are of a long span type. It costs an enormous investment to modify them into those that are of a short span type.

3) The exact data of frequency of lightning strokes, actual results of lightning damage and lightning resistant effect of the overhead ground wires are unknown.

10.6.2 11 kV Distribution Line Construction Works for Newly Constructed or Modified Substations

(1) Summary of work plan (short-term for 5 years)

See Tables of the summary of work plan and load change-over plan for each substation.

Study to be implemented in 1994.

1) TANDALE S/S: new construction (15 MVA x 1)

Construction of new TA1, TA2 and TA3 feeders must be carried out and in addition, the load must partly be separated from the following feeders for change-over. See Table 10.6.2-1 and Fig. 10.6.2-1.

Mikocheni S/S	:	MK2 & MK3
Oyster bay S/S	:	02 & 04
Ilala S/S	:	D10
Ubungo S/S	:	U2

2) CHANG'OMBE S/S: new construction (15 MVA x 1)

Construction of new CH1, CH2, CH3 and CH4 feeders must be carried out and in addition, the load must partly be separated from the following feeders for change-over. See Table 10.6.2-2 and Fig. 10.6.2-1.

Ilala S/S	:	D3 & D7
FZ-I S/S	:	F2 & F5

3) ILALA S/S: No. 5 bank

Change-over of D3 feeder of No. 3 bank and D9 feeder of No. 4 bank to newly constructed No. 5 bank must be carried out. The load must partly be separated from the U1 feeder of Ubungo S/S for change-over. See Table 10.6.2-3 and Fig. 10.6-2-1.

4) MBEZI S/S: expansion of capacity (7.5 MVA to 15 MVA)

Change-over of MB1, MB2 and MB3 feeders of the existing bank (7.5 MVA x 1) to newly installed transformer (15 MVA x 1) must be carried out. See Fig. 10.6.2-1.

Study to be implemented in 1996

1) KUNDUCHI S/S: new construction (15 MVA x 1)

Construction of new KU1, KU2, KU3 and KU4 feeders must be carried out and in addition, the load must partly be separated from the following feeder for change-over. See Table 10.6.2-4 and Fig. 10.6.2-2.

Mbezi S/S : MB2

2) KARIAKOO S/S: new construction (15 MVA x 1)

Construction of new KA1, KA2 and KA3 feeders must be carried out and in addition, the load must partly be separated from the following feeders for change-over. See Table 10.6.2-5 and Fig. 10.6.2-1.

Ilala S/S : D1, D2 & D9
Kurasini S/S : Port
City Centre S/S: C5

In addition, shutdown D8 feeder of Ilala S/S must be reused for newly constructed No. 5 bank.

3) MBAGALA S/S: new construction (15 MVA x 1)

Construction of new MG1, MG2 and MG3 feeders must be carried out and in addition, the load must partly be separated from the following feeders for change-over. See Table 10.6.2-6 and Fig. 10.6.2-3.

Kurasini S/S : Kilwa road

4) TABATA S/S: new construction (5 MVA x 1)

Construction of new TB1 and TB2 feeders must be carried out and in addition, the existing 33 kV power supply load must partly be separated for change-over to the 11 kV power supply. See Table 6.2-7.

Table 10.6.2-1 TANDALE S/S load change-over plan

Substation feeder	Tr facility capacity for estimated demand		Before taking counter-measures	Detail of change-over	After taking counter-measures
Tandale	Estimated demand	(kW)		From MK2 (+)317 From MK3 (+)473	790
		(A)		From MK2 (+) 21 From MK3 (+) 31	52
TA1	Tr facility capacity	(kVA)		From MK2 (+)615 From MK3 (+)3,420	4,035
	Estimated demand	(kW)		From 04 (+)1,022 From U2 (+)976 From D10 (+)860	2,858
		(A)		From 04 (+)57 From U2 (+)64 From D10 (+)57	178
TA2	Tr facility capacity	(kVA)		From 04(+)1,134 From U2 (+)1,515 From D10(+)1,130	3,779
	Estimated demand	(kW)		From MK2 (+)311	311
		(A)		From MK2 (+)20	20
TA3	Tr facility capacity	(kVA)		From MK2 (+)2,245	2,245
Mikocheni	Estimated demand	(kW)	3,958	To TA1 (-)317 From MK3 (+)57 To 02 (-)309	3,389
		(A)	260	To TA1 (-)21 From MK3 (+)4 To 02 (-)20	223
MK2	Tr facility capacity	(kVA)	7,675	To TA1 (-)615 From MK3(+)415 To 02 (-)600	3,875
	Estimated demand	(kW)	1,649	To TA1 (-)473 To MK2 (-)57 To TA3 (-)311	808
		(A)	108	To TA1 (-)31 To MK2 (-)4 To TA3 (-)20	53
MK3	Tr facility capacity	(kVA)	11,920	To TA1 (-)3,420 To MK2 (-)415 To TA3 (-)2,245	5,840
Oyster bay	Estimated demand	(kW)	3,029	From MK2 (+)309	3,338
		(A)	199	From MK2 (+)20	219
02	Tr facility capacity	(kVA)	2,515	From MK2 (+)600	3,115
	Estimated demand	(kW)	3,652	To TA2 (-)1,022	2,630
		(A)	240	To TA2 (-)57	183
04	Tr facility capacity	(kVA)	4,805	To TA2 (-)1,134	3,671
Ilala	Estimated demand	(kW)	4,230	To TA2 (-)860	3,370
		(A)	278	To TA2 (-)57	221
D10	Tr facility capacity	(kVA)	5,560	To TA2 (-)1,130	4,430
Ubungo	Estimated demand	(kW)	3,008	To TA2 (-)976	2,032
		(A)	197	To TA2 (-)64	133
U2	Tr facility capacity	(kVA)	4,670	To TA2 (-)1,515	3,155

Table 10.6.2-2 CHANG'OMBE S/S load change-over plan

Substation feeder	Tr facility capacity for estimated demand		Before taking counter-measures	Detail of change-over	After taking counter-measures
Chang'ombe	Estimated demand	(kW)		From D3 (+)1,240 From F5 (+)349	1,589
		(A)		From D3 (+)81 From F5 (+)23	104
CH1	Tr facility capacity	(kVA)		From D3 (+)1,815 From F5 (+)2,415	4,230
	Estimated demand	(kW)		From F2 (+)963	963
		(A)		From F2 (+)63	63
CH2	Tr facility capacity	(kVA)		From F2 (+)3,750	3,750
	Estimated demand	(kW)		From K3 (+)2,342	2,342
		(A)		From K3 (+)154	154
CH3	Tr facility capacity	(kVA)		From K3 (+)6,215	6,215
	Estimated demand	(kW)		From F2 (+)423 From K4 (+)1,294	1,717
		(A)		From F2 (+)23 From K4 (+)85	108
CH4	Tr facility capacity	(kVA)		From F2 (+)1,645 From K4 (+)3,015	4,660
Ilala	Estimated demand	(kW)	3,750	To CH1 (-)1,240	2,150
		(A)	246	To CH1 (-)81	165
D3	Tr facility capacity	(kVA)	5,495	To CH1 (-)1,815	3,680
	Estimated demand	(kW)	2,638	To F5 (-)1,426	1,212
		(A)	159	To F5 (-)86	73
D7	Tr facility capacity	(kVA)	2,460	To F5 (-)1,330	1,130
FZ-I	Estimated demand	(kW)	2,764	To CH2 (-)963 To CH4 (-)423	1,378
		(A)	182	To CH2 (-)63 To CH4 (-)23	96
F2	Tr facility capacity	(kVA)	10,760	To CH2 (-)3,750 To CH4 (-)1,645	5,365
	Estimated demand	(kW)	1,134	To CH1 (-)349 From D7(+)1,426	2,211
		(A)	74	To CH1 (-)23 From D7 (+)86	137
F5	Tr facility capacity	(kVA)	7,845	To CH1 (-)2,415 From D7(+)1,330	6,670

Table 10.6.2-2 CHANG'OMBE S/S load change-over plan

Substation feeder	Tr facility capacity for estimated demand		Before taking counter-measures	Detail of change-over	After taking counter-measures
Kurasini	Estimated demand	(kW)	3,498	To CH3 (-)2,342	1,156
		(A)	230	To CH3 (-)154	76
Industrial	Tr facility capacity	(kVA)	9,310	To CH3 (-)6,215	3,095
	Estimated demand	(kW)	4,812	To CH4 (-)1,294	3,518
		(A)	316	To CH4 (-)85	231
Kilwa road	Tr facility capacity	(kVA)	11,210	To CH4 (-)3,015	8,195

Table 10.6.2-3 ILALA S/S load change-over plan

Substation feeder	Tr facility capacity for estimated demand		Before taking counter-measures	Detail of change-over	After taking counter-measures
Ilala No.3 Bank	Estimated demand	(kW)	2,559		2,559
		(A)	168		168
D1	Tr facility capacity	(kVA)	5,695		5,695
	Estimated demand	(kW)	2,349		2,349
		(A)	154		154
D2	Tr facility capacity	(kVA)	3,215		3,215
	Estimated demand	(kW)	3,750	To Ilala No.5 bank (-)3,750	0
		(A)	246	To Ilala No.5 bank (-) 246	0
D3	Tr facility capacity	(kVA)	5,495	To Ilala No.5 bank (-)5,495	0
Ilala No.4 Bank	Estimated demand	(kW)	1,212	From U1 (+)1,234	2,446
		(A)	73	From U1 (+) 81	154
D7	Tr facility capacity	(kVA)	1,130	From U1 (+)3,055	4,185
	Estimated demand	(kW)	6,384	To Ilala No.5 bank (-)6,384	0
		(A)	419	To Ilala No.5 bank (-) 419	0
D9	Tr facility capacity	(kVA)	5,430	To Ilala No.5 bank (-)5,430	0
	Estimated demand	(kW)	4,230		4,230
		(A)			
D10	Tr facility capacity	(kVA)	5,560		5,560
Ilala No.5 Bank	Estimated demand	(kW)		From Ilala No.3 bank (-)3,750	3,750
		(A)		From Ilala No.3 bank (-) 246	246
D3	Tr facility capacity	(kVA)		From Ilala No.3 bank (-)5,495	5,495
	Estimated demand	(kW)		From Ilala No.4 bank (-)6,387	6,387
		(A)		From Ilala No.4 bank (-) 419	419
D9	Tr facility capacity	(kVA)		From Ilala No.4 bank (-)5,430	5,430
Ubungo	Estimated demand	(kW)	3,762	To D7 (-)1,234	2,528
		(A)	247	To D7 (-) 81	166
U1	Tr facility capacity	(kVA)	9,310	To D7 (-)3,055	6,255

Table 10.6.2-4 KUNDUCHI S/S load change-over plan

Substation feeder	Tr facility capacity for estimated demand		Before taking counter-measures	Detail of change-over	After taking counter-measures
Kunduchi	Estimated demand	(kW)		From Kunduchi (+)305	305
		(A)		From Kunduchi (+)20	20
KU1	Tr facility capacity	(kVA)		From Kunduchi (+)650	650
	Estimated demand	(kW)		From Kunduchi (+)1,142	1,142
		(A)		From Kunduchi (+)75	75
KU2	Tr facility capacity	(kVA)		From Kunduchi (+)2,525	2,525
	Estimated demand	(kW)		From Kunduchi (+)381	381
		(A)		From Kunduchi (+)25	25
KU3	Tr facility capacity	(kVA)		From Kunduchi (+)1,790	1,790
	Estimated demand	(kW)		From Kunduchi (+)930	930
		(A)		From Kunduchi (+)61	61
KU4	Tr facility capacity	(kVA)		From Kunduchi (+)4,000	4,000
Mbezi	Estimated demand	(kW)	4,282	To Ku1 (-) 305 To Ku3 (-) 380 To Ku2 (-)1,143 To Ku4 (-) 930	1,524
		(A)	281	To Ku1 (-) 20 To Ku3 (-) 25 To Ku2 (-) 75 To Ku4 (-) 61	100
MB2	Tr facility capacity	(kVA)	13,810	To Ku1 (-) 650 To Ku3(-)1,790 To Ku2 (-)2,525 To Ku4(-)4,000	4,845

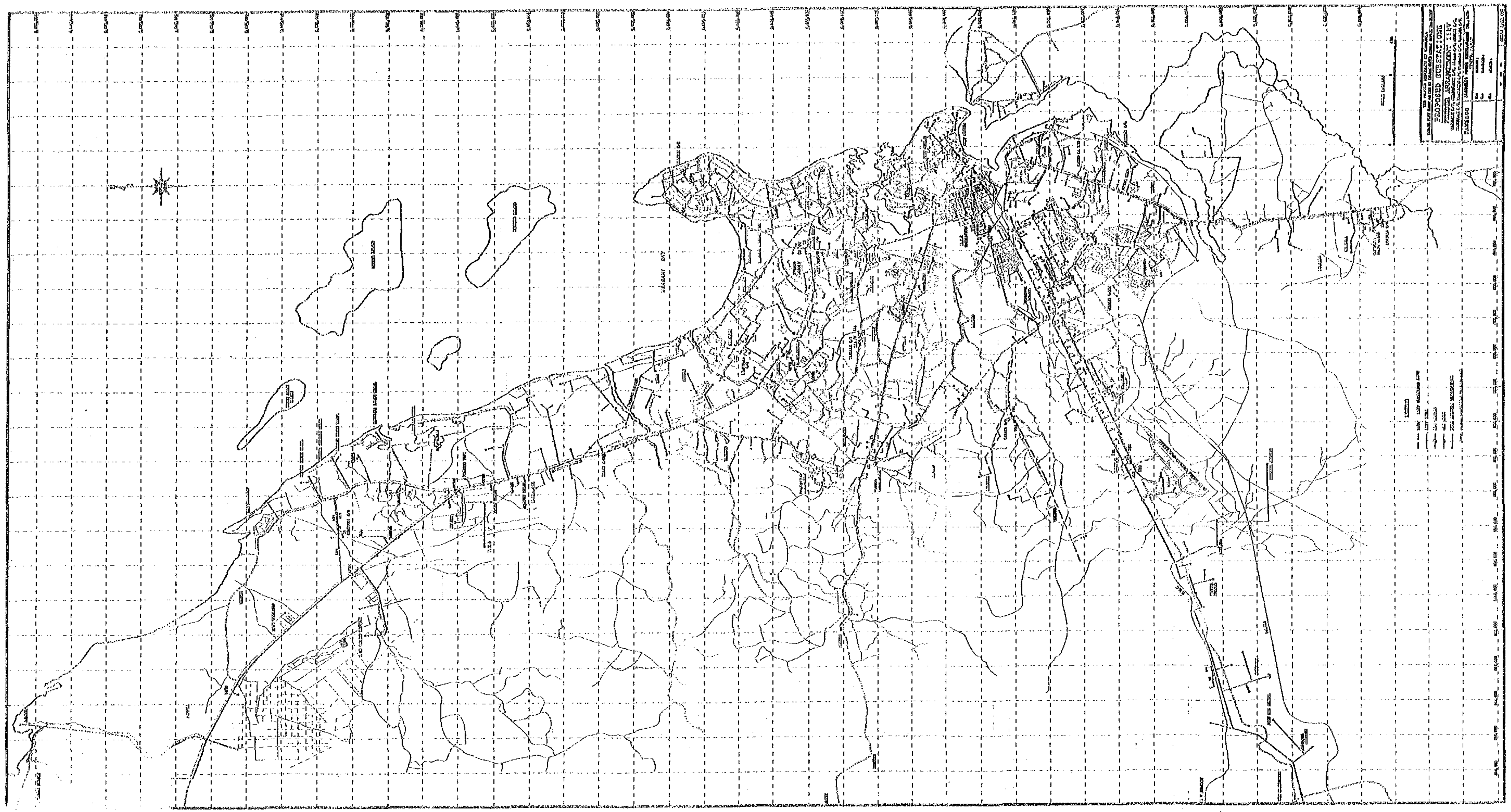
Table 10.6.2-5 KARIAKOO S/S load change-over plan

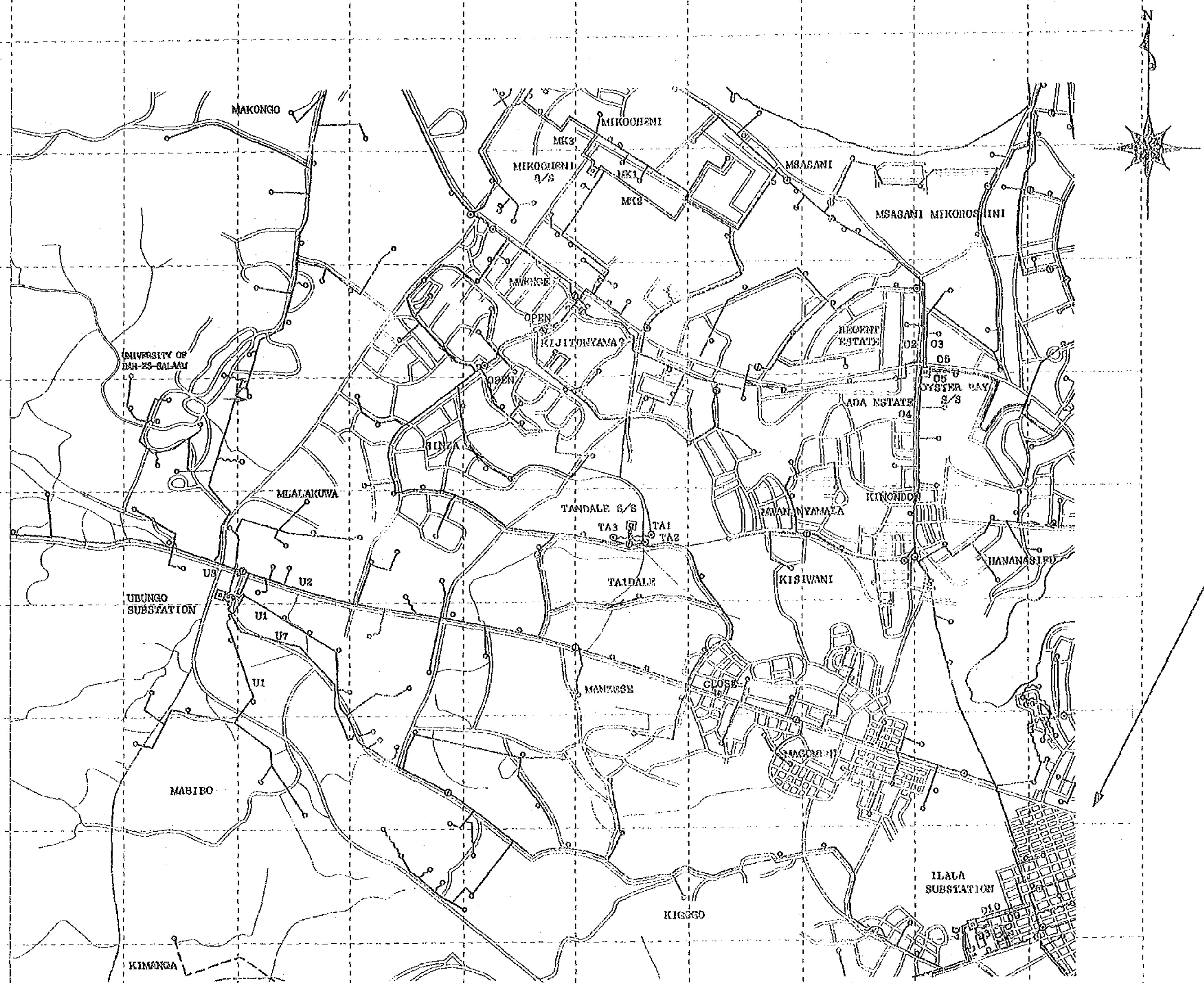
Substation feeder	Tr facility capacity for estimated demand		Before taking counter-measures	Detail of change-over	After taking counter-measures
Kariakoo	Estimated demand	(kW)		From D1(+)1,463 From Port(+)996 From D2 (+)336 From C5 (+)200	2,995
		(A)		From D1 (+)96 From Port (+)65 From D2 (+)23 From C5 (+)21	205
KA1	Tr facility capacity	(kVA)		From D1(+)3,255 From Port(+)950 From D2 (+)400 From C5 (+)500	5,100
	Estimated demand	(kW)		From D9 (+)1,991	1,991
		(A)		From D9 (+)131	131
KA2	Tr facility capacity	(kVA)		From D9 (+)1,515	1,515
	Estimated demand	(kW)		From D2 (+)846 From D9 (+)2,142	2,988
		(A)		From D2 (+)55 From D9 (+)140	195
KA3	Tr facility capacity	(kVA)		From D2 (+)1,000 From D9 (+)1,630	2,630
Ilala	Estimated demand	(kW)	2,860	To D2 (-) 90 To KA1 (-)1,463 To D8 (-)1,307	0
		(A)	188	To D2 (-) 6 To KA1 (-) 96 To D8 (-) 86	0
D1	Tr facility capacity	(kVA)	6,355	To D2 (-)200 To KA1 (-)3,255 To D8 (-)2,900	0
	Estimated demand	(kW)	2,624	From D1 (+) 90 To KA3 (-) 846 To KA1 (-)336	1,532
		(A)	172	From D1 (+) 6 To KA3 (-) 55 To KA1 (-) 23	100
D2	Tr facility capacity	(kVA)	3,100	From D1 (+)200 To kA3 (-)1,000 To KA1 (-)400	1,900
	Estimated demand	(kW)	7,136	To KA2(-)1,991 To KA3(-)2,142	3,003
		(A)	468	To KA2 (-)131 To KA3 (-)140	197
D9	Tr facility capacity	(kVA)	5,430	To KA2(-)1,515 To KA3(-)1,630	2,285
Ilala No.5 Bank	Estimated demand	(kW)		From D1 (+)1,307	1,307
		(A)		From D1 (+)86	86
D8	Tr facility capacity	(kVA)		From D1 (+)2,900	2,900
Kurasini	Estimated demand	(kW)	3,266	To KA1 (-)996	2,270
		(A)	214	To KA1 (-) 65	149
Port	Tr facility capacity	(kVA)	3,115	To KA1 (-)950	2,165
City Center	Estimated demand	(kW)	4,638	To KA1 (-)200	4,438
		(A)	304	To KA1 (-) 21	283
C5	Tr facility capacity	(kVA)	7,300	To KA1 (-)500	6,800

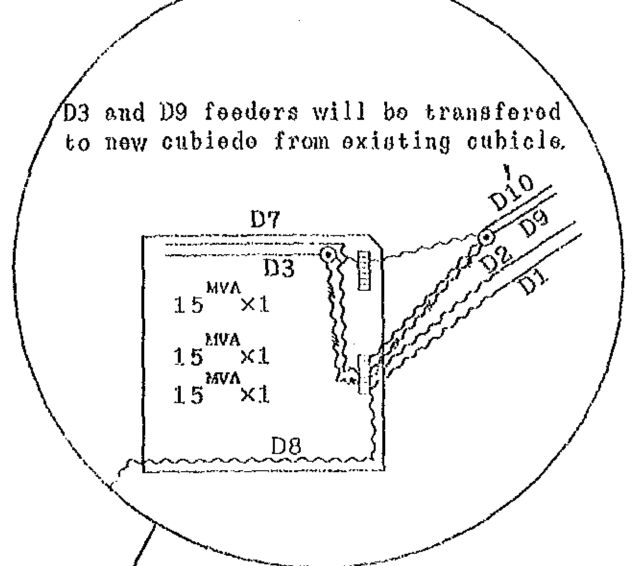
Table 10.6.2-6 MBAGALA S/S load change-over plan

Substation feeder	Tr facility capacity for estimated demand		Before taking counter-measures	Detail of change-over	After taking counter-measures
Mbagala	Estimated demand	(kW)		From K4 (+)1,655	1,655
		(A)		From K4 (+)108	108
MG1	Tr facility capacity	(kVA)		From K4 (+)3,245	3,245
	Estimated demand	(kW)		From K4 (+)536	536
		(A)		From K4 (+)36	36
MG2	Tr facility capacity	(kVA)		From K4 (+)1,050	1,050
	Estimated demand	(kW)		From K4 (+)765	765
		(A)		From K4 (+)50	50
MG3	Tr facility capacity	(kVA)		From K4 (+)1,500	1,500
Kurasini	Estimated demand	(kW)	4,180	To MB1 (-)1,655 To MB2 (-) 536 To MB3 (-) 765	1,224
		(A)	274	To MB1 (-) 108 To MB2 (-) 36 To MB3 (-) 50	80
Kilwa road	Tr facility capacity	(kVA)	8,195	To MB1 (-)3,245 To MB2 (-)1,050 To MB3 (-)1,500	2,400

Fig. 10.6.2-1







ILALA S/S

LEGEND

- 33kV 11kV DOWNGRADE LINE
- 11kV LINE
- ABS CLOSED
- ABS OPEN
- POLE MOUNTED TRANSFORMER
- GRAND INSTALLED TRANSFORMER

SCALE 1:40,000

0 1 2km

Fig. 10.6.2-2

THE UNITED REPUBLIC OF TANZANIA MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION	
PROPOSED SUBSTATIONS FEEDER ARRANGEMENT 11kV TANDALE S/S, ILALA S/S,	
TANESCO	ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN
	DR.: SUBMITTED:
	TR.: RECOMMENDED:
	CH.: APPROVED:
	SCALE 1:40,000

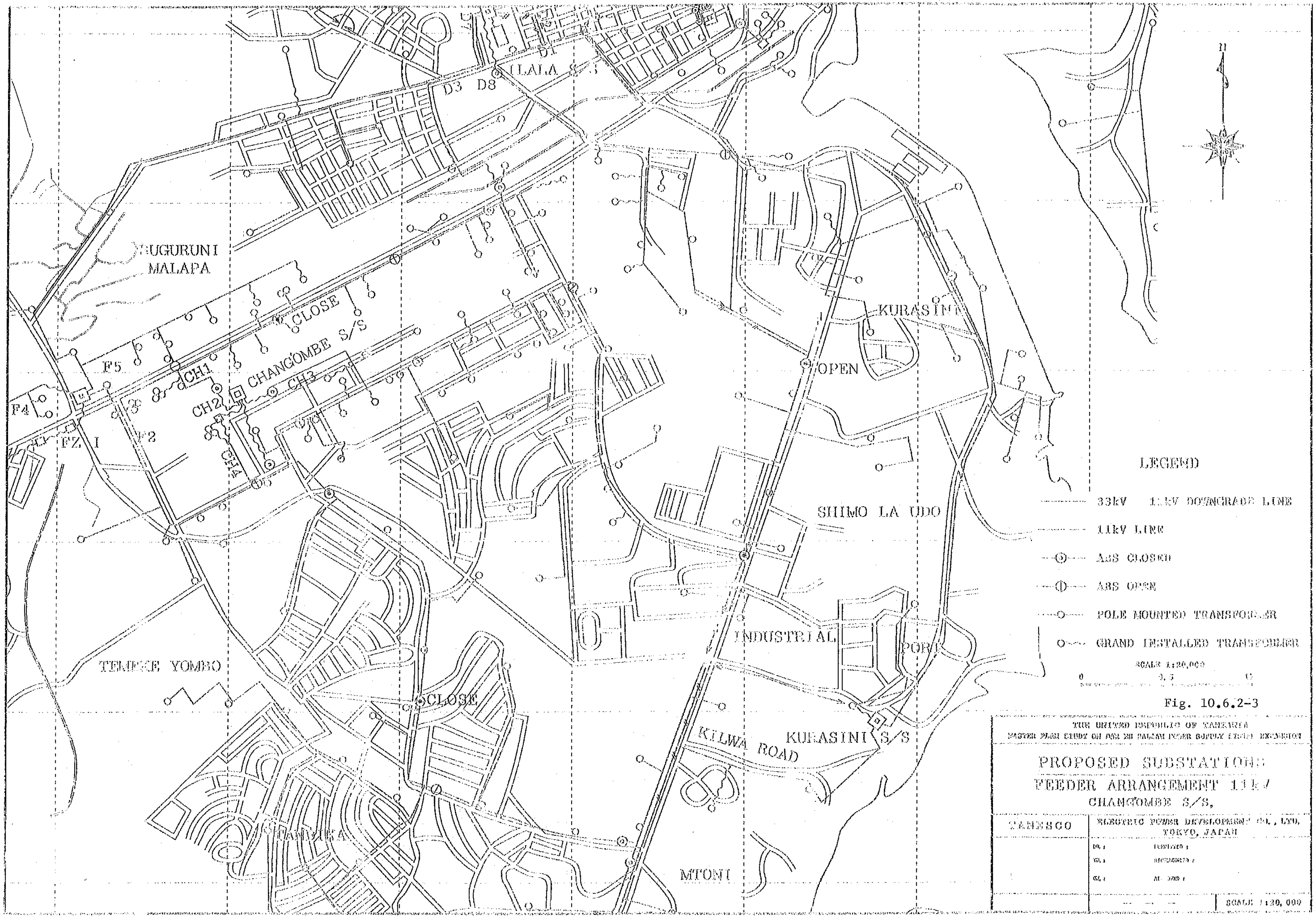
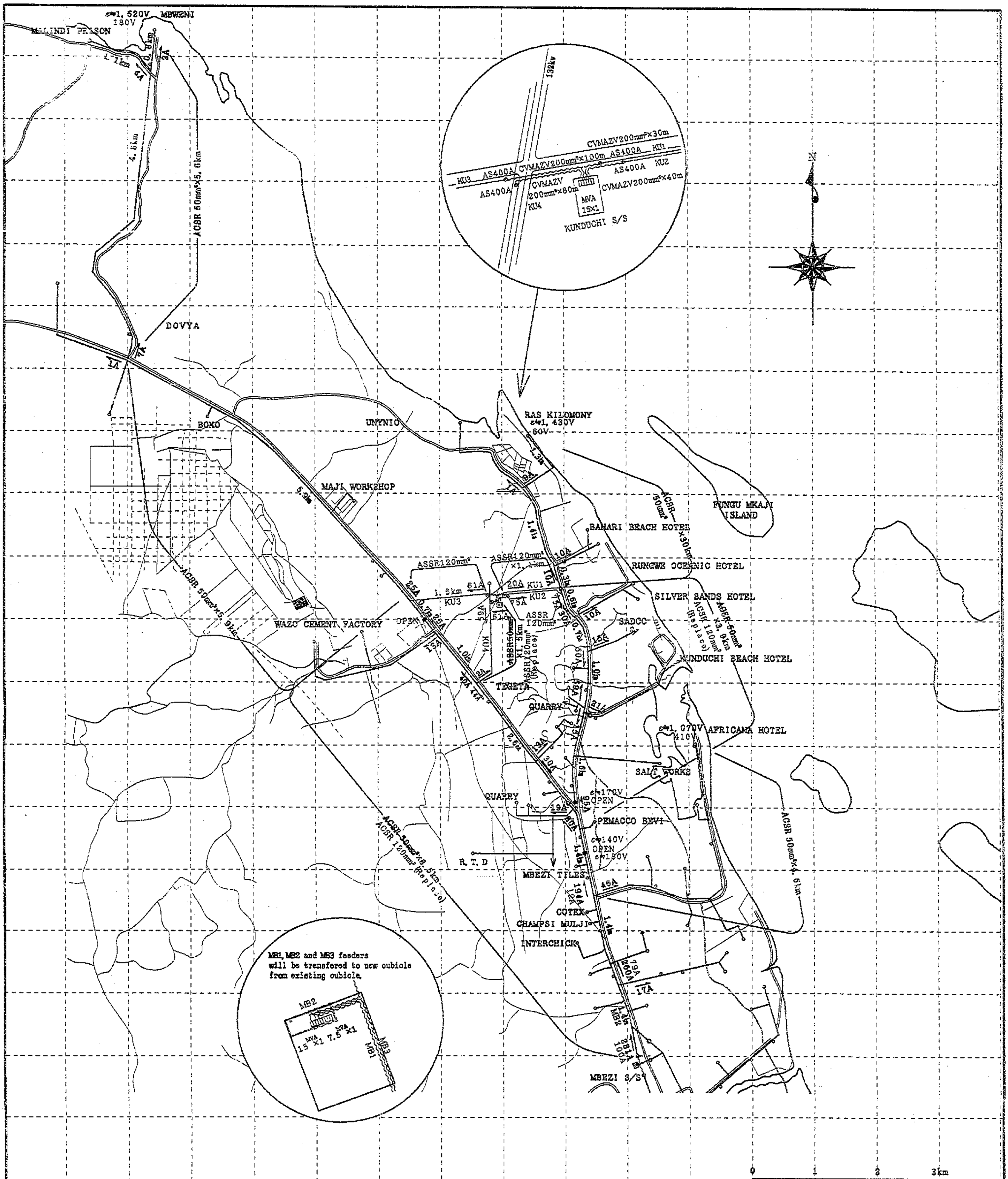


Fig. 10.6.2-3

PROPOSED SUBSTATIONS
FEEDER ARRANGEMENT 11kV
CHANGOMBE S/S,



LEGEND

-------	33kV 11kV DOWNGRADE LINE
———	11kV LINE
—◎—	ABS CLOSED
—⦶—	ABS OPEN
—○—	POLE MOUNTED TRANSFORMER
○∿∿	GRAND INSTALLED TRANSFORMER

Fig. 10.6.2-4

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

PROPOSED SUBSTATIONS
FEEDER ARRANGEMENT 11kV

MBEZI S/S , KUNDUCHI S/S

TANESCO	ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN
	DR.: SUBMITTED :
	TR.: RECOMMENDED :
	CK.: APPROVED :
— — —	Fig. 10. 6. 2-4

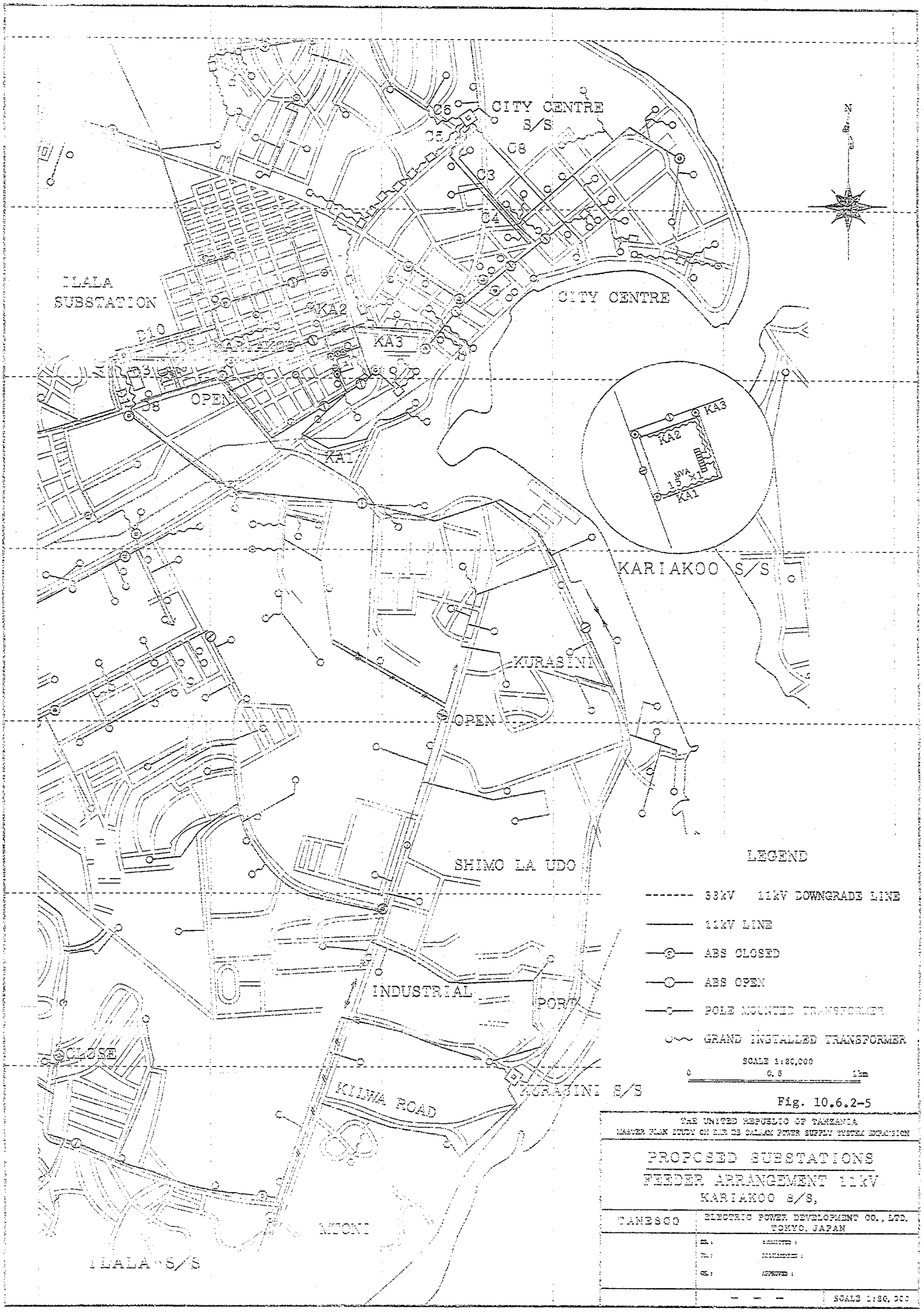


Fig. 10.6.2-5

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

PROPOSED SUBSTATIONS
FEEDER ARRANGEMENT 11kV
KARIAKOO S/S,

TANESCO	ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN
	SUBMITTED :
	RECOMMENDED :
	APPROVED :
	SCALE 1:20,000

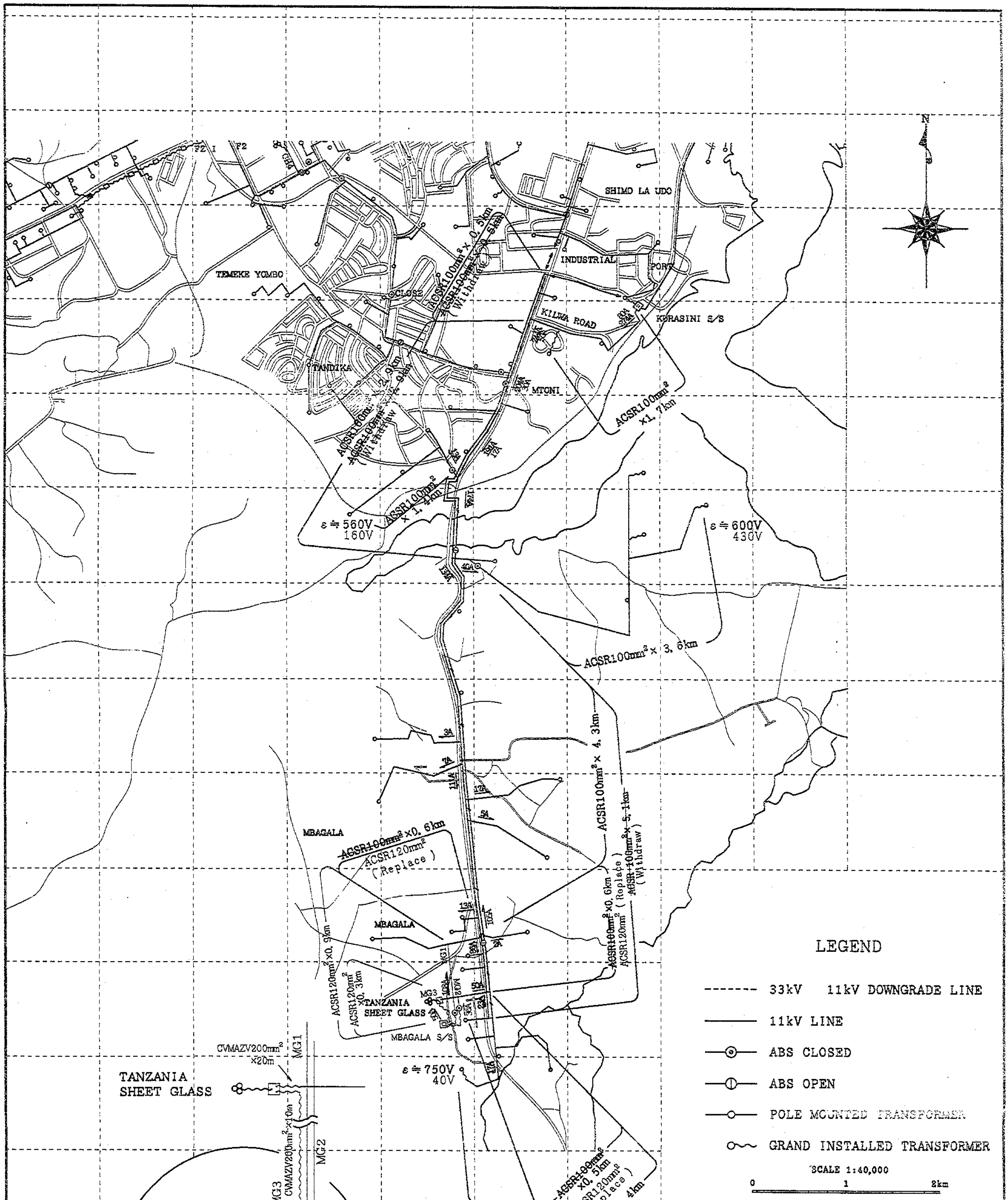


Fig. 10.6.2-6

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

PROPOSED SUBSTATIONS
FEEDER ARRANGEMENT 11kV
MBAGARA S/S,

TANESCO	ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN
	DR.: SUBMITTED:
	TR.: RECOMMENDED:
	CK.: APPROVED:
	SCALE 1:40,000

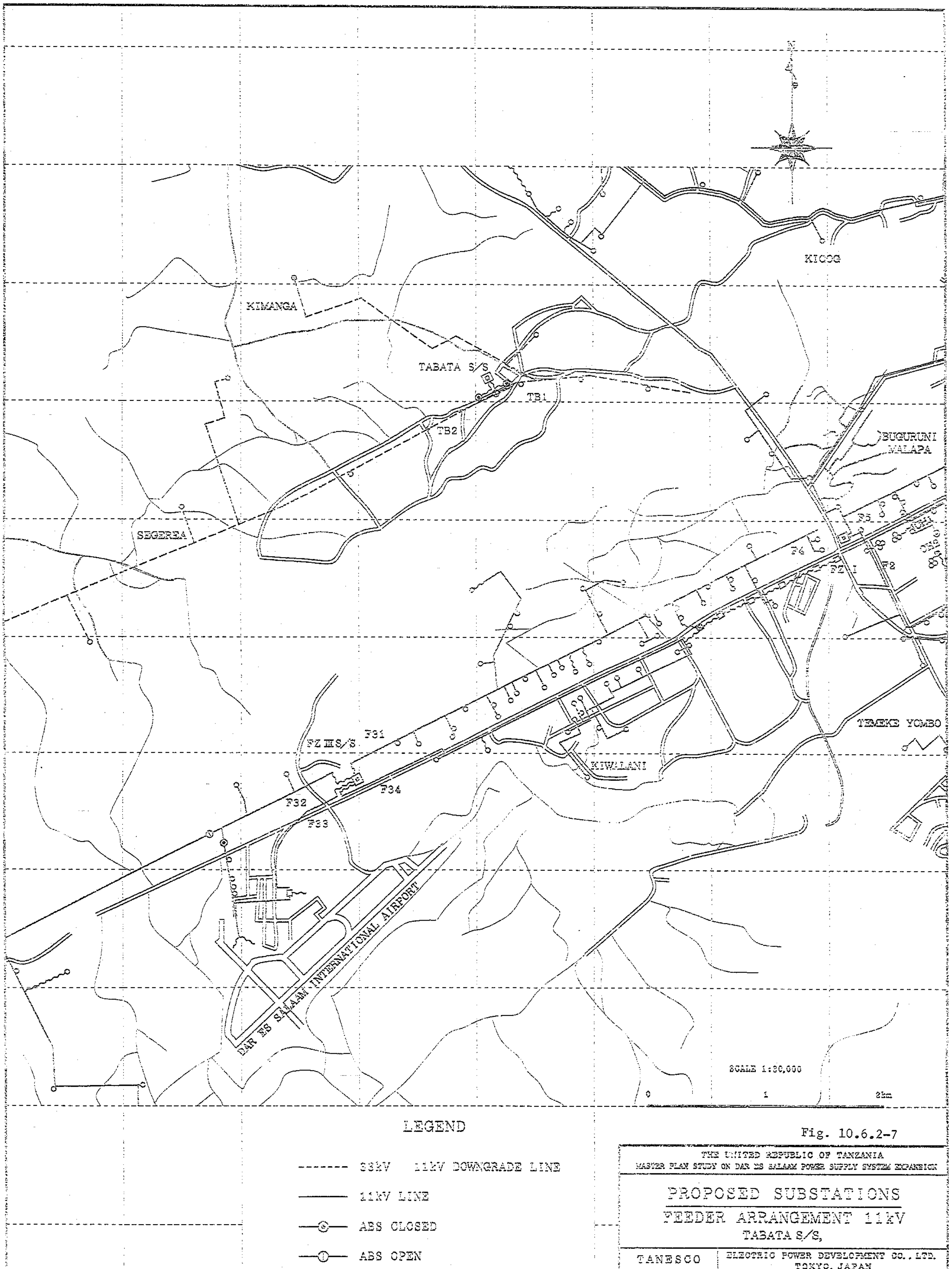

KICOG
KIMANGA
TABATA S/S
TB1
TB2
SEGEREA
BUGURUNI
MALAPA
F5
F4
FZ I
F2
TEMEKE YOMBO
FZ III S/S
F31
F32
F33
F34
KIWALANI
DAR ES SALAAM INTERNATIONAL AIRPORT
SCALE 1:30,000
0
1
2km
LEGEND
33kV 11kV DOWNGRADE LINE
11kV LINE
ABS CLOSED
ABS OPEN
POLE MOUNTED TRANSFORMER
GRAND INSTALLED TRANSFORMER
THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION
PROPOSED SUBSTATIONS
FEEDER ARRANGEMENT 11kV
TABATA S/S,
TANESCO
ELECTRIC POWER DEVELOPMENT CO., LTD.
TOKYO, JAPAN
SCALE 1:30,000

Fig. 10.6.2-7

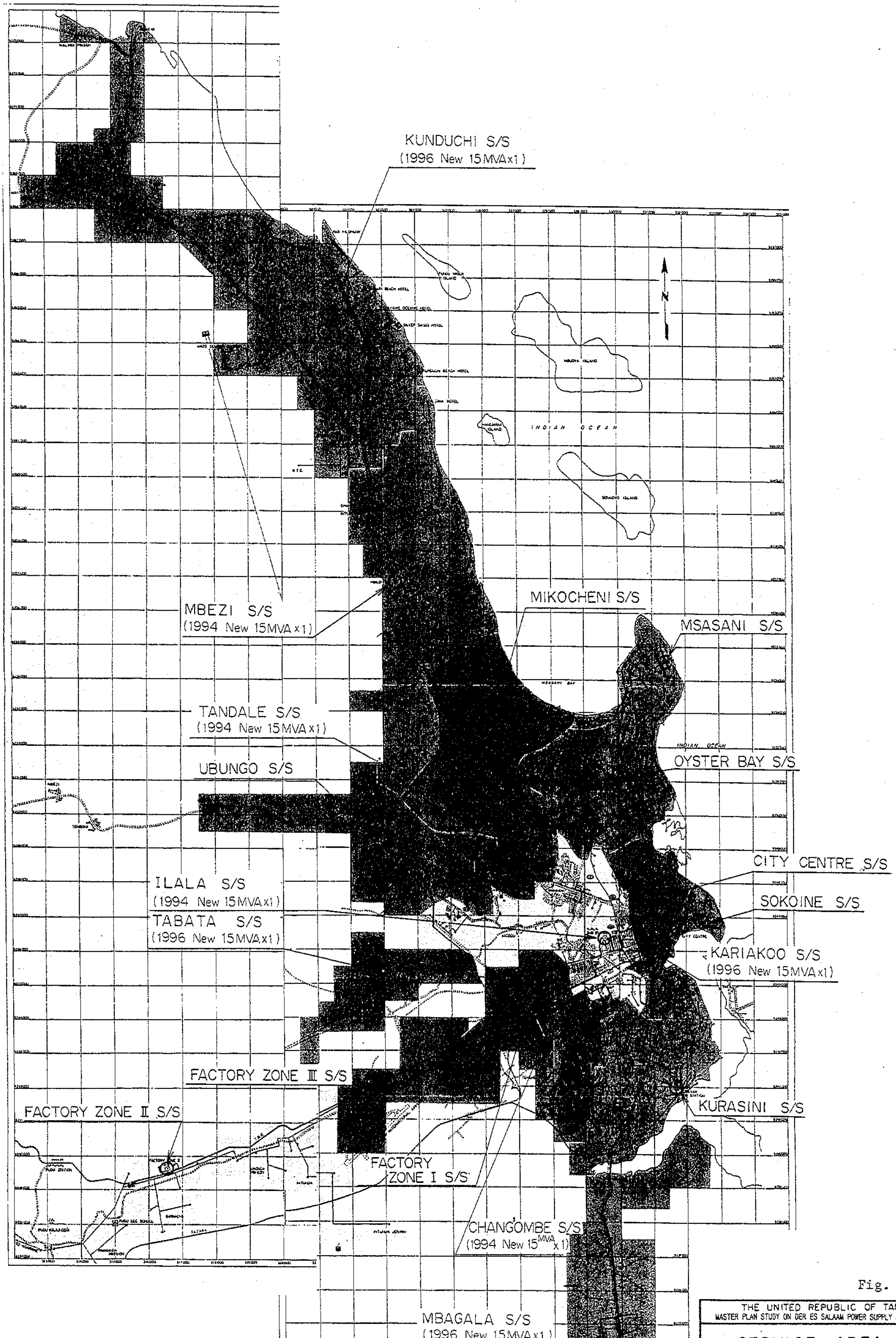


Fig. 10.6.2-8

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DER ES SALAAM POWER SUPPLY SYSTEM EXPANSION

SERVICE AREA FOR PROPOSED 33/11kV SUBSTIONS

TANESCO | ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN

DR: SUBMITTED:
TR: RECOMMENDED:
CK: APPROVED:

LOCATION	DATE	DESCRIPTION	BY
		REVISION	

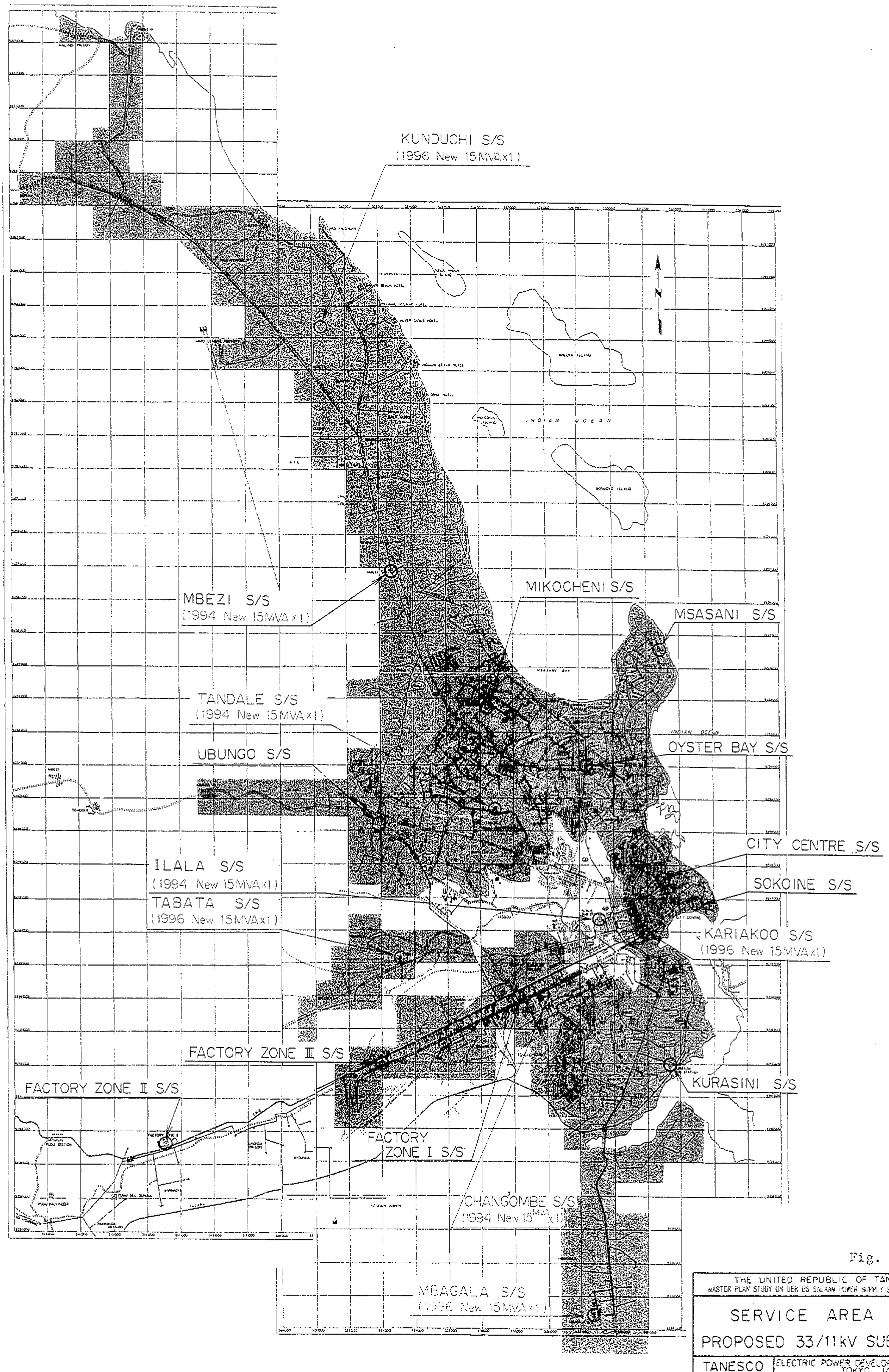


Fig. 10.6.2-8

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

SERVICE AREA FOR
PROPOSED 33/11kV SUBSTIONS

TANESCO | ELECTRIC POWER DEVELOPMENT CO., LTD TOKYO, JAPAN

DR. SUBMITTED.
TR. RECOMMENDED.
CK. APPROVED.

LOCATION	DATE	DESCRIPTION	BY

REVISION

Table 10.6.2-7 33/11 kV bank load status
Distribution substation expansion - related works

Year	Substation expansion		Before taking countermeasures: Feeder circuit (cct)	Before: Demand area (km2)	Before: Feeder area (km2/cct)	Before: Demand (kW)	Before: Load density (kW/km2)	Before: Feeder load (kW/cct)	After taking countermeasures: Feeder circuit (cct)	After: Demand area (km2)	After: Feeder area (km2/cct)	After: Demand (kW)	After: Load density (kW/km2)	After: Feeder load (kW/cct)	Remark	Remark: Feeder (cct)	Remark: Demand area (km2)	Remark: Feeder area (km2/cct)	Remark: Demand (kW)	Remark: Feeder load (kW/cct)
Plans to be implemented in 1994	TANDALE new construction 15MVA x 1		-	-		-	-	-	3	10.8	3.6	3,959	367	1,320						
		Mikocheni	4	17.6	4.4	12,811	728	3,203	4	10.8	2.7	11,401	1,056	2,850	Before countermeasures	19	70.9	3.73	64,171	3,377
		Oysterbay	5	10.1	2.0	18,300	1,812	3,660	5	9.8	2.0	17,587	1,795	3,517	After countermeasures	19		3.22		2,917
		Ilala	6	19.3	3.2	23,829	1,235	3,972	6	17.5	2.9	22,969	1,137	3,828						
		Ubungo	4	23.9	6.0	9,231	386	2,308	4	22.0	5.5	8,255	375	2,064	Balance	(+)3		(-) 0.51		(-)460
	CHANG'OMBE new construction 15MVA x 1		-	-		-	-	-	4	6.8	1.7	6,611	972	1,653	Before countermeasures	12	54.6	4.55	38,101	3,175
		Ilala	6	17.5	2.9	22,969	1,137	3,828	6	16.0	2.7	21,729	1,358	3,622	After countermeasures	16		3.41		2,381
		FZ-I	3	7.4	2.5	3,898	527	1,299	3	5.1	1.7	2,163	424	721						
		Kurasini	3	29.7	9.9	11,234	378	3,745	3	26.7	8.9	7,081	265	2,360	Balance	(+)4		(-) 1.14		(-)794
	ILALA additional installation 15MVA x 1		6	16.0	2.7	21,729	1,358	3,622	6	18.7	3.1	21,537	1,152	3,590	Before countermeasures	13	43.1	3.3	32,147	2,473
		Ubungo	4	22.0	5.5	8,255	375	2,064	4	17.7	4.4	7,021	397	1,755	After countermeasures	13		3.3		2,473
		FZ-I	3	5.1	1.7	2,163	424	721	3	6.7	2.2	3,589	536	1,196	Balance					
	MBEZI extension 7.5MVA x 1Â15MVA		3	70.4	23.5	8,270	118	2,757	3	70.4	23.5	8,270	118	2,757	7.5MVAÂ15MVA Replacement of feeder cables with new ones					

Table 10.6.2-7 33/11 kV bank load status
Distribution substation expansion - related works

Year	Substation expansion	Before taking countermeasures: Feeder circuit (cct)	Demand area (km2)	Feeder area (km2/cct)	Demand (kW)	Load density (kW/km2)	Feeder load (kW/cct)	After taking countermeasures: Feeder circuit (cct)	Demand area (km2)	Feeder area (km2/cct)	Demand (kW)	Load density (kW/km2)	Feeder load (kW/cct)
Plans to be imple-mented in 1996	KUNDUCHI new construction 15MVA x 1	-	-	-	-	-	-	4	44.2	11.1	2,758	62	690
	Mbezi	3	70.4	23.5	9,240	131	3,080	3	26.2	8.7	6,482	247	2,161
	KARIAKOO new construction 15MVA x 1	-	-	-	-	-	-	3	3.4	1.1	7,974	2,345	2,658
	Ilala	6	18.7	3.1	25,239	1,350	4,207	7	14.7	2.1	18,779	1,277	2,683
	Kurasini	3	26.7	8.9	7,909	296	2,636	3	27.7	9.2	6,913	250	2,304
	City Centre	6	4.2	0.7	14,796	3,523	2,466	6	3.8	0.6	14,478	3,810	2,413
	MBAGALA new construction 15MVA x 1	-	-	-	-	-	-	3	15.5	5.2	2,956	191	985
	Kurasini	3	27.7	9.2	6,913	250	2,304	3	12.2	4.1	3,957	324	1,319
	TABATA new construction 15MVA x 1	-	-	-	-	-	-	2	8.5	4.3	1,716	202	858

Remark

Substation		Feeder (cct)	Demand area (km2)	Feeder area (km2/cct)	Demand (kW)	Feeder load (kW/cct)
KUNDUCHI / Mbezi	Before counter-measures	3	70.4	23.5	9,240	3,080
	After counter-measures	7		10.1		1,320
	Balance	(+)4		(-) 13.4		(-) 1,760
KARIAKOO	Before counter-measures	15	49.6	3.3	47,944	3,196
	After counter-measures	19		2.6		2,523
	Balance	(+)4		(-) 0.7		(-)673
MBAGALA	Before counter-measures	3	27.7	9.2	6,913	2,304
	After counter-measures	6		4.6		1,152
	Balance	(+)3		(-) 4.6		(-) 1,152
TABATA	To modity 33 kV service feeders to 11 kV					

(2) 11 kV distribution line voltage measurement

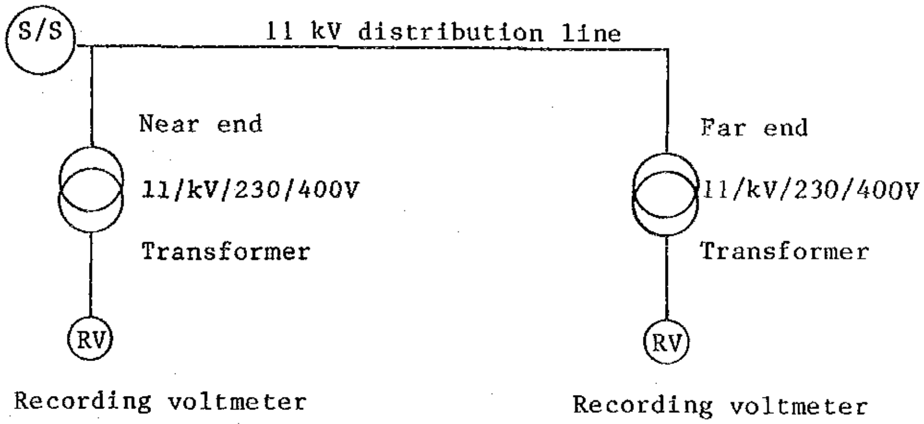
To grasp the actual situations of the voltage drop in the 11 kV distribution line, the voltage measurement was conducted with cooperation from TANESCO as to the feeders shown in Table 10.6.2-8 below, which are conceivably suffering from the large voltage drop.

Table 10.6.2-8 Voltage Measurement Plan

Substation	Feeder	Measurement point			(Ref.) Actual results of voltage drop (V) in 1991
		Near end	Far end	Total	
Mbezi	MB2	1	1	2	Max 180 A 1,860 V
Kurasini	Kilwa-Road	1	1	2	Max 231 A 420 V
Oysterbay	03	1	1	2	Max 296 A 1,090 V
	04	1	1	2	Max 177 A 710 V
Mikocheni	MK2	1	1	2	Max 190 A 880 V
Total	5	5	5	10	-

Note: The actual results of voltage drop in 1991 are calculated from the actual results of the maximum load current.

1) Recording voltmeter attached points



2) Results of measurement

See Table 10.6.2-9, Fig. 10.6.2-8 to 10.6.2-12.

Table 10.6.2-9 Measurement of the system voltage on 11 k/V dristribution lines

Name of Sub-stations	Feeder	Measuring Points		Trans-former capacity Tap Position	Measuring Period	Measuring records: Max. voltage (V)	Measuring records: Min. voltage (V)	Conversion to the primary side: Voltage drop (V)	Conversion to the primary side: Voltage fluctua-tion (V)	Remarks
Mbezi	MB2	Vicinity		(Tap 2)	'93.8.22(Thu.) -9.1 (Thu.)	8/26(Thu.) 8:00 (11,000) 230	8/26(Thu.) 19:40 (10,570) 221		430	Refer to Fig.10.6.2-8
		End	Ndege Beach	500 kVA (Tap 5)	'93.8.22(Thu.) -9.1 (Thu.)	8/26(Thu.) 8:20 (9,920) 228	8/26(Thu.) 19:40 (9,440) 217	8/26(Thu.) 19:40 Max. 1,130	480	
Kurasini	Kilwa-Road	Vicinity	Sabasaba Ground	500 kVA (Tap 2)	'93.9.14(Tue.) -9.21(Tue.)	9/20(Mon.) 2:30 (10,809) 226	9/19(Sun.) 20:30 (10,522) 220		287	Refer to Fig.10.6.2-9
		End	Land Rover TANZANIA Ltd	200 kVA Tap 5	'93.9.14(Tue.) -9.21(Tue.)	9/20(Mon.) 2:30 (9,749) 224	9/19(Sun.) 20:30 (9,357) 215	9/19(Sun.) 20:30 Max. 1,165	392	
Oysterbay	03	Vicinity	Drive in TANESCO Estate Pole No 5E2	315 kVA Tap 2	'93.9.24(Fri.) -10.11(Mon.)	9/25(Sat.) 19:00 (11,526) 241	9/25(Sat.) 23:30 (10,809) 226		717	Refer to Fig.10.6.2-10
		End	Texco Flats Pole No 13W1	100 kVA Tap 2	'93.9.24(Fri.) -10.11(Mon.)	9/25(Sat.) 19:00 (11,287) 236	9/25(Sat.) 23:30 (10,617) 222	9/25(Sat.) 19:00 Max. 239	670	
	04	Vicinity	Ada Estate Pole No 6EA	315 kVA Tap 2	'93.10.11(Mon) -10.25(Mon.)	10/24(Sun.) 5:30 (11,813) 247	10/24(Sun.) 12:30 (11,335) 237		478	Refer to Fig.10.6.2-11
		End	Mwananyamala 'A' Primary School	100 kVA Tap 2	'93.10.11(Mon) -10.25(Mon.)	10/24(Sun.) 5:30 (11,239) 235	10/24(Sun.) 12:30 (10,761) 225	10/24(Mon.) 5:30 12:30 Max. 574	478	
Mikocheni	MK2	Vicinity	TPDC House Staff	500 kVA Tap 2	'93.10.25(Mon) -11.11(Thu.)	10/28(Thu.)13:30 (11,143) 233	10/28(Thu.) 20:30 (10,617) 222		526	Refer to Fig.10.6.2-12
		End	Mwananyama 'B' Primary School	315 kVA Tap 2	'93.10.25(Mon) -11.11(Thu.)	10/28(Thu.)13:30 (10,809) 226	10/28(Thu.) 20:30 (10,330) 216	10/28(Thu.) 13:30 Max. 334	478	

(Note) 1. Tap position in parenthesis shows assumed position.
2. Max. voltage and min. voltage in parenthesis show converted voltage to the primary side.
3. Primary side voltage is converted without inner voltage drops of transformer
4. Transformer tap ratio

Tap Position	Primary Side (V)	Secondary (V)
1	11,330	230/400
2	11,000	
3	10,670	
4	10,340	
5	10,010	

Fig 10.6.2-8 MBEZI S/S MB2 Feeder Record Charts of Voltage Fluctuation at 11kV Distribution Line

THU./AUG/26/93

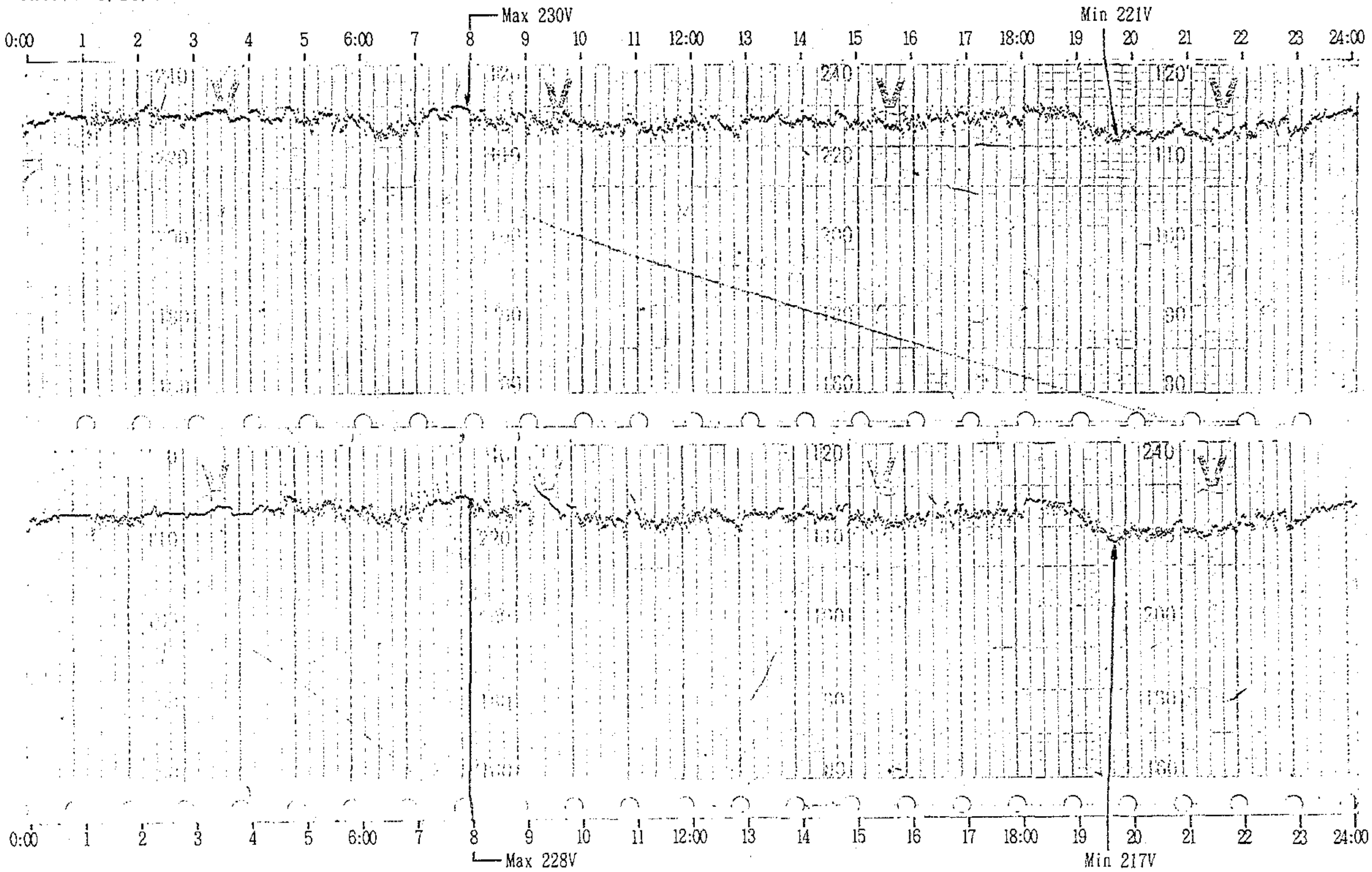


Fig 10.6.2-9 KURASINI S/S Kilwa-Road Feeder Record Charts of Voltage Fluctuation at 11kV Distribution Line

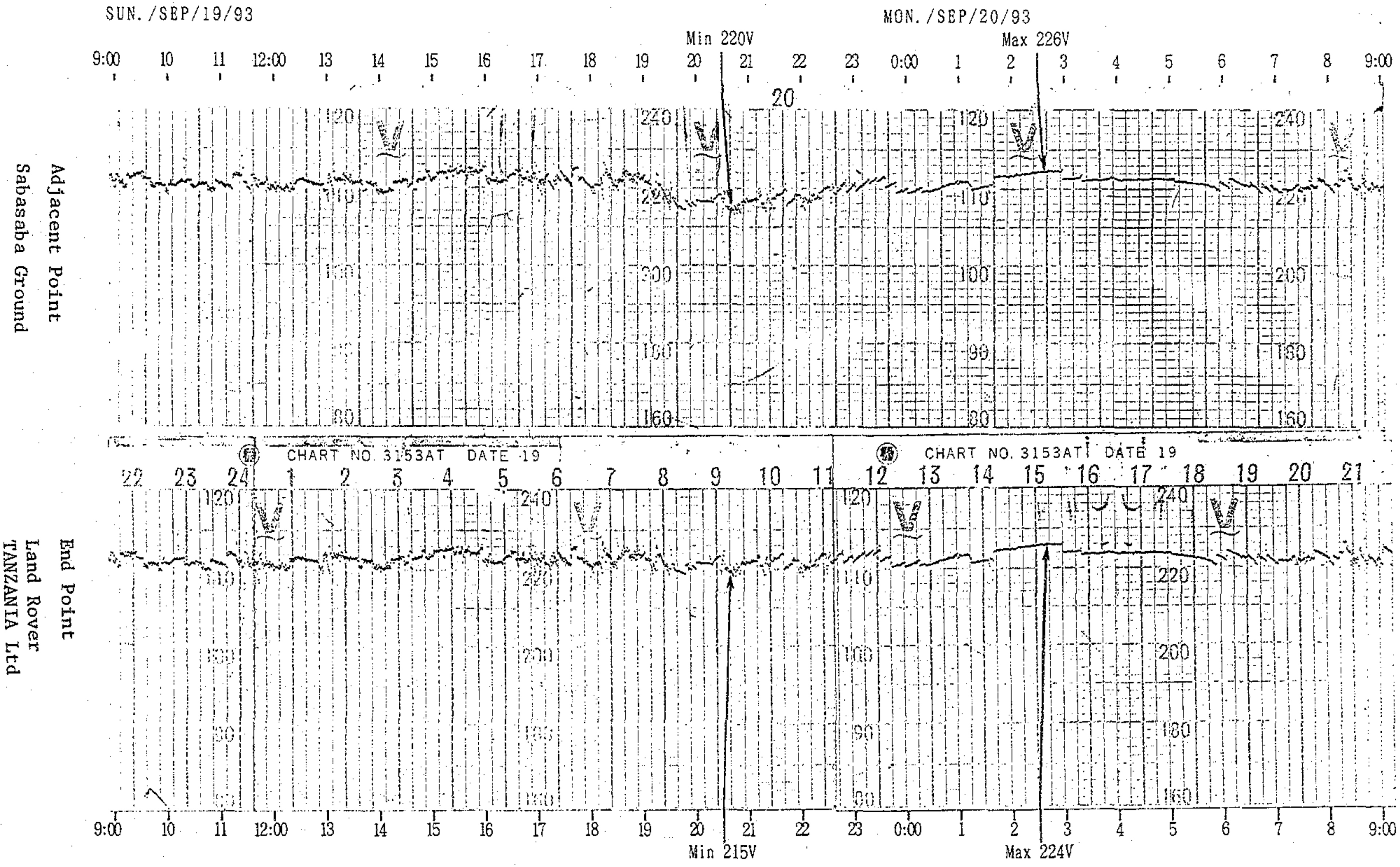
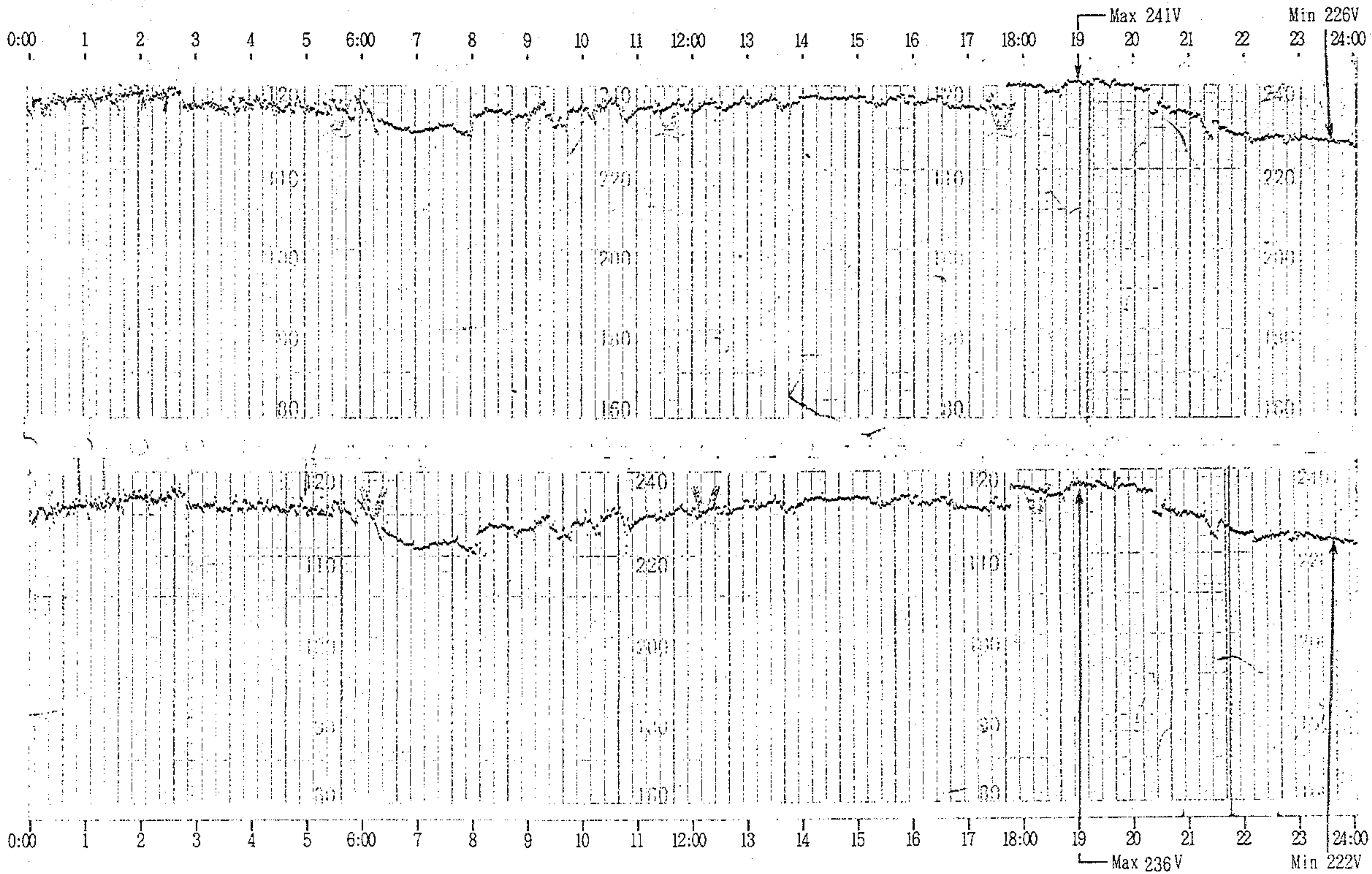


Fig 10.6.2-10 OYSTERBAY S/S
03 Feeder

Record Charts of Voltage Fluctuation at 11kV Distribution Line

SAT./SEP/25/93



Adjacent Point

Drive-in
TANESCO Estate
Pole No 5E2

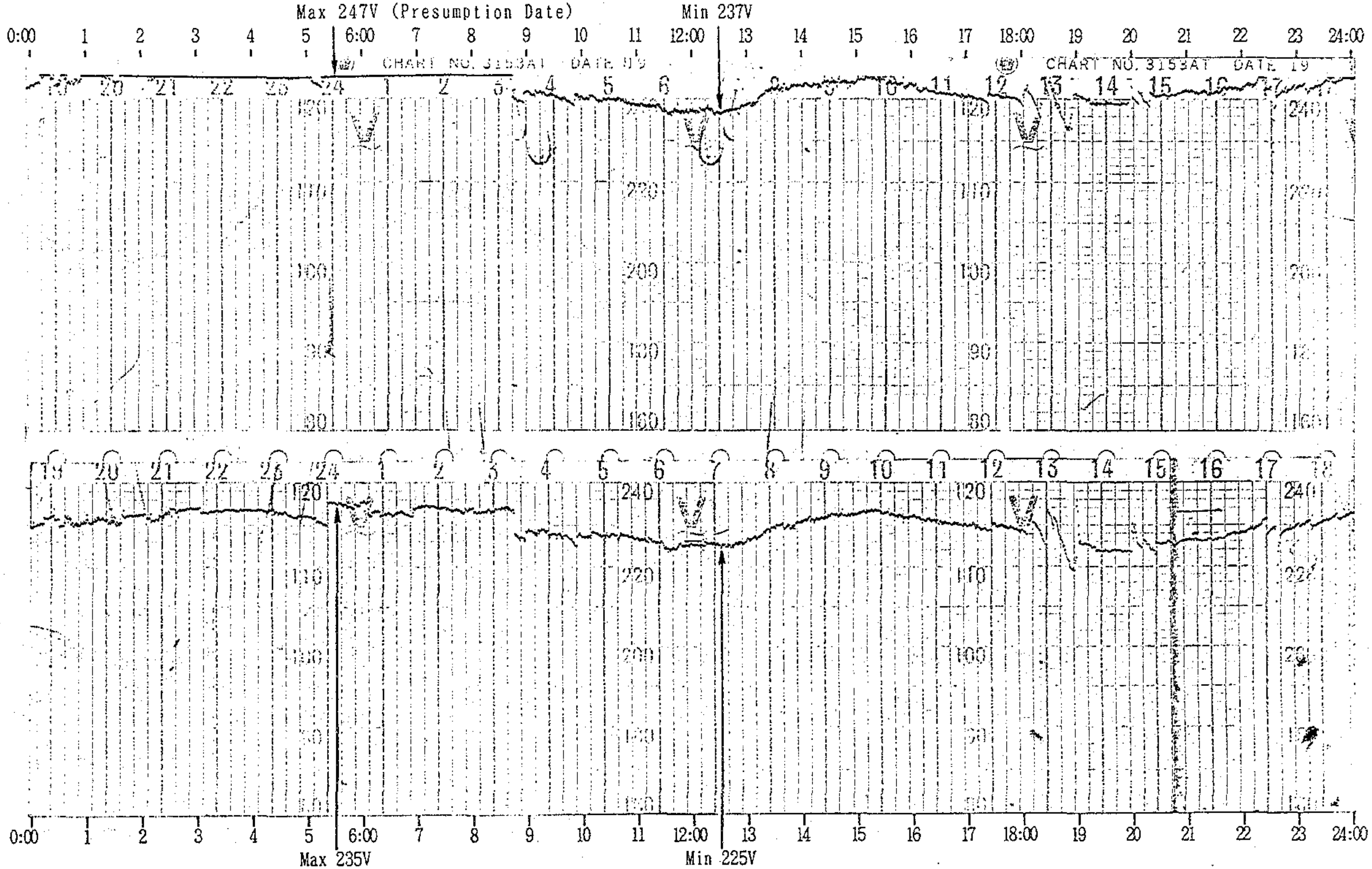
End Point

Texco Flats
Pole No 73W1

Fig 10.6.2-11 OYSTER BAY S/S
04 Feeder

Record Charts of Voltage Fluctuation at 11kV Distribution Line

SUN./OCT/24/93



Adjacent Point

Ada Estate
Pole No 6EA

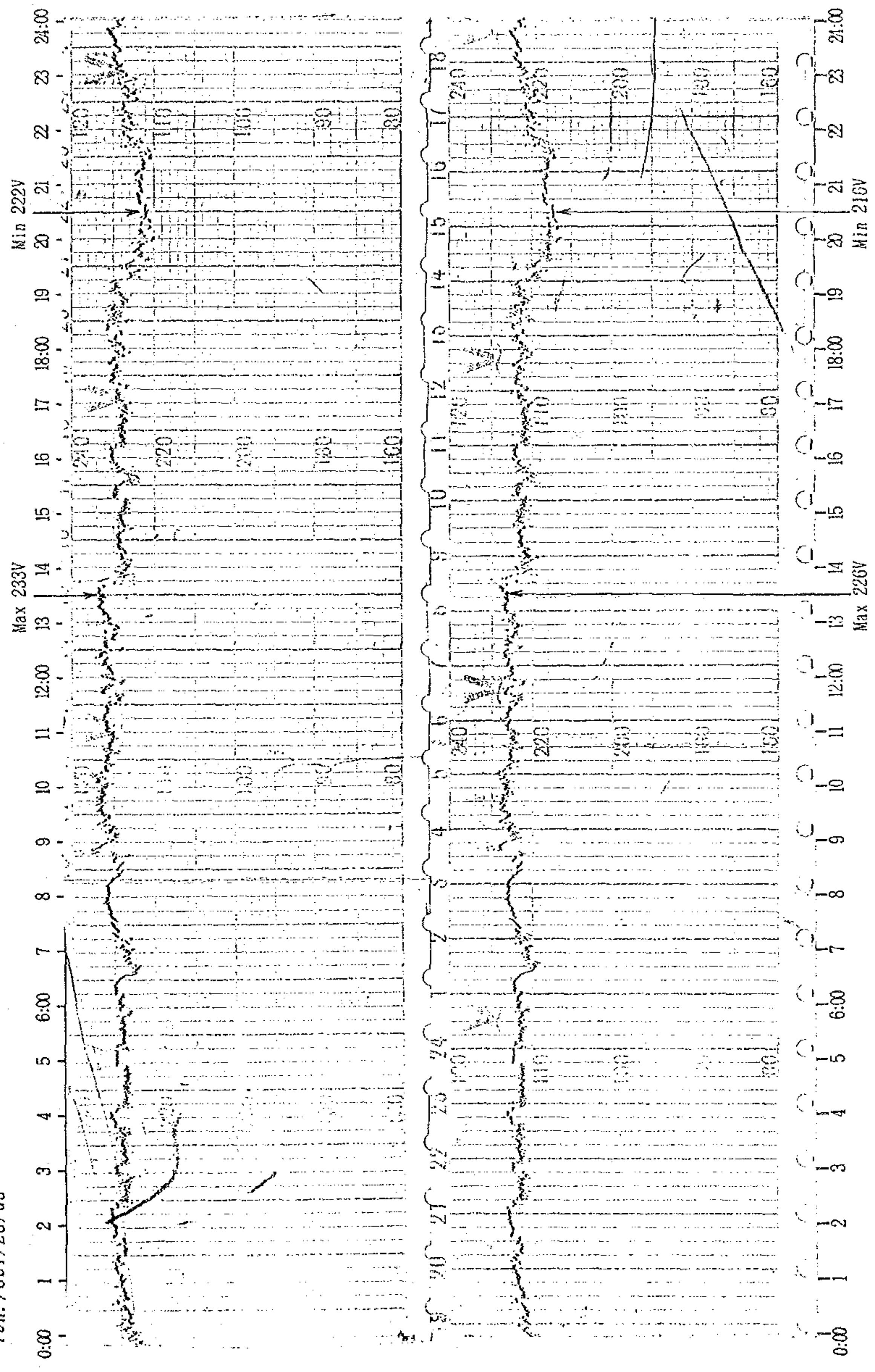
End Point

Mwananyamala 'A'
Primary School

Fig 10.6.2-12 Record Charts of Voltage fluctuation at 11kV Distribution Line

MIKOCHENI S/S
MK2 Feeder

TUH. /OCT/28/93



Adjacent Point	End Point
TPDC Staff-Estate	Mwananyamala 'B' Primary School

Table 10.6.3-1 Details of major materials for 11 kV distribution line in 1994

	Overhead line									Underground line		
	Concrete pole			Wooden pole		ACSR		Air break switch 400A	Lightning arrester	Cable CVMAZV 3x185mm2	Multi-circuit switch 400A x 3 cct	Termination treatment chelate
	14-100 (pole)	14-70 (pole)	12-50 (pole)	13m (pole)	11m (pole)	120mm2 (m)	OC-120 (m)	(set)	(piece)	(m)	(set)	(pair)
TANDALE S/S new construction												
TA1	7				66	8,800	2,900	2	6	200		2
TA2					3	300	100	3	9	100		2
TA3	3							3	9	100		2
O2					10	1,100	400					
MK2					4	600		1	3			
MK3					10	1,100	400					
U2					6	900						
Subtotal	10				99	12,800	3,800	9	27	400		6
CHANG'OMBE S/S new construction												
CH1	7					900	300	3	9	100		2
CH2	3								3	400	1	5
CH3	15					2,000	700	2	6	100		2
CH4	3							2	6	400		3
F5					10	1,800	600					
Subtotal	28				10	4,700	1,600	7	24	1,000	1	12
ILALA S/S additional installation												
D3								1	3	70		2
D7								1	3			
D9								1	3	30		2
Subtotal								3	9	100		4
MBEZI S/S Expansion												
MB1								1	3	100		2
MB2								1	3	100		2
MB3								1	3	100		2
Subtotal								3	9	300		6
Total	38				109	17,500	5,400	22	69	1,800	1	28

Table 10.6.3-1 Details of major materials for 11 kV distribution line in 1996

	Overhead line									Underground line		
	Concrete pole			Wooden pole		ACSR		Air break switch 400A (set)	Lightning arrester (piece)	Cable CVMAZV 3x185mm2 (m)	Multi-circuit switch 400A x 3 cct (set)	Termination treatment chelate (pair)
	14-100 (pole)	14-70 (pole)	12-50 (pole)	13m (pole)	11m (pole)	120mm2 (m)	OC-120 (m)					
KUNDUCHI S/S new construction												
KU1	19					2,500	800	2	6	30		2
KU2					27	11,000	3,700	1	3	40		2
KU3	26				6	5,000	1,600	1	3	100		2
KU4					61	20,900	7,000	1	3	80		2
Subtotal	45				94	39,400	13,100	5	15	250		8
KARIAKOO S/S new construction												
KA1		11	22				5,700	5	15	100		2
KA2		3	5				1,200	3	9	100		2
KA3		6					900	3	9	100		2
D8			8			1,300		1	3	800		4
Industrial								1	3			
Subtotal		20	35			1,300	7,800	13	39	1,100		10
MBAGALA S/S new construction												
MG1	19					3,300	1,200	2	6	100		2
MG2	19					3,800	1,300	1	3	200		2
MG3									3	400	1	5
Subtotal	38					7,100	2,500	3	12	700	1	9
TABATA S/S new construction												
TB1				2				2	6	200		2
TB2				2				1	3	100		2
Subtotal				4				3	9	300		4
Total	83	20	35	4	94	47,800	23,400	24	75	2,350	1	31

10.6.3 Specifications of Major Equipment and Materials

(1) Supporting structure

In the existing facilities, steel pipe poles are now in use in the center of the urban district while wooden poles are in use in the outskirts thereof and other districts. The concrete poles are not in use at all.

During the survey, it was found here and there that the steel pipe poles have rusted at the ground level being reduced in the plate thickness but are still in use as they are with insufficient supporting strength.

In view of it, the concrete poles should hereafter be exclusively used which are superior in all aspects to other poles like in design strength, total costs, maintenance, etc. Hence, the use of steel pipe poles should be limited only to the inevitable occasions.

1) Applicable types

(a) Concrete pole : To be used in the places where the design strength is particularly needed like in urban districts or in places where two circuits of outgoing line from a substation must firmly be supported.

(b) Wooden pole : All other districts than mentioned above.

2) Specifications

(a) Concrete pole (JIS-A-5309)

Nominal size	Dimension				Design load		
	Top diameter (mm)	Bottom diameter (mm)	Ground level diameter (mm)	Depth from ground level to bottom (m)	Height of loading point from ground level (m)	Load (kg)	Moment at ground level (kg-m)
12-50	190	265	252	2.1	9.65	500	4,825
14-70	190	377	345	2.4	11.35	700	7,945
14-100	220	407	371	2.7	11.05	1,000	11,050

(b) Wooden pole

Material: Oregon pines with creosote application

Pole length (m)	Top diameter (cm)	Diameter at ground level (m)
11	19 or over	26.5 or over
13	21 or over	30.5 or over

3) Assembling

As for the wire arrangement of 11 kV distribution line, various wire assembling has been done so far such as horizontal, vertical and triangular arrangements. However, the horizontal arrangement which enables simple lead-in wire arrangement from the pole transformer should exclusively be used hereafter as the standard type.

In addition, the low cost light weight arm (for general use) should also be used hereafter.

See the standard assembling drawings (Assembling type 1 to 4).

(a) Applicable type

(i) 1.8 m : for drawing-in assembling

To be used for 11 kV distribution line drawing-in arm.

(ii) 1.8 m : for anchor assembling

To be used for 11 kV distribution line anchor arm and for section switch mounting arm.

(2) Overhead wire (JEC130)

1) Applicable type

ACSR 100 mm^2 and ACSR 50 mm^2 are mostly used for the 11 kV overhead lines, CU25 mm^2 is also partly used. Covered wires are not used at all.

In this study, ACSR 120 mm^2 is planned to be used for the main sections as the standard type. In addition, covered wires should also be used as necessary from the point of view to enhancing the reliability of power supply as well as securing the safety of the facilities.

2) Specifications

Item \ Type			Bare wire ACSR	Covered wire ACSR-OE
Electric conductor	Nominal cross section (mm2)		120	120
	Stranded cable setup (wire/mm)	Aluminium	30/2.3	6/SB*
		Steel	7/2.3	1/4.2
	Outside diameter (mm)		16.5	13.6
Vinyl insulator thickness (mm)			-	1.6
Finished outside diameter (approx. mm)			-	16.8
Electric conductor tension load (kg)			5,540	3,300
20°C electric conductor resistance (Ω/km)			0.216	0.250
Roughly estimated weight (approx.) (kg/km)			540	555

(3) Insulator (ANSI C 29.5)

1) Applicable type

In the existing facilities, the 11 kV pin insulators and suspension insulators (254 mm x 146 mm) are in use in two insulator string respectively.

Hereafter, however, the solid-core insulators should be used. This is because they cost almost the same prices while increased or enhanced performance is much expected from them.

(4) Section switch (MLBS)

As before, the applicable specifications shall be as follows:

1) Specifications

Rated voltage	:	12 kV
Rated current	:	400 A
Rated frequency	:	50 Hz

BIL	:	95 kV
Power-frequency withstand voltage	:	31.5 kV
Rated short-time current (1 sec)	:	12.5 kV

(5) Lightning arrester (JEC 203)

As before, the applicable specifications shall be as follows:

1) Specification

Rated voltage	:	14 kV
Power-frequency firing potential	:	21 kV
Lightning impulse firing potential	:	50 kV
Nominal discharge current	:	5 kA
Discharge voltage	:	50 kV

(6) 11 kV CVMAZV cable (JIS, IEC)

As before, the applicable specifications shall be as follows:

Number of cores	:	3 cores
Nominal cross section	:	200 mm^2
Insulator length	:	5.5 mm
Finished outside diameter	:	80 mm
Electric resistance (20°C)	:	0.0933 (Ω/km)
Insulation resistance	:	2,000 (MΩ-km) or over
Power-frequency withstand voltage	:	26 kV/10 min
Lightning impulse withstand voltage	:	140 kV/3 times

(7) Multi-circuit switch (IEC)

As before, the applicable specifications shall be as follows:

Rated voltage	:	12 kV
Rated current	:	400A x 3 circuits
BIL	:	75 kV
Rated short-time current	:	12.5 kA (1 sec)

Fig.10.6.3-1

Type: 1

11kV, Single Circuit, Standard Pole Assembling for Intermediate Pole (Concrete Pole)

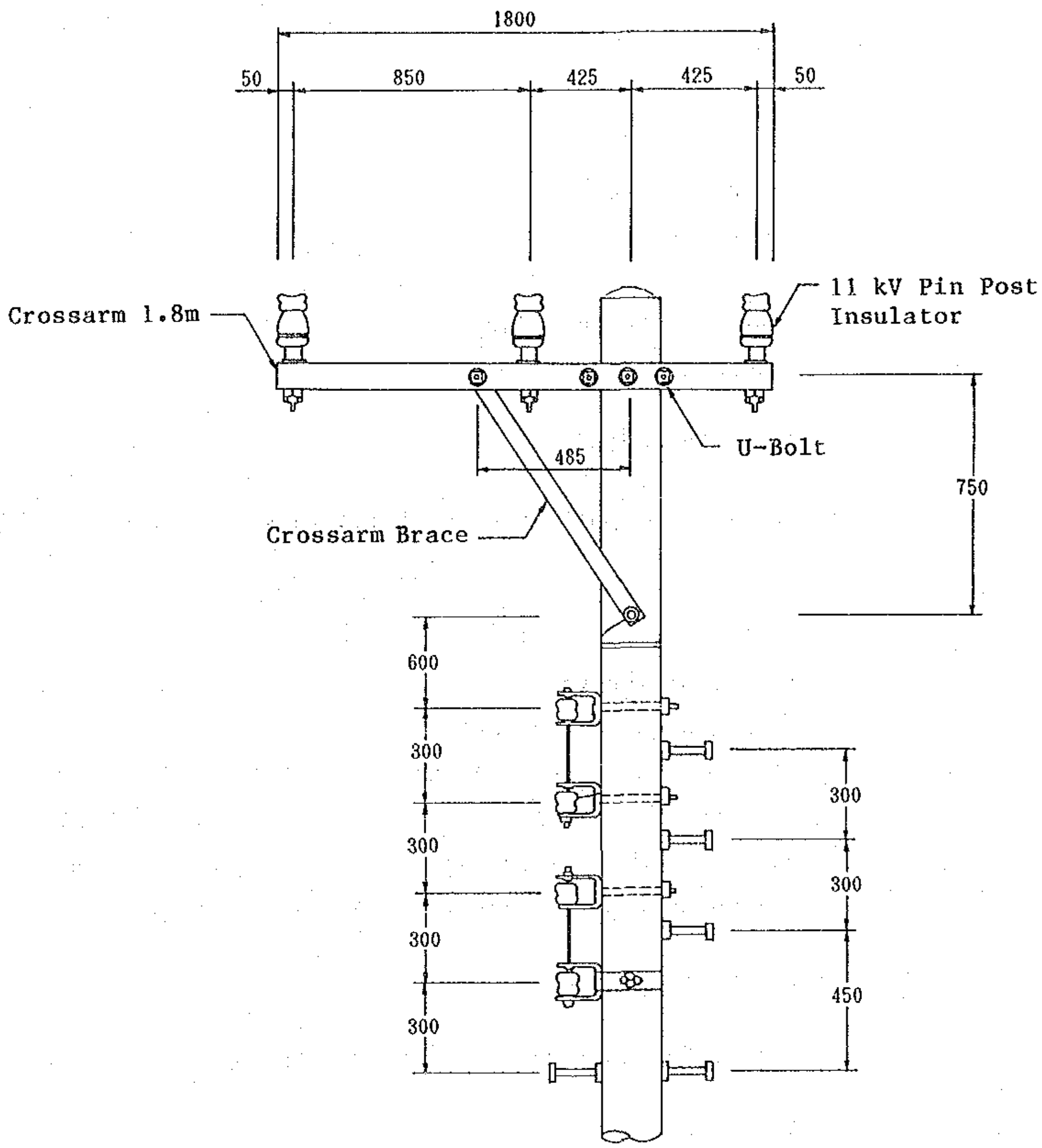


Fig.10.6.3-2

Type: 2

11 kV, Double Circuit, Standard Pole Assembling for Intermediate Pole (Concrete Pole)

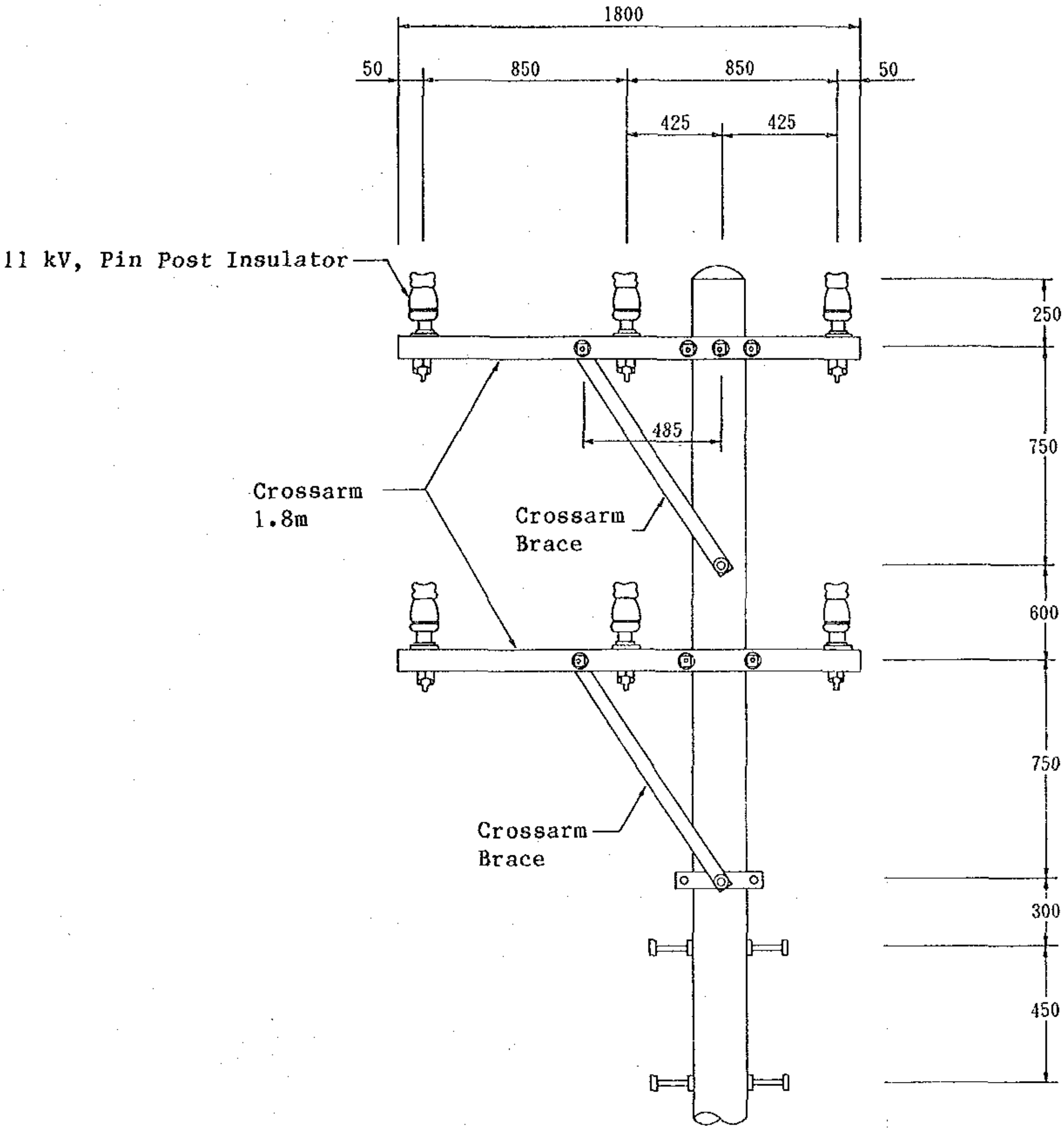
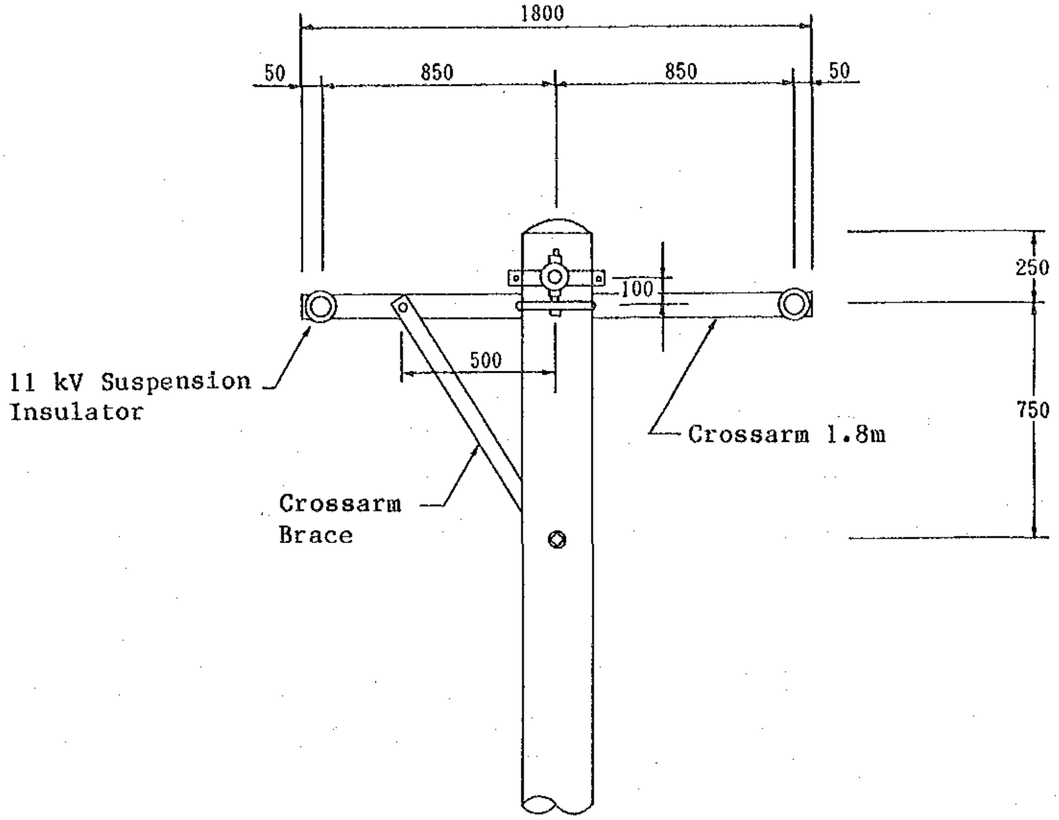


Fig.10.6.3-3

Type: 3

11 kV, Standard Pole Assembling for Deadend Pole (Concrete, Wooden Pole)



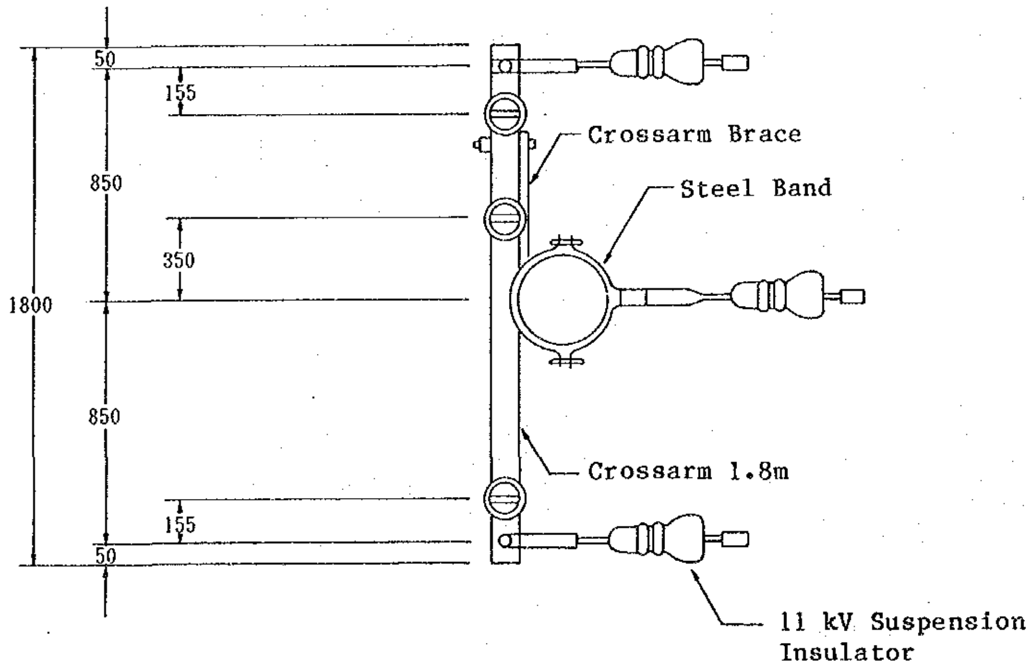
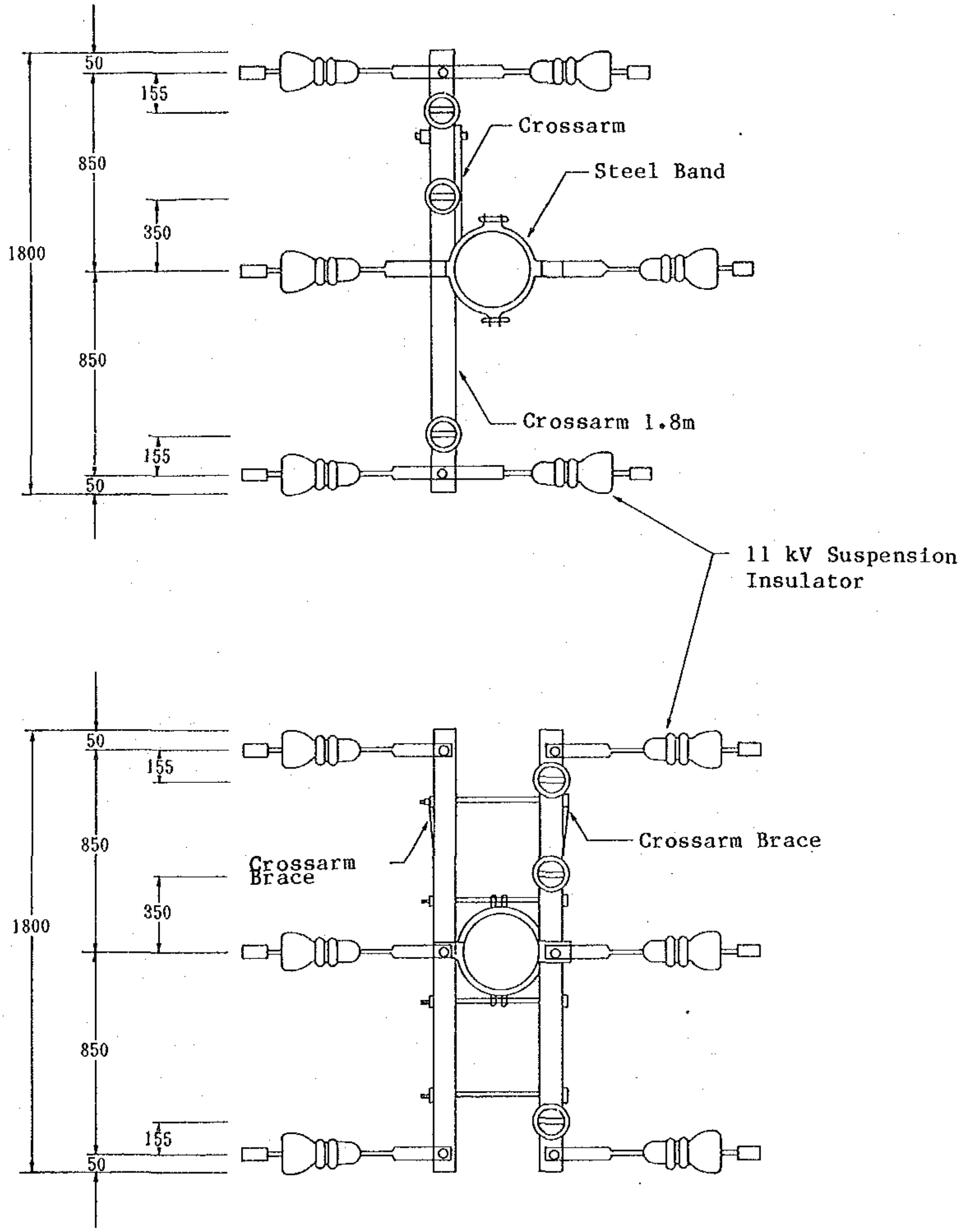


Fig.10.6.3-4

Type: 4

11 kV, Standard Pole Assembling for Deadend (Double) Pole
(Concrete, Wooden Pole)



10.6.4 Effects of Improvements

The effects of improvements on the 11 kV distribution facilities owing to the implementation of the expansion plan (short-term for 5 years) are as shown below in Table 10.6.4-1.

Table 10.6.4-1 Effect of improvements (short-terms for 5 years)

Year	Substation		Amount of reduction in annual power loss (MWH)	Amount of reduction in impeded power supply due to accidental power interruption (MWH)	Remark
1994	New Construction	TANDALE S/S 3 cct new construction	6,912	70	
		CHANG'OMBE S/S 4 cct new construction	4,844	59	
	Additional installation and expansion	ILALA S/S 2 cct change-over between banks	333	-	Change-over No.3 bank 1 cct and No.4 bank 1 cct to No.5 ban
		MBEZI S/S 3 cct change-over	-	-	Expansion of 7.5 MVA to 15 MVA Change-over to 3 cct new bank
1996	New Construction	KUNDUCHI S/S 4 cct new construction	1,428	26	
		KARIAKOO S/S 3 cct new construction (1 cct new construction)	3,276	66	( ) indicates 1 cct new construction to Ilala S/S to be shown otherwise
		MBAGALA S/S 3 cct new construction	1,384	17	
		TABATA S/S 2 cct new construction	-	-	Change 33 kV line to 11 kV
Total		8 places 20 cct new construction	18,177	238	

(1) Effect on annual reduction in power loss

The annual reduction in the power loss in 11 kV feeders owing to the construction of new substations and additional installation and expansion of existing substations are as shown below. See Table 10.6.4-4 Comparison of effects of improvements on 11 kV distribution lines - Distribution substation expansion-related works.

1) 1994 plan

(a) Tandale S/S new construction-related work

Annual reduction in power loss = (1,066 kW - 277 kW) x 8,760 hour x 10^{-3} = 6,912 (MWh)

(b) Chang'ombe S/S new construction-related work

Annual reduction in power loss = (1,319 kW - 766 kW) x 8,760 hour x 10^{-3} = 4,844 (MWh)

(c) Ilala S/S new construction-related work

Annual reduction in power loss = (165 kW - 127 kW) x 8,760 hour x 10^{-3} = 333 (MWh)

2) 1966 plan

(a) Kunduchi S/S new construction-related work

Annual reduction in power loss = (182 kW - 19 kW) x 8,760 hour x 10^{-3} = 1,428 (MWh)

(b) Kariakoo S/S new construction-related work

Annual reduction in power loss = (598 kW - 224 kW) x 8,760 hour x 10^{-3} = 3,276 (MWh)

(c) Mbagala S/S new construction-related work

Annual reduction in power loss = (191 kW - 33 kW) x 8,760 hour x 10^{-3} = 1,384 (MWh)

(2) Effect on reduction in impeded power supply due to accidental service interruption

Service interruptions to users are classified into the following three cases:

(a) Accidental service interruption due to repercussions exerted from an accident in the power supply system on the upstream side of the distribution substations or caused by the defective distribution facilities ranging from the 11 kV distribution lines to service wires to the users.

(b) Scheduled shutdown of power supply in respect of the maintenance service or repair works for the transmission, substation and distribution facilities.

(c) Service interruption on a rotation basis due to lack of supply power.

It is expected that the implementation of this expansion plan will produce effects one after above service interruptions.

Accordingly, though it may be difficult in some aspects to quantitatively grasp the produced effects, an estimate is made herewith premising the following conditions.

In view of the purpose and setup of this study, the above estimate for the produced effects should be limited to that:

(a) the cause of the above (a) Accidental service interruption is only limited to the defective distribution facilities related to the 11 kV distribution lines and thus the power supply system on the upstream side of the distribution substations and low-tension wires beyond the pole transformers are excluded.

(b) is excluded from the estimated since the frequency of the scheduled shutdown of power supply largely depends on the actual situations of the facilities, construction methods and technique and moreover there still remain unclear points.

(c) is also excluded from the estimated like (b).

1) Impeded power supply estimate due to accidental service interruption

It is known that the accidental service interruption is caused by various factors such as the deterioration in the quality of the facilities as well as weather conditions like a typhoon, thunderstorm, etc.

In this expansion study, the importance is principally attached to the construction of new 33/11 kV distribution substations and additional installation and expansion of the existing 33/11 kV distribution substations as well as to the construction of new 11 kV feeders and change-over of loads with an eye to taking necessary countermeasures to cope with the increase in demand in the future. However, since the repair works for the deteriorated facilities aiming at eliminating the latent causes of accidents are not included in this study, it is difficult to expect from this study the remarkable reduction in the occurrence of the accidents. Instead, it may be expected that the amount of the impeded power supply per accidental service interruption will remarkably be reduced. This is because the line distance/cct is shortened as a result of the implementation of this expansion study in which the load of the 11 kV feeders of the existing substations located adjacent to the new substations are partly separated for change-over.

(a) Calculation of effect on reduction in impeded power supply

(i) Concept of calculation and prerequisite

The improvement effect, the annual reduction in the impeded power supply, is calculated herewith from the following equation.

In this event, the basic data are derived from the actual results contained in the [Survey Report on Dar Es Salaam Transmission and Distribution Lines, January, 1985].

Annual reduction in impeded power supply due to accidental service interruption = annual impeded power supply (before countermeasures - after countermeasures).

Annual impeded power supply = [annual frequency of accidents/cct x demand in service interruption region x duration of service interruption (trouble shooting time + restoration time)] x total number of feeders available in all planned regions.

Where; the above equation premises the following:

(a) Frequency of accidents/cct after taking countermeasures is reduced in proportion to the reduction in the line distance but the number of feeders are inversely increased and thus the remarkable reduction in the accidents is difficult to expect as a whole in this study.

    The frequency of the accidents due to deteriorated facilities after taking countermeasures is taken for the value that is calculated by subtracting 3% from the actual result of 1984 though it might threaten to increase in the future due to progress of secular deterioration but provided however that the minimum necessary repair works will be continuously and indispensably conducted every year by TANESCO.

(b) The duration of a service interruption is taken for the value that is calculated by subtracting 10% from the average duration in the actual cases in anticipation of the effect to be exerted from the installation of new line switches though it is almost impossible to make an accurate quantitative estimate of the duration of the service interruption since it is largely depends on the actual situations of the distribution facilities, maintenance service setup, level of skilled workers, etc. and moreover it is necessary to enhance each of these factors to shorten the duration and in addition there still remain unclear points.

(ii) Actual results of accidental service interruption

Source: [Survey Report on Dar Es Salaam Transmission and Distribution Liens, January, 1995]

Table 6.4-2 Summary of service interruption in 1983 (in the region including those four substations)

Substation name	Number of feeders in operation (A)	Number of 11 kV feeder CB. trips (B)	(B) / (A) (1)
Oysterbay	5	57	11.4
City Centre	4	45	11.3
Ilala	5	45	9.0
Factory Zone I	4	22	5.5
Total	18	169	9.4

Note: (1) (B)/(A) = annual average frequency per user of service interruption due to 11 kV feeder C.B trip.

Table 10.6.4-3 Summary of service interruption in April, 1984

Substation name	Number of feeders in operation	Actual results of service interruption			
		Feeder name	Frequency (times)	Time (min)	Duration per each service interruption (min)
Ilala		D2	1	47	47
		D9	2	422	211
		D10	2	75	38
	6	3 cct	5	544	109
Oysterbay		O2	3	391	130
		O3	1	113	113
		O5	2	47	24
	5	3 cct	6	551	92
FZ-I		F2	1	6	6
		F4	2	373	187
		F5	1	26	26
	3	3 cct	4	405	101
Kurasini		Industrial	1	95	95
		Kilwa	3	151	50
	3	2 cct	4	246	62
Ubungo		U2	5	1,887	377
		U3	1	10	10
		U6	1	6	6
	4	3 cct	7	1,903	272
City Centre	6	C2	1	33	33
Mbezi	3	MB2	3	237	79
Total of seven S/S	30	16 cct	30	3,919	131

(iii) Annual reduction in impeded power supply after taking countermeasures

(1) Basic data estimate

Based on the actual results of the accidents taken place in 1984 as well as the following estimate, the effect of improvements is calculated:

- Annual frequency of accidents/cct

Based on the actual results of April, 1984, but excluding the Ubungo S/S U2 feeder accidents (5 times for 1,887 min) which seem to be very particular cases, the annual frequency of accidents is presumed to be 25 times per month almost on average.

Prior to the Adoption of Countermeasures

$$\text{Annual accident incidence/cct} = \frac{25 \text{ times} \times 12 \text{ months}}{30 \text{ cct}} = 10 \text{ times}$$

After the Adoption of Countermeasures

$$\text{Annual accident incidence/cct} = 10 \times 97\% = 9.7 \text{ times}$$

(3% reduction against pre-countermeasure incidence)

- Power outage time/cct times

  Anticipated in the same manner as above

  Pre-countermeasure power outage time/cct times

$$= \frac{2,032 \text{ min.}}{30 \text{ cct}}$$

$$= 68 \text{ minutes}$$

  Post-countermeasure ... 10% reduction against pre-countermeasures = 61 minutes

- Loss factor

$$\text{Loss factor} = \frac{\text{Average power loss (kW)}}{\text{Maximum power loss (kW)}} \times 100\%$$

$$= 40\% \text{ (predicted value)}$$

(2) Annual reduction in power interference

1994 Plan (from Table 10.6.4-4)

- Tandale S/S (3 cct new construction)

  Prior to the adoption of Countermeasures

  Annual power interference level

  = 10 times/cct x 3,377 kW x 0.4 x 1.13 hrs x 19 cct x 10^{-3} = 290 (MWH)

  After the Adoption of Countermeasures

  Annual power interference level

  = 8.4 times/cct x 2,917 kW x 0.4 x 1.02 hrs x 22 cct x 10^{-3} = 220 (MWH)

  Reduction in annual power interference level

  = 290 - 220

  = 70 (MWH)

- CHANG'OMBE S/S (4 cct new construction)

Prior to the Adoption of Countermeasures

Annual power interference level
= 10 times/ccgt x 3,175 kV x 0.4 x 1.13 hrs x 12 cct x 10^{-3} = 172 (MWH)

After taking countermeasures:

Annual impeded power supply
= 7.3 times/cct x 2,381 kW x 0.4 x 1.02 hours x 16 cct x 10^{-3} = roughly 113 (MWh)

Annual reduction in impeded power supply
= 172 - 113 = 59 (MWh)

1996 plan (from Table 10.6.4-4)

- *Kunduchi S/S (4 cct new construction)*

Before taking countermeasures:

Annual impeded power supply
= 10 times/cct x 3,080 kW x 0.4 x 1.13 hours x 3 cct x 10^{-3} = roughly 42 (MWh)

After taking countermeasures:

Annual impeded power supply
= 4.2 times/cct x 1,320 kW x 0.4 x 1.02 hours x 7 cct x 10^{-3} = roughly 16 (MWh)

Annual reduction in impeded power supply
= 42 - 16 = 26 (MWh)

- Kariakoo S/S (4 cct net construction) including Ilala 1 cct new construction

Before taking countermeasures:

Annual impeded power supply
= 10 times/cct x 3,196 kW x 0.4 x 1.13 hours x 15 cct x 10^{-3} = roughly 217 (MWh)

After taking countermeasures:

Annual impeded power supply
= 7.7 times/cct x 2,523 kW x 0.4 x 1.02 hours x 19 cct x 10^{-3} = roughly 151 (MWh)

Annual reduction in impeded power supply
= 217 - 151 = 66 (MWh)

- Mbagala S/S (3 cct new construction0

Before taking countermeasures:

Annual impeded power supply
= 10 times/cct x 2,304 kW x 0.4 x 1.13 hours x 3 cct x 10^{-3} = roughly 31 (MWh)

After taking countermeasures:

Annual impeded power supply
= 4.9 times/cct x 1,152 kW x 0.4 x 1.02 hours x 6 cct x 10^{-3} = roughly 14 (MWh)

Annual reduction in impeded power supply
= 31 - 14 = 17 (MWh)

Table 10.6.4-4 Comparison of effects of improvements on 11 kV distribution lines
Distribution substation expansion - related works

Year	Substation		Feeder	Before taking countermeasures							After taking countermeasures							Remarks
				Main line		Max	Loss Number of systems	Power	Loss	Voltage drop	Main line		Max	Loss Number of systems	Power	Loss	Voltage drop	
				ACSR (mm2)	Distance (km)	(Amps)		(kW)	(kW)	(V)	ACSR (mm2)	Distance (km)	(Amps)		(kW)	(kW)	(V)	
1994	TANDALE S/S 15MVA x 1																	
		New construction	TA1								120 100	2.0 1.3	52	0.4	790	5	110	
			TA2								100	3.56	178	0.4	2,858	25	290	
			TA3								100	3.66	20	0.4	311	1	40	
		Existing Substations	MIKOCHENI S/S															
			MK2	100	10.82	260	0.4	3,958	290	1,200	100	5.6	223	0.4	3,389	60	540	
			MK3	100	4.8	108	0.4	1,649	22	230	100	3.7	53	0.4	808	3	90	
			OYSTERBAY S/S															
			O2	100	4.22	199	0.4	3,029	67	320	100	4.22	219	0.4	3,338	70	330	
			O4	Cu 25	3.8	240	1.0	3,652	359	960	Cu 25	2.64	183	1.0	2,630	72	510	
			ILALA S/S															
			D10	100	6.51	278	0.4	4,230	199	750	100	3.36	221	0.4	3,370	27	310	
			UBUNGO S/S 1,000V															
			U2	100	8.36	197	0.4	3,008	129	720	100	3.9	133	0.4	2,032	14	230	
		Subtotal						19,526	1,066						19,526	277		Improved loss 789kW
	CHANG'OMBE S/S 15MVA x 1																	
		New construction	CH1								120 100	0.3 1.5	104	0.4	1,589	6	70	
			CH2										63	0.4	963	2	30	
			CH3								120 100	0.9 1.3	154	0.4	2,342	43	130	
			CH4								100	4.8	108	0.4	1,717	45	190	
		Existing Substations	ILALA S/S 500V															
			D3	100	2.82	246	0.4	3,750	134	300	100	2.3	165	0.4	2,510	15	160	
			D7	100	2.95	159	0.4	2,638	37	220	100	2.1	73	0.4	1,212	8	100	
			FZ-I S/S 500V															
			F2	100	2.5	182	0.4	2,764	10	170	100	1.6	96	0.4	1,378	3	60	
			F5	100	3.2	74	0.4	1,134	3	90	100	3.2	137	0.4	2,211	9	150	
			KURASINI S/S 500V															
			Industrial	100	9.52	230	0.8	3,498	798	1,240	100	3.9	76	0.8	1,156	5	100	
			Kilwa road	100	8.5	316	0.4	4,812	337	790	100	8.5	231	0.4	3,518	630	350	
		Subtotal						18,596	1,319						18,596	766		Improved loss 553kW
	Total							38,122	2,385						38,122	1,043		Improved loss 1,342kW

Table 10.6.4-4 Comparison of effects of improvements on 11 kV distribution lines
Distribution substation expansion - related works

Year	Substation	Feeder	Before taking countermeasures: Main line ACSR (mm2)	Before: Main line Distance (km)	Before: Max (Amps)	Before: Loss Number of systems	Before: Power (kW)	Before: Loss (kW)	Before: Voltage drop (V)	After taking countermeasures: Main line ACSR (mm2)	After: Main line Distance (km)	After: Max (Amps)	After: Loss Number of systems	After: Power (kW)	After: Loss (kW)	After: Voltage drop (V)	Remarks
1994	ILALA S/S 15MVA x 1 Additional installation																
	Existing Substations: ILALA S/S																
		D3															Change-over from No.3 bank to No.5 bank
		D7	100	2.1	73	0.4	1,212	8	100	100	6.1	154	0.4	2,444	82	480	
		D9															Change-over from No.4 bank to No.5 bank
	UBUNGO S/S																
		U1	100	7.4	247	0.4	3,762	157	780	100	4.7	166	0.4	2,530	45	330	
	Subtotal						4,974	165						4,974	127		Improved loss 38kW
	Total						43,096	2,550						43,096	1,170		Improved loss 1,380kW

Table 10.6.4-4 Comparison of effects of improvements on 11 kV distribution lines
Distribution substation expansion - related works

Year	Substation		Feeder	Before: Main line ACSR (mm2)	Before: Main line Distance (km)	Before: Max (Amps)	Before: Loss Number of systems	Before: Power (kW)	Before: Loss (kW)	Before: Voltage drop (V)	After: Main line ACSR (mm2)	After: Main line Distance (km)	After: Max (Amps)	After: Loss Number of systems	After: Power (kW)	After: Loss (kW)	After: Voltage drop (V)	Remarks
1996	KUNDUCHI S/S																	
		New construction	KU1								120 100	1.1 3.3	20	0.4	305	1	60	
		New construction	KU2								120 100	1.05 3.5	75	0.4	1,142	4	0	
		New construction	KU3								120 100	1.5 11.5	25	0.4	381	2	0	
		New construction	KU4								120 100	1.6 3.3	61	0.4	930	4	140	
		Existing Substations	MBEZI S/S MB2	50	20.3	281	0.4	4,282	182	1,510	100	7.4	100	0.4	1,524	8	410	
		Subtotal						4,282	182						4,282	19		Improved loss 163kW
	KARIAKOO S/S																	
		New construction	KA1								120 100	1.9 1.8	184	0.4	2,995	50	280	
		New construction	KA2								120 100	0.3 0.6	131	0.4	1,991	6	60	
		New construction	KA3								120 100	0.2 0.8	195	0.4	2,988	10	50	
		Existing Substa-	ILALA S/S D1	100	5.45	188	0.4	2,860	77	440								Load is zero after completing change-over
		Existing Substa-	D2	100	6.05	172	0.4	2,624	71	440	100	1.6	100	0.4	1,532	13	70	
		Existing Substa-	D8								100	2.9	86	0.4	1,307	17	160	
		Existing Substa-	D9	100	2.53	468	0.4	7,136	221	510	100	1.4	197	0.4	3,003	22	120	
		Existing Substa-	KURASINI S/S Port	100	4.32	214	0.9	3,266	177	630	100	2.9	149	0.9	2,270	69	300	
		Existing Substa-	CITY CENTRE S/S C5	CV 185	2.2	304	0.4	4,638	52	190	CV 185	1.8	283	0.4	4,438	37	150	
		Subtotal						20,524	598						20,524	224		Improved loss 374kW
	MBAGALA S/S																	
		New construction	MG1								120 100	1.4 7.9	108	0.4	1,655	21	430	
		New construction	MG2								120 100	0.8 1.2	36	0.4	536	1	40	
		New construction	MG3								CV MAZV 200	0.4	50	0.4	765	0.3	10	
		Existing Substations	KURASINI S/S Kilwa RD	100x2	9.52	274	0.4	4,180	191	750	100	5.2	80	0.4	1,224	11	160	
		Subtotal						4,180	191						4,180	33		Improved loss 158kW
	Total							28,986	971						28,986	276		Improved loss 695kW

(3) Effect on improvement of voltage

Owing to the construction of new substations and additional installation and expansion of the existing substations (short-term for 5 years), the excess voltage drop of the feeders that undertake the load change-over among other feeders of the adjacent existing substations to the above newly constructed or modified substations will be entirely improved.
(See Table 10.6.4-5 and Table 10.6.4-6)

Table 10.6.4-5 Voltage drop adequacy factor

Year	Plan	Number of feeders (A)	Adequate number of feeders (B)	Adequacy factor (%) (B)/(A)x100
1994	Before counter-measures	13	8	69.2
	After counter-measures	20	20	100.0
1996	Before counter-measures	6	3	50.0
	After counter-measures	17	17	100.0

Voltage drop limit for 11 kV distribution line

	Area division	Voltage drop limit (V)
Normal	A area	500
	B area	1,000
In an emergency	A area	900
	B area	1,900

Note: A area: Districts covering major government and municipal offices an important installations
B area: Other districts than the above.

Table 10.6.4-6 Improved status of voltage drop

Year	Service division (voltage drop limit)	Substation name	Feeder name	Before taking countermeasures: 500V or under	Before taking countermeasures: 1,000 or under	Before taking countermeasures: Over 1,000	Before taking countermeasures: Adequacy factor (%)	After taking countermeasures: 500V or under	After taking countermeasures: 1,000 or under	After taking countermeasures: Over 1,000	After taking countermeasures: Adequacy factor (%)
1994	A area 500V	Ilala	D3	OK				OK			
			D7	OK				OK			
			D10		NO			OK			
		Kurasini	Industrial			NO		OK			
			Kilwa road		NO			OK			
		FZ-I	F2	OK				OK			
			F5	OK				OK			
		Chang'ombe (New construction)	CH1					OK			
			CH2					OK			
			CH3					OK			
			CH4					OK			
		Subtotal		4	2	1	57.1	11			100.0
	B area 1,000V	Mikocheni	MK2			NO			OK		
			MK3	OK				OK			
		Oysterbay	O2	OK				OK			
			O4		OK				OK		
		Ubungo	U1		OK			OK			
			U2		OK			OK			
		Tandale (New construction)	TA1					OK			
			TA2					OK			
			TA3					OK			
		Subtotal		2	3	1	83.3	7	2		100.0
	Total			6	5	2	69.2	18	2		100.0
1996	A area 500V	Ilala	D1	OK							
			D2	OK				OK			
			D8					OK			
			D9		NO			OK			
		Kurasini	Kilwa road					OK			
			Port		NO			OK			
		City centre	C5	OK				OK			
		Kariakoo	KA1					OK			
			KA2					OK			
			KA3					OK			
		Mbagala	MG1					OK			
			MG2					OK			
			MG3					OK			
		Subtotal		3	2		40.0	12			100.0
	B area 1,000V	Mbezi	MB2			NO		OK			
		Kunduchi	KU1					OK			
			KU2					OK			
			KU3					OK			
			KU4					OK			
		Subtotal				1	0.0	5			100.0
	Total			3	2	1	50.0	17			100.0

(4) Maximum voltage drop of 11 kV distribution line and power loss

An example of Kunduchi S/S 4 cct new construction:

Based on Fig. 10.61-4-1 Kunduchi S/S new construction (before countermeasures/after countermeasures) current distribution drawing, the maximum voltage drop and power loss are calculated as shown below:

Maximum voltage drop

- Line intermediate section voltage drop

The voltage drop can be calculated from the following equation presuming that the load is uniformly imposed on the line section:

$$\varepsilon_{xy} = \sqrt{3} \times \frac{\tau e (Ix + Iy)\,\ell}{2} \quad [V]$$

ε_{xy}	... Voltage drop between x and y	[V]
Ix	... Current flown into the line section	[A]
Iy	... Current flown out of the line section	[A]
ℓ	... Distance of the line section	[km]
$\tau e = r\cos\theta + x\sin\theta$	... Equivalent resistance	[Ω/km]

- Line end section voltage drop

$$\varepsilon_{xy} = \sqrt{3} \times \frac{\tau e \quad Ix}{2}\,\ell \quad [V]$$

- Line total voltage drop

The total voltage drop up to the line end ϵ is the sum of the voltage drop in each section.

$$\varepsilon = \Sigma\, \varepsilon_{xy} \quad [V]$$

1) Maximum voltage drop before taking countermeasures

(a) Mbezi S/S MB2 feeder

The equivalent resistance re of ACSR 50 mm^2 is 0.6474 [Ω/km].

1. MBWENI point

$$V_{AB} = \sqrt{3} \times \frac{0.6474 \times (281+277) \times 1.4}{2} = 438 \quad [V]$$

$$V_{BC} = \sqrt{3} \times \frac{0.6474 \times (260+240) \times 1.4}{2} = 392 \quad [V]$$

$$V_{CD} = \sqrt{3} \times \frac{0.6474 \times (194+175) \times 1.4}{2} = 290 \quad [V]$$

$$V_{DE} = \sqrt{3} \times \frac{0.6474 \times (80+66) \times 1.1}{2} = 90 \quad [V]$$

$$V_{EF} = \sqrt{3} \times \frac{0.6474 \times (66+42) \times 1.5}{2} = 91 \quad [V]$$

$$V_{FG} = \sqrt{3} \times \frac{0.6474 \times (40+38) \times 1.0}{2} = 44 \quad [V]$$

$$V_{GH} = \sqrt{3} \times \frac{0.6474 \times (25+8) \times 6.6}{2} = 12 \quad [V]$$

$$V_{HI} = \sqrt{3} \times \frac{0.6474 \times (7+6) \times 4.8}{2} = 35 \quad [V]$$

$$V_{IJ} = \sqrt{3} \times 0.6474 \times 4 \times 1.1 = 5 \quad [V]$$

$$\varepsilon = \Sigma \varepsilon_{xy} \quad [V]$$

$$= V_{AB} + V_{BC} + V_{CD} + V_{DE} + V_{EF} + V_{FG} + V_{GH} + V_{HI} + V_{IJ} \quad [V]$$

$$\fallingdotseq 1.520 \quad [V]$$

2. RAS KILOMONY point

$$V_{DK} = \sqrt{3} \times \frac{0.6474 \times (95+80) \times 1.6}{2} = 157 \quad [V]$$

$$V_{KM} = \sqrt{3} \times \frac{0.6474 \times (59+40) \times 1.7}{2} = 94 \quad [V]$$

$$V_{MN} = \sqrt{3} \times \frac{0.6474 \times (30+20) \times 0.9}{2} = 25 \quad [V]$$

$$V_{NO} = \sqrt{3} \times \frac{0.6474 \times (10+10) \times 1.4}{2} = 16 \quad [V]$$

$$V_{OP} = \sqrt{3} \times 0.6474 \times 9 \times 1.3 = 13 \quad [V]$$

$$\varepsilon = \Sigma \varepsilon_{xy} \quad [V]$$

$$= V_{AB} \sim V_{CD} + V_{DK} \sim V_{OP} \quad [V]$$

$$\fallingdotseq 1.430 \quad [V]$$

3. AFRICANA HOTEL point

$$V_{CQ} = \sqrt{3} \times 0.6474 \times 46 \times 4.6 = 237 \quad [V]$$

$$\varepsilon = \Sigma \varepsilon_{xy} \quad [V]$$

$$= V_{AB} \sim V_{BC} + V_{CQ} \quad [V]$$

$$\fallingdotseq 1.070 \quad [V]$$

2) Maximum voltage drop after taking countermeasures

The equivalent resistance re = of ACSR 120 mm^2 is 0.410 [Ω/km].

(a) MBEZI S/S MB2 feeder

3. AFRICANA HOTEL point

$$V_{AB} = \sqrt{3} \times \frac{0.410 \times (100+96) \times 1.4}{2} = 97 \quad [V]$$

$$V_{BC} = \sqrt{3} \times \frac{0.410 \times (79+58) \times 1.4}{2} = 68 \quad [V]$$

$$\varepsilon = \Sigma \varepsilon_{xy} \quad [V]$$

$$\varepsilon = V_{AB} + V_{BC} + V_{CQ}$$

$$\fallingdotseq 410 \quad [V]$$

(b) KUNDUCHI S/S KU1 feeder

2. RAS KILOMONY point

$V_{ST} = \sqrt{3} \times 0.410 \times 20 \times 1.1 = 16$ 〔V〕

$V_{TN} = \sqrt{3} \times 0.6474 \times 20 \times 0.3 = 7$ 〔V〕

$\varepsilon = \Sigma\, \varepsilon_{xy}$ 〔V〕

$= V_{ST} + V_{TN} + V_{NO} + V_{OP}$

$\fallingdotseq 60$ 〔V〕

(c) KUNDUCHI S/S KU2 feeder

5. Demarcation point from KU4

$V_{ST} = \sqrt{3} \times 0.410 \times 75 \times 1.7 = 91$ 〔V〕

$V_{ML} = \sqrt{3} \times 0.410 \times 65 \times 0.7 = 32$ 〔V〕

$$V_{LK} = \sqrt{3} \times \frac{0.410 \times (50+36) \times 1.0}{2} = 31 \quad \text{〔V〕}$$

$$V_{KD} = \sqrt{3} \times \frac{0.410 \times 15 \times 1.6}{2} = 9 \quad \text{〔V〕}$$

$\varepsilon = \Sigma\, \varepsilon_{xy}$ 〔V〕

$= V_{SM} + V_{ML} + V_{LK} + V_{KD}$

$\fallingdotseq 170$ 〔V〕

(d) KUNDUCHI S/S KU3 feeder

1. MBWENI point

$V_{SR} = \sqrt{3} \times 0.410 \times 25 \times 1.5 = 27$ 〔V〕

$\varepsilon = \Sigma\, \varepsilon_{xy}$ 〔V〕

$= V_{SR} + V_{RH} \sim V_{HJ}$

$\fallingdotseq 180$ 〔V〕

(e) KUNDUCHI S/S KU4 feeder

4. Demarcation point from BMEZI S/S MB2 feeder

$$V_{SF} = \sqrt{3} \times 0.410 \times 59 \times 1.5 = 63 \quad [V]$$

$$V_{FE} = \sqrt{3} \times 0.410 \times 44 \times 1.5 = 47 \quad [V]$$

$$V_{ED} = \sqrt{3} \times \frac{0.410 \times (30+26) \times 1.1}{2} = 22 \quad [V]$$

$$V_{DU} = \sqrt{3} \times \frac{0.410 \times 7 \times 0.9}{2} = 2 \quad [V]$$

$$\varepsilon = \Sigma \varepsilon_{xy} \quad [V]$$

$$= V_{SF} + V_{FE} + V_{ED} + V_{DU}$$

$$\fallingdotseq 140 \quad [V]$$

Power loss

- Line intermediate section power loss

$$\omega xy = \frac{N}{3} \tau \frac{I^2 x + Ix\ Iy + I^2 y}{1{,}000} \ell \quad [kW]$$

where ωxy ... Power loss between x and y [kW]

τ	... Resistance/km/wire	[Ω/kW]
N	... Number of wires included in electric conductor; 3 wires	N=3
Ix	... Current flown into the line section	[A]
Iy	... Current flown out of the line section	[A]
ℓ	... Distance of the line section	[km]

- Line end section power loss

$$\omega xy = \frac{N}{3} \tau \frac{I^2 x}{1{,}000} \ell \quad [kW]$$

- Line total power loss

$$\omega = \Sigma \omega xy \quad [kW]$$

- Annual power loss

W = ωGH [kWH]

where; G: Loss factor
H: Annual power supply hours (365 x 24 = 8,760%)

1) Power loss before taking countermeasures

MBEZI S/S MB2 feeder

The resistance of ACSR 50 mm^2 is 0.5426 [Ω/km].

$$\omega_{AB} = \frac{0.5426 \times (281^2 + 281 \times 277 + 277^2)}{1,000} \times 1.4 = 177.40 \quad [kW]$$

$$\omega_{BC} = \frac{0.5426 \times (260^2 + 260 \times 240 + 240^2)}{1,000} \times 1.4 = 142.51 \quad [kW]$$

$$\omega_{CD} = \frac{0.5426 \times (194^2 + 194 \times 175 + 175^2)}{1,000} \times 1.4 = 77.64 \quad [kW]$$

$$\omega_{DF} = \frac{0.5426 \times (80^2 + 80 \times 42 + 42^2)}{1,000} \times 2.6 = 16.26 \quad [kW]$$

$$\omega_{FG} = \frac{0.5426 \times (40^2 + 40 \times 38 + 38^2)}{1,000} \times 1.0 = 2.48 \quad [kW]$$

$$\omega_{GR} = \frac{0.5426 \times (25^2 + 25 \times 25 + 25^2)}{1,000} \times 0.7 = 0.71 \quad [kW]$$

$$\omega_{RH} = \frac{0.5426 \times (25^2 + 25 \times 8 + 8^2)}{1,000} \times 5.9 = 2.85 \quad [kW]$$

$$\omega_{HI} = \frac{0.5426 \times (7^2 + 7 \times 6 + 6^2)}{1,000} \times 4.8 = 0.33 \quad [kW]$$

$$\omega_{IJ} = \frac{0.5426 \times 4^2}{1,000} \times 1.1 = 0.0095 \fallingdotseq 0.01 \quad [kW]$$

$$\omega_{DK} = \frac{0.5426 \times (95^2 + 95 \times 80 + 80^2)}{1,000} \times 1.6 = 19.99 \quad [kW]$$

$$\omega_{KL} = \frac{0.5426 \times (59^2 + 59 \times 55 + 55^2)}{1,000} \times 1.0 = 5.29 \quad [kW]$$

$$\omega_{LM} = \frac{0.5426 \times (40^2 + 40 \times 40 + 40^2)}{1,000} \times 0.7 = 1.82 \quad [kW]$$

$$\omega_{MN} = \frac{0.5426 \times (30^2 + 30 \times 20 + 20^2)}{1,000} \times 0.9 = 0.93 \quad [kW]$$

$$\omega_{NO} = \frac{0.5426 \times (10^2 + 10 \times 10 + 10^2)}{1,000} \times 1.4 = 0.23 \quad [kW]$$

$$\omega_{OP} = \frac{0.5426 \times 9^2}{1,000} \times 1.3 = 0.06 \quad [kW]$$

$$\omega_{CQ} = \frac{0.5426 \times 46^2}{1,000} \times 4.6 = 5.28 \quad [kW]$$

The total power loss is obtained as follows:

$$\omega = \Sigma \omega_{xy} \quad [kW]$$

$$= \omega_{AB} + \omega_{BC} + \omega_{CD} \cdots\cdots \omega_{LR}$$

$$= 453.79 \quad [kW]$$

Hence, the annual power loss comes to:

$$W = 453.79 \times 0.4 \times 8,760 \times 10^{-3} \quad [MWH]$$

$$\fallingdotseq 1,590 \quad [MWH]$$

2) Power loss after taking countermeasures

KUNDUCHI S/S

The resistance of ACSR 120 mm^2 is 0.252 [Ω/km].
The resistance of ACSR 50 mm^2 is 0.5426 [Ω/km].

(a) KU 1 Feeder

$$\omega_{ST} = \frac{0.252 \times (20^2 + 20 \times 20 + 20^2)}{1,000} \times 1.1 = 0.33 \quad \text{(kW)}$$

$$\omega_{TN} = \frac{0.5426 \times (20^2 + 20 \times 20 + 20^2)}{1,000} \times 0.3 = 0.20 \quad \text{(kW)}$$

$$\omega_{NO} = 0.23 \text{ (kW)}$$

$$\omega_{OP} = 0.06 \text{ (kW)}$$

The total power loss is obtained as follows:

$$\begin{aligned} \omega &= \Sigma \omega_{xy} && \text{(kW)} \\ &= \omega_{ST} + \omega_{TN} + \omega_{NO} + \omega_{OP} \\ &= 0.82 && \text{(kW)} \end{aligned}$$

Hence, the annual power loss comes to:

$$\begin{aligned} W &= 0.82 \times 0.4 \times 8,760 \times 10^{-3} \text{ (MWH)} \\ &= 2.87 \text{ (MWH)} \end{aligned}$$

(b) KU 2 Feeder

$$\omega_{SM} = \frac{0.252 \times (75^2 + 75 \times 75 + 75^2)}{1,000} \times 1.7 = 7.23 \quad \text{(kW)}$$

$$\omega_{ML} = \frac{0.252 \times (50^2 + 50 \times 36 + 36^2)}{1,000} \times 1.0 = 1.41 \quad \text{(kW)}$$

$$\omega_{LK} = \frac{0.252 \times (50^2 + 50 \times 36 + 36^2)}{1,000} \times 1.0 = 1.41 \quad \text{(kW)}$$

$$\omega_{KD} = \frac{0.252 \times 15^2}{1,000} \times 1.6 = 0.09 \quad \text{(kW)}$$

The total power loss is obtained as follows:

$$\omega = \Sigma\omega_{xy} \quad \text{(kW)}$$

$$= \omega_{SM} + \omega_{ML} + \omega_{LK} + \omega_{KD}$$

$$= 10.97 \quad \text{(kW)}$$

Hence, the annual power loss comes to:

$$W = 10.97 \times 0.4 \times 8,760 \times 10^{-3}$$

$$\fallingdotseq 38.44 \text{ (MWH)}$$

(c) KU 3 Feeder

$$\omega_{SR} = \frac{0.252 \times (25^2 + 25 \times 25 + 25^2)}{1,000} \times 1.5 = 0.71 \quad \text{(kW)}$$

$$\omega_{RH} = 2.85 \quad \text{(kW)}$$

$$\omega_{HI} = 0.33 \quad \text{(kW)}$$

$$\omega_{IJ} = 0.01 \quad \text{(kW)}$$

The total power loss is obtained as follows:

$$\omega = \Sigma\omega_{xy} \quad \text{(kW)}$$

$$= \omega_{SR} + \omega_{RH} + \omega_{HI} + \omega_{IJ}$$

$$= 3.9 \quad \text{(kW)}$$

Hence, the annual power loss comes to:

$$W = 3.9 \times 0.4 \times 8,760 \times 10^{-3}$$

$$\fallingdotseq 13.67 \text{ (MWH)}$$

(d) KU 4 Feeder

$$\omega_{SF} = \frac{0.252 \times (59^2 + 59 \times 59 + 59^2)}{1,000} \times 1.5 = 3.95 \quad \text{(kW)}$$

$$\omega_{FE} = \frac{0.252 \times (44^2 + 44 \times 43 + 43^2)}{1,000} \times 1.5 = 2.15 \quad \text{(kW)}$$

$$\omega_{EU} = \frac{0.252 \times 30^2}{1,000} \times 2.5 = 0.57 \quad \text{[kW]}$$

$$\omega_{FG} = \frac{0.252 \times (15^2 + 15 \times 13 + 13^2)}{1,000} \times 1.0 = 0.15 \quad \text{[kW]}$$

$$\omega_{GZ} = \frac{0.5426 \times 13^2}{1,000} \times 2.7 = 0.25 \quad \text{[kW]}$$

The total power loss is obtained as follows:

$$\omega = \Sigma\,\omega_{xy} \quad \text{[kW]}$$

$$= \omega_{SF} + \omega_{FE} \cdots\cdots + \omega_{GZ}$$

$$= 7.07 \quad \text{[kW]}$$

Hence, the annual power loss comes to:

$$W = 7.07 \times 0.4 \times 8,760 \times 10^{-3}$$

$$\fallingdotseq 24.77 \text{ [MWH]}$$

(e) MBEZI S/S MB2 Feeder

$$\omega_{AB} = \frac{0.252 \times (100^2 + 100 \times 96 + 96^2)}{1,000} \times 1.4 = 10.17 \quad \text{[kW]}$$

$$\omega_{BC} = \frac{0.252 \times (79^2 + 79 \times 58 + 58^2)}{1,000} \times 1.4 = 5.01 \quad \text{[kW]}$$

$$\omega_{CU} = \frac{0.252 \times 12^2}{1,000} \times 0.6 = 0.02 \quad \text{[kW]}$$

$$\omega_{CQ} = 5.28 \quad \text{[kW]}$$

The total power loss is obtained as follows:

$$\omega = \Sigma\,\omega_{xy} \quad \text{[kW]}$$

$$= \omega_{AB} + \omega_{BC} + \omega_{CU} + \omega_{CQ}$$

$$= 20.48 \quad \text{[kW]}$$

Hence, the annual power loss comes to:

$$W = 20.48 \times 0.4 \times 8,760 \times 10^{-3}$$

$$\fallingdotseq 71.76 \text{ [MWH]}$$

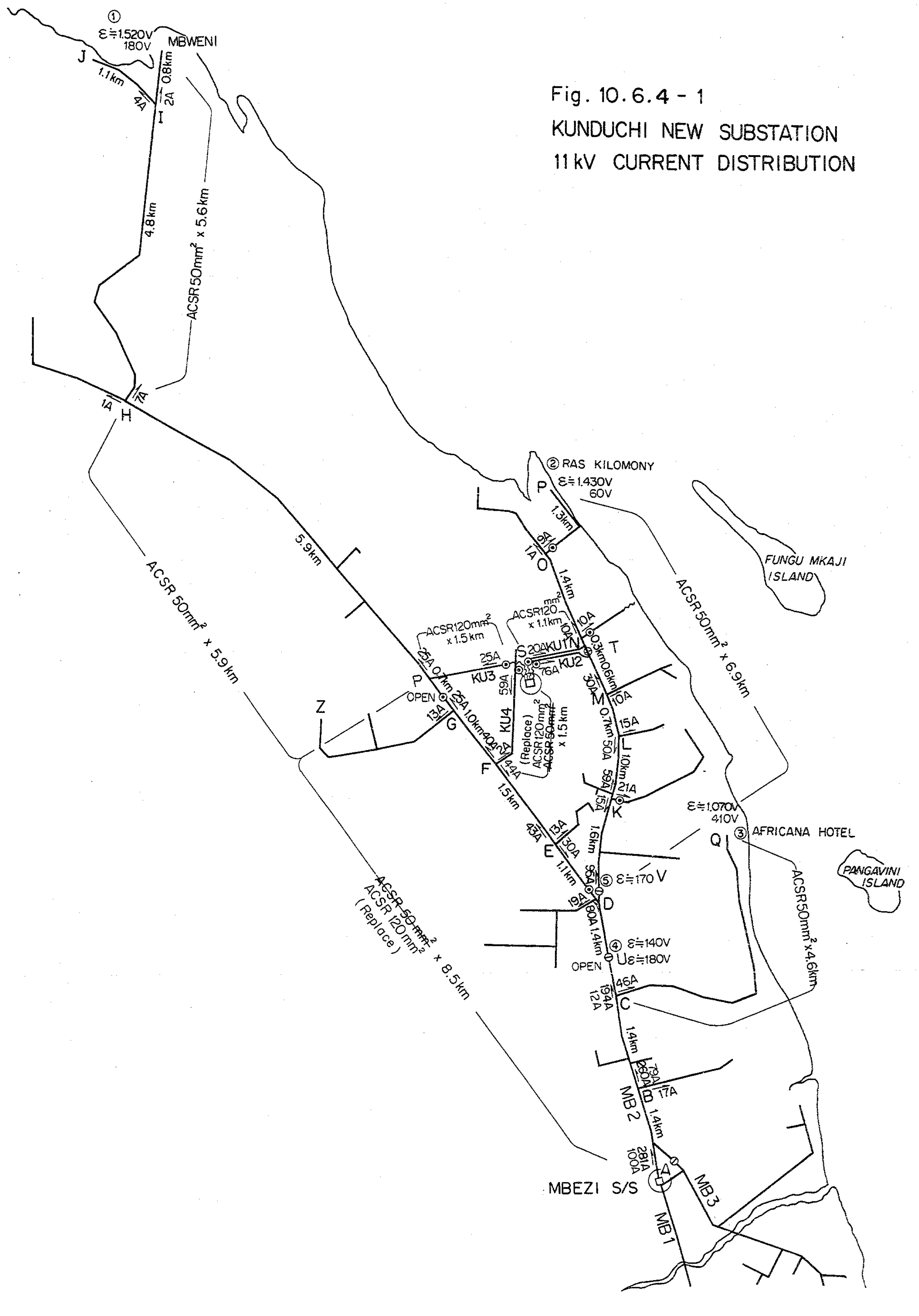
(3) Reduction in power loss

Annual reduction in power = annual power loss (before countermeasure - after countermeasures)

$$= 1.590 - (2.87 + 38.44 + 13.67 + 24.77 + 71.7)$$

$$\fallingdotseq 1.438 \text{ [MWH]}$$

Fig. 10.6.4 - 1
KUNDUCHI NEW SUBSTATION
11 kV CURRENT DISTRIBUTION



10.7 FEEDER MAINTENANCE TELECOMMUNICATIONS SYSTEM

In consideration of the facility setup, installation space, operator's works and management of maintenance service at the new substations, it is preferable that the SCADA system equivalent to the existing one should again be used for the new stations. As for the feeder maintenance telecommunications systems, they must be provided to the extent that the existing systems should partly be extended to match such use.

(1) SCADA system

The following measures should be taken for the host computer of Ilala substation.

1) Hardware: Vacant extension slots are still available in the existing facilities and thus requisite sheets should be inserted.

2) Software: Memory storage capacity is still available for each substation but it should be used to store additional monitor items after modification of the program.

It should be noted herewith that both the hardware and software of the SCADA system may frequently be upgraded from now on and thus in most cases, it may presumably be very difficult to modify or extend the old versions in the future. For this reason, in case the commencement of this study is postponed, the details of the works should be subject to review.

(2) Feeder maintenance telephone

Presently, an independent telephone number is assigned to each substation and thus communication is available over telephone by dialing either from the control room of Ilala station or each substation as necessary. The same sort of assignment of the telephone number should likewise be done for the new substations with the installation of the same telephone and cradle as the existing ones.

CHAPTER 11

CONSTRUCTION WORK PLAN

Chapter 11 Construction Work Plan

CHAPTER 11 CONSTRUCTION WORK PLAN

The present state of the power supply facilities for the Dar Es Salaam City region that is the subject of the preliminary design may be said that it has been much improved beyond our expectations as compared to that in ten years ago. Nonetheless, from a point of view of the long-term perspective of the future of Tanzania, it is not enough yet. Presently, there still exist in Tanzania frequent accidental service interruptions or burning of electric equipment due to considerable variations in the supply voltage. In view of it, it is still strongly desired that the construction of new facilities and additional installation or modification of the existing facilities should be implemented without a moment's delay.

To conduct the construction works exactly and safely, it is recommended that the construction procedures, organization setup and construction work schedule should be planned as shown below.

11.1 CONSTRUCTION PROCEDURES

The construction works should be carried out on a semi-full-turnkey basis where all works are executed under the direct management of TANESCO as a rule but as for the construction of new substations and additional installation and modification of the existing substations, the assembly and adjustment of the equipment except for the civil works thereof, should be undertaken by the respective makers. In addition, the construction works of the transmission lines and substations should be carried out step by step and moreover the construction work of the distribution lines should be carried out concurrently in the respective construction sites that are divided to match the respective power supply areas which each substation under this is scheduled to undertake.

11.2 ORGANIZATION SETUP FOR CONSTRUCTION WORK

Since the construction works under this study are carried out in accordance with the facility expansion plan, the most part of them is the new construction works and thus the modification, repair and replacement works of the existing facilities are rather less. Despite the situations, those works inevitably call for frequent scheduled shutdown of power supply due to the inclusion of such additional installation and modification works of the existing facilities. In addition, the target region of the scheduled shutdown of power failure involves among others the urban areas such as the government and municipal office district and business district, as well as densely built-up surrounding residential districts. Under the circumstances, it may presumably be rather difficult to secure an ample shutdown time.

For this reason, it is indispensable to include in the construction organization setup a special team dedicated to the preparation of the design documents, work schedule table, work procedure manuals, etc. so that the construction group can perform the works very efficiently thereby enabling the execution of the exact construction works in the minimum scheduled shutdown time as well as securing the safety of the construction works.

It should be noted further that in this study, all vehicles are equipped with a VHF transceiver or the like to facilitate the communications and secure instruction measures, which are the extremely important factors in the process of the construction and moreover allow the construction works to be carried out more efficiently.

11.3 CONSTRUCTION SCHEDULE

By taking into account the above-mentioned construction procedures and organization setup, the construction schedule is temporally established as shown in Table 11-1.

Table 11－1 Construction Schedule

	1994												1995												1996											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
SUBSTATION :																																				
1. Ilala S/S	■	■	■	■	■	■	■	■	■	■	■	■																								
2. Ubungo S/S 132kV	■	■	■	■	■	■	■	■	■	■	■	■																								
3. Tandale S/S	■	■	■	■	■	■	■	■	■	■	■	■																								
4. Chang'ombe S/S	■	■	■	■	■	■	■	■	■	■	■	■																								
5. Kurasini S/S	■	■	■	■	■	■	■	■	■	■	■	■																								
6. Mbezi S/S	■	■	■	■	■	■	■	■	■	■	■	■																								
7. Kunduchi S/S																									■	■	■	■	■	■	■	■	■	■	■	■
8. Kariakoo S/S																									■	■	■	■	■	■	■	■	■	■	■	■
9. Mbagala S/S																									■	■	■	■	■	■	■	■	■	■	■	■
10. Tabata S/S																									■	■	■	■	■	■	■	■	■	■	■	■
11.																																				
TRANSMISSION LINE :																																				
1. Ubungo-Ilala 132kV Line	■	■	■	■	■	■	■	■	■	■	■	■																								
2. Tandale S/S 33kV Line	■	■	■	■	■	■	■	■	■	■	■	■																								
3. Chang'ombe S/S 33kV Line	■	■	■	■	■	■	■	■	■	■	■	■																								
4. Ubungo-F.Z.Ⅲ 132kV Line																									■	■	■	■	■	■	■	■	■	■	■	■
5. Kunduchi S/S 33kV Line																									■	■	■	■	■	■	■	■	■	■	■	■
6. Kariakoo S/S 33kV Line																									■	■	■	■	■	■	■	■	■	■	■	■
7. Mbagala S/S 33kV Line																									■	■	■	■	■	■	■	■	■	■	■	■
8. Tabata S/S 33kV Line																									■	■	■	■	■	■	■	■	■	■	■	■
DISTRIBUTION LINE :																																				
1. Ilala S/S 11kV 2cct										■	■																									
2. Tandale S/S 11kV 3cct		■	■	■																																
3. Chang'ombe S/S 11kV 4cct				■	■	■																														
4. Mbezi S/S 11kV 3cct									■	■																										
5. Kunduchi S/S 11kV 4cct																									■	■	■									
6. Kariakoo S/S 11kV 3cct																											■	■	■	■						
7. Mbagala S/S 11kV 3cct																														■	■	■				
8. Tabata S/S 11kV 2cct																																	■	■		

CHAPTER 12

CONSTRUCTION COST

Chapter 12 Construction Cost

Page

CHAPTER 12 CONSTRUCTION COST

In this study, the construction cost is obtained by directly calculating the itemized rough construction cost in respect of substations, 132 kV and 33 kV transmission lines, 11 kV distribution lines, vehicles and tools, etc.

12.1 PREREQUISTES FOR CONSTRUCTION COST ESTIMATION

To calculate the construction cost, the following conditions are taken into account:

(1) Unit price of construction equipment and materials

As for the FOB price, the prices in 1992 are adopted and in addition, the rise in prices is included but the import duties of Tanzania is excluded.

(2) Transportation cost and insurance

The transportation cost includes the domestic transportation cost in Tanzania as well as the ocean freight, and moreover the insurance is added to the above FOB prices mentioned in (1) thus making them into CIF prices.

(3) Labor cost

The construction equipment and material costs are determined after due consideration being given to the TANESCO's current standard labor costs as well as to the actual results obtained in the similar projects in Japan.

The cost estimation for the works related to the construction of substations is done on a semi-full turnkey basis.

(4) Contingent expense

15% each of the foreign and local portions is appropriated for the contingent expense.