2-3 Basic Design

2-3-1 Design Concept

(1) Natural Conditions

1) Temperature and Relative Humidity

The Project Area has a mean annual temperature of 27 - 28°C which is approximately constant throughout the year even though a maximum temperature of 35°C has been recorded in the past. The relative humidity can reach almost 100% in the rainy season and the mean annual average is 82%, reflecting the oceanic tropical climate.

As the new generation facilities to be constructed under the Project will be housed in a building, no special measures for the external air temperature and humidity will be necessary. In the design of the air intake for engine and indoor ventilation, however, the past maximum temperature of 35°C is used. An air temperature of 40°C is adopted as the design temperature for the outdoor transmission and distribution facilities as in the case of the previous projects. The introduction of ventilation openings, use of space heaters, etc., for enclosed equipment should be considered in order to avoid an excessively high level of ambient humidity.

2) Rain

The Project Area has a rainy season from May to September and the monthly rainfall can exceed 800 mm. Roads in the 4 northern states of Babeldaob Island, where the construction of the new power transmission and distribution network is planned, are unpaved (not even gravel roads but clayey dirt roads), narrow, and have many sharp curves and undulations. Continuous rain over a few days can make these roads almost impassable, even for 4 wheel-drive vehicles. Accordingly, avoidance of the rainy season for the transportation and delivery of the equipment and materials to the Project sites is necessary. Further consideration is required for the selection of electric poles, light steel poles in addition to heavy concrete poles, to ensure the safety and ease of transportation and construction work.

3) Salt Contamination

As Palau is an island country, seawater may splash over the power lines due to strong wind. Insulators are particularly vulnerable to salt contamination. However, the high level of rainfall tends to wash away the salt deposited on insulators, reducing the chance of salt accumulation over a long period of time. Special attention should be paid under the Project to possible salt contamination to insulators (assessed by the equivalent salt deposit density) due to typhoons. Galvanizing, etc., will be applied to the steel electric poles to prevent salt contamination when such materials are selected.

The planned site for the new generation facilities at the Malakal Power Plant is near the coast. Therefore, in order to prevent salt contamination, the generating units as well as auxiliary equipment will be housed in a building and salt-proof paint will be used for the fuel tank, radiators and exposed piping.

(2) Social Conditions

As Palau was governed by the US for a long period of time, there are no traditional customs, which will seriously affect the project implementation. Nevertheless, the chieftain system still survives in all states and the chiefs are generally more powerful than governors in state administration. This fact will be taken into consideration throughout the project period.

(3) Local Construction

High level of construction activity involving civil engineering, building or plant construction work is not seen in Palau. Consequently, the local construction companies and machine leasing companies mainly have a small number of second-hand construction machines. Port Malakal does not have a large crane capable of unloading the planned generators (approximately 50 tons each in weight). There is also a shortage of transportation vehicles (dump trucks, etc.) to transport the electric poles, etc. These conditions will be taken into careful consideration when planning the procurement and use of construction machinery in the Project.

(4) Use of Local Construction Company and Materials

1) Use of Local Construction Companies

There are approximately 10 construction companies in Koror, most of which are small with 100 - 200 workers and run by American or Korean owners, etc. Most of the engineers and workers employed by these companies are foreigners, mainly from the Philippines (approximately 75%) and Taiwan/China (approximately 10%). Only a few Palauans work in the construction industry. When a large construction project is launched, engineers and workers are recruited for the project. Accordingly, the capability of local construction companies is not high and their use for the Project will be limited to the supply of workers.

Therefore, for the construction work on the Project, i.e., installation of generating facilities and construction of transmission and distribution lines, engineers and technicians will be dispatched from Japan for supervising the construction work, schedule control, quality control and commissioning tests.

2) Local Material Procurement

In the preparation of the construction plan, priority will be given to the use of local materials. While the gravel, sand, cement, reinforcing bars, etc., for the structural work are available locally, finishing materials and building facility equipment are imported. The existing generation facilities originate from the US, UK and Japan and the power transmission and distribution materials were also imported. Even in these days, a local construction companies are importing concrete poles from Japan for the construction of power distribution lines. It is, therefore, unrealistic to expect local procurement of generation facility and power line construction materials.

3) Procurement from Third Countries

For the procurement of the generation facility and power line construction materials from a third country, the selection criteria should not only be price alone, but also the product quality, delivery time and availability of spare parts and consumables after commissioning.

(5) Maintenance Capability of Project Implementation Body

It is planned that the PUC will be responsible for the operation and maintenance of the new generation facilities and power transmission and distribution network under the Project after their completion and handing-over to the Government of Palau. The PUC is currently conducting operation and maintenance work for both the Aimeliik and Malakal Power Stations and maintenance work for the existing power network constructed under a previous project. As its performance is judged to have been generally satisfactory, it is deemed to have sufficient technological capability to conduct the operation and maintenance of the facilities to be constructed under the Project. As the PUC is a young organization established some 2 years ago, it has a slight manpower shortage. At present, it plans to increase the manpower at the Malakal Power Station from the current 3 operators for each of 4 shifts to 4 operators for each shift. The PUC is also engaged in the construction of distribution lines with the cooperation of the Bureau of Public Works in the Ministry of Resources and Development.

Under the Project, Japanese engineers will conduct OJT for PUC engineers in relation to the operation and maintenance of the new generation facilities and power lines in order to ensure the effective and efficient operation of these new facilities.

(6) Design Scope and Technical Level of Facilities, Equipment and Materials

The design scope of the facilities, equipment and materials and their technical levels are determined based on the following principles, taking the conditions described in (1) ~ (5) above into consideration.

1) Principles Governing Scope of Facilities and Materials

Malakal Power Station Improvement Plan

The generating capacity of the planned new generating units for the Malakal Power Station will be equivalent to the base load required to urgently meet the power demand of Koror (the capital) and entire Babeldoab Island and the necessary but minimum configuration and specifications of the facilities have been selected to establish a stable public power supply source with easy and inexpensive maintenance.

Transmission and Distribution Grid Construction Plan for 4 Northern States of Babeldoab Island

The routes of the new transmission and distribution lines to the non-electrified 4 northern states of Babeldoab Island will be decided to ensure a fair and stable public power supply for all local inhabitants. The standards and specifications applicable to the new lines will be the same as those of the existing lines so that the new lines can be easily linked to the existing network, making the best use of the interchangeability of the new and old facilities.

2) Technical Level

The specifications of the equipment constituting the new generating facilities and power lines will be carefully specified so that they are not beyond the technical capability of the PUC which will be responsible for the operation and maintenance of such equipment following completion of the Project. As the new branch distribution lines will be constructed by the Government of Palau (PUC), equipment and materials which are appropriate for the technical level of construction in Palau will be selected.

(7) Construction Period

In view of the necessity and urgency to improve the present tight power supply situations and to provide public power supply for non-electrified areas, the Project will be implemented in the following 2 phases.

Phase I Construction:

Installation of generating units with the necessary but minimum capacity to urgently provide power supply for Koror and the construction of a new generator building.

① Construction of a generator building and exterior work at the Malakal Power Station

② Procurement and installation of new generating units (3.4 MW × 2 units), main fuel tank and its auxiliary equipment at the Malakal Power Station

Phase II Construction:

Construction of new transmission and distribution lines to the non-electrified 4 northern states of Babeldoab Island.

① Construction of transmission and trunk distribution lines in the 4 northern states of Babeldaob Island

② Procurement of equipment and materials for branch distribution lines in the 4 northern states of Babeldaob Island

2-3-2 Basic Design

(1) General

1) Design Conditions

The following design conditions are adopted to design the scale, capacity and specifications of the facilities and equipment to be constructed under the Project after examining the conditions described in 2-3-1.

① Altitude

a) Construction Site for Generating Units (Malakal Power Station)

The premises of the Malakal Power Station where the new generating units will be installed are located on gently sloping land with an altitude of 10 ~ 25 m.

b) Construction Site for New Power Transmission and Distribution Lines

The 4 northern states of Babeldaob Island for which the new power lines and substations will be constructed have an altitude ranging from 0 m to 1,000 m and can be classified as coastal zone, marine terrace zone and inland steppe zone.

② Climatic and Other Natural Conditions

a) Design temperature:

For generating facilities	35°C (maximum)
For power lines	40°C (maximum)

b) Design relative humidity — 100% (maximum)

c) Design wind velocity — 40 m/sec (average for 10 minutes)
52 m/sec (instantaneous maximum wind velocity)

d) Rainfall — 4,100 mm (annual average)

e) Annual days of lighting (IKL) — 37 days

f) Salt deposition equivalent density — 0.5 mg/cm^2

g) Seismic force:

For equipment	0.4 G (horizontal)
	0.25 G (vertical)
For buildings/foundations	0.2 G (horizontal)

h) Soil bearing capacity :

For power station	10 $tons/m^2$ (assumed)

③ Codes and Standards to be Applied

a) Japanese Industrial Standards (JIS)

b) Standards of Japanese Electro Technical Committee (JEC)

c) Standards of Japan Electrical Manufacturers' Association (JEM)

d) Japanese Cable Makers' Association Standards (JCS)

e) Technical Standards on Electrical Facilities in Japan

f) American National Standard Institute (ANSI) Standards

g) National Electrical Manufacturers' Association (NEMA) Standards

h) Rural Electrification Administration (REA) Standards

i) National Electrical Safety Code (NESC)

j) Regulations set by the Environmental Quality Protection Board (EQPB), Palau

Note: The American standards, i.e. f) through i), will only be applied to the pole-mounted transformer, the required clearances for the power transmission and distribution lines and safety facilities while the Japanese standards will be applied to all other aspects of the Project-related work.

④ Unit

In principle, SI units are used.

⑤ Electric System

The electric system to be employed under the Project will conform to the existing system as shown in Table 2-3-1.

Table 2-3-1 Power System

	Transmission Line	Distribution Line	Low Voltage (for Lighting)	Low Voltage (for Power)
Nominal Voltage	34.5 kV	13.8 kV	240/120 V	208/120V
Maximum Voltage	36.5 kV	14.2 kV	—	—
Wiring System	3 phase, 4 wire	3 phase, 4 wire	single phase, 3 wire	3 phase, 4 wire
Frequency	60 Hz	60 Hz	60 Hz	60 Hz
Earthing System	Multiple earth at neutral point	Multiple earth at neutral point	—	—

⑥ Basic Insulation Level

In designing the new transmission and distribution facilities, the following Basic Impulse Insulation Level (BIL), which was employed for the existing facilities, will be applied to ensure the coordination of insulation between equipment and the insulation level of the entire network.

a) 34.5 kV system : BIL 200 kV

b) 13.8 kV system : BIL 110 kV

⑦ Environmental Protection Regulations

In designing the new generating facilities, the regulations of the Environmental Quality Protection Board (EQPB) in Palau will, in principle, be applied as the environmental protection. However, EQPB does not have specific regulations directly related to the Project, e.g., NOx emission, SOx emission, etc. Therefore, the following standards which are generally applied in Japan have been established as the design conditions for the Project.

a) NOx emission level: 950 ppm or less (at a 13% O_2 dry)

b) SOx emission level : 250 ppm or less (at a sulphur content of fuel oil of 1%)

c) Oil contamination in discharge water : 30 ppm or less

d) Particulates : 100 mg/Nm^3 or less

e) Sound noise level : 65 dB (A) or less at the site boundary on the public road during operation of the new generating units

f) Vibration : 65 dB or less at the site boundary during operation of the new generating units

2) Layout Plan

The layout plan for the generating facilities and the transmission and distribution facilities to be constructed/installed under the Project is described below.

① Generating Facilities

The new generating facilities to be constructed under the Project will be installed in the area of the existing workshop located next to the existing power house building at Malakal power station. The existing workshop has already half collapsed and will be demolished to provide the area for the new generating facilitates by the Palau side (see MPS-M-01). This location is at the furthest end if the Malakal Power Station premises separated from the existing private and public buildings around the power station, therefore resulting in the least noise problem. This site selection was also prompted by its proximity to the existing control room in view of easy control and maintenance of the whole power station.

The main components of the new generating facilities (engine, generator, control panel, ventilation blower, etc.) will be housed in a generator building equipped with an overhead crane for maintenance purposes.

Access to the new generator building will be provided by the existing station roads. As these station roads on the premises are unpaved, hindering operation and maintenance work at the power station, sufficient concrete paving will be employed. A new road providing access to the generating units will be constructed between the existing generator building and new generator building. After completion of the Project, this road will be used as the main access of fuel tank lorries to the main fuel tank and will also be used as an access road when new generating units will be installed in the existing generator building by the Government of Palau in the future.

The radiator will be installed to the north of the existing fuel and water tanks in front of the new generator building. Demolition of the existing workshop and land preparation for the new generator building will be conducted by the Palau side.

② Transmission and Distribution Facilities

New 34.5 kV/13.8 kV transmission and distribution lines will be built along the existing roads. The selection of either roadside for the erection of poles will be decided based on the existing conditions of obstacles such as trees, houses and slopes and the degree of workability. Many of the existing roads are characterized by many curves and a sharp gradient and the unpaved, clayey surface of these roads has been damaged by downpours, requiring urgent rehabilitation by the Palau side to allow the transportation of Project-related equipment and materials prior to the commencement of construction work under the Project. Since the Compact road will be built in the same area as the new transmission and distribution lines, the location of electric poles will be decided taking into consideration the route of the Compact road. Three sub-stations to transform the transmission voltage of 34.5 kV to the distribution voltage of 13.8 kV will be constructed as shown in Basic Design Drawing BDT-01 to ensure the stability of the network system, i.e., one in Ngerdmau State and 2 in Ngeraard State.

(2) Outline of Basic Design

The basic design contents of the Project are shown in Table 2-3-2, taking the basic design principles, design standards and layout plan described in 2.3.1 into consideration.

Table 2-3-2 Summary of Basic Design

Phase	Malakal Power Station Improvement Plan		Power Network Extension Plan for Northern Babeldaob
I	Construction Work	- Generator building (approx. 980 m^2) - Foundations for generator, engine, fuel tank and auxiliary equipment - New station road and outdoor lighting; extension of foundations, fencing and roof for substation - Buildings facilities	—
	Procurement and Installation	- Procurement and Installation of two diesel generating units (3.4 MW × 2 sets) - Procurement and Installation of the following systems to accompany the above •Fuel supply system (including main fuel oil tank) •Air suction and exhaust system •Cooling water system •Piping - Procurement and Installation of the following electrical equipment for the generating unit •Local control panel •Synchronizing panel •DC power supply system •Circuit breaker cubicles (two in generator building and one in substation) •Wiring and earthing system •Remote control panel - Procurement of spare parts, and maintenance tools for generating unit and auxiliary unit - Procurement of operation and maintenance manuals for generating unit and auxiliary unit; implementation of OJT	—
II	Procurement and Construction of Power Transmission and Distribution Network	—	- Construction of 34.5 kV transmission line from Asahi Sub-Station to Ngeraard No. 2 substation (approx. 31 km) - Construction of 13.8 kV trunk distribution lines (approx. 23km) from Ngeraard No. 2 substation to Ngerchelong state and from Melekeok state to Ngiwal state - Construction of Ngerdmau, Ngeraard No. 1 and Ngeraard No. 2 Sub-stations (34.5/13.8 kV)
	Procurement of Power Distribution Materials	---	- Procurement of materials for 13.8 kV branch distribution lines (approximately 23 km) - Procurement of pole-mounted transformers, arresters and cutout switches with fuse (for 13.8 kV) - Procurement of installation manuals and maintenance manuals for power distribution materials

(3) Building Plan (Malakal Power Station Improvement Plan)

1) Plan Contents

The following facilities will be constructed at the Malakal Power Station under the Project.

① Generator building	:	steel frame, single story (2 stories in part) total floor area: approx. 980 m^2 with building services
② Toilet building	:	concrete block, single story total floor area: approx. 6 m^2
③ Equipment Foundations	:	foundations for engine, generator and oil tank, etc.
④ Station road	:	including a rainwater drainage system

2) Facility Layout Plan

The layout of the planned facilities is shown in Basic Design Drawing MPS-M-01. The layout plan has been made taking the conditions described in 2.3.2-(1)-1) into consideration.

3) Outline of Main Facilities

The basic plan for the generator building has been decided based on the floor area, sectional dimension and work flow line, all of which are coordinated to ensure the full performance of the planned generating units under the Project. Selection of the equipment and materials for the construction of facilities has been made based on a fair assessment of the locally available materials, implementation schedule, durability and future maintenance. The main specifications of each facility are listed below.

① Generator Building

a) Main Specifications

- Foundations	:	reinforced concrete; spread footings
- Ground floor slab and cable pits, etc.	:	reinforced concrete
- Upper structure (columns and beams, etc.)	:	steel frame
- Floor	:	Reinforced concrete or steel checkered plate
- Partitions	:	concrete blocks
- External walls and roof	:	slate with sound proof material
- window frames and doors	:	aluminium or steel

b) Main Rooms and Floor Area, etc.

The main rooms, their floor areas and building services of the generator building are shown in Table 2-3-3.

Table 2-3-3 Generator Building Rooms

	Room	Floor Area (m^2)	Building Services
1	Generator Room	195	lighting, ventilation, fire-fighting
2	Control Room	90	lighting, air-conditioning, fire-fighting
3	Auxiliary Equipment Room	135	lighting, ventilation, fire-fighting
4	Machine Room for Ventilation Blower	90	lighting, ventilation, fire-fighting
5	Air Suction room	50	
6	Cables and piping room	420	
	Total	980	

Note: The existing generator building is expected to provide spare parts storage, kitchenette and rest-room, etc.

c) Building Services

① Lighting : JIS standards for luminous intensity, fluorescent lamps or mercury lamps are used

② Ventilation : provided by the blower system

③ Air-conditioning : provided by the package type air-conditioner

④ Fire-fighting : ion type fire detectors and ABC fire extinguishers (3 kg type) are provided for each room

② Foundations

The foundations for the diesel engines, generators, radiator, auxiliary equipment, electrical equipment and oil tank, etc., plumbing and cable pits will be constructed for installation of the facilities procured under the Project. The foundations, cable pit and shed for the breaker cubicle will be added to the existing substation for the connection of power supply from the new generators to the existing power line.

③ Station Road, etc.

a) Station Road

As shown in Basic Design Drawing MPS-B-04, a new road will be constructed to run from the main entrance of the power station premises to the main fuel tank via the generator building. Surface concreting will be made for this road and U shaped side ditches will be provided for rainwater drainage. The rainwater will be drained to a side drain of the public road in front of the entrance to the Malakal Power Station.

b) Outdoor Lighting

Outdoor lighting will be installed around the generator building, main fuel tank and radiators for maintenance and security purposes.

(4) Generating Facility Plan (Malakal Power Station Improvement Plan)

The generating facilities to be constructed at the Malakal Power Station are described below. The basic specifications of the facilities and equipment are shown in Table 2-3-6.

1) Basic Items

① Selection of Generating System

A diesel generating unit has been selected as the generating unit for the Project in view of its use by existing power stations, ease of operation and maintenance, local natural conditions such as water resources and economic considerations.

② Fuel Composition

The fuel used by the existing Malakal and Aimeliik Power Stations is diesel oil purchased from Shell Oil. This fuel will be used for the new generating units and its composition such as water content and properties are listed in Table 2-3-4.

③ Lubricant Oil

Each generator manufacturer recommends its specific lubricant oil with different composition. As the existing power stations in Palau purchase lubricant oil from Shell Oil together with diesel oil, the use of lubricant oil which can be obtained from Shell Oil is recommended.

Table 2-3-4 Table of Fuel (Diesel Oil) Composition

Item	Unit	Testing Method	Results
Specific Gravity	15/4	JIS K2249	0.849
API (60°F)	°C		35.08
Aniline Point	°C	JIS K2256	75.0
Flash Point	°C	JIS K2265	76.0 (PMC)
Viscosity 50°C	C. St	JIS K2283	3.34
100°C	C. St	JIS K2283	1.85
Pour Point	°C	JIS K2269	-7.5
Chemical Reaction		JIS K2252	neutral
Sulphur Content	wt %	JIS K2541	0.19
Water Content	wt %	JIS K2275	0.02 or less
Ash Content	wt %	JIS K2272	0.01 or less
Residual Carbon Content	wt %	JIS K2270	0.01
Hydrogen Content	wt %		13.1
Nitrogen Content	wt %	JIS K2609	0.03
Sediment	wt %	JIS K2601	0.01 or less
Diesel Index			58.6
Na	mg/kg		0.5
Si	mg/kg		0.8
Total Calorific Value	kcal/kg	JIS K2279	10,890
Net Calorific Value	kcal/kg	JIS K2279	10,180

Source: Fuel Analysis Results of Study Team

④ Cooling Water

The existing Malakal Power Station uses municipal water supplied by the Koror State water supply system. The new generating unit will also use this water as cooling water and a supply line will be branched off from the spare stop valve of the existing water tank. The chemical analysis results of this municipal water are given in Table 2-3-5. As shown in the table, the total hardness of 290 mg/litre is acceptable as drinking water according to the Japanese water quality standard (300 mg/litre for drinking water) but is unsuitable as cooling water for the radiator and engine cooling system because of possible accumulation of scales inside the equipment. A water softener will, therefore, be installed under the Project to reduce the total hardness to approximately 10 mg/litre or less.

Table 2-3-5 Chemical Analysis Results of Municipal Water

Item	Unit	Results
pH (at 20°C)	---	7.3
Electric Conductivity (at 25°C)	μS/cm	56.0
Alkalinity (as $CaCO_3$)	mg/ℓ	31.0
Total Hardness (as $CaCO_3$)	mg/ℓ	290.0
Calcium Hardness (as $CaCO_3$)	mg/ℓ	170.0
Magnesium Hardness (as $CaCO_3$)	mg/ℓ	120.0
SS	mg/ℓ	2.0 or less
DS	mg/ℓ	73.0
COD	mg/ℓ	1.4
T-Fe	mg/ℓ	0.62
Mn	mg/ℓ	0.05 or less
Na	mg/ℓ	3.7
S_iO_2	mg/ℓ	13.0
$Cℓ^{-1}$	mg/ℓ	6.0
SO_4^{-2}	mg/ℓ	0.64
Langelier index	---	- 0.9

Source: Water Analysis Results of Study Team

2) Design Criteria

① Engine Output and Generator Capacity

The total output of the generating facilities to be constructed under the Project is determined based on the condition to cover the expected power supply shortage of approx. 6.25 MW (6.72 MW including station service power and transmission losses) against the estimated total power demand of 16.45 MW at the end of 1997, completion year of the Project. The provision of 2 generators to meet this output requirement has been decided (each having 50% of the required output) in order to establish more reliable power supply condition in plant operation. The output of each unit is determined to be 3.4 MW. Consequently, the required engine output for each generating unit and the rated capacity of each generator can be determined as shown below. As the specifications of the engine, etc. slightly vary from one generator manufacturer to another, the following calculation results should be used as reference figures.

a) Engine Output

$$Pe \geqq \frac{P}{0.7355 \times \eta_G} = 4,866PS \fallingdotseq 4,900\text{PS}$$

Where,

Pe : engine output (PS, metric horsepower)

P : generator output (3,400 kW)

η_G : generator efficiency (assumed to be 95%)

b) Generator Capacity

$$P_G = \frac{P}{Pf} = 4,250kVA$$

Where,

P_G : generator capacity (kVA)

P : generator output (3,400 kW)

Pf : generator power factor of 0.8

The Project aims at increasing the power supply capacity which is urgently required by 1997. Consequently, the Government of Palau is required to systematically install new generating facilities in view of the demand increase following the construction of the new generating units under the Project and the target should be a base load supply capacity of 16 - 20 MW in the year 2000 as put forward in the NMDP. The construction of additional generating facilities to meet this target should be carried out by the self-reliant efforts of the Government of Palau.

② Mechanical Equipment

a) Fuel Supply System

The Malakal Power Plant has 2 main fuel tanks, each storing upto 25,000 gallons (approximately 94.6 kilolitres) of fuel. The fuel is supplied by tank lorry by Shell Company which has a fuel supply contract with the PUC. However, the existing fuel tanks have deteriorated, and the existing tank capacity is sufficient for only 2 days operation of the new generating facility. This is obviously insufficient to supply the fuel to the extra generators to be installed under the Project. Accordingly, one new outdoor fuel storage tank will be constructed under the Project. This tank will be placed at the back side of the generator building (see Basic Design Drawing MPS-M-01) and will be surrounded by oil retaining walls to prevent oil leakage. The fuel will firstly be supplied to a service tank by the diesel fuel oil transfer pump and the gravity system will be used to supply fuel from the service tank to the engines. This method has been selected because the direct supply of fuel from the fuel tank to the engines by the fuel pump will require constant pump operation, resulting in an increase of the on-site power consumption. The fuel oil supply system is shown in Basic Design Drawing MPS-M-03.

Storage Capacity of Diesel Fuel Oil Storage Tank (Main fuel tank)

Fuel transportation from Singapore to Palau will take some 14 days. Therefore, assuming a fuel reserve of 2 weeks' supply (14 days), the storage capacity of the main fuel tank is calculated as follows.

$$V_m = V_l \times 3{,}400\ \text{kW} \times 24\ \text{hrs} \times 14\ \text{days} \times 2\ \text{units} = 543{,}782\ \text{litres} \fallingdotseq 550\ \text{kilolitres}$$

Where,

V_m : storage capacity of main fuel tank

V_l : fuel consumption (0.238 litres/kWh) per generating unit (3.4 MW) based on specific gravity of diesel oil of 0.85 kg/litre

It has, therefore, been decided that the storage capacity of the main fuel tank is 550 kilolitres.

Diesel Fuel Oil Service Tank

A diesel fuel service tank will be installed to supply fuel to the 2 generating units and this diesel fuel oil service tank will store enough fuel to continue approximately 2 hours of operation with 2 units. The storage capacity is calculated as follows.

$$V_s = V_l \times 3{,}400\ \text{kW} \times 2\ \text{hrs} \times 2\ \text{units} = 3{,}237\ \text{litres} \fallingdotseq 3.5\ \text{kilolitres}$$

Where,

V_s : storage capacity of fuel service tank

V_l : fuel consumption (0.238 litres/kWh) per generating unit (3.4 MW) based on specific gravity of diesel oil of 0.85 kg/litre

It has, therefore, been decided that the storage capacity of the service tank will be 3.5 kilolitres.

b) Lubricating Oil System

Given the current lack of a common lubrication system at the Malakal Power Station, a lubricating oil system for exclusive use by the new generating units will be installed under the Project. Lubricating oil will be fed to the engine by the lubricating oil transfer pump from a drum placed outdoors. See Basic Design Drawing MPS-M-04 for the lubrication system.

c) Cooling Water System

As already described in 2.3.2-(4)-1)-④, municipal water stored in the existing water tank will be used as cooling water after softening. The radiator system used by the existing generating units is selected as the cooling system for the Project. This is made because it is familiar to maintenance staff and requires lower operating cost than the cooling tower system due to the lower replenishing water supply by some 10%. Basic Design Drawing MPS-M-05 shows the cooling water system for the new generating units.

d) Compressed Air Supply System

The existing generating facilities have individual compressed air system for each unit. Therefore, a new compressed air system for each new generating unit will also be installed. While a compressor will be installed in the auxiliary machine room for each generating unit inside the generator building, 2 new compressors will have a connecting line for mutual back-up operation in case of trouble. Basic Design Drawing MPS-M-06 shows the compressed air system.

e) Air Intake and Exhaust System

Outside air will be sucked through an air intake duct to the engine via a supercharger and, after combustion, will be discharged to the outside via a silencer. Basic Design Drawing MPS-M-07 shows the intake air and exhaust system.

f) Ventilation System

A ventilation system will be installed in the generator building for ventilation of the engine room. A suction blower will be installed in the blower room above the control room and air will be fed to the engine room through a duct. Exhaust will be conducted through exhaust louvres in the roof of the generator building.

g) Sludge Treatment System

The Malakal Power Station has an outdoor oil-water separator for the existing generating units but inflow of rainwater during the rainy season results in waste oil spilling out of the pit, causing environmental pollution. In order to prevent further environmental deterioration in the power station, a sludge separation tank and an oily water separator for exclusive use by the generating units will be installed under the Project to separate oil and water so that only water is drained to the U shaped ditch beside the station road. Basic Design Drawing MPS-M-04 shows the sludge separation system. Needless to say, the separated sludge and waste oil should be disposed of in an appropriate manner to prevent environmental pollution.

h) Piping

The following piping will be installed outside of the generator building. This piping will be protected by appropriate supports, etc. and concrete trenches will be introduced to protect those pipes crossing a road. Basic Design Drawing MPS-M-01 shows the piping routes.

- Fuel oil piping
- Cooling water piping
- Waste oil piping
- Water drainage piping

③ Electrical Facilities

The generating voltage of the generating facilities to be provided under the Project is 13.8 kV, on the grounds that the largest generator (3.2 MW) in Palau at the Aimeliik Power Station adopts a generating voltage of 13.8 kV and that the existing trunk distribution voltage of 13.8 kV enables the new generating units to directly connect to the existing trunk distribution lines without the use of a transformer, resulting in high compatibility, reliability and economy. The main electrical installations are described below.

a) 13.8 kV Breaker Panel for Connection with Existing Distribution Lines

One 13.8 kV breaker panel will be installed at the Malakal substation, to connect the new generating units with the existing trunk distribution lines. This panel will be equipped with protective relays required to protect from short circuits, earth faults, etc., an operation switch and indicating lamps, etc. As it will be placed along with the existing breaker panel, it will have the same dimensions as the existing panel (see Basic Design Drawing MPS-E-02). The voltage of the direct current to operate this breaker panel will be 110 V as in the case of the existing panel.

b) 13.8 kV Generator Breaker Panel

A generator breaker panel for each generator will be installed in the control room of the generator building. A feeder terminal board will also be installed to provide the connection to the substation.

c) Generator Control Panel

A central generator control panel will be installed in the control room of the generator building so that the generating facilities can be centrally controlled from the control room. The synchronizing operation of the generators will also be made from the control room.

d) Local Control Panel

A local control panel will be installed beside the generating unit for local starting, stopping, control, measurement and fault indication.

e) Excitation Unit

The excitation control system of the brushless thyrister excitation system will be installed in the generator control panel.

f) Remote Monitoring Panel

The existing generating facilities of the Malakal Power Station are remotely monitored and controlled from the control room in the existing generator building. In order to monitor the operation of the new generating units from the same control room, a remote monitoring panel will be installed next to the existing control panel.

g) DC Power Unit

One set of DC power unit for starting, stopping, control, measurement and indication purposes in relation to the generating units and auxiliary equipment will be installed in the control room in the generator building. The voltage will be 110V. This unit will serve both new generators.

h) Transformer for Auxiliary Equipment

An outdoor transformer will be installed to supply power to the auxiliary equipment for the 2 new generators.

i) Earthing Systems

There is no common earthing system at the Malakal Power Station as each equipment has its own earthing system. This practice will be adopted for the new equipment and the following independent earthing systems will be installed.

- Earthing to protect electrical systems
- Earthing to prevent electric shocks from metal or electrical equipment
- Earthing to protect facilities and equipment from lightning

j) Cabling

Power and control cables connecting the new generating units to the 13.8 kV breaker panel to be installed in the existing substation will be laid to the east side of the existing generator building. In view of better workability, armoured cabling will be used and directly buried except at road crossing sections where the existing concrete manholes and piping trenches will be used to protect the cabling. Basic Design Drawing MPS-M-01 shows the cable routes.

3) Basic Specifications of Major Equipment

The basic specifications of the major equipment for the generating facilities are shown in Table 2-3-6, they have been decided based on the design principles, design standards, design conditions and layout plan of the facilities and equipment, etc.

Table 2-3-6 Basic Specifications of Main Equipment of New Generating Facilities

Item No.	Equipment Name	Basic Specifications
1.	Diesel Engine	Rated Operation : continuous Output : generator output 3,400 kW (approx. 4,900 PS) Revolutions : not more than 720 rpm Engine : 4 stroke cycle, trunk piston type with turbocharger, water cooling V or L type diesel engine Cooling Method : radiator system Fuel Oil : diesel oil Others : common bed type flexible mounting
2.	Generator	Rated Operation : continuous Rated Output : 4,250 kVA (3,400 kW) Frequency : 60 Hz Phases : 3 phases Rated Voltage : 13.8 kV Revolutions : not more than 720 rpm Power Factor : 0.8 (lag) Connection : Y connection, with neutral line Insulation : Class F
3.	Mechanical Systems	
3.1	Fuel Supply System	
	① Fuel Oil Storage Tank	550 kilolitres, API 650
	② Fuel Oil Unloading Pump	including motor, gear pump and filter (30 $m^3/hr \times 3$ kg/cm^2)
	③ Fuel Oil Transfer Pump	including motor, gear pump and filter (3 $m^3/hr \times 3$ kg/cm^2)
	④ Fuel Oil Service Tank	3,500 litres
	⑤ Fuel Oil Circulating Pump	including motor, gear pump and filter
	⑥ Fuel Oil Flowmeter	
	⑦ Fuel Oil Filter	primary and secondary
	⑧ Fuel Oil Pressure Regulations Valve	
	⑨ Fuel Drain Discharge Pump	including motor, gear pump and filter
	⑩ Fuel Oil Drain Tank	100 litres
3.2	Lubricating Oil System	
	① Lubricating Oil Transfer Pump	including motor, gear pump and filter
	② Lubricating Oil Sump Tank	approximately 5,000 litres
	③ Lubricating Oil Priming Pump	including motor and gear pump
	④ Lubricating Oil Cooler	including automatic temperature control valve
	⑤ Main Lubricating Oil Main Filter	50 micro
	⑥ Backwashing Oil Filter	
	⑦ Lubricating Oil Purifier	including motor and automatic discharge unit
	⑧ Lubricating Oil Pressure Regulating Valve	

Item No.	Equipment Name	Basic Specifications
3.3	Cooling Water System	
	① City Water Supply Pump	including motor and centrifugal pump
	② Jacket Cooling Water Tank	300 litres
	③ Jacket Cooling Water Pump	including motor and centrifugal pump
	④ Jacket Cooling Water Cooler	
	⑤ Jacket Cooling Water Temperature Regulating Valve	
	⑥ Radiator	
	⑦ Secondary Cooling Water Pump	including motor and centrifugal pump
	⑧ Softner	
	⑨ Chemical Injection Unit	3 kilolitres
	⑩ Soft Water Tank	300 kilolitres
	⑪ Expansion Tank	
	⑫ Soft Water Circulating Pump	
3.4	Compressed Air System	
	① Air Compressor	motor operated
	② Air Receiver	sufficient capacity to start 3 times in succession
	③ Air Pressure Reducing Valve	
3.5	Air Intake and Exhaust System	
	① Ventilation Blower	
	② Intake Air Duct	
	③ Intake Air Filter	
	④ Exhaust Gas Silencer	with exhaust pipe; exhaust outlet noise: 100 dB (A) or less
	⑤ Exhaust Gas Duct	
3.6	Sludge Treatment System	
	① Sludge Tank	100 litres
	② Sludge Collecting Pump	motor and screw pump (0.5 m^3/hr)
	③ Oily-Water Separator Tank	2,000 litres
	④ Oily-water Separator Pump	motor and screw pump (0.5 m^3/hr)
	⑤ Oily-water Tank	2 m^3
	⑥ Waste Oil Discharge Pump	motor and screw pump (0.5 m^3/hr)
	⑦ Waste Oil Tank	100 litres
	⑧ Oily-water Separator	
	⑨ Oil Check Tank	1,000 litres
	⑩ Sludge Discharge Pump	
4.	Electrical Equipment	
	① Circuit Breaker Panel for Connection to Trunk Distribution Line	24 kV vacuum circuit breaker; 600 A; 60 Hz; 12.5 kA
	② Generator Breaker Panel	24 kV vacuum circuit breaker; 600 A; 60 Hz; 12.5 kA
	③ Motor Control Panel for Auxiliary Equipment	self-standing type, including auxiliary equipment control panel
	④ Generator Control Panel	self-standing type, including AVR panel, auxiliary equipment operating panel and synchronising panel
	⑤ Remote Control Panel	self-standing type; same size as the existing panel
	⑥ DC Power Source	lead acid battery; 110 kV
	⑦ Station Transformer	outdoor, self-cooling type; 500 kVA
	⑧ Neutral Earthing Panel	self-standing type
	⑨ Substation Communication Panel	self-standing type
	⑩ Primary Panel of Station Transformer	self-standing type

4) On-the-Job Training (OJT) Plan

① Purpose of OJT

OJT will be conducted for the purpose of transferring the operation and maintenance techniques for the equipment, to be installed under the Project to the Palau counterparts during the construction period of the Project.

The specifications and types of the generating units selected under the Project have been decided taking into consideration the technical capability of the Palauan engineers for operation and maintenance. As far as the basic technological aspects of the diesel engine generating facilities are concerned, there is little difference between the planned generating units and the existing generating units or between different manufacturers. However, most of the existing facilities are old systems of more than 10 years in age and the manufacture of some of these facilities has been suspended. In view of the likelihood that some mechanical parts, electrical parts, instruments and systems combining these items, which constitute the generating facilities to be constructed under the Project, are not used in the existing generating facilities, OJT on the operation and maintenance of the new generating facilities will be provided for the Palauan engineers. This OJT will be conducted by engineers of the manufacturers of the equipment selected for the Project and delivered to Palau during the construction period. Moreover, upgrading training of the basic skills of the Palauan engineers through this OJT should lead to the effective, efficient and safe operation and maintenance of the new generating facilities after their commissioning.

② Outline of OJT

a) Type and Period of OJT

- Class room training : approximately one week (at site)
- Practical Training : approximately 3 months (at site)

b) Instructors

The instructors for the above OJT will be engineers dispatched by the manufacturers of the generating equipment selected and delivered by the Contractor and assigned to supervise the equipment installation, test operation and adjustment.

c) Trainees

The trainees of the OJT will be those Palauan engineers listed below who will be directly responsible for the operation and maintenance of the new facilities after their commissioning. The project implementation body in Palau (MRD) and PUC must appoint the OJT trainees prior to the commencement of the generator unit installation work.

• Chief Engineer			:	1
• Operation Staff	—	Electrical Engineer	:	1
		Mechanical Engineer	:	1
		Electrical Technicians	:	2
		Mechanical Technicians	:	2
• Maintenance Staff	—	Electrical Engineer	:	1
		Mechanical Engineer	:	1
		Electrical Technicians	:	2
		Mechanical Technicians	:	3

d) Contents of Training

Class room Training

Using the operation and maintenance manuals and audio-visual materials (television and video-tapes, etc.), the following basic education will be conducted on mainly the generating units.

- Characteristics and structure of generating unit
- Basics of operation and maintenance (schedule control; basic concepts of preventive maintenance; equipment functions; basics of measures to deal with accidents and breakdowns; spare parts and tool control; drawing and document control)

Practice

During the equipment installation, test operation and adjustment periods, the following practical training will be conducted.

- Disassembly and maintenance of cylinder head (mechanical)
- Overhaul and maintenance of fuel valve (mechanical)
- Grinding finishing of suction and exhaust value (mechanical)

- Overhaul and maintenance of piston (mechanical)
- Disassembly and maintenance of crank pin bearing (mechanical)
- Maintenance of motor pump (mechanical)
- Cleaning of suction filter and other filters (mechanical)
- Unit starting up and stopping (electrical)
- Emergency stopping in case of trouble (electrical)
- Remote monitoring and visual inspection methods (electrical)

(5) Transmission and Distribution Facilities (Transmission and Distribution Network Extension Plan for 4 Northern States of Babeldaob Island)

The basic specifications of the transmission and distribution lines to the 4 northern states of Babeldaob Island, i.e. Ngerchelong, Ngeraard, Ngerdmau and Ngiwal, are shown in Table 2-3-14. The following basic principles are applied in the design of these facilities.

1) Basic Design Principles

① The new facilities will be designed to have compatibility with the existing power network which was constructed under a previous grant aid project, as well as to take into consideration the transmission capacity, voltage drop, minimization of outage area during accidents, etc.

② As a part of the national trunk power line, the new facilities will be designed to have high reliability and have a capacity to easily deal with the extension due to future demand increase.

③ Efforts will be made to improve the power supply reliability in terms of a reduction of voltage fluctuations and the prevention of accidents.

④ The specifications of the equipment and materials will not exceed the levels of the existing power network with which Palauan engineers are familiar in view of the ease and safety of maintenance of the new facilities.

⑤ Efforts will be made to select standard equipment and materials and to minimise the number of items in view of the most economical system design of the planned facilities.

2) Selection of Routes

The shortest routes to the user areas will be selected so that the new power line is economical and easy to maintain. The routes for the planned 34.5 kV transmission lines and 13.8 kV trunk distribution lines under the Project are shown in Table 2-3-7. The branch distribution lines are shown in Fig. BDT-03. While the materials for the branch distribution lines will be procured by the Japanese side as part of the Project, the actual construction work will be conducted by the Palau side.

Table 2-3-7 Proposed Power Network Routes

Type of Line	Trunk Line Route under the Project	Approximate Distance	State(s) Involved	Remarks
34.5 kV Transmission Line	① Asahi Substation (constructed by previous grant aid) - Ngerdmau Substation	17 km	Ngeremlegui Ngerdmau	A 3.5 km section of road in Ngeremlegui State is missing but will be constructed by the Government of Palau prior to the commencement of the construction work under the Project
	② Ngerdmau Substation - Ngeraard No. 1 Substation	9 km	Ngerdmau Ngeraard	
	③ Ngeraard No. 1 Substation - Ngeraard No. 2 Substation	5 km	Ngeraard	
	Total	31 km		
13.8 kV Trunk Distribution Line	① Ngeraard No. 2 Substation - Ollel area	14 km	Ngeraard Ngerchelong	Transmission voltage is 13.8 kV considering the load in this area.
	② Melekeok State - Ngiwal State	8 km	Melekeok Ngiwal	A causeway (some 500 m) in Ngiwal State is currently under construction and will be completed by the Government of Palau prior to the commencement of the construction work under the Project
	③ Ngerdmau Substation - Urdmang Area (mounted on 34.5 kV line poles)	1 km	Ngerdmau	
	Total	23 km		

3) Types of Supporting Structures

As the planned power lines run near the coast, they will require anti-corrosion measures against salt contamination. Among the supporting structures (concrete poles, built-up steel pipe poles and wooden poles), concrete poles have the highest level of corrosion resistance. Given the difficult access to the construction sites with steep, narrow roads, it will be extremely difficult to transport heavy and long materials, such as concrete poles. Consequently, zinc-plated built-up steel pipe poles with corrosion resistance will be used in these areas due to their light weight and short length in order to shorten the construction period and to ensure work safety. The planned supporting structures under the Project are listed in Table 2-3-8.

Table 2-3-8 Types of Supporting Structures

Site Category	Type of Supporting Structure	Specifications	Remarks
General Section (flat road with easy access)	concrete pole	Total length: 13 m Design load: 700 kgf	Same specifications as existing concrete poles
Common Transmission and Distribution Route Section (flat road with easy access)	concrete pole	Total length: 16 m Design load: 700 kgf	as above
Mountainous Section (steep road with difficult access)	built-up steel pipe pole	Total length: 13 m Design load: 700 kgf	

4) Types of Conductors

The present power demand forecast for Babeldaob Island suggests that the required transmission line capacity will not be large in the immediate future. Once constructed, however, the power lines cannot be easily replaced and, therefore, it is necessary to provide enough capacity to meet a future demand increase due to the development of Babeldaob Island. As the use of various materials and sizes of the conductor in the connected network is not preferable from the viewpoint of maintenance, the conductor specifications of the existing power network have been adopted as shown in Table 2-3-9 in view of compatibility and interchangeability.

Table 2-3-9 Types of Conductors

Line Category	Type of Conductor	Size	Max. Allowable Current (A)
34.5 kV Transmission Line	AAC (stranded hard-drawn aluminium)	150 mm^2	430
13.8 kV Distribution Line	HDCC (stranded hard-drawn copper)	38 mm^2	220
Neutral Line (for both of the above)	HDCC (stranded hard-drawn copper)	38 mm^2	220

The voltage drop is assumed less than 10% and the transmission capacity of the planned power lines under the Project at the time of a maximum voltage drop is shown in Table 2-3-10.

Table 2-3-10 Transmission Capacity of Planned Power Lines Under the Project

Line Category	Route	Approximate Distance	Transmission Capacity (MW)
34.5 kV Transmission Line	Aimeliik Power Station - Ngeraard No. 2 Substation	49 km	Approx. 25
	Malakal Power Station - K-B Bridge - Ngeraard No. 2 Substation	78 km	Approx. 15
13.8 kV Distribution Line	Ngeraard No. 2 Substation - Konrei District (northernmost area of Ngerchelong State)	15 km	Approx. 4

5) Insulators

LP insulators will be used for the straight line poles while for the angled line poles a combination of suspension insulators and LP insulators will be used to achieve the maximum economy. The types and quantities of the insulators to be used are shown in Table 2-3-11.

Table 2-3-11 Selection of Insulators

Line Category	Type of Pole	Type of Insulator		
		LP 10	LP 30	Suspension Insulator (Ø 250 mm)
34.5 kV Transmission Line	Straight	–	1	–
	Angled	–	1 - 2	4
13.8 kV Distribution Line	Straight	1	-	–
	Angled	1 - 2	-	2

6) Standard Pole Interval and Pole Height

① Standard Spans

As described earlier, concrete poles and built-up steel pipe poles will be used to support the power lines to be constructed under the Project. Given the standard pole length of 10 - 15 m, the standard pole span is 30 - 80 m depending on the tensile strength, sag and height (ground clearance) of the suspended conductors. While it is economical to increase the span of the poles as much as possible, the actual locations of the supporting structures are determined by the actual topographic conditions in the area with many meanders and steeps areas, thereby tending to make short spans. The following standard spans have been determined based on the road conditions as well as the topographical conditions of the Project Area.

Mountainous Area : 50 ~ 60 m

Flat Areas : 60 ~ 70 m

② Ground Clearance and Horizontal Clearances between Line Conductors

In principle, the ground clearance of the transmission/distribution lines and the horizontal clearances between line conductors are determined in accordance with NESC standards. In mountainous areas with many trees, the ground clearance will be determined so as to avoid any grounding faults due to contact between conductors and trees. The clearances will be compatible with those of the existing lines as shown in Table 2-3-12.

Table 2-3-12 Ground Clearance and Horizontal Clearances between Line Conductors

Line Category	Minimum Ground Clearance (m)	Horizontal clearance (mm)
34.5 kV Transmission Line	6.4	1,190
13.8 kV Distribution Line	6.1	825

7) Distribution Substations

Distribution substations with a sufficient capacity to meet the power demand in the respective distribution area will be constructed near user areas to transform the transmission voltage (34.5 kV) to the distribution voltage (13.8 kV). The planned distribution substations under the Project are listed in Table 2-3-13. On both the primary and secondary sides of each substation transformer, a fused switch will be installed to protect the transformer and power lines. In the case of the long 13.8 kV trunk distribution line from the Ngeraard No. 2 Substation to Ngerchelong State, a load-break switch for maintenance purposes will be installed at the boundary between Ngeraard State and Ngerchelong State.

Table 2-3-13 Distribution Substations

State	Substation	Specifications	Transformer Location
Ngerdmau	Ngerdmau	Single phase transformer 34.5/13.8 kV, 75 kVA × 3, outdoor type	pole-mounted
Ngeraard	Ngeraard No. 1	Single-phase transformer 34.5/13.8 kV, 25 kVA × 3, outdoor type	pole-mounted
	Ngeraard No. 2	3-phase transformer 34.5/13.8 kV, 300 kVA × 1, outdoor type	pole-mounted

8) Distribution Transformers

Pole-mounted distribution transformers will be procured to distribute power from the 13.8 kV distribution lines to users. The capacity of these transformers will be a uniform single phase, 15 kVA, 13.8 kV/240 - 120 V to ensure interchangeability at the time of a breakdown and to simplify the distribution system. The quantity of the distribution transformers to be procured is calculated based on the criteria given below.

- General users : one transformer per 10 households
- Public facilities : one transformer per facility

Table 2-3-14 shows the number and the location of the distribution transformers to be procured under the Project. An arrester and a fused switch will be installed to protect the transformer on the primary side (13.8 kV side) of each transformer and the necessary quantities of these items will be procured under the Project. The Government of Palau is to undertake the installation of the distribution transformers, arresters and fused switches and also the procurement and installation of low voltage (240-120 V) distribution materials and equipment.

9) Circuit Breaker Panel at Transmission Outlet

The planned transmission lines under the Project will branch out from the existing Asahi Substation. When the Project is completed, the power network in Palau will be extended to cover entire Babeldaob Island. The total length of the power line will be greatly increased, requiring more complex control of the electric power system in case of trouble than before.

Table 2-3-14 Installation Sites for Distributing Transformers to be Procured Under the Project

State	Line Category	Route	13.8 kV/240 - 120 V Single Phase Transformer (15 kVA)						34.5 kV/240 - 120 V Single Phase Transformer (15 kVA)	
			For Households				For Public Facilities		For Public Facilities	
			Population	Persons/ Household	Number of Households	Number of Transformers	Facility	Number of Transformers	Facility	Number of Transformers
Ngerdmau	34.5 kV Transmission Line	Asahi S/S - Ngerdmau S/S							Road construction machinery warehouse	1
	13.8 kV Distribution Line	Ngerdmau S/S - Ngetbong	8	5.14	2	1	Ice-making plant × 1	1		
		Ngerdmau S/S -Dock	68	5.14	14	2	Jetty x 1	1		
		Ngerdmau S/S -Ngerutoi	106	5.14	21	3	State government office × 1	1		
							Primary school × 1	1		
							Clinic × 1	1		
		Sub-Total				6		5		1
								11		1
Ngeraard		Ngeraard No. 1 S/S - Ngkeklau	44	4.37	11	2				
		Ngeraard No. 2 S/S - Urrung	8	4.37	2	1	Jetty x 1	*(See Note)		
		(Branch) - Chelab	65	4.37	15	2				
		(Branch) - Ngerderemang	15	4.37	4	1	State government office × 1	1		
							Private high school × 1	1		
		(Branch) - Ngemerdang	47	4.37	11	2				
		(Branch) - Choi School		4.37	0	0	Primary school	1		
		Ngeraard No. 2 S/S - State Border (to Ollei)					Primary school	1		
		Sub-Total				8		4		0
								12		0
Ngerchelong		(from Ngeraard No. 2 S/S) State Border - Ollei					State government office × 1	1		
							Fishing port × 1	1		
							Primary school × 1	1		
							Water supply pump station × 1	1		
							Ice making plant × 1	1		
							Clinic × 1	1		
		(Branch) - Ngriil	4	4.54	1	1				
		(Branch) - Oketol	4	4.54	1	1	Jetty × 1	*(See Note)		
		(Branch) - Ngerbau	118	4.54	26	3				
		(Branch) - Ngebel	51	4.54	12	2	Jetty × 1	*(See Note)		
		Sub-Total				7		6		0
								13		0
Ngwal		Coast - Ogill	246	4.50	55	6	State government office x 1	1		
							Primary school x 1	1		
							Jetty x 2	*(See Note)		
							Clinic x 1	1		
		Sub-Total				6		3		0
								9		0
Total						27		18		1

Notes: 1) The number of ordinary households is calculated by dividing the population by the average number of persons per household in each state.
2) The mark "*" means that the transformer shall be used in common with the household's one.

13.8 KV/240 - 120 single phase transformer total	45 (4 spares)	34.5 KV/240 - 120 single phase transformer total	1 (1 spare)

As it is extremely important to swiftly and safely separate the point of a grounding or short-circuiting accident from the rest of the sound power network for the continuous operation of the system, an outdoor cubicle type breaker panel will be installed at the Asahi Substation outlet to protect the system.

An ammeter, voltmeter, watthour meter and other instruments which will become necessary to control and monitor the power flow will also be mounted on the above breaker panel.

10) Prevention of Earth Fault

Extension of the power network in Palau will require simplification of the maintenance work. Fast-growing trees and weeds climb up the power lines and could possibly result in a ground fault which lowers the reliability of the system. The PUC has been making efforts to prevent such accidents through the use of chainsaws and hatchets, etc. to cut down the trees and weeds along the transmission and distribution routes. However, its workload has been increasing, for example, 22 grounding faults occurred in 1995 due to touching and falling of trees or other causes. To minimise such accidental contact, a climber protection device which is normally used for transmission and distribution lines in mountainous regions in Japan will be attached on the pole support stay wires where the use of such a device is deemed useful in order to reduce the maintenance cost and to prevent earth faults caused by climbing creepers or ivies.

11) Specifications and Quantity of the Equipment and Materials

Table 2-3-15 shows the specifications and quantities of the equipment and materials which will be procured under the Project.

The actual quantity of conductors and electric poles for the construction should be determined based on the detailed topographic maps.

Therefore, the quantities as shown in the Table include a 5% allowance added to the quantity which has been determined by using a 1/25,000 scale map.

The specifications of the planned equipment for the power transmission and distribution network are similar to those of previous projects and the Palau side has been operating and maintaining such equipment with no major trouble or breakdowns. In view of this, the equipment involved in the power network extension work will not be included in the scope of the OJT.

Table 2-3-15 Specifications of Equipment and Materials to be Procured for Power Network Improvement Plan

Equipment/Material	Quantity	Specifications
1. 34.5 kV Transmission Line Construction Work		
(1) Transmission Conductor	93,990 m	AAC (stranded hard-drawn aluminium wire), 150 mm², for 3-phase
(2) Neutral Conductor	31,330 m	HDCC (stranded hard-drawn copper wire), 38 mm²
(3) Electric Poles		
1) Concrete Poles	24 nos	Height: 16 m; design load: 700 kgf, 34.5/13.8 kV lines
	58 nos	Height: 13 m; design load: 700 kgf
2) Steel Poles	532 nos	Height: 13 m; design load: 700 kgf
(4) Load Breaker Switch	1 set	For 34.5 kV line, 3-phase
(5) Distribution Transformer	1 set	34.5 kV/240 - 120V, 15 kVA, single phase with fuse switch
2. 13.8 kV Distribution Line Work		
(1) Suspended Distribution Conductor	68,960 m	HDCC (stranded hard-drawn copper cable); 38 mm²; for 3-phase
(2) Suspended Neutral Conductor	22,990 m	HDCC (stranded hard-drawn copper cable); 38 mm²
(3) Electric Poles		
1) Concrete Poles	240 nos	Height: 13 m, design load: 700 kgf
2) Steel Poles	188 nos	Height: 13 m, design load: 700 kgf
(4) Load Breaker Switch	1 set	For 13.8 kV line
3. Sub-Station Work		
(1) Ngerdmau Substation	1 set	• Transformer : 34.5/13.8 kV single phase 60 Hz 75 kVA × 3 • Cutout switch with fuse : for 34.5 kV: 1 set, for 13.8 kV: 1 set • Arrester : for 34.5 kV: 3 sets, for 13.8 kV: 3 sets
(2) Ngeraard No. 1 Substation	1 set	• Transformer : 34.5/13.8 kV single phase 60 Hz 25 kVA × 3 sets • Cutout switch with fuse : for 34.5 kV: 1 set, for 13.8 kV: 1 set • Arrester : for 34.5 kV: 3 sets, for 13.8 kV: 3 sets
(3) Ngeraard No. 2 Substation	1 set	• Transformer : 34.5/13.8 kV 3 phase 60 Hz 300 kVA × 1 sets • Cutout switch with fuse : for 34.5 kV: 1 set, for 13.8 kV: 1 set • Arrester : for 34.5 kV: 3 sets, for 13.8 kV: 3 sets
(4) Asahi Substation (34.5 kV transmission line outlet)	1 panel	• Circuit breaker panel : 34.5 kV 600A, with ammeter, voltmeter and watthour meter
4. Equipment and Materials for Distribution Line (to be installed by Palau side)		
(1) Distribution Conductor	70,190 m	HDCC (stranded hard-drawn copper wire), 38 mm²,
(2) Suspended Neutral Conductor	23,400 m	HDCC (stranded hard-drawn copper wire), 38 mm²
(3) Electric Poles	321 nos	Concrete poles
	70 nos	Steel poles
(4) Distribution Transformer		Steel pole 13km (Ngeraard No. 1 SS-Ngkelau)
1) For 34.5 kV Transmission Line	1 (spare)	34.5 kV/240 - 120V, 15 kVA, single phase with fuse switch
2) For 13.8 kV Distribution Line	49 (including 4 spares)	13.8 kV/240 - 120 V, 15 kVA, single phase with fuse switch
(5) Other Spare Parts	1 set	• Load breaker switch (for 34.5 kV): 1 set • Load breaker switch (for 13.8 kV): 1 set • Fuse link for cutout switch: 200%

(6) Basic Design Drawings

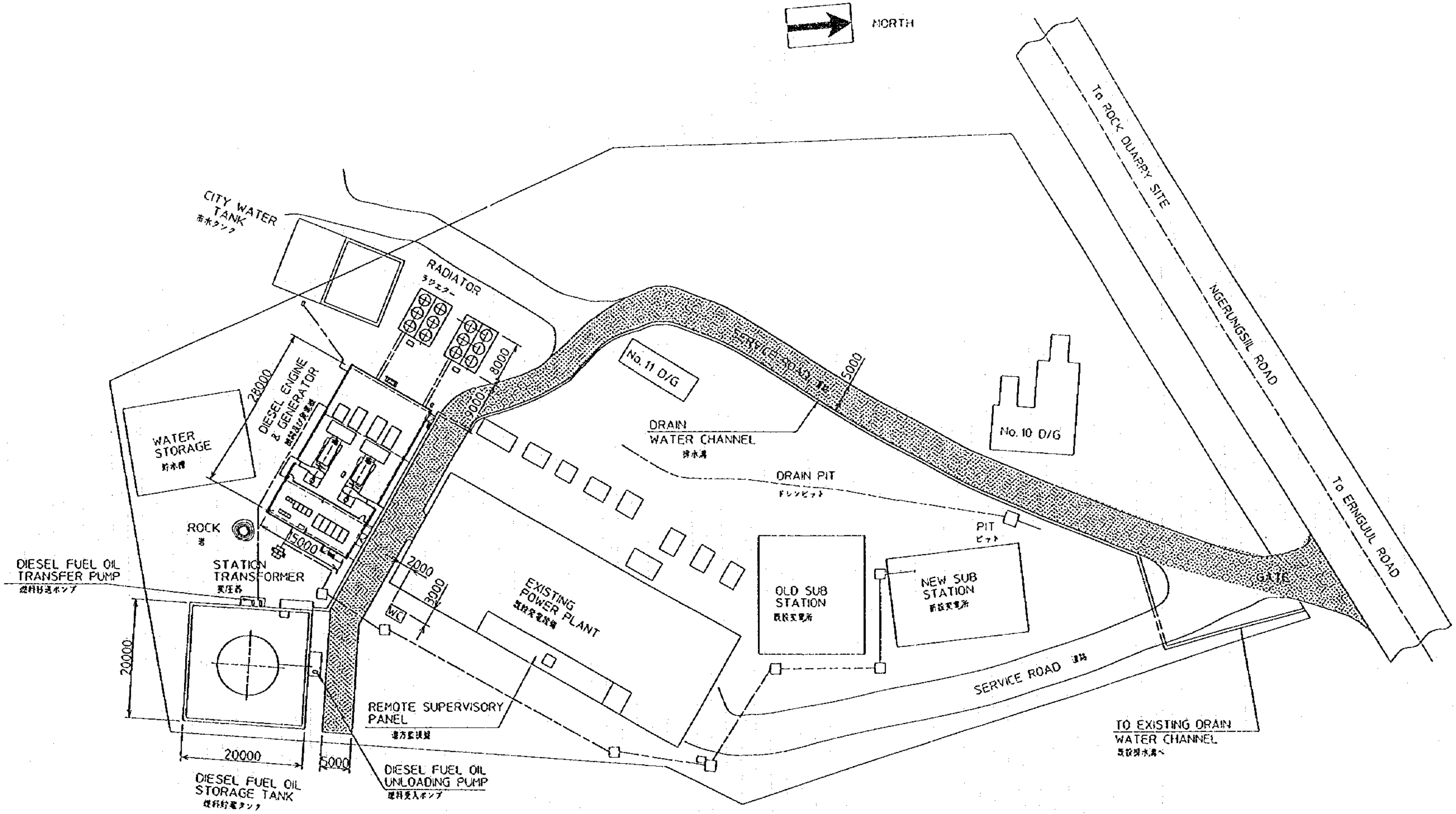
The following basic design drawings have been prepared for the Project.

1) Malakal Power Station Improvement Plan

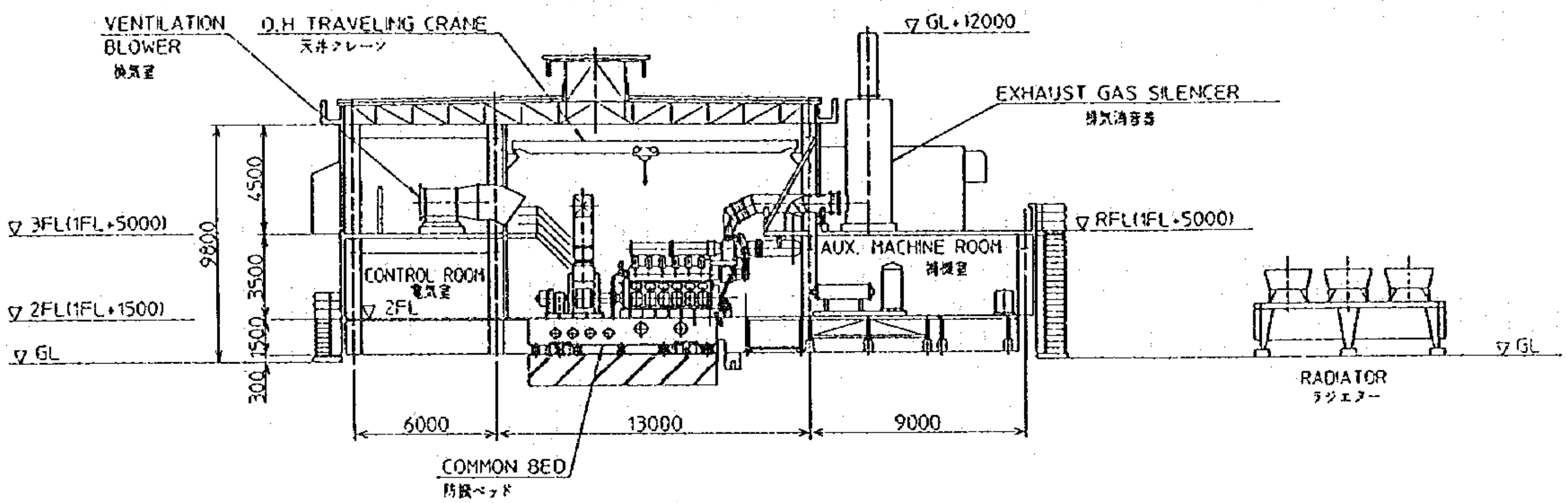
MPS-M-01	General Arrangement of the Site
MPS-M-02	Generating Facilities Layout Plan
MPS-M-03	Flow Diagram of Fuel Oil System
MPS-M-04	Flow Diagram of Lubricant Oil System
MPS-M-05	Flow Diagram of Cooling Water System
MPS-M-06	Flow Diagram of Compressed Air System
MPS-M-07	Flow Diagram of Intake Air and Exhaust Gas System
MPS-E-01	Single Line Diagram for Malakal Power Station
MPS-E-02	Substation Arrangement
MPS-B-01	General Layout Plan for Civil and Building Work
MPS-B-02	Finish Schedule for Generator Building
MPS-B-03	First Floor Plan for Generator Building
MPS-B-04	Second Floor Plan for Generator Building
MPS-B-05	Section Plan for Generator Building
MPS-B-06	Elevation Plan for Generator Building

2) Transmission and Distribution Network Extension Plan for 4 Northern States of Babeldaob Island

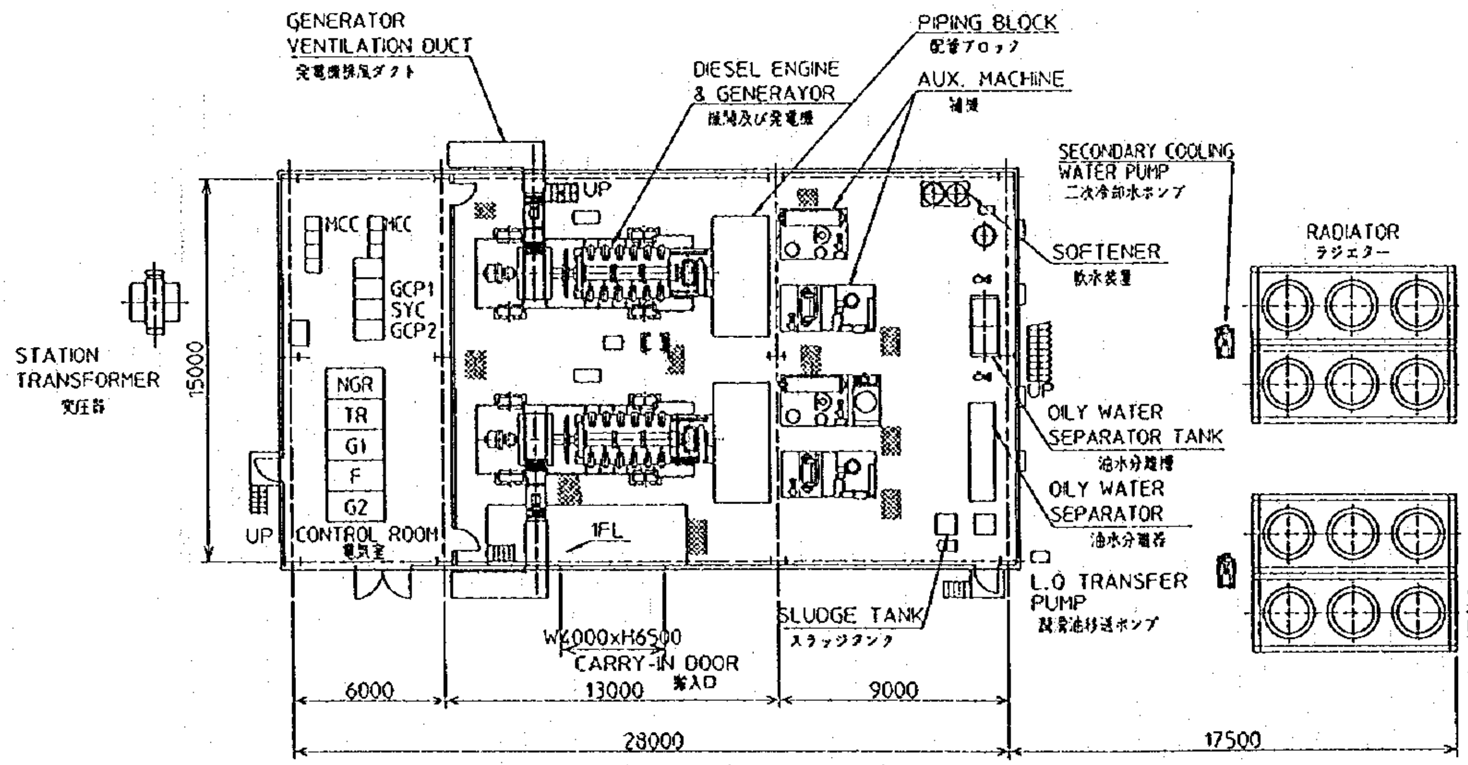
BDT-01	Planned Transmission and Distribution Routes
BDT-02	Single Line Diagram for Transmission and Distribution Network
BDT-03	Work Demarcation of Transmission and Distribution Network
BDT-04	Typical Arrangement for Supporting Structure (34.5 kV Concrete Pole)
BDT-05	Typical Arrangement for Supporting Structure (34.5 kV Steel Pole)
BDT-06	Typical Arrangement for Supporting Structure (13.8 kV Concrete Pole)
BDT-07	Typical Arrangement for Supporting Structure (13.8 kV Steel Pole)
BDT-08	Arrangement for Ngerdmau and Ngeraard-1 Substations (Single Phase Transformer × 3)
BDT-09	Arrangement for Ngeraard-2 Substation (Three Phase Transformer × 1 unit)



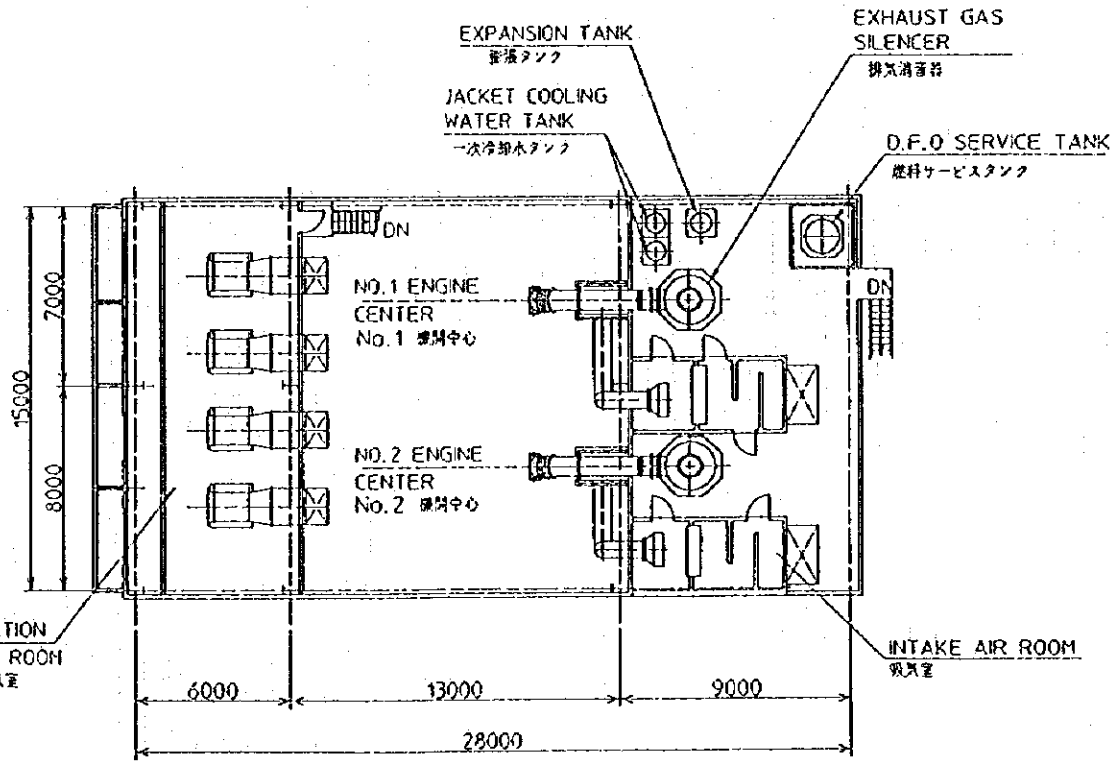
MPS-M-01 General Arrangement of the Site



CLOSS SECTION

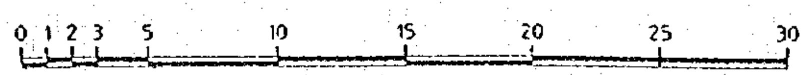


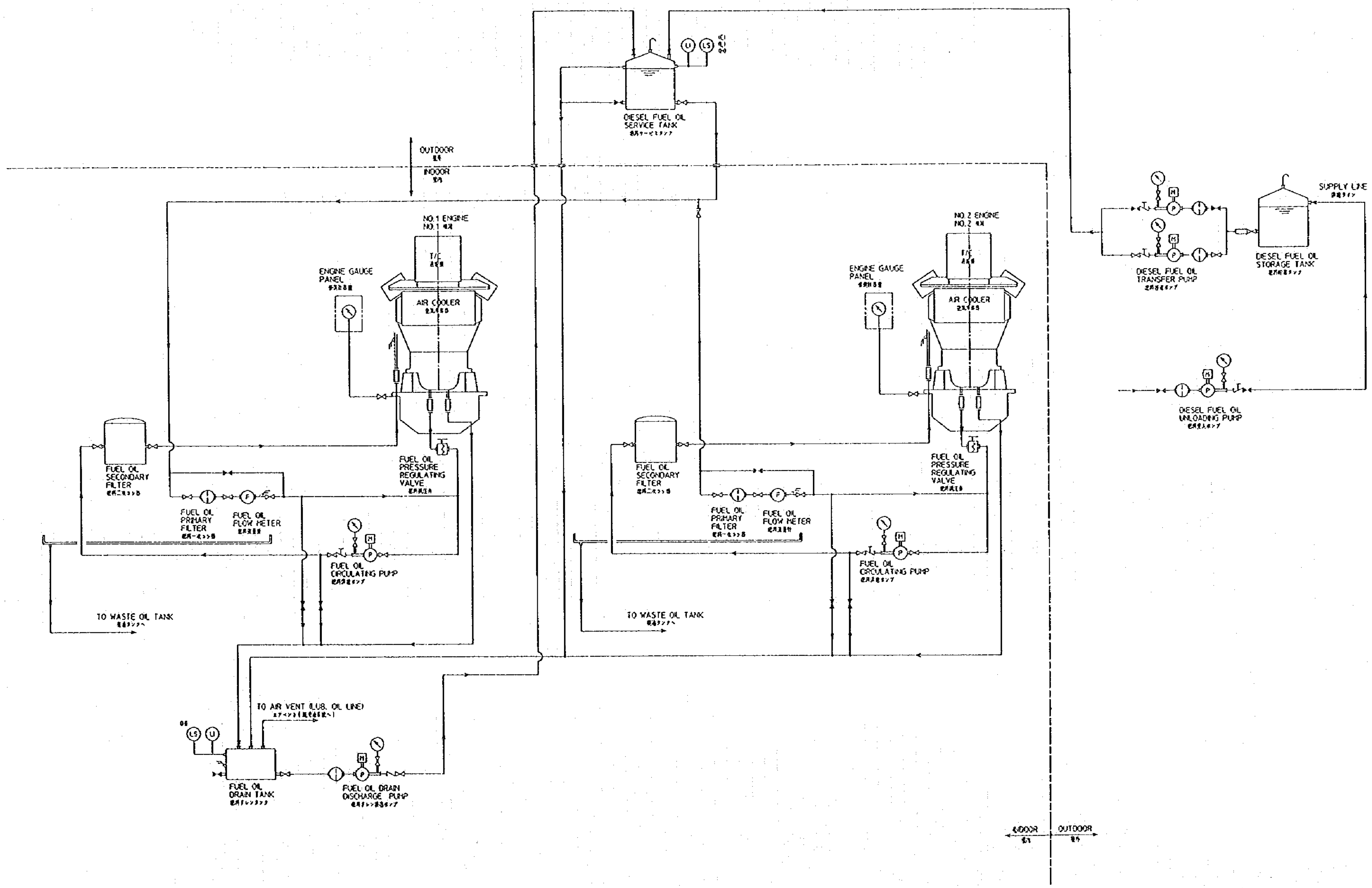
OUTDOOR AND SECOND FLOOR



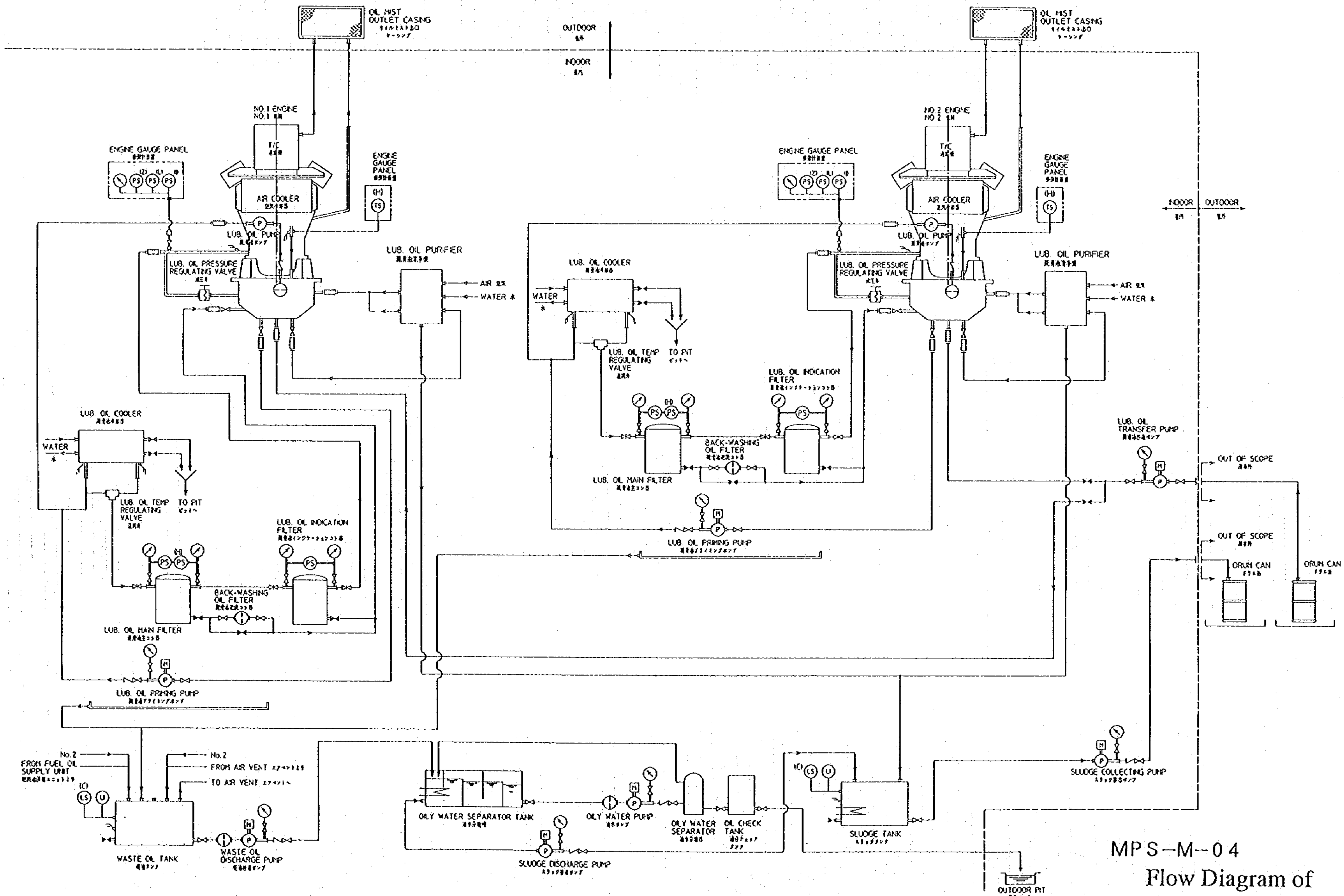
THIRD FLOOR & ROOF FLOOR

MPS−M−02 Generating Facility Layout Plan

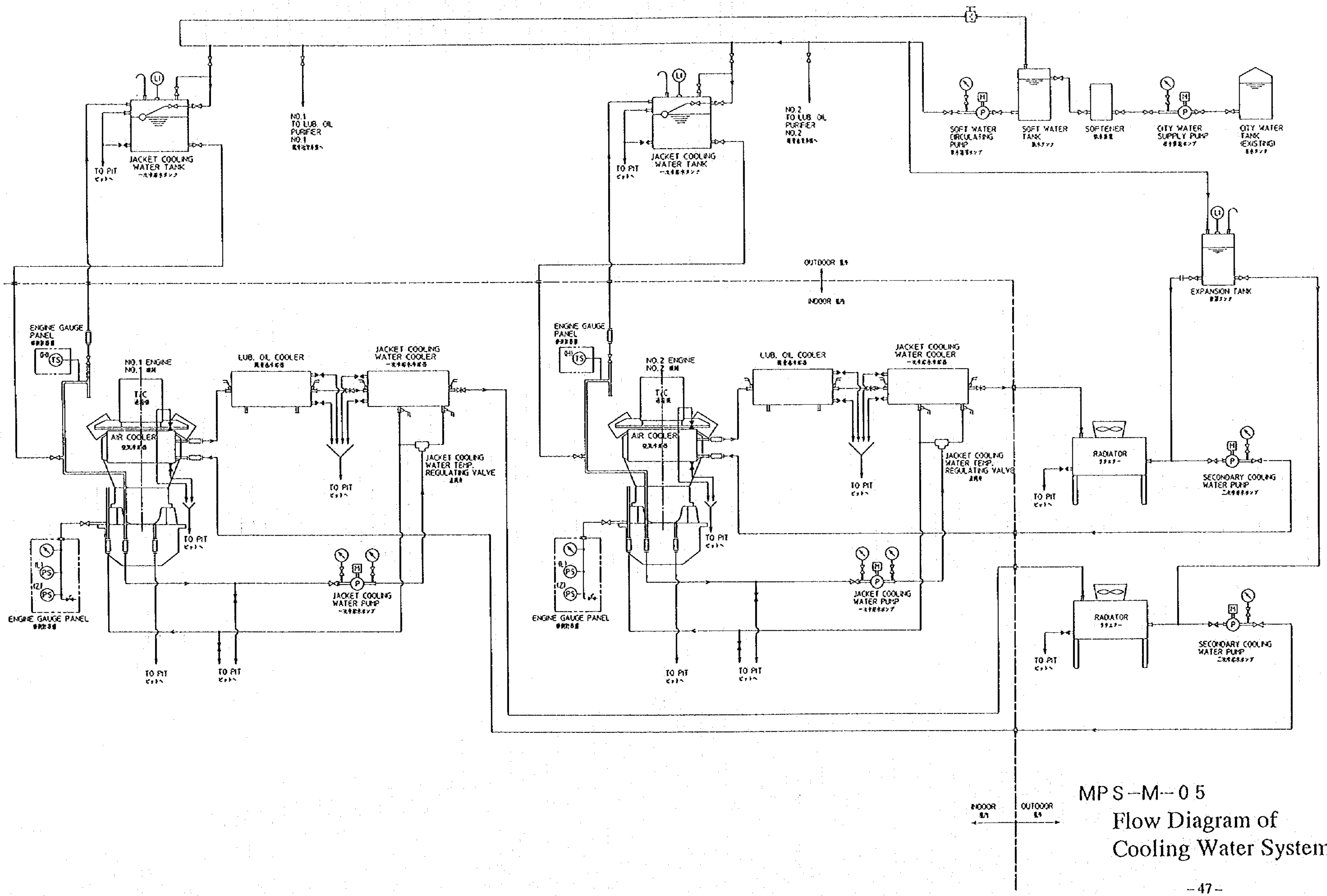




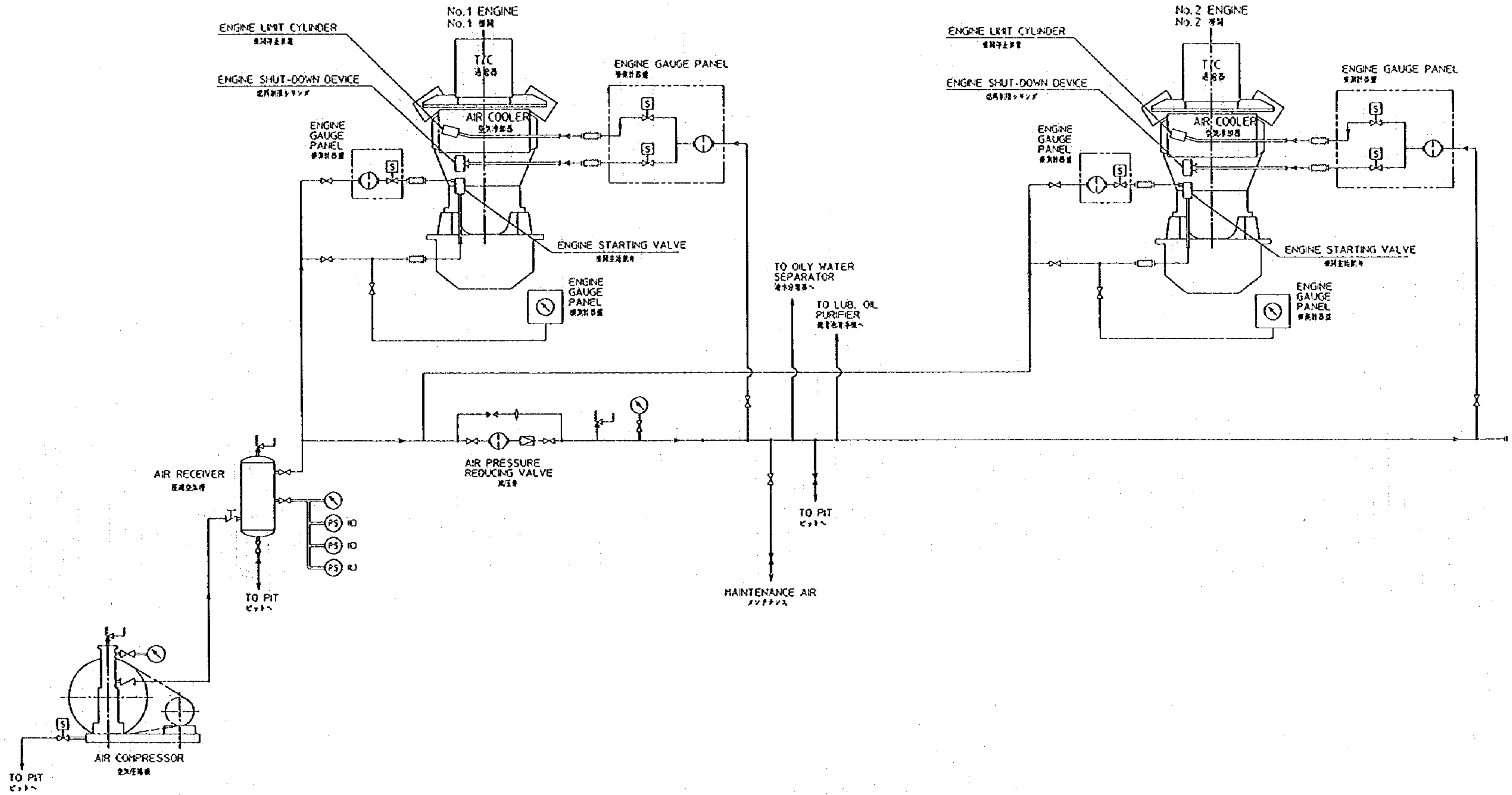
MPS－M－03 Flow Diagram of Fuel Oil System



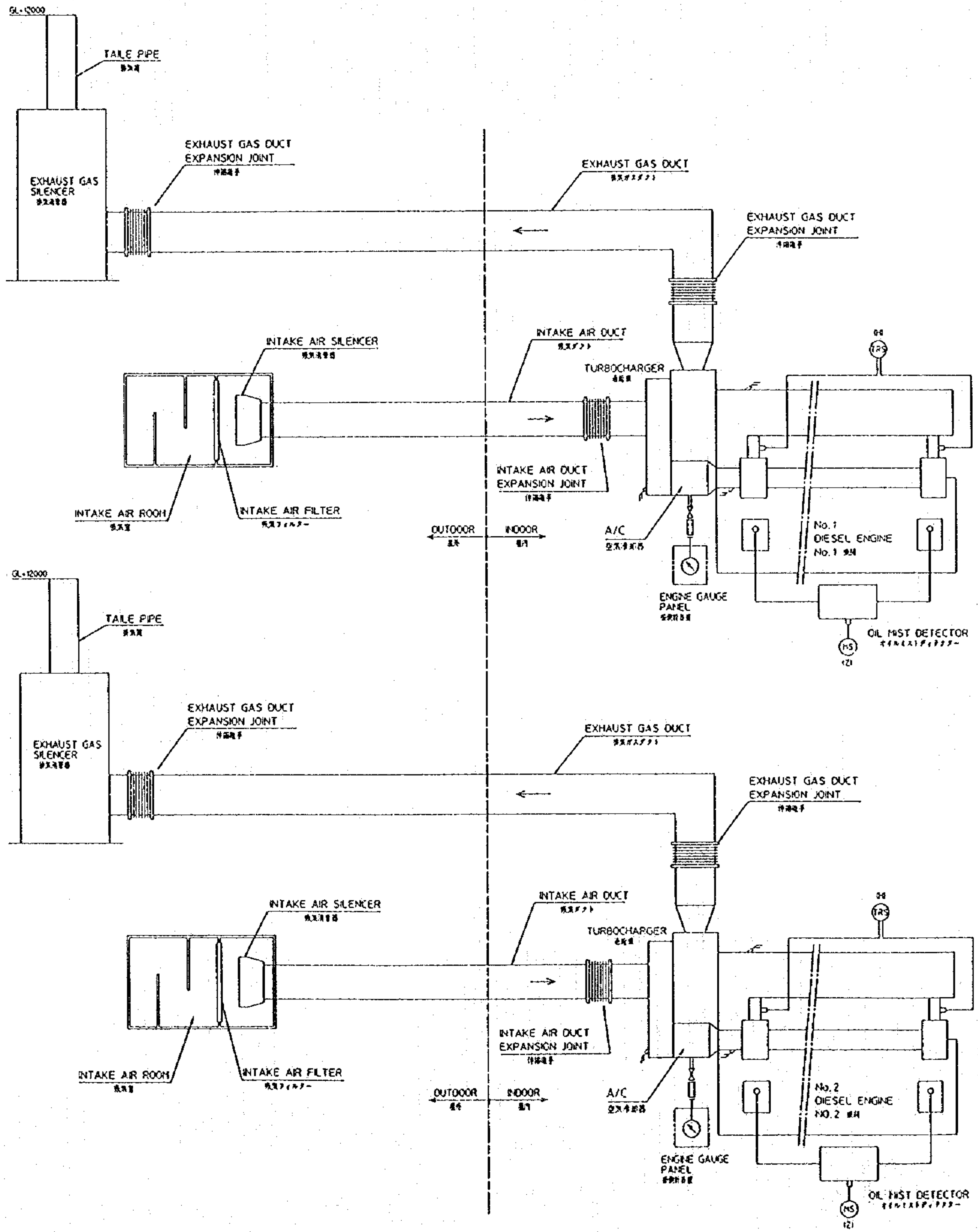
MPS-M-04
Flow Diagram of
Lubricant Oil System



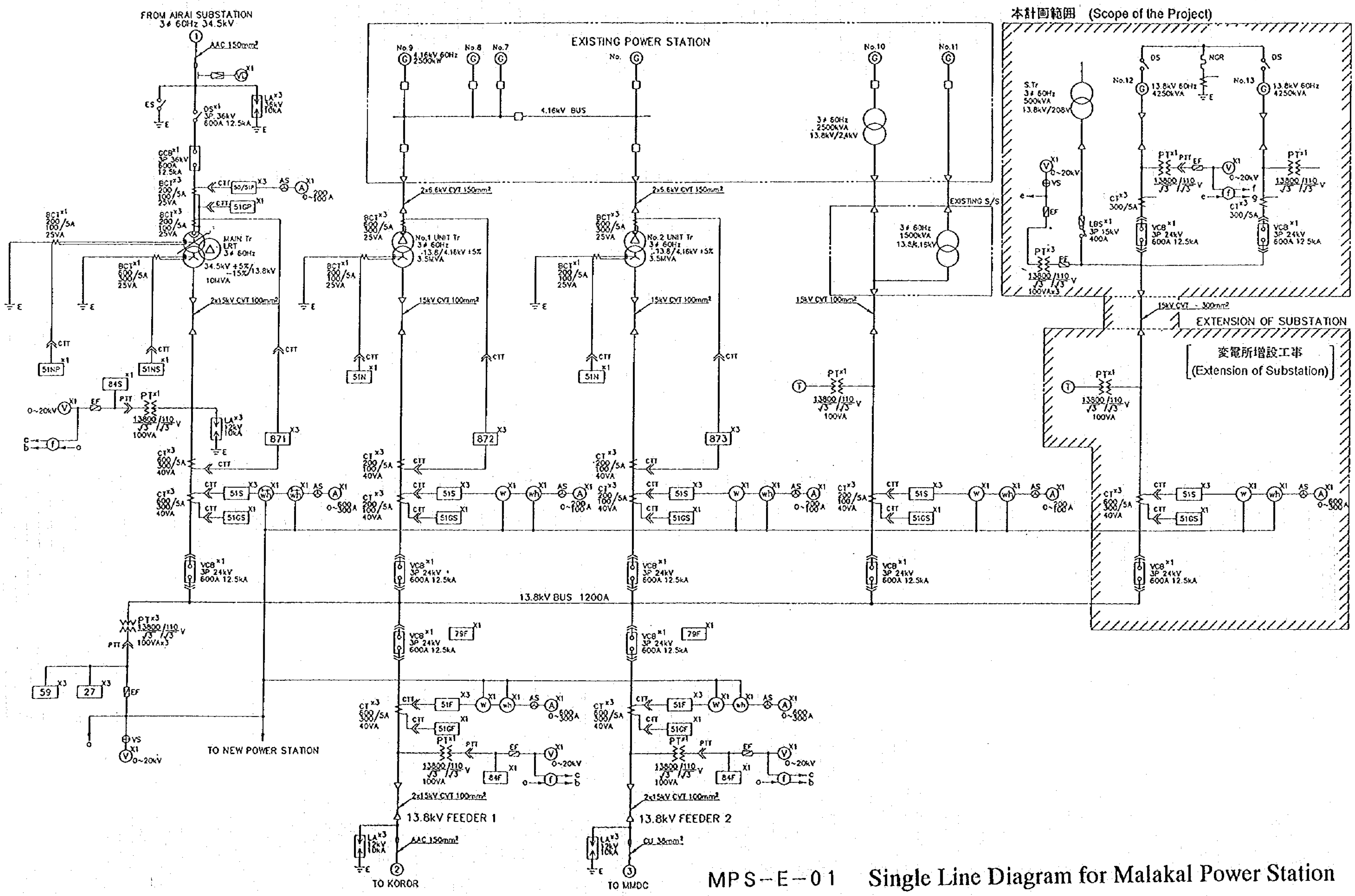
MPS-M-05
Flow Diagram of
Cooling Water System



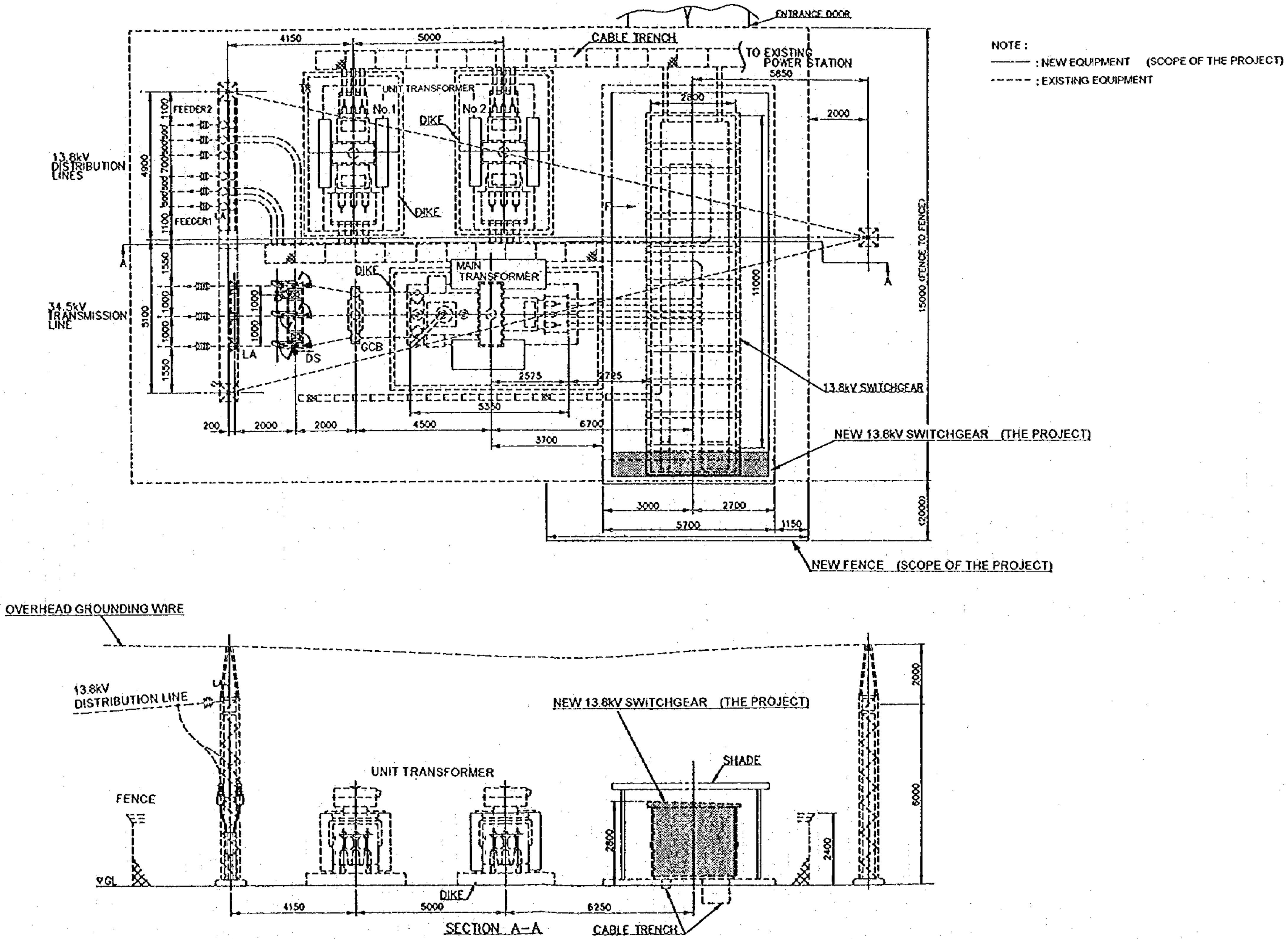
MPS-M-06 Flow Diagram of Compressed Air System



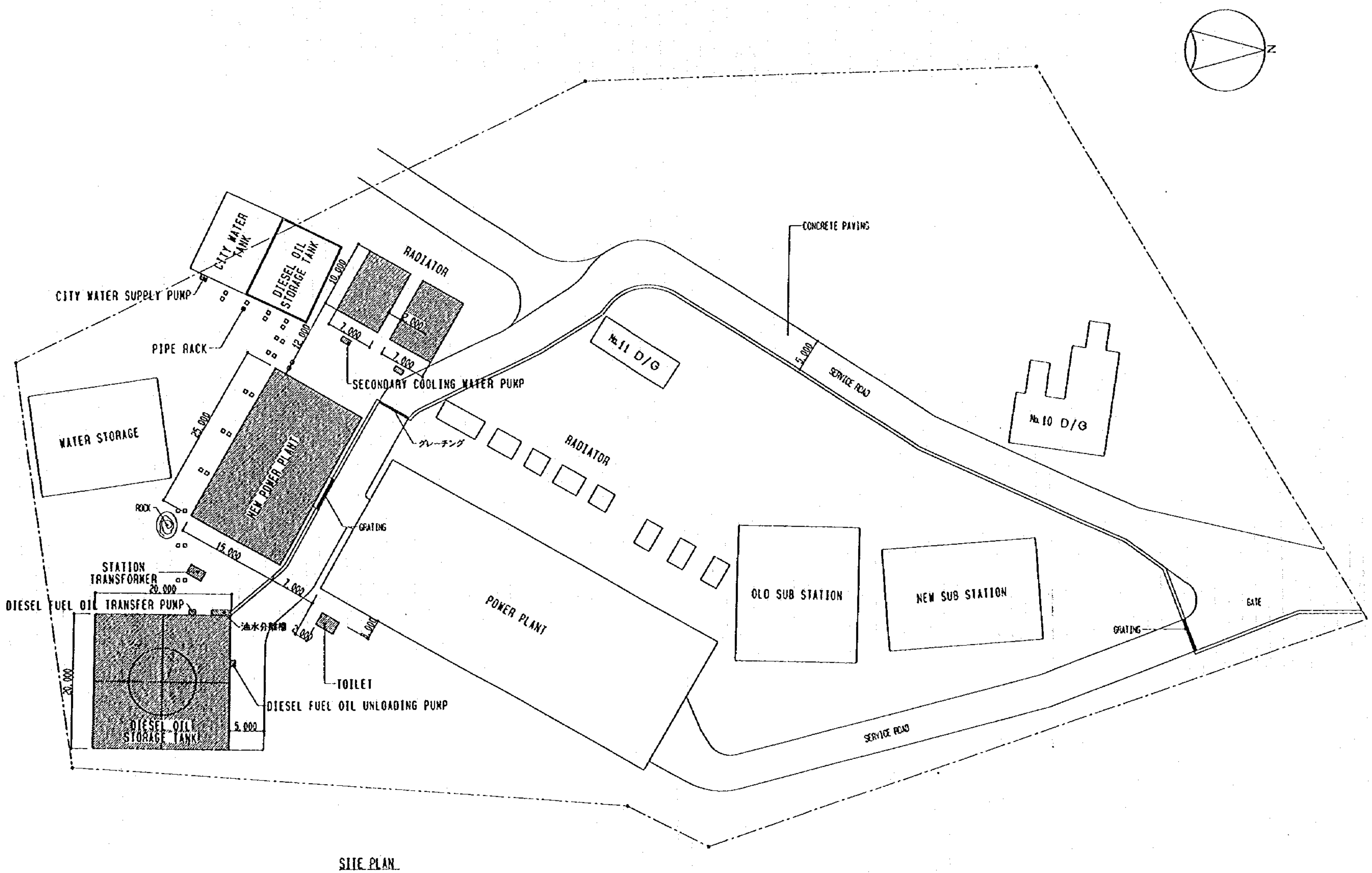
MPS−M−07
Flow Diagram of Intake Air and Exhaust Gas System



MPS－E－01 Single Line Diagram for Malakal Power Station



MPS－E－02 Substation Arrangement



MPS－B－01　General Layout Plan for Civil and Building Work

FINISHING SCHEDULE 仕上表

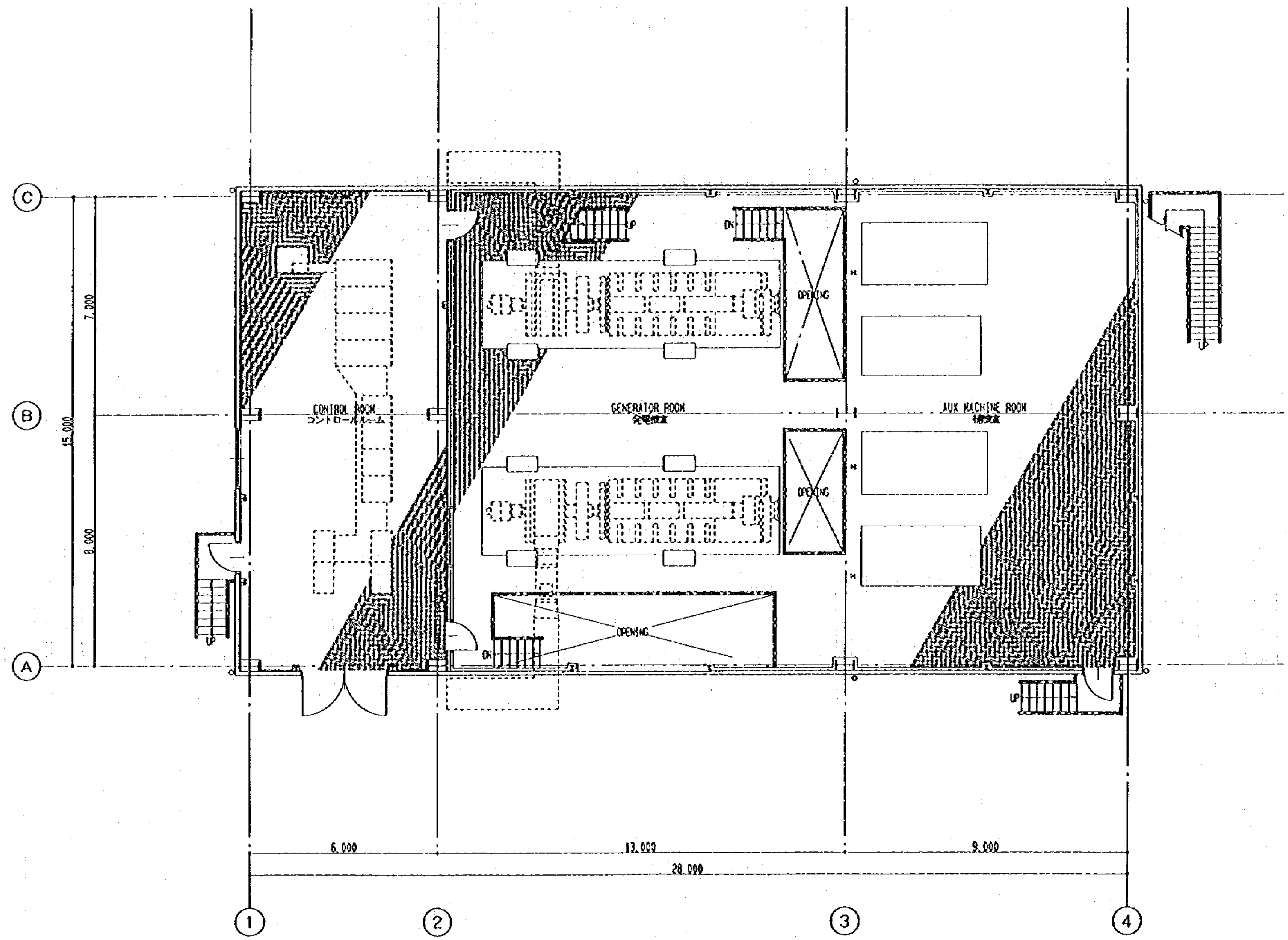
EXTERIOR SCHEDULE 外部仕上

ITEM 項目	FINISH.SPECIFCATIONS 仕上・仕様	ITEM 場所	FINISH.SPECIFCATIONS 仕上・仕様	ITEM 場所	FINISH.SPECIFCATIONS 仕上・仕様
ROOF 屋根	CORRUGATED ASBESTOS-CEMENT SHEET, GRADIENT : 3/10 大波スレート葺、勾配3/10、一部シート防水(ｱ)2.0	OPENINS 開口部	STEEL WINDOW SOP. STEEL SHUTTER SOP. STEEL DOOR SOP. 窓：スチール製 SOP、シャッター：スチール製 SOP、扉：スチール製 SOP	MONITOR モニター	ROOF : CORRUGATED ASBESTOS-CEMENT SHEET. WALL : CORRUGATED ASBESTOS-CEMENT SHEET. 屋根：大波スレート葺、壁：小波スレート
EXTERIOR WALL 外壁	CORRUGATED ASBESTOS-CEMENT SHEET 小波スレート	EXTERIOR STAIR 外部階段	STEEL STAIR SOP スチール製 SOP	MACINE FOUNDATION 機械基礎	CONCRETE STEEL TROWELLED FINISH コンクリート金ゴテ押え
WAINSCOT 腰	CEMENT MORTAR FINISH モルタル金ゴテ押え	GUTTER 樋	EAVES GUTTER : ZINC PLATE 16mm THIK. COAL TAR PAINT. DOWN SPOUT : PVC PIPE 150 φ 軒樋：亜鉛メッキ鋼板(ｱ)1.6 加工、コールタール塗、竪樋：塩ビパイプ150 φ		

INTERIOR SCHEDULE 内部仕上

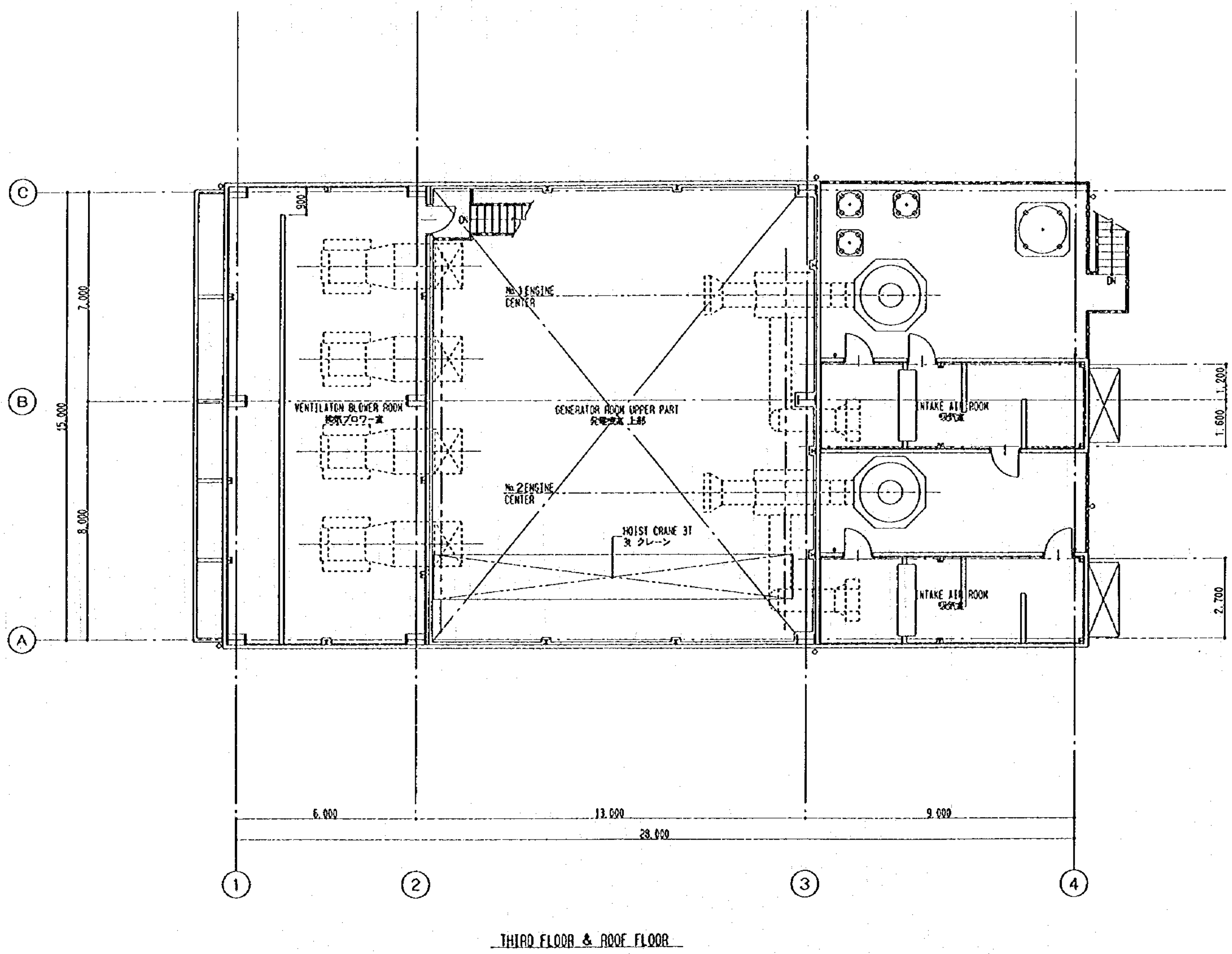
ROOM 室名	FLOOR 床	BASEBOARD 巾木	HIGH 高さ	WALL 壁（柱型）	CEILING 天井（梁型）	REMARKS 備考
GENERATOR ROOM 発電機室	CHECKERED PLATE 6mm THIK. SOP チェッカープレート(ｱ)6 SOP	EXPOSED CONCRETE コンクリート打放し	100	GLASS WOOL BOARD 50mm THIK. グラスウール(ｱ)50	GLASS WOOL BOARD 50mm THIK. グラスウール(ｱ)50	GENERATOR FOUNDATION. CRANE (3t). STEEL HANDRAIL. 発電機基礎、クレーン（3t）、手摺：スチール製
STOKER DRIVING UNIT ROOM 補機室	DITTO 仝　上	DITTO 仝　上	100	DITTO 仝　上	DITTO 仝　上	MACHINE FOUNDATION 機械基礎
CONTROL ROOM コントロールルーム	DITTO 仝　上	DITTO 仝　上	100	DITTO 仝　上	DITTO 仝　上	
VENTILATION BLOWER ROOM 換気ブロワー室	CONCRETE STEEL TROWELLED FINISH コンクリート金ゴテ押え	——		DITTO 仝　上	DITTO 仝　上	
INTAKE AIR ROOM 吸気室	DITTO 仝　上	EXPOSED CONCRETE コンクリート打放し	500	DITTO 仝　上	DITTO 仝　上	

MPS－B－02 Finish Schedule for Generator Building

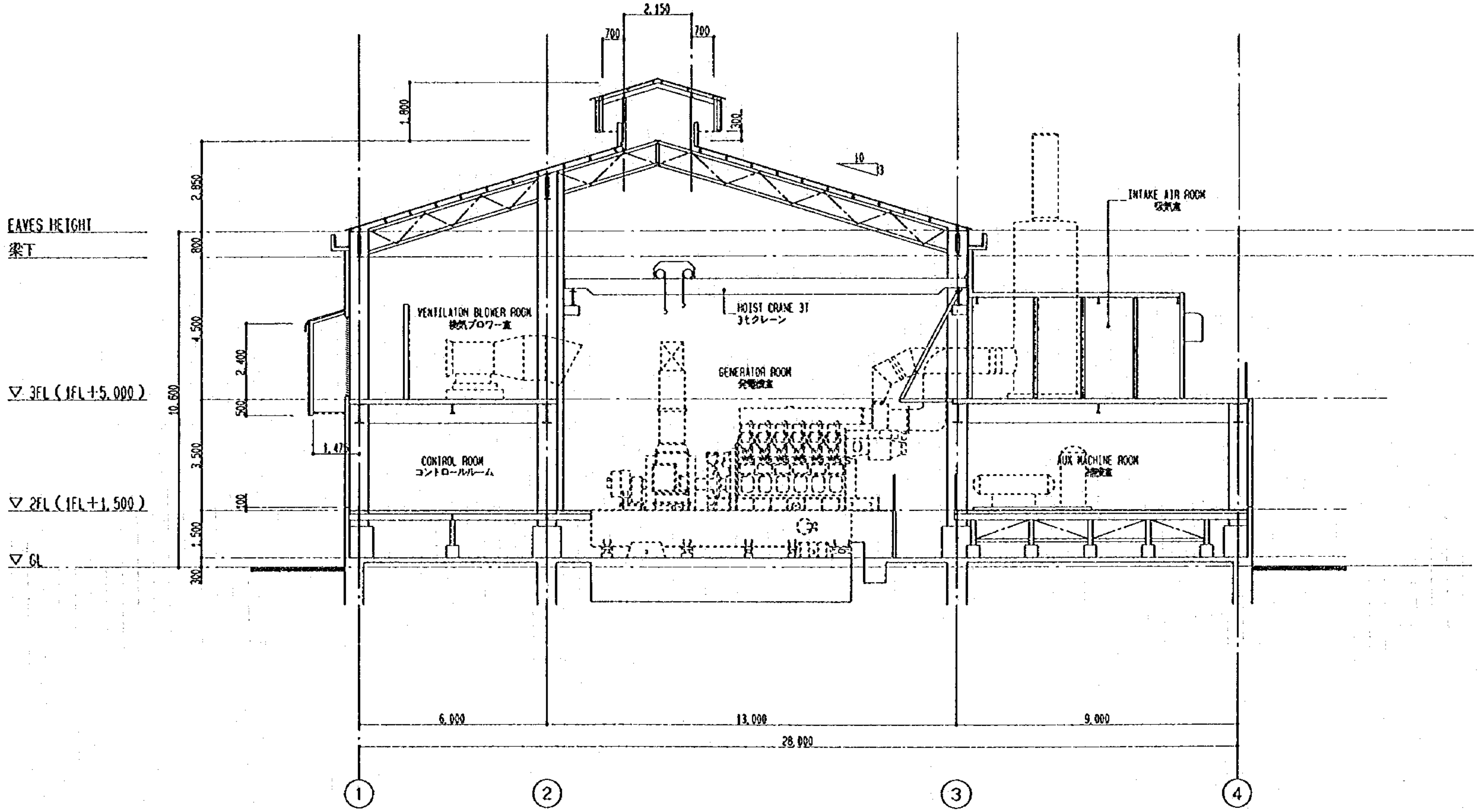


GROUND FLOOR & SECOND FLOOR

MPS－B－03 First Floor Plan for Generator Building

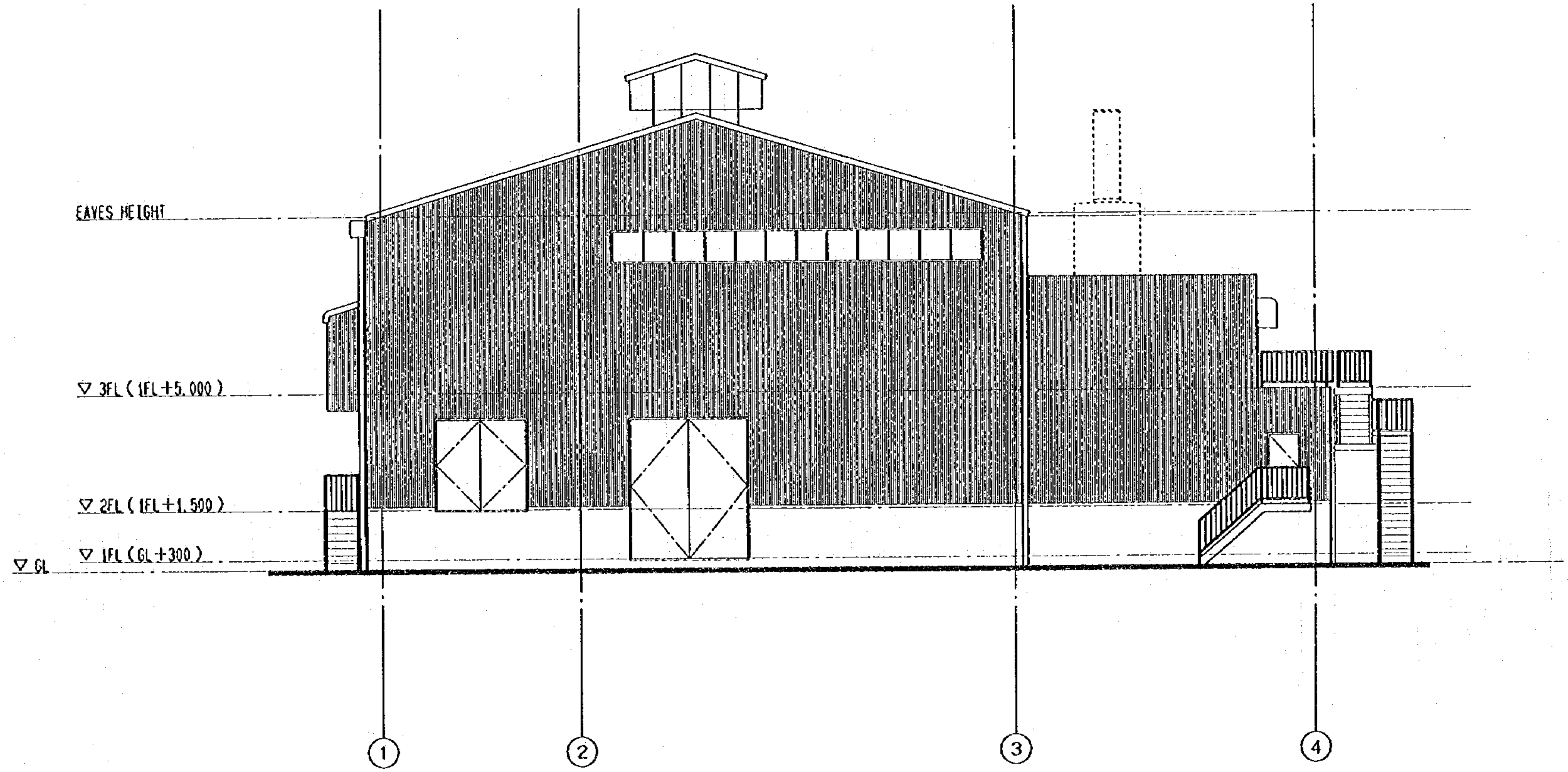


MPS－B－04 Second Floor Plan for Generator Building



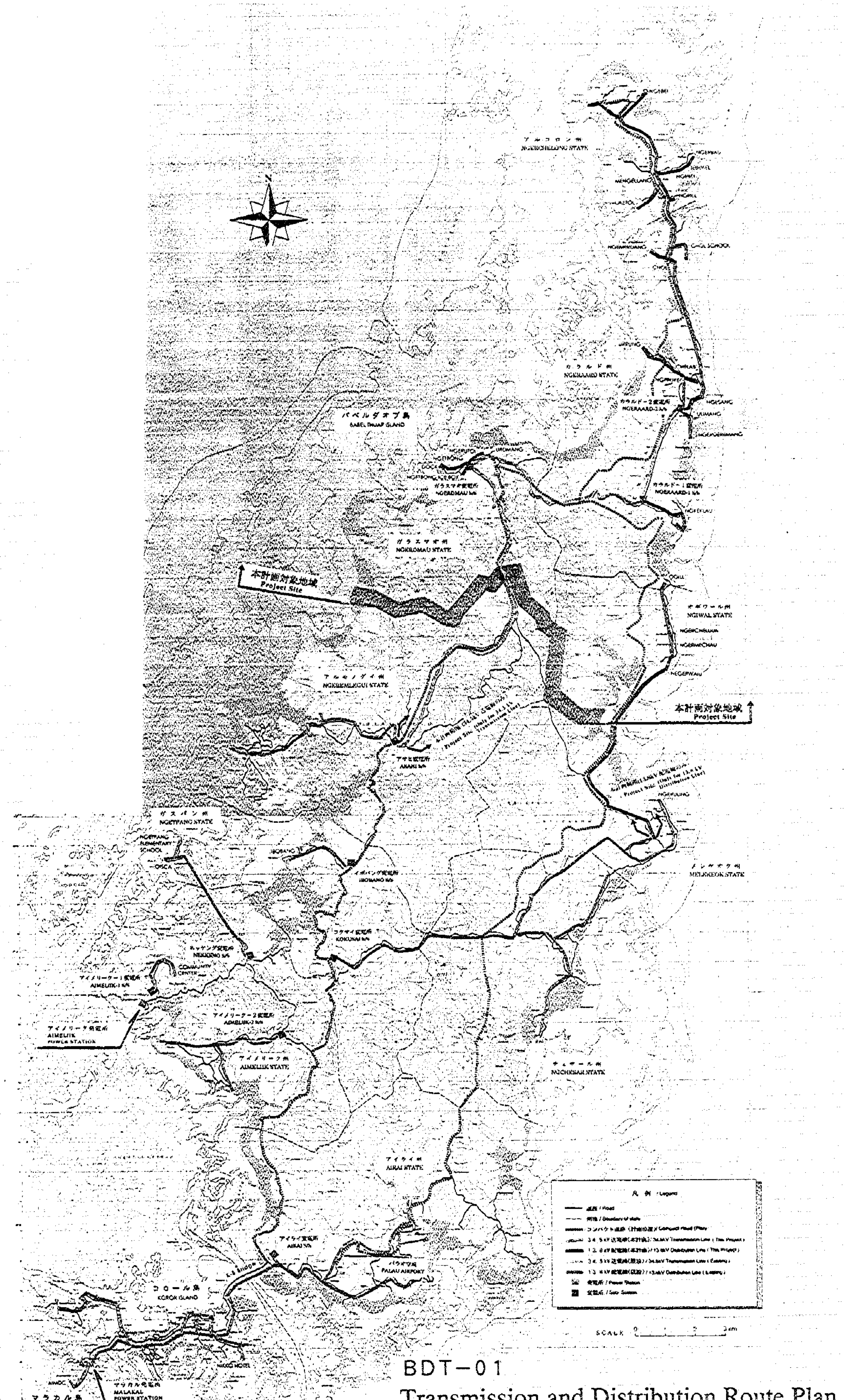
CLOSS SECTION 1 : 100

MPS－B－05 Section Plan for Generator Building

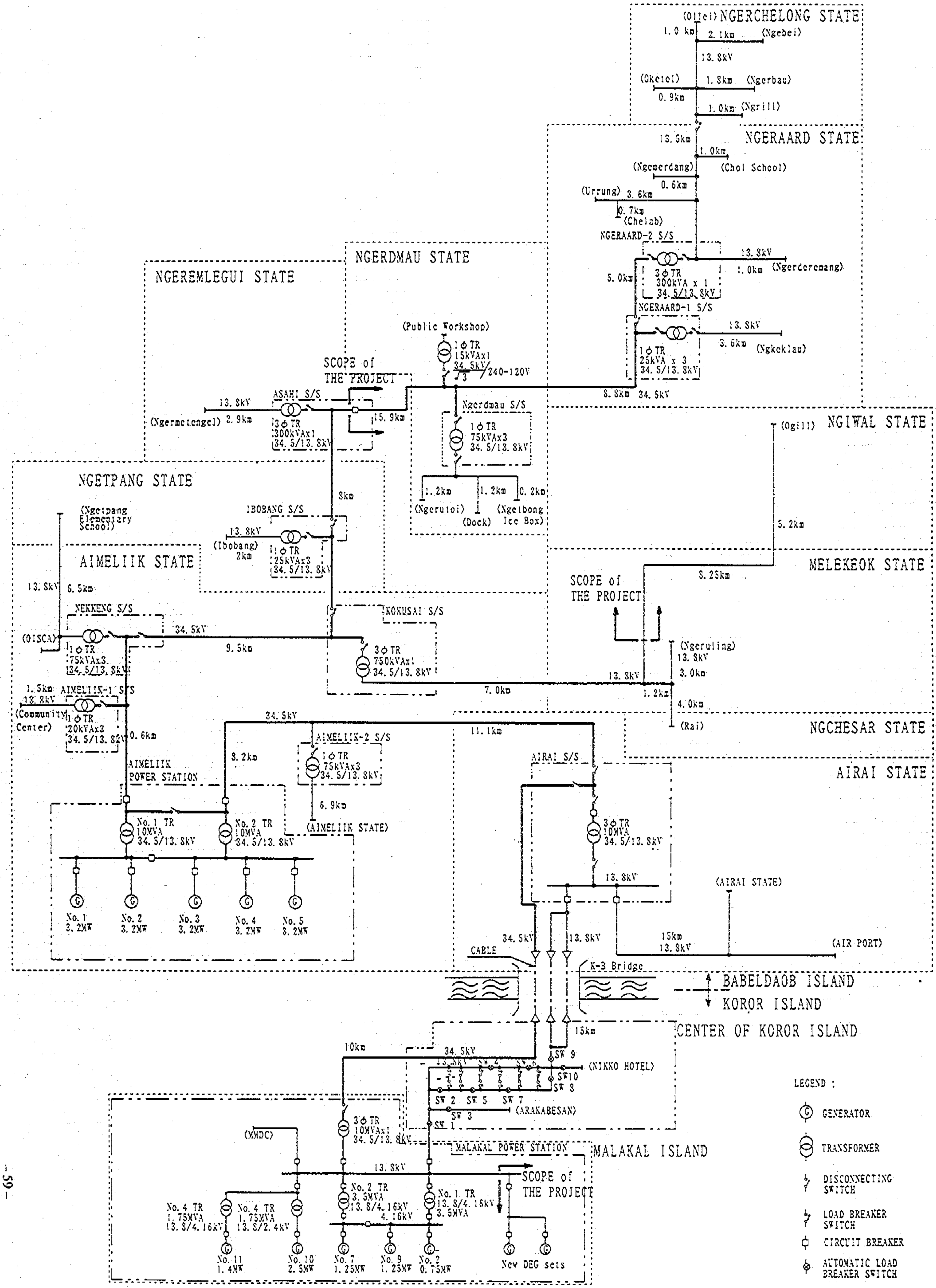


A ELEVATION 1 : 100

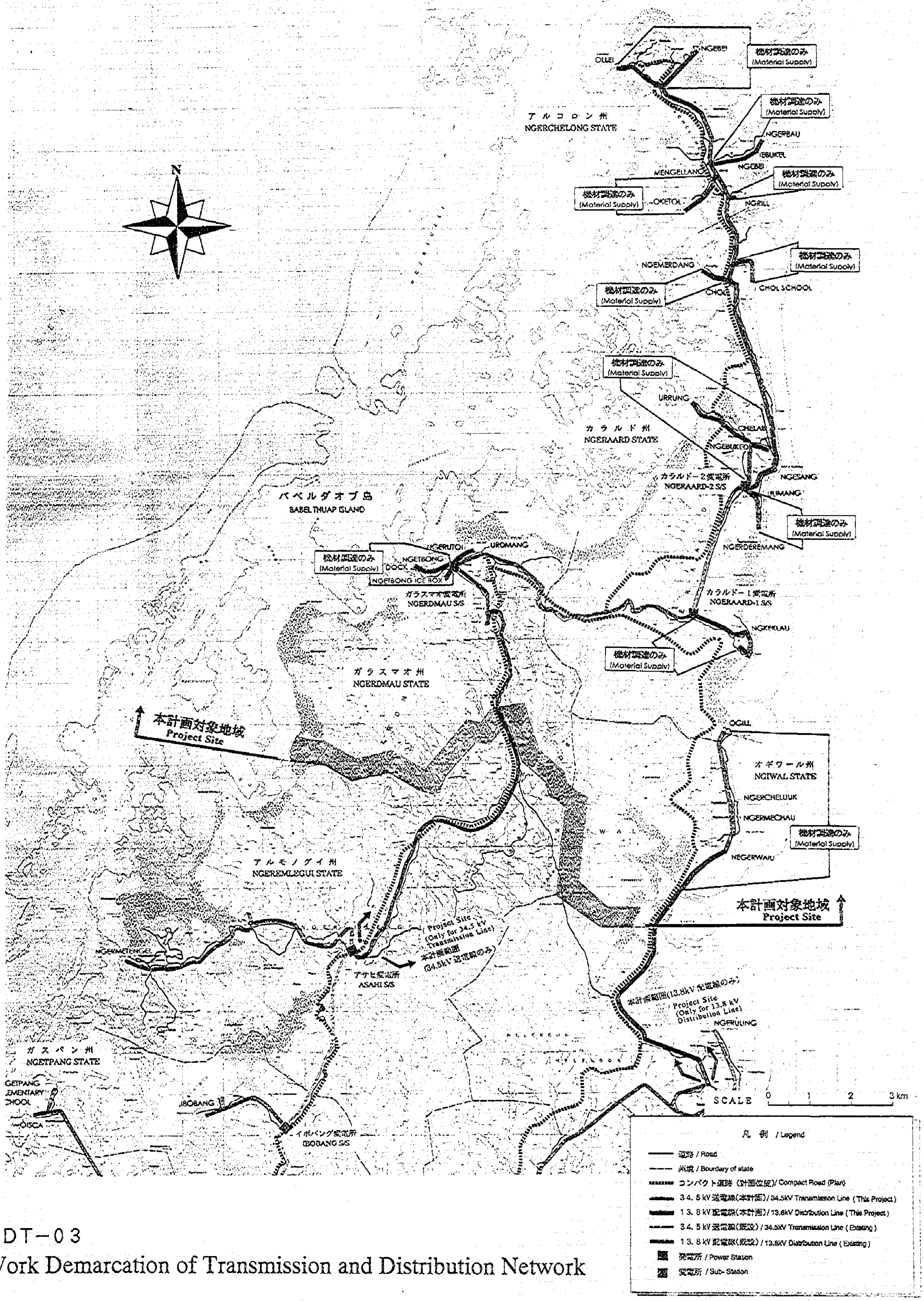
MPS－B－06 Elevation Plan for Generator Building



BDT－01
Transmission and Distribution Route Plan

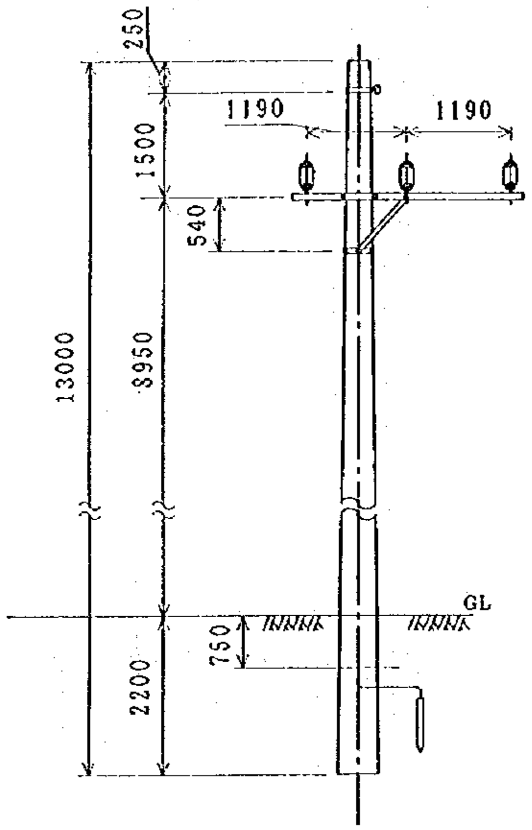


BDT−02 Single Line Diagram for Transmission and Distribution Network

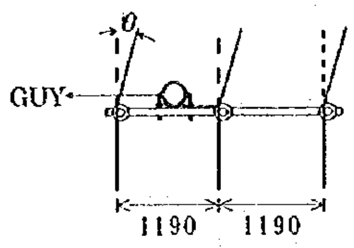


BDT－03

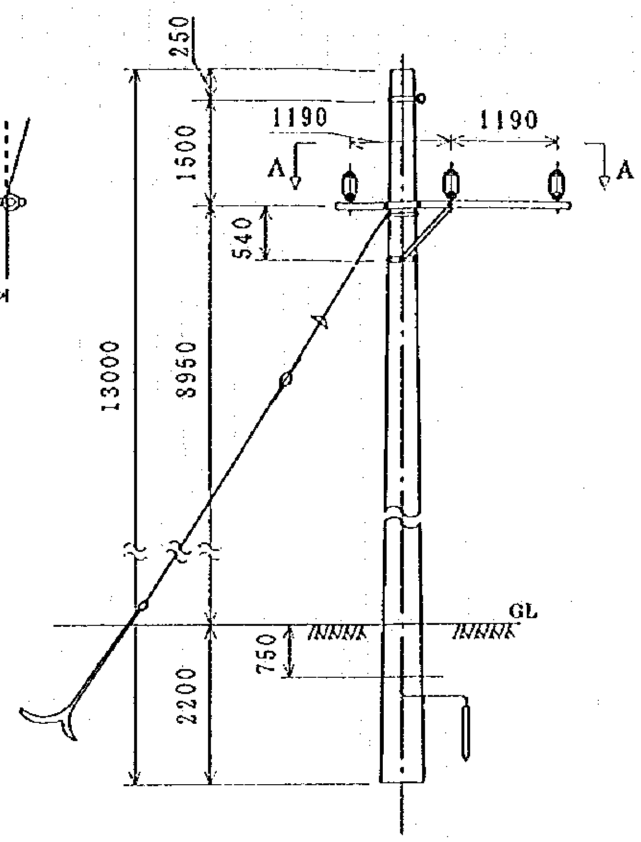
Work Demarcation of Transmission and Distribution Network



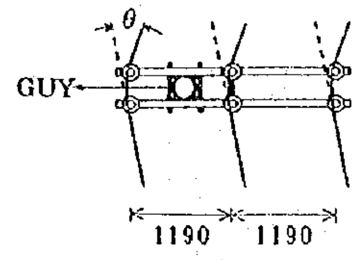
TYPE 3AC 0≦θ<5°



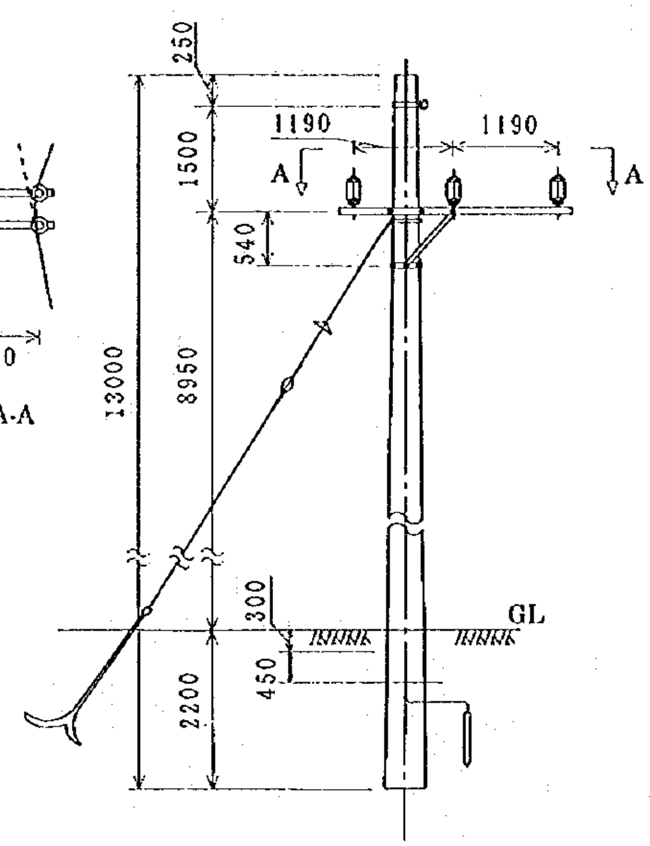
SECTION A-A



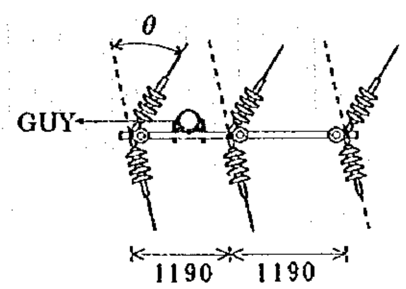
TYPE 3BC 5°≦θ<10°



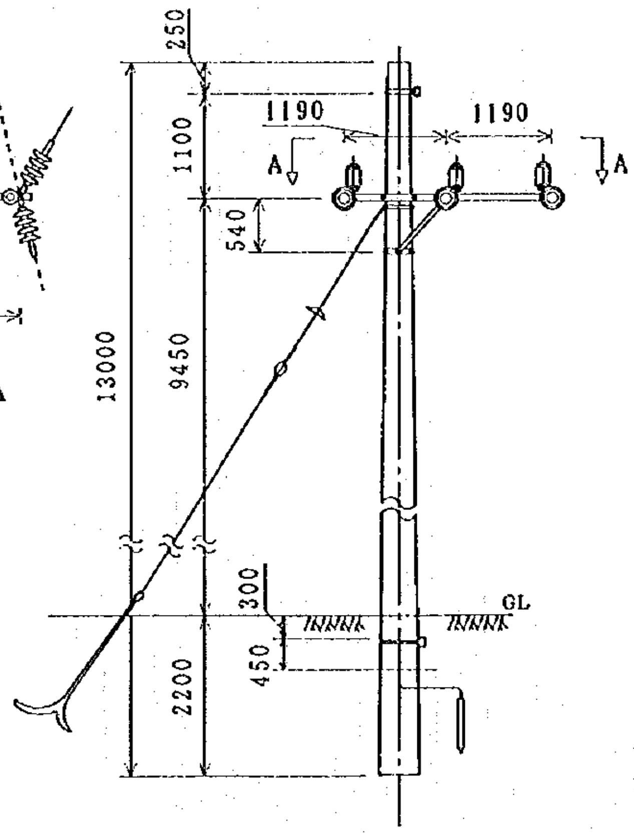
SECTION A-A



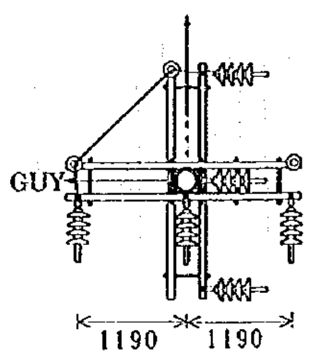
TYPE 3CC 10°≦θ<20°



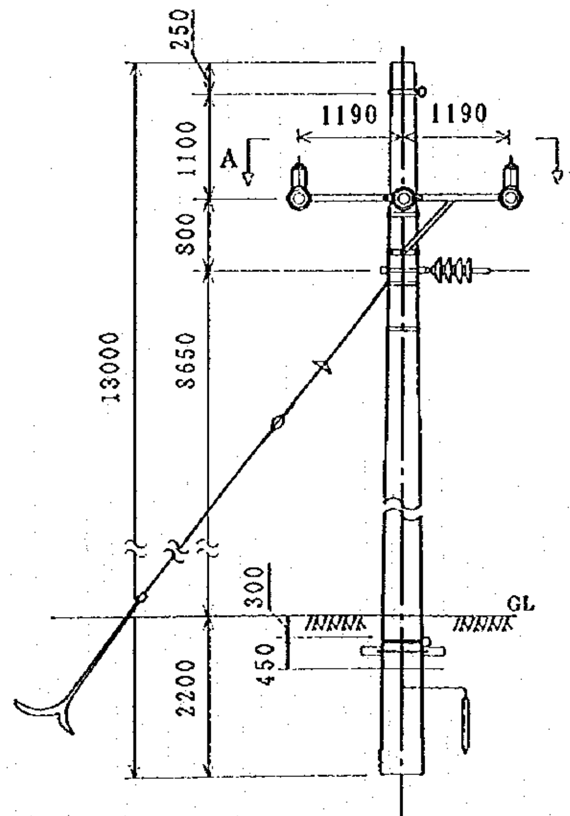
SECTION A-A



TYPE 3DC 20°≦θ<30°



SECTION A-A



TYPE 3EC θ≧30°

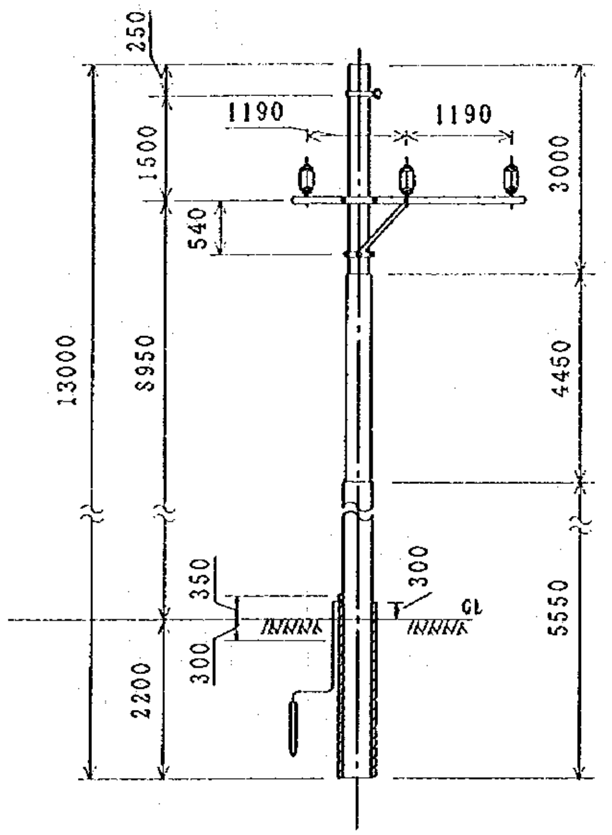
NOTE :

Type 3ST is a dead end pole.

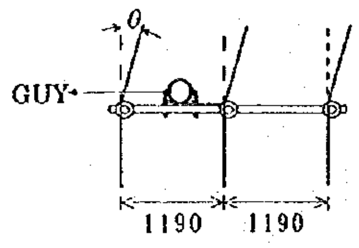
This drawing is only for reference.

BDT−04

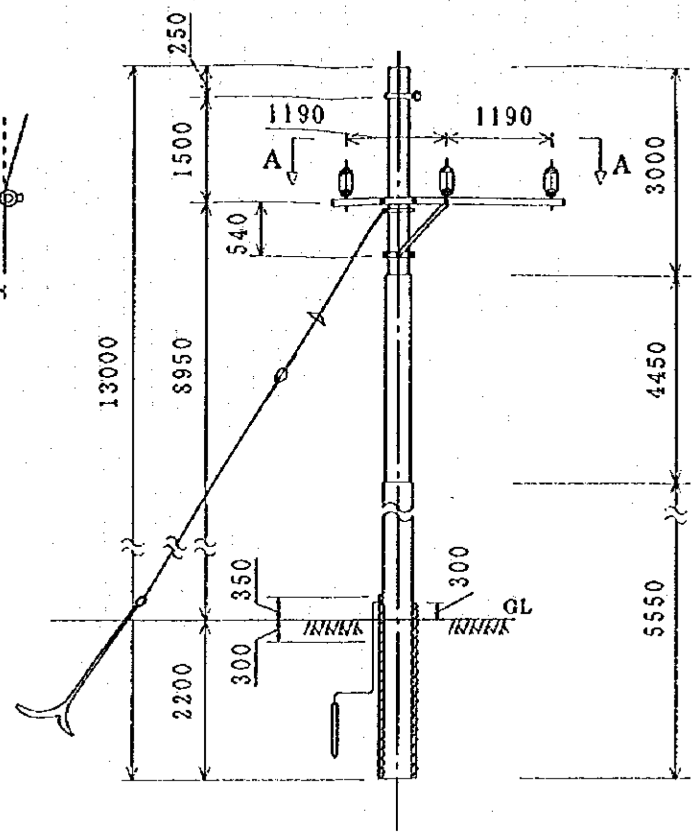
Typical Arrangement for Supporting Structure (34.5 kV Concrete Pole)



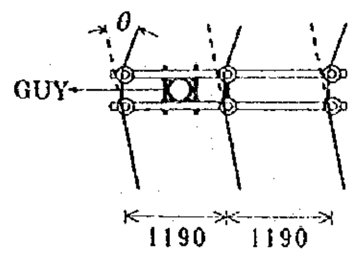
TYPE 3AS 0≦ θ <5°



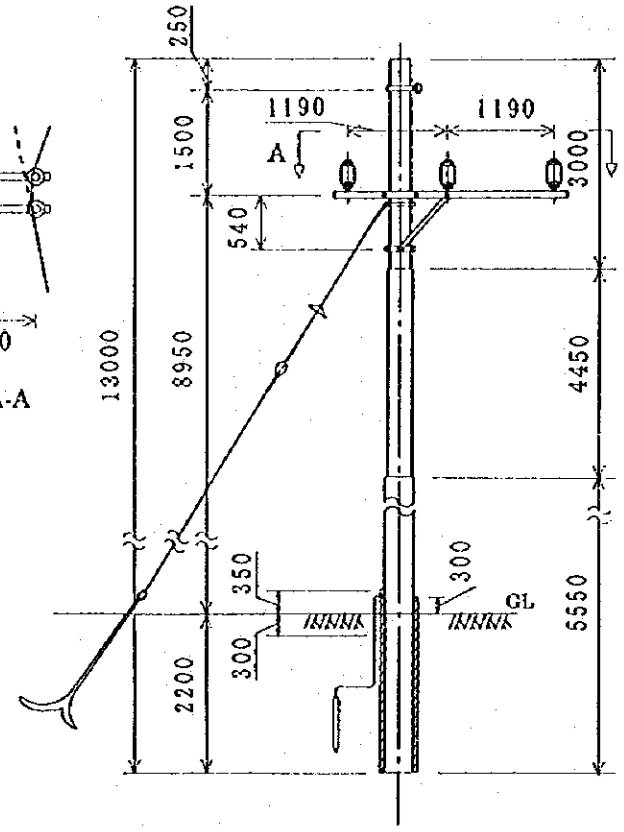
SECTION A-A



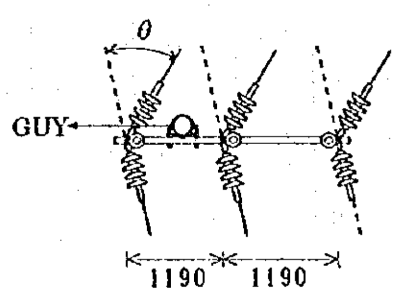
TYPE 3BS 5° ≦ θ <10°



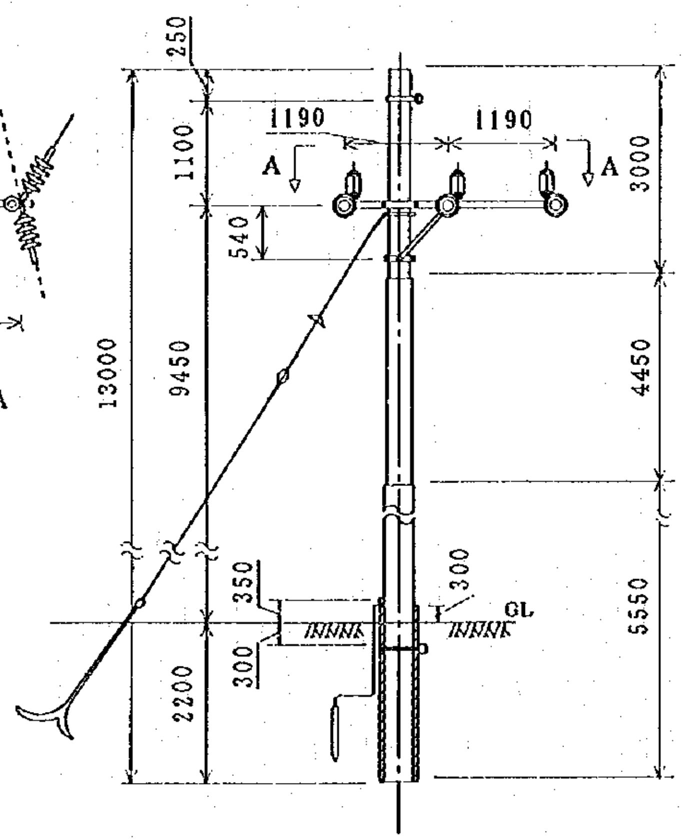
SECTION A-A



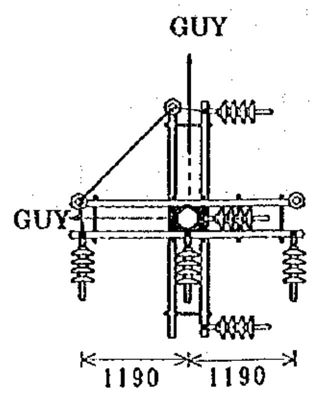
TYPE 3CS 10° ≦ θ <20°



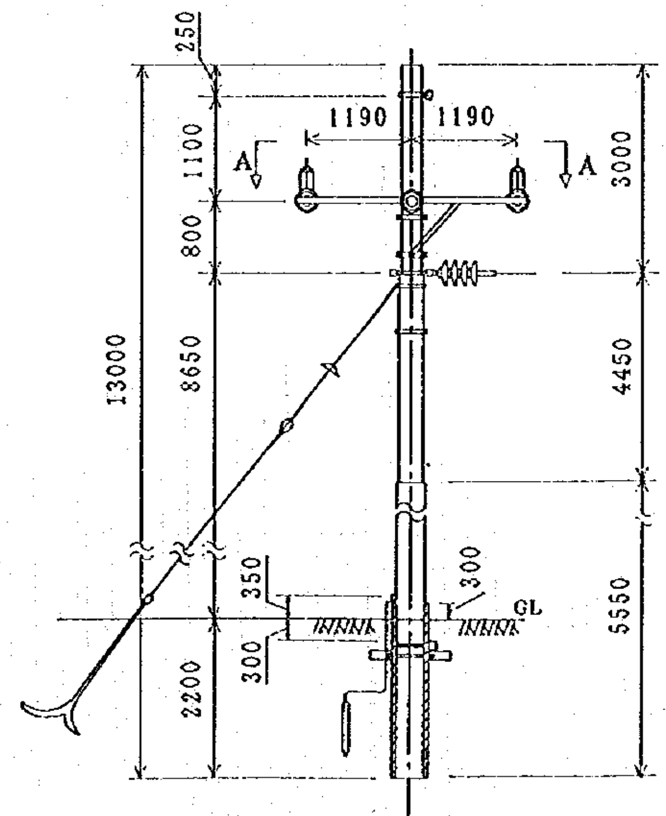
SECTION A-A



TYPE 3DS 20° ≦ θ <30°



SECTION A-A



TYPE 3ES θ ≧30°

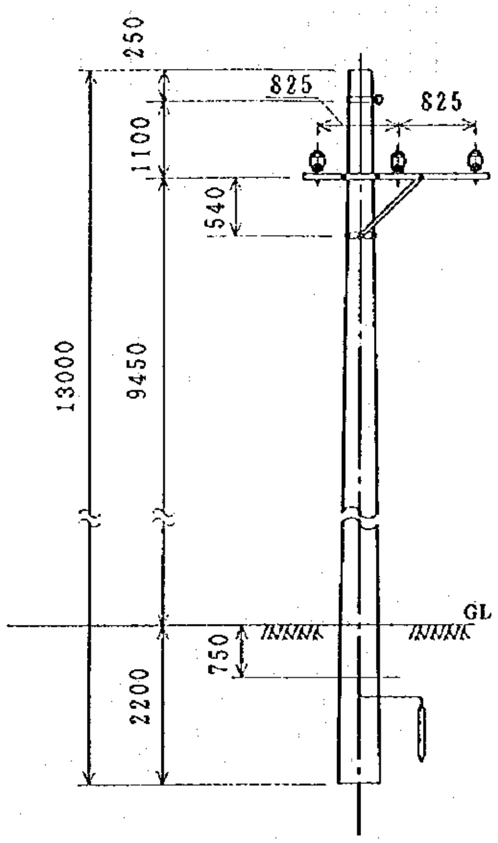
NOTE :

Type 3ST is a dead end pole.

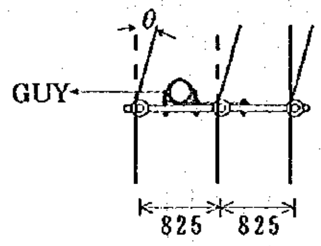
This drawing is only for reference.

BDT−05

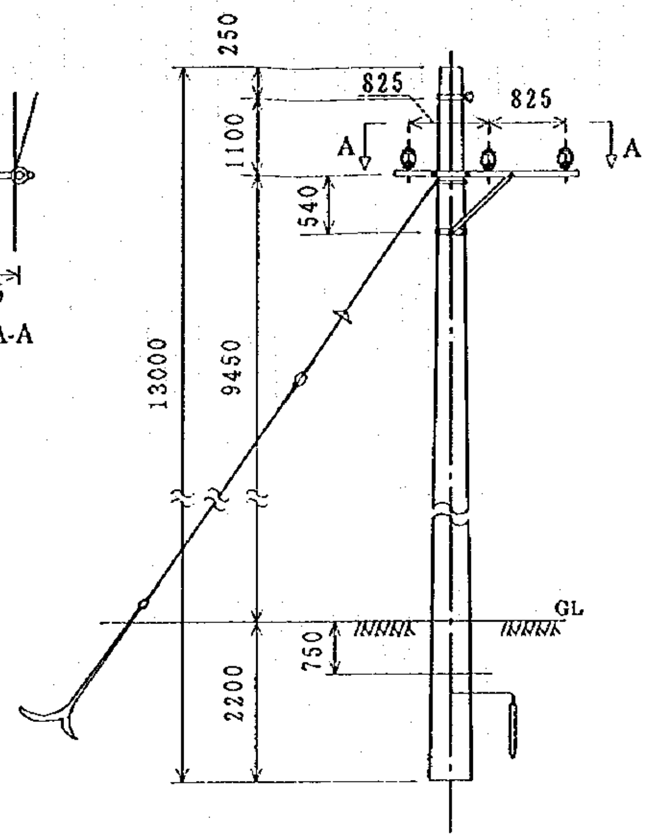
Typical Arrangement for Supporting Structure (34.5 kV Steel Pole)



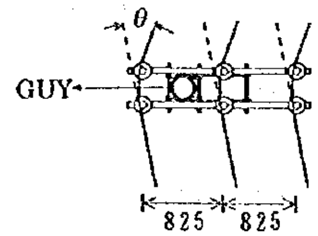
TYPE 1AC 0≦θ<5°



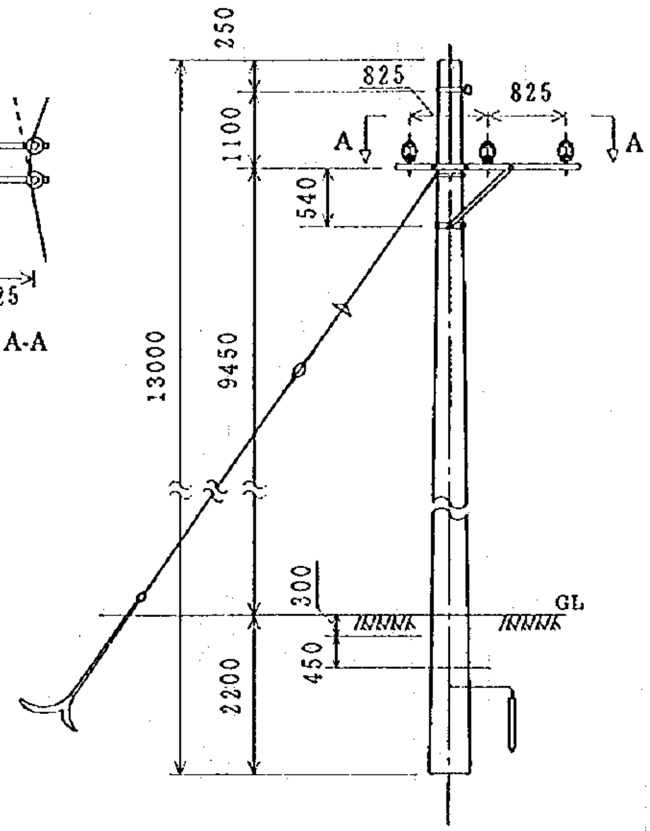
SECTION A-A



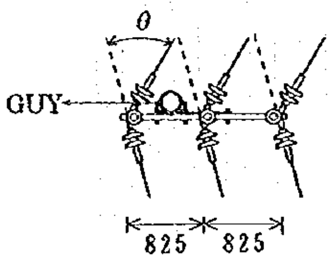
TYPE 1BC 5°≦θ<10°



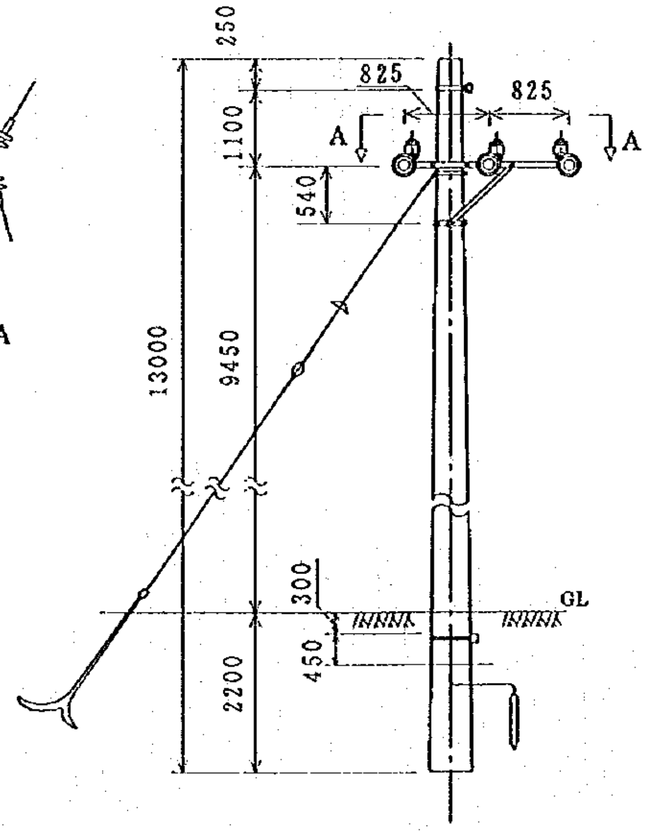
SECTION A-A



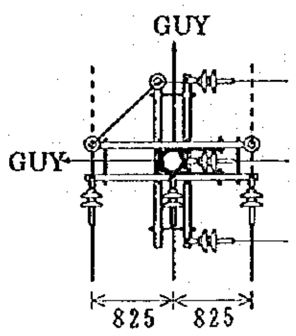
TYPE 1CC 10°≦θ<20°



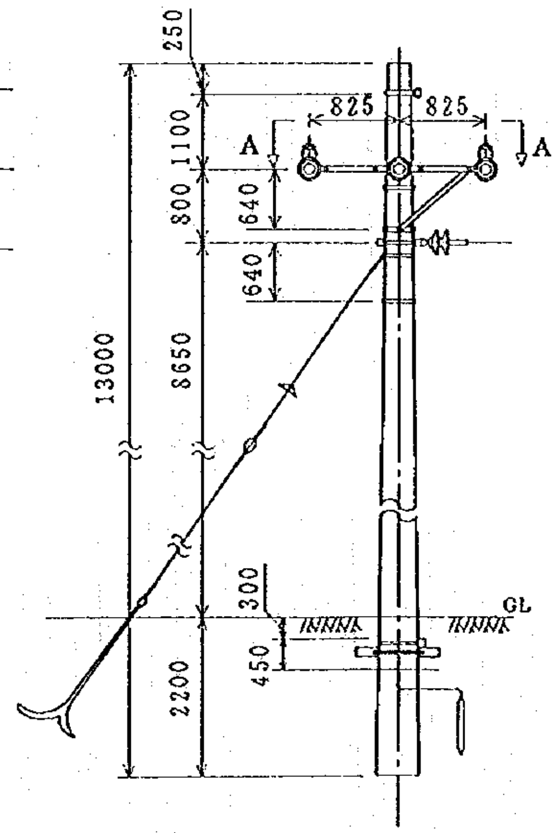
SECTION A-A



TYPE 1DC 20°≦θ<35°



SECTION A-A



TYPE 1EC θ≧35°

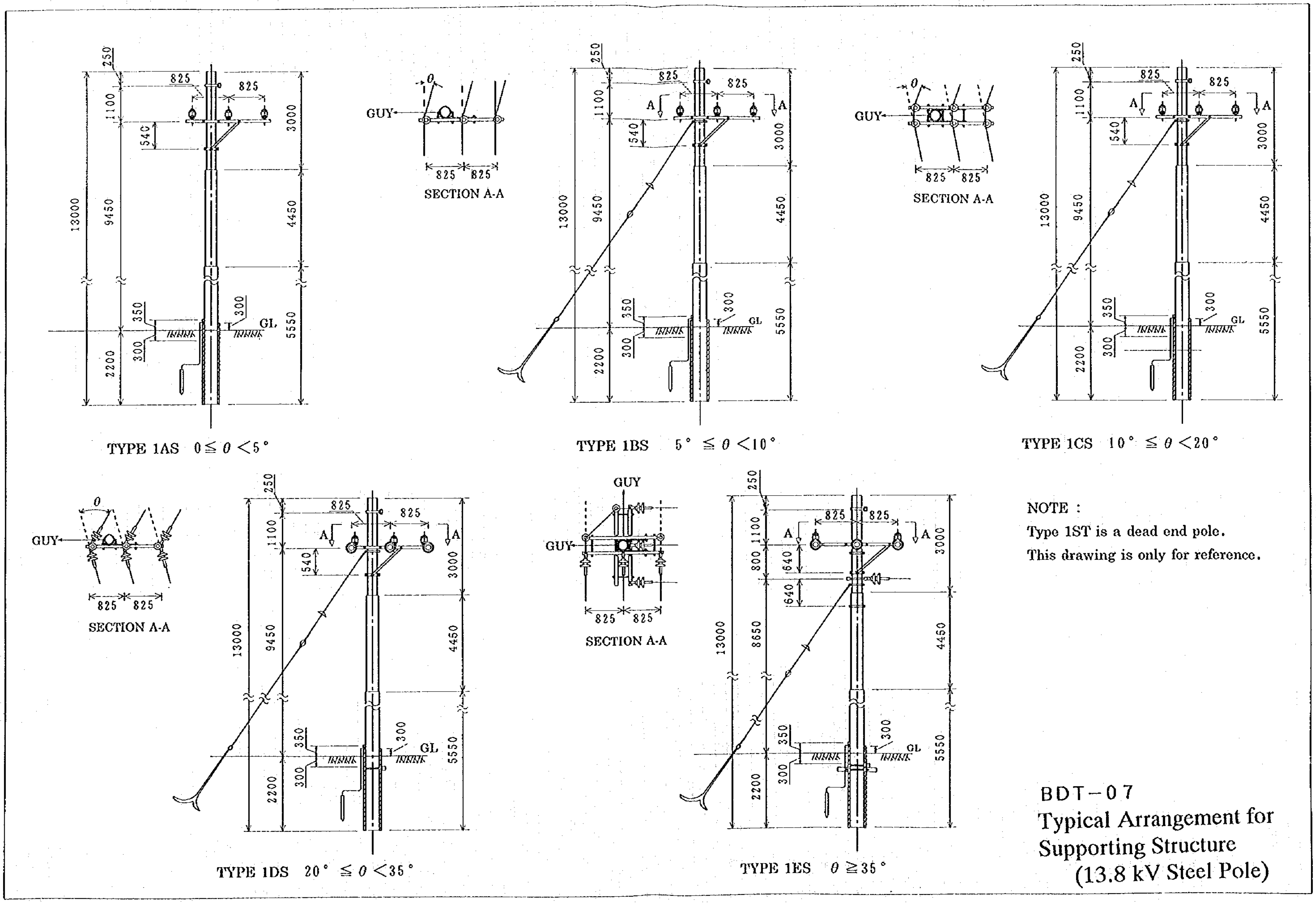
NOTE :

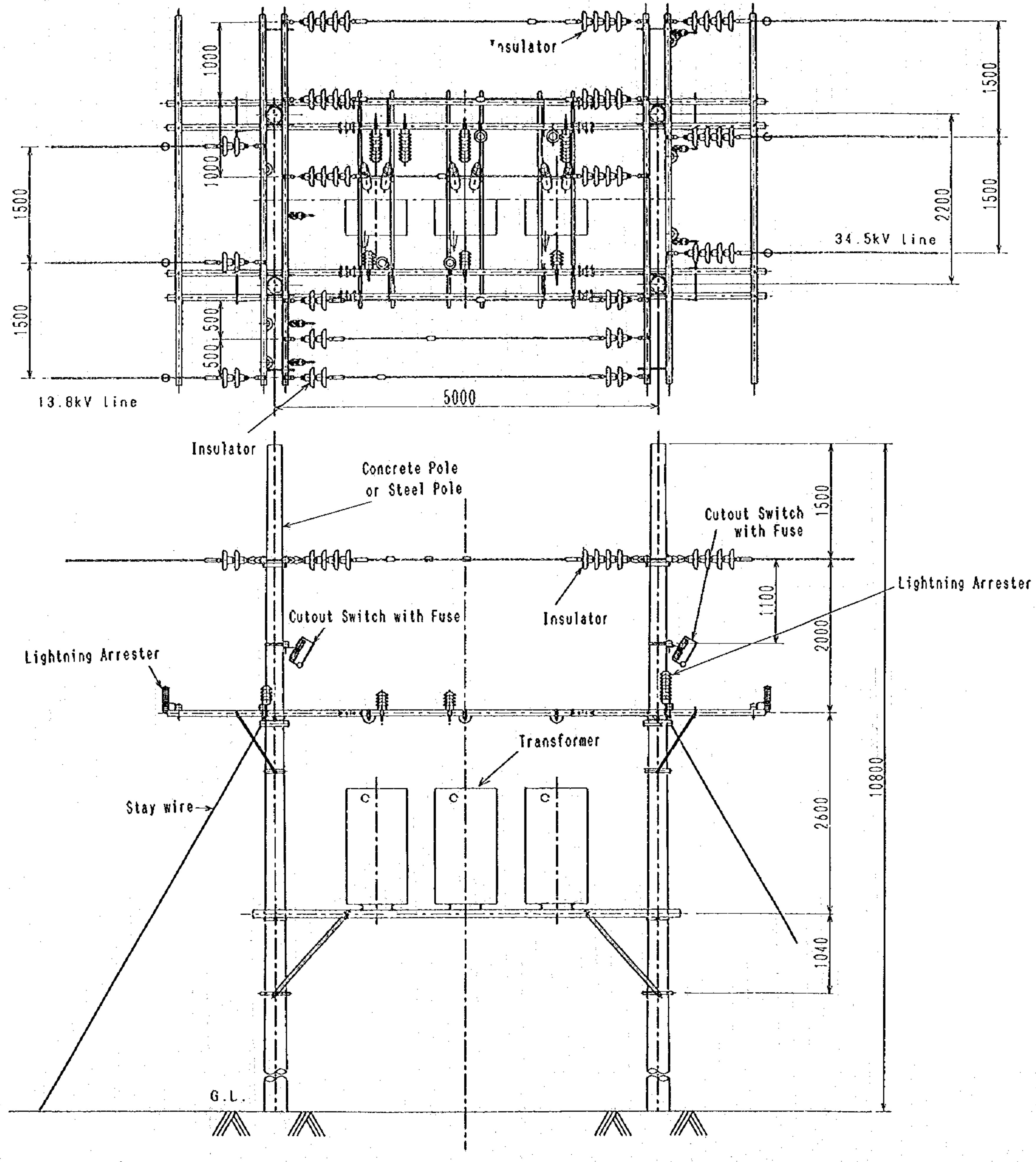
Type 1ST is a dead end pole.

This drawing is only for reference.

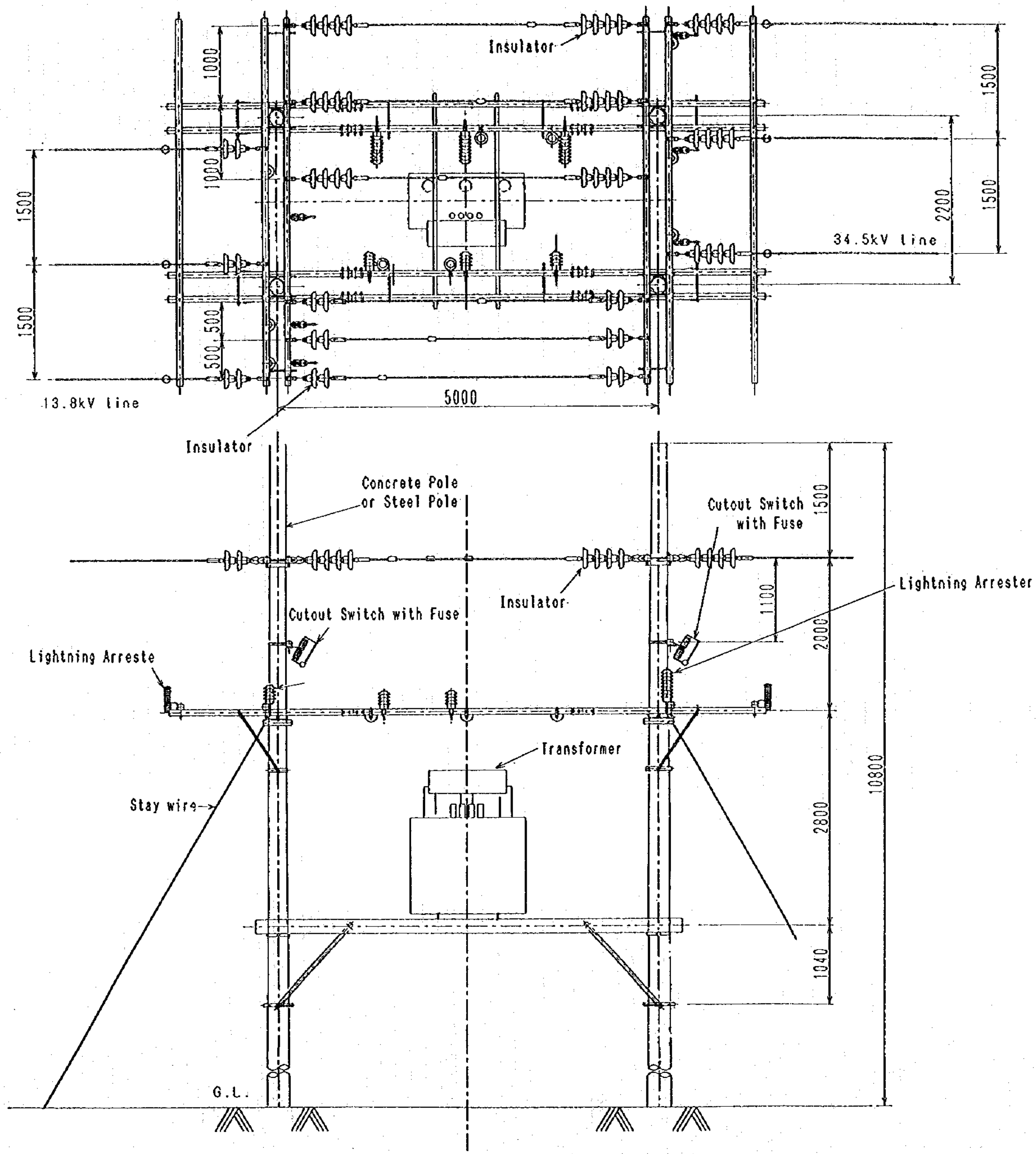
BDT-06

Typical Arrangement for Supporting Structure (13.8 kV Concrete Pole)


GUY
SECTION A-A
TYPE 1AS 0≦θ<5°
TYPE 1BS 5°≦θ<10°
TYPE 1CS 10°≦θ<20°
TYPE 1DS 20°≦θ<35°
TYPE 1ES θ≧35°
GL
NOTE :
Type 1ST is a dead end pole.
This drawing is only for reference.
BDT−07
Typical Arrangement for
Supporting Structure
(13.8 kV Steel Pole)



BDT－08 Arrangement for Ngerdmau and Ngeraard-1 Substations (Single Phase Transformer × 3 units)



BDT－09 Arrangement for Ngeraard-2 Substation (Three Phase Transformer × 1 unit)

CHAPTER 3 IMPLEMENTATION PLAN

CHAPTER 3 IMPLEMENTATION PLAN

3-1 Implementation Plan

3-1-1 Implementation Concept

The Project will be implemented within the framework of the grant aid system of the Government of Japan. Accordingly, the Project will only be implemented after its approval by the Government of Japan and the formal Exchange of Notes between the Government of Japan and the Government of Palau. The basic issues and special points for consideration for the implementation of the Project are described below.

(1) Project Implementation Body

The organization responsible for the implementation of the Project on the Palau side is the Ministry of Resources and Development (MRD) which operates and controls public services, mainly power supply, water supply and sewerage services. Following the completion of construction work under the Project, the Public Utilities Corporation (PUC) will be responsible for the operation and maintenance of the newly constructed facilities and equipment which forms part of such facilities. Consequently, in order to ensure smooth implementation of the Project, the MRD and PUC should have close contact and consultation with the Japanese Consultant and Contractor, both of which will be selected by the Government of Palau in accordance with Japan's grant aid system. For this reason MRD and PUC should select a person to be responsible for the implementation of the Project.

The person selected as the overall project manager will be required to explain the contents of the Project to staff members of the Malakal Power Station and inhabitants of the 4 northern states of Babeldaob Island in order to obtain their cooperation for the Project which will be implemented at the said power station as well as in the said states.

(2) Consultant

In order to construct the planned facilities and to procure the planned equipment under the Project, the Japanese Consultant will conclude a consultancy agreement with the Government of Palau and will conduct the detailed design and supervision of the site work for the Project. The selected Consultant will prepare the tender documents and will execute the prequalification and tender on behalf of the project implementation body.

(3) Contractor

The Contractor, which will be a Japanese corporation selected by the Government of Palau through open tender in accordance with Japan's grant aid system, will conduct the construction of the planned facilities and will procure and install the planned equipment/materials. As it is deemed necessary for the Contractor to provide after-care in terms of the supply of spare parts and the repair of equipment breakdowns in regard to new facilities and equipment, the Contractor must pay proper attention to continual liaison with the PUC.

(4) Dispatch of Japanese Supervisors

The power station construction work under the Project will be very complex in that building work and generating unit installation work will be simultaneously conducted and, therefore, proper coordination between the foundation work and installation work, etc. will be essential. These requirements make the dispatch of a site manager from Japan imperative to provide consistent management and guidance on schedule control, quality control and work safety.

The construction work under the Project will, in fact, consist of various types of work and there are few local skilled workers (technicians) for steel-framing work, air-conditioning work, plumbing work and electrical installation work. Accordingly, the Contractor will be required to dispatch Japanese engineers to supervise the schedule control and quality control, etc. Generating unit installation demands wide-ranging knowledge and high skills on the part of workers for the functions and designs of generating facilities, making it necessary for the generating unit manufacturer to dispatch experts to supervise the installation and test running/adjustment of the generating facilities.

3-1-2 Implementation Conditions

(1) Construction Work in Palau

1) Use of Local Construction Companies and Dispatch of Supervising Engineers

There are approximately 10 construction companies in Koror, most of which are small with 100 - 200 workers and run by American or Korean owners, etc. Most of the engineers and workers employed by these companies are foreigners, mainly from the Philippines (approximately 75%) and Taiwan/China (approximately 10%). Only a few Palauans work in the construction industry. When a large construction project is launched, engineers and workers are recruited for the project. Accordingly, the capability of local construction companies is not high and the use of local companies for the Project will mainly focus on the supply of workers.

Even though the construction work under the Project, i.e. installation of generating units and construction of transmission and distribution lines, is not particularly difficult, engineers and technicians will be dispatched from Japan for making the construction plan, schedule control, quality control and start-up adjustment.

2) Procurement of Construction Machinery

As in the case of engineers referred to above, there are few construction machines in the market in Palau and the leasing cost is quite high. Accordingly, the procurement of vehicles for transporting the construction equipment and materials and pole erection machinery, etc. in Japan or a third country is planned.

In the case of the power line construction work in the 4 northern states of Babeldaob Island, the installation of a small power generating unit at the workers' camp site must be considered due to the absence or shortage of power.

(2) Points to be Noted for Work Plan

1) Power Station Improvement Plan

The equipment and materials for the new generating facilities will be unloaded at Port Malakal, which lacks appropriate unloading facilities for the diesel engines (approx. 50 tons each). Moreover, a low bed trailer for the transportation of the equipment and materials from the port to the construction site cannot be hired in Palau. It will, therefore, be necessary to plan the use of a cargo vessel or barge equipped with a large crane for the transportation of the equipment to Palau and a low bed trailer for inland transportation. As there is no large mobile crane in Palau, it will be necessary to plan to install the heavy equipment on their respective foundations using hydraulic jacks and rollers.

2) Power Line Construction Plan

The monthly rainfall in the 4 northern states of Babeldaob Island where many of the new transmission and distribution lines will be constructed can exceed 800 mm during the rainy season from May to September. As the local roads are unpaved (not even gravel roads but clayey dirt roads), narrow and have many sharp curves and undulations, continuous rain over a few days can make these roads almost impassable, even for 4 wheel-drive vehicles. Accordingly, avoidance of the rainy season if possible for the transportation and delivery of the equipment and materials to the project sites is important. Further consideration is required for the partial use of the built-up steel pipe poles instead of concrete poles to ensure the safety and ease of transportation and construction work. In regard to those construction sites which are far from Koror, the use of a barge to transport the equipment and materials by sea will be necessary.

Given the fact that the new transmission and distribution lines will be constructed along the existing roads, the Government of Palau should complete the construction of the road between Asahi substation to Ngerdmau state, and upgrade the existing earth roads to at least gravel roads, fell obstructing trees and strengthen the existing road bridges, etc. to a level capable of supporting the heavier traffic associated with the construction work under the Project prior to the commencement of the said construction work.

3-1-3 Scope of Works

The scope of work to be undertaken by the Government of Japan and Government of Palau is shown in Table 3-1-1. Of the 8 generating units installed in the existing generator building of the Malakal Power Station, 5 are out of operation due to either breakdown or ageing and their removal is planned by the Government of Palau. As this removal will create space in the existing generator building for the storage of spare parts, expendables, maintenance tools and repair machines to be procured under the Project, no storage space for these items will be planned in the new generator building to be constructed under the Project. The work to repair the existing generator building will be included in the scope of work to be conducted by the Government of Palau together with the demolition of the existing workshop.

Of the work related to the power line construction, construction of the 34.5 kV transmission lines and 13.8 kV trunk distribution lines will be conducted by the Japanese side while the branch 13.8 kV distribution lines to supply power to users in villages, etc. will be constructed by the Palau side with the necessary equipment and materials being procured and supplied by the Japanese side. This has been concluded based on the judgement that relatively well developed roads in the branch line areas will allow the Government of Palau to complete the planned construction work (branch distribution lines) by its own efforts within the project period.

The Government of Palau is also required to procure and install low voltage wires, watthour meters and external lighting facilities, etc. as in the case of the previous project.

Table 3-1-1 Scope of Work

Work Item	Japan	Palau	Remarks
1. Malakal Power Station Improvement Plan			
1.1 Common Items			
(1) Demolition of Existing Workshop Building		O	
(2) Provision and Preparation of New Generator Building Site		O	
(3) Provision and Preparation of Sites for Main Fuel Tank, Radiator and Auxiliary Equipment, etc.		O	
(4) Work Related to Water Supply, Power Supply and Telephone Extension for Construction Work	(after TP)	(upto TP)	TP: Terminal Point
(5) Payment for Water, Power and Telephone Bills for Construction Work	O		
(6) Payment for Test Run Fuel, Lubricating Oil and Water	O		
(7) Payment for Fuel, Lubricating Oil and Water After Connection to the Network		O	After connection to distribution system
(8) Repair of Existing Generator Building		O	Workshop and spare parts storage
(9) Provision of Site for Temporary Facilities (Site office, Stock, Yard, etc. with Free of Charge to the Contractor		O	
1.2 Building Work			
(1) Generator Building	O		
(2) Main Fuel Tank Foundations and Oil Retaining Wall	O		
(3) Generating Unit and Its Foundations	O		Including the foundations of radiators and station service transformer etc.
(4) Equipment and Fuel Delivery Road	O		
(5) Paving of Existing Road (as indicated on drawing)	O		
(6) Cable and Piping Trenches Related to the Project	O		
(7) Independent Toilet Facilities with Septic Tank and Infiltration Tank	O		
(8) Building Services Related to the Project (Lighting, Plumbing, Ventilation and Fire-Fighting, etc.)	O		
(9) External Lighting for Security and Maintenance	O		
1.3 Generating Facilities	O		
(1) Procurement and Installation of Diesel Engine Generators (3.4 MW x 2)	O		
(2) Procurement and Installation of Mechanical Items for (1)	O		
(3) Procurement and Installation of Electrical Items for (2))	O		
(4) Procurement and Installation of Circuit Breaker Panel for Connection with the Transmission Line	O		

Work Item	Japan	Palau	Remarks
(5) Procurement and Installation of Main Fuel Tank and Fuel Service Tank	O		
(6) Procurement and Installation of Earthing Equipment Related to the Project	O		
(7) Procurement of Repair Machines Related to the Project	O	Installation	
(8) Procurement of Testing and Repair Tools Related to the Project	O	Storage	
(9) Procurement of Spare Parts and Consumables Related to the Project	O	Storage	
(10) Provision of OJT	O	Participation	
2. Transmission and Distribution Network Extension Plan for 4 Northern States of Babeldaob Island			
2.1 Common Items			
(1) Construction of Road Between Asahi S/S and Ngerdmau State		O	Incomplete section
(2) Repair of Existing Roads (Gravel Paving and Side Ditch Construction, etc.)		O	
(3) Provision of Land for Pole Installation		O	
(4) Provision of Substation Sites		O	
(5) Felling of Trees Obstructing Poles Installation		O	
(6) Repair of Existing Road Bridges (to make them capable of supporting a load of 10 tons)		O	
(7) Provision of Stock Yard and Free Loan to Japanese Side		O	
(8) Provision of Land for Site Office and Camp and Free Loan to Japanese Side		O	
(9) Application for and Obtaining of Environmental Clearance of EQPB		O	
2.2 Transmission and Distribution Lines			
(1) Procurement and Installation of 34.5 kV Transmission Lines	O		Including poles, insulators, arms and conductors, etc.
(2) Procurement and Installation of 13.8 kV Trunk Distribution Lines	O		Same as above
(3) 13.8 kV Branch Distribution Lines	Procurement and delivery at respective port	Inland transportation and installation	Same as above
(4) Connection to 34.5 kV Line at Asahi S/S and Existing 13.8 kV Power Line in Melekeok State	O		
(5) Procurement and Installation of 34.5/13.8 kV Substations (3 substations)	O		
(6) Pole-Mounted Transformers and Climber Prevention Device	Procurement and installation to trunk distribution lines	Installation to branch distribution lines	
(7) Procurement and Installation of Low Voltage (240/120 V) Distribution Lines		O	
(8) Procurement and Installation of Watthour Meters for Users		O	
(9) Procurement and Installation of Street Lighting, etc.		O	

3-1-4 Consultant Supervision

The Consultant will organize the project team in accordance with Japan's grant aid system and the concept and principles of the basic design in order to smoothly proceed with the implementation of the Project. The Consultant will also appoint at least one full-time on-site engineer to supervise schedule control, quality control and safety control and will dispatch other expert engineers in accordance with the progress of the installation, test running and adjustment and delivery testing, etc. to supervise the work conducted by the Contractor. Furthermore, the Consultant will arrange for Japanese experts to attend the inspection of equipment manufactured in Japan or a third country at the manufacturing and pre-delivery stages to prevent the equipment from having possible troubles after delivery to Palau.

(1) Supervision Principles

The Consultant will supervise the work progress to ensure punctual completion within the planned period and will supervise and guide the Contractor in order to achieve the work quality indicated in the contract without any trouble at site. The main points to be noted for the supervisory work are described below.

1) Schedule Control

The Consultant will make weekly and monthly comparisons between the actual work progress and the contract schedule submitted by the Contractor at the time of signing the contract in terms of the following items. If the Consultant foresees any delay of the work, he will issue a warning to the Contractor, requesting that the latter submit a remedial plan in view of completion of the work within the planned work period.

① Quantity of work conducted

② Quantity of equipment and materials delivered

③ Work efficiency and actual number of engineers, technicians and workers

2) Quality Control

The Consultant will supervise the Contractor in the following so as to adhere to the quality of the facilities and equipment indicated in the contract documents (technical specifications and detailed design drawings, etc.) If the Consultant deems that the quality does not meet the requirements, he will demand that the Contractor should correct, change or modify the situation.

① Checking of shop drawings and specifications for equipment

② Checking of factory inspection results for equipment or attendance at shop inspection

③ Checking of installation manual, site operation, Inspection and test manuals and working drawings for equipment

④ Supervision of site installation of equipment and attendance at test running and inspection

⑤ Checking of building working drawings

⑥ Comparison between building working drawings and completed work

3) Safety Control

The Consultant will discuss and cooperate with the representative of the Contractor with a view to supervising the on-site construction and installation work to prevent any accidents to workers with due attention paid to the following safety control principles.

① Establishment of safety control rules and selection of a person responsible for work safety

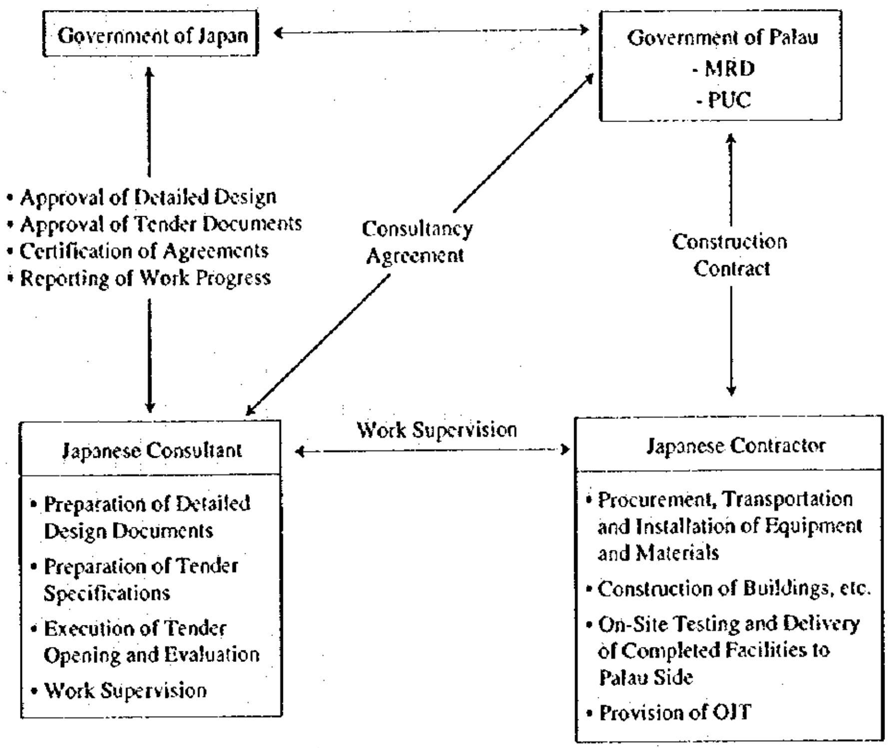
② Prevention of accidents to workers by means of periodical inspection of the construction machinery

③ Introduction of travelling routes for work vehicles and construction machinery, etc. and thorough enforcement of slow driving on the site

④ Enforcement of welfare measures and day-offs for workers

(2) Project Implementation Regime

The project implementation regime is shown in Fig. 3-1-1.



Note: The consultancy agreement and construction contract must be verified by the Government of Japan.

Fig. 3-1-1 Project Implementation Regime

(3) Work Supervisors

The Contractor will employ a local construction company or a construction company of a third country as a subcontractor to conduct the construction and installation work in accordance with the construction contract. It will be necessary for the Contractor to dispatch engineers with experience of similar work abroad to Palau to supervise the subcontractor with a view to ensuring the strict enforcement of schedule control, quality control and safety control by the subcontractor.

Given the size and contents of the Project, the Contractor's appointment of at least the following full-time on-site engineers is preferable.

- Site Office Manager (1) : general management of on-site work and in charge of OJT
- Generating Engineer (1) : instruction on and schedule control of generating unit installation work
- Power Transmission and Distribution Engineer (1) : instruction on and schedule control of power grid installation work

In addition to the above, the dispatch of engineers will be required in accordance with the progress of the work. These engineers will include, equipment installation supervisor and commissioning test engineer.

3-1-5 Procurement Plan

The equipment and materials for building construction, generating equipment and transmission/distribution equipment and related materials to be used under the Project are not manufactured in Palau. Although some imported construction equipment and materials from Japan and the US, etc. are available locally, it will be extremely difficult to secure the required quantities of the steel frames, external wall materials and building service materials for the generator building let alone the generating units and power grid equipment and materials in the local market in view of the size, contents and design specifications of the Project. Accordingly, the equipment and materials used for the Project will be procured in the following manner.

(1) Construction Materials, to be Procured in Palau

Ready-mixed concrete, Cement, Sand, Aggregates for concrete, Concrete blocks, Reinforcing bars, Timber, Paint, Plywood, Nails, Petrol, Diesel oil, Small vehicles, Mobile crane (15 - 20 tons), other materials for temporary structures

(2) Equipment and Materials, to be Procured in Japan

1) Construction Equipment and Materials

Building materials such as roofing and wall materials, etc. and building facilities such as air-conditioning equipment, etc.

2) Equipment and Materials for Generating Facility

Diesel engine generating facility, Auxiliary equipment, Electrical equipment, Fuel piping materials, Cables, etc.

3) Transmission and Distribution Facility

Distribution materials such as electrical poles, conductors, insulators, etc., and substation equipment such as distribution transformer, cutout switch, etc.

(3) Equipment and Materials to be Procured in Third Country

The possibility of procuring materials, etc. for the Project from a third country was examined at the field survey stage, at the subsequent analysis stage in Japan and at the project cost estimation stage. However, the procurement of materials, etc. for the Project from a third country was decided against due to the following reasons.

1) Equipment and Materials for Generating Facility

① US Products

There is a tendency among US generating facility manufacturers not to manufacture medium-speed diesel engine generators (continuous rating at 720 rpm or less) which are required for the Project. Instead, they mainly manufacture high-speed (1,000 - 1,500 rpm) generators with short-time rating. One manufacturer indicates the availability of medium-speed engines in its catalogue but has not produced many such engines. This manufacturer may accept an order but would require to start from the design stage for a new order. Given the fact that the required engine generators are not part of its standard manufacturing line, it will be extremely difficult for this manufacturer to deliver, install, test and adjust the units within the time-scale of Japan's grant aid system and to hand them over to the Palau side. Even if this US manufacturer could meet the delivery deadline, spare parts and expendables would have to be specially made as in the case of the generating units themselves. This could mean a long wait for the delivery of such items after commissioning of the new generating units and the operation of the generating units could be hampered due to such a lengthy delivery time and the possibly high price of spare parts, etc.

② European Products

There are several manufacturers in Europe which manufacture generating units which meet the specifications adopted for the Project. In fact, the generating units of the existing Aimeliik Power Plant were made in the UK. However, Europe is geographically quite far from Palau and the long delivery time (estimated to be double the delivery time from the US) means that it would be difficult for any manufacturer to deliver and conduct the final handing over within the time-frame of Japan's grant aid system. Moreover, the actual delivery records of spare parts and expendables to the Aimeliik Power Station from the UK show that it usually takes approximately 6 months for delivery to be made after order placement, making the PUC struggle to maintain the plant operation schedule.

Based on the above analysis results, the generating units, auxiliary equipment and electrical equipment, etc. required for the Project will be procured in Japan.

2) Equipment and Materials for Transmission and Distribution Network

① Procurement in Guam

The concrete poles commonly used in Guam are octangular reinforced concrete poles. Compared to Japanese prestressed concrete poles, those in Guam are 1.5 to 2 times larger in diameter and 3 to 4.5 times heavier. Due to the mountainous or hilly topographical nature of the 4 northern states of Babeldaob Island and the unpaved roads with many undulations and curves, it will be quite difficult to transport the concrete poles made in Guam to the construction sites. These poles are also not recommended from the viewpoint of work safety and workability. Built-up steel pipe poles are unavailable in Guam and it will be difficult to arrange their procurement there. The stock levels of cables, wires and insulators, etc. in Guam are low due to the small scale of power network construction work. The procurement of these items may be possible from the US via agents in Guam but the long transportation distance from the US is considered a disadvantage in terms of the prompt delivery and after service of the procured equipment, etc.

② Procurement in Singapore

As the distribution lines in Singapore are mainly buried underground, concrete poles, etc. are not locally produced. The same applies to built-up steel pipe poles. While cables, wires, insulators and accessories are produced locally, the specifications are based on British standards. Consequently, these products cannot be used for the power network in Palau which is constructed in accordance with US and Japanese standards. Similarly, substation equipment is produced to meet British standards and will, therefore, be incompatible with the existing equipment in Palau which was provided under the previous grant aid project.

③ Procurement in Philippines

The Philippines is not very far from Palau and produces a wide range of industrial products. While it was previously thought feasible to procure cables, and wires etc. from the Philippines, it was found that the product ranges of cable and wire manufacturers in the Philippines do not include electric wires which are suitable for the Project. Similarly, no distributing concrete poles or built-up steel pipe poles to meet the specifications set by the Project are produced in the Philippines.

Based on the above analysis results, Japanese equipment and materials for the transmission and distribution lines will be procured and their specifications will be the same as those under the previous grant aid project with which Palauan engineers are familiar.

3-1-6 Implementation Schedule

Following approval of the implementation of the Project by the Government of Japan, the E/N will be signed by the two governments to commence the actual implementation process of the Project. The construction work under the Project will largely consist of 3 stages, i.e. ① detailed design and preparation of the tender documents, ② tender and signing of the construction contract and ③ building construction, and procurement and installation of equipment and materials.

The Project has 2 components, i.e. improvement of the existing power station and the electrification of non-electrified areas, and will be implemented in the following 2 phases in view of the work size, contents and urgency of each component. Fig. 3-1-2 shows the project implementation schedule.

Phase		Work
I		1. Malakal Power Station Improvement Plan (1) Construction of generator building, etc. (2) Installation of two generator units (3.4 MW) with main fuel oil tank, auxiliary equipment and electrical equipment
II	First Stage	1. Transmission and Distribution Line Extension Plan (1) Construction of transmission lines (34.5 kV): procurement and installation of equipment and materials (2) Construction of trunk distribution lines (13.8 kV): procurement of equipment and materials only (3) Procurement of branch distribution lines (13.8 kV): procurement of materials only
	Second Stage	1. Transmission and Distribution Line Extension Plan (1) Construction of trunk distribution lines (13.8 kV): installation work only (2) Construction of substations: installation work only

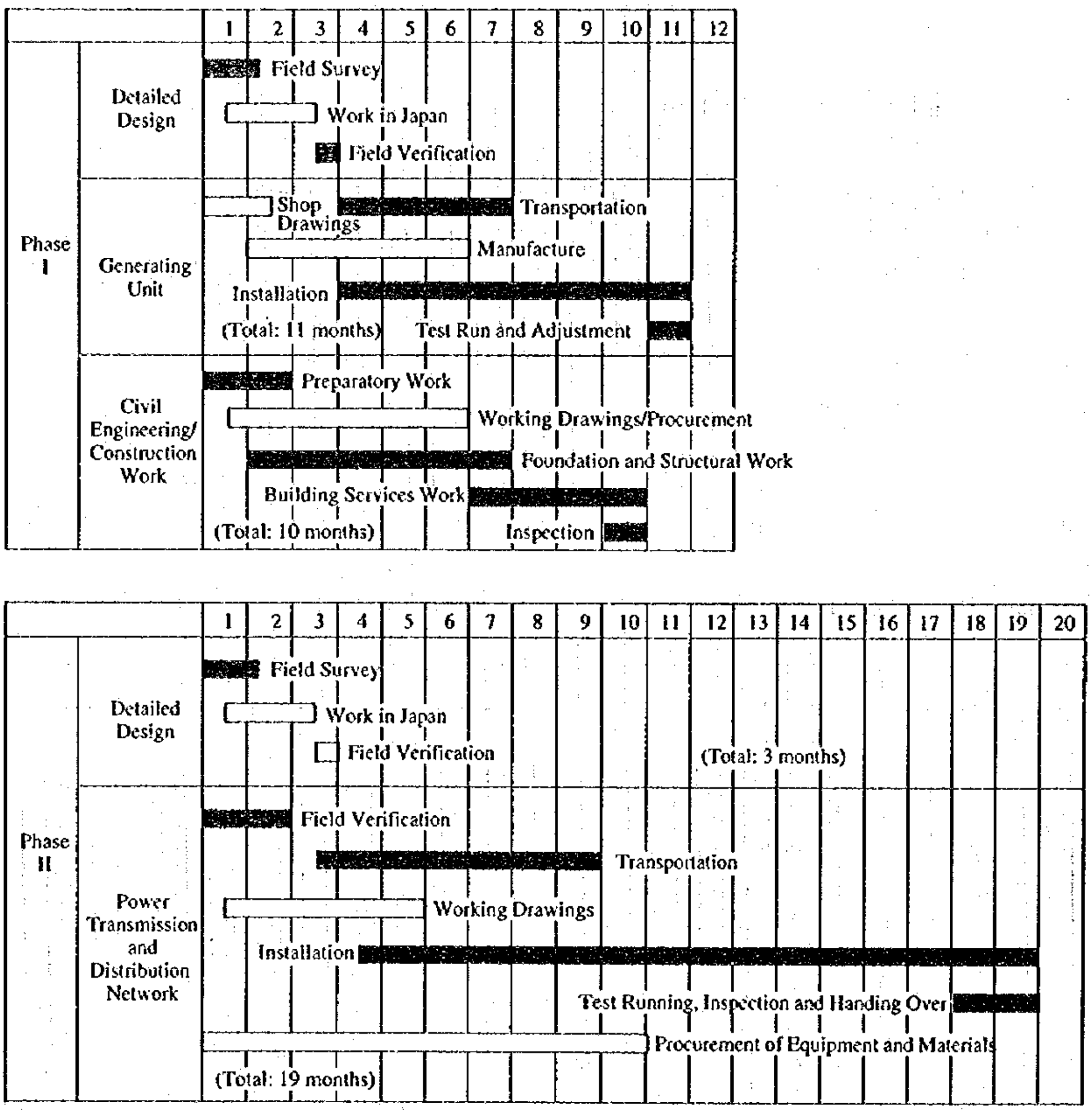


Fig. 3-1-2 Project Implementation Schedule

3-1-7 Obligations of Recipient Country

The Government of Palau has the obligation to provide and conduct the following items regarding the implementation of the Project.

(1) To Provide necessary data and information for the Project.

(2) To ensure speedy unloading and customs clearance of the goods for the Project at port and/or airport of disembarkation in the Republic of Palau.

(3) To accord Japanese nationals whose services may be required in connection with the supply of products and services under the verified contract(s) such facilities as may be necessary for their entry into the Republic of Palau and stay therein for the performance of their work.

(4) To exempt Japanese nationals from custom duties, internal taxes and other fiscal levies which may be imposed in the Republic of Palau with respect to the supply of the products and services under the verified Contracts. And to take necessary measures for such tax exemption.

(5) To bear commissions to the Japanese foreign exchange bank for the banking services based upon the banking arrangement.

(6) To bear all the expenses other than those to be borne by the Grant Aid necessary for the execution of the Project.

(7) To assign exclusive counterpart engineers and technicians to the Project in order to transfer the operation and maintenance technique for the Project and to witness and confirm construction works and qualities of equipment and materials when inspection is carried out.

(8) To use and maintain properly and effectively all the facilities constructed and equipment and materials purchased under the Japan's Grant Aid.

(9) To secure and provide cleared, embanked, leveled land and access road for Malakal power plant as well as the securing of roads and the cutting of trees necessary for the construction of power transmission and distribution lines, prior to the commencement of the construction for the Project.

(10) To construct incidental outdoor facilities, boundary fence and entrance gate at Malakal power plant by the completion of the construction for the Project.