2) Replacement of air filters

The air filters at the air inlets of the synchronous condensers, which were partly torn, are required to be repaired or replaced with new ones immediately to prevent the dusts and dirt from entering into the machines.

3) Periodical inspection of synchronous condenser

Since ageing of the equipment will be continued year after year, each part of the synchronous condensers should be inspected periodically, even after the overhaul have been executed. The detailed inspection with disassembling of the coil end covers and the bearing covers should preferably be executed once a year.

8.3 Plan of Urgent Rehabilitation

This Clause describes the plan of the urgent rehabilitation for each equipment of the substation facilities, on the basis of the results of the field investigation and analysis that are described in Subsections 8.1.2 and 8.1.3.

8.3.1 Plan of Urgent Rehabilitation for Da Nhim Power Station

(1) Rehabilitation of Transformers

The urgent rehabilitation plan for each transformer is formulated on the basis of the result of the field investigation and the laboratory analysis of the insulating oil. The transformers whose insulation was judged to be deteriorated by the oil analysis are recommended to be replaced with new ones. In case of the transformers whose insulation have not yet so deteriorated, only the necessary rehabilitation should be executed partly so that those transformers could certainly be operated continuously for a while.

1) Main transformers (1T, 2T, 3T, 4T)

The following items are recommended for the urgent rehabilitation work of each main transformer. The following rehabilitation also need to be applied to the main transformer "1T", if "1T" need not be replaced from the result of the top urgent rehabilitation described in Section 8.2.

a) Replacement of all bushings

All bushings for the main transformers is planned to be replaced with new ones, because they are used exceeding their standard service life and their oil tight construction is estimated to be deteriorated.

b) Countermeasure against vibration of transformer

The necessary repairs for the vibration problem, such as re-tightening of the cores, should be executed upon the overhaul inspection.

c) Change of insulating oils

The insulating oil for each main transformer needs to be changed after completion of the overhaul.

d) Replacement of oil circulating pumps

Since the oil circulating pumps were aged and some of them had oil leakage, all the oil circulating pumps should preferably be replaced with new ones.

e) Replacement of mechanical protective relays

All of the buchholtz relays, oil flow relays, water flow relays and dial thermometers for each main transformer need to be replaced with new ones.

f) Renewal of oil preservation system

The nitrogen gas sealing equipment is recommended to be replaced because its oil-preservation function was expected to be deteriorated by ageing. Since the nitrogen gas sealing equipment went out of use, it is recommended to change to the diaphragm type with an oil-resistant synthetic rubber air cell in the conservator.

g) Repair painting on the transformers

The damaged paint and rusted parts need to be re-painted.

h) Supply of spare parts

The following items are required to be supplied as spare parts for the main transformers.

- One 230 kV phase bushing
- One 230 kV neutral bushing
- One 13.2 kV bushing
- One buchholtz relay
- Four oil flow relays
- One water flow relay
- Two dial thermometers
- One oil level gauge

2) House-service transformers (11T, 12T, 13T, 14T)

Judging from the result of the field investigation and the oil analysis, the following rehabilitation is required for all the house-service transformers.

a) Replacement of bushings

b) Replacement of gaskets for top covers

c) Change of the insulating oils

d) Repair painting on the transformers

e) Supply of spare parts

However, it is expected that the total cost for the above rehabilitation work would be more expensive than the renewal cost of the transformers. That is why it is recommended that all the house-service transformers should be replaced with new ones.

3) 31.5 kV transformer (6T, 7T)

Judging from the result of the oil analysis, it is recommended that the 31.5 kV transformer "6T" should be replaced with a new one and that the insulating oil for "7T" should be changed. By the way, "6T" and "7T" were usually operated in parallel to supply the electric power to the Dong Duong district. Accordingly, it is preferable that "6T" and "7T" should be united in one transformer. The new 31.5 kV transformer is recommended to be installed at the place where the existing "6T" was located. The rated power of the new "6T" should preferably be increased to 10,000 kVA, taking into account the future demand.

4) 66 kV transformers (8T-A, 8T-B, 8T-C, 5T)

The 66 kV transformers of "8T-A", "8T-B" and "8T-C" were used to supply the electric power to the Substations of Thap Cham, Phan Ri, Phan Thiet and Cam Ranh, etc. The three 66 kV transformers are planned to be removed from the Da Nhim Power Station after those substations have been upgraded to 110 kV. That is why the three 66 kV transformers are excluded from the scope of the urgent rehabilitation work.

On the other hand, the following rehabilitation is recommended for the 66 kV transformer "5T".

a) Replacement of the air breather

Replacement of the air breather is recommended because the air breather was broken.

b) Replacement of cooling fan control unit

Replacement of the cooling fan control unit and its dial thermometer are recommended because the cooling fan control unit was troubled.

c) Repair painting on the transformer

The damaged paint and rusted parts need to be re-painted.

d) Supply of spare parts

One dial thermometer is required to be supplied as spare parts for the 66 kV transformer "5T".

5) Rehabilitation of 110 kV transformer (9T)

The gaskets for the hand hole of the on-load tap changer are recommended to be replaced with new ones because considerable oil leakage was observed near the hand hole.

It is noted that this existing 110 kV transformer "9T" is planned to be replaced in connection with the upgrading plan of 66 kV transmission system as described in Chapter 10.

(2) Rehabilitation of Switchgear

1) 230 kV air-blast circuit breakers

By the field investigation, no serious problems were found out on the 230 kV circuit breakers. There were only minor problems such as a little oil leakage from the dash-pots and corrosion of the local control boxes, which will not interfere with the successful operation of the circuit breakers for a while.

On the other hand, the Study Team made a trial calculation of the short-circuit current at the 230 kV bus of the Da Nhim Power Station, to check whether the short-circuit current rating of the existing circuit breaker, 8.8 kA, is still sufficient in the future or not. The calculation result shows that the prospective short-circuit current will not exceed 8.8 kA by the year 2005. Therefore, the urgent replacement of the 230 kV circuit breakers will not be required.

Since the air-blast type circuit breaker went out of date and is not manufactured any more, the replacement parts are hard to be supplied.

Under this circumstances, it is preferable that the scope of the urgent rehabilitation for the air-blast circuit breakers should be held down to the irreducible minimum of the necessity; namely, the rehabilitation of the local control boxes, whose interior was corroded due to dampness, is recommended. Since the replacement of the whole local control box seems to be very difficult from the structural point of view, the replacement of the pressure switches and door gaskets are recommended for all the air-blast circuit breakers.

2) 230 kV disconnecting switches

The local control boxes for all the disconnecting switches are recommended to be replaced with new ones because they were corroded due to dampness. Also, the six disconnecting switches of "231-1", "232-2", "271-2", "271-3", "200-1" and "200-2", which could not close perfectly, should be adjusted and repaired.

Five auxiliary switches are required to be supplied as spare parts for the 230 kV disconnecting switches.

3) 230 kV current transformers

The rehabilitation of the 230 kV current transformers will not be required in the urgent rehabilitation stage.

4) 230 kV voltage transformers

The 230 kV voltage transformers for the 230 kV transmission line circuit were deteriorated due to ageing. Taking into consideration its importance for measuring and protective relaying, it is recommended that the 230 kV voltage transformers should be replaced with new ones.

5) 230 kV lightning arresters

The rehabilitation of the 230 kV lightning arresters will not be required in the urgent rehabilitation stage.

6) 110 kV switchgear

The rehabilitation of the 110 kV switchgear will not be required in the urgent rehabilitation stage. Meanwhile, modification and additional installation of the 110 kV switchgear, which are required for the upgrading plan of the 66 kV transmission system, are described in Chapter 10.

7) 66 kV circuit breakers

By the field investigation, no serious problems were found out on the 66 kV circuit breakers. The air-blast type and oil type circuit breakers went out of date and are not manufactured any more. Therefore, their replacement parts are hard to be supplied.

Under the circumstances, the scope of the urgent rehabilitation for the air-blast circuit breakers should preferably be held down to the irreducible minimum of the necessity; namely, the rehabilitation of the local control boxes, whose interior was corroded due to dampness, is recommended. Since the replacement of the whole local control box seems to be very difficult from the structural point of view, the replacement of the pressure switches and door gaskets are recommended for all the air-blast circuit breakers.

8) 66 kV disconnecting switches

The local control boxes for all the disconnecting switches are recommended to be replaced with new ones because they were corroded due to dampness.

9) 13.2 kV indoor switchgear

The parallel resistor for the air-blast circuit breaker "543" for phase C is required to be replaced with new one.

10) 6.6 kV indoor switchgear

The pilot contacts for the magnetic-blast circuit breakers "636" and "672" are required to be replaced.

11) Compressed air supply systems for air-blast circuit breakers

For countermeasure against the deterioration of the air displacement volume of the air compressors, all the AC motor-driven type air compressors, which are operated frequently, are recommended to be replaced with new ones. The required number of the replacement unit is two for the outdoor circuit breakers and one for the indoor circuit breakers.

Also, a new air reservoir is recommended to be added to the existing compressed air supply system for the outdoor circuit breakers, to increase the air charging capacity. The capacity of the air reservoir should preferably be 1 m^3 to be identical with the existing one.

12) 230 kV steel structures and busbars

The insulator discs, which were contaminated, should be cleaned out.

(3) Renewal of Control and Relay Boards

Since almost all the instruments and relays were used exceeding their standard service life and their indication and operating characteristics were deteriorated, it is recommended that all the main control boards, relay boards, generator automatic control boards and automatic synchronizing equipment should be replaced and renewed thoroughly. And that all the control cables for each control circuits should also be replaced with new ones at the same time. The new control and relay boards are planned to be installed in the unoccupied space in the existing control room.

To modernize the power station control system, it is planned to introduce a supervisory computer system for plant supervision by visual display units, for automatic recording of plant operation and faults and for preparation of daily and monthly reports.

The control power supply system is also required to be rearranged to suit the new control and protection equipment. Therefore, such station batteries, battery charger and AC and DC distribution boards are required to be replaced.

In addition, the surge tank water level gauging system equipment; namely, the water pressure gauge (in the valve house), transmitter and receiver, and a water level indicator (in the powerhouse control room).are required to be replaced with new ones because the existing system equipment was troubled. The cables between the valve house and the powerhouse for signal transmission are also required to be replaced.

8.3.2 Plan of Urgent Rehabilitation for Saigon Substation

(1) Rehabilitation of Synchronous Condensers

From the result of the field investigation, it is recommended that the synchronous condensers should be urgently rehabilitated. However, as mentioned in the minutes of the meeting held on 20th March 1995, EVN (PC-2) was of the opinion that the synchronous condensers at the Saigon Substation were now not so important for the power system operation and therefore the rehabilitation of the synchronous condensers would not be required even though the synchronous condensers were seriously aged and deteriorated on the whole. Accordingly, it is concluded that the synchronous condensers are excluded from the scope of the rehabilitation of the Saigon Substation.

In this connection, the starting transformer (6T) and the 11 kV switchgear that are related to the synchronous condensers are also excluded from the scope of the rehabilitation of the Saigon Substation.

However, only the overhead traveling crane in the synchronous condenser building need to be rehabilitated as mentioned in Paragraph (5) below.

(2) Rehabilitation of Transformers

The urgent rehabilitation plan for each transformer is formulated on the basis of the result of the field investigation and the laboratory analysis of the insulating oil. The transformers whose insulation was judged to be deteriorated by the oil analysis are recommended to be replaced with new ones. In case of the transformers whose insulation have not yet so deteriorated, only the necessary rehabilitation should be executed partly so that those transformers could certainly be operated continuously for a while.

On the other hand, PC-2 has a plan to upgrade the 66 kV system voltage to 110 kV and to upgrade the 15 kV distribution line voltage to 22 kV in the future. Therefore, all the existing 66 kV and 15 kV equipment in the Saigon Substation will be replaced with 110 kV and 22 kV equipment in the future. The urgent rehabilitation plan for the transformers is formulated taking into account this upgrading plan in the future.

1) Main transformer (1T, 2T)

Judging from the result of the oil analysis, it is recommended that the single-phase transformers of "1T-B" (# 131879A) and "2T-C" (# 131883A) should be replaced with new ones.

By the way, the new transformers should preferably be designed taking into account the upgrading plan in the future. From this respect, the replacement of one bank of the transformer is preferable to the replacement of the two single-phase transformers. Since a three-phase transformer is more economy than three single-phase transformers, it is recommended that a three-phase transformer should be provided instead of the replacement of "1T-B" and "2T-C". It is suggested that the new three-phase transformer should be installed as "2T" and its rated power should be increased to 125,000 kVA, taking into account the future demand.

As for the remaining five single-phase transformers of "1T-A" (#131878A), "1T-C" (#131877A), "2T-A" (#131880A), "2T-B" (#131882A) and a spare (#131881A), it was estimated that their insulation condition was still good at present. The following rehabilitation is recommended to be applied to the four single-phase transformers that should be chosen from the above five ones. These four single-phase transformers are used as "1T" and its spare.

a) Replacement of bushings and gaskets

All the bushings were used exceeding their service life. Considering that the main transformer "1T" has a spare phase transformer, it is expected that troubles on any one of the bushings can be repaired without a long time interruption of the transformer operation. That is why only the gaskets for the bushings is recommended to be replaced at this urgent rehabilitation stage. In this connection, the insulating oil of the bushing is recommended to be changed when the gaskets are replaced.

Meanwhile, the existing 11 kV bushings were porcelain type of old model, which have a structural defect that will not permit easy re-tightening and easy replacement of their gaskets, so that their porcelain would possibly be broken during disassembling and re-assembling. Therefore, the 11 kV bushings are recommended to be replaced with new ones, instead of replacement of their gaskets. The new bushings should be of the current standard type.

b) Replacement of oil circulating pumps and radiator valves

Since there were oil leakage on almost all the oil circulating pumps and radiator valves, all of them should preferably be replaced with new ones.

c) Replacement of mechanical protective relays

All of the buchholtz relays, oil flow relays and dial thermometers for each single-phase transformer need to be replaced with new ones.

d) Renewal of oil preservation system

The nitrogen gas sealing equipment is recommended to be replaced because its oil-preservation function was expected to be deteriorated by ageing. Since the nitrogen gas sealing equipment went out of use, it is recommenced to change to the diaphragm type with an oil-resistant synthetic rubber air cell in the conservator.

e) Change of insulating oils

Judging from the result of the oil analysis, the insulating oil for each single-phase transformer is estimated to be deteriorated. Therefore, its insulating oil needs to be changed.

f) Repair paint on the transformers

All the exposed surfaces of the transformer, especially for the damaged paint and rusted parts, need to be re-painted.

g) Supply of spare parts

The following items are required to be supplied as spare parts for the main transformers.

- One 230 kV phase bushing
- One 230 kV neutral bushing
- Two 66 kV bushings
- Two 11 kV bushings
- One buchholtz relay
- One oil flow relay
- One dial thermometer
- One oil level gauge

2) House-service transformers (5T, 7T)

Since the oil analysis was not applied to "5T" and "7T", the degradation of the transformer insulation and oil for "5T" and "7T" could not be confirmed.

However, judging from their operation of over 30 years, the oil leakage and painting problems and their small capacity as a whole, it is recommended that the house-service transformers of both "5T" and "7T" should be replaced with new ones.

Recently the station load in the Saigon Substation was increased so that the rated power of 300 kVA was not sufficient for power supply to all the station load. That is why the rated power of the new "5T" and "7T" should be increased to 400 kVA.

3) 66 kV transformers (3T, 4T)

Judging from the oil analysis, it is recommended that the 66 kV transformers "3T" and "4T" should be replaced with new ones.

The new transformers of "3T" and "4T" should be designed to meet the upgrading plan in the future. Also, the rated power of the new "3T" and "4T" should preferably be increased to 31,500 kVA, taking into account the future demand.

4) 66 kV transformer (9T)

Since the oil analysis was not applied to "9T", the degradation of the transformer insulation and oil for each phase of "9T" could not be confirmed.

However, judging from their operation of over 30 years, the oil leakage problem, failure of the mechanical protective relays and their capacity of 2,000 kVA as a whole, the 66 kV transformer "9T" should preferably be replaced with new one.

The new 66 kV transformer "9T" should be of three-phase type designed to meet the upgrading plan in the future. Also, the rated power of the new "9T" should preferably be increased to 12,500 kVA, taking into account the future demand.

(3) Rehabilitation of Switchgear

PC-2 has a plan to upgrade the 66 kV system voltage to 110 kV and to upgrade the 15 kV distribution line voltage to 22 kV in the future. Therefore, all the existing 66 kV and 15 kV equipment in the Saigon Substation will be replaced with 110 kV and 22 kV equipment in the future. Under this circumstances, it is preferable that the existing 66 kV and 15 kV switchgear should be used as they were unless they had serious problems to interfere with their operation. That is why the scope of the urgent rehabilitation plan for the switchgear is held down to the following items.

By the way, it was confirmed by PC-2 that all the 230 kV switchgear for the Saigon Substation should be excluded from the Scope of Works for the urgent rehabilitation, as mentioned in Paragraph (1) of Section 8.1.

1) 66 kV switchgear

a) 66 kV air-blast circuit breakers

The replacement of the pressure switches and door gaskets are recommended for all the air-blast circuit breakers.

b) 66 kV disconnecting switches

The local control boxes for all the disconnecting switches are recommended to be replaced with new ones because they were corroded due to dampness. Also, the eight disconnecting switches of "734-2", "751-1", "773-2", "773-7", "774-2", "774-7", "776-7" and "700-2", which could not close perfectly, should be adjusted and repaired.

c) 66 kV current transformers

Three phases of the current transformer "777" are recommended to be replaced with new one because the phase-A had excessive oil leakage and all the three phases are required to have the same characteristics.

The current transformer "772" is also required to be replaced with new ones, because it was defective.

d) 66 kV voltage transformers

The voltage transformers for the 66 kV bus No. 1, which was defective, are required to be replaced with new ones.

e) 66 kV lightning arresters

Eleven sets of the lightning arresters for three 66 kV transformer circuits of "3T", "4T" and "9T" and eight feeder circuits are recommended to be replaced with new ones because they were deteriorated by ageing. Two sets of the lightning arresters are recommended to be provided additionally to the 66 kV bus No. 1 and No. 2.

f) Repair paint

The metallic parts and steel supporting structures for all the 66 kV switchgear, which rusted heavily, are required to be coated by anti-corrosive and final paint.

g) Compressed air supply system for 66 kV air-blast circuit breakers

For countermeasure against the deterioration of the air displacement volume of the air compressors, an AC motor-driven type air compressor, which will be operated frequently, is recommended to be replaced with new one.

h) Supply of spare parts

The following items are required to be supplied as spare parts for the 66 kV air-blast circuit breakers.

- Six sets of moving and fix contacts for 1,000 A
- Three sets of moving and fix contacts for 800 A
- Three sets of moving and fix contacts for 400 A
- 40 kg of grease for dash-pot

2) 15 kV switchgear

a) 15 kV disconnecting switches

The six disconnecting switches of "577-1", "577-7", "579-1", "579-7", "581-1" and "581-7", which were remarkably deteriorated and damaged, are required to be replaced with new ones.

b) Repair paint

The metallic parts and steel supporting structures for all the 15 kV switchgear, which rusted heavily, are required to be coated by anti-corrosive and final paint.

3) Repair paint on steel structures

The steel structures for 230 kV, 66 kV and 15 kV bays, which were heavily rusted in red, are required to be coated by anti-corrosive and final paint.

4) 66 kV static condenser banks

It is recommended that one static condenser bank, which was broken at the civil war and now demolished, are recommended to be restored. The capacity of the restored bank should preferably be 10,000 kVA identical to the other banks.

(4) Rehabilitation of Control and Relay Boards

Since almost all the instruments and relays were used exceeding their standard service life and their indication and operating characteristics were deteriorated, it is recommended that all the main control boards and relay boards should be replaced and renewed thoroughly. However, the transmission line protective relay board for the 230 kV Hoc Mon line is excluded from the scope of the rehabilitation because it is out of the scope for the Study and its protection system was unknown. The AC and DC distribution boards, which were deteriorated seriously, are also required to be replaced with new ones. All the control cables for each control circuits should also be replaced with new ones at the same time.

To modernize the substation control system, it is planned to introduce a computer system for automatic recording of plant operation and faults and for preparation of daily and monthly reports.

It is preferable that all the new control and relay boards should be installed in a new control room to be located separately from the existing control room, to avoid interference with the operation of the substation facilities during a period of the replacement of the control and relay boards. In this plan, a time required for the replacement works can be minimized because all the boards and cables can be installed at the same time in advance.

Now the fault locator at the Saigon Substation become useless because it cannot function any longer to supervise the 230 kV transmission line between the Long Binh Substation and the Da Nhim Power Station. That is why the new fault locator is recommended to be installed both at the Long Binh Substation and at the Da Nhim Power Station. Selection of the type of the new fault locator is described in Subsection 8.4.2.

The existing transmission line protective relays employs the distance relaying scheme that is not so reliable in the complicated power system at present. That is why the new transmission line protective relays are planned to employ the carrier relaying scheme. Since the carrier relaying scheme needs to use a power line carrier (PLC) channel as the transmission path for the carrier signal, some modifications are required on the existing PLC system.

(5) Repair of overhead traveling crane

All the brake shoes are required to be replaced because they were estimated to be worn out. Also, the limit switch circuits to stop traveling are required to be replaced.

(6) Modification of Existing Power Line Carrier System

As aforementioned, the carrier signals will be transmitted through the PLC channel. Therefore, the existing PLC system is planned to be modified as follows.

1) PLC system between Saigon Substation and Long Binh Substation

The transmission line Phase-A, which is not used for the PLC system, is recommended to be used for the transmission pass for the carrier signals. For this purpose, it is planned that a new PLC terminal equipment with 4 channels should be provided for Phase-A at both the Saigon Substation and the Long Binh Substation, and that 1 channel out of 4 channels should be allocated for the carrier signal transmission for the protective relays. Meanwhile, the line traps, coupling capacitors and coupling filters were already installed on Phase-A at the both substations. Such existing coupling equipment is planned to be used as they are.

2) PLC system between Long Binh Substation and Da Nhim Power Station

It is recommended that the transmission line Phase-B should be used for the carrier signal transmission by replacing the existing PLC equipment with 1 channel with new one with 4 channels at the both stations, so that 1 channel out of 4 channel could be allocated for the carrier signal transmission. Meanwhile, the existing coupling equipment on Phase-B such as the line traps, coupling capacitors and coupling filters is planned to be used as they are.

8.4 Basic Design of Urgent Rehabilitation Plan

8.4.1 Basic Design of Urgent Rehabilitation Plan for Da Nhim Power Station

(1) Common clauses for basic design of rehabilitation

The replacement components for the partial rehabilitation of the existing equipment should be brand new, equivalent specifications and suitably fitted to the original structures in case the design of the components is modified. The new components are complete with all the necessary parts and materials for modification and restoration of the original structures.

The new gaskets for replacement should preferably be prepared in the factory referring to the original manufacturing drawings. If the then drawings are missing, the new gaskets would be shaped by adjusting to the original structures at the site. This will necessitate supplying one set of special tools to shape the gaskets at the site.

The new equipment should be fabricated in compliance with the specified type and rating and should also be designed suitably for connection to the existing cables and conductors. The new equipment will be complete with all the necessary accessories, erection and maintenance tools and spare parts. The new equipment will necessitate the new foundation to be redesigned.

In principle, all electrical and electromechanical equipment will comply with the latest revision of the authorized standards of the International Electrotechnical Commission (IEC). The following voltage rating will be applied to all the electrical equipment.

	Rated Voltage	Lightning Impulse Withstand Voltage	Power-frequency Withstand Voltage
230 kV equipment :	245 kV	950 kV	395 kV
110 kV equipment :	123 kV	550 kV	230 kV
66 kV equipment :	72.5 kV	325 kV	140 kV
31.5 kV equipment :	36 kV	170 kV	70 kV
13.2 kV equipment :	17.5 kV	95 kV	38 kV
6.6 kV equipment :	7.2 kV	60 kV	20 kV

The power cables for the rehabilitation should in principle be the cross-linked polyethylene insulated cables which will offer good electric characteristics and good thermal withstandability.

(2) Basic design for rehabilitation of transformer

In addition to the common clauses described in Paragraph (1), the basic design items for the rehabilitation of the transformers are as follows.

1) Transformers to be partially rehabilitated

a) Bushings

The new bushings will be the current standard design suitable for the above mentioned voltage rating. In case the new bushing is smaller in size than the existing ones, a suitable adapter will be provided as its accessory to fit the new bushing to the transformer tank. The new bushing will be complete with suitable line terminal connectors and insulation materials to restore the lead wire insulation which will be broken during the replacement work.

b) Mechanical protective relays

The new mechanical protective relays such as buchholtz relays, water flow relays and dial thermometers will be suitable for the existing protection and alarm system for the respective transformers. Each relay will be provided with control cables between the relay and the existing local control box, and all the necessary materials for fitting the relay to the existing structures.

c) Oil preservation system

The new oil preservation system will be of the diaphragm type with an oil-resistant synthetic rubber air cell in the conservator, which will offer good maintenanceability. This type is chosen to be consistent with current practice for large transformers. Each oil preservation system will be provided with a dehydrating air breather and an oil level gauge on the conservator.

2) Transformers to be renewed

The house-service transformers of "11T", "12T", "13T" and "14T" and the 31.5 kV transformer "6T" are planned to be replaced with new ones. The principal rating for the new transformers will be as follows.

a) House-service transformer "11T", "12T", "13T" and "14T"

Type	:	Three-phase, two-winding, oil-immersed type with an off-circuit tap changer
Rated power	:	500 kVA
Voltage	:	13.8-13.2(R)-12.8 kV/380 V
Connection symbol	:	D, yn 11

b) 31.5 kV transformer "6T"

Type	:	Three-phase, three-winding, oil-immersed type with an off-circuit tap changer
Rated power	:	10,000/10,000/3,000 kVA
Voltage	:	33-31.5(R)-30/13.2/6.6 kV
Connection symbol	:	YN, d1, d1

The new 31.5 kV transformer "6T" will be equipped with ring-core type current transformers in all the bushings, for measuring and protective relaying purpose.

(3) Basic design for rehabilitation of switchgear

In addition to the common clauses described in Paragraph (1), the basic design items for the rehabilitation of the switchgear are as follows.

1) Local control boxes for disconnecting switches

The new local control boxes for the 230 kV and 66 kV disconnecting switches will be fabricated by stainless steel with the same structure and size as the originals. Each local control box will be provided with an auxiliary switches of six or more stages and cable terminal blocks. Each auxiliary switch will be operated by linking to the existing manual operating handle. Each local control box will also be provided with a signal lamp on the top to indicate the operational instruction given from the control room.

2) Compressed air supply systems for air-blast circuit breakers

The new air compressors will be of AC motor driven type. The air pressure and displacement volume of the new air compressors will be the same as those of the existing ones. As for the two air compressors for outdoor circuit breakers, the same rating will be applied to both of them although the existing ones have different ratings. The principal rating of the new air compressors will be as follows.

a) Air compressors for outdoor air-blast circuit breakers (two units)

Air pressure	:	25 kg/cm^2
Displacement volume	:	1.28 m^3/min or more

b) Air compressors for indoor air blast circuit breakers (one unit)

Air pressure	:	25 kg/cm^2
Displacement volume	:	0.47 m^3/min

The additional air reservoir for the outdoor air-blast circuit breakers will be designed for the nominal air pressure of 25 kg/cm^2 and have a capacity of 1 m^3.

(4) Basic design for rehabilitation of control and relay boards

In addition to the common clauses described in Paragraph (1), the basic design items for the rehabilitation of the control and relay boards are as follows.

1) Main control boards and relay boards

The new control and relay boards will be of duplex switchboard construction so arranged that the front panels are used as the main control boards and the rear panels are used as the protective relay boards.

The new control board design will not use the control deskboard. The mimic buses, selector and control switches, which were arranged on the existing control deskboard, will be mounted on the main control boards. Accordingly, all the measuring instruments, status and fault indicators, mimic diagrams, selector and control switches will suitably be arranged on the front surfaces of the new main control boards. The measuring and control items will follow the design concept of the existing control boards.

2) Electrical protective relays

All the new electrical protective relays will preferably be digital relays to be consistent with current world practice for type of relays. The protective relaying scheme for each circuit will conform to the present protection scheme applied, except for protection of the 230 kV transmission line.

The new protective relaying scheme for the 230 kV transmission line and the new fault locator are described in Section 8.4.2.

3) Unit automatic control board and automatic synchronizing equipment

The new unit automatic control board for the generator will employ the programmable controller using function-oriented microcomputer system, which is consistent with the current world practice for the modernized hydro plant control. The programmable controller will offer easy modification of the automatic control sequence for the generating unit.

The new automatic synchronizing equipment will be of electronic transistorized type, which is currently used, and will consist of an automatic synchronizer, a voltage balance relay and a frequency matching device.

4) Supervisory computer system

The supervisory computer system will perform the management of process data for overall control and supervision of the power station by using visual display units and for data logging of the plant operation and events. The supervisory computer system will be composed of main computer units, visual display units, keyboards, logging printers, etc.

In order to interface with the computer system, each major measuring circuit will be provided with measuring transducers for all the electrical quantities such as current, voltage, active power, reactive power and frequency, and for temperatures. Also, each watthour meter will be provided with a pulse transmitter.

The supervisory control system will incorporate all the necessary provisions for interface with the SCADA system to be established in the future.

5) Control source supply equipment

The supervisory computer system will necessitate an uninterruptible AC power supply system. This additional installation will cause to increase the capacity of the DC supply system. That is why the control source supply equipment including the station battery and the battery charger is required to be replaced thoroughly. The new control source supply system will consist of a station battery, a battery charger, a DC-AC inverter and DC and AC distribution panels. The supply voltage will be DC 220 V and AC 220 V which are the same as the existing facilities.

6) Surge tank water level gauging system

The new water level gauge will be a pressure gauge to be connected to the existing tap on the penstock in the valve house. The gauged water level is required to be indicated on the main control board, which is 2.5 km away from the gauging point. The transmitter for the water level gauge and the receiver will be selected suitably for this remote indication purpose. Meanwhile, the cables between the valve house and the powerhouse will be the control cables of 2.5 mm^2, 20 cores, self-supporting type to be installed in air along the penstock line from the valve house to the powerhouse.

8.4.2 Basic Design of Urgent Rehabilitation Plan for Saigon Substation

(1) Common clauses for basic design of rehabilitation

The replacement components for the partial rehabilitation of the existing equipment should be brand new, equivalent specifications and suitably fitted to the original structures in case the design of the components is modified. The new components are complete with all the necessary parts and materials for modification and restoration of the original structures.

The new gaskets for replacement should preferably be prepared in the factory referring to the original manufacturing drawings. If the then drawings are missing, the new gaskets would be shaped by adjusting to the original structures at the site. This will necessitate supplying one set of special tools to shape the gaskets at the site.

The new equipment should be fabricated in compliance with the specified type and rating and should also be designed suitably for connection to the existing cables and conductors. The new equipment will be complete with all the necessary accessories, erection and maintenance tools and spare parts. The new equipment will necessitate the new foundation to be redesigned.

In principle, all electrical and electromechanical equipment will comply with the latest revision of the authorized standards of the International Electrotechnical Commission (IEC). The following voltage rating will be applied to all the electrical equipment.

		Rated Voltage	Lightning Impulse Withstand Voltage	Power-frequency Withstand Voltage
230 kV equipment	:	245 kV	950 kV	395 kV
110 kV equipment	:	123 kV	550 kV	230 kV

66 kV equipment	:	72.5 kV	325 kV	140 kV
22 kV equipment	:	24 kV	125 kV	50 kV

The power cables for the rehabilitation should in principle be the cross-linked polyethylene insulated cables which will offer good electric characteristics and good thermal withstandability.

(2) Basic design for rehabilitation of transformer

In addition to the common clauses described in Paragraph (1), the basic design items for the rehabilitation of the transformers are as follows.

1) Transformers to be partially rehabilitated

a) Bushings

The new bushings will be the current standard design suitable for the above mentioned voltage rating. In case the new bushing is smaller in size than the existing ones, a suitable adapter will be provided as its accessory to fit the new bushing to the transformer tank. The new bushing will be complete with suitable line terminal connectors and insulation materials to restore the lead wire insulation which will be broken during the replacement work.

The new gaskets for the existing bushings of the main transformer "1T" should be identical in shape with the originals. The insulating oil for the bushings will also be changed when their gaskets are replaced. The type and grade of the insulating oil should be suitable for the existing bushings.

b) Mechanical protective relays

The new mechanical protective relays such as buchholtz relays, water flow relays and dial thermometers will be suitable for the existing protection and alarm system for the respective transformers. Each relay will be provided with control cables between the relay and the existing local control box, and all the necessary materials for fitting the relay to the existing structures.

c) Oil preservation system

The new oil preservation system will be of the diaphragm type with an oil-resistant synthetic rubber air cell in the conservator, which will offer good maintenanceability. This type is chosen to be consistent with current practice for large transformers. Each oil preservation system will be provided with a dehydrating air breather and an oil level gauge on the conservator.

2) Transformers to be renewed

The transformers planned to be renewed in the Saigon Substation are the main transformer "2T", the house-service transformers "6T" and "7T" and the 66 kV transformers "3T", "4T" and "9T". The principal rating for the respective new transformer will be as follows.

a) Main transformer "2T"

Type	:	Three-phase, three-winding, oil-immersed type with an on-load tap changer
Rated power	:	125,000/125,000/40,000 kVA
Rated primary voltage	:	230 kV
Rated secondary voltage	:	69 kV/115 kV
Rated tertiary voltage	:	11 kV
Connection symbol	:	YN, yn0, d1

The secondary winding for the new main transformer "2T" will be designed for dual voltage rating of 69 kV and 115 kV which can be switched over easily from the outside of the transformer by changing the connection of the secondary winding. This dual voltage rating is required for the future plan to upgrade the transmission line voltage from 66 kV to 110 kV in the future.

The new main transformer "2T" will be equipped with ring-core type current transformers of 1 ampere secondary in all the bushings, for measuring and protective relaying purpose. In addition, the new main transformer "2T" will be provided with an oil sump tank and will be installed on a new concrete foundation.

b) House-service transformer "5T"

Type	:	Three-phase, two-winding, oil-immersed type with an off-circuit tap changer
Rated power	:	400 kVA
Primary voltage	:	11.5-11.0 (R)-10.5 kV

Rated secondary voltage	:	400 V
Connection symbol	:	D, yn11

c) House-service transformer "7T"

Type	:	Three-phase, two-winding, oil-immersed type with an off-circuit tap changer
Rated power	:	400 kVA
Rated primary voltage	:	15 kV/22 kV
Rated secondary voltage	:	400 V
Connection symbol	:	D, yn11

The primary winding for both the new house-service transformers "5T" and "7T" will be designed for dual voltage rating of 15 kV and 22 kV which can be switched over easily from the outside of the transformer by changing the connection of the primary winding. This dual voltage rating is required for the future plan to upgrade the distribution line voltage from 15 kV to 22 kV in the future.

d) 66 kV transformers "3T" and "4T"

Type	:	Three-phase, two-winding, oil-immersed type with an on-load tap changer
Rated power	:	31,500 kVA
Rated primary voltage	:	69 kV/115 kV
Rated secondary voltage	:	15 kV/22 kV
Connection symbol	:	D, yn1

The primary windings for the new 66 kV transformers "3T" and "4T" will be designed for dual voltage rating of 69 kV and 115 kV which can be switched over easily from the outside of the transformers by changing the connection of the primary windings, to cope with the future upgrading plan of the transmission line voltage from 66 kV to 110 kV.

Similarly, the secondary windings will also be designed for dual voltage rating of 15 kV and 22 kV to cope with the future upgrading plan of the distribution line voltage from 15 kV to 22 kV.

The new 66 kV transformers "3T" and "4T" will be equipped with ring-core type current transformers in all the bushings, for measuring and protective relaying purpose.

e) 66 kV transformer "9T"

Type	:	Three-phase, two-winding, oil-immersed type with an on-load tap changer
Rated power	:	12,500 kVA
Rated primary voltage	:	69 kV/115 kV
Rated secondary voltage	:	15 kV/22 kV
Connection symbol	:	D, yn 1

The primary winding for the new 66 kV transformer "9T" will be designed for dual voltage rating of 69 kV and 115 kV which can be switched over easily from the outside of the transformer by changing the connection of the primary winding, to cope with the future upgrading plan of the transmission line voltage from 66 kV to 110 kV.

Similarly, the secondary winding will also be designed for dual voltage rating of 15 kV and 22 kV to cope with the future upgrading plan of the distribution line voltage from 15 kV to 22 kV.

The new 66 kV transformer "9T" will be equipped with ring-core type current transformers in all the bushings, for measuring and protective relaying purpose.

(3) Basic design for rehabilitation of switchgear

In addition to the common clauses described in Paragraph (1), the basic design items for the rehabilitation of the switchgear are as follows.

1) Local control boxes for 66 kV disconnecting switches

The new local control boxes for the 66 kV disconnecting switches will be fabricated by stainless steel with the same structure and size as the originals. Each local control box will be provided with an auxiliary switches of six or more stages and cable terminal blocks. Each auxiliary switch will be operated by linking to the existing manual operating handle. Each local control box will also be provided with a signal lamp on the top to indicate the operational instruction given from the control room.

2) 66 kV current transformers

Each 66 kV current transformer will be provided with four cores and rated as follows.

a) Current transformer "777"

Highest system voltage	:	72.5 kV
Rated current ratio	:	1,200-800/5-5-1-1 A
Rated short-time thermal current	:	40 kA
Accuracy		
- for measuring	:	1.0
- for protective relaying	:	5P20
Rated output		
- for measuring	:	40 VA
- for protective relaying	:	40 VA

b) Current transformer "772"

Highest system voltage	:	72.5 kV
Rated current ratio	:	1,200-600/5-5-1-1 A
Rated short-circuit withstand current	:	40 kA
Accuracy		
- for measuring	:	0.5
- for protective relaying	:	5P20
Rated output		
- for measuring	:	40 VA
- for protective relaying	:	40 VA

The new 66 kV current transformers will be provided with their supporting structures.

3) 66 kV voltage transformers

The principal rating for the new voltage transformers for the 66 kV bus No. 1 will be as follows.

Highest system voltage	:	72.5 kV
Rated voltage ratio	:	66 kV/$\sqrt{3}$: 110 V/$\sqrt{3}$: 110 V/3
Accuracy		
- for measuring	:	1.0
- for protective relaying	:	3P
Rated output		
- for measuring	:	400 VA
- for protective relaying	:	100 VA

The new voltage transformers will be provided with their supporting structures.

4) 66 kV lightning arresters

The new 66 kV lightning arresters will be of zinc oxide gapless type and will be provided with their supporting structures. The principal rating for the new lightning arresters will be as follows.

Rated voltage	:	84 kV or higher
Max. continuous operating voltage	:	46 kV or higher
Nominal discharge current	:	10 kA

5) Air compressors

The new air compressor for 66 kV air blast circuit breakers will be of AC motor driven type. Its principal rating will be as follows.

Air pressure	:	25 kg/cm^2
Displacement volume	:	1.28 m^3/min or more

6) 15 kV disconnecting switches

The new 15 kV disconnecting switches will be of outdoor use, three-pole, horizontal installation type designed for three-phase manual operation by a manual operating handle. The new disconnecting switches will be rated at 22 kV taking into account the future upgrading plan of the distribution line voltage from 15 kV to 22 kV. Their principal rating will be as follows.

Rated voltage	:	24 kV
Rated normal current	:	1,250 A
Rated short-time withstand current	:	25 kA

The new disconnecting switches will be provided with their supporting structures.

7) 66 kV static condenser

The new static condenser bank will have a capacity of 10,000 kVA which is the same as the existing other banks, and will be provided with a shunt reactor, discharge coils, an insulation transformer and their supporting structures.

(3) Basic design for rehabilitation of control and relay boards

In addition to the common clauses described in Paragraph (1), the basic design items for the rehabilitation of the control and relay boards are as follows.

1) Main control boards and relay boards

The new control and relay boards will be of duplex switchboard construction so arranged that the front panels are used as the main control boards and the rear panels are used as the protective relay boards.

The new control board design will not use the control deskboard. The mimic buses, selector and control switches, which were arranged on the existing control deskboard, will be mounted on the main control boards. Accordingly, all the measuring instruments, status and fault indicators, mimic diagrams, selector and control switches will suitably be arranged on the front surfaces of the new main control boards. The measuring and control items will follow the design concept of the existing control boards.

2) Electrical protective relays

All the new electrical protective relays will preferably be the digital relays to be consistent with current world practice for type of relays. The protective relaying scheme for each circuit will conform to the present protection scheme applied, except for protection of the 230 kV transmission line.

The new 230 kV transmission line protective relay will employ the directional comparison carrier relaying scheme by using the distance relays. The carrier signal will be transmitted through the PLC channel.

3) Computer system

The supervisory computer system will perform the management of process data for data logging of the plant operation and events. The computer system will be composed of main computer units, a visual display unit, keyboards, logging printers, etc.

In order to interface with the computer system, each major measuring circuit will be provided with measuring transducers for all the electrical quantities such as current, voltage, active power, reactive power and frequency, and for temperatures. Also, each watthour meter will be provided with a pulse transmitter.

The supervisory control system will incorporate all the necessary provisions for interface with the SCADA system, which will include remote control of the circuit breakers, to be established in the future.

4) Fault locator

Two types of the fault locator; pulse radar type and impedance measuring type are considered for application to the transmission lines of direct grounding system.

The pulse radar type, which were applied to the existing fault locator, will offer good performance. However, the total system price for the pulse radar type will become expensive because it will necessitate coupling equipment such as line traps and coupling capacitors on each phase of the transmission lines. The main fault locator unit of the pulse radar type will also be rather expensive than the impedance measuring type. On the other hand, the impedance measuring type will be able to make its system simply by connection to current transformers and voltage transformers, economy, and have similar performance to the pulse radar type. Thus, the impedance measuring type fault locator is usually selected for application to the transmission lines of direct grounding system in recent years. Since there is a branch for the Bao Loc Substation in mid point of the 230 kV transmission line, the fault locator will be required to be placed at both the Long Binh Substation and the Da Nhim Power Station in any case.

After all, the fault locator for the 230 kV Da Nhim line will employ the impedance measuring type and will be placed at both the Long Binh and the Da Nhim. It is preferable that the fault locator of impedance measuring type should be incorporated in the transmission line protective relays as an optional function of the relays.

5) Control source supply equipment

The supervisory computer system will necessitate an uninterruptible AC power supply system. This additional installation will cause to increase the capacity of the DC supply system. That is why a new control source supply system is required to be installed in addition to the existing equipment which will be used as stand-by. The new control source supply system will consist of a station battery, a battery charger, a DC-AC inverter and DC and AC distribution panels. The supply voltage will be DC 230 V and AC 230 V which are the same as the existing facilities.

6) Power line carrier system

The carrier signals for the 230 kV transmission line carrier protective relays will be transmitted through the PLC channel to be provided on Phase-A for the section of Saigon - Long Binh and on Phase-B for the section of Long Binh - Da Nhim. The existing coupling equipment such as line traps, coupling capacitors and coupling filters at each station will be used as they are.

Accordingly, the following new equipment will be required for the modification of the PLC system at each station.

a) For Saigon Substation

One set of PLC terminal equipment of 4 ch and 10 W
One set of teleprotection equipment
One lot of coaxial cables

b) For Long Binh Substation

One set of PLC terminal equipment of 4 ch and 10 W
One set of PLC terminal equipment of 4 ch and 20 W
Two sets of teleprotection equipment
One lot of coaxial cables

c) For Da Nhim Power Station

One set of PLC terminal equipment of 4 ch and 20 W
One set of teleprotection equipment
One lot of coaxial cables

8.5 Implementation Program of Urgent Rehabilitation Plan

8.5.1 Implementation Program of Urgent Rehabilitation Plan for Da Nhim Power Station

The rehabilitation work for the substation facilities in the Da Nhim Power Station is to be programmed to minimize a period of power interruption forced by the rehabilitation work, in good coordination with the rehabilitation work for the water turbines, the generators and the 230 kV transmission line.

All the equipment, components and materials necessary for the implementation of the rehabilitation will be procured through an international competitive bid. All the rehabilitation work will be executed by the staff of the Da Nhim Power Station and PC-2 under the guidance of the expatriate supervisors who will be dispatched from the contractor.

The implementation program of the rehabilitation of the respective substation facilities are as follows.

(1) Implementation program for rehabilitation of transformers

1) Rehabilitation of main transformers (1T, 2T, 3T, 4T)

The rehabilitation work for each main transformer is to be executed under the de-energizing condition at the same period as the rehabilitation work for the related unit of the turbine and generator unit. The main transformers need to be disassembled for their rehabilitation and therefore they will be brought out to the assembling bay in the powerhouse.

The basic members of the working group for the main transformers will be nine persons consisting of one foreman, five electricians and three unskilled workers. Some mechanics, welders and painters will also be required temporarily. Two expatriate supervisors will be required for the rehabilitation of the main transformers. With the above working members, the period of the rehabilitation work for each bank is estimated at 60 days.

2) Renewal of house-service transformers (11T, 12T, 13T, 14T)

The replacement work of the house-service transformers can be carried out in any time regardless of the period of the rehabilitation work for the turbine and generator units. The house-service transformers are to be replaced one after another successively to secure continuous station power supply.

3) Replacement of 31.5 kV transformer (6T)

The new 31.5 kV transformer "6T" will be located at the same place as the existing "6T". The new transformer will necessitate a new foundation which will be made after removal of the existing foundation. The period of power interruption caused by the replacement work is estimated at about one and a half months, including the time for the foundation work. Therefore, suitable countermeasure will be required on the system operation for tentative power supply to the Dong Duong district during this period. On the other hand, the existing 31.5 kV transformer "7T" is planned to be demolished at the replacement of "6T".

4) Rehabilitation of 66 kV transformer (5T)

The rehabilitation work for the 66 kV transformer "5T" is to be executed under the de-energized condition. Judging from the work items, the rehabilitation work can be done by the local staffs only.

(2) Implementation program for rehabilitation of switchgear

The rehabilitation work for the circuit breakers and disconnecting switches is to be executed with de-energizing the related circuits tentatively. Judging from the work items, the rehabilitation work can be done by the local staffs only.

The replacement of the 230 kV voltage transformers for the transmission line circuit is to be carried out under the de-energizing condition. Since the 230 kV transmission line is the trunk line for the PC-2's power system, a long time power interruption will not be allowed. Therefore, the replacement of the 230 kV voltage transformers is planned to be done at the same time as the rehabilitation work for the 230 kV transmission line under good coordination.

(3) Implementation program for rehabilitation of control and relay boards

The new control and relay boards are planned to be arranged in the unoccupied space in the existing control room. It is proposed that the replacement of the control and relay boards should be done in the following procedures.

a) First of all, to replace all the control source supply equipment such as the station battery, the battery charger and the DC and AC distribution panels.

b) Subsequently, to install all the new control boards at the pre-determined places.

c) To lay the new control cables only for the first unit. And then, to transfer the control circuits from the old to the new control board for the first unit.

d) To remove all the old cables for the first unit before proceeding to the second unit, in order to prevent the old and new cables from becoming mixed.

e) To transfer the control boards one after another successively in the above mentioned procedure.

f) To wire between the new control boards and a marshaling kiosk which will be provided for interface with the computer system.

g) To remove all the old control boards.

h) At the last, to install the computer system.

The working group for the control and relay boards will consist of one foreman, four electricians and ten unskilled workers. Four expatriate supervisors will be required for the guidance of the installation and the field test for the control and relay boards. On the other hand, the working group for the surge tank water level gauging system will consist of one foreman, two electrician and five unskilled workers.

With the above working members, all the rehabilitation work for the control and relay boards will be completed in four months or so.

8.5.2 Implementation Program of Urgent Rehabilitation Plan for Saigon Substation

The rehabilitation work for the substation facilities in the Saigon Substation is to be programmed to minimize a period of power interruption forced by the rehabilitation work. Therefore, it is very important to coordinate not only with the related rehabilitation works but also with the operation of the Thu Duc Thermal Power Station, which is connected to the 66 kV and 15 kV busbars for the Saigon Substation.

All the equipment, components and materials necessary for the implementation of the rehabilitation will be procured through an international competitive bid. All the rehabilitation work will be executed by the staff of the Transmission Department of PC-2 under the guidance of the expatriate supervisors who will be dispatched from the contractor.

The implementation program of the rehabilitation of the respective substation facilities are as follows.

(1) Implementation program for rehabilitation of transformers

The rehabilitation work of the transformers will start after the overhead traveling crane in the synchronous condenser building is completely rehabilitated.

1) Rehabilitation of main transformer (1T)

The rehabilitation work for the main transformer "1T" is to be executed phase by phase in the assembling bay adjacent to the synchronous condenser room..

The basic members of the working group for the main transformers will be nine persons consisting of one foreman, five electricians and three unskilled workers.

Some mechanics, welders and painters will also be required temporarily. One expatriate supervisor will be required for the rehabilitation of the main transformer "1T". With the above working members, the period of the rehabilitation work for all the four phase units including one spare unit is estimated at 90 days.

2) Replacement of main transformer (2T)

The new main transformer "2T" will be located at the same place as the existing "2T". The new transformer will necessitate a new foundation. The period of power interruption caused by the replacement work is estimated at about one and a half months, including the time for the foundation work. To prevent the other main transformers from overloading, the replacement work is to be executed during the operation period of the Thu Duc Thermal Power Station which is connected to 66 kV busbars for the Saigon Substation.

3) Replacement of house-service transformers (5T, 7T)

The house-service transformers are to be replaced one after another to secure continuous station power supply.

4) Replacement of 66 kV transformer (3T, 4T)

The new 66 kV transformers "3T" and "4T" is to be replaced one after another. The new transformers will necessitate new foundations which will be made after the existing foundations have been removed. The period of power interruption caused by the replacement work is estimated at about one and a half months for each transformer, including the time for the foundation work. The replacement work for the 66 kV transformers is to be executed when the Thu Duc Gas Turbine Plant is operated so that the transmission capacity to the 15 kV distribution system should not become short.

5) Replacement of 66 kV transformer (9T)

The new transformers will necessitate new foundations which will be made after the existing foundations have been removed. The period of power interruption caused by the replacement work is estimated at about one and a half months, including the time for the foundation work. The time for the replacement of the transformer is to be determined by due examination on the temporary power supply method to the consumers concerned.

(2) Implementation program for rehabilitation of switchgear

The replacement work for the switchgear is to be executed with de-energizing the related circuits tentatively and is to be programmed not to interfere with the power supply service. Therefore, the replacement work is to be done in good coordination with the network operation and the other rehabilitation work to minimize the period of the power interruption due to the rehabilitation work.

(3) Implementation program for rehabilitation of control and relay boards

It is preferable that all the new control and relay boards should be installed in a new control room to be located separately from the existing control room, to minimize the interference with the operation of the Substation. Concerning the site for the new control room, some places such as the previous site of the air compressor house and extension of the existing control building are considered. However, the site for the new control room is to be chosen after making the further study and discussion on several places in the detailed design stage.

The replacement of the control and relay boards is proposed to be done in the following procedures.

a) First of all, to replace all the control source supply equipment such as the station battery, the battery charger and the DC and AC distribution panels.

b) Subsequently, to install all the new control boards at the pre-determined places.

c) To lay the new control cables only for the first unit. And then, to transfer the control circuits from the old to the new control board for the first unit.

d) To remove all the old cables for the first unit before proceeding to the second unit, in order to prevent the old and new cables from becoming mixed.

e) To transfer the control boards one after another successively in the above mentioned procedure.

f) To wire between the new control boards and a marshaling kiosk which will be provided for interface with the computer system.

g) To remove all the old control boards.

h) At the last, to install the computer system.

The working group for the control and relay boards will consist of one foreman, four electricians and ten unskilled workers. Three expatriate supervisors will be required for the guidance of the installation and the field test for the control and relay boards.

8.6 Plan of Long Term Rehabilitation

As for the transformers and the switchgear that have not yet so deteriorated, the scope of their urgent rehabilitation is held down to the irreducible minimum of the necessity to enable them to be operated continuously for the time being. That is why their insulation condition will not be improved substantially by the urgent rehabilitation and their deterioration and ageing will be progressed year by year. Accordingly, the further rehabilitation will be required in the future for the transformers and the switchgear, which are partly rehabilitated in the urgent rehabilitation stage. This Clause describes a plan of the further rehabilitation for each equipment of the substation facilities. Meanwhile, the substation facilities to be replaced with new ones will necessitate no further rehabilitation for a long time on condition that the periodical maintenance and inspection to be described in Clause 8.7 should be applied to them without failure.

(1) Rehabilitation of Transformers

All the transformers that will not be replaced in the stage of the urgent rehabilitation should be examined periodically by the insulating oil analysis to diagnose their insulation condition. Whenever the serious abnormal condition is found from the oil analysis, the transformer is recommended to be replaced as soon as possible.

When the 66 kV transmission line voltage is upgraded to 110 kV, the main transformer "1T" for the Saigon Substation are required to be replaced with new ones, regardless to their insulation condition. When the transformer is required to be replaced, it should be preferable that the rated power of the transformer should be reviewed and will be changed depending on the power demand at the time.

(2) Rehabilitation of Switchgear

The 230 kV switchgear for the Da Nhim Power Station is required to be replaced before the prospective short-circuit current at the Da Nhim Power Station, which will be increased in proportion to the development of the power system, exceeds the present current rating of the respective switchgear.

All the 66 kV and 15 kV switchgear is required to be replaced when the respective circuits are upgraded to 110 kV and 22 kV.

The new 110 kV switchgear for the Saigon Substation is recommended to employ the gas insulated switchgear (GIS) instead of the conventional type because the Saigon Substation does not seem to have a sufficient space for installation of the 110 kV conventional type switchgear. Also, the employment of the GIS is expected to produce good solution for the heavy rust and corrosion problems for the steel structures and busbars.

The new 22 kV switchgear is recommended to use the metal-clad cubicle type instead of the conventional type in view of space-saving and easy maintenance.

8.7 Recommendation of Operation and Maintenance

The operation and maintenance for the substation facilities after the urgent rehabilitation are recommended to be executed by compiling the operation and maintenance rules and regulations for the respective facilities referring to the instruction manuals for the operation and maintenance which will be forwarded from the contractors. The operating status of the equipment will usually be observed and recognized by the daily and periodical inspections. The equipment that was relatively in good condition will be partly rehabilitated for the defective components only, and therefore the defective and obsolete parts, which will not interfere with the equipment operation, will be remained as they are. That is why such parts are required to be checked and inspected carefully.

The recommendable inspection and maintenance items for the major substation equipment are as follows. The inspection method will be referred to the manufacturer's instruction manuals.

(1) Transformers

1) Detailed inspection and maintenance (every seven years)

a) Interior inspection by overhaul of transformer
b) Inspection and cleaning for bushings, pressure relief valves, radiators and conservators
c) Replacement of gaskets
d) Change or purification of insulating oil

2) Detailed inspection and maintenance (every five years)

a) Overhaul inspection of auxiliary equipment such as oil pumps and cooling fans
b) Inspection of control circuits

3) Routine inspection and maintenance (every three months)

a) External inspection of auxiliary equipment, especially for operating status and bearing oil condition
b) Other general inspection

The following defective parts will not be repaired in the stage of the urgent rehabilitation and therefore is required to be inspected carefully.

Da Nhim Power Station

66 kV transformer (5T) : Oil leakage from the radiator

Saigon Substation

Starting transformer (6T) : Oil leakage from the bushings

4) Insulating oil analysis and test (every three years)

The insulating oil analysis is to be applied every six months or every twelve months to the following transformers not to be replaced in the stage of the urgent rehabilitation, to diagnose the insulation condition.

Da Nhim Power Station

Main transformers (1T, 2T, 3T, 4T)
House-service transformers (11T, 12T, 13T, 14T)

Saigon Substation

Main transformers (#131877A, #131878A, #131880A, #131881A, #131882A)
Starting transformer (6T)

(2) Switchgear

1) Detailed inspection and maintenance (every six years)

a) Overhaul inspection of interrupting parts (circuit breakers)
b) Overhaul inspection of operating mechanism (circuit breakers and disconnecting switches)
c) Inspection of local control boxes
d) Performance test

2) Routine inspection and maintenance (every two years)

a) External inspection of operating mechanism (circuit breakers and disconnecting switches)
b) Operation test (circuit breakers and disconnecting switches)
c) Inspection and cleaning of bushings and insulators
d) Looseness check of main circuit terminals and wiring
e) Measurement of insulation resistance
f) Measurement of leakage current (lightning arresters)
g) Other general inspection

The following defective parts will not be repaired in the stage of the urgent rehabilitation and therefore is required to be inspected carefully.

Da Nhim Power Station

230 kV current transformer : Oil leakage from primary terminals for main transformer "2T" circuit

Saigon Substation

66 kV circuit breakers : Oil leakage from dash-pot parts

(3) Control and relay boards

1) Detailed inspection and maintenance (every two years)

a) Calibration check of measuring instruments
b) Performance test of electrical protective relays

2) Routine inspection and maintenance (every one year)

a) General inspection and wiring check
b) Comprehensive operation check including sequence check
c) Measurement of insulation resistance

(4) Synchronous condensers

The recommendable inspection and maintenance items for the synchronous condensers, which are excluded from the rehabilitation of the Saigon Substation, are shown below for reference.

1) Detailed inspection and maintenance (every ten years)

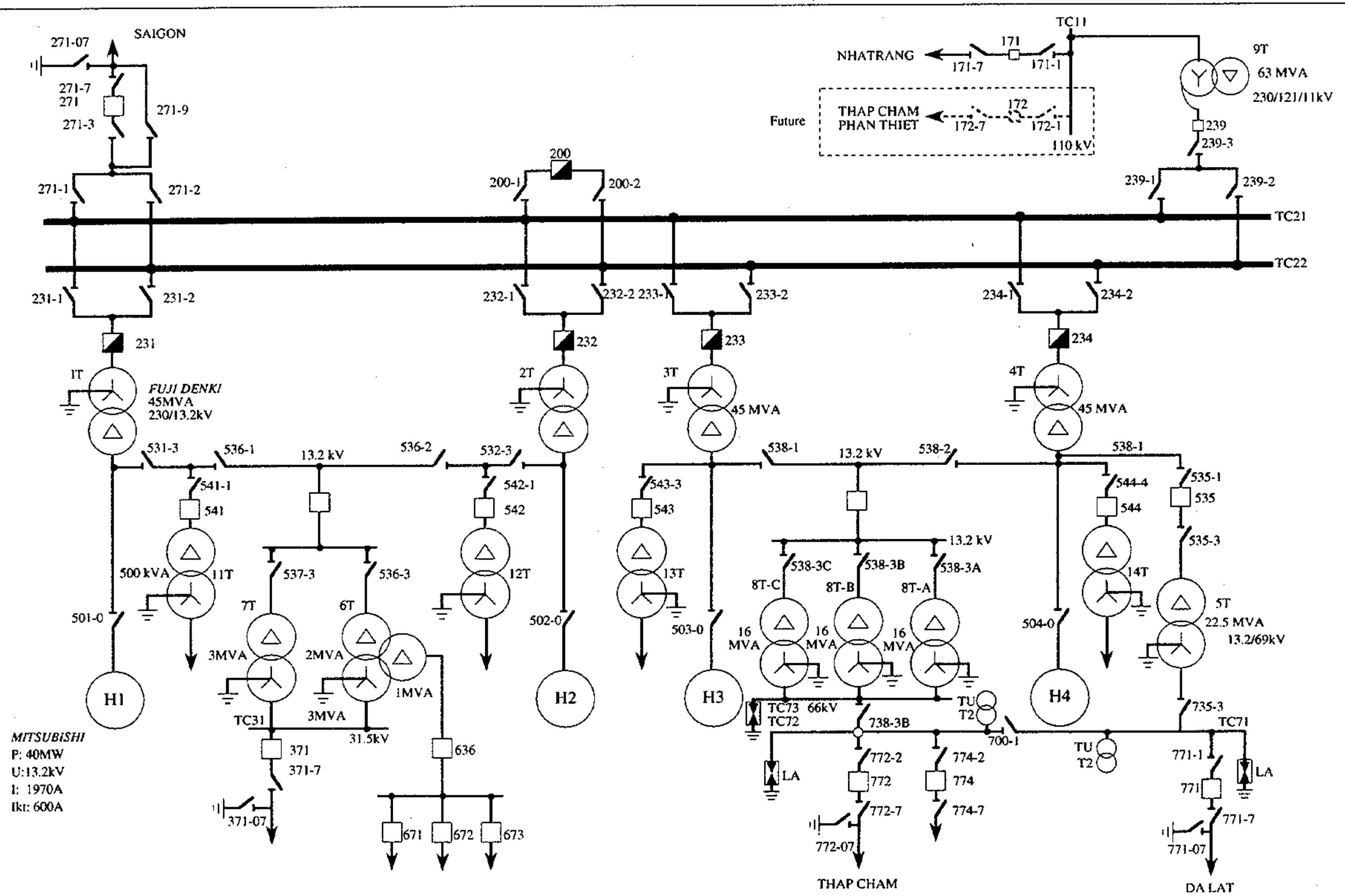
   a) Overhaul inspection by removing the rotor and cleaning

2) Detailed inspection and maintenance (every five years)

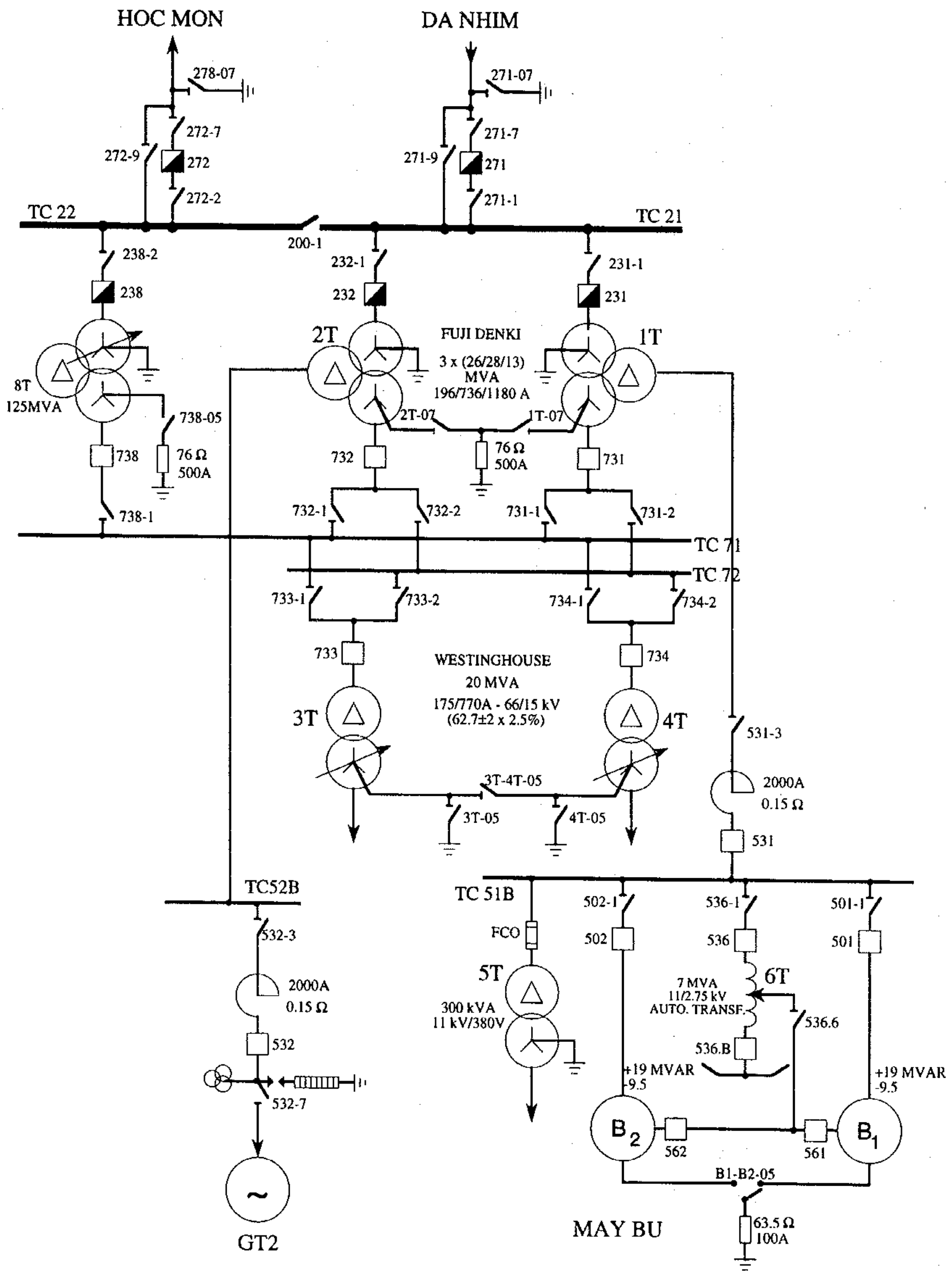
   a) Inspection and cleaning of winding insulation
   b) Inspection and cleaning of cooling water pipes for bearings
   c) Overhaul inspection of oil pumps
   d) Measurement of tan δ
   e) Sequence test for automatic start and stop

3) Routine inspection and maintenance (every one year)

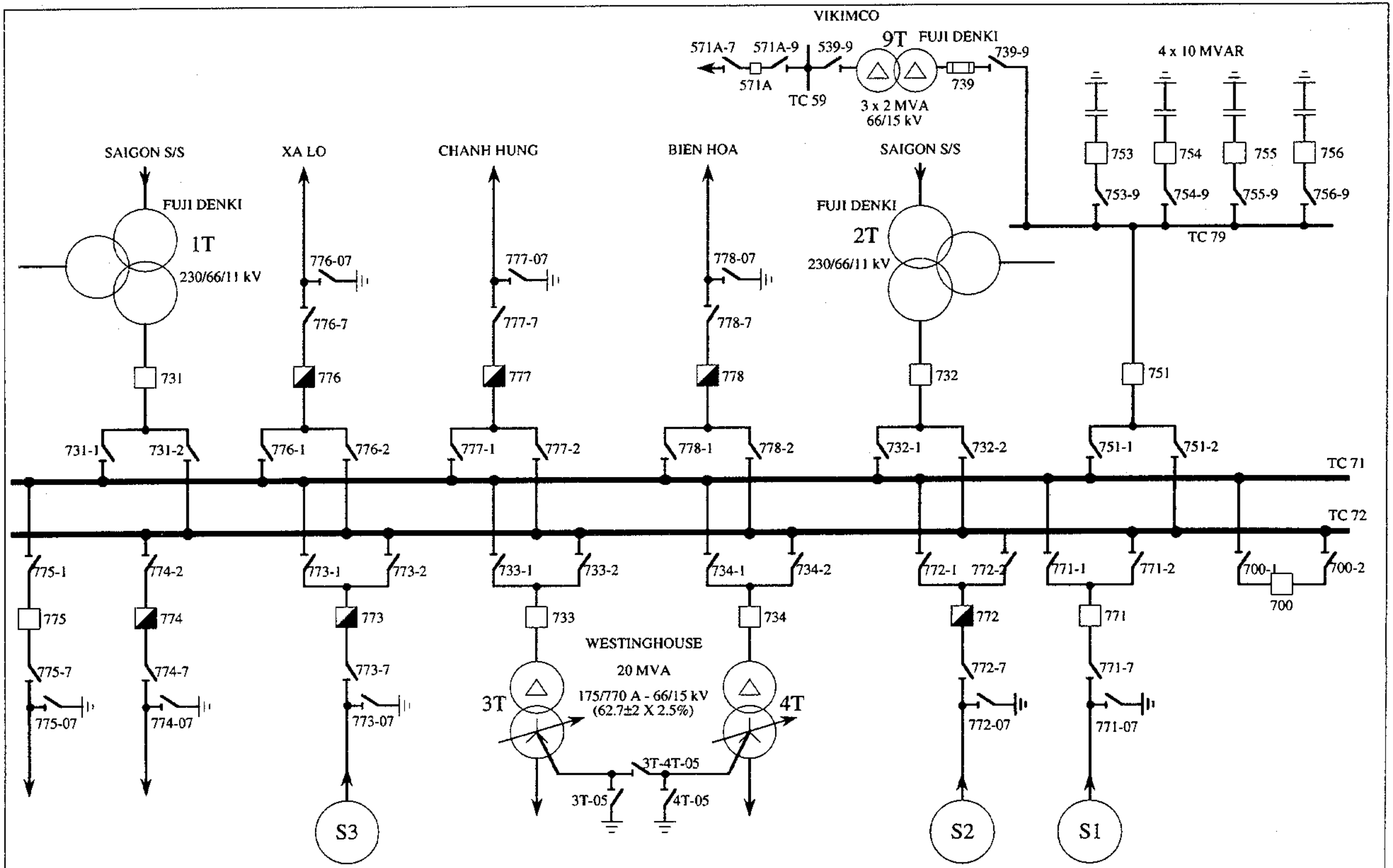
   a) Looseness check of all fastening parts
   b) Inspection of slip rings
   c) Inspection of air housing
   d) Inspection of control and alarming devices
   e) Measurement of insulation resistance



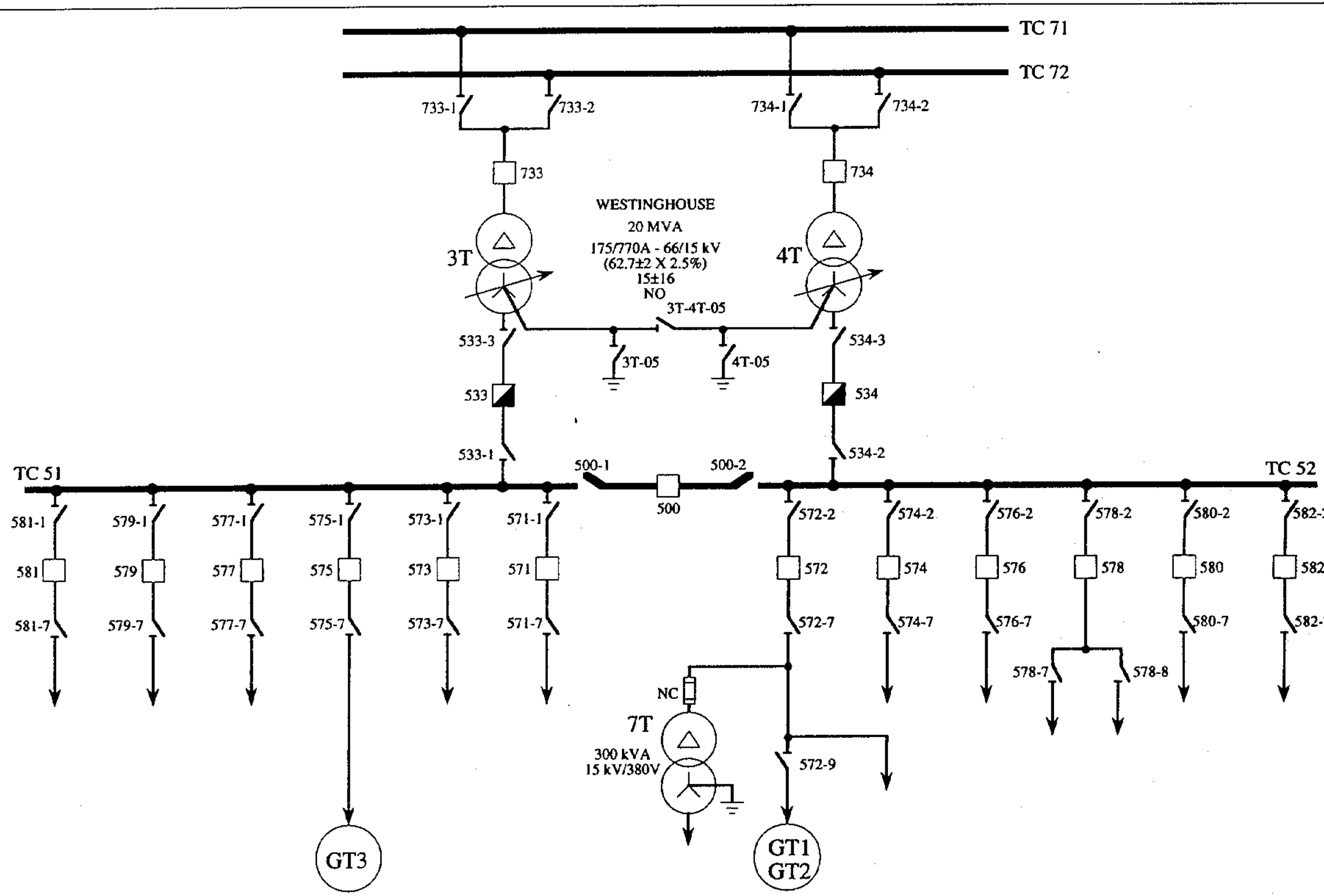
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 8.1 Existing Main Circuit for Da Nhim Power Station



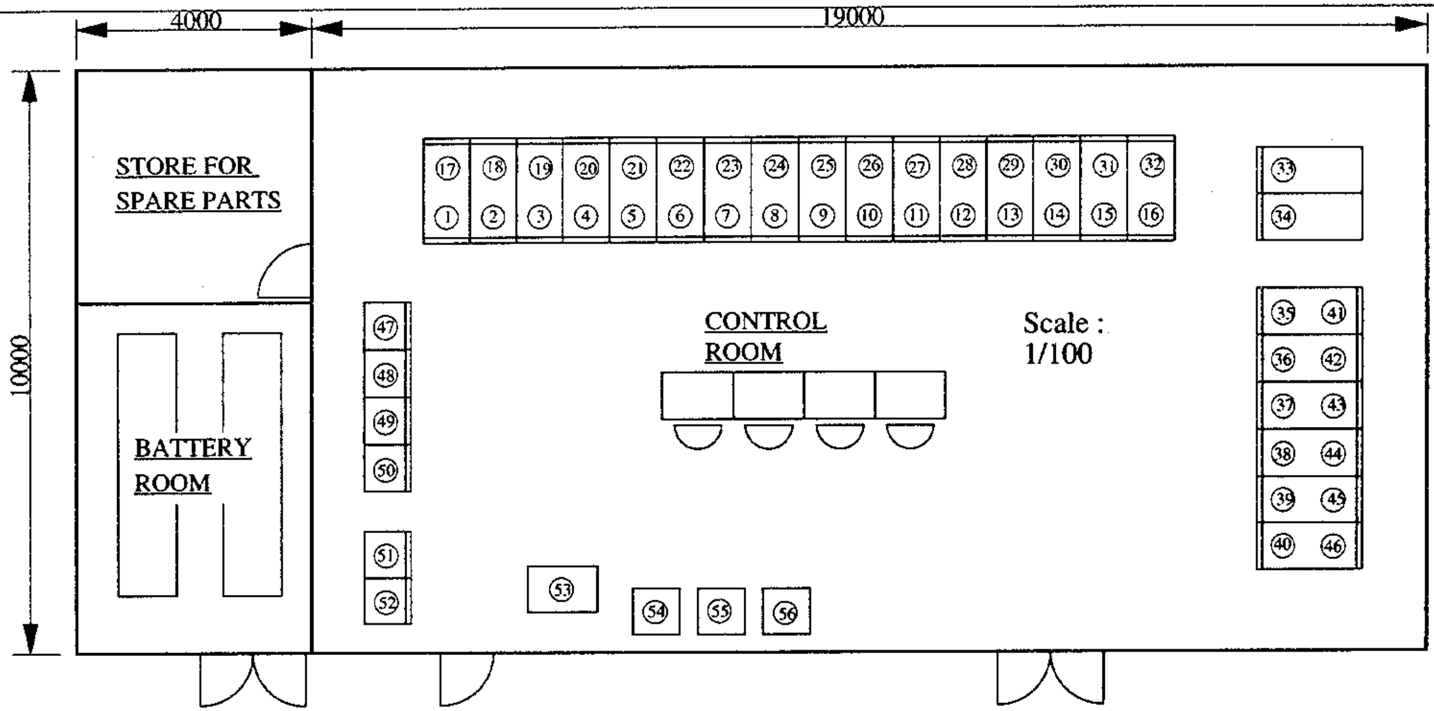
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 8.2 (1) Existing Main Circuit for Saigon Substation



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY / JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 8.2 (2) Existing Main Circuit for Saigon Substation



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 8.2 (3) Existing Main Circuit for Saigon Substation



Board Description

1	Control Board for Synchronous Condenser No. 1	18	Relay Board for Synchronous Condenser No. 2	35 - 40	Control Board for 15kV Lines
2	Control Board for Synchronous Condenser No. 2	19	Relay Board for Main Transformer "1T"	41 - 46	Relay Board for 15kV Lines
3	Control Board for Main Transformer "1T"	20	Relay Board for Main Transformer "2T"	47 - 48	AC Distribution Board
4	Control Board for Main Transformer "2T"	21	Relay Board for Main Transformer "8T"	49 - 50	DC Distribution Board
5	Control Board for Main Transformer "8T"	22	Relay Board for 230kV Transmission Line for Long Binh	51	Battery Charger
6	Control Board for 230kV Transmission Line for Long Binh	23	Existing Relay Board for 230kV Transmission Line for Hoc Mon	52	DC-AC Inverter
7	Control Board for 230kV Transmission Line for Hoc Mon	24 - 27	Relay Board for 66kV transmission Lines	53	Computer Unit for Data Logging and Event Recording System
8 - 11	Control Board for 66kV Transmission Lines	28	Relay Board for 66kV Bus	54 - 56	Logging Printer
12	Control Board for 66kV Buc-Tie	29	Relay Board for Transformer "3T"		
13	Control Board for Transformer "3T"	30	Relay Board for Transformer "4T"		
14	Control Board for Transformer "4T"	31	Relay Board for Transformer "9T"		
15	Control Board for Transformer "9T"	32	Relay Board for Static Condenser Banks		
16	Control Board for Static Condenser Banks	33	Existing Automatic Control Board for Synchronous Condenser No. 1		
17	Relay Board for Synchronous Condenser No. 1	34	Existing Automatic Control Board for Synchronous Condenser No. 2		

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 8.3 Arrangement Plan of Control Room for Saigon Substation

CHAPTER 9

230 KV TRANSMISSION LINE FACILITIES

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CHAPTER 9 230 KV TRANSMISSION LINE FACILITIES

9.1 Field Investigation and Results

9.1.1 Field Investigation

This section comprises the approaches, procedures, and results of the field investigation for 230 kV transmission line facilities, conducted by the Study Team of the facilities requested by GOV.

(1) Confirmation of the Facilities Requested

GOV requested the GOJ to study the rehabilitation of the 230 kV Da Nhim-Saigon transmission line facilities. Through the first discussion held with the Transmission Department of PC-2, the Study Team confirmed that the following facilities should be studied:

1) Tower materials (galvanized steel equal angles, steel plates, bolts, and nuts with washers)
2) Power conductors (ACSR 410 sq.mm, midspan joints, repair sleeves, and dampers)
3) Overhead earthwires (galvanized steel stranded wire 90 sq.mm and midspan joints)
4) Insulators (insulator units, hardware for insulator sets, and accessories of the power conductors and overhead earthwires)
5) Tools for rehabilitation and maintenance

The above items are those as agreed upon between GOV and the JICA Study Team for the Scope of Works for the rehabilitation of the Da Nhim power system. The facilities, which were constructed over 30 years ago, were damaged during the civil war. The rehabilitation of the damaged facilities was attempted once before, but was suspended due to the outbreak of the war. After the war, the facilities were very quickly repaired by the Vietnamese.

Repairs were carried out tentatively since there was a shortage of materials. There are still many unrepaired and incomplete facilities, which are used for power transmission. Since the line is the sole means of transmitting power generated at the Da Nhim power plant to Ho Chi Minh City, urgent rehabilitation of the facilities is required.

(2) Investigation Procedure

The Study Team conducted the investigation of the facilities through the following procedures:

1) The Study Team received a list of materials and tools for the rehabilitation of the 230 kV transmission line from the Transmission Department of PC-2 and confirmed the necessity for them through discussions held with its counterparts.
2) The manufacturers of the facilities no longer possess all the detailed design and manufacturing drawings of the facilities. However, PC-2 possesses most of these drawings in its offices. These were useful to the Study Team for examining the materials required for rehabilitation.
3) The Study Team and its counterparts investigated the damaged or incompletely repaired facilities at the site and confirmed the urgent necessity for rehabilitation.
4) Through the field investigation, the Study Team examined the missing members and tentatively repaired members of the towers, while referring to the manufacturing and erection drawings.
5) The Study Team also investigated the power conductors, overhead earthwires, and insulator sets in order to examine the actual conditions and necessity for rehabilitation.
6) The Study Team visited PC-2's warehouse of the Saigon substation and Don Duong office to investigate the materials and tools stored for the maintenance of the transmission line. The Study Team showed its counterparts the list and drawings of tools and devices for construction and maintenance of the transmission lines for PC-2's easy reference.
7) The Study Team was given an explanation of the measures regarding the tentative repair work carried out on the existing transmission facilities by PC-2, and the specific measures for rehabilitation to be implemented under the Project.
8) The Study Team held discussions with its counterparts regarding PC-2's maintenance manual for the transmission lines and the actual maintenance works, now carried out by each maintenance group.

9.1.2 Results of the Field Investigation

This section deals with the results of the Study Team's investigation of the existing facilities obtained through the field inspections and discussions.

(1) Steel Towers

The tentative and urgent repairs of the damaged towers were achieved using the remainder of the materials supplied by Japan during the war, and the unspecified materials procured in the domestic market at the time. Therefore, tower materials of an unsuitable quality and size were obliged to be used. The materials procured in the domestic market were not galvanized, but were only painted.

The Study Team investigated the existing towers in the field for the examination of the material list prepared by PC-2. Through the field investigation, the Study Team found the following conditions and confirmed the necessity for urgent rehabilitation:

1) Existing tower members having a smaller sectional area due to damage caused by bullets
2) Many missing members from the designed structures
3) Members different from the designed quality and size
4) Deformed members due to serious rust
5) Deformed members due to their improper fabrication
6) Rust on most of the members used for the tentative repairs due to the members not being galvanized, but only painted

Due to the shortage of materials, many of the towers have missing members. Some of these towers fell down in strong winds, interrupting the supply of power for a long period of time.

It is anticipated that the same destruction of the towers and interruption of the supply of power, lasting a long time, will occur repeatedly unless the urgent rehabilitation of the towers is carried out.

The materials listed by PC-2 are, in the most part, adequate to cover the urgent rehabilitation and maintenance purposes. The Study Team and its counterparts reexamined, in detail, the material list referring to the Study Team's field inspection and the tower drawings. Then, the list was amended in order to include more specific materials and the necessary steel plates, bolts, nuts, and washers were added.

The Study Team visited PC-2's factory and confirmed that all the machinery necessary for the fabrication of the tower materials, is in the factory. The factory has experience in the manufacture of steel towers up to 220 kV.

(2) Power Conductors and Overhead Earthwires

The original power conductors and overhead earthwires were composed of 410 sq.mm of ACSR and 90 sq.mm of Galvanized Steel Stranded Wire (GSW), respectively. It was necessary to use different sizes of ACSR and GSW for tentative repairs due to the shortage of materials. The joints of these conductors and earthwires were not made using the proper joint sleeves, but by using temporary materials such as clips or aluminium tapes. These temporary joints have not yet been replaced with proper joints, which results in the degradation of their mechanical strength, the conductors and earthwires breaking, corona noises, and increasing energy loss at the temporary joints.

The Study Team observed that the individual broken wires were not repaired due to the shortage of repair sleeves and midspan joints. PC-2 reported that the conductors frequently break due to the melting of the unrepaired points or temporary joints of the power conductors. Unless these unrepaired points and joints are urgently repaired, the power conductors as well as earthwires will continuously break in the same way as above. For the stable and economical operation of the transmission line, it is necessary to repair the conductors and earthwires with the proper sleeves and joints and also to replace the seriously damaged conductors and earthwires with new materials.

The materials listed in Table 9.1 are those amended by PC-2 and the Study Team through discussions. The original dampers are of a torsional type. Some damaged or missing dampers are replaced with Stockbridge type dampers. The Study Team recommends that the Stockbridge type dampers be newly procured for rehabilitation because they are easily installed. There is no functional difference between the both types, if the unit weight and fixing positions of the dampers are the same.

(3) Insulators

The line is located far from the sea, therefore no salt contamination is reported by PC-2. However, much fog on the high land and artificial pollution from factories are very serious problems in the areas of the Bao Loc and Saigon-Long Binh substations. Many insulators which are placed on about 40 towers, are rusted and corroded at their pin parts resulting in a great reduction of their strength. Cracked and missing insulators have also been observed in many insulator sets. The original insulators are Japanese made porcelain insulators. Existing insulators on the 230 kV line are the standard units of the world and are suitable for any high voltage lines. PC-2 has no spare porcelain insulators, therefore, it inserts glass insulators into the porcelain insulator sets. Since corrosion of the pin parts of the insulators will become more rapid, many insulators should be procured including those for replacement of the damaged units and future maintenance purposes. Based on this situation, PC-2's requirement for insulators is reasonable.

The Study Team recommends PC-2 to utilize fog type insulator in the polluted areas. The insulator's creepage distance is longer than that of the standard unit, and is used in polluted conditions.

Hardware used for the mechanical and electrical functions for the insulator sets should be of properly designed models. Since drawings for the original design are kept in the PC-2 office procurement of additional hardware is possible.

(4) Tools for Rehabilitation and Maintenance

The Study Team confirmed that the amount of tools stored in the warehouses in the Saigon substation and Don Duong office is very small. The tools stored are mainly tools which were supplied 30 years ago and are in a state of disrepair. The tools are commonly used by the 9 maintenance groups. The total quantity of usable tools is not sufficient for even 1 maintenance group. Efficient repair work is not expected. Many tools and devices for the rehabilitation and maintenance works are necessary.

Through discussions held between PC-2 and the Study Team, the items needed and quantity of tools to be procured were determined in order to carry out the rehabilitation works, within a limited period of time, smoothly and efficiently; taking into account PC-2's rehabilitation practices and the quantity of tools, which PC-2 can collect from other maintenance offices in the region.

Communications equipment is important for carrying out repairs and the maintenance works. PC-2 confirmed that a sufficient quantity of VHF radio equipment for the works is available.

(5) Maintenance Works and Manuals

The Study Team had no chance to visit a site of the daily maintenance patrol, but had a chance to visit PC-2's working site to upgrade the line from 66 kV to 110 kV. The Study Team did, however, visit the construction site of the 220 kV transmission line between the Phu Lam 500 kV substation and 220 kV Hoc Mon substation. The construction of the above was implemented by the Power Construction Company No.2 (PCC-2). From these inspections, the Study Team understood the ample capability of PC-2 and PCC-2 for repair and construction of lines.

The present maintenance manuals are commonly prepared for the lines from 1 kV to 230 kV. The Study Team presented the maintenance manuals for the Da Nhim-Saigon 230 kV transmission line, which were prepared during the construction period of the line.

9.2 Urgent Rehabilitation Plan

This section deals with the recommended rehabilitation plan for each facility of the transmission line. The plan is prepared on the basis of the Study Team's investigation of the facilities and discussions held with the Transmission Department of PC-2.

9.2.1 Rehabilitation of the Towers

(1) Tower Foundations and the Surrounding Areas

As far as the Study Team are concerned no tower foundations need to be repaired. In addition, PC-2 reported to the Study Team that no foundations need to be restored. However, it is estimated that the ground around some tower foundations in the mountainous areas would have been eroded during the 30 years after their completion. Less volume of soil above the foundations reduces the safety factor for the uplifting force of the foundation and causes disruption of the foundations and then the superstructure.

The Study Team suggested that PC-2 inspects the foundations through daily patrols of the line and protect them using methods shown in Figure 9.1, if such foundations are found.

Each tower is provided with earthing angles and counterpoises for reducing the tower earthing resistance. The counterpoises were buried in the ground and along the line route but at a shallow level. It is feared that some counterpoises are missing and that the tower footing resistance may increase causing back-flashover to the insulators. The number of counterpoises as well as the number of earthing angles and the measured footing resistance of each tower are recorded in the line tabulations prepared during the construction. It is recommended that the number of counterpoises be inspected and the footing resistance at each tower be measured, referring to the tabulations. Materials used for the construction of the counterpoise are the same as those of the overhead earthwires. The wire will be used for supplementing for the missing counterpoises, if any. In measuring the tower footing resistance, it is noted that the overhead earthwires of the tower should be insulated from the tower using insulator units or other materials. Terminal clamps for the counterpoises can be produced in the PC-2's factory.

(2) Superstructures of the Towers

Many of the towers still have missing members, bolts and nuts, or have been repaired by temporary members of different quality and size from the original design. If the assumed design force would be applied to these towers, they may be seriously damaged or corrupted.

The Da Nhim-Saigon 230 kV transmission line is one of the trunk lines in the PC-2 region. Accordingly, the facilities should urgently be restored to their original design capability.

It is observed that the components of tower structures have been slightly distorted from their design and their initial installation due to the repeated loading over 30 years and that they have also been damaged during the war. Therefore, the steel members to be supplemented or replaced may not be fabricated in the dimensions shown on the manufacturing drawings.

The following procedures are recommended for the fabrication of the tower members:

1) Reinspection of all the towers by maintenance groups in order to assure the erection numbers of each member to be supplemented or replaced.
2) Cutting the newly imported galvanized materials of a proper size into lengths shown on the corresponding manufacturing drawings, at PC-2's factory.
3) Measurement of the distance between the bolt holes on the present member, and drilling the corresponding bolt holes using a portable drilling set.
4) Application of the zinc-rich paint to the cutting and drilling parts.

The fabrication of gusset plates is also carried out in the same manner. Large sized steel angles and plates that are provided with a bent process will be fabricated in PC-2's factory in accordance with the specified bent angle shown on the manufacturing drawings. Bolt holes will be made on site the same as for other materials. It is easy to procure bolts, nuts and washers, since their sizes are standard. The bolt lengths will be selected so that a projection of more than 3 screws will remain after the nuts and washers are tightened.

The required tower rehabilitation is to their lower structures, and therefore the rehabilitation of the towers will be carried out under the energizing condition of the transmission line. The upper part of the tower should be repaired under the deenergizing condition at the time when power conductors will be repaired, for safety reasons.

After that repairing work, all bolts and nuts of the towers should be confirmed on the firm tightening condition.

9.2.2 Rehabilitation of the Overhead Earthwires and Power Conductors

Although linemen of the maintenance groups of PC-2 are skillful at the urgent rehabilitation work due to their abundant experience in the tentative repair works, the following should be noted in the works:

(1) Preparatory Investigation

Before the field works begin, the following investigation should be completed by all 9 maintenance groups for the whole section and all the towers, for the efficient and complete rehabilitation of the line:

1) Confirmation of the actual existing facilities in accordance to the items recorded in the line material schedules.
2) Investigation of the span, phase, and position where individual wires of the overhead earthwires or power conductors are broken (for the application of the repair sleeve).
3) Investigation of the span, phase, and position where improper joints are used (for the application of the midspan joints).
4) Confirmation of the spans where overhead earthwires or power conductors should be completely replaced.
5) Investigation of the shortage of or missing vibration dampers.
6) Access conditions and time required for the repair work of the places and towers.

An adequate control of the work schedule is required for the replacement of the overhead earthwires and power conductors because of the work under the deenergized condition. Although the deenergizing schedule should be determined by PC-2 in consideration of the overall generating program, it should be scheduled as short as possible but with allowance for the greatest safety.

For the works of the overhead earthwires and power conductors, temporary earthing devices should always be installed for the prevention of accidents due to currents induced by lightning and charging currents. After the works, the removal of the temporary earthing devices should be confirmed before reenergizing.

(2) Rehabilitation of the Overhead Earthwires

Broken individual wires will be repaired and the overhead earthwires will be partially replaced by applying midspan joints. The procedures of the works are as below:

1) The earthwire will be pulled down to the ground after the removal of the clamps from the tower. Before the removal of the earthwires from the tension type tower, temporary back-stay wires should be installed to the top of the tower for reinforcing the tower strength.
2) Come-along clamps will be provided at both sides of the part to be repaired, and the come-along clamps will be fixed to temporary anchors in the ground for balancing the tension of the earthwire.
3) Broken individual wires will be repaired in the manner that the related part will be cut and connected again by applying and compressing a midspan joint.
4) In case a portion of the earthwire needs to be replaced, the length of the portion should be measured after the works mentioned in 2) above. The new earthwire's length will be prepared as calculated in advance, for necessary sag adjustment and take into account the extension of the midspan joint after compression. After cutting the portion from the existing earthwires, the new earthwire thus prepared will be connected by compressing midspan joints on both its sides.
5) The repaired earthwire will be pulled up and fixed by the clamp to the tower after the removal of the come-along clamps from the temporary anchors.
6) The repair of the earthwire will be completed after sag adjustment (if necessary) and the removal of the temporary back-stay wires.

(3) Rehabilitation of the Power Conductors

The repairing works' procedures are the same as those for the overhead earthwires. However, broken individual wires of the power conductors will be repaired by applying a repair sleeve without cutting the portion needing repaired, if the number of individual wires is less than 4 wires. If the conductor has more than 4 individual wires broken it should be repaired by a midspan joint in the same way as for the earthwires.

A hydraulic compressor to compress repair sleeves and midspan joints is provided with a remote operating tube of 20 to 25 meters long. The compressor set on a tower can compress repair sleeves or joints positioned in the extent of the remote tube. Therefore, it is not necessary to pull down a conductor or an earthwire to the ground. Compression of the repair sleeves or midspan joints on unreachable positions will be carried out by the compressor set on an aerial conductor car to be procured or a temporary scaffolding or by pulling down the earthwire or power conductor.

The replacement and sag adjustment of the power conductors will be executed in the same manner as for the overhead earthwires. Since the working tension of the power conductors is much higher than that of the overhead earthwires, careful attention should be paid to the strength and installation of the temporary guywires connected to the towers and anchors. The strength of the towers is designed for the assumed condition of breakage of an earthwire or only one conductor. Accordingly, it is recommended that the replacement of the earthwires or the conductors should be carried out one by one for safer work.

Sag of the earthwires and conductors is observed by an observing device with a telescope and a vertex fixed on the opposite tower. Sags and tensions of the earthwires and power conductors should be calculated before observing the various conductor temperatures of each span.

After the sag adjustment, armour rods should be rewound or replaced with new materials at the suspension clamps, and necessary dampers should be installed at every span.

9.2.3 Rehabilitation of the Insulators and Insulator Sets

The works will be executed under the deenergizing condition at the same time as the rehabilitation of the power conductors for safety purposes. The works will be divided into two (2), one is the replacement of the insulator units only, and the other is works related to the repair of the power conductors.

(1) Replacement of the Insulator Units or Fittings

Efficient works will be carried out without removing the power conductor from the insulator set. A damaged insulator unit is easily replaced with a new unit using a special device called the insulator replacer. The complete insulator set or fittings on the conductor side will be replaced by holding the power conductor to the tower crossarm using devices such as the chain block or lever block.

It is recommended to carry out the following additional works at the same time as the replacement of the insulator units or insulator fittings:

1) cleaning of the insulators and fittings
2) inspection of the missing or damaged insulator pins, retaining pins or their condition and replacement of the parts, if needed.
3) measurement of the arcing-horn gap and correction of the gap, if necessary.
4) inspection of the bolt-tightening condition of the suspension clamps and condition of the armour rods winding
5) measurement of insulation clearance of the jumper conductors at the tension insulator sets

The above-mentioned items will be inspected in the periodical inspection of the line.

Fog type insulators will be used for the towers located in the foggy or polluted areas. The creepage distance of the insulator is longer than that of the standard unit. In 1998, IEC's (International Electrotechnical Commission) publication 815 recommends that insulators with a creepage of 25 mm/kV should be in selected for use in the badly polluted areas. The total creepage distance required for the 230 kV insulator set used in the badly polluted areas should be 5,759 mm. Since 14 units of insulator are used per one insulator set for the Da Nhim-Saigon 230 kV transmission line, the required creepage distance per insulator unit for the area is 410 mm. Such special type insulators will be used in the badly polluted areas of the line, reported by PC-2.

(2) Replacement of the Insulators With Power Conductors

The power conductors will be rehabilitated mostly after the removal of the insulator sets. At the same time the repair of the insulator will be carried out smoothly under the following conditions: that the insulator sets will be removed from the tower crossarm or the sets will remain fixed on the tower crossarm after the removal of the conductor.

Even in the case of the repair of the power conductor only, the related insulator sets should be inspected in accordance with the items mentioned in the above sub-clause (1).

9.3 Basic Design for Urgent Rehabilitation

This section states the basic design of the facilities to be rehabilitated.

9.3.1 Facilities around the Tower Foundations

Figure 9.1 shows the preventive measures taken against soil erosion around the tower foundations in reference to PC-2's maintenance works. Any of the following measures will be taken depending on the actual situation of soil erosion:

1) Grass treatment
2) Installation of a simple protective stockade
3) Installation of a masonry wall or concrete wall

For the protection of washed soil on the gently sloped land, timber wedges will be provided in order to maintain a sufficient volume of filled soil, and then grass will be planted on the filled soil. For protection on the steeply sloped land, the simple protective stockade, masonry wall or concrete wall should be provided. After the installation of such protection works, drainage ditches should be provided around the foundations, and dewatering pipes should be installed through the stockades and walls.

These provisions are able to be carried out by the transmission line maintenance groups, for the necessary cases using locally available materials.

9.3.2 Rehabilitation of the Tower Structures

(1) Major Materials to be Procured

The quality of the original materials for the structures is SS-41 and SS-50 of JIS (Japanese Industrial Standard). These materials are specifically applied in accordance with the detailed design of the structures, and therefore materials of the same quality resulting from the design should be used in the rehabilitation of the towers. Figure 9.2 shows the structural outlines of each type of tower in the original design, proved by the actual load tests.

These materials are widely used in Japan for general steel structures and are, accordingly easily procured. In the case of the procurement of the materials from other countries other than Japan, the quality of the materials should be specified to be equivalent to or more superior than those materials. The technical particulars of SS-41 and SS-50 are as follows:

JIS G-3101 : Rolled Steel for General Structures

Grade	Materials	Thickness (mm)	Yield Strength	Tensile Strength
2	SS-41	$t \leqq 16$	25 kg/mm^2	41 kg/mm^2
		$16 < t \leqq 40$	24 kg/mm^2	41 kg/mm^2
3	SS-50	$t \leqq 16$	29 kg/mm^2	50 kg/mm^2
		$16 < t \leqq 40$	28 kg/mm^2	50 kg/mm^2

The hot dip galvanizing treatment will be specified in order to prevent all steel materials from rusting, including bolts, nuts, and washers in the following quantities:

For bolts and nuts : more than 350 g/m^2
For other steel materials : more than 550 g/m^2

Although several standard lengths of steel materials are manufactured, equal angle steel 6 m and 8 m long and steel plates 1.5 m x 3.0 m wide will be specified in consideration of the ocean and inland transportation of the materials.

Before shipping, all the materials should be subjected to the following inspections and tests:

1) Material strength test : tensile strength and bending strength
2) Galvanizing test : quantity of zinc and uniformity test
3) Appearance inspection : dimensions and galvanizing condition of bolts, nuts, and washers selected at random
4) Function test : insertion and turning test condition of bolts and nuts selected at random

(2) Fabrication of the Procured Materials

All procured materials should be galvanized in the manufacturer's factory, but galvanizing will be damaged on the locally fabricated portions of the materials. Zinc-rich paint will be applied in order to prevent rust generated from cutting or drilling parts after local fabrication.

The equal angle steel will be cut in PC-2's factory for the length measured at the existing towers. To match the cut steel materials to the existing structure, bolt holes will be drilled at each tower site using hand drilling machines, which will be procured. Bolt holes should be made in accordance with the specified gauge dimensions in order to maintain the proper strength of the materials. The gauge dimensions are specified for each size of steel material, diameter of bolts, and number of bolts to be used. The holes should be drilled with reference to the standard gauges shown in Table 9.2.

9.3.3 Overhead Earthwires and Power Conductors

(1) Overhead Earthwires and Hardware

The overhead earthwires of the 230 kV Da Nhim-Saigon line are generally used for overhead transmission lines worldwide, and their technical particulars are as follows:

1)	Standard applied	:	JIS G-3537 or equivalent standard
2)	Minimum strength of the wire	:	90 kg/sq.mm
3)	Construction of the stranded wire	:	7 nos./4.0 mm diameter
4)	Section and outside diameter	:	87.99 sq.mm and 12.0 mm
5)	Ultimate tensile strength	:	7,280 kg

The length of the wires per drum will be specified at 1,000 m for easy transportation and handling in the field. Galvanizing on the wires should be more than 230 kg/sq.mm. The individual wires and stranded wires will be tested and inspected in consideration of the following items:

- dimensions, construction, and appearance tests of individual and stranded wires
- tensile strength, elongation, and twisting tests of individual and stranded wires
- galvanizing test for adhesive quantity and uniformity
- appearance inspection of the drums and weight measurement

Hardware such as midspan joints and clamps will be procured based on the following specifications:

The midspan joints should be made from galvanized steel and should be compression type joints, like the original joints. The ultimate tensile strength required should be more than that of the overhead earthwires.

The suspension clamps should be clip type clamps, while the tension clamps should be bolt-tightening type clamps, like the original types. Materials for the clamps should be either steel or malleable iron. The tension clamps will have fittings such as an U-clevis and a chain link for fixing to the towers.

From the design of tower structures, the suspension clamps will be designed so that the earthwires will not slip from the clamp at a load less than 1,600 kg which is equivalent to 60% of the maximum working tension of the earthwires. The strength of the tension clamps should be set at more than 90% of the ultimate tensile strength of the earthwires. Figure 9.3 shows the suspension and tension clamp sets.

(2) Power Conductors and Hardware

The power conductors used for the line are the widely used ACSR 410 sq.mm. The conductors are of one of the standard sizes and are manufactured in accordance with the requirements of JIS, which has the following characteristics. It can be procured from the world market.

1)	Standard applied	:	JIS C-3110
2)	Stranding (nos./diameter)	:	Aluminium 26/4.5 mm, Steel 7/3.5 mm
3)	Calculated section	:	Aluminium 413.4 sq.mm, Steel 67.35 sq.mm, Total 480.8 sq.mm
4)	Diameter of the strands	:	Aluminium 28.5 mm, Steel 10.5 mm
5)	Weight of the stranded conductor	:	Aluminium 1,145 kg/km, Steel 527.9 kg/km, Total 1,673 kg/km
6)	Electrical resistance (20°C)	:	0.0702 ohm/km or less
7)	Minimum tensile strength	:	13,890 kg
8)	Young's modules	:	Aluminium 6,300 kg/sq.mm, Steel 21,000 kg/sq.mm
9)	Linear expansion coefficient	:	Aluminium 23 x 10^{-6}/°C, Steel 1.5 x 10^{-6}/°C
10)	Direction of outermost lay	:	S-stranding (same stranding as existing conductors)

The standard length of the power conductor on one drum will be specified at 1,000 m taking into account easy transportation to the site. The following tests and inspections will be conducted at the manufacturer's factory before shipping:

(i) Aluminium individual wires
- measurement of the diameter and appearance of the wire
- tensile strength, elongation, and twisting tests
- measurement of electrical resistance

(ii) Steel individual wires

- measurement of the diameter and appearance of the wire
- tensile strength, elongation, and twisting tests
- galvanizing test (quantity and uniformity)

(iii) Complete conductors

- measurement of the diameter and appearance of the complete conductor
- tensile strength test
- measurement of electrical resistance

(iv) Appearance inspection and weight measurement of the drum

Hardwares such as repair sleeves, midspan joints, suspension clamps, tension clamps, armour rods, and vibration dampers will be procured together with the power conductors.

The repair sleeves will be applied to the positions on the conductors where more than 4 aluminium individual wires are broken. The sleeve, which is made of aluminium, will completely cover a damaged part of the conductor and will be compressed together with the power conductor. The conductivity of the aluminium sleeve should be the same as that of the aluminium of the power conductor. The length of the sleeve should be for a standard length to ACSR 410 sq.mm. It is noted that a part possessing breakage of more than 5 aluminium individual wires should be repaired by applying midspan joints.

The midspan joints are composed of a steel sleeve and an aluminium sleeve. The steel sleeve should be made of the same materials as that of the steel wires, and the aluminium sleeve should be made of the same materials as that of the aluminium wires. The sleeves should be compression type sleeves and supplied with corrosion-proof compound materials.

The suspension clamps will be designed as trunnion type clamps, which will allow the conductors to move freely in the clamps so that the conductors will not be subjected to unnecessary stress. Materials of the clamps should be aluminium alloy in order to prevent electrical corrosion and for lighter weight. The diameter of the grooves of the clamps should be properly dimensioned for winding of a preformed armour rod set. Construction of the clamps should be designed so that the clamps will release the conductors at a force of 3,120 kg, which is equivalent to 60% of the maximum working tension of the power conductors, taking into account the design condition of the tower structures.

The tension clamps are composed of three parts; a steel body to hold the steel core of ACSR, an aluminium clamp for covering a complete ACSR, and an aluminium-made jumper lug for a jumper conductor. All parts should be compression type parts and the tension clamp's tensile strength should be more than the ultimate breaking strength of the power conductor. Special compounds will be used for preventing the steel parts covered by the aluminium clamp, from rusting.

The armour rod set is used for preventing aluminium individual wires from breaking as a result of the weakness of the materials caused by the repeated vibration of the power conductor due to wind load. The original armour rod set was a tapered type set with clamps on its both ends. Additional and supplementary armour rod sets will be preformed type sets, for easy installation and maintenance.

The vibration damper should be of the galvanized Stockbridge type and its weight should be 6.3 kg for ACSR 410 sq.mm used. Any projection from the damper will not be allowed in order to prevent the generation of corona.

9.3.4 Insulators and Insulator Hardware

(1) Insulator

Insulators used for the line are porcelain-made and are standard unit of cap and pin type insulators. The technical characteristics of the insulator units are as follows. The insulators to be procured should be the same type and have the same characteristics. The figures in brackets in the table are those of the fog type insulator units to be used for the heavily polluted areas and highland towers.

1)	Dimensions	:	254 mm x 146 mm (254 mm x 146 mm)
2)	Insulator type (both types)	:	Cap and pin type with ball and socket
3)	Power frequency withstand voltage (wet)	:	50 Hz, 40 kV (41 kV)
4)	Lightning impulse withstand voltage	:	105 kV (120 kV)
5)	50% impulse flashover voltage	:	125 kV (150 kV)
6)	Power frequency oil puncture voltage	:	140 kV (140 kV)
7)	Electromechanical load	:	16,500 kgf (12,000 kgf)

8) Creepage distance : 280 mm (430 mm)

9) Minimum tensile testing load : 6,600 kgf (4,800 kgf)

Retaining pins should be made of stainless steel and conform to the dimensions recommended by IEC standards.

(2) Insulator Sets and Hardware

Insulator sets and hardwares to be procured should be manufactured the same as electrical and mechanical characteristics as the existing sets and hardware. The characteristics should be proved in the tests conducted in the manufacturer's laboratory.

The characteristics of the insulator sets are as follows:

	Single Suspension Set	Double Suspension Set	Single Tension Set	Double Tension Set
Number of units on a string	1 x 14	2 x 14	1 x 14	2 x 14
Power frequency withstand voltage (wet)	480 kV	480 kV	480 kV	480 kV
50% impulse flashover voltage	1,100 kV	1,100 kV	1,100 kV	1,100 kV
Electromechanical strength	10,000 kgf	10,000 kgf	10,000 kgf	10,000 kgf

Figure 9.4 presents the details of the existing insulator sets. The hardware to be additionally procured for maintenance purposes is preferably the same as the existing parts. However, other models or types of hardware will also be permitted to be used if the strength of the parts will be more than that of the existing parts and the parts can be completely interchangeable with the existing parts.

9.3.5 Tools for the Rehabilitation Works and Maintenance

As discussed in the sub-clause 9.1.2 (4), PC-2 faces to serious difficulties with the proper maintenance of the transmission lines due to the shortage of tools. It is urgently necessary to supplement many tools and devices not only for the rehabilitation works but also for the periodical line maintenance works.

Table 9.1 summarizes the items and quantities of the required tools and devices together with their specifications. The table was prepared after several discussions were held with PC-2 and an investigation of the existing tools stocked by PC-2 was carried out by the JICA Study Team.

9.4 Implementation Program of the Urgent Rehabilitation Works

PC-2 has not yet prepared the specific implementation program for the rehabilitation of the 230 kV transmission line. This section will discuss the draft program of the works prepared on the basis of the information given to the Study Team by PC-2 and the results of the Study Team's field investigation of the existing facilities, work forces, and capability of the PC-2's transmission line groups. The draft program will be examined for the preparation of a more detailed schedule and amended for a more realistic program by PC-2.

9.4.1 Organization of Working Groups

Tower structures will be able to be repaired under the line energized condition, except for the main legs of the structures. The works can be carried out at any time by the ordinary maintenance groups.

The repair of the overhead earthwires, power conductors, and insulators should be executed under the scheduled de-energized condition. PC-2 reported that the scheduled shutdown of the transmission line, as a result of periodical maintenance is only for 3 to 4 days annually. During this period it is impossible to complete all the necessary repairs to the facilities. To limit the line deenergizing period for the repair works within 10 days, it may be necessary to organize 19 gangs; 16 gangs for repairing the power conductors as well as for insulator replacement and 3 gangs for repairing the overhead earthwires. Each gang involved in the repair of the former will be composed of 15 to 20 workers and each gang for the latter will be composed of 10 workers.

The total number of workers at any one time is estimated at 320 consisting of 220 linemen and 100 general workers. The PC-2 Engineer confirmed that it is not so difficult to organize this work force for short periods. Transportation of materials and preparatory works will be carried out in advance of the repair works under the deenergizing condition. Figure 9.5 shows the work flow of the repair works of the power conductors and overhead earthwires.

9.4.2 Technical Capability for Implementation

The PC-2 working forces have abundant experience in similar repair works and construction works of the transmission lines. The seriously damaged 230 kV Da Nhim-Saigon line, over 257 km in length with 729 towers, was tentatively restored within 6 months without the sufficient tools and devices. In addition, PC-2 has much experience in the construction of 110 kV and 66 kV transmission lines. In consideration of the facts, it is not so difficult for PC-2's work force to complete the rehabilitation of various facilities within a limited period of time.

However, it may be necessary in the implementation of the rehabilitation works, to dispatch one or two transmission line experts to PC-2 for the preparation of the specific fieldwork schedules, management of the work flow, instruction on how to use the new tools and devices properly, and other considerations.

9.4.3 Work Schedule

The rehabilitation of the tower structures will be conducted at the earliest time after the arrival of the procured materials and fabrication of the specific members of the towers, at PC-2's factory.

The rehabilitation of the overhead earthwires, power conductors, and insulators will proceed in accordance with the draft schedule in Figure 9.5. It is estimated that it will take 8 to 10 days to complete the rehabilitation works, if the work forces are organized in the dry season. A more specific schedule will be prepared by PC-2 taking into account the draft schedule, periodical shut down schedule of the 230 kV line, PC-2's other work schedules, etc.

It is strongly recommended to investigate the latest conditions of the facilities once more and ensure the exact places, items, and quantities of the facilities to be repaired over the whole line.

9.5 Recommendations for the Operation and Maintenance of the Facilities

It is assured that the rehabilitated facilities will be well maintained by the present organization of 9 groups with 17 linemen and two radio equipped vehicles per group. Supplemented tools and devices as well as spare materials will certainly reinforce the operation and maintenance works.

The Study Team suggests that PC-2 will amend the present operation and maintenance manual for the transmission lines to a specific manual with concrete items to be inspected and tables of items to be recorded. The manuals forwarded by the Study Team will be referred to by the amended manual. It is also recommended that all drawings of facilities and manuals should be kept by each maintenance group for the proper maintenance of the line.

9.6 Other Recommendations

The rehabilitation of the 230 kV transmission lines will return the facilities to their original designed conditions. It is necessary to maintain the rehabilitated facilities by regular operation and maintenance works, and also to be continuously supplemented with materials needed for the operation and maintenance.

PC-2 does not seem to possess a program to develop the future power system of the Da Nhim - Saigon 230 kV transmission line. The Study Team recommends the following programs in order to develop the future power system:

(1) Additional 230 kV transmission line

In developing the Ham Thuan and Da Mi hydroelectric power stations (total capacity of around 470 MW), a new 230 kV transmission line will be developed between the stations and Ho Chi Minh City. The two power stations are located near the Da Nhim power station. The new 230 kV or 220 kV transmission line to be constructed under the Project should be connected with the Da Nhim power station for more stable power transmission to the Ho Chi Minh area. In addition, it is anticipated to operate and maintain the facilities with some time allowance. It is very important for comprehensive system operation. Therefore, it is recommendable to construct the interconnection line between the power stations and the Da Nhim power station.

(2) Overall Inspection of the Facilities

After the completion of the new line mentioned above, the 230 kV Da Nhim-Saigon transmission line will be allowed to shut down for a sufficient time. PC-2's maintenance groups will then carry out the detailed overall inspection of the line facilities under the deenergizing condition and will be able to rehabilitate the further deteriorated facilities or replace them with new facilities. In addition, the connection of the 230 kV line to the Bao Loc substation may be amended from the existing T-form to π form.

Table 9.1 Required Materials and Tools for Urgent Rehabilitation of 230 kV Transmission Line

Materials

No.	Description	Unit	Q'ty	Specifications
M 1.	Galvanized Steel Angle			
	L 40 x 40 x 3	meter	11,280	6 m long, SS-41
	L 45 x 45 x 4	meter	4,560	6 m long, SS-41
	- ditto -	meter	7,140	6 m long, SS-50
	L 50 x 50 x 4	meter	1,140	6 m long, SS-41
	- ditto -	meter	720	6 m long, SS-50
	L 50 x 50 x 6	meter	288	6 m long, SS-41
	L 60 x 60 x 5	meter	1,920	8 m long, SS-41
	- ditto -	meter	40	8 m long, SS-50
	L 65 x 65 x 6	meter	240	8 m long, SS-41
	L 80 x 80 x 6	meter	88	8 m long, SS-41
	L 90 x 90 x 7	meter	1,000	8 m long, SS-50
	L 100 x 100 x 7	meter	18	8 m long, SS-41
	L 100 x 100 x 10	meter	1,000	8 m long, SS-50
	L 130 x 130 x 9	meter	504	8 m long, SS-50
	(Total Weight)		(105 tons)	
M 2.	Galvanized Steel Plate			
	4.5 mm thick	sheet	20	1.5 m x 3.0 m, SS-41
	6 0 mm thick	sheet	6	1.5 m x 3.0 m, SS-41
	9.0 mm thick	sheet	2	1.5 m x 3.0 m, SS-41
	12.0 mm thick	sheet	2	1.5 m x 3.0 m, SS-41
	(Total Weight)		(6 tons)	
M 3.	Galvanize Bolt and Nut			
	12 mm dia. x 40 mm long	piece	7,500	SS-41, with flat and spring washers
	16 mm dia. x 40 mm long	piece	7,500	SS-50, with flat and spring washers
	16 mm dia. x 50 mm long	piece	3,000	SS-50, with flat and spring washers
	16 mm dia. x 60 mm long	piece	1,000	SS-50, with flat and spring washers
	20 mm dia. x 60 mm long	piece	500	SS-50, with flat and spring washers
	(Total Quantity)	(piece)	(19,500)	
M 4.	Insulator Set			
	Single Suspension Set	set	50	Complete set with insulator units
	Double Suspension Set	set	50	Complete set with insulator units
	Single Tension Set	set	40	Complete set with insulator units
	Double Tension Set	set	40	Complete set with insulator units
	Standard Insulator Disc	unit	10,000	254 mmx 146mm porcelain
	Fog Type Insulator Disc	unit	2,000	254 mmx 146mm porcelain
M 5.	Preformed Armour Rod	set	300	For ACSR 410 sq.mm
M 6.	Midspan Joint			
	For Power Conductor	set	500	For ACSR 410 sq.mm
	For Groundwire	set	100	For Galvanized Stranding Wire 90 sq.mm
M 7.	Repair Sleeve	set	300	For ACSR 410 sq.mm
M 8.	Compression Dead-End Clamp	set	120	For ACSR 410 sq.mm with Jumper Lug
M 9.	Vibration Damper	set	300	Stockbridge Type for ACSR 410 sq.mm
M10.	Hardware for O.H Earthwire			
	Suspension Clip	set	100	For Galvanized Stranding Wire 90 sq.mm
	Complete Tension Set	set	50	For Galvanized Stranding Wire 90 sq.mm

No.	Description	Unit	Q'ty	Specifications
M11.	Power Conductor	meter	60,000	ACSR 410 sq.mm
M12.	Overhead Earthwire	meter	20,000	Galvanized Stranding Steel Wire 90 sq.mm

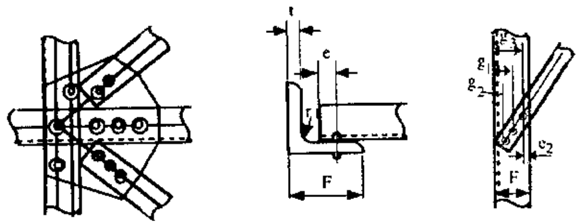
Tools for Maintenance Work

No.	Description	Unit	Q'ty	Specifications
T 1.	Engine Winch	set	2	Mounting on 4 WD Vehicle
T 2.	Conductor Tensioner	unit	2	1.2 m dia. Shoe-Chain Type
T 3.	Hand Winch	set	4	20 tons capacity in combination with pulley
T 4.	B.V Winch	set	6	4 tons capacity in combination with pulley
T 5.	Chain Hoist	set	6	4.5 - 6.0 tons capacity
T 6.	Tirfor	set	6	Type T-35 (3 tons capacity)
T 7.	Aluminium Ladder	set	6	5m + 7m(12m) long per set, Aluminium-made
T 8.	Insulator Replacer	set	6	Complete set for 254 mm x 146 mm
T 9.	Torque Wrench	set	4	200 -900 kgf-cm
T10.	Gin Pole	set	5	15 m long in total
T11.	Turnbuckle	set	20	3 - 5 tons capacity
T12.	Hydraulic Compressor	set	4	with a 25m tube and dies for ACSR 410 sq.mm and Galvanize Stranding Steel Wire 90 sq.mm
T13.	Hydraulic Cutter	set	4	For ACSR 410 sq.mm, Model : SS-55A
T14.	Nylon Rope (12 mm dia.)	km	4	In 200 meter coil
	Nylon Rope (16 mm dia.)	km	4	In 200 meter coil
T15.	Hand Drill	set	6	For bolt holing at site
T16.	Pulling Grip for Power Conductor	set	10	Braid Type Grip for ACSR 410 sq.mm
	Pulling Grip for O.H Earthwire	set	10	Braid Type Grip for GSW 90 sq.mm
T17.	Swivel for 2,500 kg Pulling	set	20	Clevis-type
	Swivel for 4,000 kg Pulling	set	20	Clevis-type
T18.	Fault Insulator Detector	set	10	Gap-type Detector for 230 kV Line
T19.	Aerial Conductor Car	set	4	For Single Conductor Use
T20.	Earthing Roller	set	4	
T21.	Temporary Earthing Equipment	set	30	For Transmission Line Use
T22.	Conductor Cutter With Dies	set	6	ACSR 410 sq.mm, 336.4 MCM, 397.5 MCM, 200 sq.mm, 185 sq.mm and 200 sq.mm
T23.	Line Throwing Equipment	set	4	Spring-type
T24.	Portable Hydraulic Punch	set	4	For Bolt-holing of 12 mm, 16 mm and 19 mm
T25.	Ratchet Spanner	set	20	For Bolts of smaller of 14 mm and 16 mm dia.
	- ditto -	set	20	For Bolts of 16 mm and 18 mm dia.
	- ditto -	set	20	For Bolts of 20 mm and 22 mm dia.
T26.	Tension Meter	set	3	For 1 ton use
	- ditto -	set	3	For 3 tons use
	- ditto -	set	3	For 5 tons use
T27.	Come-along Clamp	set	24	For ACSR 410 sq.mm
T28.	Wire Rope, 10 mm dia.	km	5	In 200 m Coil with 25 connectors
	Wire Rope, 12 mm dia.	km	5	In 200 m Coil with 25 connectors
	Wire Rope, 14 mm dia.	km	5	In 200 m Coil with 25 connectors
T29.	Wire Grip	set	16	Model WG-4000
T30.	Pulley Block	set	200	309mm dia., Aluminium made, urethane-lined
T31.	Snatch Block	set	10	Type IS-150
	- ditto -	set	12	Type 2S-150
T32.	Safety Belt for Lineman	set	200	With 2 m Safety Rope
	Spare Safety Rope	meter	400	Rope only

Table 9.2(1) Bolt Gauges for Main Leg Members

(Unit: mm)

Angle Size	Bolt Size	Gauge r_1	M12 g0	M12 g2	M12 g1	M12 g3	M16 g0	M16 g2	M16 g1	M16 g3	M20 g0	M20 g2	M20 g1	M20 g3	M22 g0	M22 g2	M22 g1	M22 g3	M24 g0	M24 g2	M24 g1	M24 g3
L 50	4	6.5	•30.5		30		•35.5		28													
	6	"	•32.5		"		•37.5		"													
L 60	4	6.5	35.5		35		•35.5		35													
	6	"	36.5		"		•36.5		"													
L 65	6	8.5	39.5		40		•39.5		40													
	8	"	41.5		"		•41.5		"													
L 70	6	8.5	39.5		40		•39.5		40		•44.5		40									
L 75	6	8.5	39.5		45		44.5		45		•44.5		45									
L 80	6	8.5	39.5		50		44.5		50		49.5		50									
L 90	6	10	41		55		46	*45	55	*65	51		55		•51		55					
	7	"	42		"		47	* "	"	* "	52		"		•52		"					
	10	"	45		"		50	* "	"	* "	55		"		•55		"					
L 100	7	10	42		60		47	*45	60	*75	52		60		57		60		•57		60	
	10	"	45		"		50	* "	"	* "	55		"		60		"		•60		"	
L 120	8	12	45	*50	70	*90	50	*50	70	*90	"	*50	70	*90	60		70		65		70	
L 130	9	12	46	55	77.5	100	51	55	77.5	100	56	55	77.5	100	61	*60	77.5	*95	66		77.5	
	12	"	49	"	"	"	54	"	"	"	59	"	"	"	64	* "	"	* "	69		"	
L 150	10	14					54	65	90	115	"	65	90	115	64	65	90	115	69	70	90	110
	12	"					56	"	"	"	61	"	"	"	66	"	"	"	71	"	"	"
	15	"					59	"	"	"	64	"	"	"	69	"	"	"	74	"	"	"
	19	"					63	"	"	"	68	"	"	"	73	75	95	"	78	75	92.5	"
L 175	12	15					57	70	105	140	62	70	105	140	67	70	105	140	72	75	105	135
	15	"					60	"	"	"	65	"	"	"	70	"	"	"	75	"	"	"
L 200	15	17					62	75	120	165	67	75	120	165	72	80	120	160	77	80	120	160
	20	"					67	"	"	"	72	"	"	"	77	"	"	"	82	"	"	"
	25	"					72	"	"	"	77	"	"	"	82	"	"	"	87	"	"	"
L 250	25	24					79	90	150	210	84	90	150	210	89	100	155	210	94	100	155	210
	35	"					89	"	"	"	94	"	"	"	99	"	"	"	104	"	"	"



Note: 1. $g_0 = t + r_1 + e_1 + 5$, Gauges with mark (•) exclue allowance of 5 mm.

2. $g_2 \geq t + r_1 + e_1$

3. $g_3 \leq F - e_2$

4. Gauges with mark (*) are used for the lowest panels.

Table 9.2(2) Bolt Gauges for Web Members

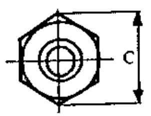
(Unit: mm)

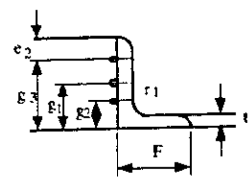
Standard Gauges

Angle Size	t	Gauge r_1	M12 g_2	M12 g_1	M12 g_3	M16 g_2	M16 g_1	M16 g_3	M22 g_2	M22 g_1	M22 g_3	M22 g_2	M22 g_1	M22 g_3	M24 g_2	M24 g_1	M24 g_3
L40	3	4.5		20													
	5	"		"													
L45	4	6.5		22.5			22.5										
	6	"		25													
L50	4	6.5		25			25										
	6	"		"			"										
L60	4	6.5		30			30			30							
	5	"		"			"			"							
	6	8.5	30	32.5	45		32.5			325.							
L65	8	"	"	"	"		"			"							
L70	6	8.5	30	35	45	30	35	45		35			35				
L75	6		30	37.5	50	30	37.5	50		357			37.5				
L80	6	8.5	35	40	50	35	40	50	35	40	50		40			40	
L90	6	10	40	45	60	40	45	60	40	45	60		45			45	
	7	"	"	"	"	"	"	"	"	"	"		"			"	
	10	"	"	"	"	"	"	"	"	"	"		"			"	
L100	7	10	40	50	70	40	50	70	40	50	70	40	50	70		50	
	10	"	"	"	"	"	"	"	"	"	"	"	"	"		"	
L120	8	12	45	60	85	45	60	85	45	60	85	45	60	85	45	60	85
L130	9	12	45	65	95	45	65	95	45	65	95	45	65	95	45	65	95
	12	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
L150	10	14				50	75	115	50	75	115	50	75	115	50	75	115
	12	"				"	"	"	"	"	"	"	"	"	"	"	"
	15	"				"	"	"	"	"	"	"	"	"	"	"	"
	19	"				55	"	"	55	"	"	55	"	"	55	"	"
L175	12	15				55	87.5	140	55	87.5	140	55	87.5	140	55	87.5	140
	15	"				"	"	"	"	"	"	"	"	"	"	"	"
L200	15	17				65	100	165	65	100	165	65	100	165	65	100	165
	20	"				"	"	"	"	"	"	"	"	"	"	"	"
	25	"				"	"	"	"	"	"	"	"	"	"	"	"

Average Gauges

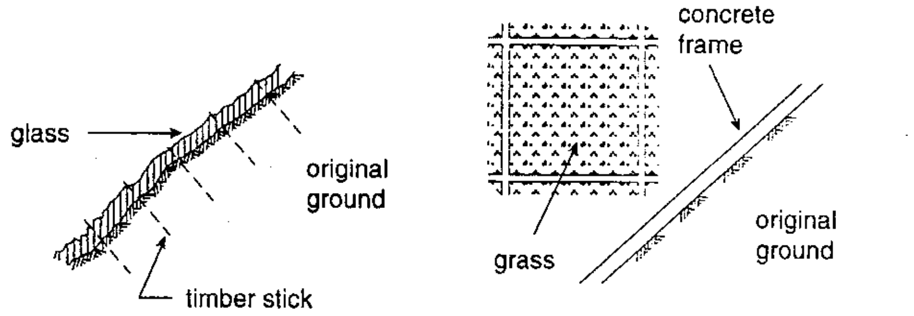
Angle Size	t	M12 In	M12 Out	M16 In	M16 Out	M20 In	M20 Out	M22 In	M22 Out	M24 In	M24 Out
L40	3										
	5										
L45	4	22	26								
	6										
L50	4	24	28	24	28						
	6	22	28								
L60	4	28	32	28	32	28	32				
	5	27.5	32.5	27.5	32.5	27.5	32.5				
L65	6	29.5	35.5								
	8	28.5	36.5	28.5	36.5						
L70	6	32	38	32	38	32	38				
L75	6	34.5	40.5	34.5	40.5	34.5	40.5	34.5	40.5		
L80	6			Inside	37		Outside	43			
L90	6			"	42		"	48			
	7			"	41.5		"	48.5			
	10			"	40		"	50			
L100	7			"	46.5		"	53.5			
	10			"	45		"	55			
L120	8			"	56		"	64			
L130	9			"	650		"	69.5			
	12			"	59		"	71			
L150	10			"	70		"	80			
	12			"	69		"	81			
	15			"	67.5		"	82.5			
	19			"	65.5		"	84.5			
L175	12			"	81.5		"	93.5			
	15			"	80		"	95			
L200	15			"	92.5		"	107.5			
	20			"	90		"	110			
	25			"	87.5		"	112.5			



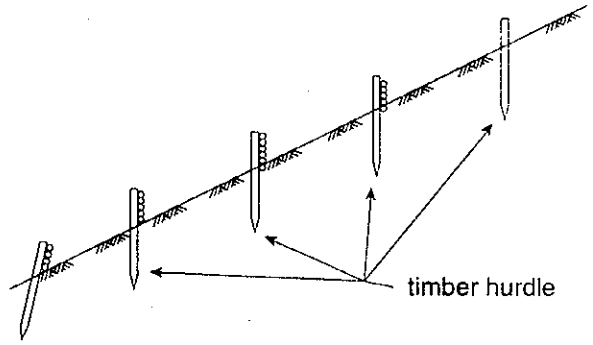


Note:
1. Gauges on a row: $g_1 \geq 0.5 \times F$
2. Gauges on2 rows: $g_2 \leq t + r_1 + C/2$
3. $g_3 \leq F - e_1$
4. Two gauges are principally not used for the materials below L100.

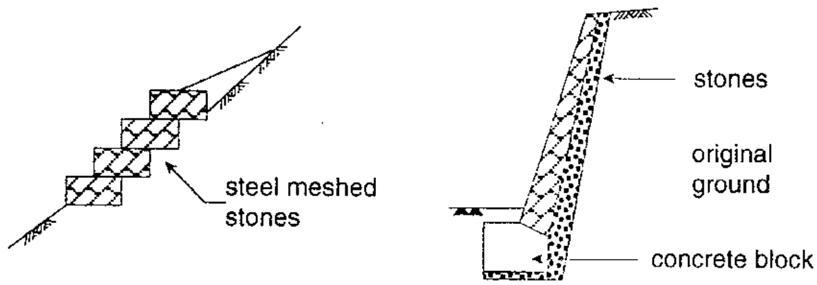
GRASSING



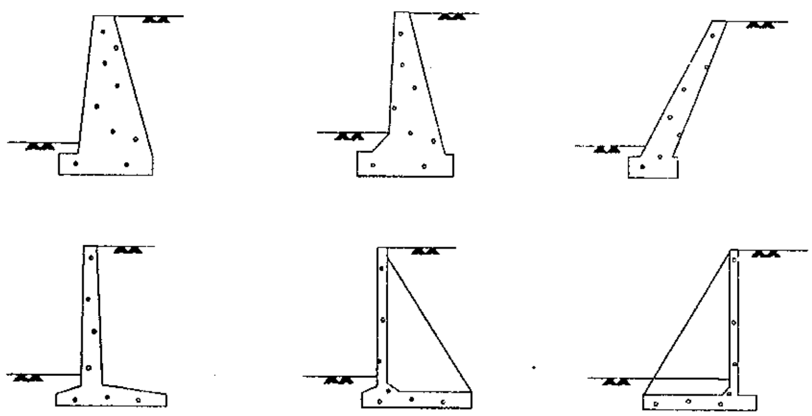
SLOPE PROTECTION



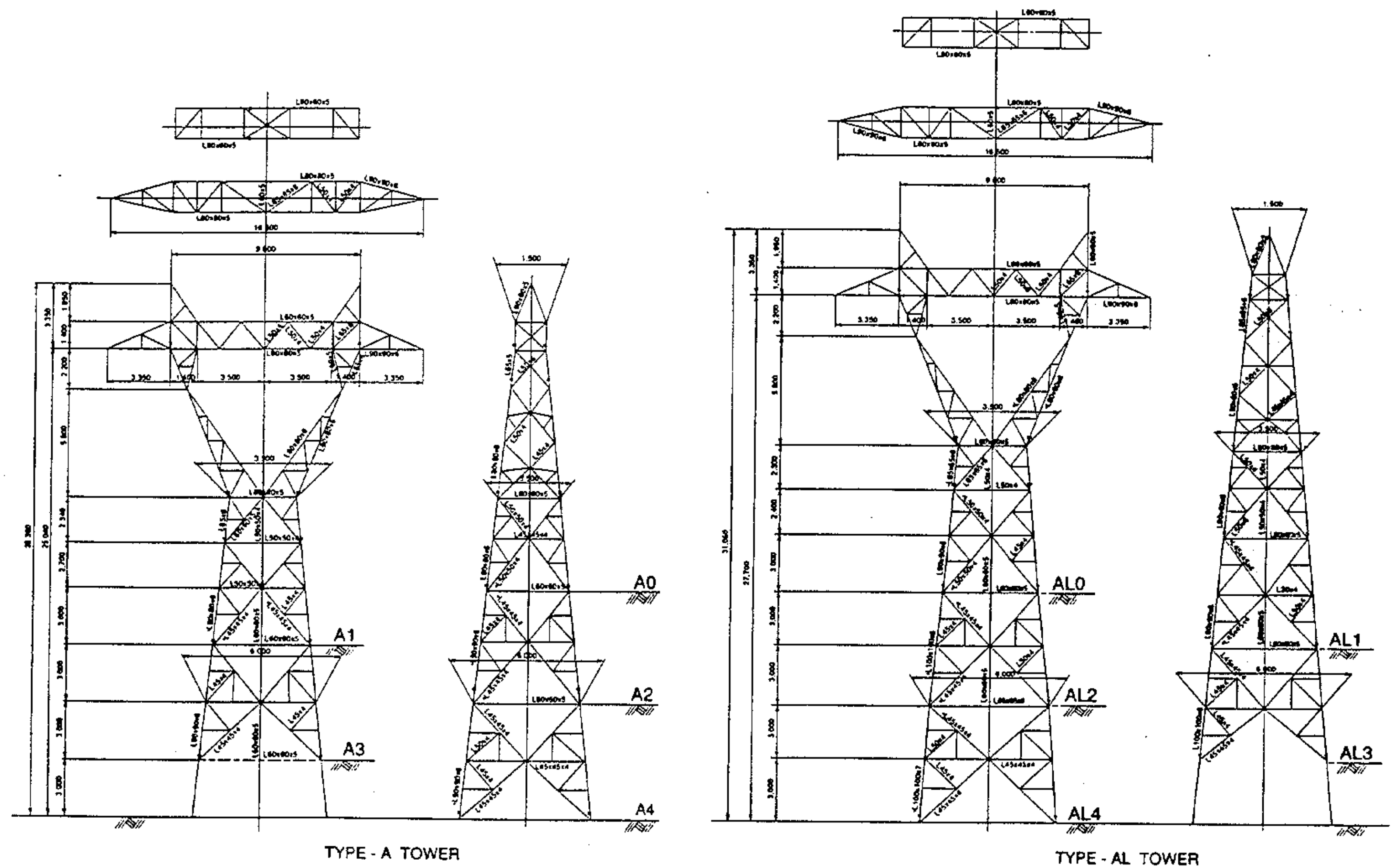
STONE REVENTMENT



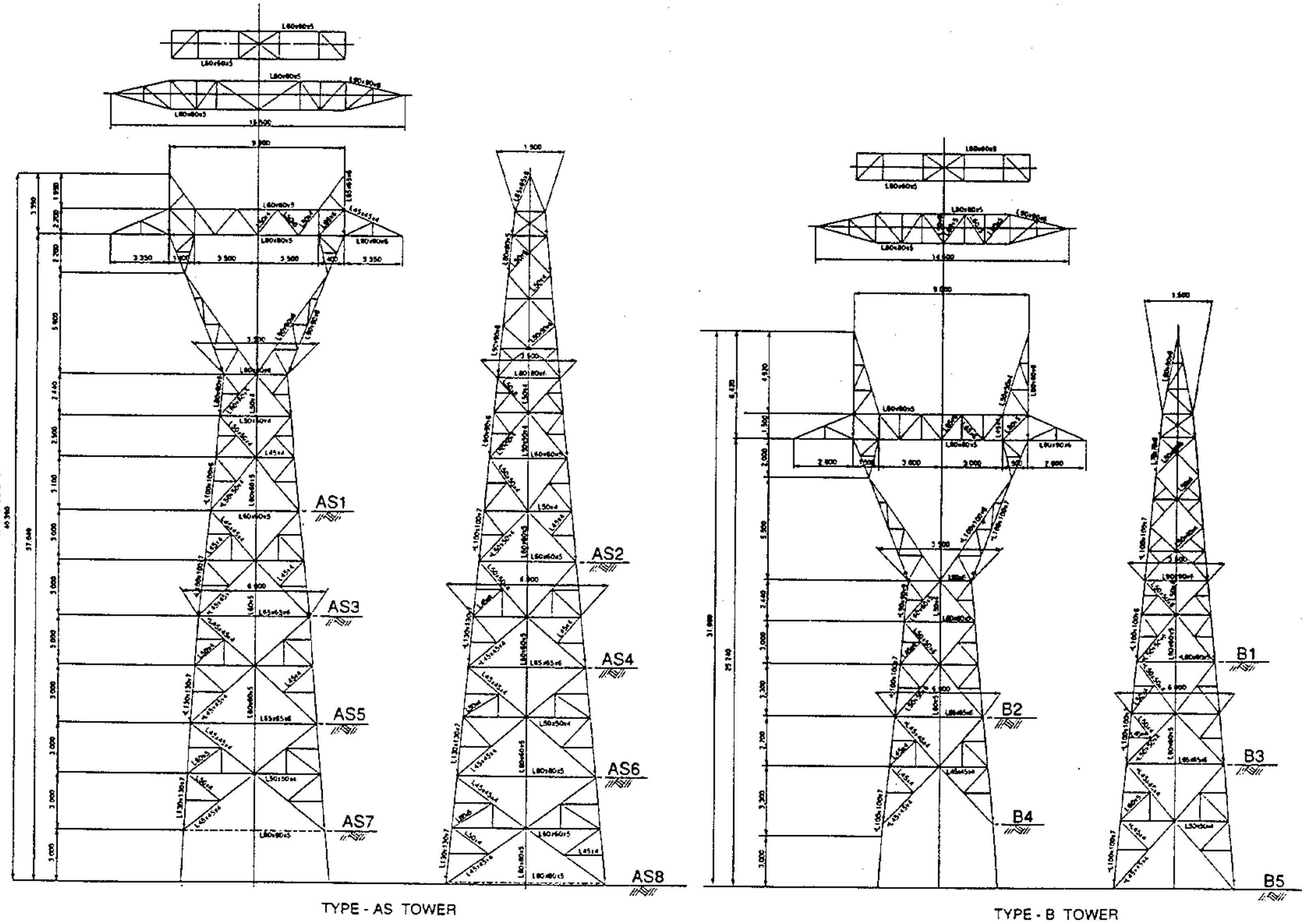
MASONRY



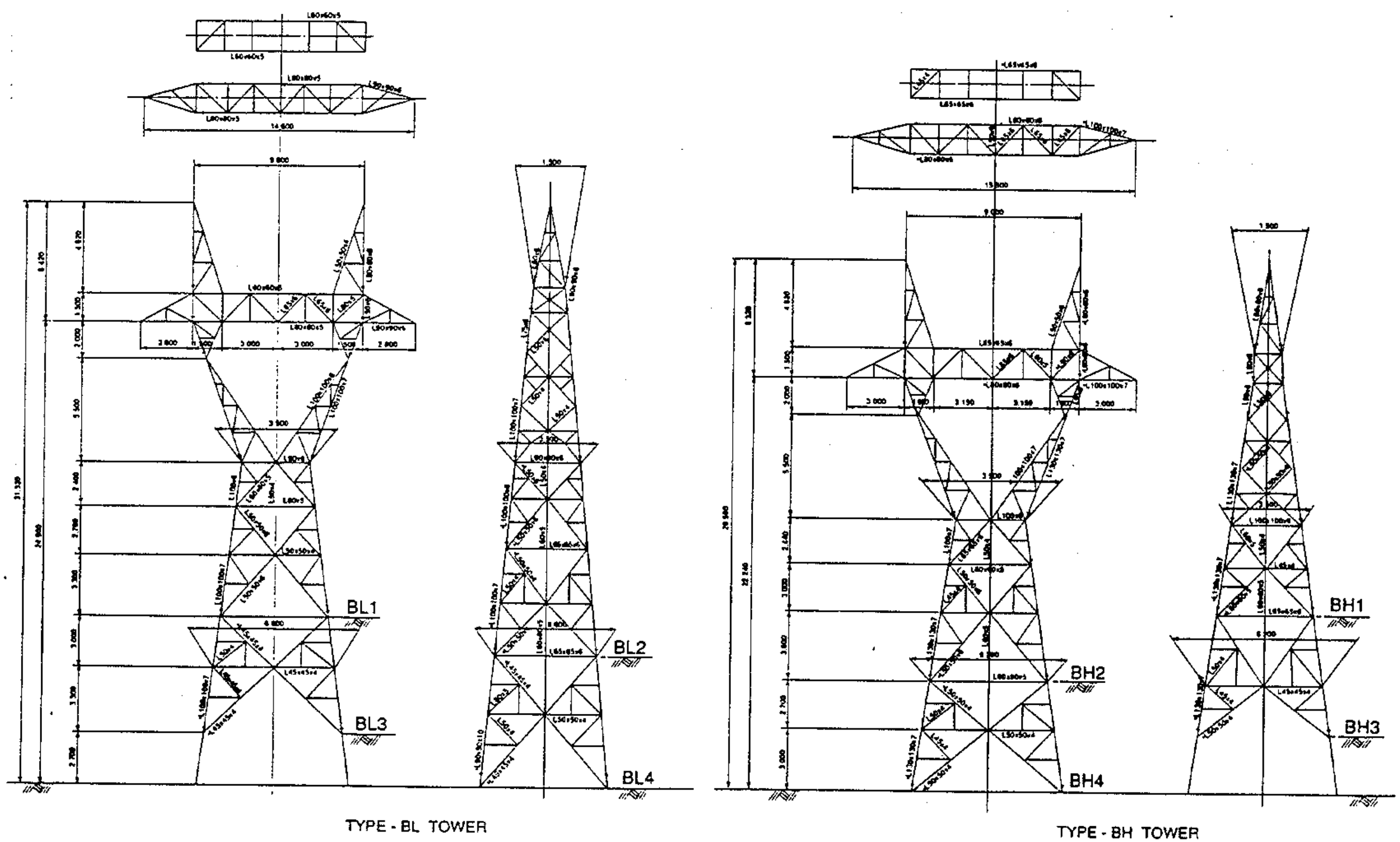
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.1 Maintenance of Surrounding of Tower Foundation



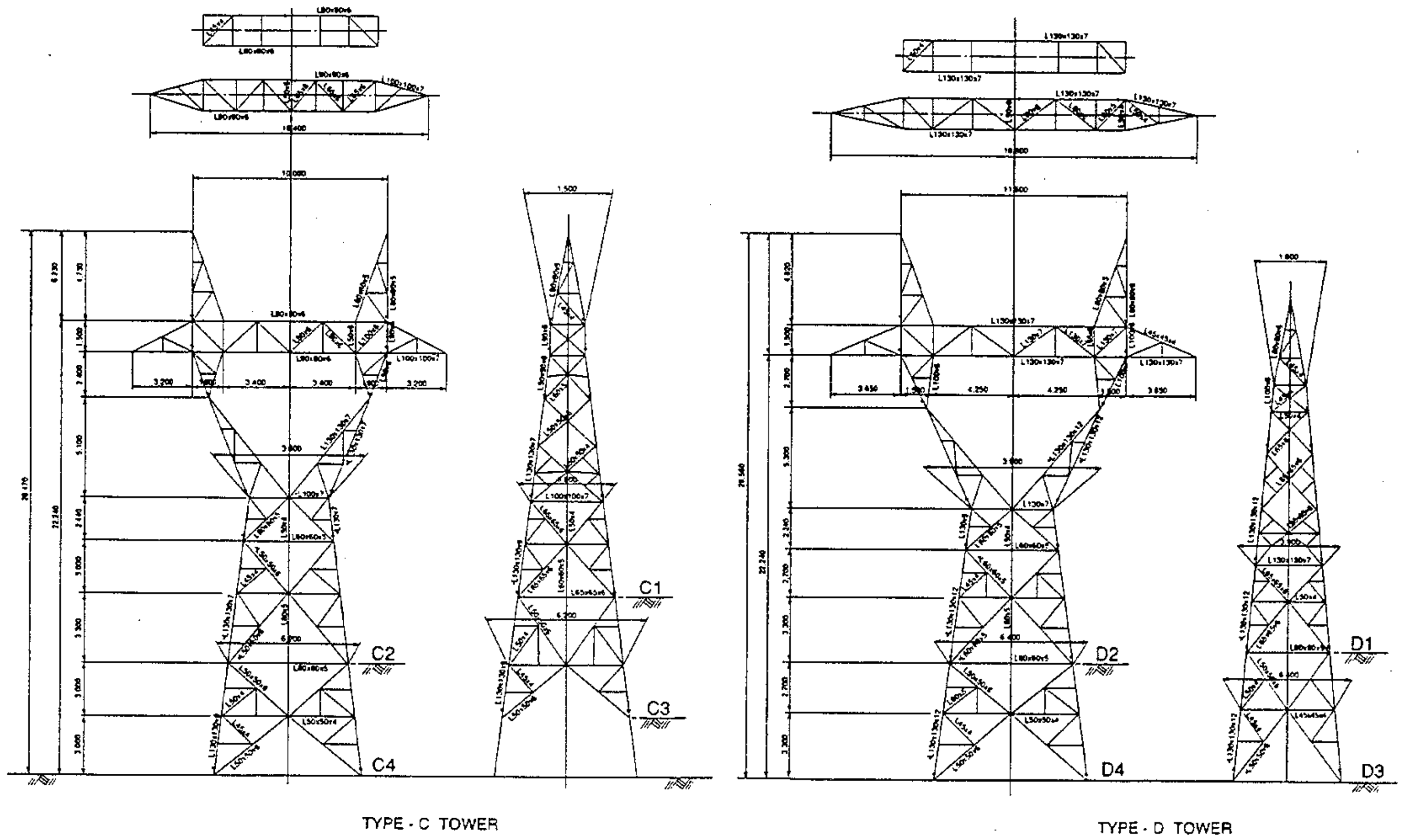
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.2 (1) Outline of Towers



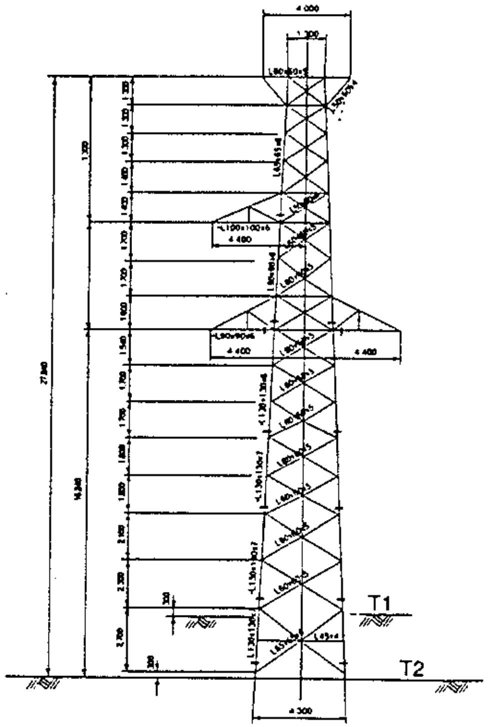
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.2 (2) Outline of Towers



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.2 (3) Outline of Towers

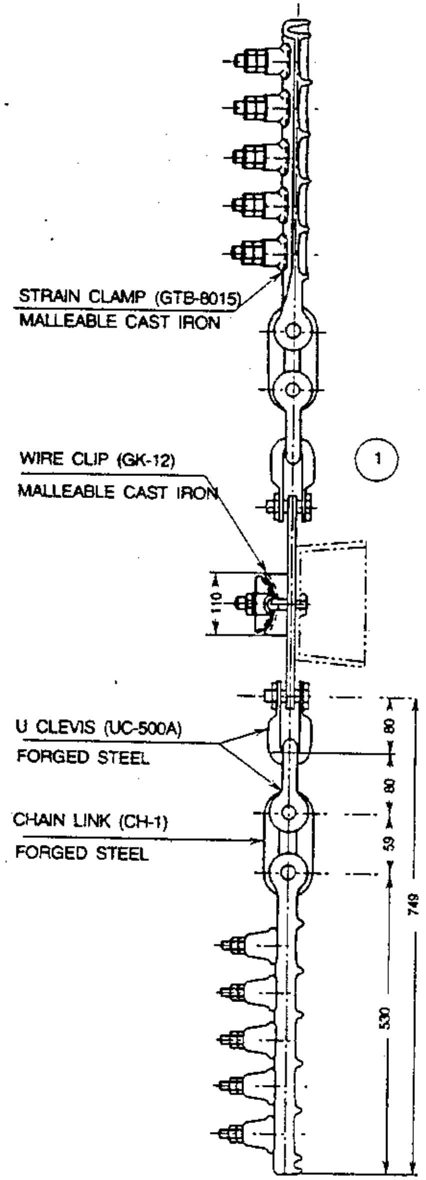


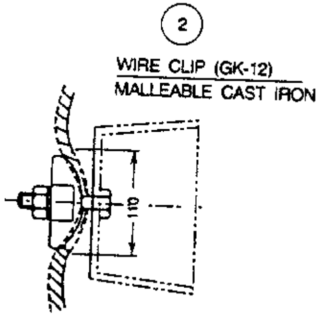
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.2 (4) Outline of Towers

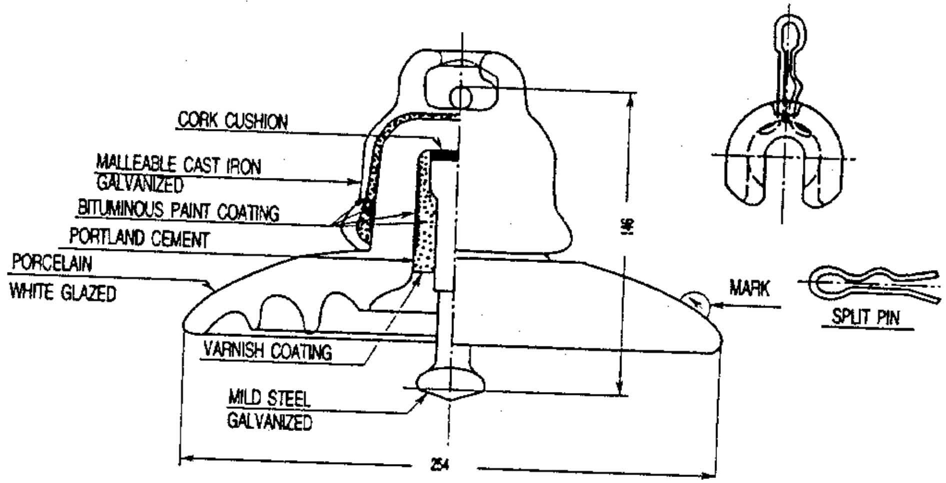


TYPE - T TOWER

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.2 (5) Outline of Towers







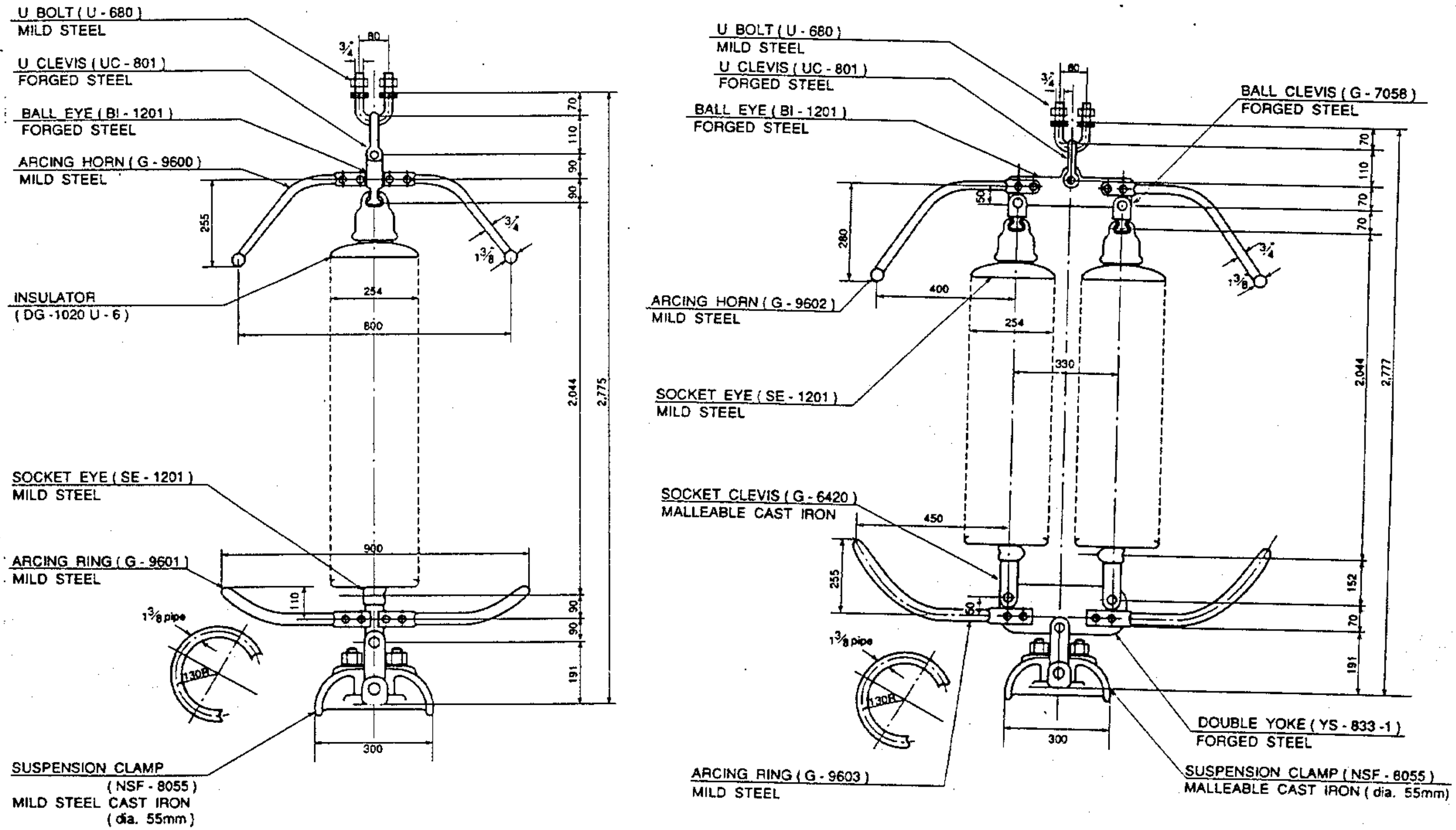
TECHNICAL DATA

Dry flashover voltage	80 KV
Wet flashover voltage	50 KV
Withstand dry test voltage	75 KV
Withstand wet test voltage	42 KV
Impluse flashover voltage (1 x 50/μ pcs.)	125 KV
Puncture voltage	140 KV
Leakage distance	280 mm.
Electro-Mechanical strength	10,000 Kg
Routine proof test load	3,500 Kg
Impact strength	1.15 Kg-m
Radio influence voltage of 1000 KC at 10 KV	50/μv
Net weight (Approx.)	5 Kg

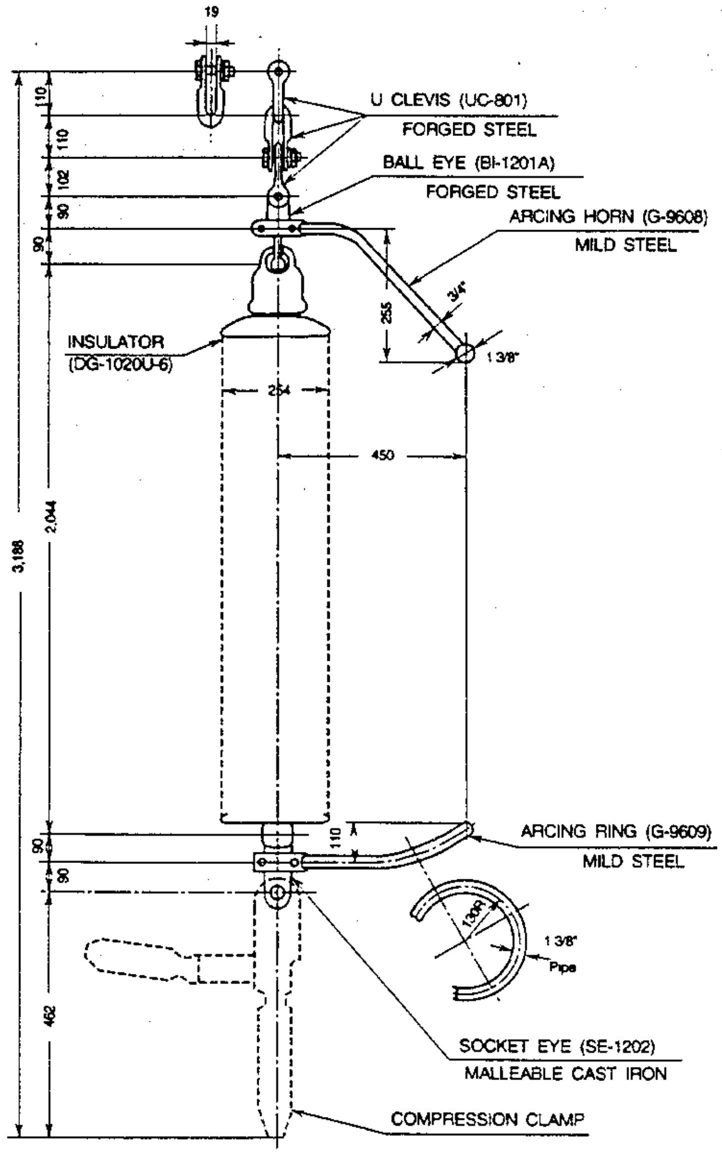
MARK

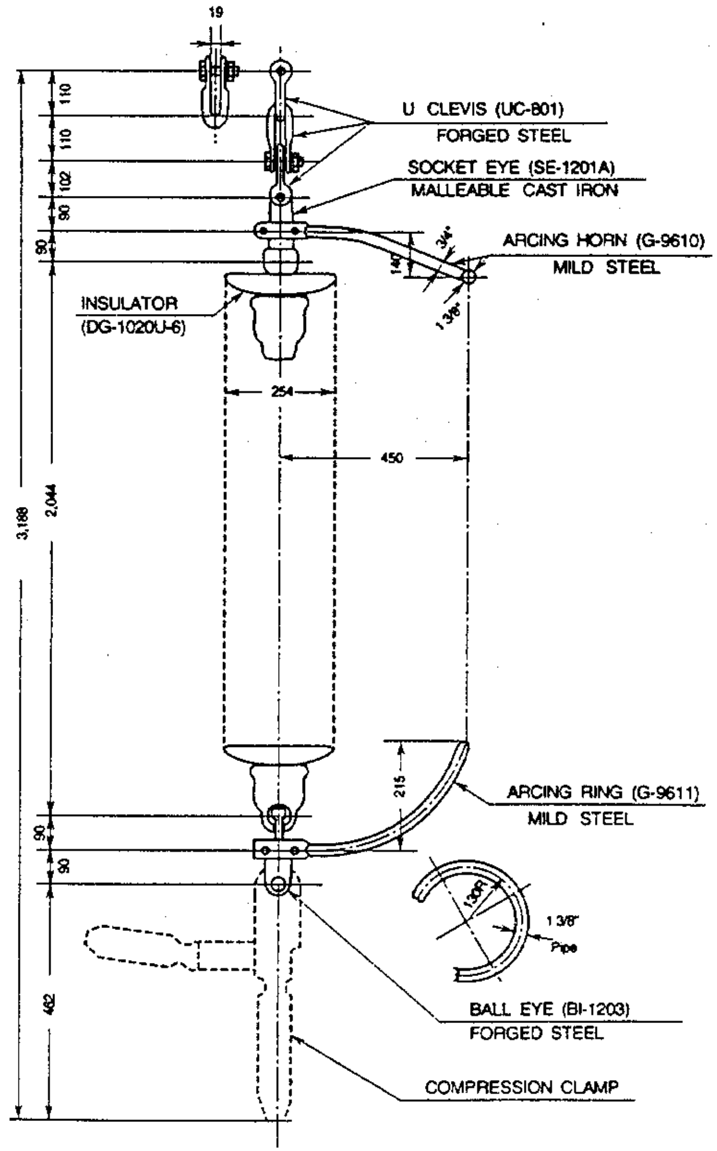
Note: The insulator shall have ball and socket connection which meet the requirements of NEMA standard class No. 52-5

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.3 Suspension and Tension Type Hardwares of Overhead Earthwire

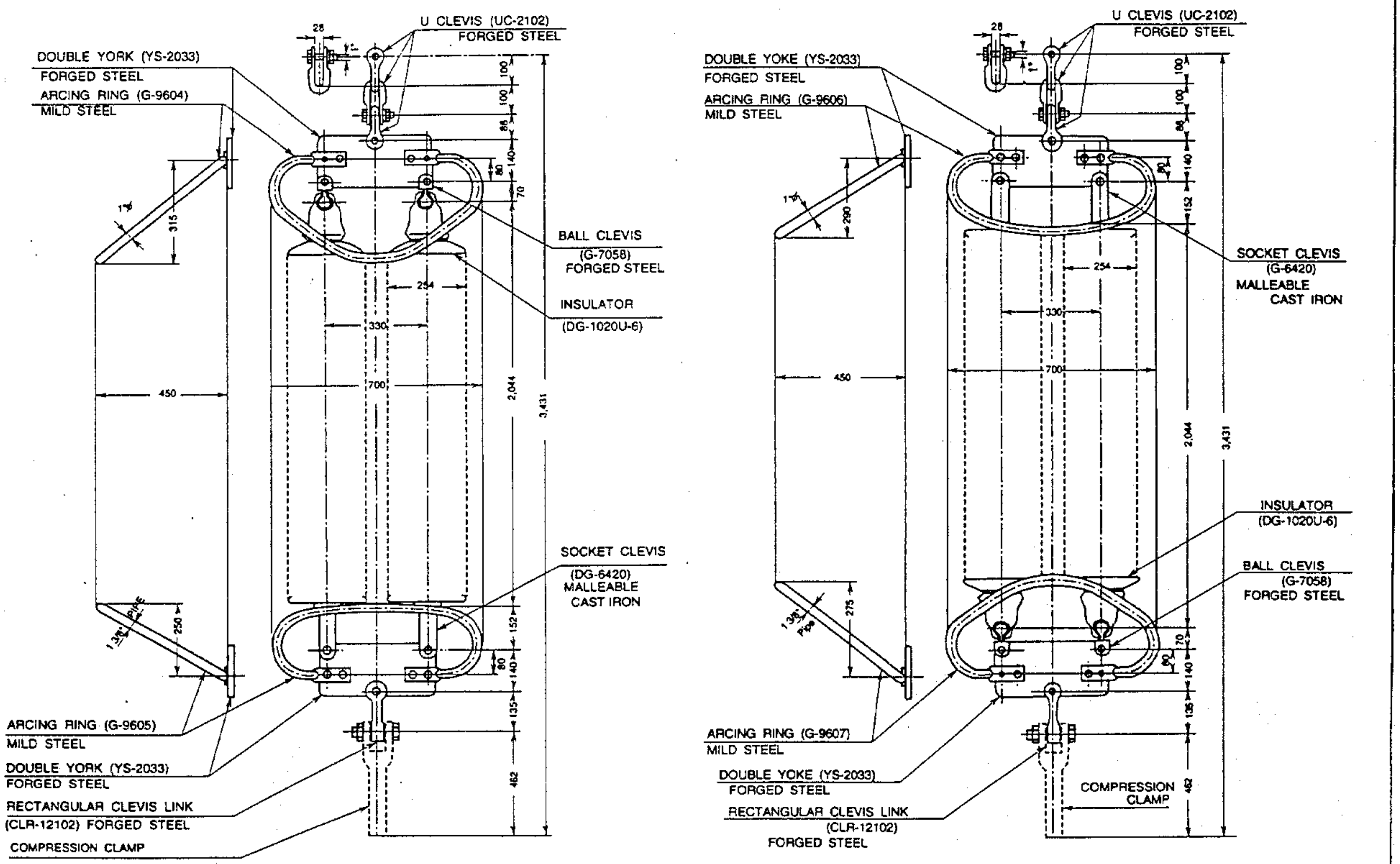


FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.4 (1) 230 kV Insulator Sets





FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.4 (2) 230 kV Insulator Sets



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.4 (3) 230 kV Insulator Sets

Section		Gang No.	Working Days									Worker/Gang			Total Workers		
	Tower No.		1	2	3	4	5	6	7	8	9	Line-men	General	Total	Line-men	General	Total
	ACSR																
1	24-26	1										10	5	15	30	15	45
2	36-37	2										13	7	20	78	42	120
3	38-43	2															
4	44-46	3										10	5	15	40	20	60
5	48-49	3															
6	55-57	3										13	7	20	39	21	60
7	58-60	3															
8	62-67	4										13	7	20	65	35	100
9	68-79	5										13	7	20	104	56	160
10	82-84	6										13	7	20	39	21	60
11	90-91	6										10	5	15	30	15	45
12	92-95	7										13	7	20	39	21	60
13	96-98	7										13	7	20	39	21	60
14	100-101	8										13	7	20	78	42	120
15	102-107	8															
16	108-110	9										10	5	15	30	15	45
17	114-118	1										13	7	20	65	35	100
18	19-120	1															
19	121-123	9										10	5	15	30	15	45
20	124-128	10										13	7	20	52	28	80
21	129-130	11										13	7	20	65	35	100
22	131-132	11															
23	134-136	11															
24	138-142	12										13	7	20	52	28	80
25	143-144	12										13	7	20	26	14	40
26	145-147	12															
27	151-152	10										10	5	15	30	15	45
28	154-155	13										13	7	20	91	49	140
29	156-157	13															
30	158-161	13															
31	164-166	13															
32	167-170	14										13	7	20	65	35	100
33	171-172	14															
34	439-441	15										13	7	20	65	35	100
35	498-499	15															
36	501-502	16										10	5	15	30	15	45
37	503-504	16										7	3	10	14	6	20
	GSW																
38	439-440	17										7	3	10	35	15	30
39	441-444	17															
40	502-503	18										7	3	10	42	18	60
41	532-534	18															
42	535-536	19										7	3	10	35	15	50
43	542-544	19															
	Total	19													1380	682	1990

Figure 9.5
Draft Implementation Schedule of Rehabilitation of Overhead Earthwire and Power Conductor

CHAPTER 10

UPGRADE OF TRANSMISSION FACILITIES

CHAPTER 10 UPGRADE OF TRANSMISSION FACILITIES

10.1 Field Investigation and Results

10.1.1 Field Investigation

This clause comprises the approaches, procedures, and results of the field investigation, conducted by the Study Team of the facilities requested by the GOV.

(1) Confirmation of the Facilities Requested

GOV requested GOJ to study the upgrade of the existing 66 kV Da Nhim power system. Through the first discussion held with the Transmission Department of PC-2, the Team confirmed the request as follows:

1) Capacities of the existing electric facilities in the power system are reaching their limit due to the increase of power demand. In order to meet the needs of further power demand, the existing 66 kV power systems should be reinforced urgently by upgrading the existing 66 kV facilities to 110 kV power systems, except the Da Nhim-Dalat 66 kV system. The facilities to be upgraded are the substations at Da Nhim, Thap Cham, Phan Ri, Phan Thiet, and Cam Ranh, and the transmission line facilities connecting each substation.

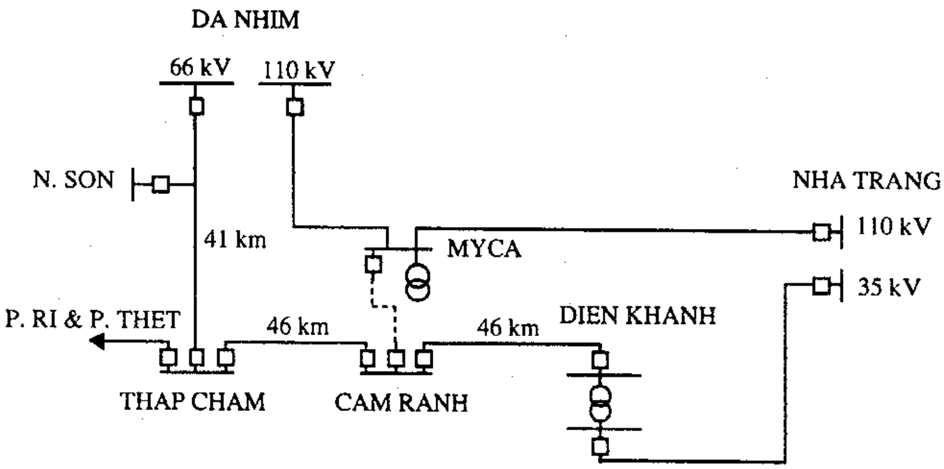
2) The existing substations are facilitated by 66 kV systems, however, all the substation facilities should be renewed to 110 kV system. The existing transmission facilities from the Da Nhim power station to the Cam Ranh substation via the Thap Cham substation and the line facilities from the Thap Cham substation to the Phan Thiet substation via the Phan Ri substation are originally designed and constructed for 110 kV-132 kV system. Therefore, renewal of the transmission line facilities is not necessary, but some rehabilitation to these facilities will be required.

Through the discussion, it was disclosed that the existing Cam Ranh substation and the line extending from the Thap Cham substation to the Cam Ranh substation are now under the management of PC-3. Accordingly, PC-2 has no detailed information regarding the condition of these facilities.

However, the Study Team could obtain information regarding the present condition of the facilities directly from the director of the Transmission Department No.2 of PC-3 who was invited by the director of PC-2 to join the discussions held between the Study Team and PC-2.

According to the explanation, a new 66 kV substation called the Dien Khanh substation was constructed in 1993 in the middle place of the Cam Ranh-Nha Trang line and is now supplying Da Nhim power to its surrounding area.

If the Cam Ranh substation and the related transmission line are upgraded, the upgrade of the 66 kV transmission line from the Cam Ranh substation to the Dien Khanh substation as well as to the Dien Khanh substation is necessary. The director of PC-3 requested the Study Team to study these facilities together with the Cam Ranh substation and the Thap Cham-Cam Ranh line. The Study Team explained that the study was to carried out up to the Cam Ranh substation in accordance with the agreement of both Governments. The Team, however, investigated these facilities on the way to the office of the Transmission Department of PC-3 in the Nha Trang City in order to hold discussions concerning the Cam Ranh substation and the Thap Cham-Cam Ranh line.



(2) Investigation Procedures

The Study Team conducted the investigation of the facilities through the following procedures:

1) Confirmation, prior to the field inspection, from the drawings and other documents kept by PC-2 that the existing facilities of the Da Nhim-Thap Cham and Thap Cham-Cam Ranh lines are designed and constructed for 110 kV system. The Study Team also examined the drawings of the facilities of the Thap Cham-Phan Ri-Phan Thiet line for reference in the field investigation.

2) Examination of the material lists, which were prepared and explained by PC-2 and PC-3, required for the upgrade of the transmission line facilities of the Da Nhim, Thap Cham, and Cam Ranh substations.

3) Collection of the past power records and demand forecasts of the areas covered by the substations to be upgraded for examining the propriety of the upgrade plan.

4) Examination of an alternative plan for additional 66 kV circuits in order to increase transmission capacity.

5) Confirmation of the premises for the new substation sites.

6) Investigation of the actual situation of the existing Da Nhim-Thap Cham and Thap Cham-Cam Ranh-Dien Khanh transmission lines which was carried out together with the PC-2 and PC-3 counterparts. Examination of the rearrangement of the line connections to the new substations.

7) Investigation of the Thap Cham-Phan Ri-Phan Thiet line as well as the Phan Ri and Phan Thiet substations for line connections to these new substations and for examination of the materials needed for the upgrading.

8) Discussions with the PC-2 counterparts on the appropriate maintenance of the lines.

10.1.2 Power Records and Power Demand Forecasts

The following are the power data recorded by each substation and power demand forecasts prepared by PC-2 and PC-3:

(1) Power Supply Records

The table shows the records for the power supplied from the Da Nhim power station through the existing 66 kV transmission lines. It is note worthy that the Dien Khanh substation started to supply power in 1993, the records before this year are those for the distribution feeders which supplied power to the district.

From the table and PC-2's and PC-3's explanations, the following situations are understood:

1) Average annual growth rates in the area planned for the upgrade were recorded at such high levels as 20% for energy consumption and 17% for the maximum power demand, over the last 4 years.

2) It is analyzed that the rapid growth rates in the districts of Phan Ri and Phan Thiet would be caused by the considerably new electrification.

3) Energy consumption in the comparatively electrified districts of Cam Ranh and Dien Khanh has grown at a remarkably high rate in spite of PC-3's restrictions on the power supplied to new applicants due to the shortage of power sources. This is believed to be caused by the promotion of continuous electrification of the existing domestic consumers.

4) About 70% of the power demand in the Cam Ranh district is shared by the domestic and service consumers. However, in the Dien Khanh district, industrial and agricultural consumers share more than 70% of the total energy consumption.

Substation		1990	1991	1992	1993	1st 6 mth 1994	Average Growth
Ninh Son (completed in 1989)							
Energy Received	(GWh)	1.80	1.90	2.50	2.20	-	6.90%
Maximum Demand	(MW)	0.60	0.60	0.80	0.70	-	5.27%
Thap Cham (completed in 1975)							
Energy Received	(GWh)	25.30	26.90	25.20	31.60	-	7.70%
Maximum Demand	(MW)	6.30	6.60	6.40	8.00	-	8.29%
Phan Ri (completed in 1990)							
Energy Received	(GWh)	-	3.00	3.40	6.90	-	51.66%
Maximum Demand	(MW)	-	1.00	1.10	2.30	-	51.66%
Phan Thiet (completed in 1989)							
Energy Received	(GWh)	15.20	22.40	25.60	31.10	-	27.22%
Maximum Demand	(MW)	4.20	5.70	6.50	7.90	-	23.44%
Cam Ranh (completed in 1974)							
Energy Received	(GWh)	9.50	10.06	11.56	19.20	-	26.41%
Maximum Demand	(MW)	3.05	3.30	3.90	4.00	5.20	9.46%
Dien Khanh (completed in 1993)							
Energy Received	(GWh)	10.39	11.49	12.74	16.55	-	16.96%
Maximum Demand	(MW)	3.00	3.20	3.50	4.30	6.40	12.75%
Total							
Energy Received	(GWh)	62.19	75.75	81.04	107.55	-	20.11%
Maximum Demand	(MW)	17.15	20.40	22.20	27.20	-	16.62%

(Source: PC-2 Energy Center & PC-3 Transmission Department No.2)

(2) Power Demand Forecast

An official demand forecast is issued by the Ministry of Energy after the ministry has approved the draft demand forecast prepared by each power company.

In addition to the comprehensive forecast of each region, PC-2 and PC-3 prepared the following demand forecasts for the districts which are subject to the system upgrade in this study. The demands are forecasted on the basis of the past trends of the demands and in consideration of the new local development program of the related districts.

Substation		1993	1994	1995	1996	1998	2000	Average Growth
Ninh Son								
Energy Required	(GWh)	2.2	2.5	4.9	5.7	7.4	10.2	24.5%
Maximum Demand	(MW)	0.7	0.8	1.4	1.6	2.1	2.8	21.9%
Thap Cham								
Energy Required	(GWh)	31.6	40.5	49.8	51.4	79.3	101.3	18.1%
Maximum Demand	(MW)	8.0	10.3	11.9	13.6	18.8	24.0	17.0%
Phan Ri								
Energy Required	(GWh)	6.9	8.8	10.7	13.2	19.5	28.7	22.6%
Maximum Demand	(MW)	2.3	2.8	3.4	4.2	6.2	9.1	21.7%
Phan Thiet								
Energy Required	(GWh)	31.1	34.4	38.6	39.4	53.2	67.4	11.7%
Maximum Demand	(MW)	7.9	8.8	9.8	10.0	13.5	16.8	11.4%
Cam Ranh								
Energy Required	(GWh)	19.2	20.0	45.0	60.0	105.0	130.0	31.4%
Maximum Demand	(MW)	4.0	5.5	8.0	10.0	14.5	16.0	21.9%
Dien Khanh								
Energy Required	(GWh)	16.5	22.0	66.0	80.0	120.0	160.0	38.3%
Maximum Demand	(MW)	4.3	10.0	12.0	15.0	18.0	20.0	24.6%
Total								
Energy Required	(GWh)	107.5	128.2	215.0	249.7	384.4	497.6	24.5%
Maximum Demand	(MW)	27.2	38.2	46.4	54.4	73.1	88.7	18.4%

(Source: PC-2 Energy Center & PC-3 Transmission Department No.2)

Analyses on the PC-2's and PC-3's forecasted demands for each district are as follows:

Ninh Son district:

The energy required and the maximum power demand will grow at higher rates than the past trends. It is assumed that the number of consumers will increase, but energy consumption per consumer will not increase as much.

Thap Cham district:

The increase of new big consumers such as hotels and governmental offices, in addition to the diffusion of domestic electrical apparatus will result in the growth of energy consumption and the maximum demand at rates of more than twice the past records.

Phan Ri district:

It is assumed that electrification of the district has almost been developed and the growth will not be as remarkable as before because of the limited population and consumers.

Phan Thiet district:

The electrification of the district has been promoted and the increase of new consumers which was recorded over the last several years, is not expected. However, energy consumption and the maximum demand in the district are estimated to increase at 11% per annum.

Cam Ranh and Dien Khanh districts:

PC-3 restrains the electrification of new applicants and increase of energy consumption of the present consumers because of the shortage of power sources and facilities. The rapid increase of energy consumption and the maximum demand is easily estimated if the power source will be ensured and new facilities for the delivery of energy will be provided in the districts. PC-3 is constructing a new 110 kV substation at My Ca on the existing 110 kV transmission line extending from the Da Nhim power station to the Nha Trang substation and also a new 110 kV design transmission line between the My Ca substation and the existing Cam Ranh substation. PC-3 forecasts a higher growth of energy consumption and power demand in the districts in the years immediately after the completion of these facilities.

10.1.3 Examination of the Upgrade Plan

According to the districtwise the power demand forecasts prepared by PC-2 and PC-3, the current flow of the existing 66 kV Da Nhim-Thap Cham line will exceed the current capacity of the existing power conductor in the year 1996.

Even before the current flow exceeds the capacity, the economic operation of the lines will not be expected because of the occurrence of huge energy losses and the sharp voltage drops of the power conductors. Urgent countermeasures should be implemented on the lines.

The trial calculation shows that the total power loss of the 66 kV power system was 3.2 MW (11.8%) for the maximum load of 27.2 MW in 1993 and will increase to 13.2 MW (24%) in 1996. While, the annual energy loss of the system will increase from 28.7 GWh in 1993 to 50.0 GWh in 1996.

Assuming that the line will be upgraded to 110 kV, the power loss and energy loss in 1996 will be reduced from 13.2 MW to 4.8 MW and from 50 GWh to 18 GWh. Applying the present average power tariff of 450 Dong/kWh to the energy loss, Dong 1.44×10^{10} (approximately US$ 1,440,000) will be saved in the year 1996 only, if the lines are upgraded to 110 kV.

There are generally three measures which are considered to increase the capacity of the existing transmission lines; (a) upgrade of the operating voltage of the system, (b) increase of the number of circuits of the existing voltage line, and (c) increase of the power conductor size.

To upgrade the operating voltage is to reduce the current, under the same amount of power, and it results in the increase of its transmission capacity. Such an upgrade of the system requires the renewal of the transmission lines and substations. The transmission line facilities of the Da Nhim-Thap Cham, Thap Cham-Phan Ri-Phan Thiet, and Thap Cham-Cam Ranh lines have been originally designed and constructed for 110 kV to 132 kV systems for future upgrading. Accordingly, if the power system are upgraded, the renewal of the transmission line facilities is not required. The construction of 110 kV substations will only be required.

If the number of circuits of existing 66 kV lines increase, new 66 kV transmission line facilities will additionally be required and the existing 66 kV substation equipment shall be extended. The addition of the same scale of facilities will increase the transmission capacity to twice the existing capacity.

Replacement of the existing power conductors with larger conductors will increase the transmission line capacity in proportion to the current capacity of the conductors. For the larger conductors and extension of the substation equipment, new and stronger supports for the transmission lines and additional equipment for the substation are needed. This will require a similar or larger amount of additional investment than the above-mentioned increase of circuits.Also, a long duration of the power interruption is required.

A comparison was made between the upgrade of the system voltage and the increase of the number of circuits of 66 kV lines. Construction costs were estimated under the following conditions, including the substations at Thap Cham, Phan Ri, Phan Thiet, and Cam Ranh.

	Upgrade	Addition of 66 kV
Addition of the 66 kV Transmission Line (229 km)	x	o
Construction of the 110 kV Transmission Line	x	x
Extension of the 66 kV Substations (4 stations)	x	o
Construction of the new 110 kV Substations (4 stations)	o	x
Extension of the Da Nhim Switchyard	o	o

Note: o : facility required x : facility not required

Estimated costs are approximately US$ 19,000,000 for the upgrade plan and US$ 33,000,000 for one additional circuit plan for the 66 kV system. Thus, the upgrade plan is more economical than the additional circuit plan.

Besides, the country decided on the plan not to construct new 66 kV power systems but to upgrade the existing 66 kV power systems to higher voltage systems for efficient system operation.

From this examination, it was concluded that the upgrade plan of the Da Nhim 66 kV system, intended by the power companies, is quite reasonable.

The My Ca 110 kV substation constructed by PC-3 will send power to the upgraded Cam Ranh substation after the year 1999 when the implementation of the upgrade plan would have been completed. The Dien Khanh substation will receive the power from the Cam Ranh substation. Thus, the Cam Ranh and Dien Khanh substations will be supplied power not through the Thap Cham substation but through the My Ca substation. The Upgraded Cam Ranh and Dien Khanh substations will supply power to their local demands till the year 2018 without further reinforcement.

On the other hand, new hydropower stations are to be developed at Ham Thuan and Da Mi by the year 2000 - 2003, and the stations are planned to be connected to the Phan Thiet substation by 110 kV transmission lines. Then, the upgraded Phan Thiet and Phan Ri substations will be able to supply power of the new power stations to their local demands by the year 2029 through the upgraded facilities.

Under the demand forecasts and power flow, the Da Nhim - Thap Cham line after the upgrade will mainly deliver the Da Nhim power to the Thap Cham, Phan Ri and Phan Thiet until completion of the new hydropower stations. The upgraded Da Nhim - Thap Cham line will transmit 79.4 MW from the current capacity of the conductors. Hence, the line will continuously supply power for the Da Nhim power station to the Thap Cham till the year 2013. After the year the Thap Cham substation will be supplemented power from the Phan Ri substation till the year 2018 for its demand. New reinforcement of the system should be programmed before the year, accordingly.

10.1.4 Results of the Field Investigation of the Transmission Lines

(1) Overhead Earthwires and Power Conductors

The following earthwires and conductors are used in the respective sections of the Da Nhim 66 kV transmission lines:

		Earthwire	Conductor	Diameter of the Conductor
Da Nhim-Thap Cham	:	Steel 22 mm^2	ACSR 336.4 MCM	18.28 mm
Thap Cham-Phan Ri	:	Steel 50 mm^2	ACSR 185 mm^2	18.80 mm
Phan Ri-Phan Thiet	:	Steel 50 mm^2	ACSR 185 mm^2	18.80 mm
Thap Cham-Cam Ranh	:	Steel 22 mm^2	ACSR 336.4 MCM	18.28 mm
Cam Ranh-Dien Khanh	:	Steel 22 mm^2	ACSR 300.0 MCM	17.27 mm

It is necessary to examine the outside diameter of the existing power conductors for generation of corona while upgrading the voltage of the system. The minimum outside diameter of the power conductor of the 110 kV power systems is 15 mm for generation of corona in rainy conditions. The diameter of the power conductors used for the existing 66 kV lines is larger than the minimum diameter as seen in the above table. Accordingly all the existing power conductors can be applied to the 110 kV transmission lines as they are.

The existing overhead earthwires and power conductors are believed to be in good condition except for the individual wires which were partially broken.

1) Da Nhim-Thap Cham section (about 41 km)

It was observed at many positions that the overhead earthwires were broken and were tentatively repaired by parallel-groove clamps because of the shortage of the proper midspan joints. This may cause the wires to break completely resulting in the supply of power being interrupted. Properly designed midspan joints should be procured for repair and maintenance. Damage was observed on the power conductors, therefore, proper midspan joints and repair sleeves should be procured for repair.

2) Thap Cham-Phan Ri-Phan Thiet section (about 137 km)

There are no parts of the overhead earthwires or power conductors to be repaired. In this section, compression type midspan joints are used for jointing the earthwires and twisting type McIntire sleeves are used for the power conductors.

3) Thap Cham-Cam Ranh section (about 46 km)

In this section no parts of the overhead earthwires have to be repaired. Conductor joints in the same span, which have been tentatively repaired by improper hardware, are observed in many spans. Such spans should be replaced with new conductors for safe operation. In addition, it may be necessary for proper midspan joints and repair sleeves for the power conductors to be procured.

4) Cam Ranh-Dien Khanh section (about 46 km)

Two overhead earthwires are installed in this section. In several sections one wire out of the two wires is missing. Proper midspan joints and repair sleeves of power conductors and overhead earthwires should be procured for the rehabilitation of the line to the original design. PC-3 plans to replace all the existing power conductors in this section with new materials.

Tables 10.1 and 10.2 summarize items, quantities, and specifications for the necessary materials and maintenance tools for the upgrade and urgent repair of the existing 66 kV transmission line facilities, on the basis of the discussions with the Transmission Departments of PC-2 and PC-3.

(2) Supports

1) Da Nhim-Thap Cham-Cam Ranh section

In this section, galvanized steel towers are used for the river crossing sections and terminal points, while, galvanized steel tube supports are used for other sections and positions. These supports were supplied by the Japanese manufacturers for the 110-132 kV design system. The total number of supporting positions is 604 over 87 km. The Study Team examined the necessary conductor clearances of the existing supports on the manufacturing drawings for the operation of the 110 kV power systems and confirmed that the existing supports are provided with sufficient clearances for the 110 kV systems. The results of the examination are shown on Figure 10.1. Accordingly, the supports can be used for the upgraded power systems without any modification being made to them.

However, some tubular poles were damaged by shell boring through them during the war, and many crossarms and staywires remain unrepaired after being damaged. These damaged facilities should be replaced with new materials. The Study Team discussed and agreed with PC-2 on the materials required for the urgent repair of the supports, which is summarized in Table 10.1.

2) Thap Cham-Phan Ri-Phan Thiet section

Galvanized steel towers are used at heavy angle positions, terminal positions, and as supports in hilly areas in this section. Other supports are locally manufactured concrete poles that are extended by flange joints. The design conditions of the supports in this section seem to be different from those of the Da Nhim-Thap Cham-Cam Ranh section. However, the supports were designed by PIDC-2 for the 110 kV transmission lines use on the basis of regulations set out by the former USSR. Accordingly, it is not necessary to modify the existing supports in order to upgrade the transmission voltage.

The total number of the existing supports in this section is 771 consisting of 719 concrete poles and 52 steel towers. Approximately 250 supports or 35% of the total number of concrete poles possess seriously rusted crossarms. In addition, bent and damaged crossarms are observed. According to PC-2's report, the crossarms of 230 concrete poles should be replaced with new arms for the safe operation of the line. The damage and loss of many stay wires, grounding materials, and other fittings of the concrete poles are also observed. These materials and fittings should be supplemented or replaced.

At present, PC-2 has only this line for supplying power to the surrounding areas, but no other alternative facilities. Therefore, it is impossible to shut down the line for a long period. The repair of the line facilities should be limited to the bent crossarms which may cause more serious damage to the supports, in addition to the repair of the staywires and grounding materials, which will be implemented under the line energizing condition. Table 10.3 presents the necessary materials for such repairing works.

It is noted that the damaged on rusted crossarms will be replaced with the locally fabricated materials as mentioned in the Minutes of Meeting (Item 7-2) of No. F/D-3 of 14th and 15th March, 1995.

3) Cam Ranh-Dien Khanh section (proposed by PC-3)

The line mostly runs through paddy field and the supports in this section are tarpainted timber poles constructed in 1975. PC-3 reported that many of the poles have been rotted at their lower parts and have fallen down. The Study Team confirmed that many rotten poles reinforced by additional timber poles or concrete poles existed at the site. The Study Team also observed rusted or bent crossarms, broken or missing staywires, more than in the Thap Cham-Cam Ranh section. The line facilities are designed for a 110 kV line in the same way as the Thap Cham-Phan Thiet line, although many parts of the existing facilities should be rehabilitated.

PC-3 plans to replace all the existing timber poles (317 positions) with local manufactured concrete poles, in an attempt to upgrade the line voltage. New poles will be erected in the right-of-way of the existing transmission line utilizing the present overhead earthwires, power conductors, and insulator sets. As observed in the figure on page 10-2, the shut down of this section for some time will not affect the power supply in the power systems, since the Nha Trang-Dien Khanh 35 kV line can cover power demand in the Dien Khanh area. Table 10.2 summarizes the necessary materials for the rehabilitation and replacement of the existing timber supports.

(3) Insulators and Hardware

1) Da Nhim-Thap Cham-Cam Ranh section

Since the facilities were designed and constructed for 110 kV-132 kV lines, no modification is required for upgrading the line voltage. Insulators used in this section are of a porcelain type manufactured in Japan.

Since no supplemental procurement of insulators has been carried out after the construction of the line, no spare porcelain insulators are stocked by PC-2 and PC-3. Therefore, cracked insulators are inevitably used for the Da Nhim-Thap Cham section. At present, no serious operational impediment exists for the 66 kV operation, but the many insulator sets should be completely rehabilitated before the line is upgraded to a 110 kV system.

Due to the same reasons, PC-3 reduces the number of applied insulator units in the Thap Cham-Cam Ranh section, from the original 8 units per set to 6 units per set, and mixes glass insulators with the original porcelain insulators. Moreover, many insulator sets have only 4 or 5 units, which may cause frequent flashover faults even under the present 66 kV operation. About 30% of this line is constructed close to the sea coast, therefore, special insulators were originally applied for this part. Due to the shortage of special insulators, standard insulators are used, which results in the pin parts of many insulators being corroded or going missing.

2) Thap Cham-Phan Ri-Phan Thiet section

Insulator sets in this section are also designed and constructed for 110 kV systems, therefore, no modifications of the sets are required. PC-2 reported that all the insulator units used in this section are glass insulators supplied by the former USSR manufacturers. Most of the line route is aligned with the sea coast at a distance of 3-4 km (500 m at the closest portion) from the sea. Therefore, the facilities are subjected to salt contamination. As yet there are not definite records of line faults caused by salt contamination, because it has only been 5 years since the facilities were constructed. Neither special insulator units for preventing salt contamination nor an increase in the number of the units per set are applied to the line close to the sea coast. It is foreseen that line faults caused by salt contamination will increase unless preventive measures are taken.

To prevent salt contamination of the insulators the maintenance groups should periodically wash the salt away. In addition, there are principally two ways to the prevent contamination; one is to apply special insulators which have a longer creepage distance, and the other is to increase the number of insulator units per set in order to increase the creepage distance. The latter requiring longer insulator sets needs longer crossarms and higher poles in order to maintain the necessary insulation clearances between the power conductors and the supports or ground. The line facilities in this section are not constructed for longer insulation sets. Since the latter is not applicable for this line, it is recommended that the existing standard insulator units near the sea coast be replaced with the longer creepage insulator units in the future.

The hardware of the insulator sets is sufficiently galvanized and firmly fitted and no rust is observed on them at present. Accordingly, replacement or supplement of any hardware will not be required for upgrading.

3) Cam Ranh-Dien Khanh section

The original insulator units in this section are glass-made units manufactured in the former USSR. Due to the shortage of insulators, various kinds of units are mixed. In addition, most of the insulator sets have only 6 units per set for the operation of the 66 kV system. Not only for the upgrade of the line but also for the operation of the 66 kV system, many insulators should immediately be procured. PC-3 prefers glass insulators to porcelain insulators.

Although the detailed specifications of the insulator units imported from the former USSR, USA, Italy, and France are not clear, the Study Team confirmed, from the trial assembly at the Saigon substation, that various types of insulator units presently used by the line sections to be upgraded are interchangeable.

The procurement of insulators is given top priority among all the other materials, which is also the case with the 230 kV rehabilitation plan. Tables 10.1 and 10.2 show the quantities and specifications required by PC-2 and PC-3.

(4) Tools and Devices for Repair and Maintenance

Tools and devices required are the same as those used by the 230 kV transmission line, however, they should be procured separately because of the different areas to be covered.

The shortage of tools in PC-2 is remarkable. Minimum quantities of hydraulic compressor sets, insulator exchangers, pulleys, etc. required for the normal maintenance work should be urgently procured. The tools proposed by PC-2 and PC-3 are summarized in Tables 10.3 and 10.4 together with the specifications of each tool.

(5) Maintenance Works

At present, the Da Nhim-Thap Cham-Phan Ri-Phan Thiet lines, approximately 180 km with 1,051 supports, are being patrolled by one group of 17 linemen.

Since there are no steep hills in the sections and access to the line is easy, it will be adequate to carry out daily patrols of one support at the rate of once a month by a pair of linemen where the pair will patrol 5 supports a day. The repair of the facilities will be conducted by PC-2's additional work forces. However, the works are not expected to be efficiently carried out since there is a shortage of tools and devices.

The Study Team's expectation to join the daily patrols and to visit the repair work site was not realized by PC-2, but the Study Team could have the chance to inspect PC-2's construction of the 110 kV line in Ho Chi Minh City. The Study Team believes that the working group's ability is sufficient for carrying out the repair works of the existing transmission lines.

10.1.5 Results of the Field Investigation of the Substations

(1) Existing 66 kV substation facilities

The Thap Cham Substation and the Cam Ranh Substation were constructed in 1974 under the financing of Japanese Loan. Afterwards, these substations were modified and extended in compliance with the development of the network demand. As a result, the products of various countries are now installed in these substations. Most of the substation equipment are seriously deteriorated and seems to nearly reach their service life for use. The other 66 kV substations to be upgraded seem to be similar condition to these substations.

Some of the 66 kV substation equipment in the existing substation, which are still in good condition, are planned to be used by relocating to the other 66 kV substations.

The insulating oils for the main transformers in the Thap Cham Substation and the Phan Thiet Substaton was taken and brought back to Japan to analyze the present condition of the transformer insulation. The result of the oil analysis is described in Subsection 8.1.4 of Chapter 8.

(2) Land for new 110 kV substations

The power interruption of so long period will not be allowed for the upgrading works of each substation of Thap Cham, Phan Ri, Phan Thiet and Cam Ranh, for the reason of the network operation management. Accordingly, the new 110 kV substations need to be constructed without interfering with the operation of the existing substations and are planned to be constructed at the new land adjacent to the existing 66 kV substation. The land for the new 110 kV substations has already been choosen and obtained by PC-2 and PC-3. The land is mostly flat and will have no difficulties for the land formation works.

On the other hand, the new 110 kV substation facilities are required to be installed in the Da Nhim Power Station for power supply to the aforesaid new 110 kV substations. The new 110 kV substation facilities for the Da Nhim Power Station are planned to be installed in the area adjacent to the existing 110 kV switchgear bay for power supply to the Nha Trang Substation. The installation of the new 110 kV substation facilities will become short of the capacity of the existing 230/110 kV transformer. Then the following two alternatives were considered as the countermeasure.

Alternative-1: Additional installation of a new 63 MVA transformer

This plan will necessitate extension of the 230 kV double-bus and additional installation of new 230 kV and 110 kV switchgear.

Alternative-2: Replacement of existing 63 MVA transformer by 125 MVA one

This plan will offer no extension of the 230 kV double-bus and no additional transformer bay and will permit the existing 230 kV and 110 kV switchgear to be used as they are. However, the total cost of this plan will be rather expensive than that of Alternative-1.

After discussion with PC-2 on this matter, it was concluded that the existing 63 MVA transformer should be replaced by a new 125 MVA one as mentioned in Alternative-2.

The land for all the new 110 kV substation facilities is located in the premises of the Da Nhim Power Station.

(3) Construction, operation and maintenance

All the substation and transmission facilities of 110 kV or lower in the PC-2 region are to be planned and designed by the energy center of PC-2 and constructed by the transmission department of PC-2. PC-3 has, at present, no concrete design of new substations for Cam Ranh and Dien Khanh. The Study Team is to recommend basic design of the substations to PC-3 in consideration of the Vietnamese design practice. Operation and maintenance of all the substations and transmission lines are also in charge of the transmission department of PC-2 and PC-3. Accordingly, the construction, operation and maintenance for the new 110 kV substations will be done by PC-2 and PC-3.

10.2 Upgrade Plan for the Transmission Line Facilities

This subsection discusses the recommendable upgrade plan for the transmission line facilities on the basis of the results of the Study Team's field investigation previously mentioned.

10.2.1 Supports and Related Facilities

(1) Foundations and Surroundings of the Supports

The foundations and surroundings of the supports of the Da Nhim-Thap Cham-Cam Ranh and Thap Cham-Phan Ri-Phan Thiet line section do not need to be repaired.

Existing timber supports in the Cam Ranh-Dien Khanh section in the PC-3 region will be replaced with concrete poles for semipermanent use.

There seems no possibility of such erosion occurring around the foundations of the supports, as was pointed out of the 230 kV transmission line towers because the line runs on almost flat land.

Existing steel tubular poles and concrete poles are reinforced by staywires which are fixed to anchors buried in the ground. The volume of soil above the anchor is important for the strengthening the staywires. PC-2's and PC-3's maintenance groups are employed for placing soil above the anchors, when required. Accordingly, no reinforcement or modification of the foundations is required.

The lowering of the earthing resistance of the supports below the designed value (10 ohms) is important for preventing back-flashover due to lightning currents from the supports to the power conductors. Earthing wires are provided on each support in order to reduce its footing resistance. Procurement of the earthing materials is necessary in order to supplement the missing materials and replace the damaged wires. It is recommended to periodically measure the earthing resistance of the supports in order to confirm the value of the resistance. When measuring the accurate resistance, the overhead earthwires should be insulated from the supports.

(2) Supports

Principally, it is not necessary to procure new supports for the purpose of upgrading the Da Nhim-Thap Cham-Phan Ri-Phan Thiet and Thap Cham-Cam Ranh lines, since the existing supports are useful for the 110 kV systems. Only several additional supports will be necessary for replacing the damaged supports and for connecting the upgraded lines with the new 110 kV substations. Such additional supports will comprise steel tubular poles with staywires.

For replacing the damaged crossarms in the Da Nhim-Thap Cham-Cam Ranh section and Thap Cham-Phan Ri-Phan Thiet section, new galvanized steel crossarms should be procured in the original design.

Staywires and other accessories will also be procured in order to supplement the lines except the Cam Ranh-Dien Khanh line.

10.2.2 Overhead Earthwires and Power Conductors with Accessories

As stated in the Subsection 10.1.4(1), it is planned by PC-3 to replace all the power conductors in the Cam Ranh-Dien Khanh section. For other sections, procurement is only necessary for some parts of the wire, conductor, and their accessories in order to supplement the damaged or lost parts and for maintenance purposes.

For efficiently carrying out the repair works, it is recommended PC-2 and PC-3 to investigate more accurately the present situation along the whole line in order to confirm the work items and quantities of each line and for preparing the required work schedules, work procedures, and work forces. It is noteworthy that the same safety measures mentioned for the rehabilitation works of the 230 kV transmission line should be considered.

The works of the overhead earthwires and power conductors required for the Da Nhim-Thap Cham, Cam Ranh-Dien Khanh, and Thap Cham-Phan Ri-Phan Thiet sections are only carried out in order to repair the midspan joints and repair sleeves. The work procedures