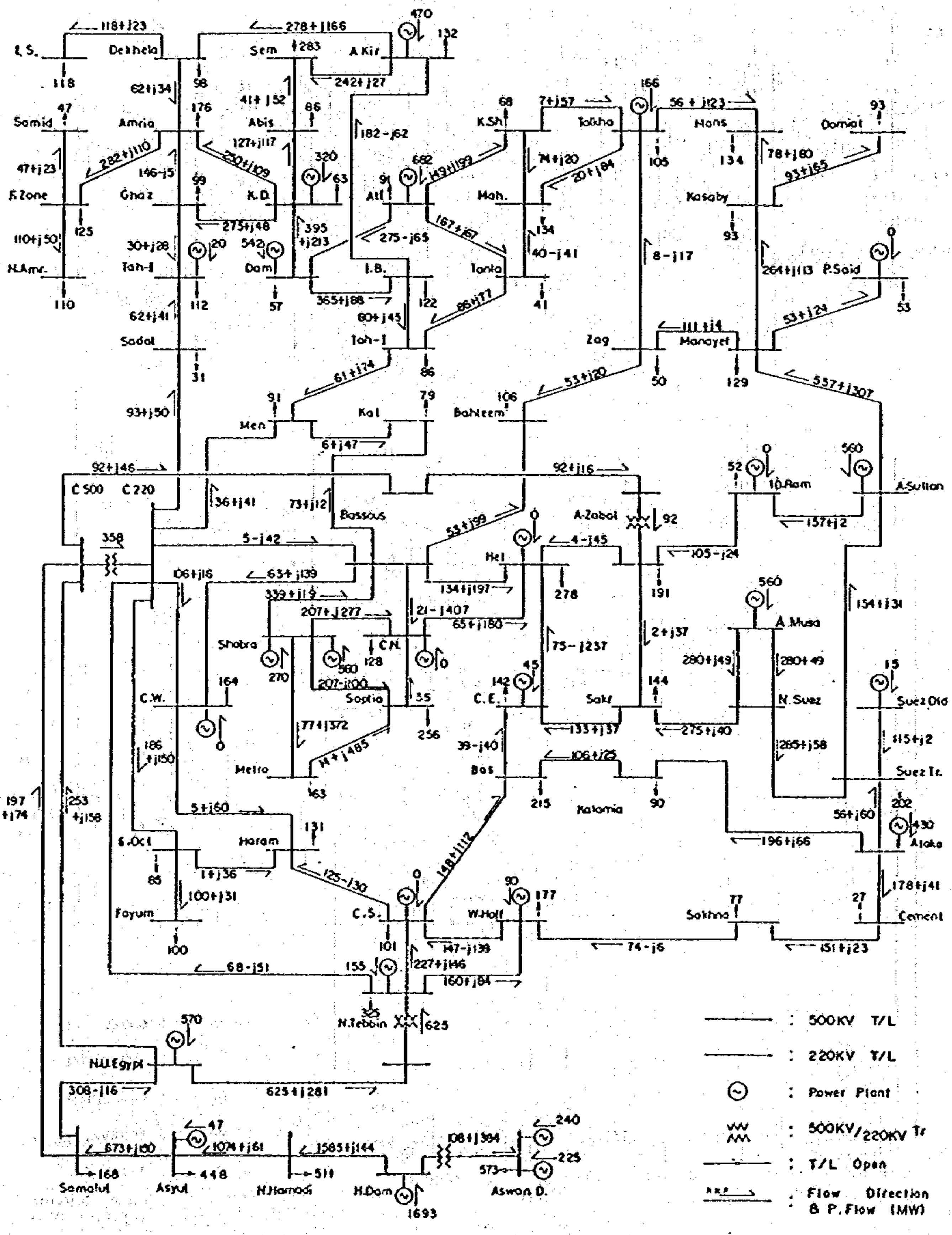


Fig. 4-24 Load Flow in 1989 (Peak) Case L-89-4

Conditions : I) All Loop

II) A.Muso-Kotomio 500KV T/L

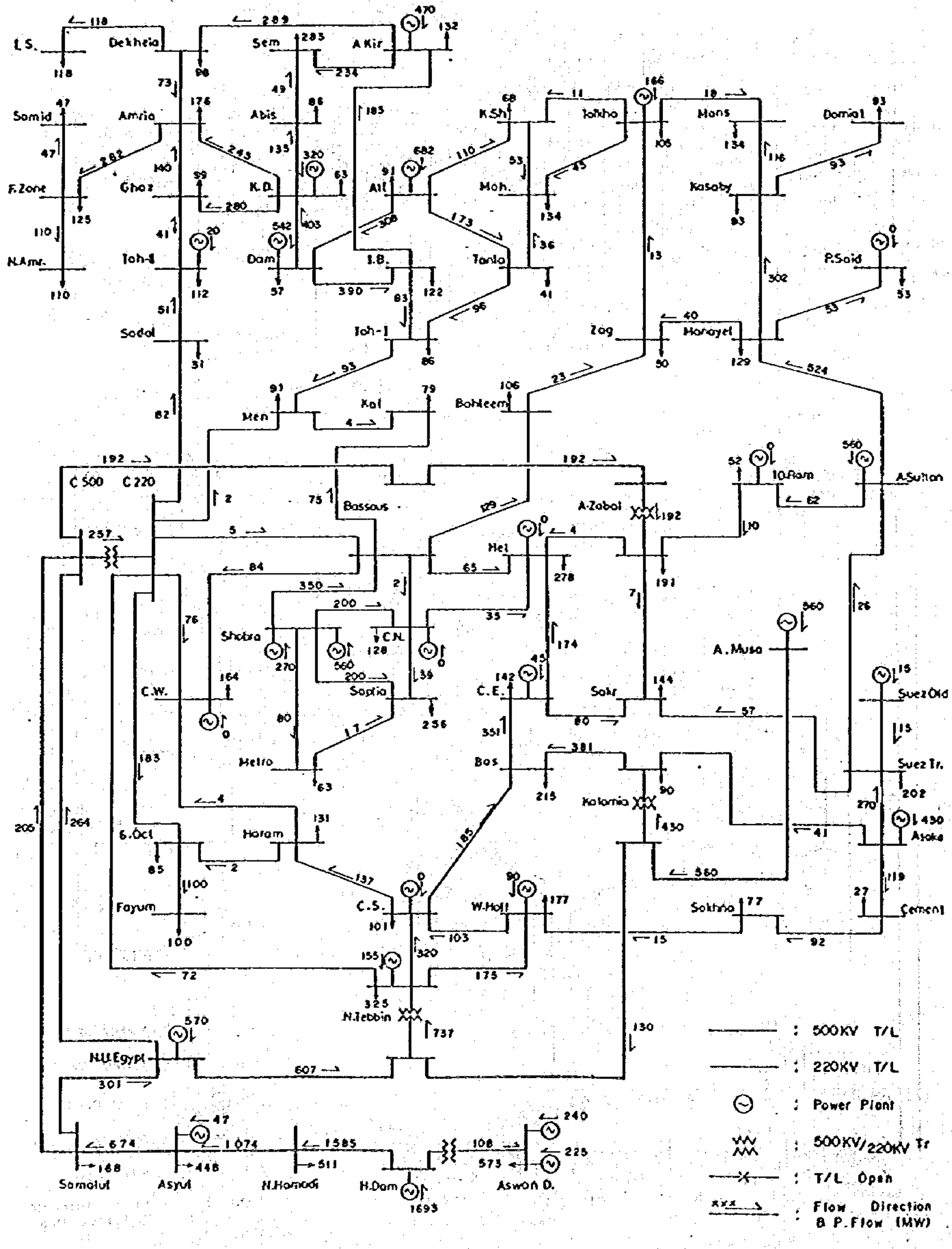


Fig. 4-25 Short Circuit Capacity in 1989 (Case S-89-1)

Conditions: i) All Loop.

ii) A.Musa – N.Suez 220 kV T/L.

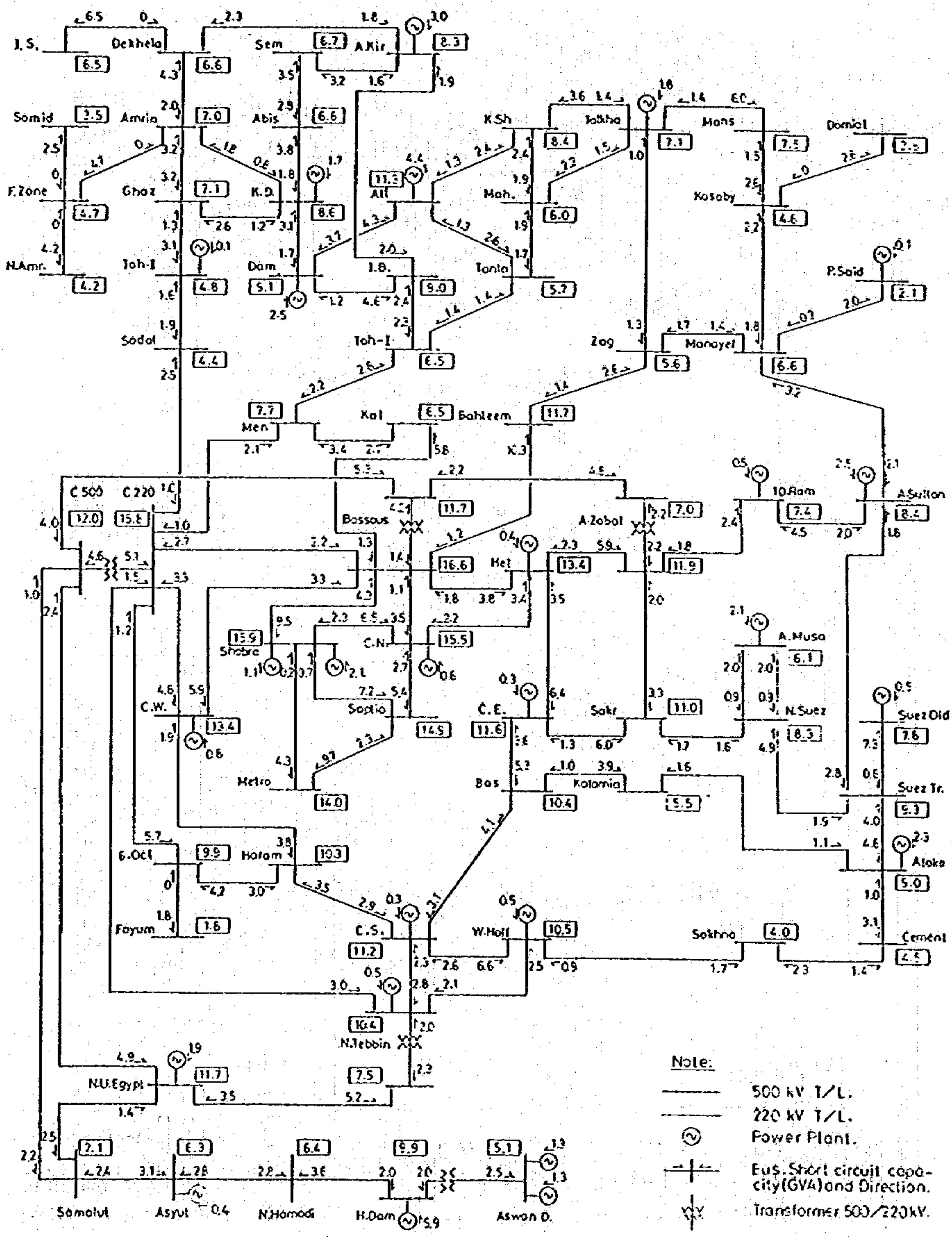
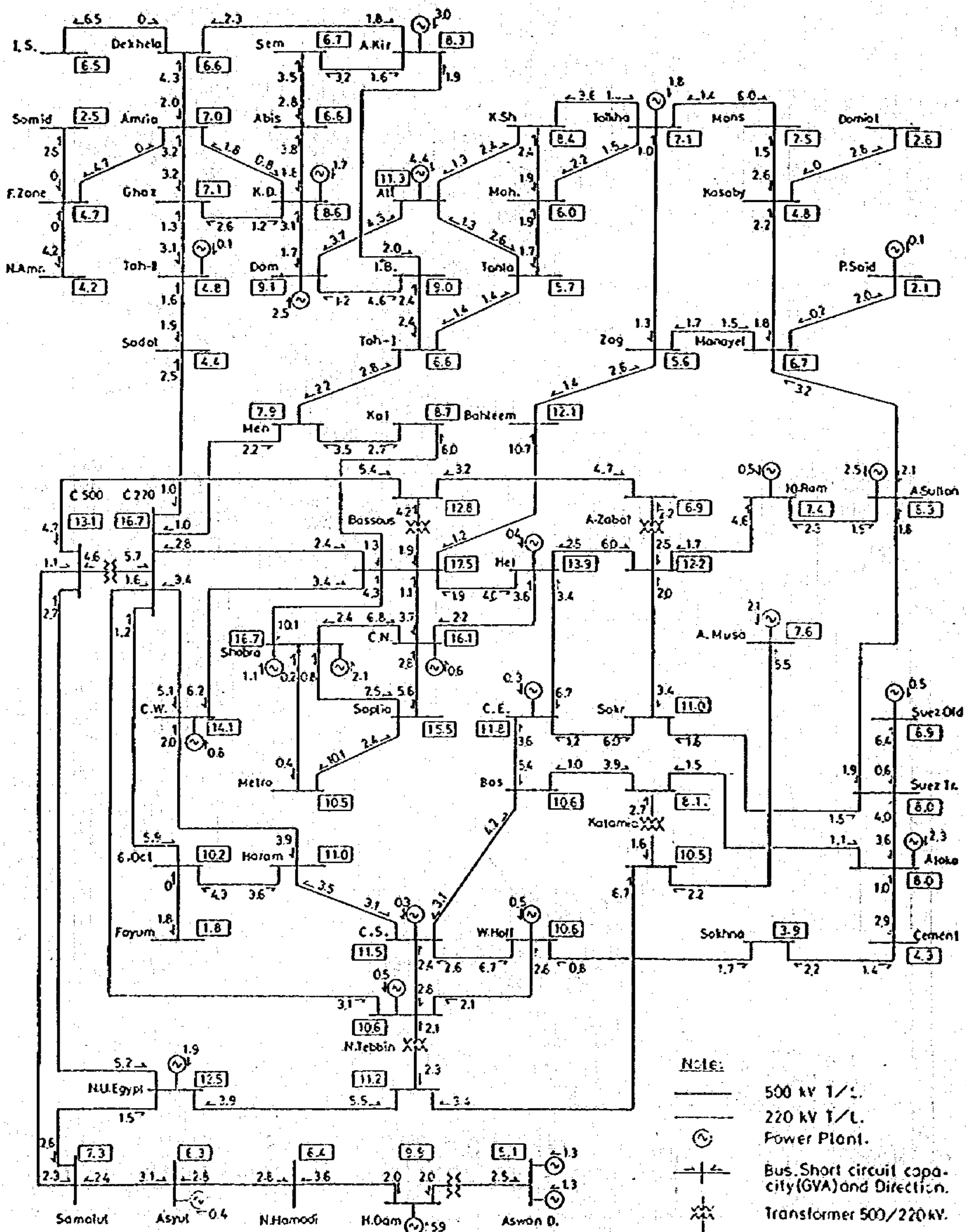


Fig. 4-26 Short Circuit Capacity in 1989 (Case S-89-2)

Conditions: i) All Loop.
ii) A Musa - A Zabal 500kV T/L.



3) Study of Short Circuit GVA at Each Substation Busbar

a. Comparison of the Short Circuit Capacity in 1990

When Ayun Musa PS has become 1,200 MW plant (December 1990), the study of short circuit GVA was checked on following two cases. One is Ayun Musa PS is interconnected directly to unified system with 500 kV lines and another the station is interconnected to New Suez SS with 220 kV four circuits and from their step upped to 500 kV and interconnected to unified system. Fig. 4-27 and Fig. 4-28 show the distribution of short circuit GVA at each station by each case.

The short circuit GVA at each busbar of main substation in Cairo area and canal area is shown in Table 4-29 from the calculated data. No distinguished difference in two cases is except 220 kV busbar at Ayun Musa PS.

In the case of 220 kV interconnecting system, there are 25 line circuit breakers in Canal area which its short circuit GVA is in the range of 9 GVA to 14 GVA. (See Table 4-30)

There are 13 breakers at New Suez SS, 4 at Ataka PS and 8 at Suez Tr. SS.

It is no problem for the breakers at New Suez SS and ATaka PS, because they are designed their capability for short circuit GVA at 15 GVA.

Four circuit breakers at Suez Tr. SS which exceed 10 GVA are 2 units for 220/60 kV transformer and 2 units for Old Suez PS. To separate 220 kV system in operation is one of the countermeasures to decrease short circuit GVA.

Short circuit GVA at Suez Tr. SS becomes 9.9 GVA in separate system condition from 11.5 GVA in all loop operating system.

b. Conclusion

The comparison of Case B and Case D is shown in Table 4-31.

Construction Cost

Case B is cheaper than Case D about $100 million in 1st stage and $70 million in whole stage.

Construction Period

Case B is shorter than Case D about 12 months in 1st stage.

Load Flow and Voltage Condition

Both cases are same condition. There is no problem except Abu Sultan - Manayef line. The line carries the load more than 500 MW in both cases. The reason is that new power plants are constructed in Cairo and Suez areas and the old and minor capacity power plants in Alex. and Delta areas are stopped in normal condition. So, the load flow of the line becomes larger amount.

Short Circuit GVA

Ayun Musa Bus and 220 kV side Bus of New Suez are operated in separate condition in Case B. The reason is to decrease the short circuit GVA of stations around Suez. Case B in above operating condition becomes same condition of Case D.

Conclusion

Case B, 220 kV interconnecting system, is recommendable for the interconnecting system for Ayun Musa PS.

Fig. 4-27 Short Circuit Capacity in 1990 (Case S-90-1)

Conditions: i) All Loop.

ii) A.Musa - N.Suez 220kV T/L.

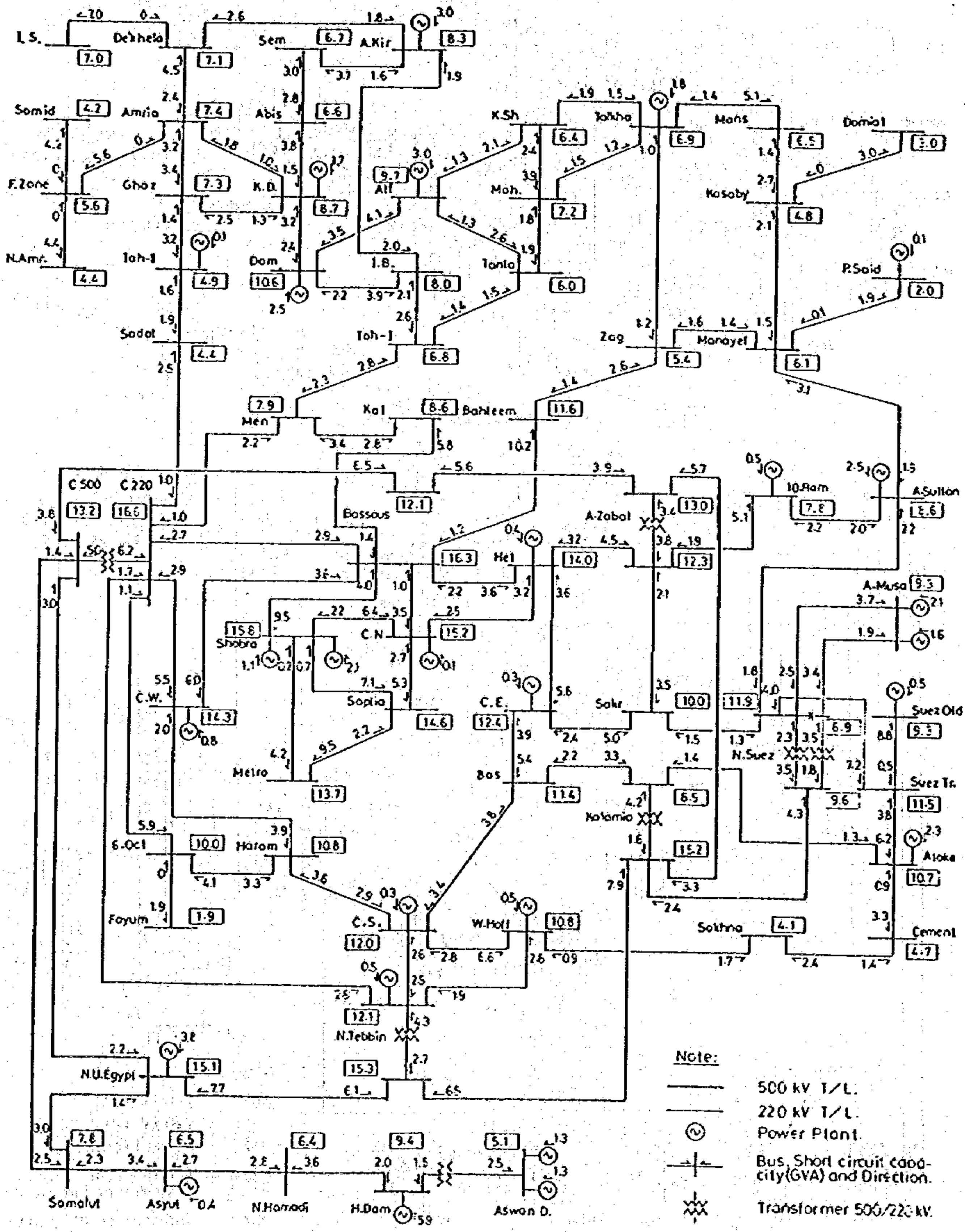


Fig. 4-28 Short Circuit Capacity in 1990 (Case S-90-2)

Conditions: i) All Loop.
ii) A.Musa – N.Suez 500 kV T/L.

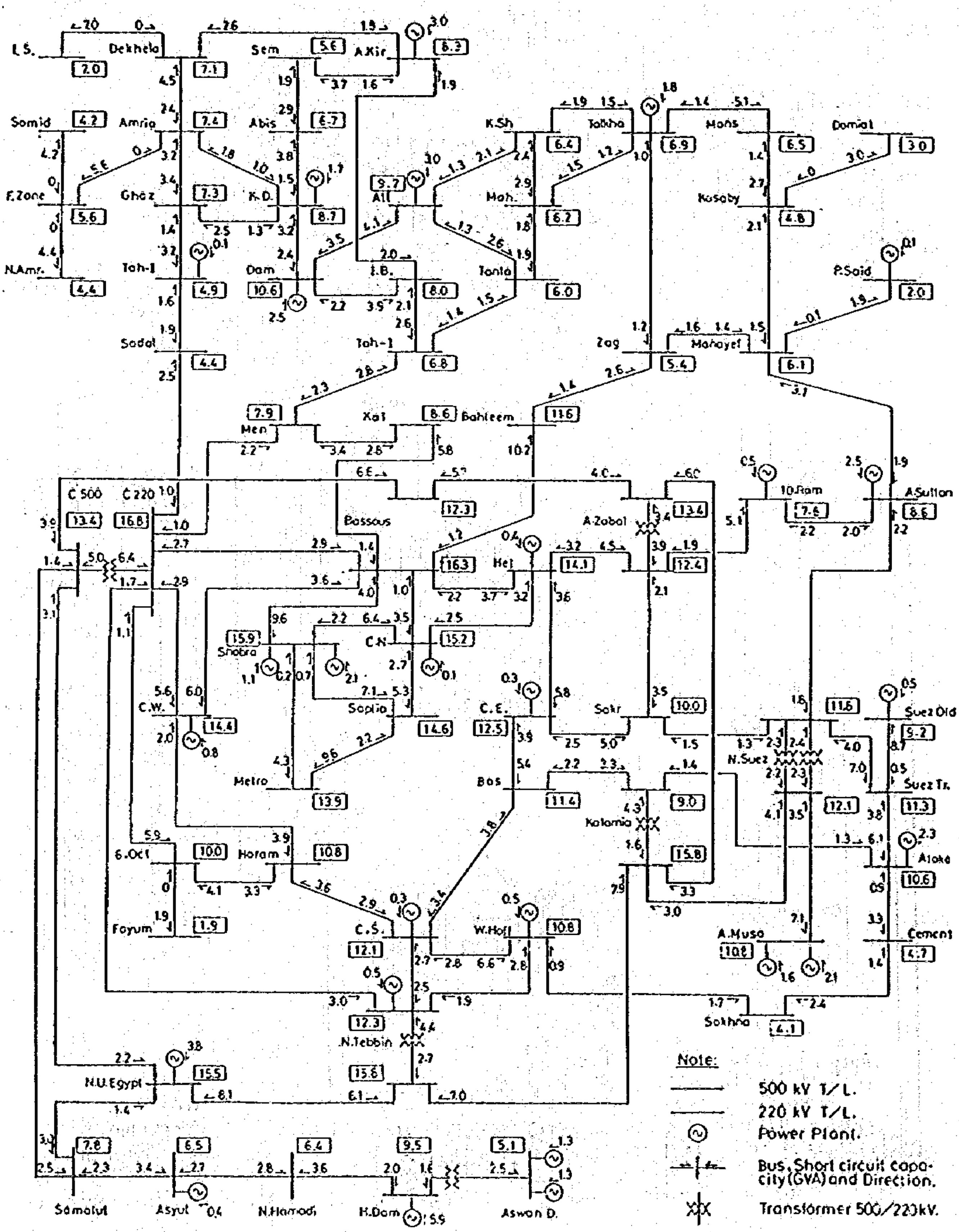


Table 4-29

Names of SS		Short Circuit GVA 220kV Case B	500kV Case D	(B)-(D)	(B)/(D) x 1 (%)
Canal Area	New Xuez 500	9.6	12.1	-2.5	126
	Ayun Musa 500	-	10.9	-	-
	10 Ramadan	7.8	7.8	0	100
	Zagazig	5.4	5.4	0	100
	Manayef	6.1	6.1	0	100
	Abu Sultan PS	8.6	8.6	0	100
	Suez Tr.	11.5	11.3	0.2	102
	Suez old PS	9.4	9.3	0.1	101
	Ataka PS	10.6	10.6	0	100
	New Suez SS #1	11.4	11.8	- 0.4	97
	New Suez SS #2	5.4	-	-	-
	Ayun Musa 220kV (#2 Bus)	5.6	10.9	- 5.3	52
	Cement	4.7	4.7	0	100
Cairo Area	A.Zaabal 220kV	12.3	12.4	- 0.1	99
	Cairo East	12.4	12.5	- 0.1	99
	Basateen	11.4	11.5	- 0.1	99
	Cairo South	12.0	12.1	- 0.1	99

Note: The reason why there is no significant difference between Case B and Case D on Short Circuit GVA
When the bus at Ayun Musa PS and New Suez SS wwo kVside, each, is not separated, the short circuit GVA at related station's bus becomes larger than Case D.
To decrease the short circuit GVA in case B, buses at Ayun Musa PS and New Suez 220 kV side are separated as shown in the figure.
On this system operation, the short circuit GVA condition in Case B becomes similar condition as Case D.

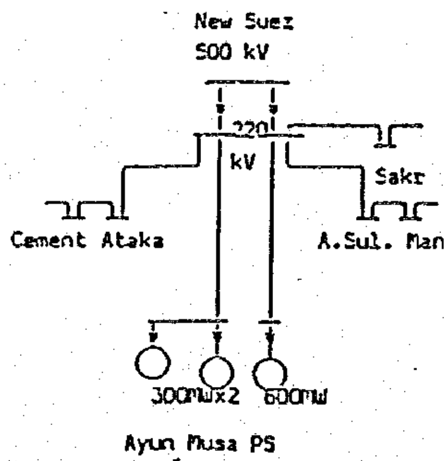


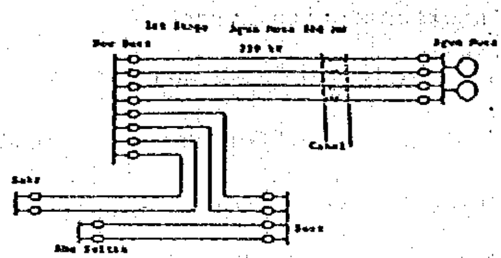
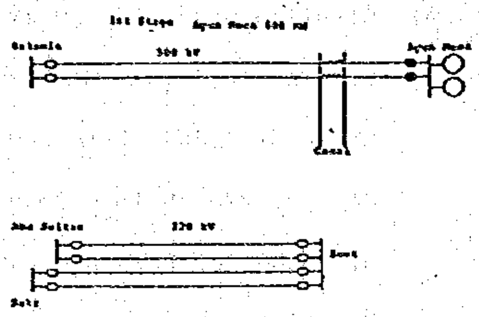
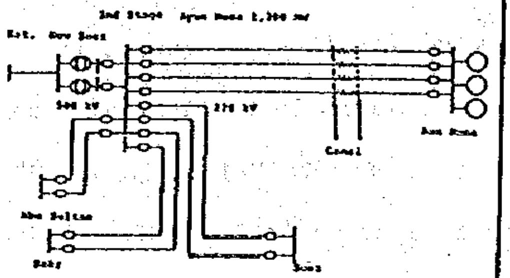
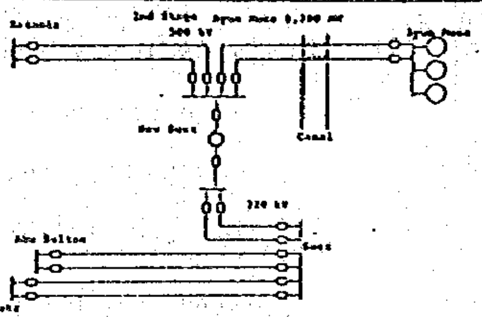
Table 4-30

Short Circuit GVA by Circuit Breaker Grade

Unit : No. of Unit

CASE	AREA	RAPTURED CAPACITY (GVA)				TOTAL
		>14	>9	>8	<8	
220KV	Central Cairo Area	38	41	7	26	112
	Southern Cairo Area	0	84	9	9	102
	Canal Area	0	25	2	68	95
	Alex. Delta Area	0	12	12	160	184
	Upper Egypt Area	0	0	2	24	26
	Total	38	162	32	287	519
500KV	Central Cairo Area	38	43	7	24	112
	Southern Cairo Area	7	77	9	9	102
	Canal Area	0	31	2	60	93
	Alex, Delta Area	0	12	12	160	184
	Upper Egypt Area	0	0	2	24	26
	Total	45	163	32	277	517

Table 4-31

	CASE: 220 kV 4 circuites	CASE: 500 kV 2 circuits
System Map	 	
	 	
Main Items of Construction	1st Stage 1. Ayun Musa PS 300 MW x 2 2. New Suez SS 3. Ayun Musa--New Suez 220 kV 4 circuits 2nd Stage 1. Ayun Musa PS 1,200 MW 2. New Suez uprate to 500kV Station(2 trans.) 3. New Suez --Katamia 500 kV T/L	1st Stage 1. Ayun Musa PS 300 MW x 2 2. Ayun Musa --Katamia 500kV 2 circuits 2nd Stage 1. Ayun Musa PS 1,200 MW 2. New Suez 500 kV ss (one trans.) 3. New Suez-- Suez SS 220kV T/L two circuits
Construction Cost (Unit:10^6\$) 1\$=240 Yen	1st Stage 1. AyunMusa-New Suez line 12.9 2. Canal Crossing 20.4 3. New Suez branch line 0.2 4. New Suez ss 13.1 Sub Total 46.6 2nd Stage 1. New Suez SS uprate 500kV 78.2 2. New Suez-Katmia 500kV one line 45.8 Sub Total 124.2 Total 170.8	1st Stage 1. Ayun Musa-Katamia 500kV 2 circuit 104.2 2. Canal crossing 19.5 3. Ayun Musa PS increase 15.0 4. Katamia SS 10.4 Sub Total 149.1 2nd Stage 1. New Suez 500kV SS 83.9 2. New Suez-Suez 220kV 2 circuits 0.4 Sub Total 84.3 Total 246.4
Construction period	Manufacturing 10 mo. Erection 12 mo. Total 22 mo.	Manufacturing 12 mo. Erection 24 mo. Total 36 mo.
Load flow & Voltage	Except Abu Sultan - Manayef line, the others are no problem.	- ditto -
Short circuit GVA	In 1990, Ayun Musa PS & New Suez SS 220kV buses operate on separate bus condition. Then, distribution of short circuit GVA is same condition of Case D.	New Suez 220kV bus, Suez Tr SS and Ataka PS exceed a little more than 10 GVA.
Emergency case	One circuit or one route of interconnecting lines between Canal and Cairo area is tripped out in emergency, there is no problem to transmit the output of Power station in Canal area.	- ditto -

4) Detailed Study of 220 kV Interconnecting System

The following load estimations for 1989 and 1990 by area, shown in Table 4-32 and 4-33 are used for detailed study of CAse B, 220 kV interconnecting system for Ayun Musa PS.

a. Study of Load Flow and Voltage Conditions in Normal Conditions

a) In 1989: Ayun Musa PS Output 600 MW (Stage 1)

There is three power stations in Canal Area, Ayun Musa PS (600 MW), Abu Sultan PS (600 MW) and Ataka PS (600 MW), and their total capacity is 1,800 MW. Adding to these new thermal power stations, Shoubra PS (900 MW) and North Upper Egypt PS (600 MW) will be constructed in Cairo area.

Since these new high efficiency power stations come into unified power system, gas engine and inter combustion engine generators, high fuel cost, and old low efficiency small thermal power plants become to margin units.

So, Alex. and Delta areas where few new power stations are constructed, will become to receive a big amount of power from Canal area and Cairo area and interconnecting lines between areas will become to carry heavy loads.

Fig. 4-23 shows the load flow at peak time in 1989 in normal condition. The output of new thermal power plants in Canal area are as follows.

Ayun Musa PS	..... 560 MW
Abu Sultan PS	..... 560 MW
Ataka PS	..... 430 MW
Total	1,550 MW

i) Interconnecting lines between Canal Area and Delta Area, (Abu sultan - Manayef Line)

The load flow of the line is 557 MW. The load flow of the line is affected by the load which is supplied from Manayef SS to Delta area, rather than the total output of power stations in Canal area. The load flow Case D, 500 kV interconnecting line for Ayun Musa PS, is also about 500 MW. The load flow of the line under the following conditions are studied.

Case M-1

Load at Manayef SS ... Constant
Output of power stations
in Canal area ... Variable

Case M-2

Load at Manayef SS ... Variable
Output of power stations
in Canal area ... Constant

The result is shown in Table 4-34.

The 20% of the change of output of power stations is the variation of load flow of the line, and 60% of the change of Manayef load is the variation of the line. So, it is necessary to install additional lines according to the increase of the load in Delta area.

ii) Interconnecting lines between Cairo area and Canal area

There are four (4) 220 kV interconnecting lines between subjected areas. That are, Abu sultan - 10 Ramadan, New Suez - Sakr kouridge, Ataka - Katamia and Ataka - Wadi Hoff via Sokhna. The load flows on these lines are no problem in normal condition by the change of output of power stations in Canal area s shown in Table 4-35.

b) In 1990: Ayun Musa PS Output 1,200 MW (Stage 2)

When the output of Ayun Musa PS becomes 1,200 MW on 1990, the output of North Upper Egypt PS is scheduled 1,200 MW also. Alex. and Delta areas also have not any new big power station, and have not constructed any new interconnecting line also. According to the increase of Delta and Alex. areas at Manayef SS, Abu sultan - Manayef line carries more than 600 MW. Fig. 4-29 shows the load flow at peak in 1990 in normal condition. Refer to pages D-5 and D-6 of APPENDIX-D.

i) Interconnecting line between Delta area and Canal area

The quantity of load flow on Abu Sultan - Manayef line is 630 MW. The quantity does not decrease when Abu sultan - New Suez line is cut off as shown in Table 4-36.

To separate Abu Sultan - New Suez tie is no good for the countermeasure of above mentioned over load and for the reliability of system operation. After 1991, a nuclear power plant and/or a coal-fired thermal plant is scheduled to develop in Alex. area or Delta area. So, the balance of load and generation will be improved remarkably after these new developed power plant. But the load demand at Manayef SS and Port Said SS will increase year by year, the quantity of load flow on Abu Sultan - Manayef line will keep high level. By the reason, it is recommendable to construct additional transmission line between the stations.

ii) Interconnecting line between Cairo area and Canal area

An additional 500 kV line will be constructed as an interconnecting line between Cairo area and Canal area. so, there is no problem for load flow and voltage condition after the increase of output power of Ayun Musa PS.

Conclusion

There is no problem for interconnecting lines except Abu Sultan - Manayef line when the output of Ayun Musa power plant becomes the final stage, 1,200 MW.

To keep sufficient interconnecting capacity between Abu Sultan and Manayef, it is necessary to construct a new interconnecting line.

b. Study of Voltage Condition and Reactive Power Control Facility

kW Balance by areas in 1990 is shown in Table 4-28. Mine features of the balance are as follows.

. Canal area is sending power to other areas in all round the clock.

. Upper Egypt area is sending power to other areas about 343 MW at peak time, but is receiving power from Cairo area about 586 MW at midnight.

. Cairo area is receiving power from other areas about 760 MW at peak time, but is sending power to Upper Egypt area about 381 MW at midnight.

. Alexandria and Delta areas are always receiving power from 912 MW to 423 MW at any time.

Alex. and Delta areas become to lower operating voltage and Upper Egypt area also becomes lower voltage condition at midnight, if no countermeasure facility is installed.

Table 4-37 and Table 4-38 show the balance of reactive power by area of which voltage conditions of stations are kept in the range of (220 kV -5%).

Man features of voltage condition by area are as follows.

a) Cairo area will be able to control voltage condition by operating generators in the area and synchronous condenser at Cairo 500 SS.

b) The voltage condition in Canal area is higher comparably in any time, operating generators in the area must keep high power factor, upto 1.00.

c) Alex. area is necessary about 400 MVar static condenser to improve the lower voltage condition. But after 1990, a nuclear power plant and/or a coal-fired power plant will be installed in the area and will improve the condition. So, it is necessary to check more detailed study for the installation.

d) Delta area is necessary to install 500 MVar static condenser for the improvement of lower voltage condition. There is no plan to install a new big thermal power plant. The plan for the installment of static condenser should be checked as soon as possible.

e) Upper Egypt area will be able to control the voltage condition by generator's Var output and the control of on load tap changer. But it is desirable to study the installment of switch at the head of shunt reactor at High Dam.

Figs. 4-30 and 4-31 show the voltage condition at peak and midnight in 1989 and 1990.

Table 4-32

BALANCE OF LOAD DEMAND AND SUPPLY IN 1989

AREA	LOAD (MW) 1983 JAN.	LOAD (MW) 1989 DEC.	GENERATION (MW) IN 1989 HYDRO	THERMAL	GAS	(TOTAL)	BALANCE [B]-[A]
PEAK		[A]				[B]	
CAIRO	1427	2827	0	1400	290	1690	-1137
SUEZ	193	306	0	1550	15	1565	1259
DELTA	850	1410	0	625	765	1390	-20
ALEX	491	1417	0	790	20	810	-607
U. EGYPT	899	1700	2205	0	0	2205	505
(TOTAL)	3860	7660	2205	4365	1090	7660	0
DAY TIME		[A]				[B]	
CAIRO	1043	2208	0	1380	90	1470	-738
SUEZ	141	281	0	1470	0	1470	1189
DELTA	622	1291	0	550	422	972	-319
ALEX	417	772	0	460	0	460	-312
U. EGYPT	673	1378	1558	0	0	1558	180
(TOTAL)	2896	5930	1558	3860	512	5930	0
MID NIGHT		[A]				[B]	
CAIRO	763	1466	0	1358	90	1448	-18
SUEZ	127	254	0	1460	0	1460	1206
DELTA	563	1159	0	550	170	720	-439
ALEX	336	613	0	200	0	200	-413
U. EGYPT	699	1438	1102	0	0	1102	-336
(TOTAL)	2488	4930	1102	3568	260	4930	0

Table 4-33

BALANCE OF LOAD DEMAND AND SUPPLY IN 1990

AREA	LOAD (MW) 1983 JAN.	1990 DEC.	GENERATION (MW) IN 1990 HYDRO	THERMAL	GAS	(TOTAL)	BALANCE [B]-[A]
PEAK		[A]				[B]	
CAIRO	1427	3015	0	2255	0	2255	-760
SUEZ	193	548	0	2344	0	2344	1796
DELTA	850	1824	0	616	491	1107	-717
ALEX	491	1650	0	988	0	988	-662
U. EGYPT	899	1727	2020	50	0	2070	343
(TOTAL)	3860	8764	2020	6253	491	8764	0
DAY TIME		[A]				[B]	
CAIRO	1043	2203	0	2087	0	2087	-116
SUEZ	141	401	0	2277	0	2277	1876
DELTA	622	1335	0	285	0	285	-1050
ALEX	417	1411	0	988	0	988	-423
U. EGYPT	673	1341	1054	0	0	1054	-287
(TOTAL)	2896	6691	1054	5637	0	6691	0
MID NIGHT		[A]				[B]	
CAIRO	763	1614	0	1995	0	1995	381
SUEZ	127	360	0	2067	0	2067	1707
DELTA	563	1197	0	285	0	285	-912
ALEX	336	1130	0	540	0	540	-590
U. EGYPT	699	1294	708	0	0	708	-586
(TOTAL)	2488	5595	708	4887	0	5595	0

Table 4-34

CHANGE OF LOAD FLOW ON TIE LINE between ABU SULTAN PS and MANAYEF SS (1989)

UNIT: MW

CASE No.	(1)	(2)	(3)	(4)	(5)
GENERATOR & LOAD CONDITION					
A.SULTAN P.S. OUTPUT	560	560	560	560	560
AYUN MUSA P.S. OUTPUT	560	460	360	360	360
ATAKA P.S. OUTPUT	430	430	430	430	430
MANAYEF & DELTA LOAD	557	557	557	657	457
BASSOUS SENDING POWER	146	246	346	446	246
TIE LINE LOAD FLOW					
A.SULTAN --- MANAYEF	560	555	551	620	482

Table 4-35

CHANGE OF LOAD FLOW ON TIE LINE between CAIRO AREA and CANAL AREA (1989)

UNIT: MW

CASE No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GENERATOR & LOAD CONDITION								
A.SULTAN P.S. OUTPUT	560	560	560	560	560	560	460	360
AYUN MUSA P.S. OUTPUT	560	560	460	360	0	0	560	560
ATAKA P.S. OUTPUT	430	560	430	430	430	430	430	430
MANAYEF & DELTA LOAD	557	557	557	400	400	557	557	557
TIE LINE LOAD FLOW								
ATAKA --- SOKHNA	177	170	164	146	93	98	170	161
ATAKA --- KATAMIA	213	202	194	168	90	98	204	189
ATAKA --- SUEZ Tr	39	188	71	116	246	234	55	80
NEW SUEZ --- SUEZ Tr	163	14	130	86	-45	-32	146	122
NEW SUEZ --- SAKR	221	300	188	161	49	43	204	190
NEW SUEZ --- A.SULTAN	175	246	140	113	-4	-11	210	247
A.SULTAN --- 10 RAMADAN	175	231	146	220	119	15	128	82
A.SULTAN --- MANAYEF	560	575	555	452	437	534	542	525

Fig. 4-29 Load Flow in 1990 (Peak) Case L-90-I

Conditions : i) All Loop

ii) N.Suez 220KV Bus Separate

iii) Reference — Bus is C.500

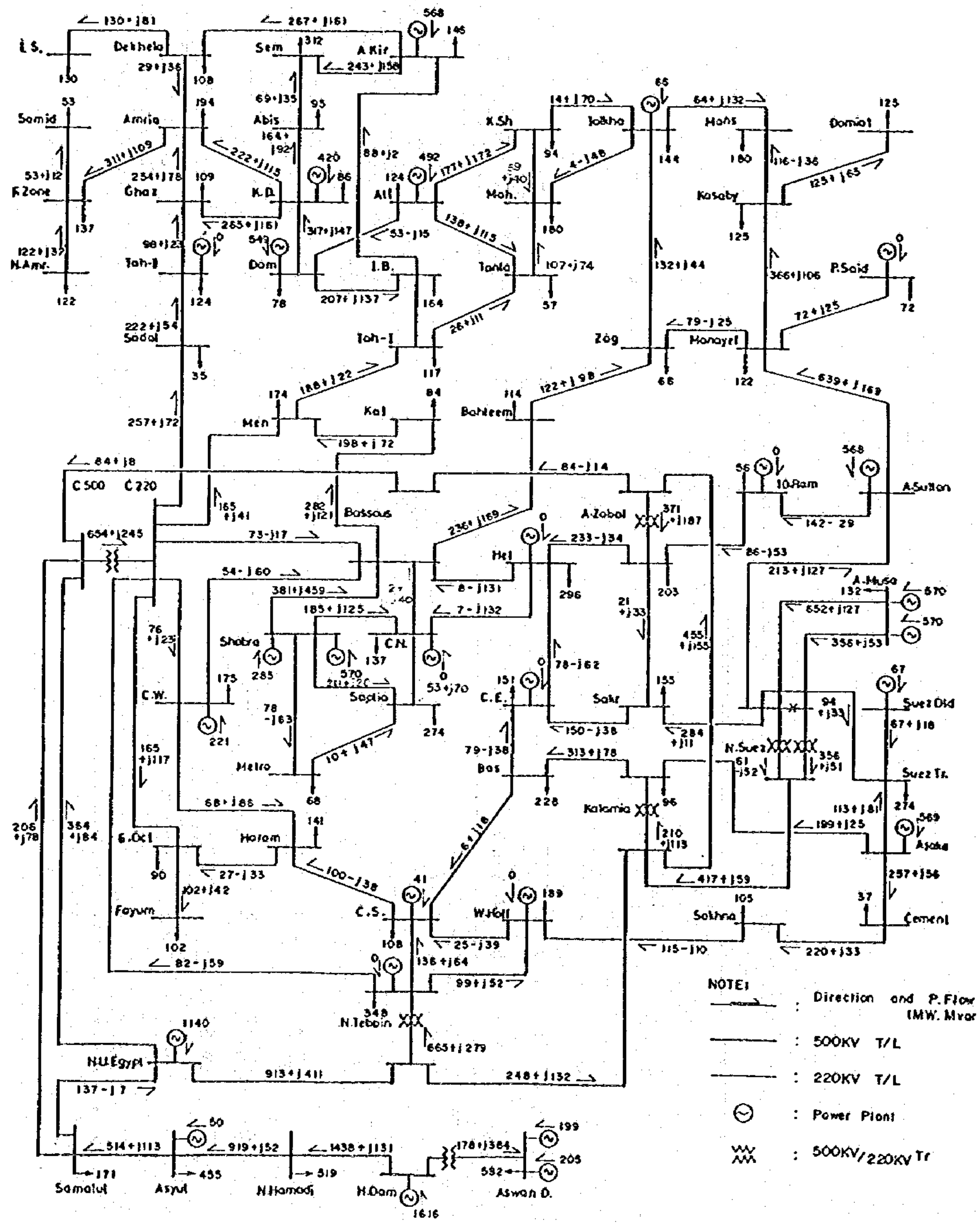


Table 4-36

LOAD FLOW IN EMERGENCY CASE -- CANAL AREA -- (1990)

UNIT : (MW)

TRANSMISSION LINE	NORMAL	1 CIRCUIT OFF								1 ROUTE OFF					
		ATAKA ~ SOKH.	ATAKA ~ KATAN.	N.SUEZ ~ SAKR	N.SUEZ ~ A.SUL.	A.SUL. ~ 10.RUM.	N.S.500 ~ KAT.500	KAT.500 ~ KAT.220	A.SUL. ~ HANAYEF	ATAKA ~ SOKH.	ATAKA ~ KATAN.	N.SUEZ ~ SAKR	N.SUEZ ~ A.SUL.	A.SUL. ~ 10.RUM.	A.SUL. ~ HANAYEF
ATAKA --- SOKHNA	206	232	323	307	300	298	334	319	300	0	366	328	309	301	329
ATAKA --- KATAMIA	264	288	104	276	260	265	303	338	268	307	0	208	282	271	297
ATAKA --- SUEZ Tr	0	45	79	-18	-3	4	-131	-91	-2	190	200	-60	-25	-6	-60
NEW SUEZ --- SUEZ Tr	195	155	121	219	204	197	332	202	203	11	1	261	·227	207	261
NEW SUEZ --- SAKR	238	248	242	152	257	241	333	219	253	287	250	0	306	265	365
NEW SUEZ --- A.SULTAN	191	194	192	202	139	180	322	129	154	205	105	222	0	112	-130
A.SULTAN --- 10 RAMADAN	79	79	79	79	47	59	179	25	121	80	80	78	-37	0	438
N.SUEZ --- KATAMIA 500	363	390	431	414	388	309	0	347	378	485	542	504	455	403	491
N.SUEZ 220 -- N.SUEZ 500	-1	-14	-7	73	32	6	-227	79	21	-64	-16	206	121	50	193
KATAMIA 500 -- KATA.220	172	180	233	190	173	170	-4	0	179	213	333	223	177	171	234
A.SULTAN -- HANAYEF	679	682	680	691	650	689	711	671	600	693	683	711	605	680	0
ATAKA P.S.	566	566	566	566	566	566	566	566	566	566	566	566	566	566	566
AYUN MUSA P.S.	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140
A. SULTAN P.S.	568	568	568	568	568	568	568	568	568	568	568	568	568	568	568
HANAYEF & DELTA LOAD	734	734	734	734	734	734	734	734	734	734	734	734	734	734	734

Table 4-37

SUMMARIZED MVAR BALANCE (1990)

ITEM	VAR LOAD (MVAR)			VAR SUPPLY (MVAR)				
	LOAD	L.LOSS	TOTAL	L.CHARGE	GENERTOR	S.H/R.C	Sh.R	TOTAL
PEAK								
NO S.C.	5429	1804	7233	3409	4363	121	-660	7233
INSTALLED S.C.	5429	1804	7233	3409	3717	767	-660	7233
DAY TIME								
NO S.C.	5016	1194	6210	3409	3317	144	-660	6210
INSTALLED S.C.	5016	1194	6210	3409	2536	925	-660	6210
MID NIGHT								
NO S.C.	2710	1065	3775	3409	918	108	-660	3775
INSTALLED S.C.	2710	1065	3775	3409	737	389	-760	3775

Table 4-38

MVAR BALANCE OF EACH AREA

1990 PEAK (NO S.C.)

AREA ----->	CAIRO	SUEZ	DELTA	ALEX	U.EGYPT	TOTAL
GENERATOR P.F.	(0.88)	(0.95)	(0.80)	(0.80)	(0.90)	
DEMAND	-1868	-339	-1130	-1022	-1070	-5429
GENERATOR	1217	770	830	741	805	4363
LINE LOSS	-349	-435	-240	-178	-602	-1804
LINE CHARGE	1139	288	274	184	1524	3409
S.C. or R.C	121	0	0	0	0	121
Sh. R	0	0	0	0	-660	-660
(TOTAL)	260	284	-266	-275	-3	0

1990 PEAK (INSTALLED S.C.)

AREA ----->	CAIRO	SUEZ	DELTA	ALEX	U.EGYPT	TOTAL
GENERATOR P.F.	(0.96)	(0.96)	(0.80)	(0.80)	(0.90)	
DEMAND	-1868	-339	-1130	-1022	-1070	-5429
GENERATOR	658	683	830	741	805	3717
LINE LOSS	-349	-435	-240	-178	-602	-1804
LINE CHARGE	1139	288	274	184	1524	3409
S.C. or R.C	67	0	400	300	0	767
Sh. R	- 0	0	0	0	-660	-660
(TOTAL)	-353	197	134	25	-3	0

1990 DAY TIME (NO S.C.)

AREA ----->	CAIRO	SUEZ	DELTA	ALEX	U.EGYPT	TOTAL
GENERATOR P.F.	(0.88)	(0.95)	(0.80)	(0.80)	(0.80)	
DEMAND	-1652	-300	-1001	-1058	-1005	-5016
GENERATOR	1126	748	214	741	488	3317
LINE LOSS	-296	-441	-179	-158	-120	-1194
LINE CHARGE	1139	288	274	184	1524	3409
S.C. or R.C	144	0	0	0	0	144
Sh. R	0	0	0	0	-660	-660
(TOTAL)	461	295	-692	-291	227	0

1990 DAY TIME (INSTALLED S.C.)

AREA ----->	CAIRO	SUEZ	DELTA	ALEX	U.EGYPT	TOTAL
GENERATOR P.F.	(0.97)	(0.97)	(0.80)	(0.80)	(0.80)	
DEMAND	-1652	-300	-1001	-1058	-1005	-5016
GENERATOR	523	570	214	741	488	2536
LINE LOSS	-296	-441	-179	-158	-120	-1194
LINE CHARGE	1139	288	274	184	1524	3409
S.C. or R.C	25	0	500	400	0	925
Sh. R	0	0	0	0	-660	-660
(TOTAL)	-261	117	-192	109	227	0

1990 MID NIGHT (NO S.C.)

AREA ----->	CAIRO	SUEZ	DELTA	ALEX	U.EGYPT	TOTAL
GENERATOR P.F.	(0.99)	(0.99)	(0.80)	(0.80)	(0.95)	
DEMAND	-782	-174	-580	-547	-627	-2710
GENERATOR	89	94	214	405	116	918
LINE LOSS	-289	-382	-184	-103	-107	-1065
LINE CHARGE	1139	288	274	184	1524	3409
S.C. or R.C	108	0	0	0	0	108
Sh. R	0	0	0	0	-660	-660
(TOTAL)	265	-174	-276	-61	246	0

1990 MID NIGHT (INSTALLED S.C.)

AREA ----->	CAIRO	SUEZ	DELTA	ALEX	U.EGYPT	TOTAL
GENERATOR P.F.	(1.00)	(1.00)	(0.80)	(0.80)	(0.95)	
DEMAND	-782	-174	-580	-547	-627	-2710
GENERATOR	0	0	215	406	116	737
LINE LOSS	-289	-382	-184	-103	-107	-1065
LINE CHARGE	1139	288	274	184	1524	3409
S.C. or R.C	-11	0	300	100	0	389
Sh. R	-100	0	0	0	-660	-760
(TOTAL)	-43	-268	25	40	246	0

Fig. 4-30 Voltage Condition in 1989 (Case V-89-1)

Conditions : I) All Loop

II) A.Musa — N.Suez 220KV T/L

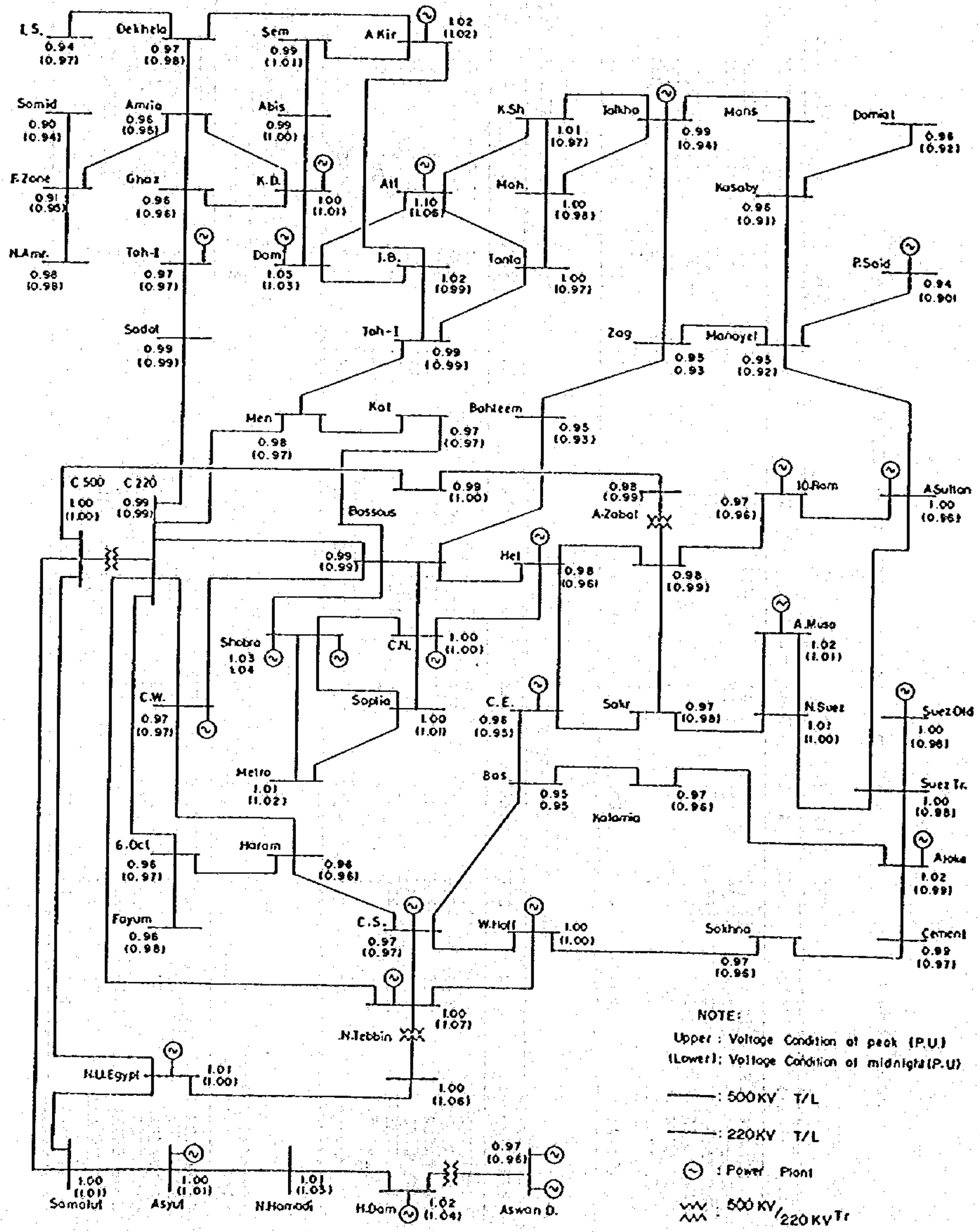
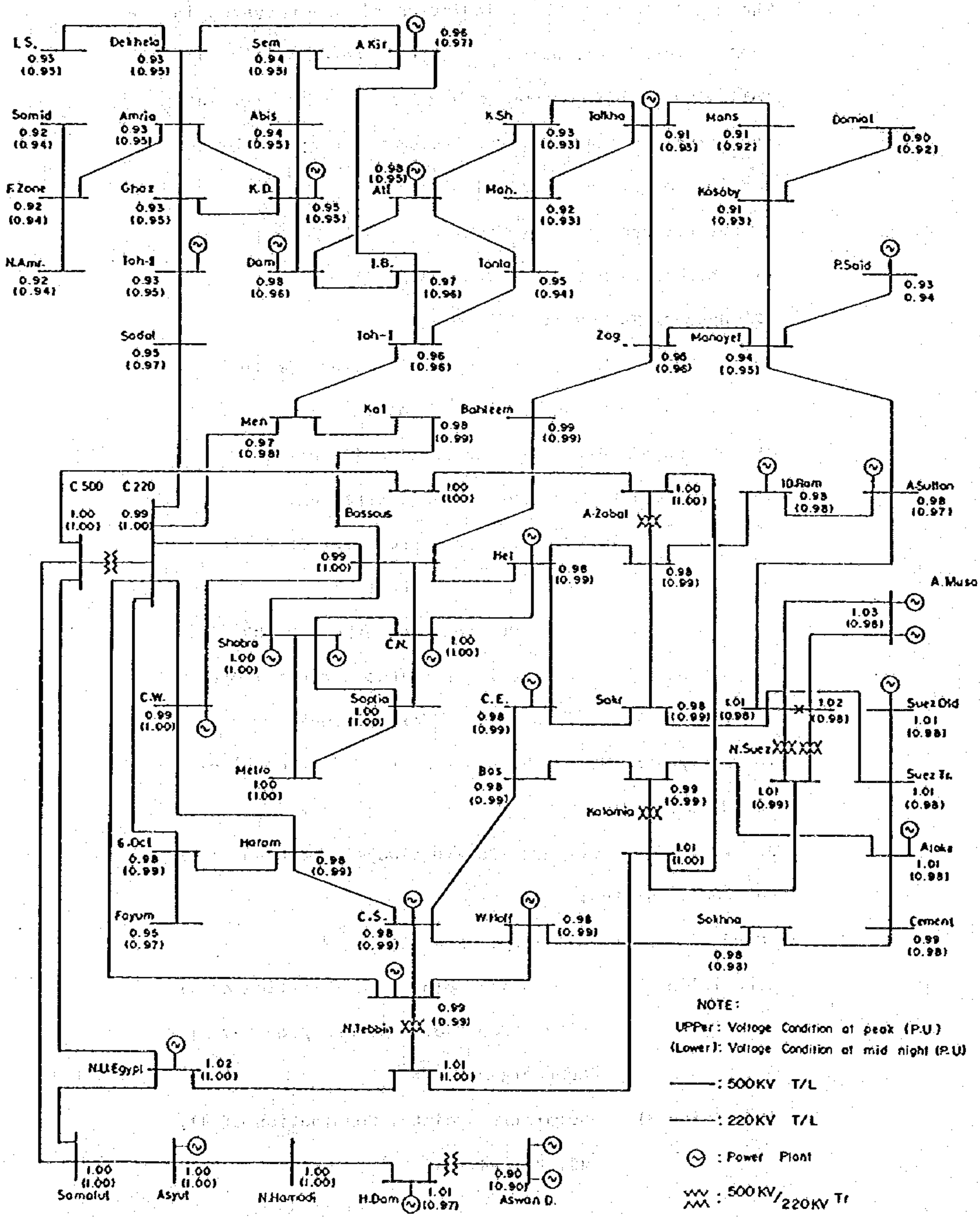


Fig. 4-31 Voltage Condition in 1990 (Case V-90-1)

Conditions : I) All Loop

II) N. Suez 220KV Bus Separate



2) Study of Emergency Case of Transmission Line

a. Study of Short Circuit GVA

a) Studied Cases

The short circuit GVA calculation of power system in 1990 covered following 8 system conditions. The following 10 buses were assigned as a system separating point and studied power system was composed by the combination of bus separating points.

(Point for system separation)

#1 Shoubra PS Bus (for system separation)

#2 Bassous SS bus, (- ditto -)

#3 C 500 SS - N. Tebbin 220 kV line (for opening)

#4 C. South - Haram SS line (- ditto -)

#5 Abu Sultan PS - New Suez SS line (- ditto -)

#6 Ayun Musa PS bus (for system separation)

#7 New Suez 220 kV #2 Tr side: For Suez SS 4 circuits

#1 Tr side: For other 220 kV lines

#8 New Suez - Suez line 1 route (two circuits) open

#9 Heliopoise - C. East line (for opening)

#10 Abu Zaabal SS 220 kV bus - Sakr SS (for opening)

(Studied Cases)

220 kV buses at New Suez SS are always separated #1 Tr Bus and #2 Tr Bus.

(Condition 1) All loop: See Fig. 4-27

(Condition 2) Separating points: Combination of #1 & #2. See Fig. 4-32 and page D-7 of APPENDIX-D.

(Condition 3) Separating points: Combination of #1, #2, #3, #4 & #5

(Condition 4) Separating points: Combination of #1, #2, #3, #4 & #7

(Condition 5) Separating points: Combination of #1, #2, #3, #4, & #8

(Condition 6) Separating points: Combination of #1, #2, #3, #4, #7 & #9

(Condition 7) Separating points: Combination of #1, #2, #3, #4, #7 #9 & #10
See Fig. 4-33.

(Condition 8) Separating points: Same as Case S-90-4
Bassous SS: 500/220 kV Tr. 500 MVA x 1
See Fig. 4-34.

b) Results of Study

Table 4-39 shows the variation of short circuit GVA by system condition.

i) Condition 1 (All loop)

Cairo area: Most of substation and PS buses have short circuit GVA more than 10 GVA. More highest value is 16.6 GVA at C. 500 SS 220 kV bus.

The quantity of short circuit GVA becomes more than 10 GVA at substations near around Suez SS in Canal area.

The short circuit GVA at Damanhour PS and Bahateem SS only exceeds 10 GVA in Alex. and Delta Areas.

ii) Condition 2 (Separate at Shoubra PS and Bassous SS)

Many substations in Cairo area decrease their short circuit GVA from 3% to 40%. Even though, short circuit GVA at 12 substations exceeds more than 10 GVA.

Short circuit GVA at stations in Canal area decreased a little. But that of New Suez SS, Suez SS and Ataka PS exceeds more than 10 GVA yet.

Short circuit GVA at Damanhour PS exceeds more than 10 GVA.

iii) Condition 3 (Condition 2 & C. South separate from C. West system)

The number of substations where short circuit GVA exceeds more than 10 GVA becomes only 6 in Cairo area. The only one substation where short circuit GVA exceeds 10 GVA is new Suez SS #1 Tr. bus.

Damanhour PS is only one where short circuit GVA exceeds 10 GVA in Alex. area.

iv) Condition 4 (System condition nearly same Condition 3 except New Suez 220 kV bus arrangement)

The condition in Cairo, Delta and Alex. areas is same as of Condition 3.

Short circuit GVA at all stations in Canal area is below 10 GVA.

v) Condition 5 (Two circuits of New Suez - Suez line off, others are same as Condition 3)

No remarkable change on short circuit GVA compared to Condition 4.

vi) Condition 6 (Adding Heliopolise - C. East line off to Condition 4)

Short circuit GVA at C. 500 SS, C. West PS and Abu Zaabal SS exceeds 10 GVA in Cairo area.

Other areas are same condition of Condition 4.

vii) Condition 7 (C. South system separate from C. West and C. North system)

Cairo 500 SS and C. West are only two stations where short circuit GVA exceeds 10 GVA.

viii) Condition 8 (Bassous SS installed, system condition is same as Condition 7)

No remarkable change occurs in short circuit GVA compared to Condition 7.

The most effective system configuration to decrease short circuit GVA is Condition 7 or Condition 8. The load flow in two cases are calculated and the results are shown in Figs. 4-35 and 4-36. There are no problems in load flow condition. Refer to pages D-8 and D-9 of APPENDIX-D.

Fig. 4-32 Short Circuit Capacity in 1990 (Case S-90-3)

Conditions: i) Bassous and Shobra Buses Open.
ii) A.Muso-N.Suez 220 kV T/L.
iii) N.Suez 220kV Bus Separate.

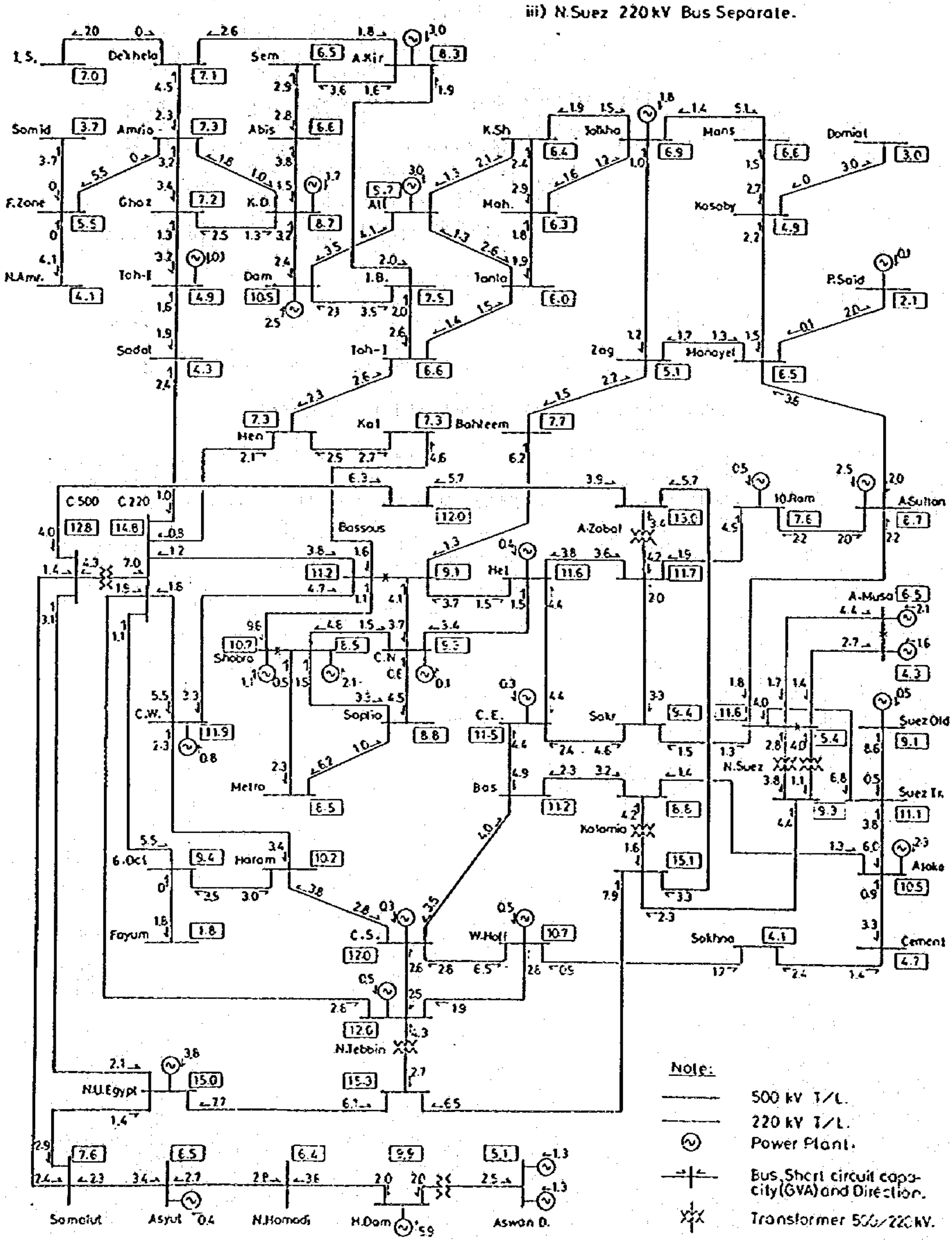


Fig. 4-33 Short Circuit Capacity in 1990 (Case S-90-4)

Conditions: i) Bassous and Shobra Buses Open.
ii) A.Musa - N.Suez 220 kV T/L.
iii) N Suez 220 kV Bus Separate.
iv) C.200 - N.Tebbin, Haram - C.S., Hel - C.E., A.Zabal - Sakr; Lines Open.

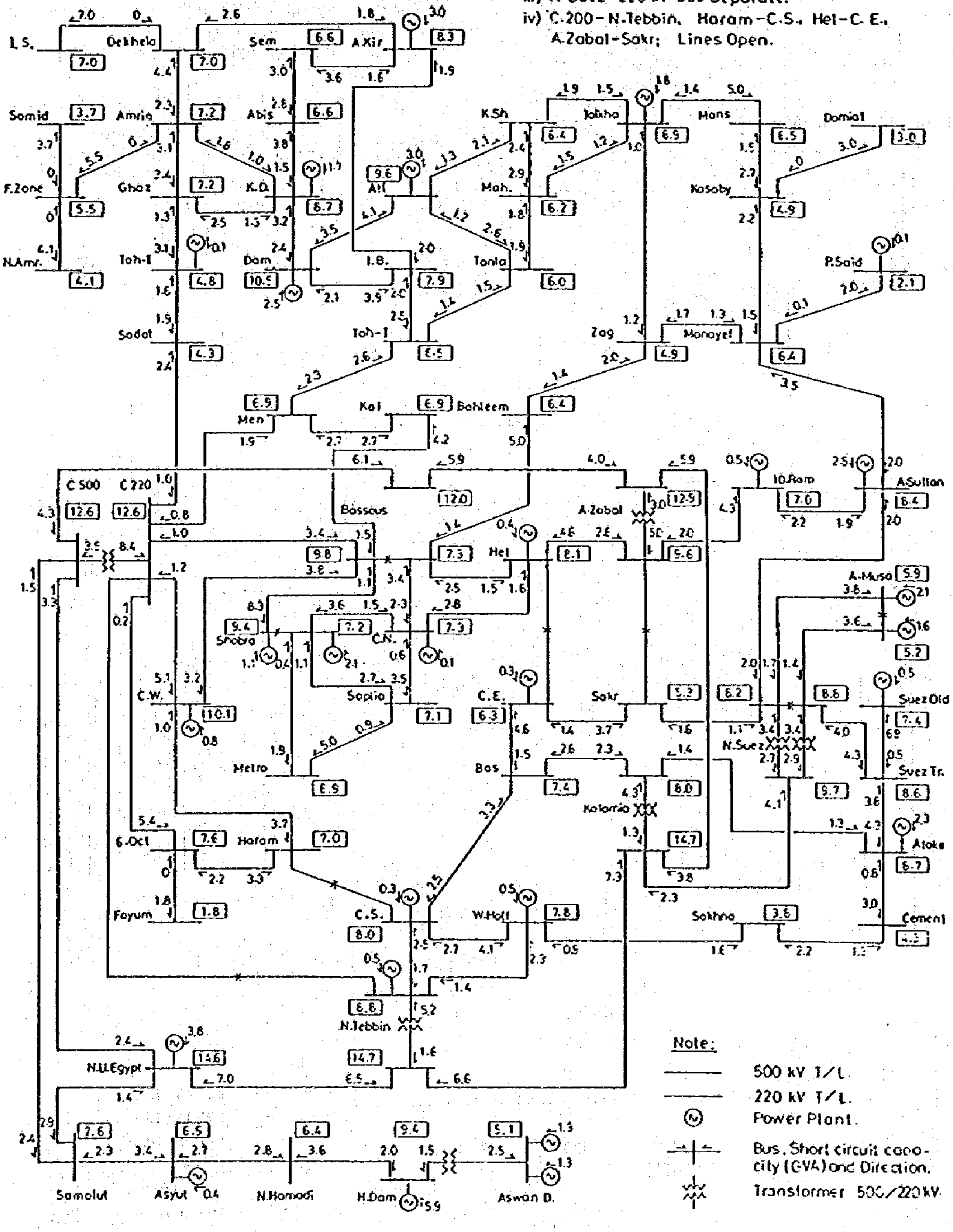


Fig. 4-34 Short Circuit Capacity in 1990 (Case S-90-5)

Conditions: i) Bassous and Shobra Buses Open.
ii) A.Musa-N.Suez 220 kV T/L.
iii) N.Suez 220 kV Bus Separate.
iv) C.200-N.Tebbin, Haram-C.S., Hel.-C.E., A.Zabal-Sakr; Lines Open.
v) Bassous 500/220 kV Step down Tr. is installed

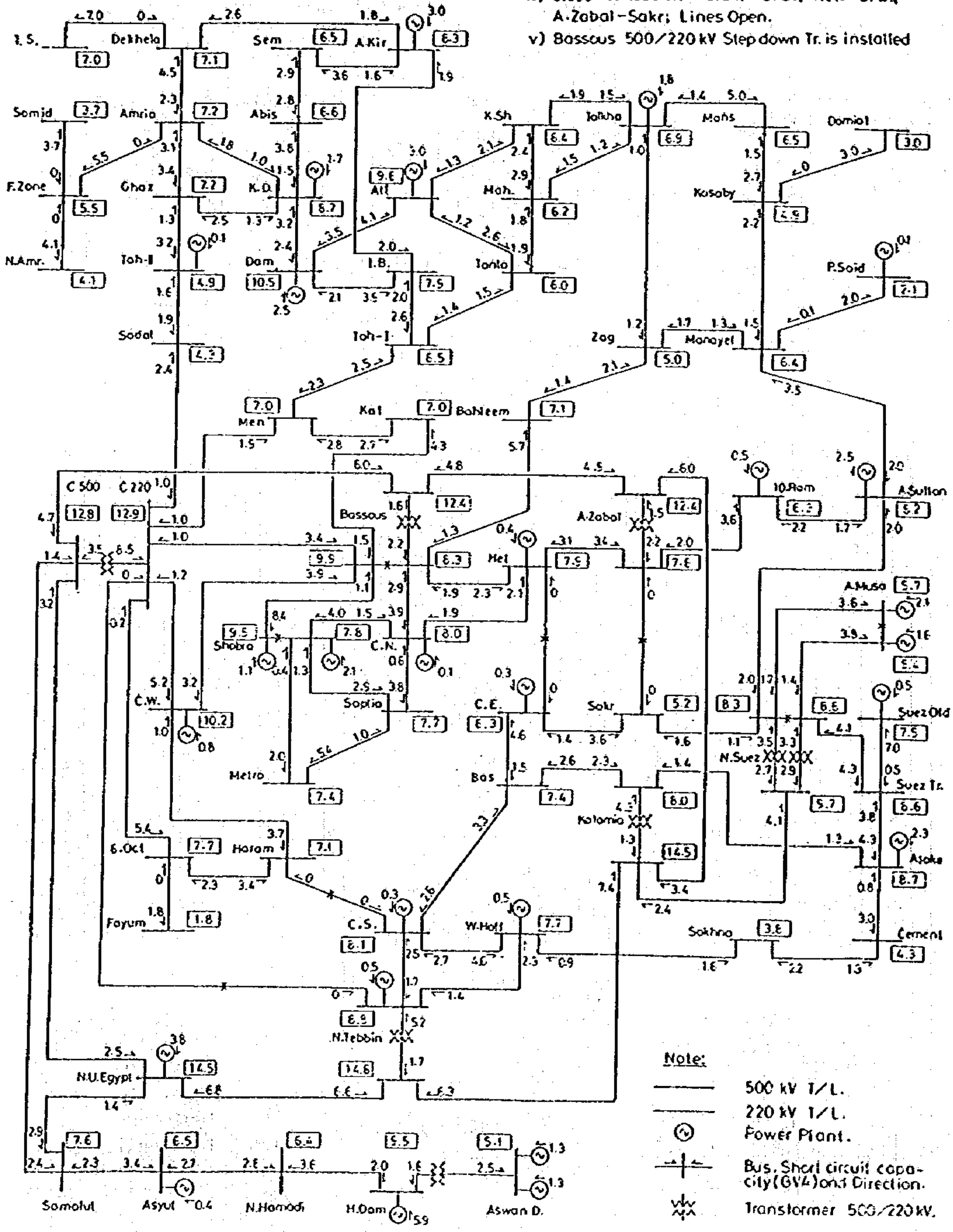


Table 4-39 VARIATION OF SHORT CIRCUIT GVA BY SYSTEM CONDITION (1990)

UNIT : GVA

SUBSTATION NAME	CONDITION (1) [A]	CONDITION (2) [B]	CONDITION (2) % [B]/[A]	CONDITION (3) [C]	CONDITION (3) % [C]/[A]	CONDITION (4) [D]	CONDITION (4) % [D]/[A]	CONDITION (5) [E]	CONDITION (5) % [E]/[A]	CONDITION (6) [F]	CONDITION (6) % [F]/[A]	CONDITION (7) [G]	CONDITION (7) % [G]/[A]	CONDITION (8) [H]	CONDITION (8) % [H]/[A]
Cairo Area															
C.500 220kV Bus	16.6	14.8	89.2	12.7	76.5	12.7	76.5	12.7	76.5	12.7	76.5	12.6	75.9	12.9	77.7
C. West	14.2	11.9	83.8	10.1	71.1	10.1	71.1	10.1	71.1	10.1	71.1	10.1	71.1	10.2	71.8
Bassous #1	16.2	11.1	68.5	9.8	60.5	9.8	60.5	9.8	60.5	9.8	60.5	9.8	60.5	9.9	61.1
Bassous #2	16.2	9.2	56.8	9.0	55.6	9.0	55.6	9.0	55.6	7.7	47.5	7.3	45.1	8.3	51.2
Shoubra #1	15.8	10.6	67.1	9.5	60.1	9.5	60.1	9.5	60.1	7.6	48.1	7.2	45.6	7.8	49.4
Shoubra #2	15.8	9.0	57.0	8.8	55.7	8.8	55.7	8.8	55.7	9.5	60.1	9.4	59.5	9.5	60.1
Soptie	14.5	8.8	60.7	8.7	60.0	8.6	59.3	8.6	59.3	7.5	51.7	7.1	49.0	7.7	53.1
C. North	15.1	9.3	61.6	9.1	60.3	9.1	60.3	9.1	60.3	7.8	51.7	7.4	49.0	8.0	53.0
Heliopolise	13.9	11.5	82.7	11.2	80.6	11.2	80.6	11.2	80.6	8.8	63.3	8.1	58.3	7.9	56.8
A. Zaabal 220kV	12.3	11.7	95.1	11.5	93.5	11.4	92.7	11.4	92.7	11.2	91.1	9.6	78.0	7.6	61.8
C. East	12.4	11.5	92.7	11.0	88.7	11.0	88.7	11.0	88.7	8.2	66.1	6.3	50.8	6.3	50.8
Basateen	11.4	11.1	97.4	10.2	89.5	10.3	90.4	10.3	90.4	6.7	58.8	6.4	56.1	7.4	64.9
Katamia 220kV	8.9	8.9	100.0	8.6	96.6	8.6	96.6	8.6	96.6	8.2	92.1	7.9	88.8	8.0	89.9
Sakr	9.9	9.5	96.0	9.2	92.9	9.2	92.9	9.2	92.9	8.6	86.9	5.3	53.5	5.2	52.5
10 Ramadan	7.8	7.6	97.4	7.4	94.9	7.5	96.2	7.5	96.2	7.4	94.9	7.0	89.7	6.3	80.8
C. South	11.9	11.9	100.0	9.1	76.5	9.2	77.3	9.2	77.3	8.6	72.3	8.0	67.2	8.1	68.1
Wadi Hoff	10.7	10.7	100.0	8.6	80.4	8.6	80.4	8.6	80.4	8.2	76.6	7.8	72.9	7.7	72.0
N. Tebbin 220kV	12.2	12.0	98.4	9.4	77.0	9.4	77.0	9.4	77.0	9.1	74.6	8.8	72.1	8.8	72.1
Haram	10.7	10.2	95.3	7.0	65.4	7.0	65.4	7.0	65.4	7.0	65.4	7.0	65.4	7.1	66.4
Canal Area															
A. Sultan	8.8	8.7	98.9	6.7	76.1	8.4	95.5	8.4	95.5	8.4	95.5	8.3	94.3	8.2	93.2
N. Suez #1	12.0	11.6	96.7	10.0	83.3	8.5	70.8	8.5	70.8	8.5	70.8	8.1	67.5	8.3	69.2
N. Suez #2	12.0	5.4	45.0	5.3	44.2	8.9	74.2	8.7	72.5	8.9	74.2	8.8	73.3	8.8	73.3
Suez tr.	11.5	11.2	97.4	9.8	85.2	8.9	77.4	8.7	75.7	8.8	76.5	8.8	76.5	8.6	74.8
Ataka	10.7	10.5	98.1	9.4	87.9	8.8	82.2	8.7	81.3	8.7	81.3	8.7	81.3	8.7	81.3
Ayun Musa #1	9.4	6.6	70.2	6.2	66.0	5.8	61.7	5.8	61.7	5.8	61.7	5.7	60.6	5.7	60.6
Cement	4.7	4.7	100.0	4.4	93.6	4.4	93.6	4.4	93.6	4.4	93.6	4.3	91.5	4.3	91.5
Hanayef	6.7	6.5	97.0	5.9	88.1	6.4	95.5	6.4	95.5	6.4	95.5	6.4	95.5	6.4	95.5
Alex. Area															
Damanhour	10.6	10.5	99.1	10.5	99.1	10.5	99.1	10.5	99.1	10.5	99.1	10.5	99.1	10.5	99.1
K. Dawar	8.7	8.7	100.0	8.6	98.9	8.6	98.9	8.6	98.9	6.9	79.3	6.9	79.3	8.7	100.0
Amira	7.4	7.3	98.6	7.3	98.6	7.3	98.6	7.3	98.6	7.3	98.6	7.3	98.6	7.2	97.3
A. Kir	8.4	8.3	98.8	8.3	98.8	8.3	98.8	8.3	98.8	8.3	98.8	8.3	98.8	8.3	98.8
Delta Area															
Atf.	9.7	9.7	100.0	9.6	99.0	9.6	99.0	9.6	99.0	9.6	99.0	9.6	99.0	9.6	99.0
I.S.	8.0	8.0	100.0	7.9	98.8	7.9	98.8	7.9	98.8	7.9	98.8	7.9	98.8	7.9	98.8
Sahteen	11.5	7.7	67.0	7.6	66.1	7.6	66.1	7.6	66.1	6.7	58.3	6.4	55.7	7.1	61.7
Zagazig	5.5	5.1	92.7	5.0	90.9	5.1	92.7	5.1	92.7	5.0	90.9	4.9	89.1	5.0	90.9
Talkha	7.0	7.0	100.0	6.8	97.1	6.9	98.6	6.9	98.6	6.9	98.6	6.9	98.6	6.9	98.6
500kV Bus															
C. 500	13.2	12.9	97.7	12.6	95.5	12.6	95.5	12.6	95.5	12.6	95.5	12.6	95.5	12.8	97.0
A. Zaabal	13.0	13.0	100.0	13.0	100.0	13.0	100.0	13.0	100.0	13.0	100.0	12.9	99.2	12.4	95.4
Katamia	15.2	15.1	99.3	14.8	97.4	14.9	98.0	14.9	98.0	14.7	96.7	14.7	96.7	14.5	95.4
N. Tebbin	15.3	15.3	100.0	14.9	97.4	15.0	98.0	15.0	98.0	14.8	96.7	14.7	96.1	14.6	95.4
North Upper E.	15.0	15.0	100.0	14.7	98.0	14.8	98.7	14.8	98.7	14.7	98.0	14.6	97.3	14.5	96.7
N. Suez	9.6	9.3	96.9	8.9	92.7	9.9	103.1	9.8	102.1	9.8	102.1	9.7	101.0	9.7	101.0
Samalut	7.7	7.7	100.0	7.7	100.0	7.7	100.0	7.7	100.0	7.7	100.0	7.7	100.0	7.6	98.7
High Dam	9.5	6.5	68.4	9.5	100.0	9.5	100.0	9.5	100.0	9.5	100.0	9.5	100.0	9.5	100.0

Fig. 4-35

Load Flow 1990 (Peak) case L-90-4

Conditions: i) Bassous Shobra Bus Separate
ii) C200 - N Tebbin, Haram - C.S, Hel - C.E, A Zabal - Sakr Lines Open
iii) New Suez 220kv Bus Separate

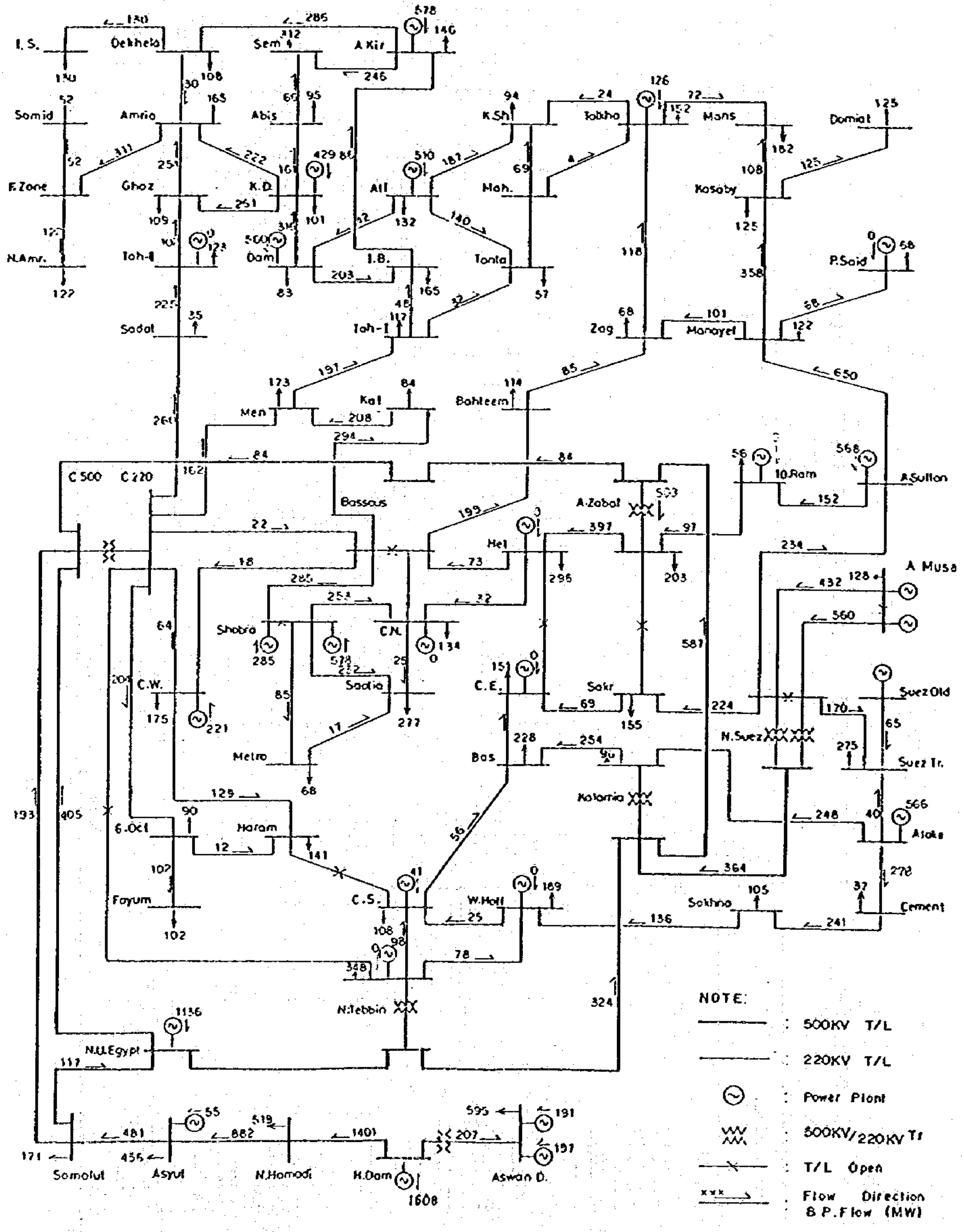
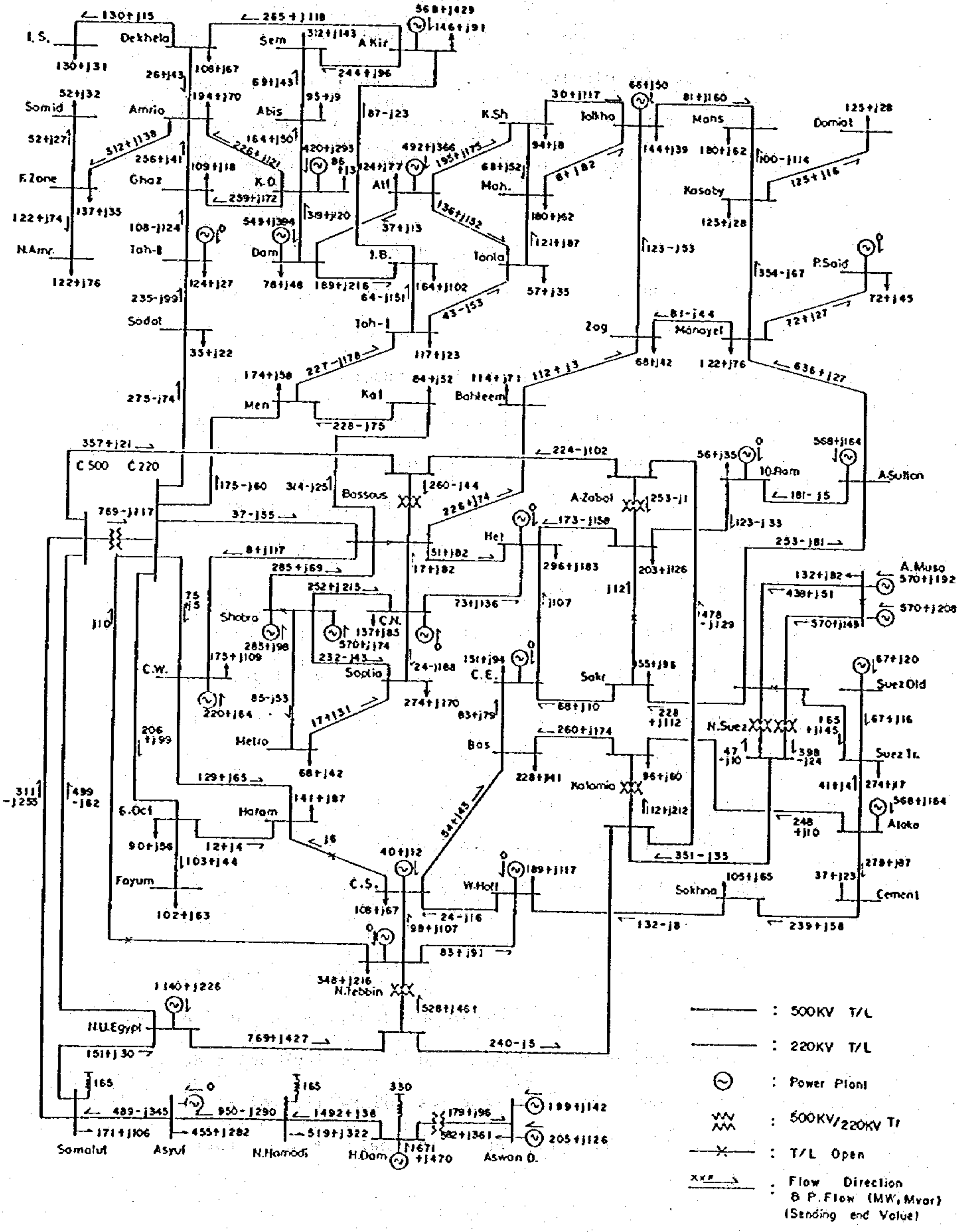


Fig. 4-36 Load Flow in 1990 (Peak) Case L-90-5

Conditions
I) Bassous, Shobra Bus Separate.
II) C200-N.Tebbin, Haram-C.S, Hel-C.E, A.Zabal-Sakr Lines Open
III) Bassous 500/220KV Step Down Tr. Is Installed.
IV) N.Suez 220KV Bus Separate.



b. Study of Load Flow in Emergency Case

When the output of Ayun Musa PS is 600 MW, only Abu Sultan - Manayef line exceeds the load flow than rated capacity at one circuit fault. But, when the output of the power station becomes 1,200 MW, many lines become overload condition at one circuit fault as shown in Table 4-40.

In calculation, the capacity of Abu sultan - Manayef line is assumed as bundle conductors line. The probability of load flow more than 50% of line capacity is 99.5%. This means that existing single conductor line carries more than its rated capacity around the clock. Some lines in Alex. and Upper Egypt areas exceeds the rated capacity in emergency case. More detailed study will be necessary to discuss future expansion plan about these lines.

When one circuit related to Ayun Musa PS is tripped out, including 500 kV New Suez - Katamia line, and one route of these lines is tripped out, the variations of other concerned line's load flow are shown in Table 4-36 and refer to Figs. 4-37 and 4-38.

The main characteristics are as follows.

a) One circuit and two circuits fault on 220 kV line

Max. load flow at 500 kV New Suez - Katamia line is only 540 MW.

When one circuit of Abu Sultan - Manayef line is tripped out, the load flow of Abu Sultan - 10 Ramadan line becomes 438 MW (91% of rated capacity) and that of New Suez - Sakr line becomes 365 MW (76% of rated capacity). The other lines are below 60% of rated capacity.

b) When 500 kV New Suez - Katamia line is tripped out

New Suez - Suez line ... 332 MW

Ataka - Katamia line ... 363 MW

Ataka - Sokhna line ... 334 MW

New Suez - Sakr line ... 333 MW

New Suez - Abu Sultan line ... 322 MW

The load flow in emergency case is below 77% of rated capacity.

So there is no problems in concerned lines to Ayun Musa PS in emergency cases except Abu sultan - Manayef line.

Table 4-40 T/L 1cct and TRANSFORMER 1 BANK FAULT CONDITION (1989)

	OVER LOAD LINES		NO. of CIRCUIT	BASE LOAD FLOW MW	BASE LOAD FLOW %	OVER LOAD STATE (%) MAX FLOW	MEEN FLOW	0 ~ 50	50~ 80	80~ 100	100~ 120	120 OVER	FAULT POINT	
PEAK	L224	A.SULTAN--MANAYEF	2	557	58	116	59	0.5	99.0	0.0	0.5	0.0	L224	A.SULTAN--MANAYEF 1cct off
	L305	AMRIA -- F.ZONE	2	282	59	116	61	0.0	99.5	0.0	0.0	0.5	L305	AMRIA -- F.ZONE 1cct off
DAY TIME		NONE												
MID NIGHT		NONE												

T/L 1cct and TRANSFORMER 1 BANK FAULT CONDITION (1990)

	OVER LOAD LINES		NO. of CIRCUIT	BASE LOAD FLOW MW	BASE LOAD FLOW %	OVER LOAD STATE (%) MAX FLOW	MEEN FLOW	0 ~ 50	50~ 80	80~ 100	100~ 120	120 OVER	FAULT POINT	
PEAK	L224	A.SULTAN--MANAYEF	2	638	70	125	70	0.5	98.6	0.5	0.0	0.5	L224	A.SULTAN--MANAYEF 1cct off
	L304	AMRIA -- GHAZ	2	256	55	101	56	1.9	97.2	0.5	0.5	0.0	L304	AMRIA -- GHAZ 1cct off
	L305	AMRIA -- F.ZONE	2	312	68	136	69	0.0	99.5	0.0	0.0	0.5	L305	AMRIA -- F.ZONE 1cct off
	L404	H.DAM -- ASWAN DAM	2	179	69	139	72	0.0	0.5	99.1	0.0	0.5	L404	H.DAM -- ASWAN DAM 1cct off
DAY TIME	L224	A.SULTAN--MANAYEF	2	635	69	118	69	0.0	99.5	0.0	0.5	0.0	L224	A.SULTAN--MANAYEF 1cct off
	L305	AMRIA -- F.ZONE	2	269	59	118	59	0.0	99.5	0.0	0.5	0.0	L305	AMRIA -- F.ZONE 1cct off
MID NIGHT	L151	CAIRO 200 -- SADAT	2	310	68	105	68	1.5	97.6	0.5	0.5	0.0	L151	CAIRO 200 -- SADAT 1cct off
	L224	A.SULTAN--MANAYEF	2	593	63	108	63	0.5	99.0	0.0	0.5	0.0	L224	A.SULTAN--MANAYEF 1cct off
	L301	SADAT -- TAHIR II	2	310	63	106	62	4.4	94.7	0.5	0.5	0.0	L301	SADAT -- TAHIR II 1cct off

Fig. 4-37 LOAD FLOW IN EMERGENCY CASE ... 220 kV T/L of Canal area (1990)

(1 Circuit Off)

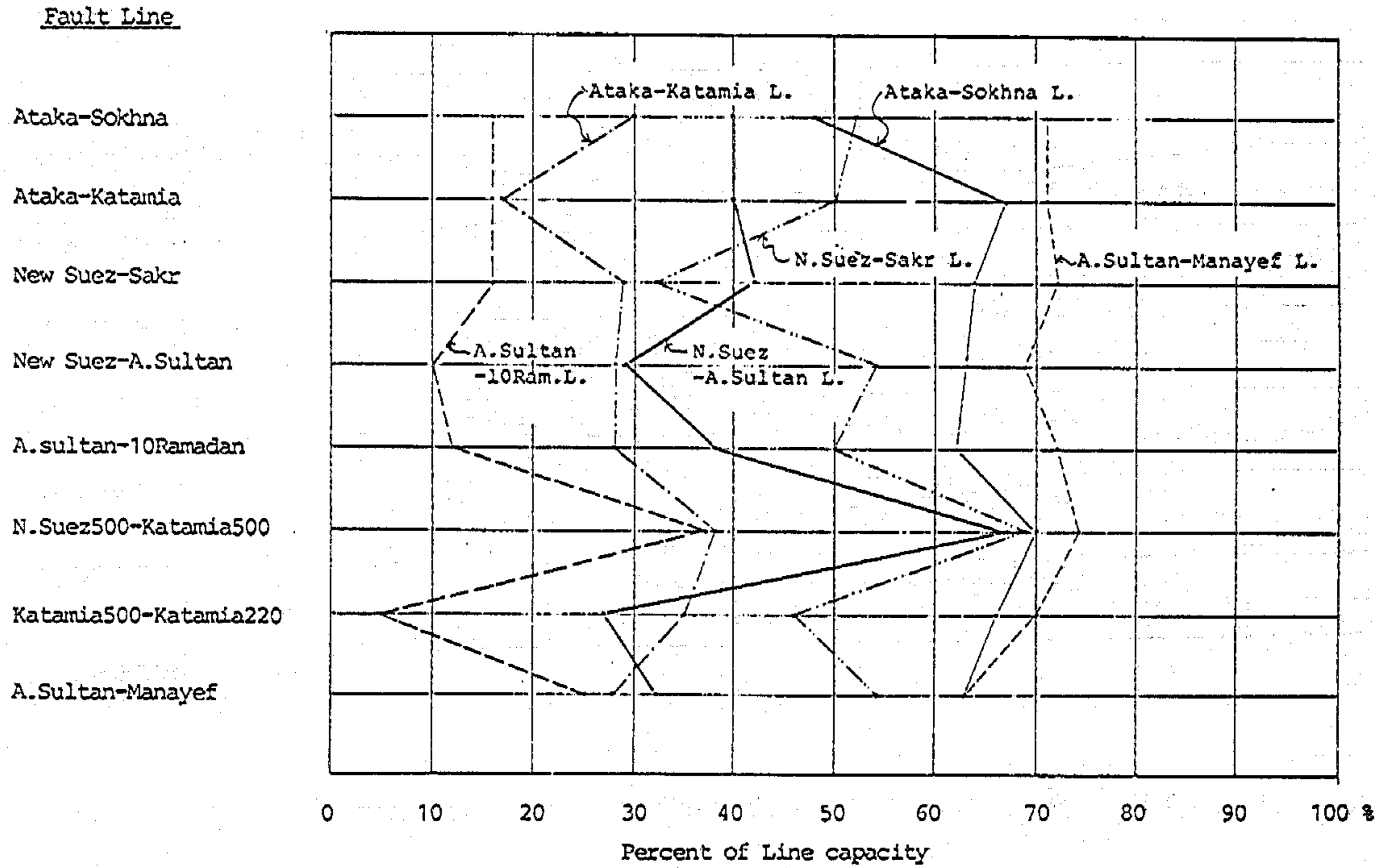
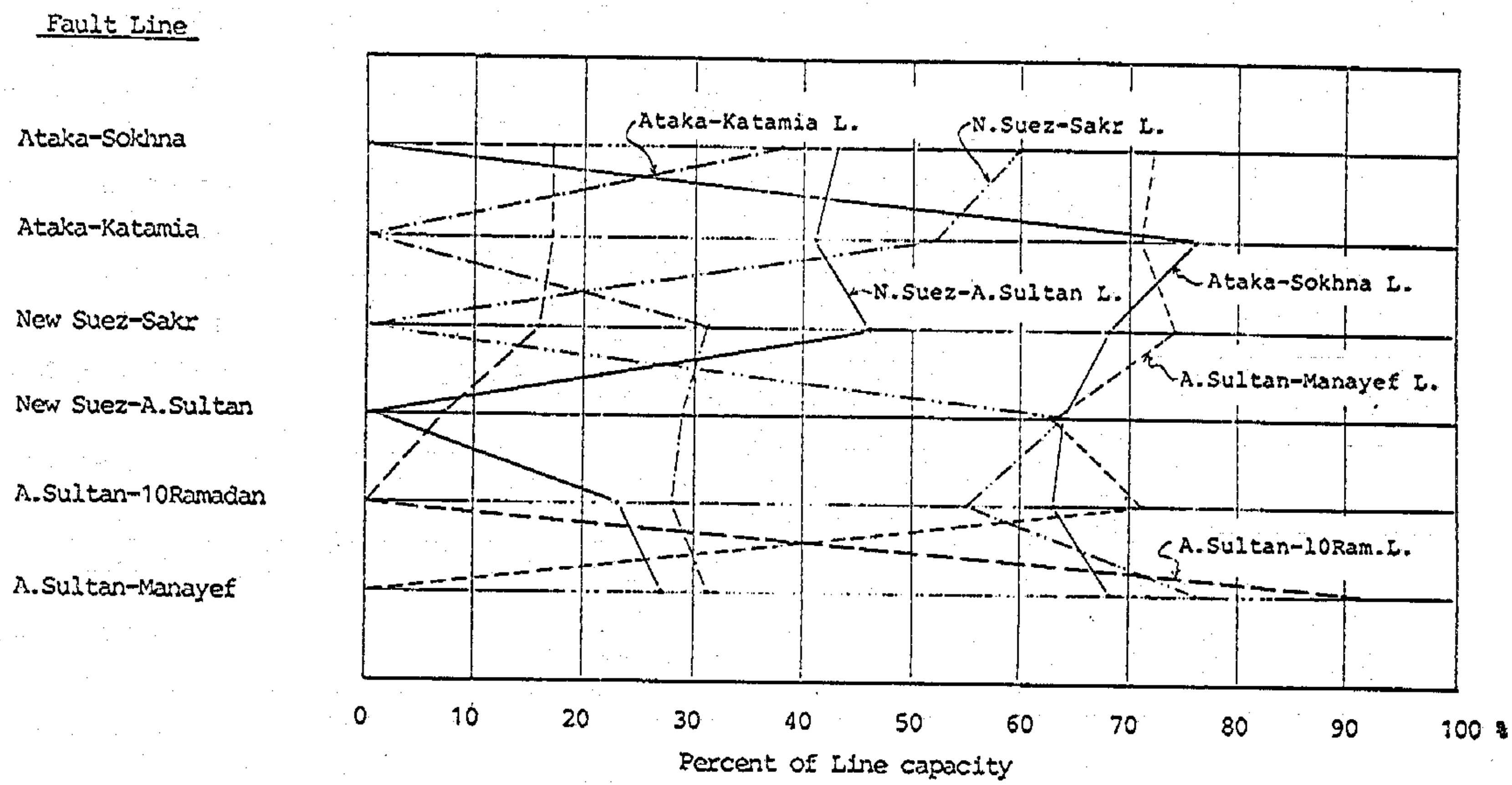


Fig. 4-38 LOAD FLOW IN EMERGENCY CASE ... 220 kV T/L of Canal area (1990)

(1 Route Off)



6) Study of Transient and Dynamic Stability in Fault Condition

Transient and dynamic stability of generating units at Ayun Musa PS was studied on two cases. One is the output of Ayun Musa PS is 600 MW and another 1,200 MW. The fault condition are 3 phase grounding fault and reclosing OK or not. The fault point are selected nearer to Ayun Musa PS in each case. The angle change was checked until 10 sec. after fault occurred for dynamic stability study.

The results of study are shown in Table 4-41, and in Fig. 4-39 to Fig. 4-45.

There is no problem in transient and dynamic stability of generating unit in 1,200 MW output with 220 kV interconnecting system.

7) Conclusion

The following interconnecting system is recommendable for the interconnecting system for Ayun Musa PS from above mentioned detailed studies.

a. The capacity of Ayun Musa PS is 600 MW.

Between Ayun Musa PS and New Suez SS

220 kV AAAC 620 mm² x 2, 4 circuits (2 circuits tower 2 route)

(including Cable 2 km crossing canal through Ahmed Hamdi Tunnel)

Branch from Existing Sakr SS - Suez line

b. The Capacity of Ayun Musa PS is 1,20 MW.

Between New Suez and Katamia

500 kV ACSR 500 mm^2 x 3, one circuit

Branch from existing Abu Sultan - Suez line

New Suez SS 500 kV/220 kV Tr.

750 MVA x 2

Above system configurations are shown in Table 4-42.

8) Recommendation for 220 kV System

To solve the bottle neck of 220 kV system, it is necessary further study to establish countermeasure plan.

a. To increase the capacity of Abu Sultan - Manayef line

A new line construction including T branch system from Abu Sultan - 10 Ramadan line should be studied.

b. There are many transmission lines in Alex. and Upper Egypt areas which load flow in emergency case exceeds the rated capacity.

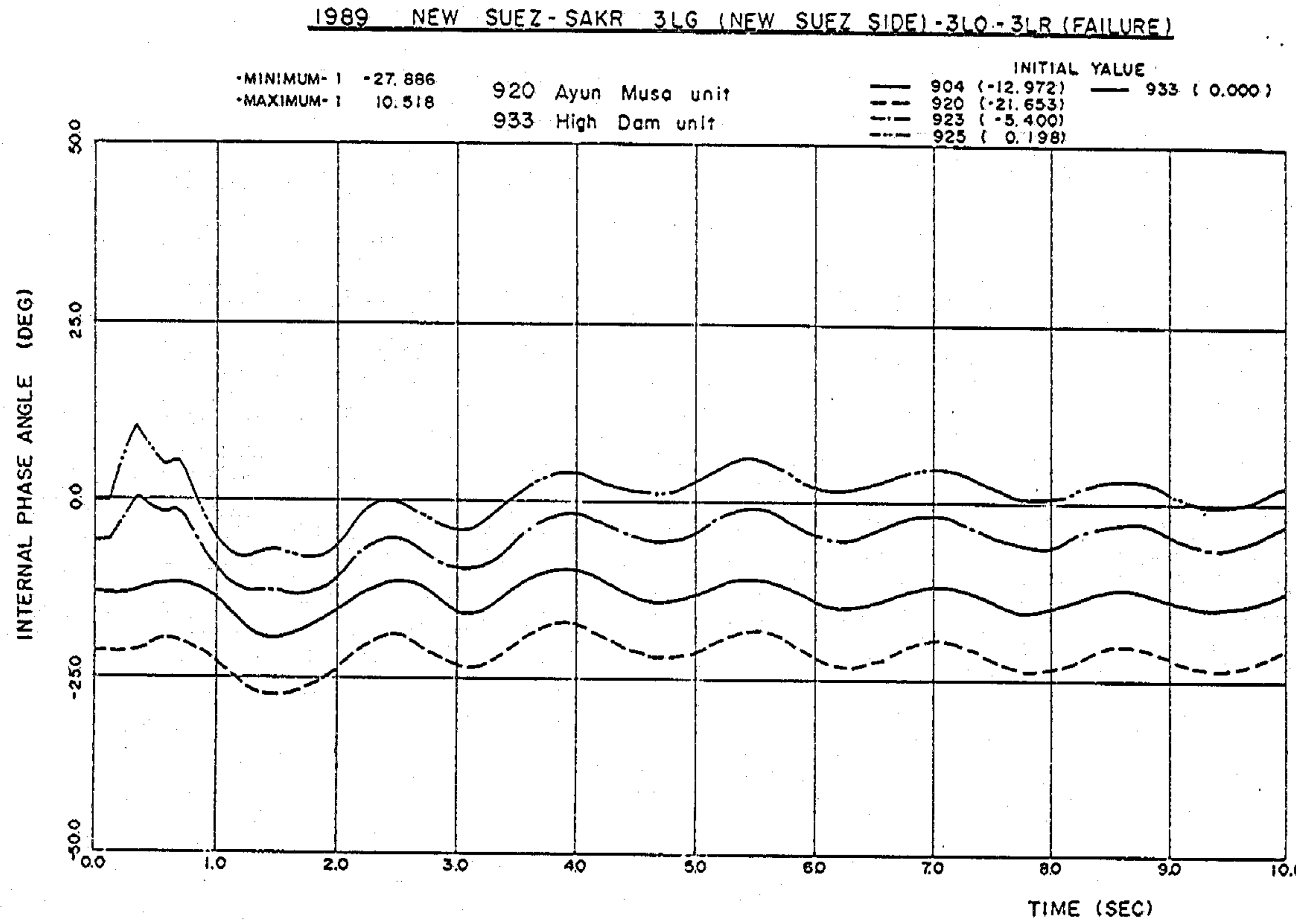
For these lines, it is necessary to check the load estimation and check the countermeasure for the overload conditions.

Table 4-41

RESULT of TANSIENT STABILITY STUDY

CASE	OUTPUT of AYUN MUSA (MW)	T/L in FAULT	FAULT POINT	FAULT CONDITION	RESULT	Difference of Phase Angle between AYUN MUSA and ASWAN H.D.
89-1	600	NEW SUEZ - SAKR LINE 1 CIRCUIT	NEW SUEZ SIDE	3ϕ LG -- 3ϕ TRIP -- 3ϕ RECLOSE -- 3ϕ TRIP	STABLE	21.6° -- 31.2°
89-2	600	NEW SUEZ - SAKR LINE 2 CIRCUIT	-ditto-	2 LINE 3ϕ LG -- 2 CIRCUITS TRIP	STABLE	21.6° -- 33.6°
89-3	600	AYUN MUSA - NEW SUEZ LINE 1 CIRCUIT	AYUN MUSA SIDE	3ϕ LG -- 3ϕ TRIP -- 3ϕ RECLOSE -- 3ϕ TRIP	STABLE	21.6° -- 34.3°
89-4	600	AYUN MUSA - NEW SUEZ LINE 1 CIRCUIT	-ditto-	3ϕ LG -- 3ϕ TRIP	STABLE	21.6° -- 35.6°
90-1	1200	AYUN MUSA - NEW SUEZ LINE 1 CIRCUIT	AYUN MUSA SIDE	3ϕ LG -- 3ϕ TRIP -- 3ϕ RECLOSE -- 3ϕ TRIP	STABLE	8.6° -- 23.6°
90-2	1200	AYUN MUSA - NEW SUEZ LINE 2 CIRCUIT	-ditto-	2 LINE 3ϕ LG -- 2 LINE TRIP	STABLE	8.6° -- 25.44°
90-3	1200	NEW SUEZ - KATAMIA 500kV	NEW SUEZ SIDE	3ϕ LG -- 3ϕ TRIP -- 3ϕ RECLOSE -- 3ϕ TRIP	STABLE	8.6° -- 23.3°

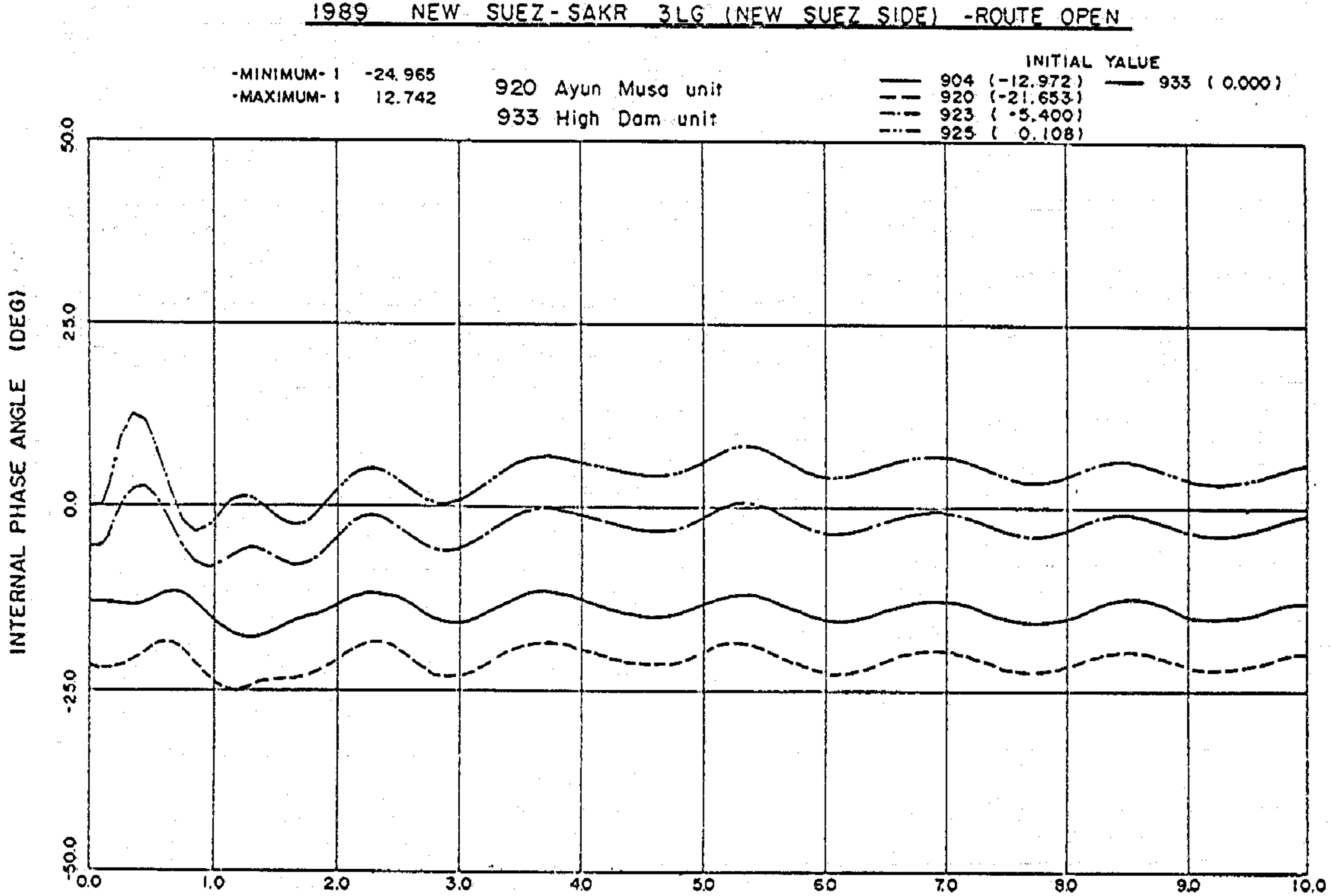
Cose 89 - 1



1989 NEW SUEZ - SAKR 3LG (NEW SUEZ SIDE) - 3LO - 3LR (FAILURE)
·MINIMUM- 1 -27.886
·MAXIMUM- 1 10.518
920 Ayun Musa unit
933 High Dam unit
INITIAL VALUE
904 (-12.972)
920 (-21.653)
923 (-5.400)
925 (0.198)
933 (0.000)
INTERNAL PHASE ANGLE (DEG)
50.0
25.0
0.0
-25.0
-50.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
TIME (SEC)

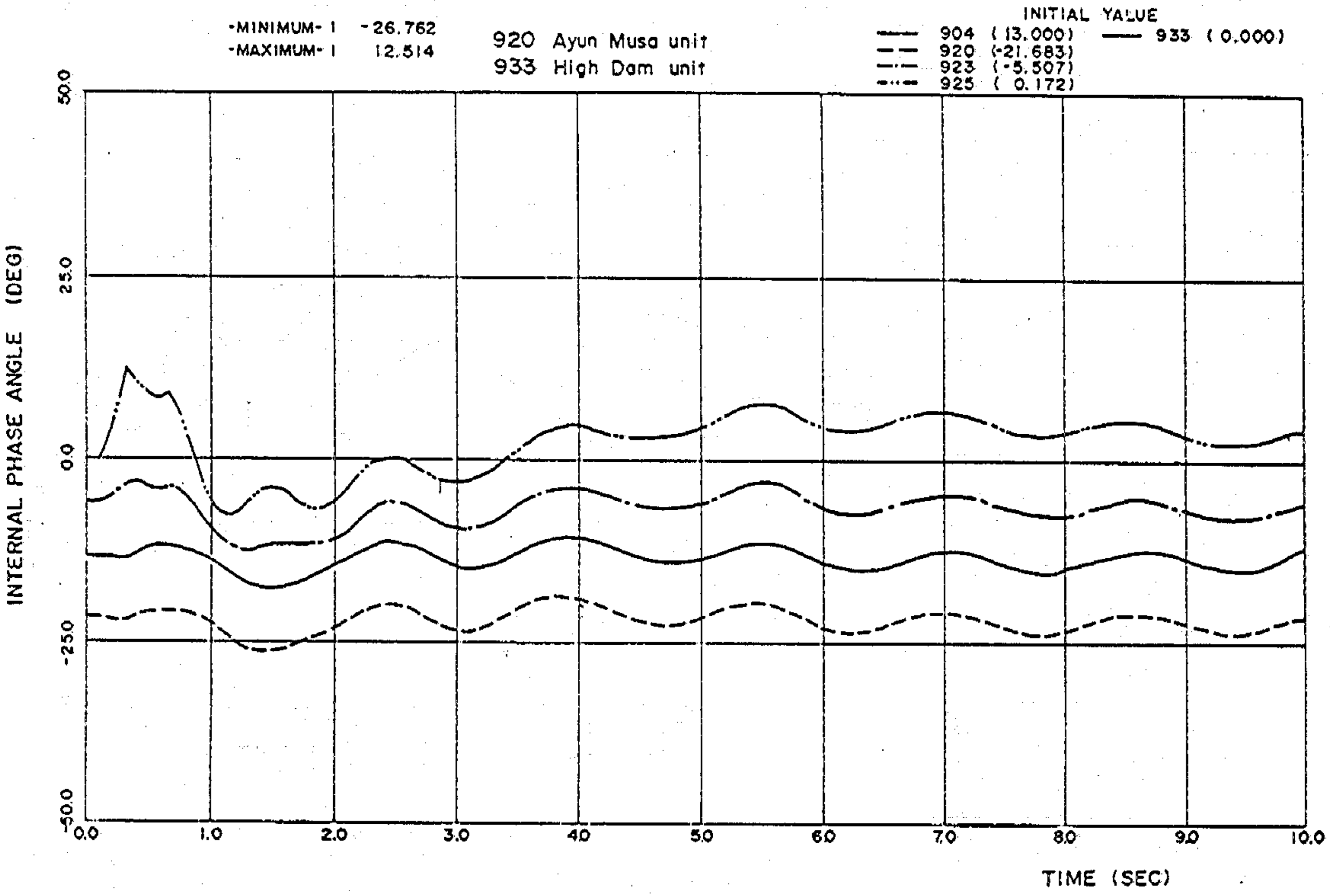
Fig. 4-40

Case 89-2



Case 89 - 3

1989 AYUN MUSA - NEW SUEZ 3LG (AYUN MUSA SIDE) - 3LO - 3LR (FAILURE)



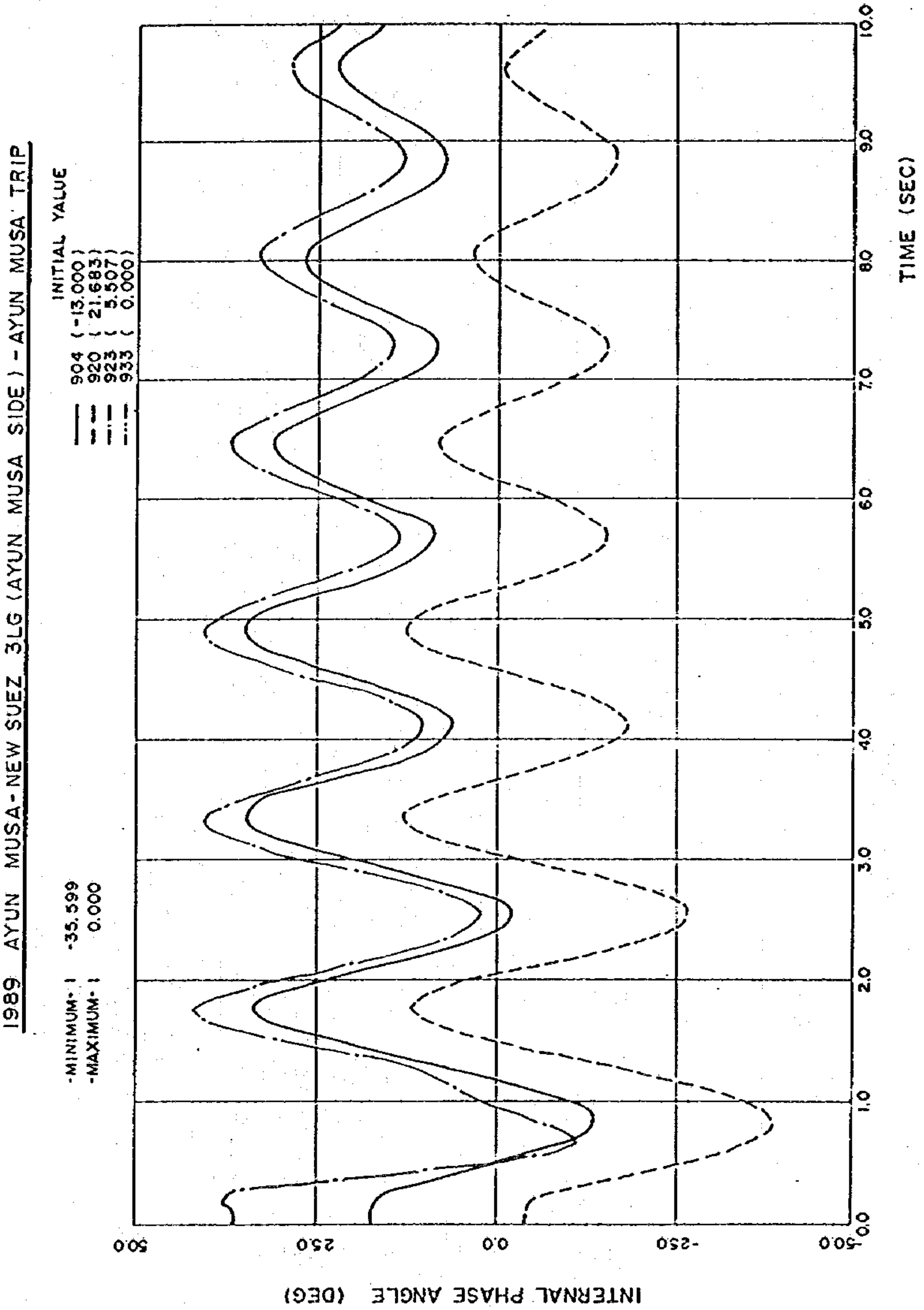


Fig. 4-42
Case 89-4

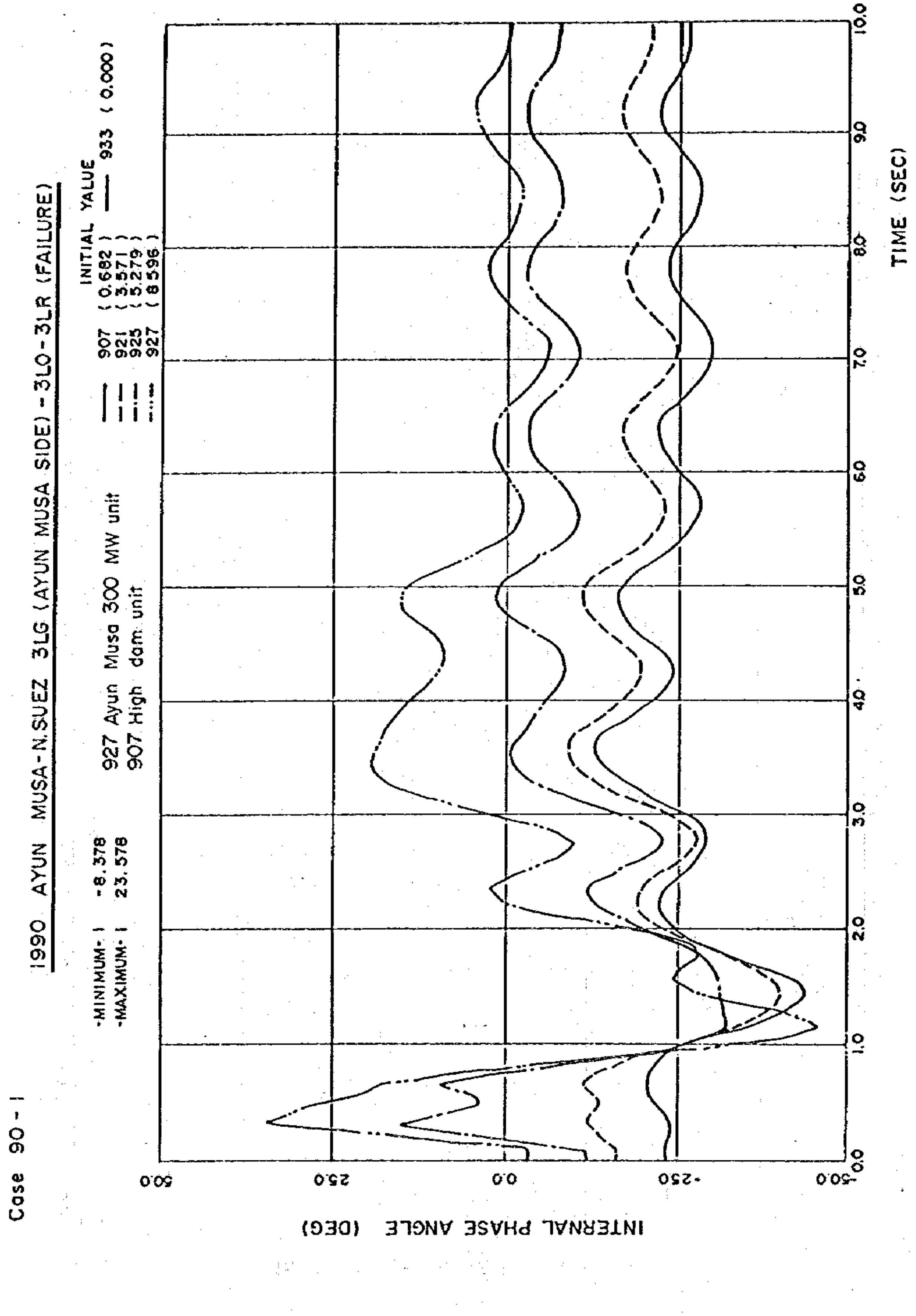

Case 90 - I
1990 AYUN MUSA-N.SUEZ 3LG (AYUN MUSA SIDE) - 3LO-3LR (FAILURE)
-MINIMUM- I -8.378
-MAXIMUM- I 23.578
927 Ayun Musa 300 MW unit
907 High dam unit
INITIAL VALUE
907 (0.682)
921 (3.571)
925 (5.279)
927 (8.596)
933 (0.000)
INTERNAL PHASE ANGLE (DEG)
50.0
25.0
0.0
-25.0
-50.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
TIME (SEC)

Fig. 4−44

Case 90 - 2

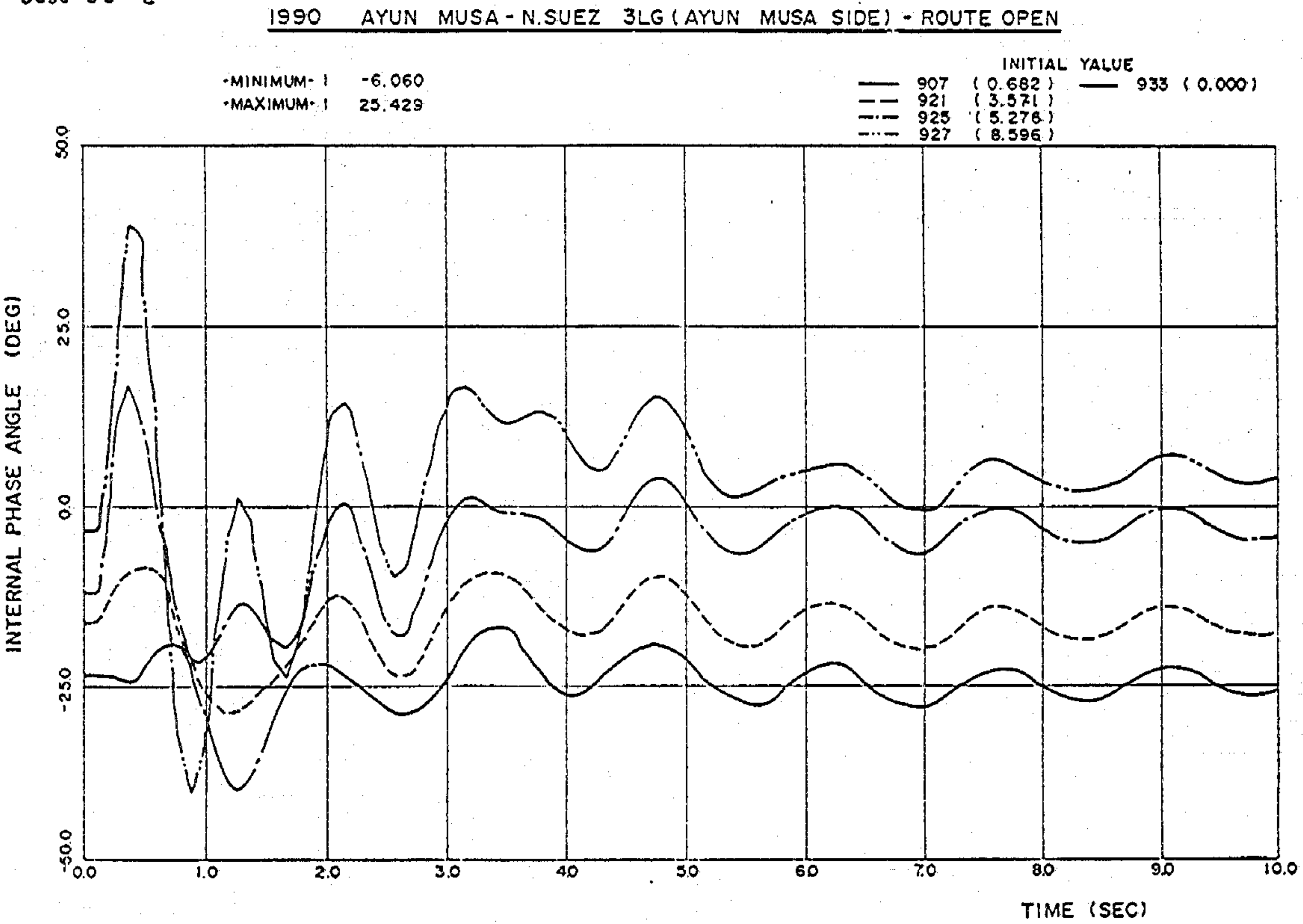


Fig. 4-45
Case 90-3

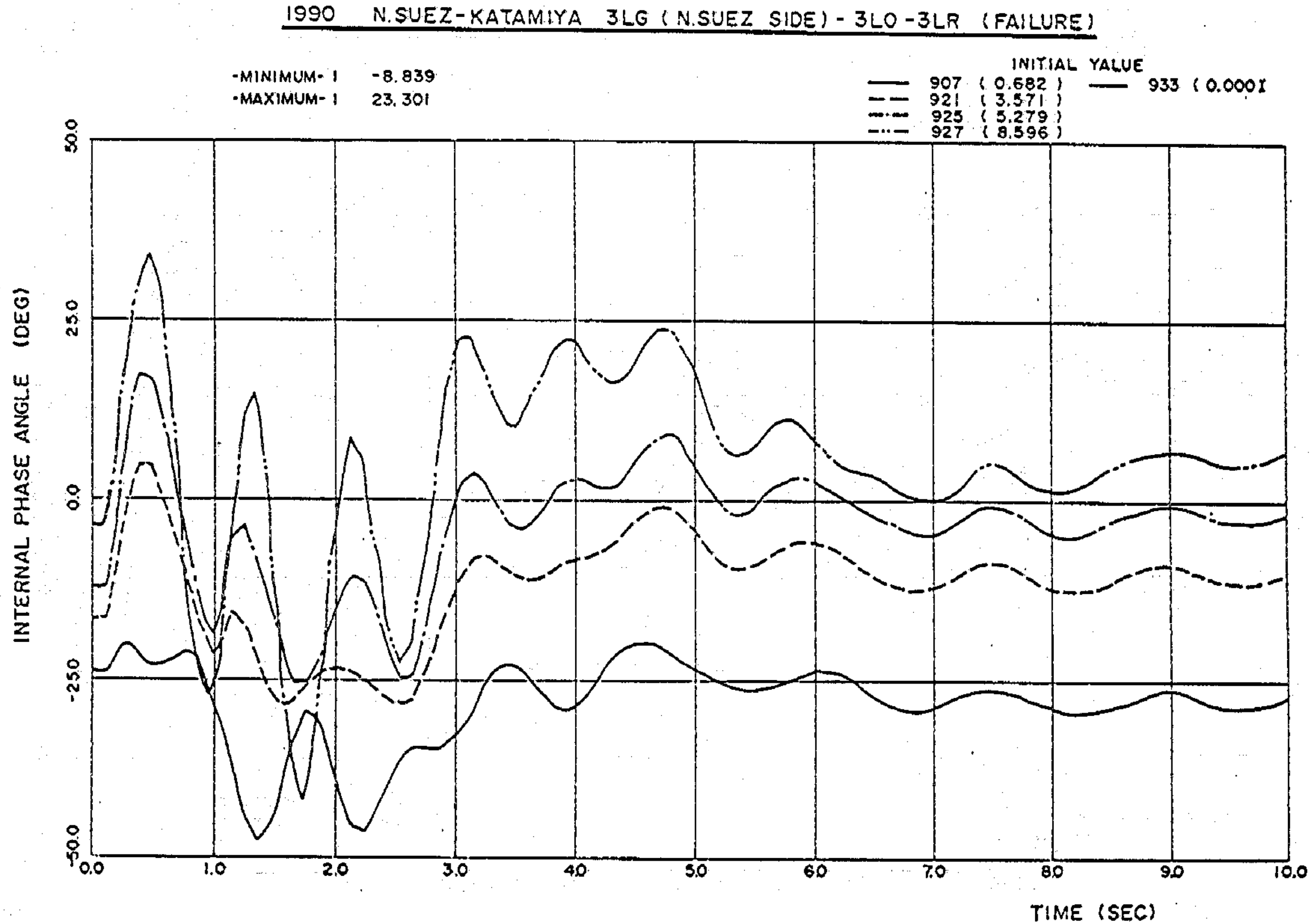
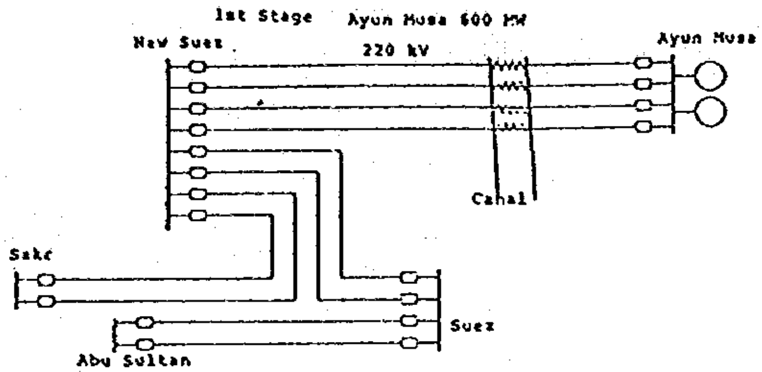
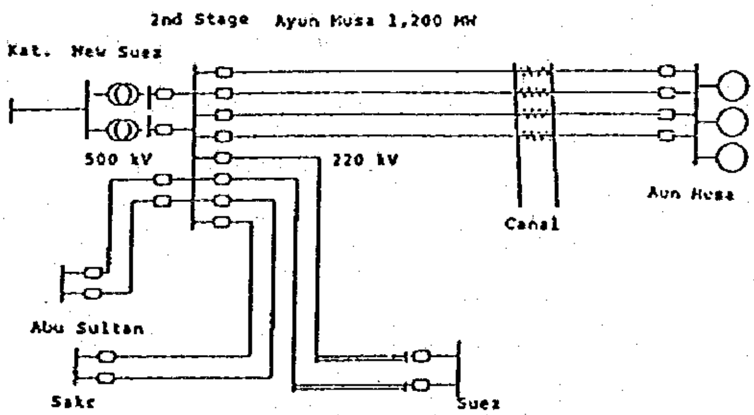


Table 4-42 Out Line of Final Plan

	CASE: 220 kV 4 circuites
System Map	
	
Main Items of Construction	1st Stage 1. Ayun Musa PS 300 MW x 2 2. New Suez SS 3. Ayun Musa--New Suez 220 kV 4 circuits 2nd Stage 1. Ayun Musa PS 1,200 MW 2. New Suez uprate to 500kV Station(2 trans.) 3. New Suez --Katamia 500 kV T/L

4-8 PROCEDURE OF DEVELOPMENT

4-8-1 Time Schedule Prior to Commencement of Construction Works

1) For materialization of the Sinai Coal-fired Thermal Power Project, EEA should commence the preparation of the implementation program necessary for the application for financing of the fund for the Project, as soon as they receive this Feasibility Report.

As this Project is of a large scale, the construction works would be carried out in three phases as shown below, and the fund would be financed by more than one financing organization.

First Phase

Construction of harbor facilities, the power plant site reclamation works, detailed design of main equipments and materials of the power plant for 300 MW x 2, foundation works for the boiler, turbine and generator, construction of powerhouse for No.1 Unit and New Suez Substation

Second Phase

Manufacturing and erection of No. 1 Unit and related civil and architectural works for No.1 Unit and foundation works and construction of powerhouse for No.2 Unit and construction of 2 circuits of 220 kV transmission lines out of 4 circuits (including Suez Canal crossing)

Third Phase

Manufacturing and erection of No. 2 Unit and related civil and architectural works for No.2 Unit, and construction of remaining 2 circuits of 220 kV transmission line

2) EEA will hire the services of a consultant for this Project. The services of the consultant will cover the review of the Feasibility Report, preparation of the tender documents including detailed design, assistance in tendering, assistance in tender evaluation, assistance in contracting, assistance in construction supervision, etc.

3) EEA will call tenders by the tender documents prepared by the consultant, and after evaluation of the tenders, will conclude the contract with the selected contractor.

4-8-2 Construction Works

Upon conclusion of the contract, the contractor will carry out the design and manufacture, and when the equipment are manufactured, will ship and deliver to the site after obtaining the export license.

During the period from the start of manufacture to the delivery to the site, the contractor will carry out the preparatory works on the site, such as the construction of temporary facilities for construction works.

The time period from the consultant services agreement to the taking over of No. 2 unit is estimated to be 57 months.

CHAPTER 5

PRELIMINARY DESIGN OF MAJOR EQUIPMENT

(1st Stage 300 MW x 2 Units)

CHAPTER 5. PRELIMINARY DESIGN OF MAJOR EQUIPMENT

5-1 DESIGN CONDITIONS FOR MAJOR EQUIPMENT

5-1-1 Design Conditions

1) Ambient Temperature and Humidity

a. Average Temperature	:	22.4 °C
b. Maximum Temperature	:	35.9 °C
(Average)	:	(27.8 °C)
c. Minimum Temperature	:	9 °C
(Average)	:	(17.7°C)
d. Maximum Humidity	:	64%
(Average)		(39%)
e. Design Temperature		
For Boiler	:	30 °C
For Electrical Equipment	:	40 °C
For Underground Cable	:	27 °C
For Transmission Lines		
Max.	:	42 °C
Min.	:	5 °C
f. Design Humidity for Boiler	:	52 %

2) Wind Velocity

Max.	:	35 m/s
Min	:	8.9 m/s

3) Seismic Coefficient : V=0.05W

(V: total lateral force, W: total weight above ground level)

4) Sea Water Temperature

Max.	:	28 °C
Design	:	27 °C

5) Tide level and ground level

a. Mean low water spring (L.W.L)	:	+ 0.4m
b. Mean low water neap	:	+ 0.7m
c. Mean sea water level (Gulf of Suez)	:	+ 1.205m
d. Mean sea water level (Alexandria Port)	:	+ 1.145m (EL ± 0m)
e. Mean high water neap	:	+ 1.6m
f. Mean high water spring	:	+ 1.9m
g. Maximum wave height	:	+ 2.5m
h. Design wave height	:	+ 1.5m
i. Ground level		
Power Station	:	+ 5.145m(EL + 4.0m)
Pier	:	+ 4.145m(EL + 3.0m)
j. Max. Velocity of tidal flow	:	1.5 knot

6) Rain fall

Monthly average	:	1.2mm
Monthly max	:	23.5mm

7) Fuel Analysis

a. Coal

		Blended Coal	Single Coal
Calorific Value	kcal/kg	6,500	6,100 - 6,900
Surface Moisture	%	6.9 - 8.8	6.9 - 9.2
Proximate Analysis			
Inherent Moisture	%	2.8 - 8.3	2.5 - 9.3
Ash	%	8.9 - 17.8	6.3 - 19.2
Volatile Matter	%	28.1 - 35.1	24.3 - 43.3
Fixed Carbon	%	36.8 - 53.4	37.7 - 58.4
Ultimate Analysis			
Carbon	%	68.5 - 82.3	67.2 - 84.4
Hydrogen	%	4.1 - 5.6	3.7 - 5.8
Nitrogen	%	1.0 - 1.7	0.9 - 1.8
Oxygen	%	7.4 - 15.3	6.2 - 16.1
Sulphur	%	0.8 - 1.3	0.3 - 2.9
Fuel Ratio		0.9 - 2.1	0.9 - 2.4
Hard Grove Grindability Index		41 - 68	38 - 72
Ash			
Softening Point	°C	1,260 - 1,600	1,260 - 1,600
Melting Point	°C	1,300 - 1,600	1,300 - 1,600
Ash Analysis			
SiO_2	%	45.3 - 73.4	40.4 - 75.5
Al_2O_3	%	15.1 - 30.7	18.1 - 37.5
Fe_2O_3	%	1.3 - 11.6	0.6 - 13.5
CaO	%	1.0 - 5.4	0.1 - 5.7
TiO_2	%	0.4 - 1.8	0.5 - 2.3

MgO	%	0.2 - 1.8	0.2 - 2.2
SO_3	%	1.3 - 5.2	0.1 - 4.9
P_2O_5	%	0.1 - 0.7	0.1 - 0.9
Na_2O	%	0.2 - 1.6	0.1 - 1.9
K_2O	%	0.2 - 2.4	0.3 - 3.9

b. Heavy Oil

Flush Point	Max. 150°F
Keinematic Viscosity Max. 2000sec(R1 at 100°F)	
Pour Point	Max. 100°F
Carbon Residue	Max. 11 wt%
Moisture	Max. 1 vol%
Ash	Max. 0.1 wt%
Sulphur	Max. 2.5 wt%
Specific Gravity	Max. 0.99 15/4 °C
Calorific Value	Min. 10,000 kcal/kg
(Low Calorific Value)	

c. Light Oil

Flush Point	Max. 65 °C
Pure Point	Max. 4.5 °C (Winter)
	Max. 12.5 °C(Summer)
Sulphur	Max. 1 wt%
Carbon Residure	Max. 0.08 wt%
Distillation	90 Vol% at 360 °C
Kinematic Viscosity	6.2 cst. at 30 °C
Specific Gravity	Min. 0.85
[Calorific Value (Gross)]	10,900 kcal/kg

8) Sea Water Analysis

PH	8.2
Conductivity (micro mho/cm)	61,600
Turbidity (ppm)	2.1
M-Alkali (ppm as $CaCO_3$)	130
Chrome-Ion (ppm as Cl)	24,000
Total hardness (ppm as $CaCo_3$)	7,740
Calcium Hardness (ppm as $CaCO_3$)	1,230
Magnecium Hardness (ppm as $CaCO_3$)	6,510
Sulfuric Acid Ion (ppm as SO_4)	2,500
Silica Ion (ppm as SiO_2)	0.1

5-1-2 Design Standard

The following standards of Japan in principal and/or internationally accepted similar standards will be applied to design, manufacture and construction of the Project

- Japanese Industrial Standards
- Japanese Electrotechnical Committee
- The Standard of Japan Electrical Manufactures' Association
- Japanese Electric Association Code
- Standard of Architectural Institute of Japan
- Standard of Civil Institute of Japan
- Technical Standard of The Japan Port and Harbor Association
- Technical Standard of The Japan Road Association

Table 5-1 Properties of Domestic Coal and Imported Coal

Properties of domestic coal (Maghara)

Country of Origin	Brand	Calorific Value kcal/kg	Surface Moisture %	Proximate Analysis				Ultimate Analysis					Fuel ratio	HGI	Fusibility of Ash			Ultimate Analysis of Ash %									
				Inherent Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Carbon %	Hydrogen %	Nitrogen %	Oxygen %	Sulphur %			Softening Point °C	Melting Point °C	Pour Point °C	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5
Egypt literature	Maghara	7,270	—	4.90	6.50	50.70	37.90	70.66	5.67	1.04	8.26	2.97	0.75	—	1,220 -1,290	1,290 -1,340	1,320 -1,360	—	—	—	—	—	—	—	—	—	—
in Japan	Maghara	7,140	—	5.14	3.95	50.51	40.39	73.74	5.83	1.22	12.21	2.83	0.8	51	1,290	1,430	1,440	65	3.3	4.0	4.4	0.4	6.2	0.4	Trace	Trace	Trace
for power station	Maghara	6,140	—	4.2	19.2	43.3	33.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Fuel ratio = $\frac{\text{Fixed Carbon}}{\text{Volatile Matter}}$

Properties of Imported Coal (Australia)

Country of Origin	Brand	Calorific Value kcal/kg	Surface Moisture %	Proximate Analysis				Ultimate Analysis					Fuel ratio	HGI	Fusibility of Ash			Ultimate Analysis of Ash %									
				Inherent Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Carbon %	Hydrogen %	Nitrogen %	Oxygen %	Sulphur %			Softening Point °C	Melting Point °C	Pour Point °C	SiO	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5
Australia	Lemington	6,860	7.0	2.3	9.0	34.0	54.0	80.3	5.0	1.7	12.4	0.59	1.59	48	1,260	1,300	1,325	51.7	22.6	9.55	5.70	1.60	3.50	1.90	1.42	1.03	0.91
	Work Worth	6,670	7.0	3.2	13.8	29.3	53.7	63.3	4.4	1.5	11.1	0.47	1.83	49	1,400	1,550	1,560	75.5	18.1	2.7	—	0.2	0.7	0.1	—	0.6	—
	Hunter Valley	6,800	9.0	3.5	13.5	34.0	49.0	82.2	5.1	1.8	10.5	0.6	1.44	55	1,500	1,570	>1,600	68.6	24.0	2.7	0.7	—	—	0.5	1.1	1.1	0.3
	Lithgow	6,400	7.0	3.2	17.4	29.2	50.2	67.5	4.2	1.5	8.2	0.59	1.72	39	1,500	1,500	1,500	60.7	30.6	0.6	—	0.2	1.3	0.1	3.0	0.5	0.1
	Invincible	6,720	8.0	2.5	16.5	30.0	51.0	83.3	5.4	1.9	8.6	0.7	1.70	48 - 55	>1,600	>1,600	>1,600	69.1	25.1	0.75	0.26	0.27	0.40	0.30	0.60	—	—
	Cross Valley	6,570	8.0	2.5	17.0	24.5	56.0	84.0	4.5	1.6	9.1	0.4	2.29	50 - 55	>1,600	>1,600	>1,600	66.2	32.0	0.71	0.09	0.22	0.93	0.30	0.60	—	—
	Wambow	6,700	9.0	3.0	14.0	32.0	51.0	82.9	5.5	1.6	9.5	0.5	1.59	47 - 51	1,280	1,400	1,460	67.8	18.6	5.37	1.72	2.23	1.66	0.63	1.07	—	—
	South Blackwater	6,370	8.5	6.8	10.5	24.3	58.4	70.7	3.7	1.28	13.2	0.28	2.40	72	1,500	1,540	1,540	50.8	35.0	3.5	0.3	0.8	2.2	0.4	0.3	2.3	0.8
	Saxonbale	6,530	7.0	3.8	16.1	27.3	52.8	70.8	4.4	1.49	6.2	0.4	1.93	47	1,465	1,500 or more	1,500 or more	72.8	20.3	1.7	0.3	0.3	0.1	0.3	1.6	0.5	0.1
	BHP	6,690	7.0	3.0	15.6	30.9	50.5	70.1	4.7	1.72	7.0	0.4	1.63	52	1,355	1,500 or more	1,500 or more	64.2	23.1	4.1	3.9	0.7	0.3	0.8	1.2	0.9	0.7
	Newlands	6,800	8.0	2.7	14.0	25.8	57.5	84.4	5.0	1.7	8.4	0.51	2.23	54	1,550	—	>1,600	53.5	37.5	2.4	0.7	0.4	0.4	0.4	0.5	1.8	1.3
	Briglow	6,120	8.38	9.3	12.5	49.5	37.7	67.2	5.1	0.85	12.6	0.46	0.93	38	1,370	1,500	1,520	54.9	28.3	3.8	4.7	1.4	2.65	0.96	0.40	—	0.1

Fuel ratio = $\frac{\text{Fixed Carbon}}{\text{Volatile matter}}$

Properties of Imported Coal (U.S.A.)

Country of Origin	Brand	Calorific Value kcal/kg	Surface Moisture %	Proximate Analysis				Ultimate Analysis					Fuel ratio	HGI	Fusibility of Ash			Ultimate Analysis of Ash %									
				Inherent Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Carbon %	Hydrogen %	Nitrogen %	Oxygen %	Sulphur %			Softening Point °C	Melting Point °C	Pour Point °C	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5
U.S.A. (Eastern Part)	Kanawha	6,890	6.90	—	10.50	35.80	46.90	76.3	5.4	1.4	6.2	0.75	1.31	49	1.482	1,482	1,482	52.94	34.67	3.30	1.10	0.80	0.77	0.72	2.13	—	0.67
	Drummond	6,390	8.0	—	12.0	31.0	49.0	78.4	4.9	1.4	8.6	0.6	1.58	45	—	—	1,363	40.4	29.51	13.49	4.7	1.51	4.85	0.47	2.10	1.29	0.36
U.S.A. (Western Part)	Colo Wyo	6,510	—	7.8	4.93	36.44	50.83	73.22	4.97	1.6	14.38	0.47	1.39	50	1.295	1.326	1.344	43.4	23.3	5.4	9.4	1.6	—	3.1	0.6	1.0	—
	Plateau	6,700	—	5.5	9.45	41.49	43.57	67.20	4.66	1.29	16.09	0.76	1.05	45 - 50	1.282	1.357	1.421	62.2	17.6	3.5	4.8	1.2	—	0.7	0.9	1.0	—

Fuel ratio = $\frac{\text{Fixed Carbon}}{\text{Volalile Matter}}$

5-2 PRELIMINARY DESIGN OF POWER PLANT FACILITIES

5-2-1 Plot Plan

The plot plan was prepared by the following basic plan.

1) Ground Area

A sufficient ground area of 60 has. (500 m x 1,200 m) will be prepared for the dual type power plant (capable of exclusive coal firing and exclusive oil firing) of 1,200 MW (300 MW x 4U or 300 MW x 2U + 600 MW x 1U) of ultimate plant output with appurtenant facilities of coal unloading and storage, fuel oil tanks, switchyard, etc.

2) Powerhouse

In consideration of future extention of unit(s) and prevention of coal dust scattering, the powerhouse will be located on the northern windward area of the site.

3) Coal Storage Yard

a. Coal storage yard will have sufficient length and width for operation of stackers and reclaimers for speedy handling of large quantities of coal to store and coal reclaimed.

The domestic coal and imported coal will be stored separately and coal blending facilities will be installed for blending of coal to the required calorific value. The general layout will be considered on the basis of coal piles of 50 m base width and 15 m height, and the storage area will be required for 670×10^3 tons (60 days operation of 1,200 MW generating units). In consideration of wind direction, the storage area will be arranged on the southern part of the site.

b. The domestic Maghara coal will be transported by trucks, and the coal receiving facilities will be located near one end of the coal yard so that receiving and handling of coal is easy, and the exclusive entrance gate and road will be prepared.

c. The slope of conveyors will be less than 15° of the angle of repose of coal by locating the conveyor transfer houses at strategic points.

4) Heavy Oil Tanks

Heavy oil storage tanks with capacities for 30 days operation at 600 MW will be installed on the inland side of the coal yard in line with the layout of existing power stations and so that direct sea wind may be avoided.

5) Light Oil Storage Tank

In consideration of convenient receiving and supply of light oil, the light oil storage tank will be installed on the seaside space between No. 1 boiler and No. 2 boiler.

6) Condenser Circulating Water

Circulating water will be taken from one side of the coal unloading pier and discharged on the other side, so that recirculation of discharged water may be prevented.

No building or structure will be built on the intake pipe lines and discharge channel line.

7) Water Plant

Seawater desalination plant, raw water tank, demineralizing plant, demineralized water tank will be located in one section for easy arrangement of water flow.

8) Gas Turbine Generator

In consideration of convenient location for the gas turbine generator operation, it will be arranged near the central control room and light oil storage tank between No. 1 boiler and No. 2 boiler.

9) Service Building

The service building will be located adjacent to the powerhouse facing to the front gate for the sake of appearances as a power plant.

10) Warehouses

Four warehouses will be built for parts for the periodical maintenance, boilers, turbines and electrical equipment, respectively, and they will be located collectively in the warehouse area, together with the lubricating oil warehouse, garage and gas cylinder store.

11) Machine Shop

Two buildings for the machine shop and one building for the workers station will be prepared as the machine shop.

12) Outdoor Switchyard

The outdoor switchyard will be located strategically in consideration of effective utilization of land, future extension and arrangement of transmission line lead-outs.

13) Workers Stations

Workers stations will be prepared separately for different trades and will be located near the work places.

14) Green Belts

Since the power plants is located in the desert area where there are no greens and practically no rain, green belts will be created around the powerhouse, roadsides, between the main gate to the service building and in front of the service building, planted with locally suited trees and grasses and watered with the waste water from the power plant.

15) Fuel Receiving Berth

Fuel receiving berth will be planned so as not to be an obstacle for navigable part of Suez Canal and to minimize the excavation required.

16) Ash Disposal Area

Ash disposal area for 320 x 10^3 tons of disposed ash for the initial 10 years operation of 600 MW units will be prepared in the shallow sea to the south side of the power plant site. The area of approximately 1,000 m x 950 m will be encircled with seawalls in consideration of minimizing the construction cost.

17) Unloading Quaywall

By use of the dredged sand and pebbles produced from the power plant site and the berth, temporary road with a width of 100 m and unloading quaywall will be constructed on the north side of the ash disposal area for unloading of construction materials and equipment, especially heavy weighted equipment.

18) Location and Area for Residence

The housing area for estimated 854 employees for the 1,200 MW power plant will be sufficient for the resident houses, community service facilities, and have an area of 400 m x 1,750 m, and will be located between the power plant site and the national road in consideration of wind direction, prevention of noise and dust.

5-2-2 Outline of Power Plant

1) Output

No. 1 Unit 300 MW (at main transformer end)

No. 2 Unit 300 MW (at main transformer end)

2) Steam Conditions

Main Steam Pressure (at turbine inlet)	:	169 kg/cm²g
Main Steam Temperature	:	538 °C
Reheated Steam Temperature	:	538 °C
Condenser Vacuum	:	710 mmHg

As steam conditions of this 300 MW class power unit, steam pressure of 169 kg/cm²g and steam temperature of 538°C/538°C, which have been widely adopted with high reliability is adopted.

3) Boiler

a. Dual type boiler

Boiler will be planned to use coal as the main fuel (approximately 20% domestic coal and 80% imported coal), but in consideration of unavailability of importated coal due to unanticipated situation of foreign countries, it will be of dual type, capable of operating with exclusive use of substitute fuel. As the substitute fuel, heavy oil will be adopted by the following considerations.

i. Transportation facilities for gas are difficult to realize since the gas transmission pipeline will be of very large scale.

ii. Heavy oil makes the design easier and is more economical, and handling of oil is easier and safer than gas since the measures against inflammable gas explosion are not needed to be considered.

Average calorific value of 6,500 kcal/kg for the boiler design blended coal of domestic and improted coal will be adopted for this plant, and on the other hand, simple coal with a calorific value ranging from 6,100 kcal/kg to 6,900 kcal/kg will be considered in the boiler design. With regard to the imported coal, selection of the coal will be made in consideration of the market conditions, the effect on boiler such as calorific value, ash contents, fusing point, grindability, etc.

b. Outdoor type boiler

As the unit size gets larger, the boiler size also becomes larger, and construction of the boiler walls has been improved to be of skin casing type or welded panel type with reduced gas leakage. From the view points of economization of construction cost and shortening of the erection periods, more and more outdoor type boilers are adopted, and for this project the outdoor type boilers will be adopted.

c. Drum type boiler

Boilers are classified into the drum type (natural circulation and forced circulation) and the once-through type (subcritical and supercritical). For the relatively easy operation, maintenance, boiler water quality management, and less construction cost, the drum type boiler will be adopted for this power plant.

Effect of coal characteristics on boiler and mill

a) Effect on boiler

i. Abraision of heating surface by ash

Various measures against abraision by ash are considered in the boiler design.

It is said that much abraision is caused by higher ash volume and larger contents of such components as SiO_2, Fe_2O_3, Al_2O_3, etc, in ash.

On the other hand, since abraision progress is affected largely by gas speed, lower gas speed should be selected, and it is necessary to see that partial increase in gas speed and ununiform gas distribution will not occur in the furnace.

Therefore, the following measures will be considered against abraision by ash in the design.

- Selection of suitable gas speed
- Uniform ash distribution in gas
- Installation of suitable abraision prevention material

b) Effect on Mill

i. Palverizing capability of mill

Coal characteristics (carbonization, grain size, water content and grindability), fineness, drying air temperature, etc. affect the grinding capability of mill.

Especially, in case of coal with an extremely small Hardgroove index, a considarably big capacity of mill is necessary, and use of small grindability index coal is not economical, and therefore, Hardgroove index should be carefully checked at the selection of coal. Prior to the selection of coal, the Hardgroove index should be taken into consideration from the view point of economic aspects.

ii. Abraision of mill

Components of coal such as SiO_2, Fe_2O_3, Al_2O_3, etc. affect abraision of mills.

As for abraision of mills, it is generally said that the higher contents of the above components result in larger abraision.

However, the abraision loss has not been clarified by quantitative analysis, and it is estimated by manufacturer's own method.

And the countermeasures against abraision have been taken in accordance with the above estimation.

In this project, countermeasures against abraision such as inner lining with wear resistant material and buildup welding of wearing parts will be taken.

Consideration on Boiler Design

a) Countermeasures against slagging

Slagging is caused by deposits of melted coal ash on furnace walls and other heating surfaces subjected to radiant heat, and the deposits will gradually increase by accumulation of deposited ash in case of relatively low melting point of ash and high coking property of coal used.

Since troubles such as low heat absorption, clogging of opening parts in the furnace will occur, the countermeasures against the troubles should be considered.

Countermeasures

Gas temperature in the furnace should be lowered below the melting point of the ash to prevent slagging.

The following countermeasures will be considered in this plant.

i. Suitable furnace sectional area will be adopted for decrease of thermal load of the furnace and uniform heat transfer.

ii. Reduction of thermal load around the burner zone by lowering of capacity of individual burners.

iii. Superheater will be installed on the upper part of the furnace for lowering the furnace outlet temperature than the melting point of ash.

iv. Suitable width will be considered for the portion where radiant heat is applied for prevention of clogging of gas path due to clinker growth.

v. Suitable sootblower to be adopted.

b) Countermeasures against fouling

Fouling is caused by ash deposits on heating surfaces not directly subjected to radiant heat from the furnace, and it occurs in case where the coal including much basic salts such as sodium is used.

Countermeassurs against fouling should be taken since the fouling will affect the boiler performance.

Countermeasures

Fouling, in principle, will be prevented by suitable operation of soot blowers, and the following measures will be considered as countermeasures against fouling.

i. Widening of tube pitch of convection part.

ii. Selection of suitable tube thickness.

iii. Suitable arrangement of soot blowers.

d. Combustion equipment

a) Fuel Management

i. Coal

i) Coal consumption and characteristics

For management of the unit performance, it is necessary to comprehend the coal consumption and characteristics.

For the said purpose, coal scales with integrating meters will be installed, and the coal consumption will be managed with the aid of the scales. As for the coal characteristics such as moisture content, calorific value, etc., coal sampling units will be installed and the coal will be analyzed in the laboratory.

ii) Moisture content of coal

Normally, coal is pulverized by mills after drying. Heating air temperature at mill inlet will be controlled so that the coal with high moisture content can be dryed sufficiently.

iii) Particle size of pulverized coal

In case of pulverized coal combustion, particle size will affect the combustion conditions. For suitable particle size, suitable pulverizers will be selected, and for sufficient management of pulverizer performance, particle sampling units will be installed at the pulverizer outlets.

iv) Burner area

It is very important that the better fuel combustion will be maintained by suitable excess air ratio.

With regard to design of burner area, secondary combustion air will be distributed suitably so that optimum excess air ratio can be obtained.

ii. Heavy oil

i) Oil consumption and characteristics

In the same manner as coal, oil consumption integrating meter is equipped in the line, and management of the oil consumption will be performed by the meter.

For analysis of oil characteristics such as sulfur content, calorific value, etc., oil sampling unit will be installed.

ii) Heavy oil burner

To increase contact surface of oil with air, oil should be atomized. Optimum excess air ratio should be maintained for the combustion.

b) Combustion Management

i. Excess Air Ratio

The most important point in the combustion control is to maintain good combustion by suitable air excess ratio. For deciding the optimum excess air ratio it is necessary to conduct a combustion test for each unit, to adjust various portions of boiler automatic controllers and to obtain the best conditions of combusting conditions, flue gas conditions and thermal efficiency.

The excess air ratio varies by the conditions of the fuel injected into the furnace, mixture of fuel with air, etc. Delicate control of the combustion equipment is required for maintaining the optimum excess air ratio.

i) In case of coal-fired boiler, particle size of pulverized coal affect largely the condition of combustion, and management of mills is very important. If the pulverizing mechanism of mill is damaged, particle sizes are not uniform and coal can not be completely pulverized, and thus unstable and incomplete combustion will result. Non-uniform pulverized coal distribution from mill to the respective burners due to abraision of pulverized coal distributor will cause unstable combustion.

ii) In the case of fuel oil firing, fuel atomizing conditions are affected by burner conditions, number of burners, oil delivery pressure, oil temperature and so forth.

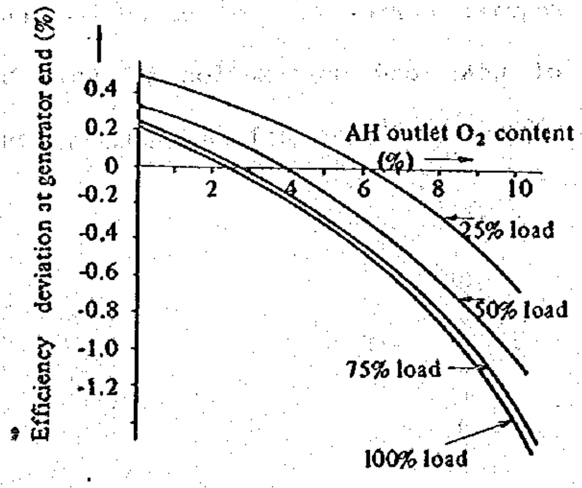
When burners are used for a long time, combustion becomes inferior due to deposition of carbon, wear of tips and so forth. Therefore, cleaning of guns and replacement of tips should be carried out at suitable intervals. Tips require strict control based on inspection of wear and deformation of hole bore, cracking and dents as well as capacity test.

Suitable number of burners should be selected in accordance with the load, and it is important to use each burner in the range of oil pressure of good atomizing characteristics. Atomizing becomes inferior when the oil pressure drops. In an extreme case, black smoke is emitted with unburnt components.

iii) For mixture of fuel with air, air flow should be suitably distributed by the adjustment of the air damper (or air register) for each burner, and efforts should be made to operate with as low excess air as possible in the range in which good combustion can be maintained.

Typical relationship between oxygen content in exhaust gas and generator end thermal efficiency deviation is shown in the following figure.

TYPICAL RELATIONSHIP BETWEEN OXYGEN CONTENT IN EXHAUST GAS AND GENERATOR END THERMAL EFFICIENCY DEVIATION



ii. Exhaust Gas Temperature

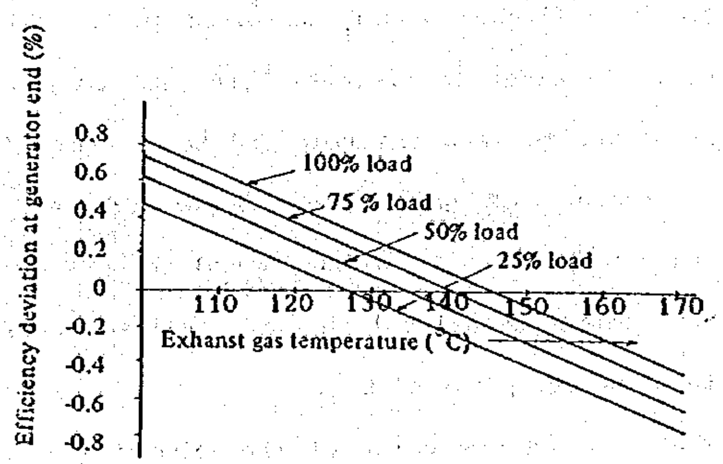
The target value of the exhaust gas temperature is determined by the metal temperature in the cold end of the regenerative air preheater (AH). Contamination and corrosion of elements occur due to the influence of SO_3 contained in the exhaust gas. In order to prevent these problems, it is necessary to keep the cold end temperature (mean temperature of gas outlet temperature and air inlet temperature = cold end metal temperature) of the element at a level that is equal to or higher than the dew point of SO_3.

The measured dew point of the exhaust gas added with a safety factor is determined as the target metal temperature, but it is necessary to determine a suitable temperature level with corrosion loss of the AH element periodically measured.

For daily control, keep the exhaust gas temperature at the target value by suitably operating the steam air preheater (SAH). Furthermore, monitor the draft loss and temperature efficiency of the AH and effectively execute soot blow to keep heat transfer surfaces clean. In addition, periodically measure the oxygen content at AH outlet to grasp the AH leaked air caused by damage to AH seal plates or other reason, in order to keep it at the control target or less. These items should be controlled as total thermal efficiency of the plant, is affected, not only the power loss of the draft fans.

Typical relationship between exhaust gas temperature and generator end thermal efficiency deviation is shown in the following figure.

TYPICAL RELATIONSHIP BETWEEN EXHAUST GAS TEMPERATURE AND GENERATOR END THERMAL EFFICIENCY



iii. Steam Pressure and Temperature

Rise of steam pressure and steam temperature is very effective for elevation of thermal efficiency. It is, therefore, necessary to make efforts to keep the steam pressure and steam temperature at specified levels.

Combustion control of a boiler in general is made so that the steam pressure is always maintained, and when the boiler load changes, combustion control (fuel and air) meeting the change is made. But steam temperature varies in accordance with steam flow rate (load), fuel, combustion airflow, combustion gas flow, spray rate. It also varies in accordance with factors such as contamination of the furnace. As a general trend, when the load rises, the hot gas flow increases and steam temperature rises. When the load decreases, the hot gas flow decreases and the steam temperature drops. In addition, the fact that time constants of boilers are very large is considered to be a difficult point of steam temperature control. In order to maintain the steam temperature at the operation target value, therefore, it is necessary to monitor the steam temperature, to grasp the characteristics of the boiler and to make suitable adjustments as required.

c) Pulverized coal firing equipment

For firing pulverized coal, there are the direct firing system and the bin system, and the direct firing system of simpler system formation, easier operation and lower construction cost will be adopted for this power plant.

d) Coal pulverizer (coal mill)

i. Mill type

There are vertical bowl mills and horizontal tube mills, and the vertical bowl mills will be adopted for its merits of less power consumption, better load response and lower noise.

ii. Numbers and Capacities of Mills and Burners

i) In the determination of numbers and capacities of mills and burners, the number of burners will be determined after the determination of number of mills.

ii) As for the determination of number and capacity of mills, especially, necessity of standby mill and the minimum load of the unit should be taken into consideration.

In general, standard capacity of mill will be determined based on size of mill crushing part, and then the capacity will be restudied based on grindability and grain size of the coal used.

In consideration of a case of use of low grade coal, the mill capacity will be determined with some margin so that the mill may be operated stably.

Generally, four to six mills will be installed for base load power plant from the view point of equipment layout in the powerhouse.

iii) The following considerations will be made on the determination of number of mills;

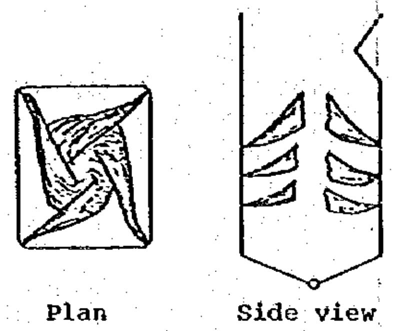
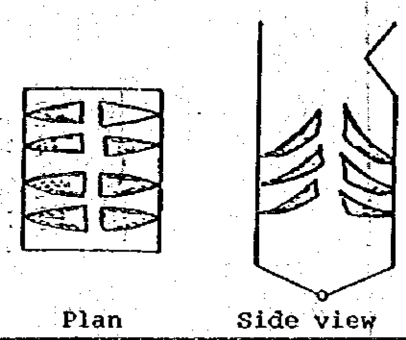
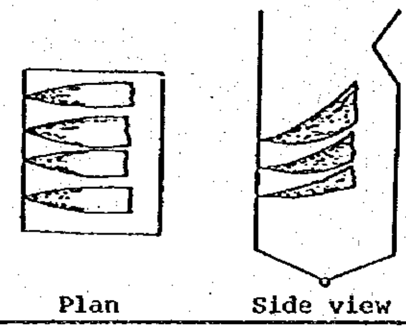
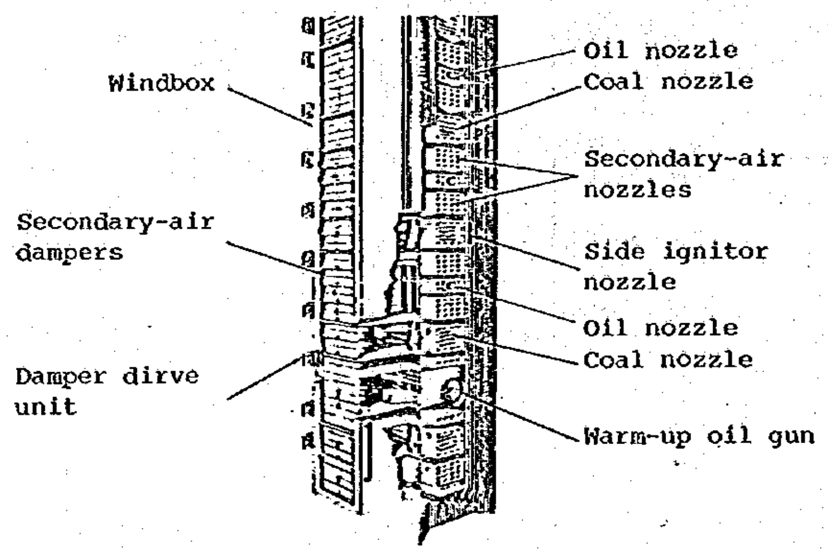
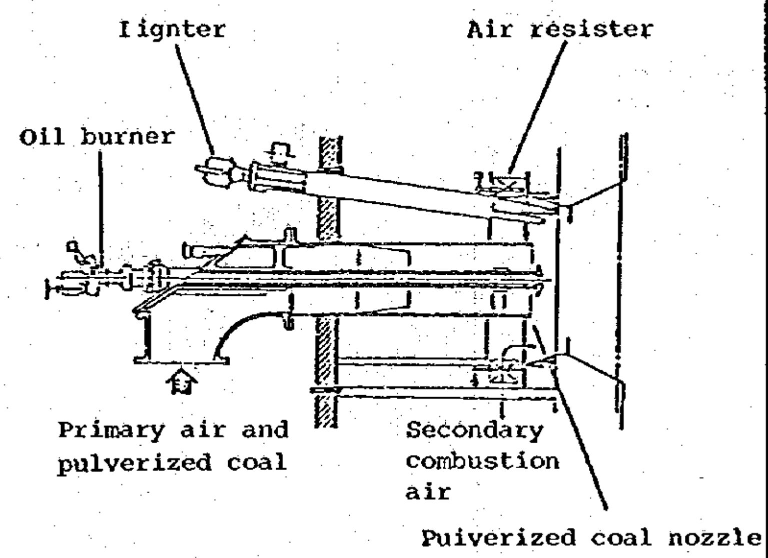
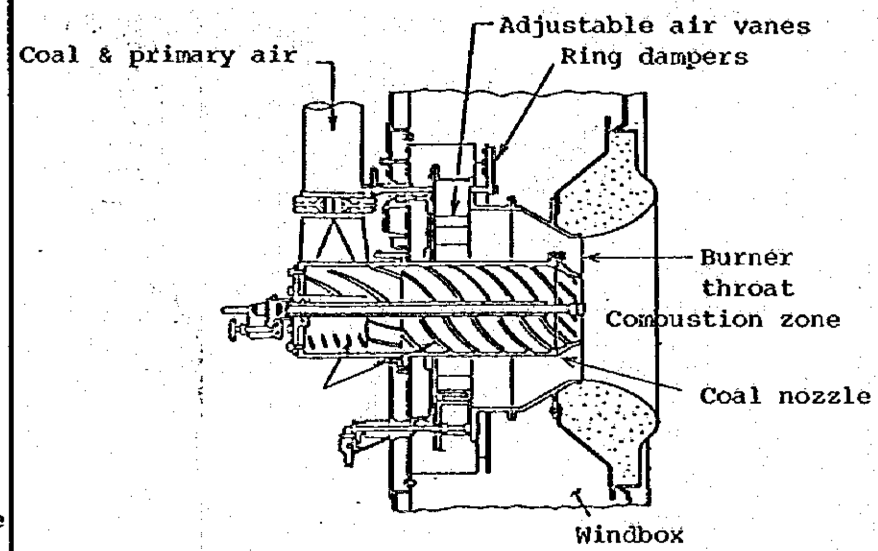
- Prevention of slagging due to high thermal load in burner zone.
- Prevention of increase in burning time and uncombustible loss due to excessive capacity of burner.

Normally, allowable heat input to a burner is approximately 43×10^6 kcal/h.

iv) Burner arrangement will be determined in consideration of uniform heat distribution in the burner zone and easy operation of burners.

There are three types of burner arrangement, the tangential firing, the oppored firing and the front or near firing systems.
These three systems are of similar performance and reliability, and it is difficult to say which system is better. The boiler manufacturers adopt their own systems based on their past experiences. Therefore, when the boiler manufacturer is determined, the burner arangement will be determined of necessity, and it is very rare that a boiler manufacturer adopts a burner arrangement not of their own.

Table 5-2 Burner Arrangement and Construction

<table>
<tr><th></th><th>Tangential Firing</th><th>Opposed Firing</th><th>Front or Rear Firing</th></tr>
<tr><td>Arrangement</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>Contruction of Burners</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>Outline Features</td><td>. This system is called the corner firing, and the burners are located on the four corners. The pulverized coal nozzles, the combustion air nozzles, and the heavy oil nozzles are arranged alternately in vertical arrangement, and each nozzle is separated with partitions. Different from the other systems, the flames form a vortex in the furnace. In this system, the movable tip of the nozzle allows the flame angle to beadjusted ± 30° up and down for steam temperature control.</td><td>. Burners are located on the front wall and the rear wall. This system is sometimes called the opposite system, and is adopted for large boilers.
Burners are designed so that both pulverized coal and oil can be fired mixedly.
In this system the pulverized coal nozzle, heavy oil nozzle and combustion air nozzle compose one burner structure and necessary number of such burners are installed.</td><td>. Burners are located either on the front wall or on the rear wall, and sometimes on the side wall. This system is called sometimes the single wall firing system.
Burners are of similar construction to the opposed firing system and necessary number of burners are installed.</td></tr>
</table>

e) Primary air fan

Primary air fan is used to send hot air (primary air) to the coal pulverizer for coal drying and blowing the pulverized coal to the burners. There are two systems, namely the coal air system where the primary air fan is located upstream of the air preheater and the hot air system where the primary air fan is located downstream of the air preheater. And the cold air system will be adopted for this power plant because the air handled is clean and at lower temperature and consequently smaller number of fans are required as compared with the hot air system.

f) Heavy oil firing equipment

i. Atomizing system

The atomizing system is classified into two, the pressure atomizing system and the medium atomizing system (steam atomizing and air atomizing). The medium atomizing system requires lower oil pressure than the pressure atomizing system, the maintenance of the system being easier, and can make the atomized fuel particles finer for better mixing with the combustion air.

Therefore, the medium atomizing system is adopted for this project.

The atomizing medium for heavy oil will be steam and that for light oil (for start-up) will be air.

ii. Heavy oil pump

There are centrifugal pumps and screw pumps for the heavy oil pump, and the screw pump better suited for high viscosity oil will be adopted.

e. Balanced draft system

For the draft system of the boiler, there are the forced draft system with the use of the forced draft fan only and the balanced draft system with the use of the forced draft fan and the induced draft fan. And for the pulverized coal firing boilers, the balanced draft system with the furnace gas pressure slightly lower than the atmospheric pressure is usually adopted in consideration of gas leakage from the furnace.

The balanced draft system will be adopted for this project.

f. Air preheater and steam air preheater

There are two types of air preheaters, the regenerative type (revolving type or stationary type) and the conduction type, and in the utility power stations, the regenerative type is used almost exclusively. Thus, the regenerative type will be adopted for this project.

A steam air preheater will be installed upstream of the regenerative air preheater for the purpose of preventing corrosion of the low temperature elements of the air preheater by the sulphuric acid formed from the sulphur content in the fuel.

The steam air preheater will keep the regenerative air preheater inlet air temperature higher so that the temperature of the low temperature elements of the air preheater would not go below the dew point of the flue gas. In addition, although there are two types of air preheater; one is separate type for heating mill primary air and secondary combustion air, and the other is three-path type which heats the above two kinds of air simultaneously, more economical three-path type will be adopted to this project comparing with the separate type.

g. Boiler feedwater pump

For driving the boiler feedwater pumps, electric motors and steam turbines are used. As the unit sizes get larger, the feedwater pump driving power also gets larger, and in this connection, steam turbine-driven pumps are more popularly used, in consideration of reduction of station service power and hence the station service transformer capacity and the voltage drop at the time of startup of the feedwater pumps.

For this Project, the steam turbine driven boiler feed pumps will be adopted for normal operation and the electric motor driven pumps will also be installed for boiler start-up and as stand-by units.

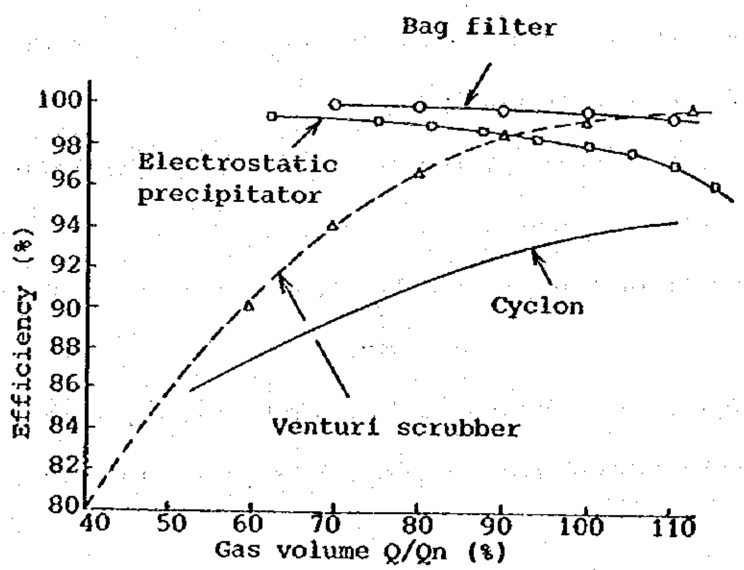
Two turbine-driven pumps of 55% capacity each and one electric motor-driven pump of 55% capacity will be installed per unit.

h. Dust collector

For the dust collector in coal-fired thermal power plants, two types of collectors, or the electrostatic precipitator and the bag filter, are possible. As for the electrostatic precipitator, fine particles smaller than 0.1 mm in diameter can be easily collected and the range of applicable handling gas characteristics is wide.

Furthermore, the pressure loss and the operating cost are low and, it can be operated for several years without special maintenance. Therefore, electrostatic precipitators have been adopted for large power plants.

On the other hand, performance of the bag filter type dust collector, is not affected by the kind of coal used and gas volume and it can be operated with high efficiency as indicated in the following curves.



However, there are several problems of higher pressure loss, wider installation space and short service life of the bag.

In this project, it is recommendable to adopt the electrostatic precipitator in consideration of the fact that this power plant is planned to be operated with fuel oil as well as coal and the following reasons:

a) Bag filter type dust collector has disadvantages in high pressure loss, large installation space and high equipment cost, and frequent maintenance like replacement of bags.

b) Since combustion gas of fuel oil, in general, contains approximately 10% of moisture and approximately 20 ppm of sulfuric anhydride (SO_3) and the dust particle size is finer, the specific surface of dust is larger and the particles absorb much sulfuric anhydride, the bag filter suffer clogging.

c) The average sizes of the particles produced by pulverized coal and heavy oil combustion are approximately 25 microns and 15 microns respectively. Therefore, smaller size of particle produced by heavy oil combustion are unsuitable for dust collection by bag filter.

d) The bag filter type dust collectors have not yet been actually applied to oil-fired thermal power plant.

Table 5-3 Comparison table of EP and Bag filter

	E.P	Bag Filter
1. Efficiency (%)	90 - 99	90 - 99
2. Collectable particle size (micron)	20 - 0.01	20 - 0.1
3. Pressure loss (mm H_2O)	10 - 20	100 - 200
4. Utility consumption		
a. Electricity	100 (base)	210
b. Steam	100 (base)	220
5. Equipment cost	100 (base)	117
6. Maintenance Cost	100 (base)	180
7. Operation		
a. Start/stop	No problem	Moisture absorption in bag may occur in case of frequent unit start and stop.
b. Deterioration	Decrease in performance due to dust deposit on electrodes	Filter to be replaced because of decrease in performance due to clogging of filters.
8. Maintenance		
a. Monitoring	. Charging conditions and hammering	. Pressure loss (damage of bag) . Reverse purging devices
b. Inspection and repair during periodic overhaul	. Internal inspection of plates, insulators and hammering devices	. Internal inspection of reverse purging devices
9. Reliability	High	. When the bag is damaged the filtering Chamber should be switched to spare chamber
10. Adaptability to coal	Some limitation depending on coal	No limitation

With electrostatic precipitators, there are the hot temperature type installed upstream of the air preheater and the low temperature type located downstream of the air preheater. The high temperature type is larger in size and involves larger heat loss due to radiation and larger electric power consumption than the low temperature type and special consideration must be made with the materials. Therefore, the low temperature type will be adopted for this project.

Comparison of cold-side EP and hot-side EP is shown in the following table.

Table 5-4(1) Comparison of Cold-Side EP and Hot-Side EP

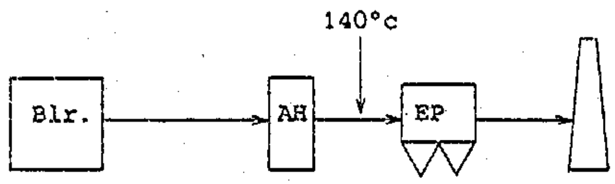
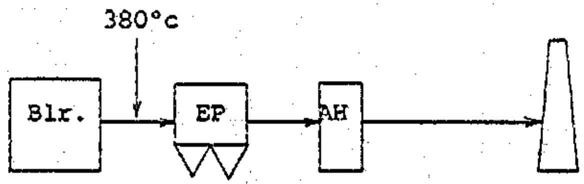
Item	Cold-Side EP	Hot-Side EP
1. Outline		
2. Features and Problems	(1) These have been many units in service with reliable records, no particular problems involved in design, manufacture and operation. (2) Economical in case exhaust gas is not too large in volume and with dusts of good collectibility (low electric resistance and high S content). (3) Flexibility with respect to the kinds of coal is small and the performance (size) of EP may vary widely according to kinds of coal. (4) In case of high resistivity dust, back corona might occur. (5) In case of high resistivity dust, the peeling effect is small and the performance is lowered.	(1) Flexibility with respect to kinds of coal (S content) is large and the performance (size) of EP does not change much for a variety of coal. (2) Fluidity of dust is high and there is less risk of ash clogging. (3) As the gas volume to be treated is large, the cross section gets large, requiring wider layout space, and complicated duct work. (4) Special consideration is necessary structurally and materially against heat expansion. (5) Full care must be given to heat radiation. (6) Because of high temperature, dust handling is rather difficult.

Table 5-4(2) Comparison of Cold-Side EP and Hot-Side EP

Item	Cold-Side EP	Hot-Side EP
3. Countermeasures Against Problems	(1) For coal producing poor collectivity dust, larger EP must be built. (2) The size of EP will be decided for the coal of poorest collectibility dust, and fluctuation of kinds of coal will be coped with by coal blending. In the worst case, conditioning of gas with chemical injection would be necessary. (3) High efficiency hammering and collection electrodes will be adopted.	(1) Materials for high temperature will be selected and thermal expansion will be absorbed by sliding, and heat insulation will be made. (2) Flying of ash will be prevented by adequate hammering. (3) For special coal with poor dust collectibility, blending of coal will be made to raise the performance.
4. Problems in Operation and Maintenance	(1) No particular problem.	(1) Cooling time is required before internal inspection. (2) Re-scattering of dust is liable to occur, and hammering must be adjusted to match the operating conditions.
5. Collecting Efficiency	(1) Efficiency is raised by increase of EP size, but it varies widely by the kinds of coal. (2) Against decline of efficiency due to kinds of coal, improvement is possible with coal blending or chemical feed.	(1) Irrespectively with the coal, a certain level of efficiency can be obtained. (2) Decline of efficiency due to kinds of coal, blending only is possible for the improvement of efficiency.

Table 5-4(3) Comparison of Cold-Side EP and Hot-Side EP

Item	Cold-Side EP	Hot-Side EP
6. Cost and Others	(1) Volume: Base	140%
	(2) Dust collecting surface: Base	160%
	(3) Utility: Base	240%
	(4) Cost	
	Initial cost: Base	Initial cost: 160%
	Running cost: Base	Running cost: 200%

i. Ash disposal equipment

i) Bottom ash and fly ash disposal equipment

For disposal of the bottom ash and the fly ash, there are many systems by the combination of the continuous type and wet type, etc. And for this project, in consideration of the fact that the ash disposal area is prepared adjacent to the power plant, the most suited method of the intermittent water sluicing through piping will be adopted for disposal of bottom ash and the intermittent vacuum transport and water sluicing for fly ash.

Furnace bottom ash disposal system

Furnace bottom ash disposal system is classified into two; batch disposal system and continuous disposal system. These two systems are, furthermore, classified into the dry type and the wet type.

Here, ash disposal systems by water sluicing in slurry form widely adopted in Japan and the USA and by water pit belt conveyor adopted in Europe and America are compared in the following tables.

ii) Utilization of fly ash

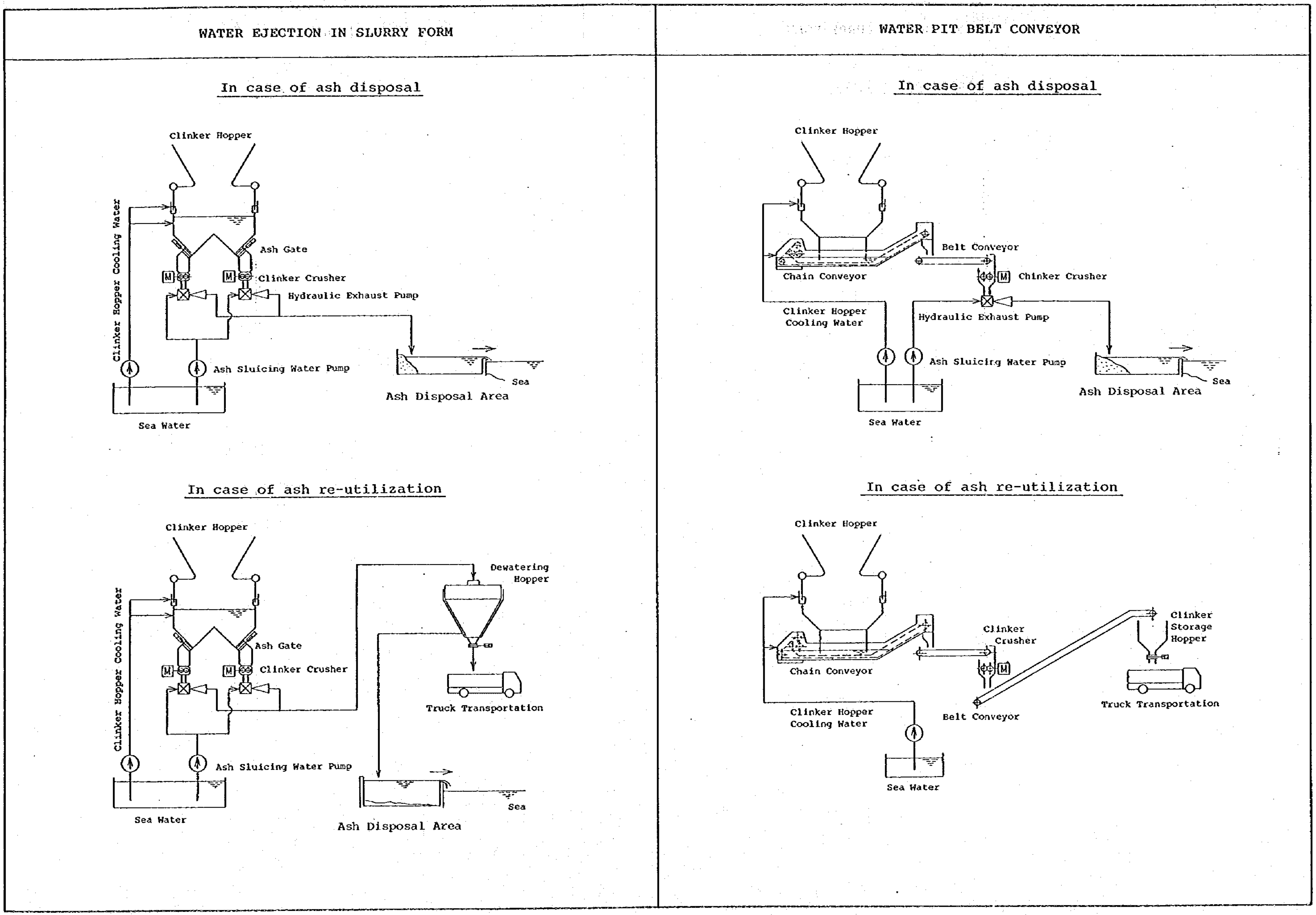
Fly ash is used for earth filling, roadway subgrade, cement, fertilizer, agricultural land, concrete aggregate, etc. However, further studies including marketing balance in Egypt should be conducted for future utilization.

Since the demand of fly ash could not be forecast, fly ash collecting equipment will not be forecast, fly ash collecting equipment will not be installed in this stage, but in consideration of future utilization of the ash, space for the equipment will be considered.

Table 5-5 Comparison Table of Furnace Bottom Ash Disposal Systems

Items \ System	Water Ejection System in Slurry Form		Water Pit Belt Conveyor System	
	Direct Ash Disposal	Ash Re-utilization	Direct Ash Disposal	Ash Re-utilization
Outline of Ash Disposal	In this system, clinker hopper made by welded steel plates with heat resistant and wear resistant lining is installed in the furnace bottom. Water is filled in the hopper to cool down instantaneously the hot clinker dropping from the upper portion. Stored clinker is discharged from the lower gate at 8-hours interval, and crushed into ash with a size of 10 to 20 mm by clinker crusher. Then, the ash in slurry form is transported by hydraulic exhaust pump through ash disposal pipe. Since the operating time is short (1 - 2 hours), maintenance can be conducted during boiler operation.		In this system, clinker is continuously conveyed outside by chain conveyor immersed in bottom water. The clinker is instantaneously cooled down and crushed into ash, and then the ash is dewatered at the ramp of the chain conveyor and transported by conveyor to clinker crusher. Since the system is operated continuously, maintenance is difficult during normal boiler operation, and maintenance frequency of the chain conveyor is relatively high because of wear of the chain.	
	In this system, clinker ash in slurry form is directly transported by hydraulic exhaust pump up to ash disposal area.	In this system, clinker ash is transported to dewatering hopper, and after dewatering the clinker ash only clinker is transported outside by truck.	In this system, clinker ash is crushed into ash with a size of 10 to 20 mm, and then transported by hydraulic exhaust pump to ash disposal area.	In this system, clinker ash is crushed into ash with a size of 10 to 20 mm, and transported to clinker storage hopper once and then transported by truck outside.
Operation /8 hour	Batch (1 to 2 hours)	Batch (1 to 2 hours)	Continuous	Continuous
Ash Transportation	Hydraulic Exhaust Pump	Hydraulic Exhaust Pump and Truck	Chain Conveyor Belt Conveyor Hydraulic Exhaust Pump	Chain Conveyor Belt Conveyor Truck
Transportable Distance	Intermediate	Long	Intermediate	Long
Disposal of Waste Water	Much	Much	Less	Less
Power Consumption	Intermediate	Intermediate	Much	Less
Maintenance	Easy	Easy	Difficult	Difficult
Maintenance Frequency	Low	Intermediate	High	High
General Conclusion	○	△	x	x

Fig. 5-1 Coal Ash Utilization



j. Stack

There are stacks of independent type (1 stack per 1 boiler) and collective type for thermal power plants, and the collective type will be adopted for its merit of better dispension of sulphur oxides by the higher effective height due to the collective effect of the flue gas.

The height of stack is determined to be 85 m by the maximum concentration of SOx reaching the ground surface and distance of maximum concentration on the ground surface and also in consideration of the wind rose and other local conditions in the area, and steel made collective type stack will be adopted since steel made collective type has advantages of less construction period and lower construction cost than that of concrete made self-supported type. As for the decision of stack height, refer to subsection 4-5-7, Stack Height in Chapter 4. Comparison of concrete made self-supported stack and steel made collective stack is tabulated in the following.

Comparison of concrete made self-supported stack and steel made collective stack

Design conditions	1. Flue gas flow : 1,052,000 to 1,196,000 m^3/h/unit 2. Gas velocity : 28 m/sec 3. Gas temperature: 135 °C 4. Stack height : 85 m

Items \ Stacks		Self-supported Stack: One unit	Self-supported Stack: Two unit	collective stack
Load (ton)	Upper parts	2,300	4,600	500 (steel) + 490 (lining) = 990
	Foundation	3,400	6,800	2,280
	Total	5,700	11,400	3,270
Erection schedule (month)	Foundation	2		2
	Upper part	6		3
	Lining	6 (brick)		4
	Total	14		9
Cost (yen)	Foreign currency	419×10^6	838×10^6	710×10^6
	Domestic currency	140×10^6	280×10^6	130×10^6 (15.5%)
	Total	559×10^6	$1,118 \times 10^6$	840×10^6
Service life		More than 50 years		More than 50 years (Repairs of external painting and internal lining are needed)

4) Turbine

a. Tandem Compound Type

Types of turbines are classified into the tandem compound type and the cross compound type. The tandem compound type, economical in construction cost and easy in operation and with many records will be adopted for 300 MW class turbine.

b. Turbine Bypass Line

The turbine bypass line is provided not only in case of the once-through type but in case of the drum type boilers, for metal-matching and protection of reheater tubes at the time of unit start-up and for shortening of start-up time. The turbine bypass line will be adopted for this project, too.

c. Condenser

The condenser will be of the single-path surface type, and will be designed for 27°C of seawater temperature, 85% cleanliness factor and condenser vacuum of 710 mmHg.

Condenser tube materials of high heat conductivity and high corrosion resistivity will be selected.

The condenser back wash system and condenser tube cleaning system will be provided for periodic cleaning of condenser tubes and removal of organic growths and deposits of foreign matters inside the tubes to maintain the condenser vacuum.