CHAPTER 3 OUTLINE OF THE PROJECT AREA

CHAPTER 3 OUTLINE OF THE PROJECT AREA

3-1 Location and General Condition of the Area

3-1-1 Location of Project Area

As the chart at the beginning of this report shows, Kingtom Power Station as the project site is situated along the coast about 2 km to the west of the center of Freetown city. Its altitude is about 5 m above sea level.

3-1-2 Present Status of Kingtom Power Station

Basic design drawing SLB-01 (see 5-3-2-(2)) shows facilities and equipment layout at Kingtom Power Station.

(1) Control Status of Operation and Maintenance

This power station was built in a considerably small plot of land as is noted from the number and size of its facilities. Much oil leakage was observed from the fuel supply pipe and leaked oil was spread over an extensive area. Particularly, the pump room and basement room were stained with oil, making normal maintenance control difficult.

As for the status of operation of the generating facilities, 2 sets of SULZER diesel generating facilities are operated only to about 50% of their installed capacity as described in detail later (see 3-4). These 2 diesel generating sets are operated without satisfactory maintenance and inspection. This is because there is no time for periodical maintenance due to the chronic shortage of power in the greater Freetown area. Moreover, spare parts are in short supply due to lack of funds. Since the generating facilities must be operated in such poor maintenance condition, it is a frequent occurrence that both generating sets develop trouble and stop operation simultaneously. Table 3-1 shows the record of the number of power failures at the power station. Table 3-2 shows the average length of power failures.

NPA is making plans to implement a periodical maintenance and inspection plan in an attempt to improve this situation. However, the plan has not been implemented as intended due to lack of funds and an acute shortage of power supply. Table 3-3 shows NPA's periodical maintenance and inspection plan (draft).

Table 3-1 Record of Number of Power Failures at Kingtom Power Station

(Unit: No. of times)

	1985	1986	1987	1988	1989
January	22	23	13	13	17
February	41	30	12	18	16
March	45	22	18	27	21
April	38	14	20	40	16
May	38	11	7	25	21
June	38	10	14	14	39
July	34	14	24	20	23
August	29	16	35	5	37
September	57	2	30	8	54
October	87	7	25	12	37
November	18	1	21	21	-
December	36	5	14	21	-
Total	483	155	233	224	*281 (Total until Oct.)

Source: NPA

Table 3-2 Average Length of Power Failures at Kingtom Power Station (min/time)

Year	1987	1988	1989
Ave. failure time	22 min	25 min	30 min

Source: NPA

Table 3-3 Periodical Maintenance & Inspection Plan (draft)

Generating facilities	Overhaul	Periodical inspection
No.4 (Sulzer)	1.5 month/year	0.5 month/year
No.5 (Sulzer)	1.5 month/year	0.5 month/year
No.6 (KHD)	0.75 month/year	0.5 month/year
No.7 (KHD)	0.75 month/year	0.5 month/year
No.8 (KHD)	0.75 month/year	0.5 month/year
No.9 (KHD)	0.75 month/year	0.5 month/year

Source: NPA

Notes:

1) The above shows the duration of time per year for which the generating set will be shut down for overhaul or scheduled inspection and repair.

2) This plan has not been implemented yet because of acute power shortage situation in the greater Freetown area.

(2) Present Status of Existing Facilities

EDF Report shown in Table 3-2 describes the present status of the existing facilities generally as follows.

1) SULZER UNITS (DEG No.4 - 5)

(a) Sulzer engines

These units were commissioned respectively in 1979 and 1980. The two units have been in operation for approximately 50,000 hours, i.e., less than half of their service lifetime.

However, these engines are in a very bad working condition due to the lack of preventive maintenance for many years. They are now kept in constant operation to maintain energy supply, thereby increasing the risk of major breakdown.

At present, output is limited to 50% of nominal output due mainly to a deterioration of turbochargers and insufficient cooling. Operation parameters, and especially exhaust gas temperatures are outside reference conditions. Fuel is not heated at the nominal 120°C because of steam system failure.

The water treatment system does not work any more, causing extreme fouling of the cooling subsystem.

Those very bad combustion conditions combined with a low output level leads to excessive fuel consumption. Poor maintenance has caused substantial deterioration and leakage of oil, water and exhaust gas in the powerhouse, causing an extreme soiling of the whole equipment and foundations.

(b) Mechanical auxiliary systems

The mechanical auxiliary systems are also in poor condition and do not allow the engines to work properly, especially with regard to fuel heating, cooling system, oil treatment and control system.

(c) Electrical auxiliary systems

The control section is faulty or out of operation. The AC system is completely out of service. The cable system is in operational condition but the lighting system is faulty and inadequate.

2) MAN UNITS (DEG No.1 - 3)

(a) Generators

All 3 units of Diesel engine generators are stopped at the present time. The No. 1 unit was stopped in 1985 after 70,000 hours of operation. Its engine was removed, and there are also plans to remove also the generator.

The No. 2 unit and the No. 3 unit are in better state comparing with the No. 1 unit, and as a fact the No. 2 unit was started again in 1988 but both units are stopped at the present time due to the lack of preventive maintenance and shortage of spare parts. Moreover, all 3 units have defects in their foundation, and it is presumed to be quite difficult to resume the operation even after carrying out the restoration work. Under the circumstances, the NPA is planning to remove the existing units and substitute them with new equipment with aid of the EEC and other sources.

(b) Mechanical auxiliary systems

Heat exchangers are leaking and need repair. All flange connections are leaking, and insulation is completely destroyed.

The cooling system has been modified as explained for Sulzer units.

(c) Electrical auxiliary system

All the electrical auxiliaries are in extremely bad condition. Repairs have been performed in a very bad manner. Most fuses are jumpered which means loss of protection for cables, boards and consumes. Lack of maintenance causes a lot of damage on electrical equipment. Electrical auxiliary system will be simplified to minimize maintenance.

3) KHD STANDBY SETS (DEG No.6 - 9)

(a) Generators

The four KHD Standby generators were commissioned in 1986.

However, many failures such as crankshaft damages, etc., have occurred during the last two years.

The reasons for the defects could be a high contamination, or a chemical incompatibility of the heavy fuel oil (HFO) and an insufficient purification, or a chemical incompatibility of the HFO and the lube oil.

In December 1989, all four sets were out of service due to maintenance work financed by NPA. They were planned to re-start their operation at the end of 1989.

The electrical part is still in very good condition and does not need repair. Maintenance has to be performed according to the manufacturer's instructions.

b) Mechanical and electrical auxiliary system

They are still in good condition but several modifications have to be carried out to improve engine operation and reliability.

4) COMMON SYSTEMS

(a) Common mechanical systems

① Cooling water system

The seawater is pumped from the Sierra Leone River at the pumphouse. Four newly installed pumps provide water for the heat exchange plant. The cooled water is distributed to the different coolers of MAN and SULZER engines. The rehabilitation works should be carried out so that the total shutdown periods of the engines are reduced to a minimum.

Part of the system has been renewed by Alfa Laval.

② Heavy fuel oil system

The HFO is supplied by barges to the pumphouse. A transfer pipe leads to each of the two storage tanks. Many leakages can be observed along the pipe lines.

③ Diesel oil system

The diesel oil system is in bad condition. Pumps have to be overhauled. Piping shows many leakages. A complete overhaul of valves, cocks, gaskets, etc. is necessary.

④ Steam and condensate system

The boiler is in very poor condition. The output of the steam production is insufficient.

⑤ Municipal water and water treatment

Two water storage tanks for city water are in quite good condition. Their tanks are also utilized for the fire fighting system.

⑥ Fire fighting system

The diesel driven fire pump for the fire fighting to the power station building is not operated at all due to high oil contamination.

(b) Common electrical system

11 kV switchgears are in an unsafe and unreliable condition due to:

- Non performance of cleaning and maintenance and frequent switching due to network and station failures,

- Non availability of spares and consumables.

Moreover, a neutral earthing system will be required for modification.

3-2 Natural Conditions

3-2-1 Climate

The temperature remains nearly unchanged at about 27°C throughout the year. During the dry season from October to May, the average monthly rainfall is less than 100 mm. During the rainy season from June to September, the average monthly rainfall reaches as high as about 800 mm.

3-2-2 Sand Storms

Sand storms called Harmattan occur during the period from November to March.

3-3 Social Condition (Environment)

3-3-1 Port

The nation's largest port of Queen Elizabeth II should be used for unloading machinery, equipment and materials to be shipped from Japan. Although large vessels can berth at this port, there are no cargo handling facilities that can unload heavy equipment. Therefore, vessels equipped with cranes must be used for unloading heavy equipment of the project such as the diesel engine.

3-3-2 Road

Road conditions are poor. Both roads in the city and main roads are paved but due to poor maintenance there are potholes everywhere, which seriously hinder traffic.

There is one bridge (Kingtom Bridge) in the inland transport route from the Queen Elizabeth II Port to the project site. It is considered that this bridge presents no problem to the transport of Project equipment.

3-3-3 Telecommunications

Although telephone and telex communication facilities are available, the local communication condition is very poor. Particularly, instantaneous international communications are extremely difficult to make.

3-3-4 Living Environment

In low lying areas of undulating Freetown City, a large number of residents live in slate roofed apartment houses. High class houses of concrete block construction stand in high ground areas.

The quality of city water is good but water could not be supplied to houses on high ground because water pressure is too low due to defective pumping facilities, frequent power failures, etc. Thus, many houses on high ground install a water tank inside the building. Many communal faucets are installed along roads in low lying areas and are used by many residents.

Freetown City and its suburbs are dotted with hotels. However, few hotels have stand-by generators, telex, telephone and other useful facilities.

As for means of public transport, no railway service is operated now and only city and private owned bus services are available.

3-4 Outline of the Sector Concerned in the Area

3-4-1 Power Supply Situation in Greater Freetown Area

(1) Operation Status of Power Station

NPA, the nation's public power supply agency, runs 2 power stations in the greater Freetown area, Kingtom and Falcon Bridge power stations.

In Falcon Power Station, 5 sets of diesel generating facilities (with a total installed capacity of 5.5 MW) are installed. However, only 2 sets are operated at present due to obsolete equipment and a lack of spare parts. (See Table 3-5)

These generating sets use, as main fuel, diesel oil, which is more costly than heavy oil. Therefore, to save operating cost, NPA uses the generating facilities at Falcon Bridge to supply power to Kingtom Power Station for initial start (black start) of the latter's generating facilities only in emergency when all the generating facilities at Kingtom Power Station have stopped. Thus, Falcon Bridge Power Station does not supply power to consumers.

Consequently, the greater Freetown area depends for power supply solely on Kingtom Power Station, the subject for the project, and its operation status has great impact on both the nation's economy and civic life. Thus, its importance in Sierra Leone is very high.

Kingtom Power Station has 9 sets of diesel generating facilities as shown in Table 3-4. Of these sets, 3 (Maker: MAN) are not operating at present due to damage to the foundation, expired life of machinery, etc.

The power station is generating power with the remaining 6 sets. Among them, 4 sets (Maker: KHD) are operating only as emergency power generating facilities and do not supply power to base load because these diesel engines are of high-speed specifications. For the layout drawing of the generating facilities at Kingtom Power Station, see Fig. 4-1 in Chapter 4 and Basic Design Drawing SLB-01 (see 5-3-2-(2)).

For the above reasons, ultimately only 2 sets (Maker: Sulzer) out of total 9 at this power station can supply power to base load. However, the output of even these 2 sets has dropped to about 50% of their installed capacity due to a lack of spare parts, etc. As a result, as of December 1989, the total generated energy is only 12.7 MW as against the peak demand of about 40 MW in the greater Freetown area.

NPA also owns Guma Dam Hydroelectric Power Station (its installed capacity: 2.2 MW) but this power station has not been operating since 1982 due to mechanical failures.

Table 3-4 Generated Energy of Kingtom Power Station

As of December 1989

Unit No.	DEG Manufacturer	Commencement Year of Operation	Installed Capacity (MW)	Available Capacity (MW)	Remarks
1	MAN	1971	6.6	-	Out of order
2	MAN	1964	6.6	-	Out of order
3	MAN	1964	6.6	-	Out of order
4	SULZER	1978	9.2	5.2	Under operation
5	SULZER	1980	9.2	4.5	Under operation
6	KHD	1986	3.0	1.5	Emergency use only
7	KHD	1986	3.0	-	Out of order
8	KHD	1986	3.0	1.5	Emergency use
9	KHD	1986	3.0	-	Out of order
	(Total)		(50.2)	(12.7)	

Source: NPA

Table 3-5 Generated Energy of Falcon Bridge Power Station

As of December 1989

Unit No.	DEG Manufacturer	Commencement Year of Operation	Installed Capacity (MW)	Available Capacity (MW)	Remarks
1	ENGLISH ELECTRIC	1962	1.5	-	Out of order
2	ENGLISH ELECTRIC	1962	1.5	-	Out of order
3	MIRRLEES	1976	1.0	-	Out of order
4	MIRRLEES	1976	1.0	0.8	Black start use only
5	MIRRLEES	1976	1.0	0.8	Black start use only
	(Total)		(6.0)	(1.6)	

Source: NPA

(2) Power Supply Situation

As described in (1) above, the power supply is far short of the demand (the total generated energy is only about 30% of the peak demand). This forces NPA to systematically cut power to the greater Freetown area every day.

The plan for power distribution to consumers including stop and start of power supply is carried out NPA's Power Distribution Division located at Blackhole Road about 5 km away from Kingtom Power Station.

No systems are available at this facility to remotely monitor generated energy, status of distribution networks, etc. Therefore, it communicates with the power station and each of substations (total 6 places) by wireless to obtain information on constantly changing power demand and operation status of the power station and issues power distribution instructions based on this information.

According to the engineer in charge of Power Distribution Division, important consumers that are given priority in power supply are as follows:

- Hospitals, schools, National Assembly buildings, President's Official Residence, government agencies, etc.

However, when the study team inquired at the national hospital (Connaght Hospital), the largest institution in Freetown City, it learned that although hospitals are given priority as important consumers in NPA's power distribution plan, little or no power is supplied to even the national hospital, a public welfare institution which many citizens use, due to acute shortage of power.

The study team was also informed that the power to schools is also mostly cut although the Sierra Leone Government directs its major attention to education, aiming to turn out capable persons who will support development of the country in the future. Street lights on major roads in Freetown City have not been used at all since 1987 due to the power shortage, and the maintenance of security and order is seriously affected by blackout conditions at night. Under these conditions, a power cut repeated everyday imposes serious restrictions on medical services, civil life and economic activities.

Table 3-6 shows the transition of power consumption by consumer in the greater Freetown area.

As this table shows, power consumption at hospitals and schools sharply dropped in 1987/88 compared with the previous year 1986/87. This reflects the effect of systematic power cuts to hospitals and schools due to the power shortage resulting from the lower generated energy.

Table 3-6 Transition of Annual Power Consumption by Consumer in Greater Freetown Area

No.	Category	Tariff class	1984/85 Power consumption (MWh)	1984/85 Ratio (%)	1985/86 Power consumption (MWh)	1985/86 Ratio (%)	1986/87 Power consumption (MWh)	1986/87 Ratio (%)	1987/88 Power consumption (MWh)	1987/88 Ratio (%)
1	General consumers	1	42,783	48.1	29,803	47.7	32,487	51.9	28,484	56.4
2	Small commerce and industry	2	8,600	9.7	7,145	11.4	6,727	10.7	5,540	11.0
3	Hospital and schools	3	13,766	15.5	6,418	10.3	6,367	10.2	116	0.2
4	Churches and mosques	3A	7,092	8.0	3,306	5.3	3,280	5.2	60	0.1
5	Large commerce and industry	4	16,070	18.1	15,768	25.2	13,669	21.8	16,245	32.1
6	Street lighting	5	405	0.5	20	0.0	10	0.0	0	0.0
7	Temporary facilities	6	151	0.2	62	0.1	86	0.1	87	0.2
8	Welding facilities	7	0	0.0	0	0.0	0	0.0	1	0.0
	(Total)		88,867	100.0	62,522	100.0	62,626	100.0	50,533	100.0

Source: NPA

Remarks: Average ratio of combined total power consumption from 1984 to 1987 is 12.0%.

3-4-2 Future Plan and Power Balance in Greater Freetown Area

(1) Future Plan

NPA has the following 2 medium-range plans:

1) Rehabilitation of existing diesel generating facilities at Kingtom Power Station (part of "Capital Area Power Supply Improvement Plan" planned as a project under aid from EEC, etc. (see Chapter 1))

2) Construction of Bunbuna Hydroelectric Power Station (planned as a project under aid from the Italian government, etc.)

Tables 3-7 and 3-8 show the contents of these 2 plans. The data for completion of the plan shown in each of these tables is the year in which NPA wishes to complete the plan. However, according to NPA, implementation of these plans will be delayed for reasons of sources of funds and financing conditions.

Table 3-7 Future Plan for Kingtom Power Station

Unit No.	DEG Manufacturer	Installed capacity (MW)	Generated energy (as of Dec. 1989) (MW)	Planned available capacity after rehabilitation (MW)	Expected completion and source funds	Remarks
4	SULZER	9.2	5.2	7.5	1991, EEC, etc.	Indoors
5	SULZER	9.2	4.5	7.5	1991, EEC, etc.	Indoors
6	KHD	3.0	1.5	2.5	1991, EEC, etc.	Outdoors
7	KHD	3.0	(in trouble)	2.5	1991, EEC, etc.	Outdoors
8	KHD	3.0	1.5	2.5	1991, EEC, etc.	Outdoors
9	KHD	3.0	(in trouble)	2.5	1990, EEC, etc.	Outdoors
	Total		12.7	25.0		

Source: NPA

Aside from these plans, NPA plans to remove from the power house of Kingtom Power Station generating set Nos. 1 to 3 (Maker: MAN), which are not operating at all due to accidents or expired machinery life, and install new diesel generating facilities. NPA has asked EEC, World Bank, etc., for a study of fund allocation to this plan.

Table 3-8 Other Future Plans

Name of project	Planned completion	Source of funds	Descriptions of projects
Bunbuna Hydraulic Power Station	1995	Italian Government or Africa Development Bank or Islamic Development Bank	Construction of 30.5 MW output hydraulic power station

Source: NPA

Remarks: Civil work for this project has already been started. However, the source of funds for machinery and electric equipment has not been decided yet.

(2) Power Demand and Supply Balance

The chart below shows the transition and forecast of power demand and supply balance in the greater Freetown area from 1985 through 1995 when Bunbuna Hydroelectric Power Station is scheduled to be completed. (This future plan shows the year by which NPA wishes to complete construction.)

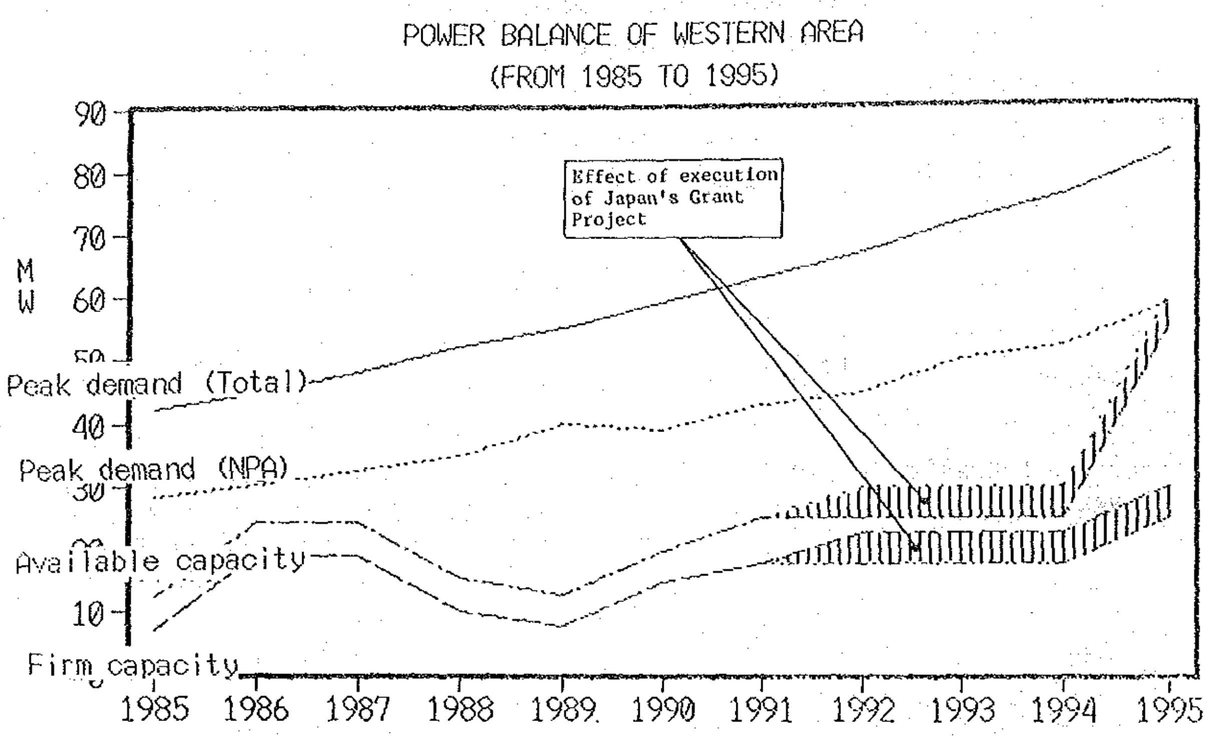


Fig. 3-1 Transition and Forecast of Power Demand and Supply Balance in Greater Freetown Area

In the above chart, the planned year of completion for this project was set at 1992. Appendix 8 shows the expected power demand and supply balance in the greater Freetown area on which the above chart was based.

According to this power demand and supply balance, the total generated energy will fall short of the peak power demand until 1995 when Bunbuna Hydroelectric Power Station is scheduled for completion. Thus, it is predicted that the acute power shortage will continue, thereby requiring repeated systematic power cuts as practiced at present.

CHAPTER 4 OUTLINE OF THE PROJECT

CHAPTER 4 OUTLINE OF THE PROJECT

4-1 Objectives

As described in Chapter 1, the power supply situation in Sierra Leone is extremely serious. Restriction of power supply, which has been practiced on a regular basis, has led to increasing dissatisfaction among residents and brought about adverse effect on economic activities. This restriction is also hindering activities of public welfare facilities such as hospitals and schools, which many citizens use.

As shown in 3-4-2, the power demand and supply balance as of 1989 is the worst ever because output of the generating facilities dropped due to lack of spare parts, accidents, etc., while demand continues to grow. Total output will remain only about 25 MW even in 1991 when the rehabilitation of the existing facilities at Kingtom Power Station (KHD generating facilities x 4 sets and Sulzer x 2 sets) planned by NPA is scheduled to be completed under aid from EEC, etc. Thus, it is anticipated that of a peak demand of about 43 MW, only about half can be met with generated energy.

From this, it is predicted that a tight supply situation requiring repeated systematic power cuts as practiced now will have to be continued in the greater Freetown area until generated energy catches up with peak demand with the completion of Bunbuna Hydroelectric Power Station in 1995.

Sierra Leone is seriously concerned with this situation and intends to complete this project as an emergency measure so that a stable supply of power, particularly to social welfare facilities, will be ensured. At present, these facilities are also subjected to repeated power cuts because of the acute power shortage, even though they are given priority as important consumers and are public facilities indispensable to civil life.

In view of these situations, this project has the following objectives: To construct the generating facilities as an emergency measure to cope with the power supply situation in Sierra Leone and thereby provide the greater Freetown area, the nation's center, with a social foundation to support residents' stable living and to manage and maintain social welfare facilities.

4-2 Study and Examination on the Request

4-2-1 Study of the Project's Propriety and Necessity

As already described (see 3-4-1), the power supply situation in the greater Freetown area is extremely serious at present. The output of the generating facilities has dropped due to the effect of the nation's financial difficulties and lack of adequate maintenance control over a long period. In 1989, the generating facilities were able to supply only about 30% (12.7 MW) of peak demand (40 MW).

Because of this shortage, a power cut on a regular basis has been practiced as an inevitable consequence and has been seriously affecting civil life, social welfare facilities and economic and industrial activities.

If this condition was left as it is without making an appropriate improvement in power supply and without taking any emergency measures, residents' dissatisfaction would further grow, and medical services and education activities indispensable to residents' lives would become stagnant.

Consequently, it is considered necessary to urgently undertake this project and prevent the stagnation of social welfare activities by properly operating the generating facilities to be built under the project.

As will be clear from the future power demand and supply balance in the greater Freetown area described earlier (see 3-4-2), it is considered that these generating facilities will continue to assume the responsibility for supplying power to base load under the capital area's power supply system even after completion of the planned two major projects (the rehabilitation of the existing facilities of Kingtom Power Station and construction of Bunbuna Hydroelectric Power Station). From this, it is believed that the early implementation of this project will contribute to the securing of a stable power supply in the capital area. Thus, the project will significantly contribute not only to residents' activities but to the stability of Sierra Leone's economy and development. Base on these points, the project is considered proper as a subject for grant aid.

4-2-2 Study of Implementation and Management Plans

(1) Personnel Assignment Plan

NPA is the agency responsible for implementation of this project on the Sierra Leone side, and the Generation Division of the Engineering Department is directly involved. (See 2-1-1)

This section is expected to assume the responsibility for operation and maintenance control of the generating facilities after their completion. The section has a staff of 155 members. It is considered possible to maintain and operate the generating facilities with the present personnel strength after completion of the project. This is because OJT provided to existing maintenance control personnel during implementation of the project is expected to improve technical and other capabilities of existing personnel.

(2) Study of Maintenance Control Cost

1) As described earlier (see 3-4-2), the generating facilities to be installed under the project are expected to be operated to supply power to the base load in the greater Freetown area upon completion. In this case, the annual operation rate of the generating facilities will be about 90% and annual operation hours about 7,800 hours.

Under these conditions, the operation and maintenance cost (expenditure) required for the generating facilities is estimated at 184.6 million leones.

Revenue from the supply of power after deduction of power loss including transmission loss is roughly estimated at 212.65 million leones. Thus a profit of about 28.04 million leones can be expected from the operation balance (revenues from sale of power minus maintenance control cost).

Appendix 9 shows a table for forecast operation balance by operation rate. As is clear from this table, the operation balance will result in a profit at each operation rate. From this, it is determined that the maintenance control cost of the generating facilities can be fully recovered after commencement of their commercial operation.

2) Reserve funds for future use

When operating a power station, reserve funds are necessary for replacement of generating facilities, considering the deterioration of their functions as they become obsolete. These funds should be set aside as depreciation cost.

When depreciation cost of the generating facilities is calculated by fixed amount method with no salvage value, assuming their serviceable life is 15 years, the anticipated operation balance will be as shown in Appendix 9.

As shown in the above table, if the generating facilities are operated at an operation rate of more than 80%, the operation balance, even allowing for depreciation cost, will result in a profit (about 0.24 million leones at an operation rate of 80%). Thus, reserve funds for future can be secured. However, if the operation rate drops to about 75%, it is expected that the operation balance will turn into a deficit (about 1.7 million leones) if allowance is made for depreciation cost.

From this fact, in its operation plan, NPA should practice appropriate maintenance control of the generating facilities so that these facilities maintain the required functions over a long period and that their operation rate will not drop due to trouble, etc.

4-2-3 Study of Relations and Overlapping with Other Aid Plans

Other aid plans related to this project include the aforementioned "Capital Area Power Supply Improvement Plan" under aid from EEC, etc. (see Chapter 1).

This aid plan can be divided into 2 parts as follows:

(1) Rehabilitation of the existing diesel generating facilities in Kingtom Power Station

(2) Reorganization of NPA

The project under review calls for construction of the new generating facilities (No.10 DEG) in Kingtom Power Station. Thus, the project has relations with above plans in both construction plan and maintenance control plan after completion of the new facilities.

Consequently, in implementation of the Project, it is necessary to carry out construction work upon accurately understanding contents, the time of execution, etc., of the above plans.

(1) Study of Construction Plan

When implementing the Project for the construction of the generating facilities, it is believed possible to avert its overlapping with the above plans and eliminate interference with other projects by paying particular attention to the following points. Fig. 4-1 shows the demarcation between the area under this project and the block for the rehabilitation plan under aid from EEC, etc.

1) Connection between the new generating facilities for the project and the existing facilities (fuel, steam, cooling water and power distribution systems) should be carefully designed, taking into account the present condition of the existing facilities and NPA's plan for their rehabilitation and improvement, so that the installation of the new generating facilities will neither cause a change in the system of the existing facilities nor require other rehabilitation work, etc.

2) The new generating facilities should be installed where they will not interfere with NPA's planned rehabilitation and improvement work or other future projects.

(2) Study on Plan for Maintenance Control After Completion of Project

Of the above 2 plans, the plan for reorganization of NPA is considered indispensable to the continued stabilization of the power supply situation in Sierra Leone in the future. This is because, as the plan itself points out, the root of the aggravated power supply situation that Sierra Leone faces at present is believed to be the lack of NPA's management ability as the electric energy supply sector.

Consequently, it is desired that after construction of the generating facilities NPA maintain these facilities with O & M technology which NPA will acquire through OJT to be provided in the course of execution of the Project. NPA should combine this technology with management ability as the electric energy supply sector to be developed under the above major plan when it will be implemented as a higher project, formulate an optimum maintenance control plan, and manage power supply service in the country.

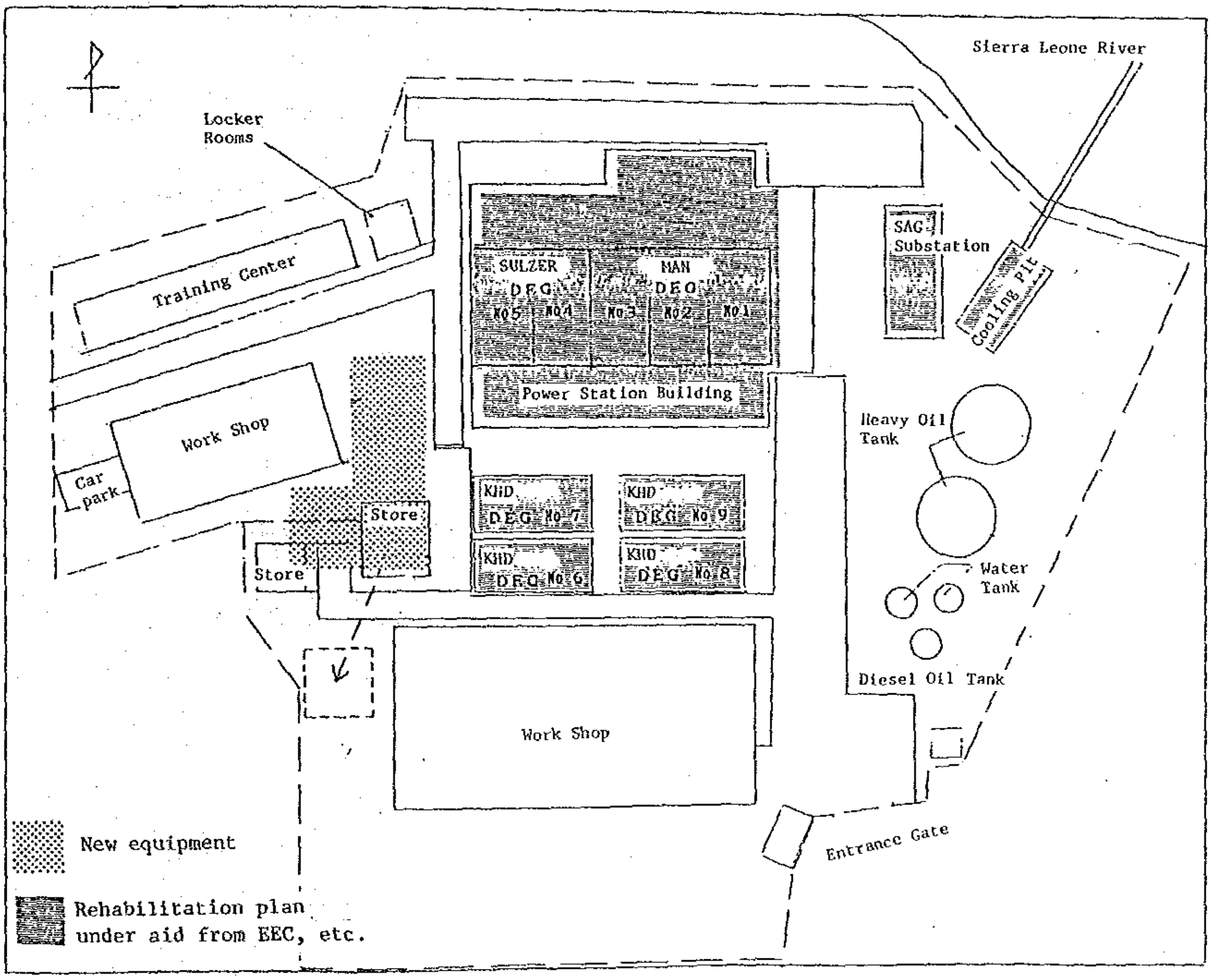


Fig. 4-1 Present Status and Future Plan of General Layout at Kingtom Power Station

4-2-4 Study of Component Elements of the Project

This project consists of the following 3 elements: (1) construction of diesel generating facilities with installed capacity of 5 MW, (2) procurement of spare parts, and (3) implementation of OJT on O & M technology.

These 3 elements are organically interwoven with each other. It is considered that the project could not produce its intended effect if any one of these elements is missing.

The chart below shows interrelations between these component elements.

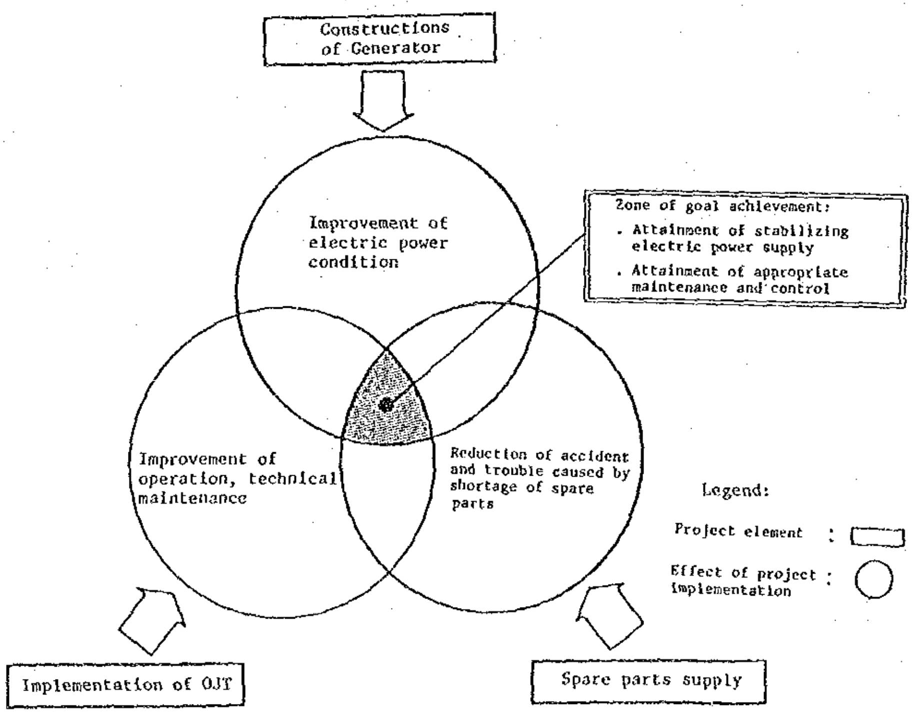


Fig. 4-2 Interrelation of Component Elements of Project

4-2-5 Study of Scale of Generating Facilities

As described earlier (see 4-1), the objective of this project is to stabilize civil life and operate and maintain social welfare facilities such as hospitals, schools, etc., by undertaking emergency construction of generating facilities.

Consequently, in studying the scale of the generating facilities, the required installation capacity should be determined by defining the users of generated energy as hospitals, schools, etc., and assuming completion date of the project as 1992.

(1) Study of Ratio of Demand for Social Welfare Facilities to Peak Demand

According to the transition of power consumption by consumer in the greater Freetown area as described earlier (see Table 3-6), the ratio of power consumption by social welfare facilities such as hospitals and schools to total power consumption generally had ranged from 15 to 10% before 1987 when substantial power cutting was started. The ratio in the period from 1984 to 1986 averaged about 12%.

Considering Sierra Leone's industrial structure, which mainly consists of small enterprises and agriculture, as well as the country's social life, the ratio of power demand by consumer is believed to be nearly the same as the ratio of consumption by the same consumer category. Based on this, power demand for social welfare facilities is assumed to be the average value (12%) of the above power consumption to peak power demand in the subject area.

With industrial development and population increase, social welfare facilities are expected to grow because the improvement of social welfare is one of Sierra Leone's development targets as shown in the aforementioned (see 2-3-1) national development plan.

For this, it is expected that power demand for social welfare facilities will grow in proportion to the growth of peak demand. Accordingly, it is considered appropriate to apply the above ratio (12%) even to 1992, the completion date of the project.

(2) Expected Peak Demand

Peak demand in the greater Freetown area in 1992 is assumed to be 45 MW as indicated by NPA. (See Appendix 8 "Table for Forecast Power Demand in Greater Freetown Area") Also, the nation's expected peak demand in 1989 is 40 MW according to the above table. NPA expects peak demand to grow at an annual rate of about 5% from 1989 to 1992.

This growth ratio is considered appropriate because it is nearly equal to the ratio of population growth in the greater Freetown area (see Table 2-1).

(3) Installed Capacity Required for the Project

Based on results of the above study, the installed capacity required for the project can be obtained as follows:

(Expected peak demand in 1992)		(Ratio of load of hospitals and schools to total load)		(Required installed capacity)
45 MW	x	0.12	=	5.4 MW

The capacity of the generating facilities requested by Sierra Leone (5 MW) falls slightly short of the required installed capacity obtained from the above formula (5.4 MW). However, since the shortfall (0.4 MW) can be supplied from the existing generating facilities, the scale of the proposed generating facilities is considered appropriate.

4-2-6 Study of the New Facilities Location

As described earlier (see 3-4-2), all the existing generating facilities in the power house at the power station are subject for rehabilitation under funds to be obtained from EEC, World Bank, etc. Moreover, there is no space for installation of the generating facilities for the project in this power house.

Under the above circumstances, for the project, which aims to improve the power supply situation as an emergency measure, it is necessary to select outdoor type diesel generating facilities which do not require construction of another building and which feature a short construction period. As for the location of the new generating facility, a plot of land surrounded by the existing power house, training room and repair shop was selected. NPA already indicated that they will relocate the warehouse of spare parts for Sulzer generators currently on this plot. Thus, the construction site can be secured.

However, the foundation for the generating facilities must be constructed because in this area no foundation exists that can be used for the new generating facilities.

4-2-7 Study on Necessity of Technical Cooperation

The Government of Sierra Leone understands that lack of adequate maintenance control technology is one of the contributing factors to the aggravated power supply situation which the nation faces at present, particularly the drop in the output of the generating facilities.

Based on this understanding, the Government of Sierra Leone strongly desires a transfer of technology for maintenance control of the generating facilities to be installed under the Japan's grant aid in order to make effective use of the facilities over a long period for improvement of the nation's power supply situation. Technology requested ranges from basic technology pertaining to composition and assembly of facilities to high level O & M technology that must be imparted through actual operation and maintenance work. In the stage when the project has been implemented under grant aid, Sierra Leone requests Japan's assistance in the following forms:

(1) To provide training to NPA staff in Japan in generating facilities

(2) To dispatch technical assistance (specialist) engineers in O & M of the generating facilities to Sierra Leone after completion of the project (electrical engineer and mechanical engineer: 1 each)

It is considered that the necessity of Japan's technical cooperation in the above is very high in view of the present condition of power stations in Sierra Leone as well as the technical level of NPA staff.

However, since this project is for construction of facilities under grant aid, it is difficult to include the above request into the project. Instead, it is considered desirable that the Government of Sierra Leone make this request to the Government of Japan separately.

4-2-8 Basic Policy of the Project

It is considered appropriate that this project should be implemented under Japan's grant aid because the foregoing study has confirmed its effect, viability, and Sierra Leone's execution capability, and because the effect of the project conforms to Japan's grant aid system. Accordingly, as a grant aid project, the basic design will be made by studying the following general items of the project.

Table 4-1 shows comparison in contents between Sierra Leone's request and the project plan.

Table 4-1 Comparison in Contents Between Sierra Leone's Request and Project Plan

Item	Contents of Sierra Leone's request	Contents of project plan
(1) Procurement and installation of diesel generating facilities with 5 MW output (including necessary auxiliary machines and electric equipment)	x	x (To be outdoor type)
(2) Test run, adjustments and acceptance test of above generating facilities	x	x
(3) Supply of spare parts for above generating facilities	x	x
(4) Foundation work for above generating facilities	x	x
(5) Provision of OJT in O & M technology for above generating facilities during execution of project	x	x
(6) Provision of training in Japan in generating facilities	x	(To be made separate request)
(7) Dispatch of specialists after completion of project	x	(To be made separate request)

4-3 Project Description

4-3-1 Execution Agency and Operational Structure

The execution agency for this project in Sierra Leone is the National Power Authority (NPA) and its division in charge is Generation Division of Engineering Department (see 2-2-1).

This section is expected to assume responsibility for maintenance, control and management of the generating facilities after completion of the project.

4-3-2 Plan of Operation (Activity)

(1) Project Policy

By implementing this project, Sierra Leone strongly desires (1) urgent improvement in power supply and (2) provision of adequate maintenance control to the generating facilities after start of operation.

Taking these points into consideration, the project will be formulated with following particular points in mind:

1) Facilities construction plan

a) To construct new diesel generating facilities with 5 MW output with the objective of urgently improving the power shortage situation

b) To shorten the construction period as much as possible

c) To carefully design this project so that it will not have an adverse effect on other projects that NPA plans to undertake

d) To make effective use of existing facilities

e) To give considerations that serviceable life of machines in procured equipment will be extended and their maintenance and control costs be kept low

f) To pay attention to the general appearance of facilities to be newly installed under the project (distribution panel and remote control board) so that these new facilities will conform to existing facilities in configuration, etc., when installed next to them

g) To install communication systems for maintenance purposes to facilitate operation and maintenance control after procurement as requested by Sierra Leone (see Appendix 6)

h) To give consideration to prevention of environmental pollution when the project is completed and supply necessary facilities for pollution control

2) Equipment procurement plan

a) To procure necessary spare parts and tools for stable operation of the generating facilities after completion of the project

b) To procure equipment and materials for improved safety of operation (such as soundproof head covers)

c) To provide teaching materials so that acquired technology can be reviewed

3) OJT plan

a) To have trainees understand the flow of O & M and the relative importance of maintenance work that they will conduct

b) To have Japanese engineers provide practical education to trainees during construction work at the site

4) Operation plan for the generating facilities

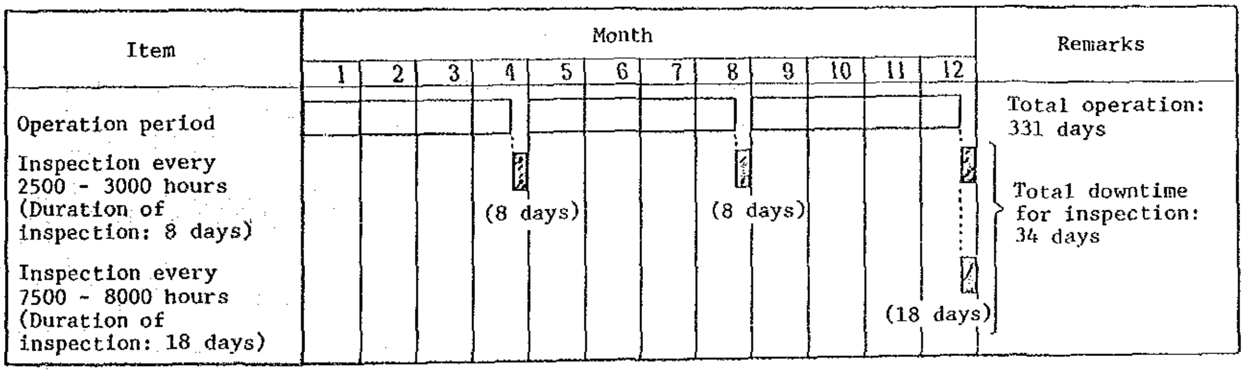
As described earlier (see 4-2-2-(2)), the generating facilities to be installed under the project are believed to supply power to base load in the greater Freetown area.

From this, the operation plan for the generating facilities should be made under the following conditions:

Annual rate of operation: About 90%
Annual operation hours : About 7,800 hours

Items for periodical inspection, which is required for proper operation of the generating facilities, are as shown in the maintenance control plan to be described later (see 4-3-5).

Considering these periodical inspection items, the annual operation plan of the generating facilities under the above conditions for the initial year is shown in Fig. 4-3.



Remarks: Based on annual operation rate of 90%

Fig. 4-3 Annual Operation Plan for Project Generating Facilities

4-3-3 Location and Condition of the Project Site

The generating facilities to be installed under the project call for an area of about 400 m^2. As a result of the field survey, a vacant lot surrounded by the power house, training room built under aid from GTZ, and repair shop, as shown on the power station facilities layout drawing given in Fig. 4-1, was selected as the construction site for this project. However, the necessary area could not be secured from this vacant lot alone. As a result of discussion with NPA, it was decided to secure the necessary area for the project by relocating the warehouse for spare parts of the existing Sulzer generating sets and removing the unused brick warehouse. (These warehouses will be relocated and removed by the Government of Sierra Leone.) Regarding the warehouse for spare parts of Sulzer Generating sets, it was decided to move this warehouse to the place shown on the power station facilities layout drawing upon consultation with NPA.

4-3-4 Outline of Facilities and Equipment

The construction plan for the new generating facilities and procurement plan for equipment and materials is outlined below.

(1) Construction Plan for the Generating Facilities

1) Outdoor type diesel generating facilities (with 5 MW output, 1 set) will be constructed.

2) Equipment and systems necessary for operation of the generating facilities will be constructed as follows:

a) Fuel supply system
b) Lubricant oil supply system
c) Cooling water supply system
d) Steam supply system
e) Compressed air supply system
f) Air supply and exhaust systems
g) Sludge treatment system
h) Piping facilities

3) Electric equipment and system necessary for operation of the generating facilities will be installed as follows:

a) 11 kV switchgear for connection with existing facilities
b) 11 kV switchgear on generator side
c) Local control panel
d) Remote control panel
e) Excitation system
f) DC power unit
g) Transformer for auxiliary equipment
h) Grounding system
i) Communication system for maintenance
j) Cabling facilities

4) Test run, adjustments and acceptance test for the above facilities will be conducted.

(2) Procurement Plan for Equipment and Materials

1) To procure spare parts that cover the needs for operation hours corresponding to one complete cycle of periodical inspection (overhaul) of the generating facilities

2) To procure tools necessary for maintenance, inspection and service of the generating facilities

3) To procure teaching materials for OJT

(3) OJT Plan

1) To provide education by engineers sent to the site from the Contractor in Japan

2) To provide education in the general flow and outline of O & M in class room training (about 1 week)

3) To give education in operation and maintenance control technology through practical training during execution of construction work (about 5 months)

4-3-5 Maintenance Plan

(1) Basic Policy

In maintenance control of the power station, it is essential that operation and maintenance (O & M) and protection of facilities environment be provided to ensure stable supply of power in response to demand.

One of the major contributing factors to the tight power supply situation in Sierra Leone is a lack of proper maintenance control of the existing facilities including their preventive maintenance, as already described (see 3-1-2). To improve this present situation, to maintain the performance and function of the project generating facilities and to secure stable power supply to the greater Freetown area, adequate maintenance and control including preventive maintenance should be provided with reliability, safety and efficiency of the generating facilities as the main pillars of specific maintenance operation.

Fig. 4-4 shows basic conception for maintenance control.

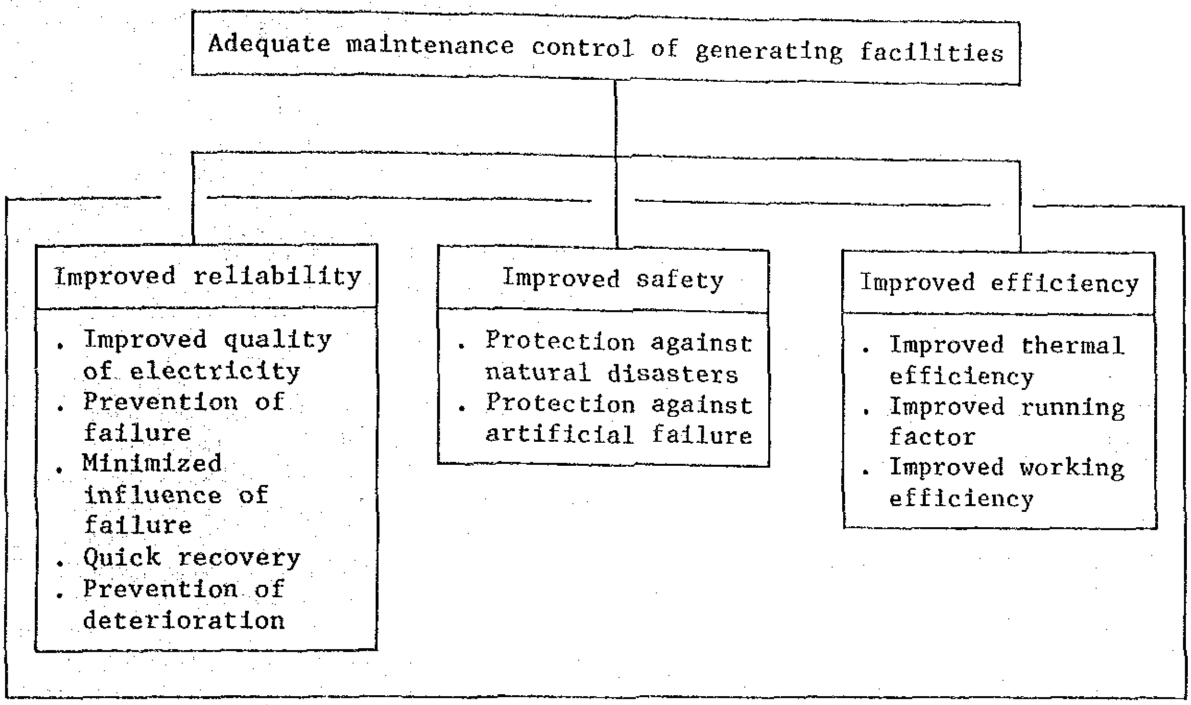


Fig. 4-4 Basic Conception for Maintenance Control of Generating Facilities

The basic policy for formulating maintenance control plan of generating facilities is as follows:

(1) Conduct of preventive maintenance
(2) Systematic control
(3) Effective use of records and data, and their reflection in the future plan

In this Project, with the above basic points in mind, the Sierra Leone side is required to carry out operation and maintenance of the generating facilities after completion of the project according to the operation and maintenance manuals to be supplied and O & M technology through OJT which the Japanese contractor will provide during execution of the construction.

(2) Items for Periodical Inspection

Table 4-2 shows standard items for periodical inspection of the subject generating facilities.

Personnel concerned in Sierra Leone are required to develop a maintenance control plan for the generating facilities according to this table and incorporate the maintenance control plan into the entire operation plan for Kingtom Power Station.

Table 4-2 Standard Items for Periodical Inspection

	Inspection frequency	Main items of work
Diesel engine	Daily inspection	- Check fuel oil level, and oil level in lubricant sump tank and lubricant tank - Check water level in jacket water tank, and pressure of starting air tank
	Inspection every 1000 hours	- Check bolts and nuts for their tightness - Clean fuel and lubricant filters
	Inspection every 2500 to 3000 hours	- Check exhaust valve, starting valve, fuel valve and fuel pump - Check piston valve and liner
	Inspection every 7500 to 8000 hours	- Check piston and cylinder liner, and replace gasket - Replace piston ring, oil scraping ring and O-ring - Analyze cylinder head and replace gasket O-ring in exhaust valve - Check fuel injection valve and replace nozzle - Disassemble and inspect supercharger and replace ball bearing, etc. - Change lubricant sump tank oil (based on results of analysis)
	Inspection every 16000 hours	In addition to above inspection and replacement at every 7500 to 8000 hours, check and replace following items: - Check and replace crank pin bearing - Check and replace exhaust valve rotator - Disassemble and replace lubricant pump
Generator	Daily inspection (during operation)	- Visually check each part, check for abnormal sound, and check each part for temperature
	Inspection once a month	- Check for abnormal vibration - Check lubricant flow and leak from bearing - Perform simple cleaning
	Inspection once a year	- Measure insulation resistance and check lead wires and connection - Check accessories such as space heater - Visually check and clean bearing

(3) Procurement Plan for Fuel Oil

Table 4-3 shows the expected annual consumption of main fuel (heavy fuel oil, HFO) necessary for operation of the generating facilities.

NPA is required to make and implement a procurement plan for fuel oil shown in the table so that smooth operation of the generating facilities will be maintained.

Table 4-3 Anticipated Annual Fuel Consumption by Subject Generating Facilities

Item	Unit	Rate of operation				
		75%	80%	85%	90%	95%
Consumption of heavy oil c per hour	ℓ/hr	1,131	1,131	1,131	1,131	1,131
Annual consumption of HFO	ℓ/yr	7,327,329	7,815,818	8,304,307	8,792,795	9,281,284

Remarks: Fuel consumption of the generating facilities was calculated based on 0.21 kg/kWh. For HFO, the following specification was used:

- Specific gravity of HFO : 0.95
- Lower heating value HFO at Kingtom Power Station : 9,970 kcal/kg
- Heating value of HFO of ISO Code: 10,200 kcal/kWh

4-4 Technical Cooperation

As already described (see 4-2-7), it is considered necessary to extend technical cooperation. Specifically, to obtain the intended effect from the generating facilities by providing adequate maintenance control after completion of the project, it is believed necessary to plan the transfer of O & M technology through Japan's technical cooperation.

Table 4-4 shows an outline of technical cooperation that is considered necessary.

Table 4-4 Technical Cooperation Considered Necessary

Item	Objective	Remarks
Training in generating facilities to be provided in Japan	To have trainees acquire basic knowledge of engine	
Dispatch of specialists	To give technical guidance on O & M of generating facilities to be practiced after completion of the project	Mechanical engineer : 1 Electric engineer : 1

CHAPTER 5 BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5-1 Design Policy

5-1-1 Policy on Natural Conditions

(1) On Temperature Condition

The temperature in the subject area is nearly constant, being moderate at about 27°C throughout the year.

(2) On Precipitation Condition

In the subject area, the June - September period is the rainy season. Since the monthly rainfall may reach as much as about 800 mm during this period, no local work could be undertaken for safety reasons. It is therefore necessary to plan the execution of earth work, concreting work, underground installation, etc., other than in this period.

5-1-2 Policy on Construction Situation

In selecting the construction plan, equipment and materials will be as a rule procured locally as much as possible. However, adequate equipment materials are not locally available except for aggregate such as sand and gravel because few large scale construction projects have been undertaken. Consequently, most equipment and materials must be supplied from either Japan or some other countries.

Construction of the generating facilities for the project requires skilled engineers and technicians. These engineers and technicians will be sent to the site from Japan.

5-1-3 Policy on the Executing Agency's Maintenance Control Capabilities

The mainstay generating facilities in the country at present are diesel plants. Thus, NPA is considered to be very familiar with the operation and maintenance of these power generating facilities. Based on this understanding, diesel generating facilities will be supplied under this project.

Furthermore, considering NPA's financial situation (see 2-2-2), economic design will be used so that the running cost of the generating facilities can be held down to the minimum possible.

5-1-4 Policy on Scope and Level of Facilities, Equipment, etc.

Considering the various aforementioned conditions, the scope and technical level of the facilities to be constructed, equipment and materials procured under this project will be based on the following basic design:

(1) Policy on Scope of Facilities, Equipment, etc.

Composition of the facilities, type and quantity of equipment and materials and contents of OJT will be determined in order to accomplish stable supply of power to social welfare facilities, the objective of this project (see 4-1), through ① construction of generating facilities, ② procurement of equipment and materials such as spare parts, and ③ provision of OJT under the Project.

(2) Policy on Technical Level

For specifications of each item of equipment for the generating facilities, careful consideration will be taken not to deviate from the technical level of the existing facilities whose maintenance and control NPA is familiar with.

OJT under this project will be provided to develop NPA's engineers to the technical level at which they can operate the generating facilities, analyze data on failure records, etc., and plan and execute adequate measures (perform preventive maintenance), with NPA's present O&M technology as the basis.

5-1-5 Design Policy on Facilities and Construction

As a result of a study taking into account the above basic policies, land feature of Kingdom Power Station, existing generator building, present equipment arrangements, and operating condition of electric and mechanical equipment, as well as future expansion plans, the project facilities will be built under the following design policy:

(1) The generating facilities for this project will be located where they will not affect the rehabilitation and improvement work that NPA plans to undertake in the future.

(2) The generating facilities will be installed outdoors because no space is available in the existing generator building. Furthermore, to shorten the local construction period as much as practicable, the outdoor type generating facilities with an enclosure for the diesel generator, which require no generator building, will be used.

(3) Power generated by the generating facilities will be supplied through the existing 11 KV distribution system.

(4) Connection between the project generating facilities and existing facilities (fuel, steam, cooling water and power distribution systems) will be designed by taking into account the present condition of the existing facilities and rehabilitation and improvement plans for these facilities that NPA will undertake in the future. In other words, due consideration will be given to this design so that it will neither require changes in the system of the existing facilities nor necessitate additional rehabilitation work, etc.

With all these points in mind, the project generating facilities will make the fullest use of any of the existing facilities that may possibly be used for the new facilities.

(5) As for the engine, a medium speed type will be used to allow a reduction in installation space.

(6) HFO, which the existing facilities use and is available at low cost, will also be used as main fuel for the Project generating facilities.

(7) Since the plan calls for procurement of most equipment and materials from Japan (see 5-4-4), Japan's standards and codes will be as a rule referred to in the design and manufacture of the generating facilities.

5-2 Study and Examination on Design Criteria

As a result of study on above various conditions, the following design criteria have been established for use in defining the scale and specifications of the Project:

5-2-1 Climatic and Site Conditions

1)	Ambient temperature	: 35°C max
2)	Temperature inside enclosure of diesel generator	: 45°C max
3)	Relative humidity	: 98% max
4)	Mean annual precipitation	: Approx. 3,500 mm Approx. 800 mm/month in July - September period Approx. 300 mm/month in June and October
5)	Wind velocity	: 120 km/h (33.3 m/s) max
6)	Earthquake	: Not particularly considered
7)	Measures against salt damage	: Measures will be taken on housing of major pieces of equipment
8)	Measures against dust	: Dust condition shall be considered
9)	Soil bearing pressure	: 10 tons/m^2 or over (based on GTZ Report)

5-2-2 Composition of Fuel

At present, Kingtom Power Station uses both heavy oil (HFO) and diesel oil. Main specification of these oils are as shown below. These oils are equivalent to heavy oils C and A, respectively according to JIS classification.

Table 5-1 Specifications of Fuels Used at Kingtom Power Station

Item	Unit	Heavy oil	Diesel oil
Specific gravity (60°F)	—	17.36	32.0
Dynamic viscosity (50°C)	Stokes (cSt)	134.9	3.5
Pour point	°C	5	-20 or less
Flash point	°C	92	106
Sulfur content	%	0.47	0.13
Water content	%	0.02 or less	0.02 or less
Ashes	%	0.02	0.02 or less
Calorific value	Kcal/kg	9,970	10,250

5-2-3 Composition of Cooling Water

Table 5-2 shows an analysis of water supplied to Kingtom Power Station at present.

Table 5-2 Analysis of Water Supplied to Kingtom Power Station

Item	Unit	Water
PH value, 18°C	—	7.0
Conductivity	μs/cm	23.0
Chlorine ion	Cl^- mg/ℓ	1.86
Total hardness	$CaCO_3$ mg/ℓ	5.7
Silica	mg/ℓ	2.82

5-2-4 Generating System

Generating system will be 3 phase, 3 wire, 11 kV, 50 Hz.

5-2-5 Use of Existing Facilities

As a result of a study based on the policies described in 5-1-5, the facilities that can be used for the project among the existing common facilities are as shown in Table 5-3.

Table 5-3 Existing Facilities that will be Used for This Project

Item		Application
Machinery Equipment	(1) Heavy oil tank (407,000 gallons x 2 units)	To be used for main fuel
	(2) Diesel oil tank (11,000 gallons x 1 unit)	To be used for starting or stopping generator
	(3) Fire-fighting water tank	To be used for cooling water and steam. (For steam, water in this tank is used after passing through water softening system.)
	(4) Drain ditch	To discharge waste oil and waste water after sludge is removed
	(5) Header for steam supply (located in existing generator building)	To conduct surplus steam for use in bottom heater heavy of oil tank
Electric Equipment	(1) 11 kV distribution system (installed in generator building)	To connect existing distribution system with project generating system
	(2) Grounding system (grounding electrode)	To connecting grounding systems of project equipment with existing grounding electrode
	(3) Cable pits (in generator building)	To use cable pits, cable racks, etc., for installation of cables for this project

5-2-6 Applicable Standards

The following standards shall be applied to the design of this project:

(1) Japanese Industrial Standards (JIS)
(2) Japanese Electrotechnical Commission (JEC)
(3) The Standard of Japan Electrical Manufacturers Association (JEM)
(4) Japan Cable Makers Association (JCS)
(5) International Electrotechnical Commission (IEC)
(6) International Standardization Organization (ISO)
(7) Other Relative Japanese Standards

5-3 Basic Plan

5-3-1 Site and Facilities Arrangement Plans

As described in section 4-2-2, the generating facilities will be located in the vacant lot alongside the Training Center in the Power Station compound.

In making the layout arrangement plan, particularly the following points will be taken consideration:

(1) The engine will be installed as far away from the existing Training Center and classroom building as possible to minimize the effect of noise from the generating facilities on these buildings.

(2) To facilitate work for cable connection with the existing 11 kV distribution system, the generator of the project generating facilities will be installed facing toward this distribution system.

(3) To facilitate maintenance work on the diesel generating facilities, the enclosure will be designed to be of a construction that will slide in the direction of the extension of both the engine and generator, and rails will be installed for this sliding movement.

(4) The generating facilities will be installed in such a manner that space will be left for maintenance of the existing KHD generating facilities in the planned construction site.

5-3-2 Facilities Plan

(1) Details of Plan

1) Decision on engine output and generator capacity

The rated output of the generator for this Project is 5 MW, and the required engine output and rated capacity of the generator can be calculated as follows:

a) Engine output

$$Pe \geqq \frac{P}{0.7355 \times \eta_G} \geqq \frac{5,000}{0.7355 \times 0.96} \geqq 7,090 \text{ (P.S)}$$

Pe: Engineer output (P.S. HP)

P: Generator output (kW)

η_G: Generator efficiency to be assumed 96%

b) Generator capacity

$$P_G = \frac{P}{Pf} = \frac{5,000}{0.8} = 6,250 \text{ (kVA)}$$

P_G: Generator capacity (kVA)

P: Generator output (kW)

Pf: Generator power factor 0.8

2) Machinery and equipment plan

a) Fuel supply facilities

Although the existing heavy oil and diesel oil tanks have already been used for about 25 years since their construction, no damage or breakage detrimental to the project can be found. Since it is considered that these tanks can continue to be used, they will be used for the project.

However, the existing fuel piping is considered unfit for use for the project because of oil leaks and extensive oil stains. Thus, fuel piping needs to be newly installed for the project. The new piping will be connected with the existing fuel system within the existing tank yard where the above tanks are located.

b) Lubricant oil facilities

Since no lubricant oil facilities that can commonly be used are available at this power station, lubricant oil facilities exclusively for the project generating facilitates need to be installed.

c) Cooling water facilities

At this power station, common cooling water facilities that use sea water are available for the existing generating facilities (MAN and SULZER diesel generating facilities located in the generator building). However, these cooling water facilities are included in NPA's future rehabilitation and improvement plan because of their deterioration, damage, etc. From this, it is concluded that the existing cooling facilities cannot be used under the project because of possible effect on other plans. Consequently, cooling facilities exclusively for the project generating facilities will be installed.

Radiator cooling system will be used for following reasons:

① The existing KHD generating facilities use the radiator system and NPA's operating personnel are familiar with maintenance control of this cooling system.

② The running cost is low because the radiator system requires only about 1/10 of the volume of make-up water that cooling tower system uses.

d) Steam facilities

The existing boiler built in 1964 is still in operation for the existing SULZER generating facilities and heavy oil storage tank. However, its deterioration is much advanced.

For this reason, NPA plans to replace or repair major components of the boiler proper under future rehabilitation and improvement plan. However, NPA's plan does not include increased steam production to supply steam to the project generating facilities.

Therefore, steam facilities exclusively for the generating facilities will be installed to increase the viscosity of the main fuel of heavy oil. For the following reasons, exhaust gas boiler type will be employed:

① Considering the acute power shortage in the project area, an electric heater type could not be used because power consumption in the power station must be held down to the minimum.

② NPA's maintenance control personnel are familiar with operation of exhaust gas boiler type because the existing SULZER generating facilities use this type in their auxiliary boiler facilities.

For effective utilization of energy, surplus steam generated from the exhaust gas boiler of the project will be supplied to the existing steam piping header for use in the heater of the fuel storage tanks.

e) Compressor

The existing compressor, built in 1978, is in advanced stage of absoluteness and is not being operated in a satisfactory condition. This requires installation of a compressor exclusively for the generating facilities of the project.

f) Air supply and exhaust facilities

Since no connection with the existing facilities and integral system is required, ordinary facilities needed for this project will be installed.

g) Sludge treatment facilities

No sludge treatment facilities for processing waste water and waste oil exist in the Power Station. These wastes are discharged into the Sierra Leone River with rain water through the storm water drain in the compound, thereby causing a serious adverse effect on the environment in the vicinity. GTZ Report, referred to in 2-3-2, already pointed out the need for installation of an oil separator tank at the terminal point of the drain system before wastes are discharged into the River.

Under the project, to prevent the installation of the generating facilities from polluting the environment, a sludge separation tank and an oil separation tank will be installed in the waste oil system to separate oil from water and discharge only waste water into the existing drain channel.

NPA is required to properly process separated sludge and waste oil so that they will not cause environmental pollution.

h) Piping route

The project requires the pipes shown below. These pipes will be installed along the existing piping lines for each maintenance control because the maintenance personnel at the Power Station are believed to be familiar with the existing piping lines.

The pipes will be laid with the necessary protective devices such as support. Particularly, in sections where pipes cross roads, the pipes will be protected by providing piping trenches of concrete in the underground portion of such sections.

- Heavy oil pipes
- Diesel oil pipes
- Steam pipes
- Water supply pipes

3) Plan for electric equipment

Since power generated by the project generating facilities is supplied through the existing 11 kV distribution system, particular care will be taken to conform voltage, etc. of this power to the existing facilities. Major items of electric equipment will be designed in the following manner:

a) 11 kV switchgear for connection with existing 11 kV distribution system

To connect power to be generated by the project generating facilities with the existing 11 kV distribution system, necessary protective relays, etc., for protection of the 11 kV switchgear and cables will be provided on the ground floor of the generator building.

Since this 11 kV switchgear is installed in line with the existing 11 kV switchgear, its configuration will be the same as that of the existing board. DC power for operation of this new 11 kV switchgear will be supplied from a DC power source to be installed within the enclosure for the project generating facilities. This is because the existing DC power sources do not function at all due to failure of their batteries. A DC voltage converter will also be installed because of the need to convert the voltage of power generated to the same 220 V DC as the voltage of power supplied from the existing facilities.

b) 11 kV switchgear on generator side

A switchgear for the generator set will be installed within the enclosure for the outdoor generating facilities.

c) Local control panel

A control board will be installed within the enclosure to start, stop, control, and monitor the generating facilities as well as to give warning.

d) Remote control panel

All the existing generating facilities in the Power Station are monitored and controlled by the remote control located in the existing central control room. Consequently, the project generating facilities also need to be controlled in the same manner. For this purpose, a remote control panel for remote monitor and load control of the project generating facilities will be installed on the existing remote control panels.

e) Excitation system

A brushless thyristor type excitation system will be installed on the local control panel.

f) DC power source unit

A dedicated DC power source unit as per (a) above will be installed within the enclosure.

g) Transformer for auxiliary equipment

An outdoor type transformer will be installed near the enclosure for the auxiliary equipment which is necessary for operation of the generating facilities.

h) Grounding facilities

Grounding facilities required for the project are as follows:

① Grounding facilities for protection of power systems (As in the case with the existing facilities, neutral point resistance grounding system will be used.)

② Grounding facilities for prevention of shock from metal parts or electric equipment

③ Grounding electrode for common use by 1 and 2 above

According to the GTZ Report, the existing grounding protection facilities do not function properly and require modification work.

Therefore, an outdoor type neutral point grounding resistance board for the project will be installed near the covering.

For the grounding electrode, the existing ones will be used because the Power Station employs a common grounding pole system.

i) Communication system for maintenance

An interphone system for maintenance purposes will be installed both within the enclosure of the project outdoor generating facilities and in the existing central control room.

j) Cable laying route

Cables will be installed by using the existing cable pits in the generator building because it is believed space is available for installation of cables for the project in the existing cable pits. Openings will be provided in the part of the outer walls of the generator building to draw in cables from the outside the building. Cables will be protected outdoors by conducting them through underground conduits.

4) Basic specifications of major items of equipment

Considering the aforementioned design policy and design criteria, and the performance of generating facilities similar in size to the Project, basic specifications of major items of equipment are defined as follows:

Table 5-4 Basic Specifications of Major Items of Equipment

Main equipment	Basic specification	
(1) Diesel engine	Rating	: Continuous
	Output	: Generator output 5,000 kW (7,090 PS)
	Revolution speed	: Not more than 750 rpm
	Type	: Four stroke cycle, trunk piston type diesel engine with supercharger and air cooler
	Cooling system	: Closed cycle water cooling with radiator
	Fuel	: Diesel oil for starting and stopping Heavy oil for normal rating
	Elastic fastening equipment with common baseplate	
(2) Generator	Rating	: Continuous
	Rated output	: 5,000 kW
	Phase	: 3 phase
	Rated voltage	: 11 kV
	Revolution speed	: Same as engine
	Power factor	: 0.8 (lag)
	Frequency	: 50 Hz
	Winding connection	: Y connection, with neutral drawout
	Excitation	: Brushless thristor system
(3) Enclosure for D/G set	Structure	: Steel structure
	Noise insulation	: Approx. 80 - 85 dB(A) at point of 1 m from the outside
	Hook for maintenance	: The strength of structure must be enough to overhaul piston.
	Illumination	: Approx. 300 luxes
	Fire fighting equipment	: Two (2) sets of "ABC" dry chemical fire extinguishers, portable type
	Automatic fire alarm system ventilation blower and duct	: Ionization type smoke sensor, connecting panel in the power house
(4) Mechanical equipment		
1) Fuel oil system		
① Heavy oil transfer pump	Electric motor, gear pump, and filter included	

Main equipment	Basic specification
② Heavy oil buffer tank	1,000ℓ
③ Diesel oil transfer pump	Electric motor, gear pump, and filter included
④ Diesel oil service tank	1,000ℓ
⑤ Heavy oil purifier unit	Electric motor, automatic sludge discharge type
⑥ Heavy oil service tank	1,000ℓ
⑦ Fuel oil mixing tank	100ℓ, fuel oil change-over cock included
⑧ Fuel oil flow meter	
⑨ Fuel oil filter	Primary, secondary and third filter
⑩ Fuel oil heater	Steam regulating valve included
⑪ Fuel oil pressure regulating valve	
⑫ Fuel oil drain discharge pump	Electric motor, gear pump and filter included
⑬ Fuel oil drain tank	100ℓ
2) Lub. oil system	
① Lub. oil sump tank	Approx. 7,000ℓ
② Lub. oil priming pump	Electric motor, gear pump
③ Lub. oil cooler	Lub. oil temp. regulating valve included
④ Lub. oil main filter	50μ max.
⑤ Back-washing oil filter	
⑥ Lub. oil purifier unit	Electric motor, automatic sludge discharge type
⑦ Lub. oil pressure regulating valve	
⑧ Lub. oil transfer pump	Electric motor, gear pump
3) Cooling water system	
① Water feed pump	Electric motor, centrifugal pump
② Jacket water expansion tank	250ℓ
③ Jacket cooling water pump	Electric motor, centrifugal pump

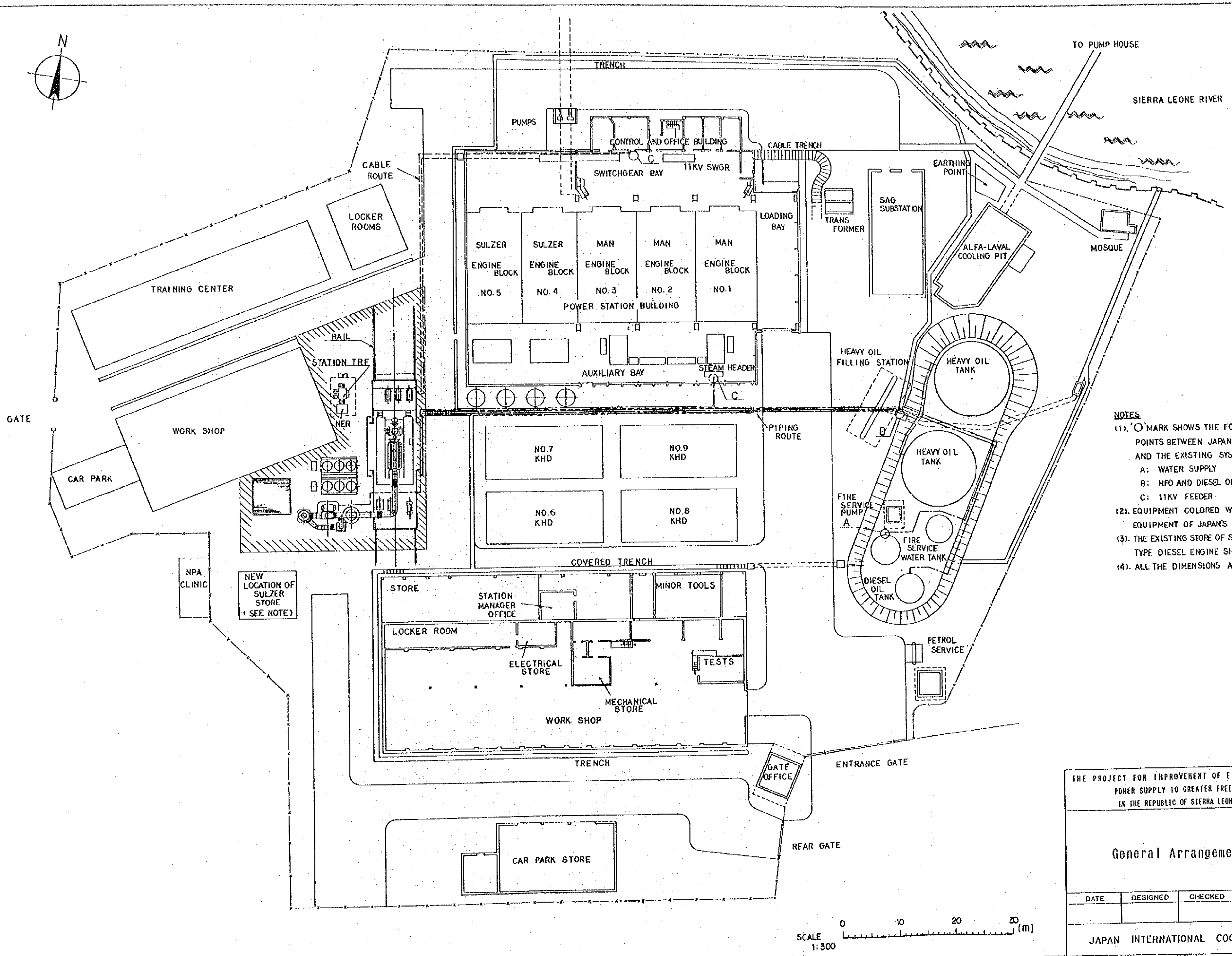
Main equipment	Basic specification
④ Jacket cooling water temp. regulating valve	
⑤ Cooling water radiator	
⑥ Secondary cooling water pump	Electric motor, centrifugal pump
⑦ Chemical feed unit	50ℓ
4) Steam system	
① Exhaust gas boiler	Steam evaporation : 1 t/h
② Feed water pump	Electric motor, centrifugal pump
③ Feed water tank	3 kℓ
④ Softener	$1.63m^3/h$
⑤ Softener feed water pump	Electric motor, centrifugal pump
5) Compressed air system	
① Air compressor	Electric motor driven
② Air receiver	Volume for three times start-up
③ Air pressure reducing valve	
6) Air intake and exhaust gas system	
① Exhaust gas silencer	Tail pipe included, noise level approx. 100 dB(A) at outlet
② Exhaust gas ducts	
③ Intake air ducts	
④ Intake air filter	
⑤ Intake air silencer	
7) Sludge treatment system	
① Sludge tank	300ℓ
② Sludge discharge pump	Electric motor, screw pump
③ Sludge separator tank	2,000ℓ
④ Oily water transfer pump	Electric motor, screw pump
⑤ Oily water separator	$1m^3/h$
⑥ Waste oil transfer pump	Electric motor, screw pump
⑦ Waste oil tank	1,000ℓ

Main equipment	Basic specification
(5) Electrical equipment	
① 11kV switchgear for line connection	12kV, 1200A, 50Hz, 25kA, BRUSH type, vacuum circuit breaker
② 11kV switchgear for generator	12kV, 1200A, 50Hz, 25kA, vacuum circuit breaker
③ Local control panel	Generator control panel and auxiliary control panel
④ Remote control panel	Desk type (same shape as the existing panel)
⑤ Excitation system	Including AVR panel
⑥ DC power supply unit	Lead-acid battery, including DC-DC converter (110V/220VDC)
⑦ Auxiliary transformer	11kV/400V, 300kVA, including primary disconnecting switch (12kV, 200A)
⑧ Neutral earthing panel	6.9kV, 10.2 ohm
⑨ Communication system for maintenance	Interphone, to be installed in local control panel and remote control panel

(2) Basic Design Drawings

The Power Station for the project is as shown in Fig. SLB-01 and contents of the basic design of the generating facilities are as shown in Figs. SLB-02 to -11.

SLB-01 General Arrangement Drawing
SLB-02 Generating Facilities Layout Drawing
SLB-03 Fuel Oil System Drawing
SLB-04 Lubricant Oil System Drawing
SLB-05 Cooling Water System Drawing
SLB-06 Steam System Drawing
SLB-07 Compressed Air System Drawing
SLB-08 Sludge Treatment System Drawing
SLB-09 Single Line Connection Diagram
SLB-10 11 kV Switchgear Layout Drawing
SLB-11 Remote Control Layout Drawing



NOTES

(1). 'O' MARK SHOWS THE FOLLOWING CONNECTING POINTS BETWEEN JAPAN'S GRANT-AID PROJET AND THE EXISTING SYSTEM.

A: WATER SUPPLY

B: HFO AND DIESEL OIL

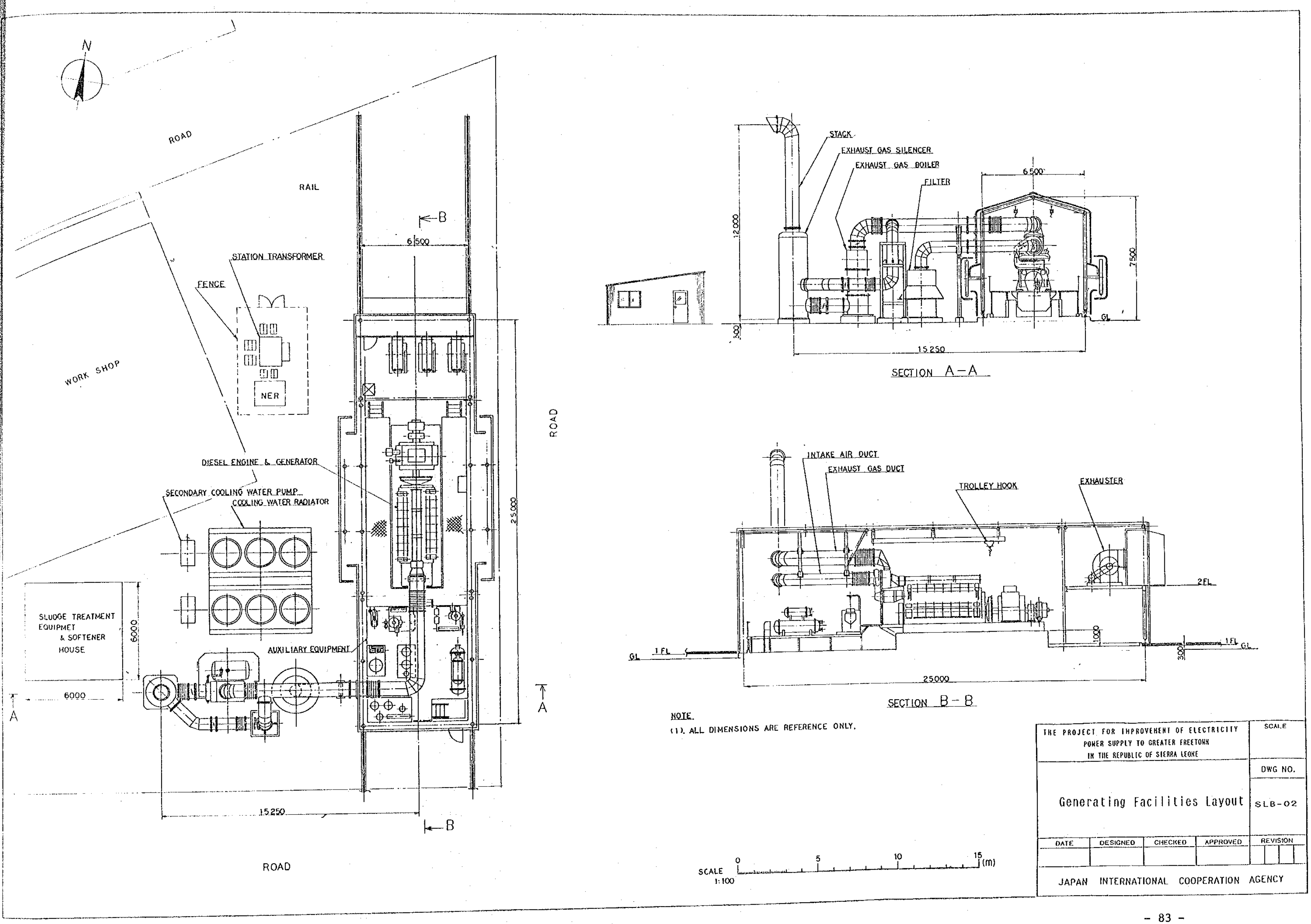
C: 11KV FEEDER

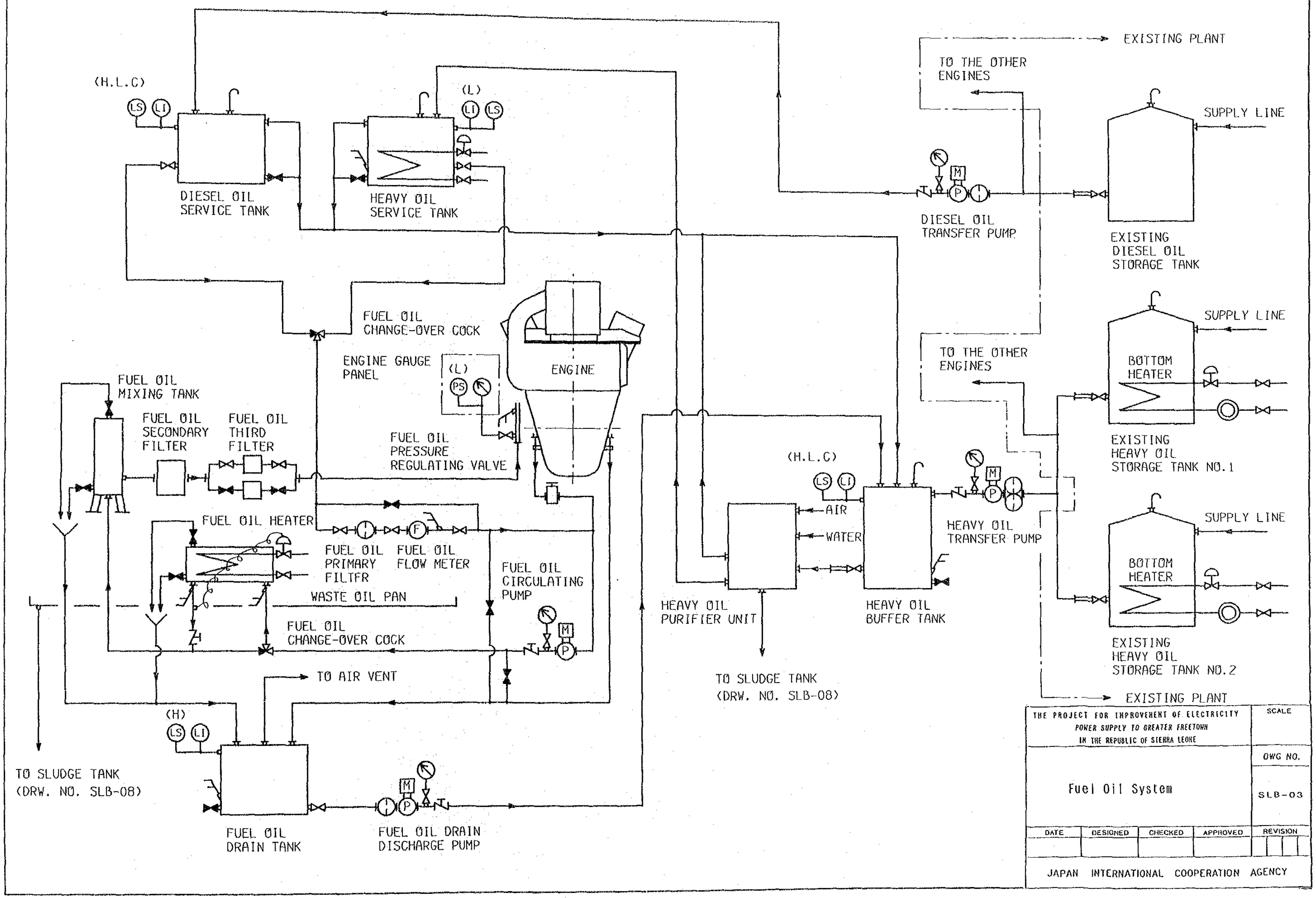
(2). EQUIPMENT COLORED WITH ▨ SHOWS EQUIPMENT OF JAPAN'S GRANT-AID PROJET.

(3). THE EXISTING STORE OF SPARE PARTS FOR SULZER TYPE DIESEL ENGINE SHALL BE RELOCATED BY NPA.

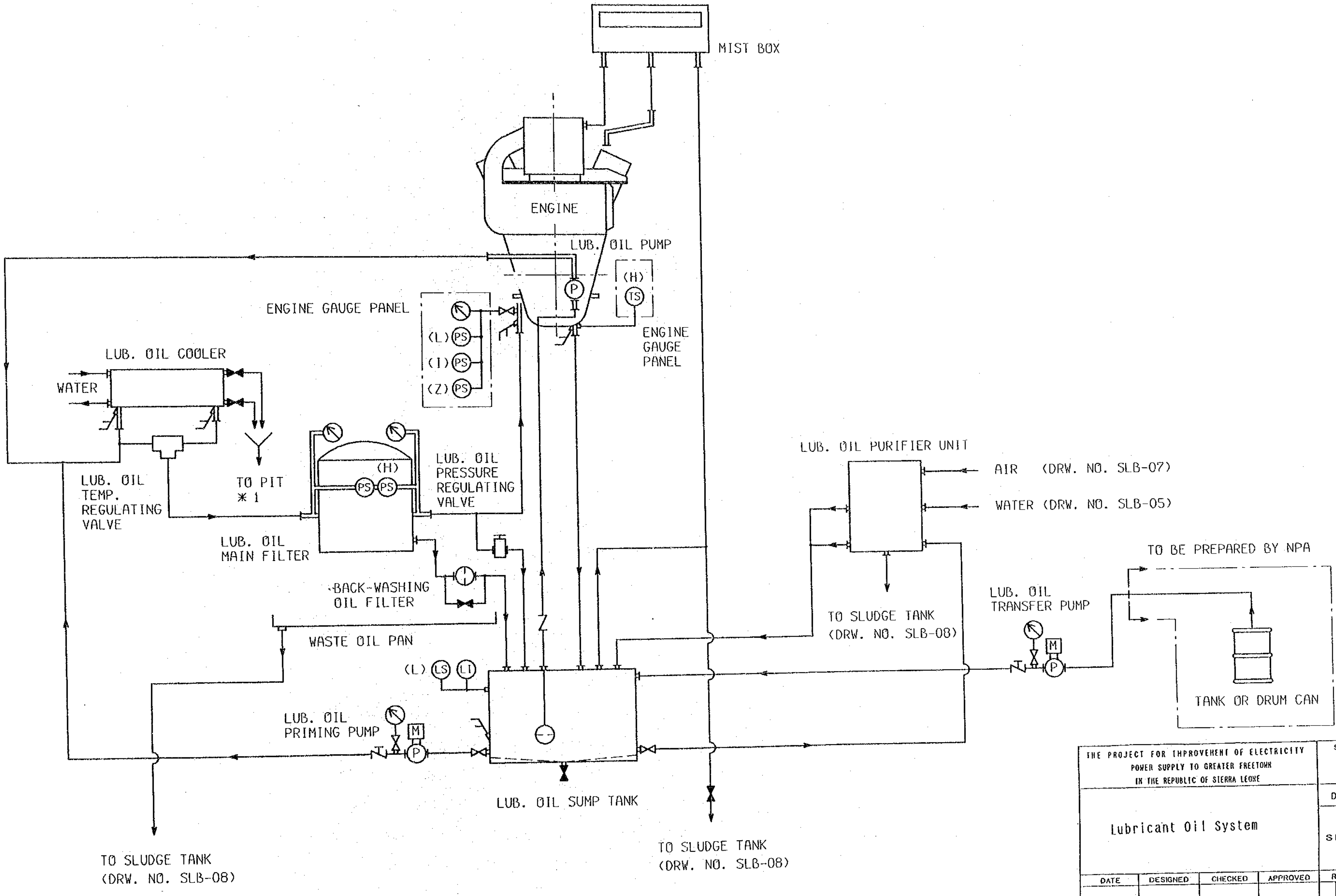
(4). ALL THE DIMENSIONS ARE REFERENCE ONLY.

THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE				SCALE
General Arrangement				DWG NO. SLB-01
DATE	DESIGNED	CHECKED	APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY				


N
ROAD
RAIL
WORK SHOP
STATION TRANSFORMER
FENCE
NER
DIESEL ENGINE & GENERATOR
SECONDARY COOLING WATER PUMP
COOLING WATER RADIATOR
SLUDGE TREATMENT EQUIPMET & SOFTENER HOUSE
AUXILIARY EQUIPMENT
6500
25000
6000
15250
ROAD
ROAD
B
A
STACK
EXHAUST GAS SILENCER
EXHAUST GAS BOILER
FILTER
12000
7500
300
GL
15250
SECTION A-A
INTAKE AIR DUCT
EXHAUST GAS DUCT
TROLLEY HOOK
EXHAUSTER
2FL
1FL
1000
25000
SECTION B-B
NOTE
(1). ALL DIMENSIONS ARE REFERENCE ONLY.
SCALE 1:100
0 5 10 15 (m)
THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE
SCALE
DWG NO.
Generating Facilities Layout
SLB-02
DATE
DESIGNED
CHECKED
APPROVED
REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY

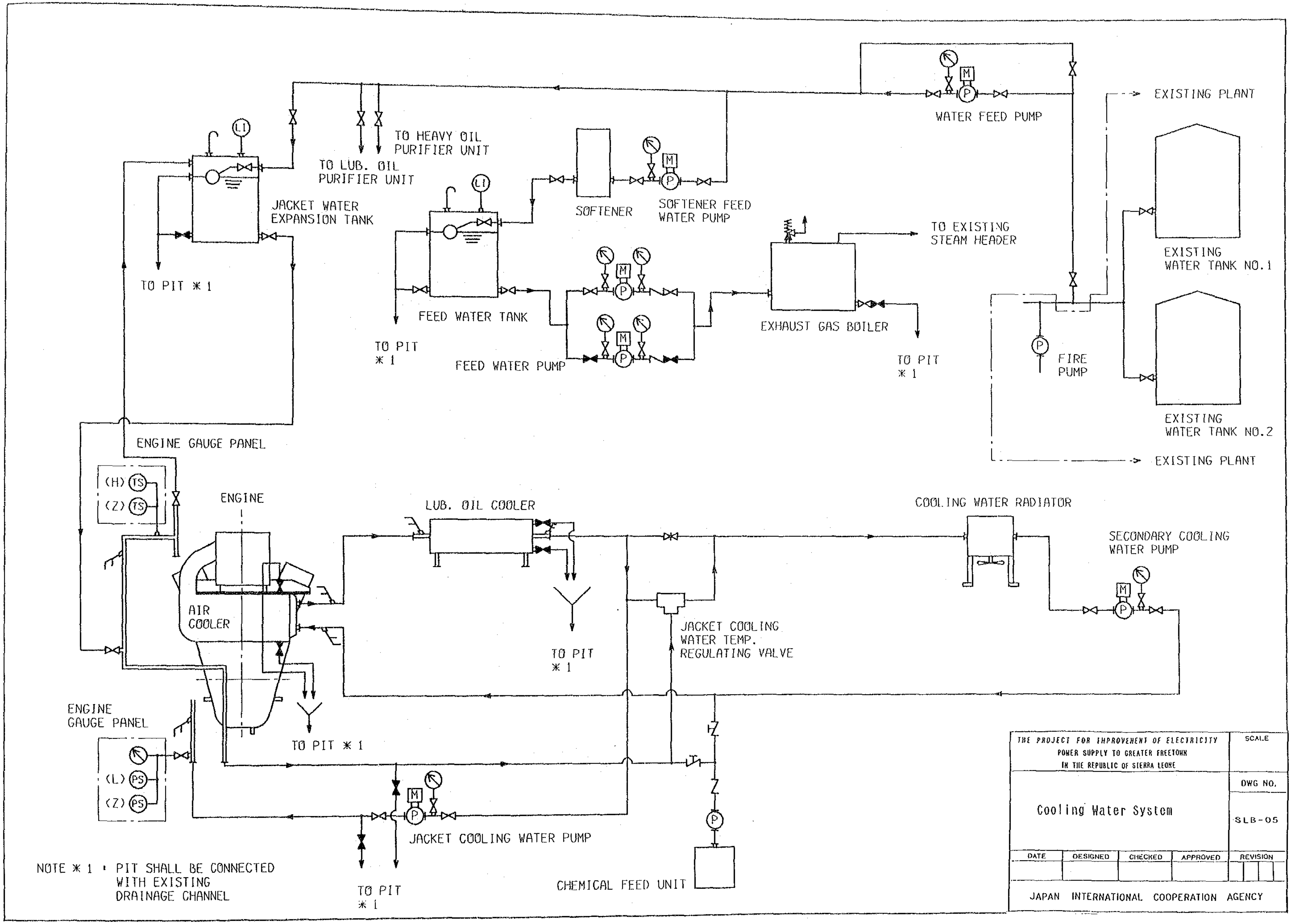


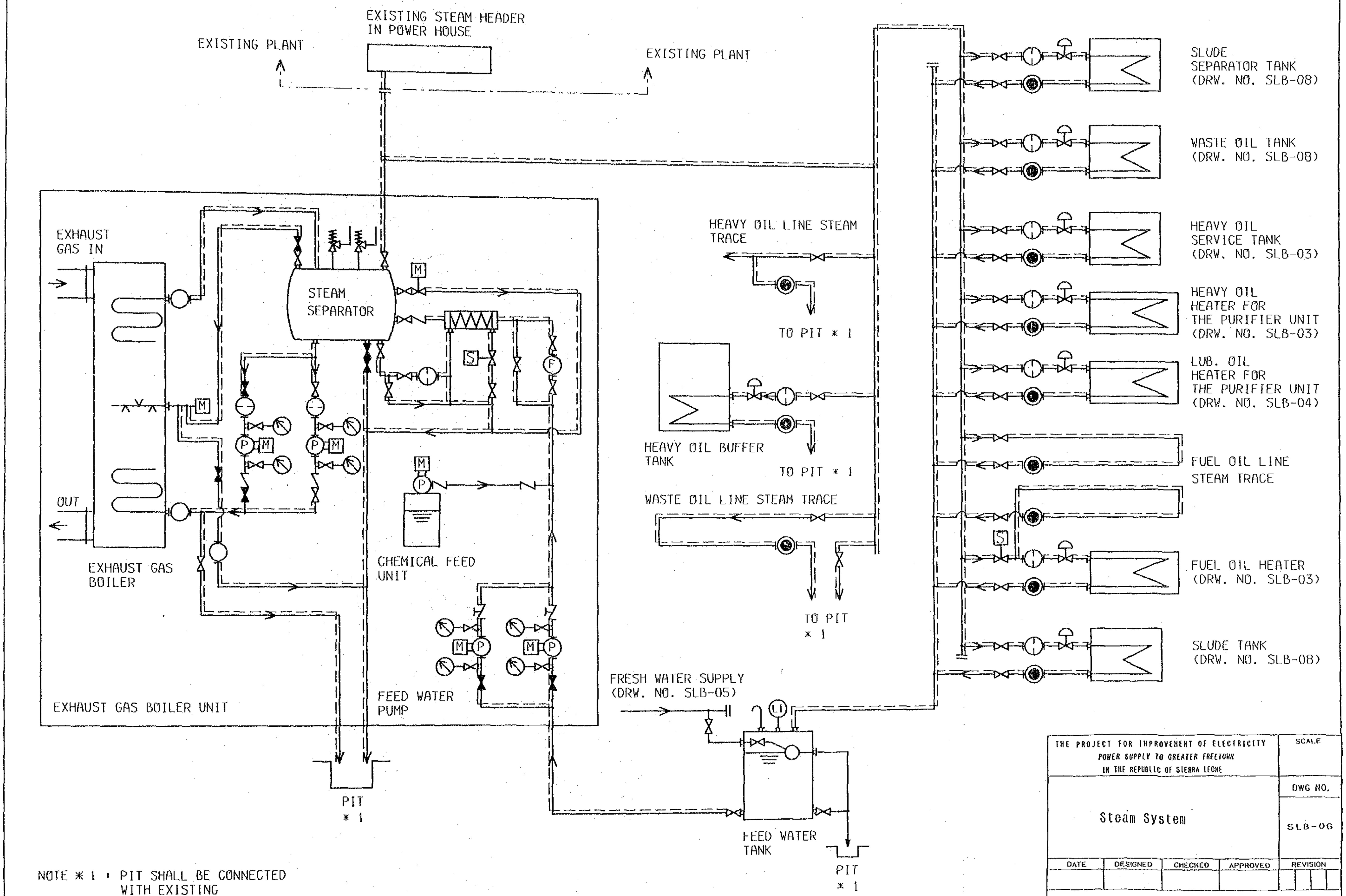
THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE	SCALE
Fuel Oil System	DWG NO. SLB-03
DATE / DESIGNED / CHECKED / APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY	



NOTE ※ 1 : PIT SHALL BE CONNECTED WITH EXISTING DRAINAGE CHANNEL

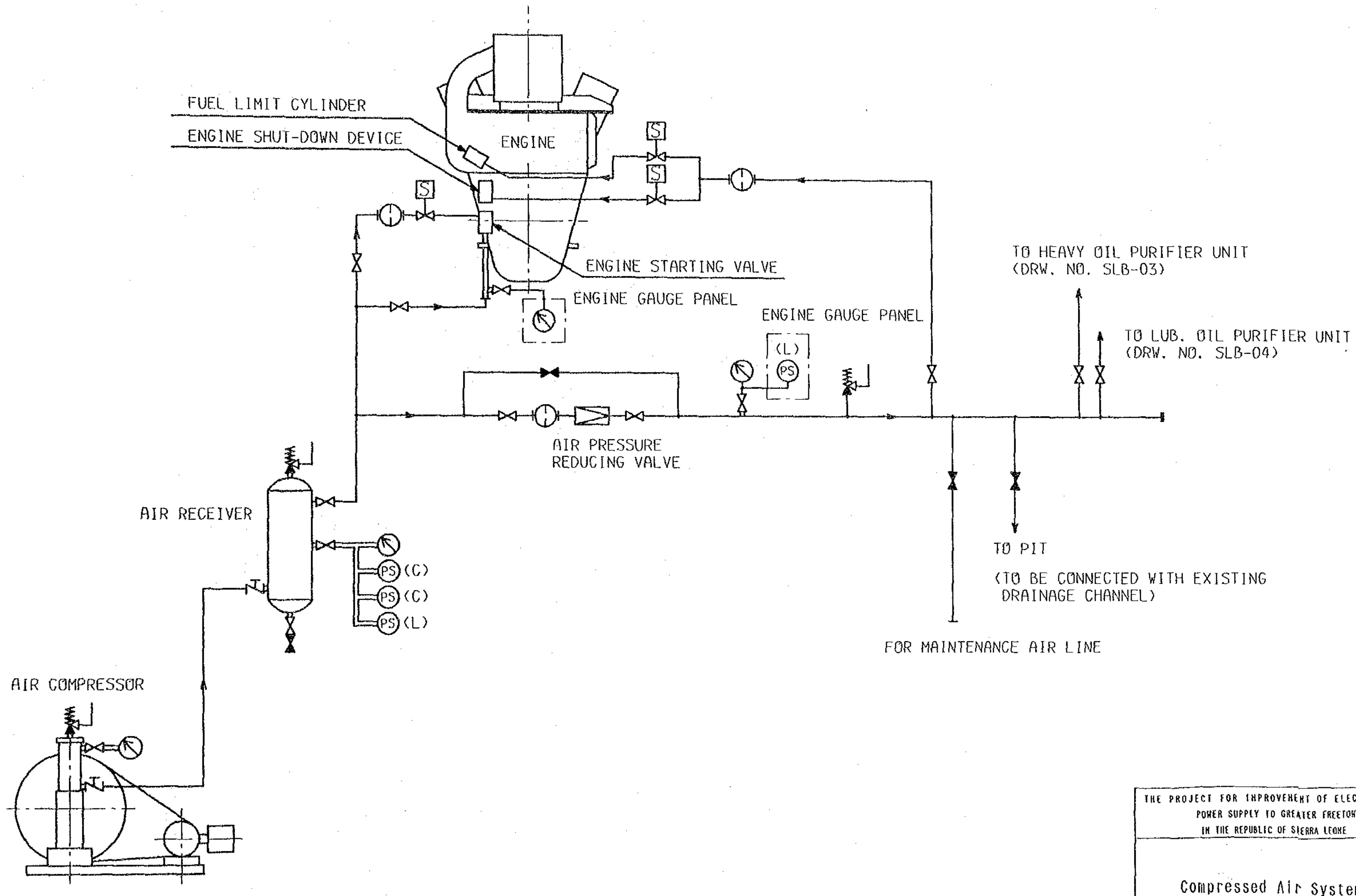
THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE				SCALE
Lubricant Oil System				DWG NO. SLB-04
DATE	DESIGNED	CHECKED	APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY				


EXISTING PLANT
WATER FEED PUMP
TO HEAVY OIL
PURIFIER UNIT
TO LUB. OIL
PURIFIER UNIT
JACKET WATER
EXPANSION TANK
SOFTENER
SOFTENER FEED
WATER PUMP
TO EXISTING
STEAM HEADER
EXISTING
WATER TANK NO.1
TO PIT ＊1
FEED WATER TANK
EXHAUST GAS BOILER
TO PIT
＊1
FEED WATER PUMP
TO PIT
＊1
FIRE
PUMP
EXISTING
WATER TANK NO.2
ENGINE GAUGE PANEL
EXISTING PLANT
(H) TS
(Z) TS
ENGINE
LUB. OIL COOLER
COOLING WATER RADIATOR
SECONDARY COOLING
WATER PUMP
AIR
COOLER
JACKET COOLING
WATER TEMP.
REGULATING VALVE
TO PIT
＊1
ENGINE
GAUGE PANEL
TO PIT ＊1
(L) PS
(Z) PS
JACKET COOLING WATER PUMP
NOTE ＊1 : PIT SHALL BE CONNECTED
WITH EXISTING
DRAINAGE CHANNEL
TO PIT
＊1
CHEMICAL FEED UNIT
THE PROJECT FOR IMPROVEMENT OF ELECTRICITY
POWER SUPPLY TO GREATER FREETOWN
IN THE REPUBLIC OF SIERRA LEONE
SCALE
DWG NO.
Cooling Water System
SLB-05
DATE
DESIGNED
CHECKED
APPROVED
REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY

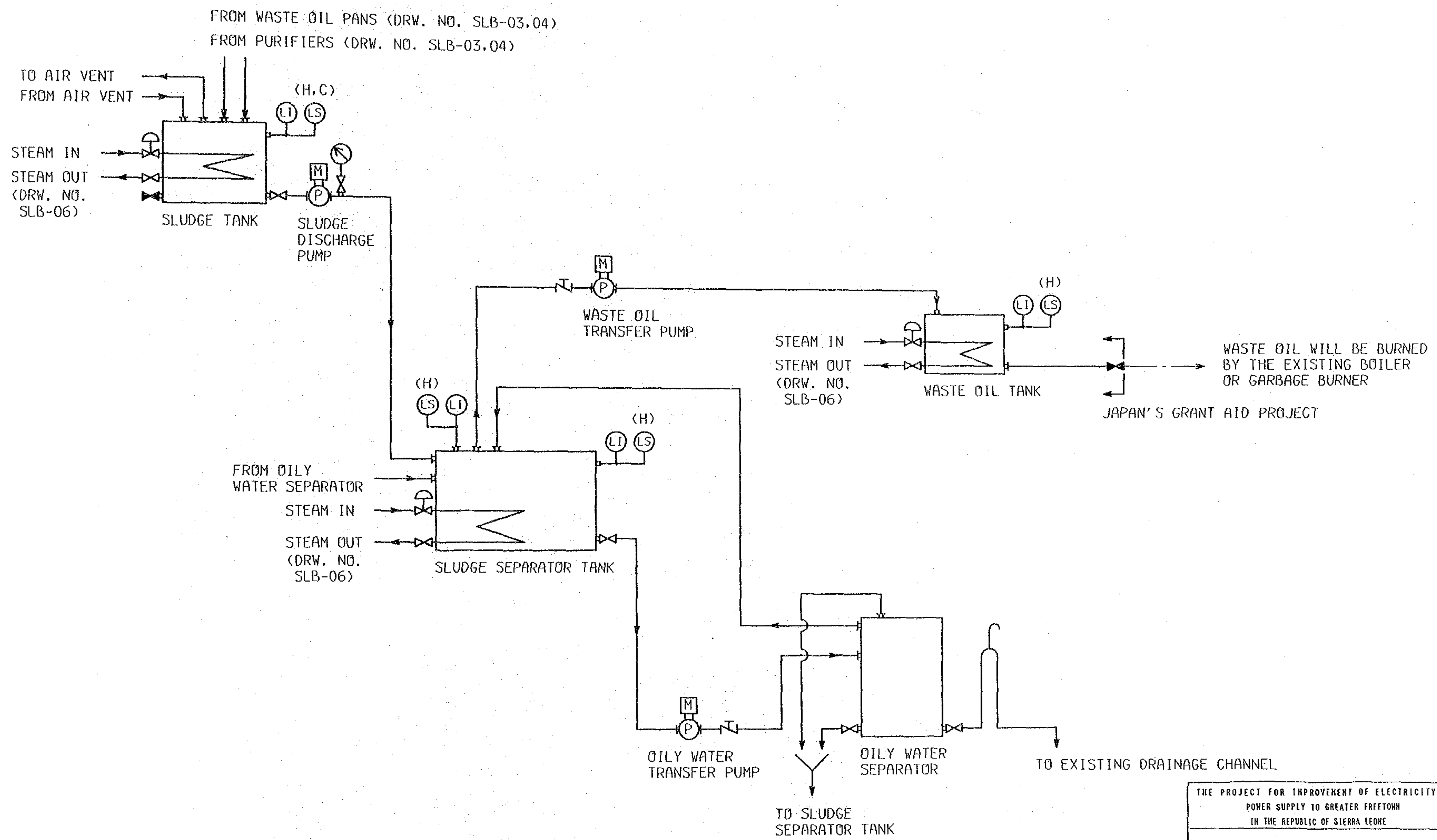


NOTE * 1 : PIT SHALL BE CONNECTED
WITH EXISTING
DRAINAGE CHANNEL

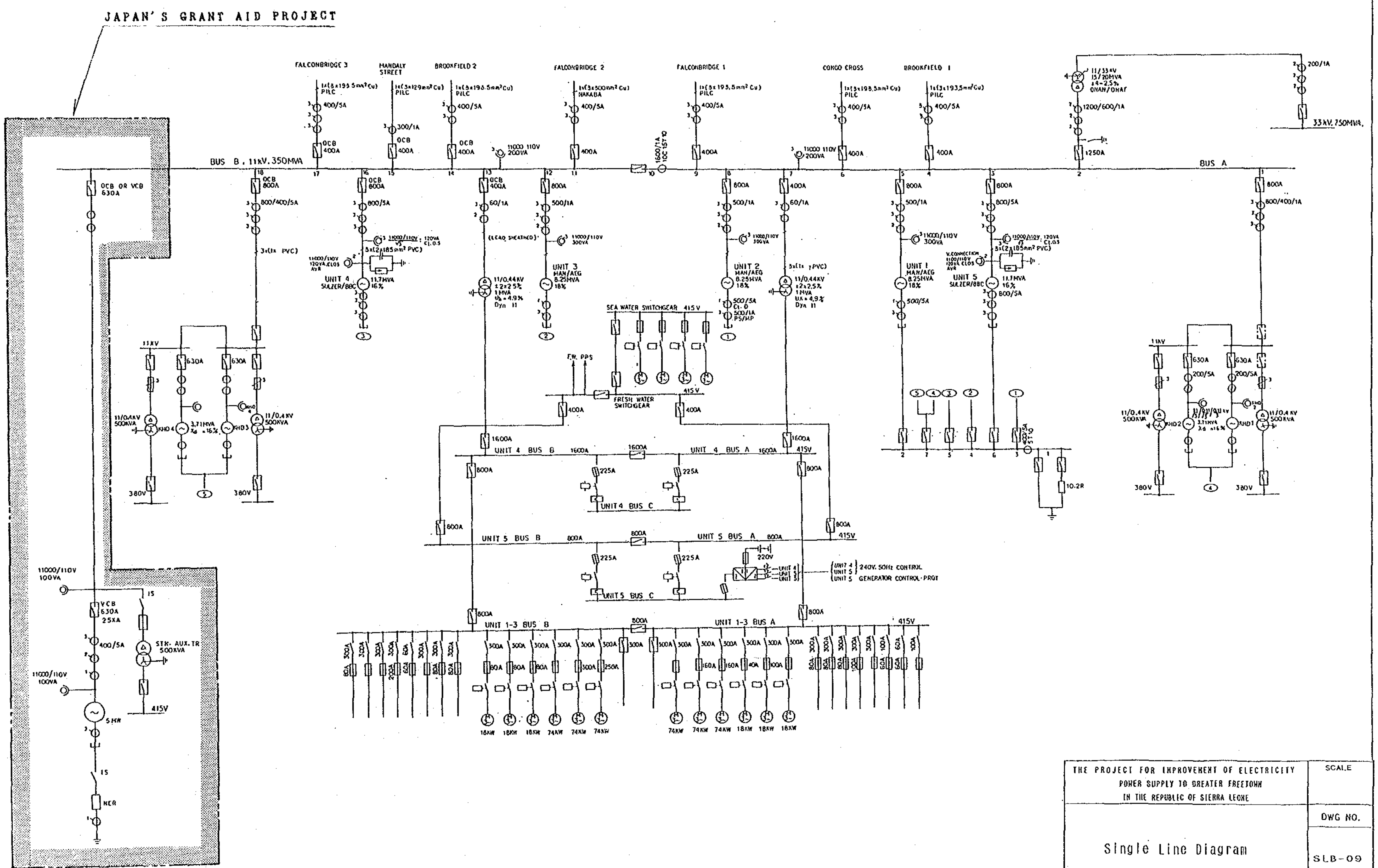
THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE				SCALE
Steam System				DWG NO. SLB-06
DATE	DESIGNED	CHECKED	APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY				



THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE				SCALE
Compressed Air System				DWG NO. SLB-07
DATE	DESIGNED	CHECKED	APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY				



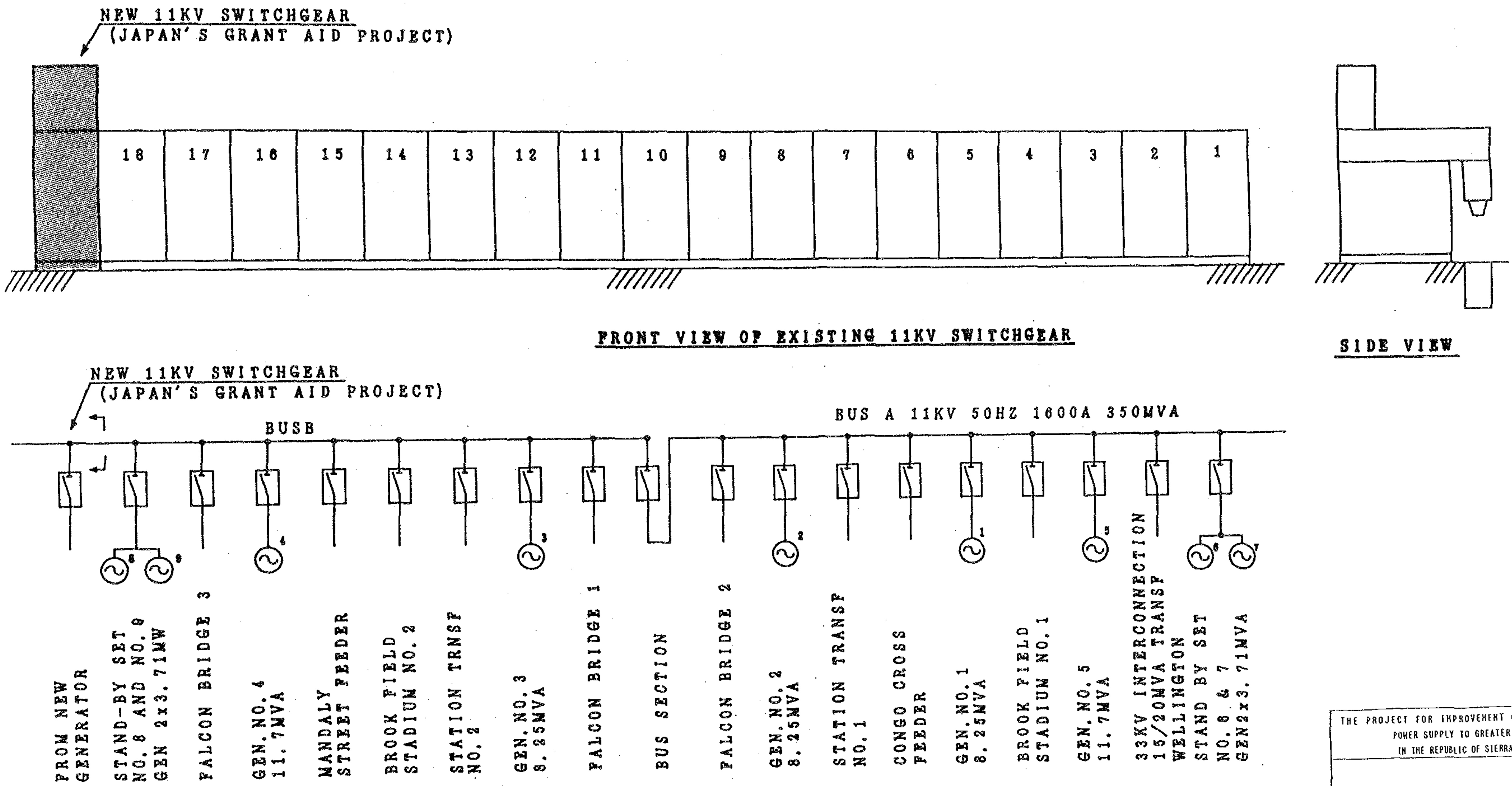
THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE	SCALE
Sludge Treatment System	DWG NO. SLB-08
DATE / DESIGNED / CHECKED / APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY	



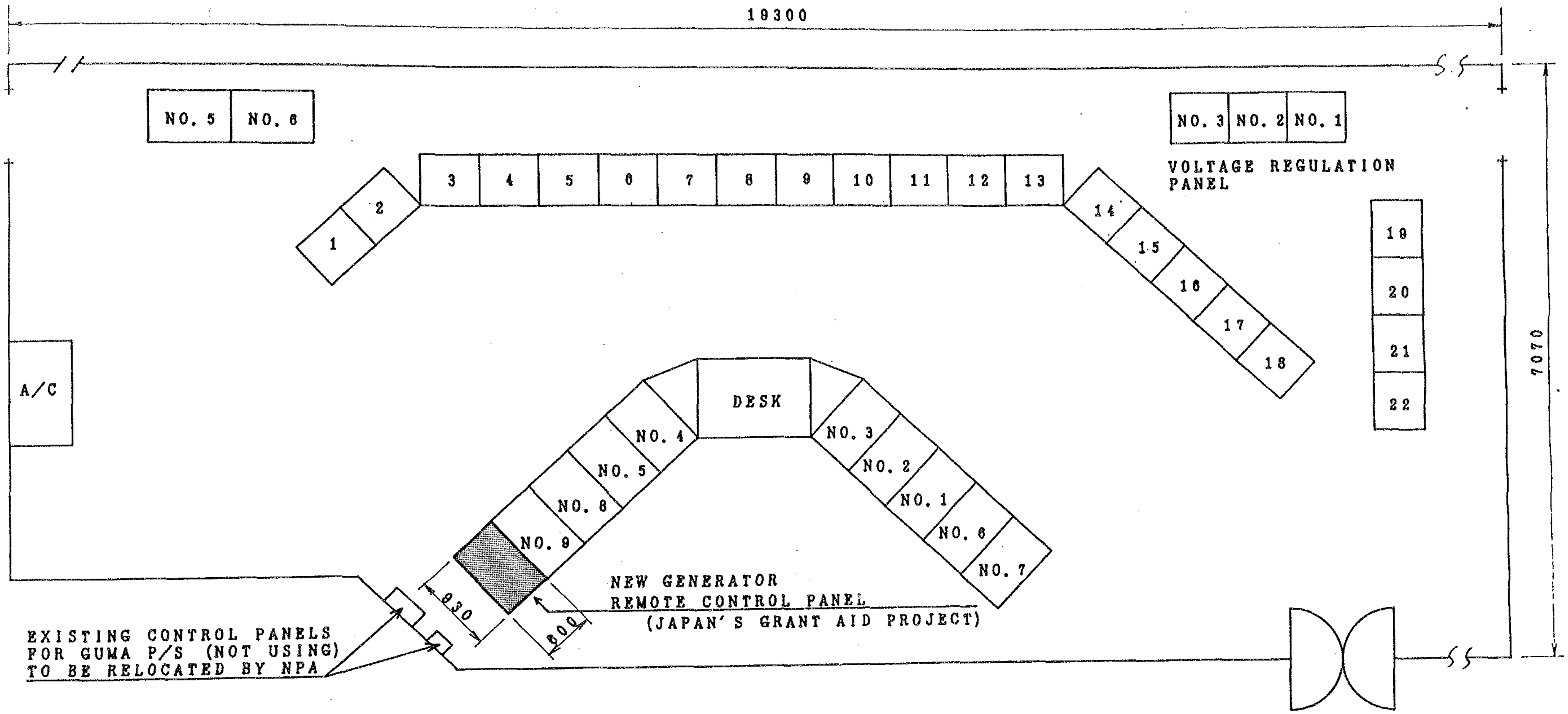
THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE	SCALE
	DWG NO.
Single Line Diagram	SLB-09

DATE	DESIGNED	CHECKED	APPROVED	REVISION

JAPAN INTERNATIONAL COOPERATION AGENCY



THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE	SCALE
Layout of 11 kV Switchgear	DWG NO. SLB-10
DATE / DESIGNED / CHECKED / APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY	



1	15/20MVA 33/11KV TRANSFORMER	9	STATION TRANSFORMER NO. 2	17	GENERATOR NO. 1
2	FALCON BRIDG NO. 3	10	GENERATOR NO. 3	18	BROOK FIELD STADIUM NO. 1
3	GENERATOR NO. 5 CONTROL	11	FALCON BRIDGE NO. 1 FEEDER	19	METERING AND RECORDING PANEL
4	GENERATOR NO. 5 PROTECTION	12	BUS SECTION	20	ALAMES PANEL
5	GENERATOR NO. 4 CONTROL	13	FALCON BRIDGE NO. 2 FEEDER	21	STANDARD TIME PANEL
6	GENERATOR NO. 4 PROTECTION	14	GENERATOR NO. 2	22	BUS ZONE PROTECTION PANEL
7	MANDALAY STREET	15	STATION TRANSFORMER NO. 1		
8	BROOK FIELD STADIUM NO. 2	16	CONGO CROSS FEEDER		

THE PROJECT FOR IMPROVEMENT OF ELECTRICITY POWER SUPPLY TO GREATER FREETOWN IN THE REPUBLIC OF SIERRA LEONE	SCALE
Layout of Remote Control Panel	DWG NO. SLB-11
DATE / DESIGNED / CHECKED / APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY	

5-3-3 Equipment and Materials Procurement Plan

(1) Contents of Plan

According to the aforementioned plan policy (see 4-3-2), the equipment and material procurement plan will be formulated as follows:

1) To procure spare parts for 16,000 hours of operation (for 1 major overhaul cycle)
2) To procure tools for maintenance
3) To procure teaching materials for OJT

(2) Major Items of Equipment and Materials

1) Spare parts

a) Diesel engine parts
b) Auxiliary equipment and its parts
c) Generator parts
d) Electric equipment parts

2) Tools for maintenance

Tools required for work such as periodical inspection and overhauls of the generating facilities, as well as for replacement of parts

3) Materials for OJT

Contents and quantity of OJT materials are as follows:

a) Training materials : 20 copies
b) O & M manual : 20 copies

5-3-4 OJT Plan

(1) Details of OJT Plan

According to the basic policy as stated in 4-3-2, OJT will be conducted as follows:

1) Period for conduct of OJT

Classroom training	:	about one week
Practice for maintenance and operation	:	about five months at the time of construction work

2) Instructor

One engineer will be sent by a Japanese contractor as a trainer.

3) Trainees

Engineers who will be directly engaged in maintenance control of the generator after the completion of the Project, as appointed by Sierra Leone, should participate in the training.

a) One general coordinator

b) Maintenance engineers

- One mechanical engineer
- One electrical engineer

c) Maintenance technicians

- Three mechanical technicians
- One electrical technicians

4) Detail of training

a) Classroom training

① Control technology

- O & M schedule control (conception for preventive maintenance, functional analysis of facilities, effective scheduling for O & M work)
- Control of spare parts and tools
- Documents control for O & M

② Technology related to rehabilitation of generating facility

b) Practice of rehabilitation work for generating facility

a) Maintenance of cylinder head
b) Dismantling and maintenance of fuel valve
c) Grinding finish of inlet and outlet valve
d) Dismantling and maintenance of piston
e) Overhaul and inspection of crank pin bearings
f) Maintenance of motor pump
g) Cleaning of air inlet filter, radiator filter and so on

5) Training method

a) After the conduct of OJT, training materials will be provided to trainees for practical use as O & M.

b) O & M manual for generating facility will be provided to use as practice related to maintenance and inspection.

5-4 Implementation Plan

5-4-1 Construction Condition

(1) Situation of Local Construction

1) Engineers and workers capable of executing foundation and other work can be locally employed.

2) No engineers capable of executing installation, adjustments, etc., of such large generating facilities as for the project can be locally employed.

3) It is believed construction equipment and machinery for work can be locally supplied except for special items such as welding machines.

4) Queen Elizabeth II Port will be selected for unloading equipment and materials because it is the nation's largest unloading port. However, since no large cargo handling equipment is available at this port, heavy derricks need to be used.

5) For inland transportation for about 5 km from the port to the project site, roads can be used if care is taken in transport although they have many potholes.

   However, many low overhead utilities lines and telephone cables (about 4 m above the ground) run over roads and these lines and cables must be temporarily relocated by NPA during transport.

(2) Instructions to be Followed in Execution

1) The rainy season runs from June to September. No local work can be undertaken during this period because the monthly rainfall may reach as high as about 800 mm. It is therefore necessary to conduct concreting work, underground installation work, etc., other than in this period.