Federal Ministry of Power (FMP)
Jebba Hydro Electric Plc. (JHEP)
The Federal Republic of Nigeria

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR
EMERGENCY REPAIR AND
OVERHAUL WORKS FOR
THE JEBBA HYDRO POWER STATION
IN
THE FEDERAL REPUBLIC OF NIGERIA

MARCH 2012

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YACHIYO ENGINEERING CO., LTD.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey to Yachiyo Engineering Co., Ltd.

The survey team held a series of discussions with the officials concerned of the Government of the Federal Republic of Nigeria, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Nigeria for their close cooperation extended to the survey team.

March, 2012

Kyoko KUWAJIMA
Director General,
Industrial Development and Public Policy Department
Japan International Cooperation Agency

Summary

① Outline of the Country

The Federal Republic of Nigeria (hereafter referred to as Nigeria), facing onto the Gulf of Guinea in the central part of Western Africa, covers an area of 924,000 square kilometers, has a population of approximately 140 million (2007, according to the National Bureau of Statistics, Nigeria) and is one of the world's biggest producers of petroleum. Its national land area is approximately 2.5 times the size of Japan and is divided into the semi-arid north, which has a Sub-Saharan climate, and the marshy south that is partitioned by the Benue River and Niger River. In terms of cultural background too, the country is divided into the northern and southern halves with distinct living styles in each. Nigeria holds the largest reserves of petroleum and natural gas in Africa; in 2010 it produced 2.15 million barrels per day, and crude oil and natural gas accounted for approximately 75 percent of total export value that year. The per capita GNI of Nigeria is US$1,180 (2011, World Bank), and the Human Development Index is 0.295 (United Nations Development Plan, 2011), making Nigeria 186th out of 187 countries.

② Background of the Project

The main power stations of Nigeria were constructed during the period from the middle of the 1960s to the latter part of the 1980s, however, facilities are badly deteriorated, they cannot undergo overhaul due to insufficient spare supply capacity and there is a lack of spare parts and engineers. As a result, power shortages occur all over the country. Currently, approximately 65 percent of the generating facilities owned by the Power Holding Company of Nigeria (PHCN) have been in use beyond the statutory service life (15 years) and are in need of urgent upgrading. Due to the lack of maintenance of generating facilities and suspension of new investments due to the economic stagnation of Nigeria, deterioration of PHCN-owned generating facilities is advancing and major power outages are frequently occurring in even urban centers. Accordingly, many enterprises and large-scale users operate their own private generators. In order to address the deterioration of generating facilities, the Government of Nigeria had plans to rapidly promote the introduction of IPPs and boost generating equipment capacity to 10,000 MW by December 2010, however, it has been slow putting these plans into effect and the issue of power shortages has still not been resolved. The peak demand for power in Nigeria is growing every year and the demand for power has recently reached approximately 6,800 MW. Meanwhile, although the total plant capacity of existing thermal and hydropower generating facilities is given as 6,600 MW, actual output in July 2010 is 3,825 MW due to deterioration of equipment at hydropower dams, thus creating an absolute shortage in supply capacity.

Jebba Hydro Power Station, which is operated by Jebba Hydro Electric Plc. (JHEP) under the jurisdiction of PHCN, utilizes the hydroelectric energy of the Niger River and is equipped with six water turbine and generator units possessing rated plant capacity of 578.4 MW. The plant was completed in 1985. Together with Kainji Hydro Power Station and Siroro Hydropower Station, this

plant has helped shoulder the burden of power supply in Nigeria. However, plant output is greatly restricted at present because the Unit 4 and 6 generators suffered major damage as a result of a lightning-induced failure in April 2009. The Nigeria side has tendered repairs for Unit 6 through its own funding and the necessary work is currently being implemented. Against such a background, the Government of Nigeria issued a request to the Government of Japan seeking the urgent rehabilitation of the Unit 4 generator (96.4 MW, vertical axis propeller turbine) at Jebba Hydro Power Station. Based on the request, the Government of Japan consigned JICA to implement the preliminary survey from January 17 to February 2, 2011, in which it ascertained the contents of the request and verified its appropriateness. Based on the survey findings, the governments of the two countries signed the Exchange of Notes (E/N) on April 11, 2011, while JICA and the Government of Nigeria signed the Grant Agreement (G/A) on May 17 the same year.

③ Outline of the Study findings and contents of the Project

Based on the above preliminary survey, the Government of Japan decided to implement the preparatory survey (the survey) and JICA dispatched the survey team to Nigeria from July 27 to August 19, 2011 in order to confirm the contents of the request and discuss the implementation contents with the Nigeria officials, conduct field investigation of the Project site and collect related materials. After returning to Japan, based on the materials collected in the field, the team examined the necessity, appropriateness and social and economic effects and so on of the Project and compiled the findings into the draft report on the preparatory survey. JICA dispatched the study team to explain the draft report on the preparatory survey from January 18 to January 27, 2012, and the team explained and discussed the draft report with the Nigeria side and reached a basic agreement with the Government of Nigeria.

In the survey, based on the findings of the preliminary survey, rough design and cost estimation were carried out on the necessary and optimum contents and scale to realize the achievements described within the framework of the concluded E/N and G/A. In addition, examination was conduced on the contents of the Nigerian scope of works, implementation plan and important points in operation and maintenance for achieving the Project goals such as restoring generation capacity of Unit 4 and so on.

In particular, concerning the scope of the assistance, the contents of the request were prioritized via field survey, etc. upon conducting evaluation of the technical appropriateness based on the thinking described in the table below.

Table Contents of Rehabilitation Equipment, Instruments and Parts for Unit 4 Generator

Item	Contents
Restoration of parts broken by the accident of 2009	Renew the insulation of the stators and rotor coils. Specifically, through replacing the coil that carries current in the generator rotor and stator, renew the coil insulation that experiences temperature increase following use and degradation over an extended period. Since current flow through conducting wire generally tends to slow down when temperature increases, replacing insulated parts makes it possible to reduce temperature

	and improve safety and efficiency. Such repair work is referred to as insulation renewal. Moreover, through replacing the parts that connects coils to coils and securing balance, it is possible to minimize vibration and achieve smooth and stable rotation.
Overhaul in line with deterioration over time	Replace the parts (thrust bearings and air cooler, etc.) that can only be replaced when the generator undergoes disassembly.
Equipment improvement	Also conduct parts replacements (sensors, etc.) related to equipment improvement over the extend that is possible.

As a result, basic agreement was reached with the Nigerian side concerning the following general contents of assistance

1) Stator core and associated parts
2) Stator coil and associated parts
3) Rotor pole
4) Rotor rim support modification parts
5) Repair parts and instruments
6) Current transformer for measuring instruments
7) Site work

④ Project implementation schedule and project cost estimation

The supervising government agency on the Nigerian side is the Federal Ministry of Power (FMOP), and the implementing agency is JHEP. It is estimated that approximately 21.5 months will be required as the equipment procurement lead-time from signing of the procurement agent agreement to installation. Moreover, the expenses to be borne by the Nigerian side are is estimated to be 106 million yen if the project implemented.

⑤ Project evaluation

It is anticipated that Project implementation will bring about the following effects.

- Appropriateness

  The Project will contribute to the realization of Nigeria's development plans that emphasize increased production of power, i.e. the 7 Point Agenda that was indicated in 2007 and the National Energy Policy. Also, since it will impart benefits to the general public including impoverished people, it is deemed to have high relevance as the Japanese Grant Aid Scheme undertaking. In terms of benefiting population, as a result of Project implementation, it will be possible to supply stable power to approximately 140 million residents of Nigeria. As the Project will lead to improvement of electric power equipment and enhancement of the peak generating output, it will help alleviate the problems at times of peak power, make it possible to extend utilization times and thereby contribute to improvement of citizen lifestyles and economic

development. Because power interruptions and voltage drop will be mitigated when operating x-ray and other medical instruments in hospitals and using power tools in industrial plants, it will become possible to use such instruments and tools for longer times, thereby making a contribution to economic development. The Unit 4 generator, which is targeted for improvement in the Project, is a large-scale unit made by a Japanese maker and possessing rated output of 96.4 MW. Since Nigeria has no makers capable of making a generator of similar scale, and the unit targeted for rehabilitation in the Project was made in Japan, there is deemed to be necessity and technical advantage in having a Japanese enterprise implement the Project work. Because the repair of Unit 4, which is having to operate in a damaged state, is an urgent requirement and expected to benefit the citizens of Nigeria including people living in poverty, it is deemed to be appropriate for implementation under the grant aid scheme of the Government of Japan.

- Effectiveness

  The following effects are anticipated as a result of Project implementation.

(1) Quantitative effects

1) Maximum output

Due to vibrations and such problems, Unit 4 is currently unable to generate sufficient even if water intake is increased from the dam. Because the Project will result in the renewal of meters needed in order to monitor temperature, etc. in coils, thrust bearings, coolers and other devices, it will become possible to safely secure output and the maintenance load will be mitigated. Concerning the reference value, output in 2010 has been adopted as the value for during and after 2009 when the accident occurred.

Indicator	Reference Value (2010)	Target Value (2016)
Maximum output (MW)	45.9 MW (47.6%)	96.4 MW (100%)

2) Available electric energy

Through replacing main parts such as rotor coils, stator coils and thrust bearings and so on in Unit 4, vibrations during operation will be reduced and it will be possible to provide stable power supply. In other words, setting the annual generated amount of power of Unit 4 as the quantitative indicator, the goal is to restore stable power supply based on rehabilitation aiming to attain an average value of this generated amount equivalent to the value prior to the accident in 2009. Specifically, the goal shall be to achieve an average amount of power generation in three years after Project completion equivalent to the mean value of power generation in the 10 years prior to the accident. (The appendices indicate movements in the generated amount of power at Jebba Hydropower Station).

Indicator	Reference Value (mean value from 1999 to 2008)	Target Value (mean amount of generated power over 3 years from 2014)
Available electric energy (GWh/year)	226 GWh/year	226 GWh/year

3) Frequency of major accidents

Operation of Unit 4 was suspended for three months as a result of the accident in 2009. It is currently barely operating but could be stopped by a vibration-caused accident again. In the case where repairs are conducted, it is anticipated that emergency stoppages lasting one month or more will be reduced to zero.

Indicator	Reference Value (2010)	Target Value (2013)
Frequency of major accidents (entailing stoppage of 1 month or longer)	1	0

4) Greenhouse gas emission reductions

When calculated based on the available electric energy in paragraph 2) above, the reduced amount of emissions of greenhouse gases will be as follows.

	Electric energy contributing to emissions reduction (GWh／year)	Baseline emissions (tCO_2／year)	Project emissions (tCO_2／year)	Leakage (tCO_2／year)	Total emissions reduction (tCO_2／year)
No.4 Generator	226	191,000	0	0	191,000

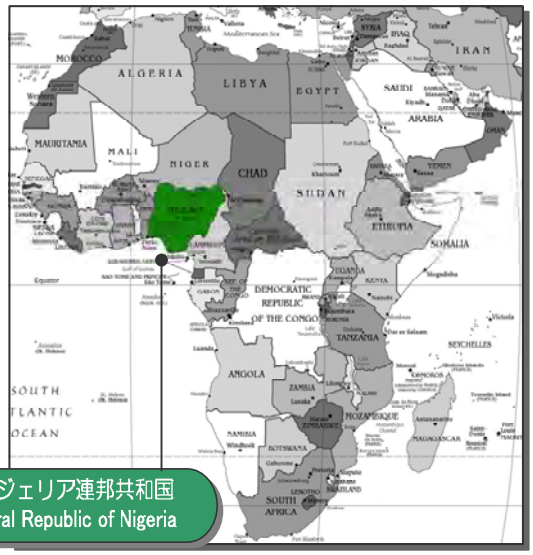
(2) Qualitative effects (Project overall)

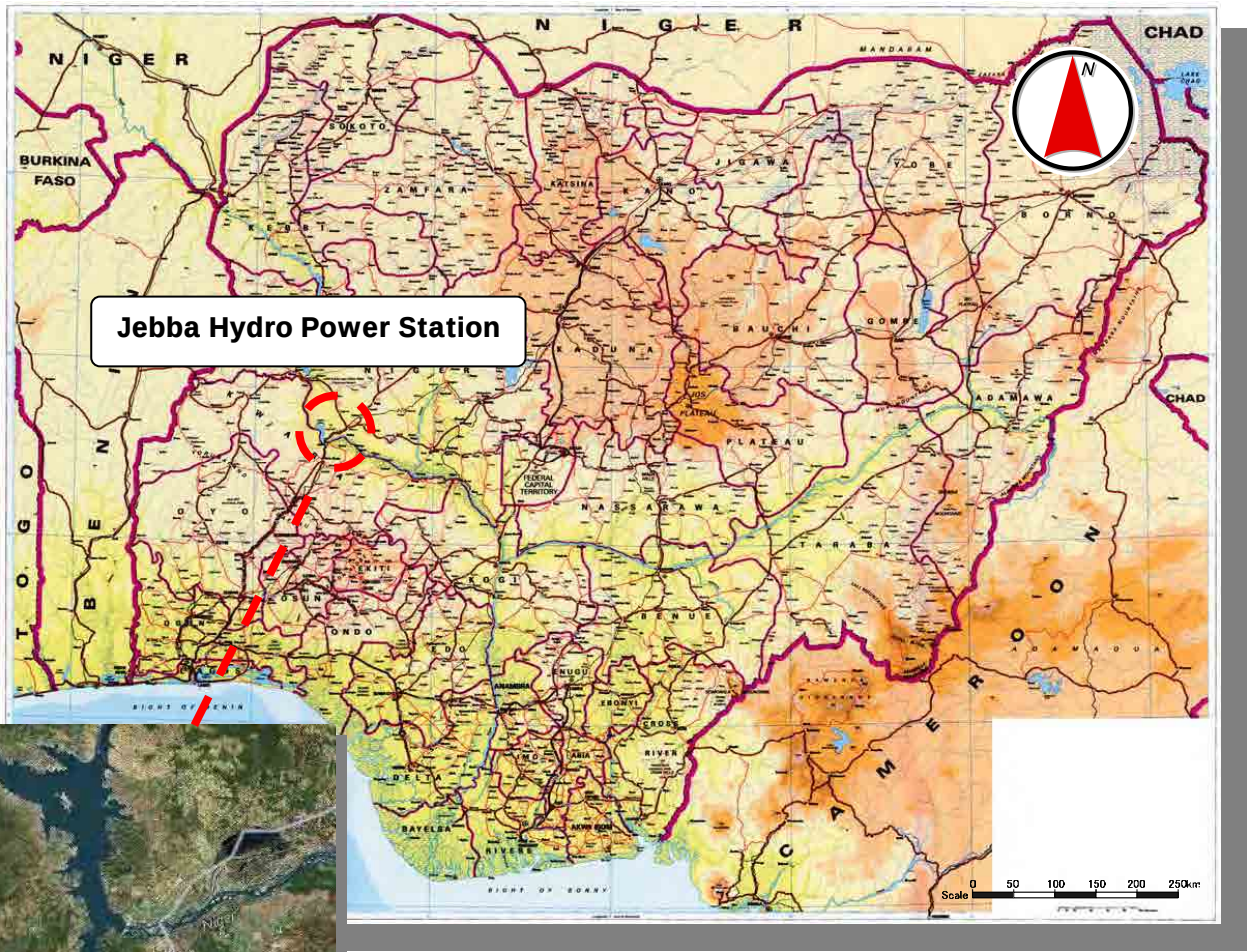
Current Conditions and Problems	Project Measures (target works)	Project Effects and Improvements
In Nigeria, power interruptions frequently occur due to deterioration and overload of power generation facilities, and these are impeding the development of local industries.	Repair of the generator meters and display lamps, etc.	Repair of the dial thermometer and so on will make it possible to manage temperature, conduct stable operation and prevent accidents. As a result, stable power supply will be realized, thereby enabling local manufacturing and industries to be vitalized.
In Nigeria, power interruptions frequently occur due to deterioration and overload of power transmission and distribution facilities, and these are impeding the stable operation of medical care agencies.	Repair of the generator coils and metal, etc.	Repair of the coils and metal will reduce vibrations and stabilize the power waveform of the generator. As a result, stable power supply will be provided to hospitals and universities, and contribution will be made to the stable operation and vitalization of such medical and educational facilities and enhancement of services for residents.

Current Conditions and Problems	Project Measures (target works)	Project Effects and Improvements
In Nigeria, power interruptions frequently occur due to deterioration and overload of power generation facilities, and these are adversely affecting the living environment of local residents.	Repair of the generator	Through the provision of stable power supply, the living environment of citizens in Nigeria will be improved.
Jebba Hydropower Station is incurring increasing maintenance costs due to frequently occurring failures and part replacements, and this is placing a burden on JHEP finances.	Repair of the generator	Upgrading of instruments in the hydropower station will lead to less frequent parts replacements and thus allow maintenance costs to be reduced.

Contents

Location Map






GENERATOR 4

List of Figures & Tables

Chapter 1

Chapter 3

Abbreviations

A/A	Agent Agreement
A/P	Authorization to Pay
AC	Alternate Current
AFREN	African Rural Electrification Network
ASEAN	Association of Southeast Asian Nations
CDF	Comprehensive Development Framework
CEO	Chief Executive Officer
DAC	Development Assistance Committee
DC	Direct Current
ECN	Energy Commission of Nigeria
EIAJ	Electronic Industries Association of Japan
E/N	Exchange of Notes
FMOP	Federal Ministry of Power
G/A	Grant Agreement
GSM	Global System for Mobil Communication
IEC	International Electrotechnical Commission
IPP	Independent Power Plant
ISO	International Organization for Standardization
JCS	Japanese Electrical Wire and Cable Maker's Association Standards
JEC	Japanese Electrotechnical Committee
JEM	Standards of Japan Electrical Manufacturer’s Association
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
JHEP	Jebba Hydro Electric Plc.,
KEPCO	Korea Electric Power Corporation
NAPTIN	National Power Training Institute of Nigeria
NBET	Nigeria Bulk Energy Trader
NCC	National Control Center
NEEDS	National Empowerment Economic Development Strategy
NEPA	National Electricity Power Authority
NGO	Non-Governmental Organizations
NITEL	Nigeria Telecommunications Plc
NIPP	National Integrated Power Project
O&M	Operation and Maintenance
OJT	On the Job Training
OPEC	Organization of the Petroleum Exporting Countries
PHCN	Power Holding Company of Nigeria
PRSP	Poverty Reduction Strategy Paper
REB	Rural Electrical Board

RTD	Resistance Temperature Detector
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
VAT	Value-Added Tax

CHAPTER 1

BACKGROUND OF THE PROJECT

Chapter 1 Background of the Project

1-1 Background of the Assistance

The Federal Republic of Nigeria (hereafter referred to as Nigeria), located in the central part of Western Africa next to Guinea and possessing a population of roughly 140 million (2007, according to the National Bureau of Statistics, Nigeria), is one of the world's biggest producers of petroleum. Nigeria is also a multiethnic country possessing more than 250 ethnic groups and 500 languages. Its national land area is approximately 2.5 times the size of Japan and is divided into the semi-arid north, which has a Sub-Saharan climate, and the marshy south that is partitioned by the Benue River and Niger River. In terms of cultural background too, the country is divided into the northern and southern halves with distinct living styles in each.

Nigeria previously struggled with an accumulated debt burden of around US$40 billion due to inefficient fiscal management by past military administrations, however, reforms by the civil administration of President Obasanjo, who came to power in 1999, earned international praise, and the Paris Club nations agreed to reduce Nigeria's debt of US$30 billion by 60 percent at the summit that was held in October 2005. When President Obasanjo's term of office came to an end in 2007, Umaru Yar'Adua was elected as the new president, however, he passed away in May 2010 and was subsequently replaced by his vice president Goodluck Jonathan. The administration of President Jonathan inherited the 7-Point Agenda of his predecessor and is tackling reform. Peak power demand in Nigeria is increasing every year and the power demand has reached approximately 6,800 MW recently, however, the actual capacity as of July 2010 is 3,825 MW due to the failure of plans to boost generating facilities and the deterioration of existing facilities. As a result, there is an absolute shortage of power supply.

Against such a background, the Government of Nigeria issued an urgent request to the Government of Japan seeking rehabilitation of the Unit 4 generator (96.4 MW, vertical axis propeller turbine) at Jebba Hydro Power Station in order to improve conditions at the station. Based on the request, the Government of Japan consigned JICA to implement the first preparatory survey from January 17 to February 2, 2011, in which it ascertained the contents of the request and verified the appropriateness of assistance. Based on the survey findings, the governments of the two countries signed the E/N on April 11, 2011, while JICA and the Government of Japan signed the G/A on May 17 the same year.

1-2 Outline of the Project

Unit 4, which is the target for the request for urgent rehabilitation, has been operating at approximately half its maximum capacity due to damage of the generator coils following lightning induced failure of the circuit breaker in April 2009. In the preliminary survey that was implemented in January 2011, the necessity and appropriateness of the request as a target for grant aid assistance were confirmed.

In the survey, based on the findings of the preliminary survey, rough design and cost estimation were carried out on the necessary and optimum contents and scale to realize the achievements described within the framework of the concluded E/N and G/A. In addition, examination was conduced on the contents of the Nigerian scope of works, implementation plan and important points in operation and maintenance for achieving the Project goals such as restoring generation capacity of Unit 4 and so on.

In particular, concerning the scope of the assistance, the technical appropriateness of the requested

contents was evaluated and the contents were prioritized. As a result, agreement was eventually reached with the Nigerian side concerning the following general contents:

1) Stator core and associated parts

2) Stator coil and associated parts

3) Rotor pole

4) Rotor rim support modification parts

5) Repair parts and instruments

6) Current transformer for measuring instruments

7) Site work

Jebba Hydro Power Station, which utilizes the Jebba Reservoir (storage capacity 1 billion cubic meters) constructed on Niger River, which runs through the west of Nigeria, was completed and commenced operation in 1985, and it comprises six water turbine and generator units. Kainji Hydro Power Station (760 MW) is situated further upstream on the same river, and Jebba utilizes the water discharged from here to generate power. Effective head is 27.6 meters and the rated plant capacity is 578.4 MW (96.4 MW/unit x 6 units). Table 1-2-1 shows the outline specifications.

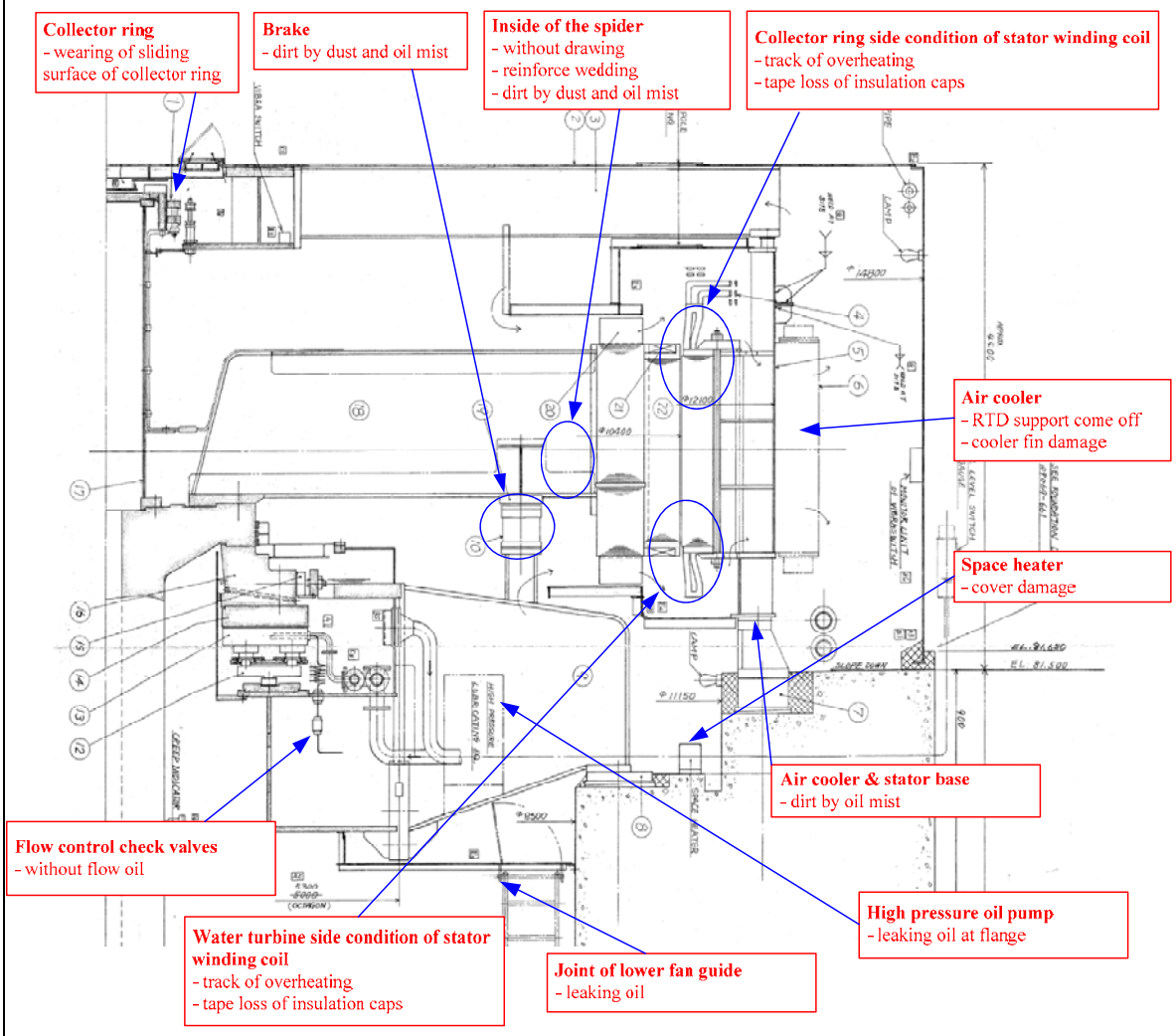
Table 1-2-1 Outline Specifications of Jebba Hydropower Station

Item / Contents	Unit No.					
	Unit 1 (2G-1)	Unit 2 (2G-2)	Unit 3 (2G-3)	Unit 4 (2G-4)	Unit 5 (2G-5)	Unit 6 (2G-6)
1. Water turbine	**Fixed Blade Propeller Single Runner**					
(1) Maker	Escher Wyss/Vatech/ANDRIZ, Austria					
(2) Turbine Blade (number of blades)	5 blades (blade diameter: 7,100 mm)					
(3) Guide Vane(Wicket Gate)	24					
(4) Effective head (m)	Min.25.0 m~Max.29.7m					
(5) Effective flow (m3/sec)	376 m^3/sec.					
(6) Effective water level during operation (m)	103.0～93.0m					
(7) Maximum output (MW)	96.4MW (Output at Max. Rated Head: 102.7 MW)					
(8) Rotations (rpm)	93.75 rpm, Runner Away Speed: 179rpm					
2. Generator	**Type : Synchronous (Commissioning Year 1985)**					
(1) Maker	HITACHI, Japan					
(2) Output (MVA/MW)	103.5MVA/96.4MW					
(3) Rotations / rotating direction	93.75 rpm/clockwise direction					
(4) Cooling method	Air Cooling: 12 Air Coolers/One Generator					
(5) Power factor	0.85					
(6) Voltage (kV), current (A)	16,000V/3,735A					
(7) Frequency (Hz)	50 Hz					
(8) Poles	64					
(9) Applicable standard	ANSI C50.12 (1965)					
3. Auxiliary equipment						
(1) Control system	Analog local control (each unit)					
(2) Main transformer	16/330kV、119MVA×6					

Item / Contents	Unit No.					
	Unit 1 (2G-1)	Unit 2 (2G-2)	Unit 3 (2G-3)	Unit 4 (2G-4)	Unit 5 (2G-5)	Unit 6 (2G-6)
(3) Overhead traveling crane for maintenance	Main crane 225 t x 2 units (auxiliary crane 50 t/15 t)					
(4) In-station transformer	11kV/415V、2MVA×4					

The water turbine generator in question underwent generator rotor repair 10 years ago. At this time, concerning the speed governor, the speed detection section and other electric control sections from Unit 1 to Unit 3 were updated from analog to digital. Although such partial equipment repairs have been carried out, no major overhaul of the entire plant including transformers and other transforming equipment has been implemented in 27 years since the plant started operation. As a result, power generating efficiency of the plant has declined due to equipment deterioration. Meanwhile the operating times and output of each unit in 2010 are as indicated in Table 2-1-3, and among these Unit 6 has been idle since the accident that occurred on April 21, 2009.

Table 1-2-2 Conditions of Generator

1. Outline	The particulars of the generator are as indicated in Table 1-2-1 Outline Specifications of Jebba Hydropower Station. The generators at Jebba are 100 MW large-scale synchronous units with a vertical axis. Since the water turbine has a small effective head and few rotations, it has a large number of poles, which generate power by rotating with the water turbine axis inside the generator. The poles are known as coils comprising copper wire wrapped around silicon steel plate, and the number of poles decreases as the generator rotating speed increases. Hydropower stations usually have an effective head of around 80 meters with rotation speed of 500 rpm, making it necessary to have 12 poles. On the other hand, Jebba Hydro Power Station has rotation speed of approximately 93 rpm and 64 poles. Therefore, it is necessary to expand the pole attachment base known as the spider, and this means that the spider will become extremely large and heavy (approximately 450 tons).  **Figure 1-2-1 Problem Areas in Unit 4**
2. Condition of problems	After commencing operation in 1985, Unit 4 underwent autonomous overhaul in 2011 and has continued operation, however, since vibrations and other problems are arising, it is currently being operated at around 50% of the maximum output. Possible causes of vibration are as follows: - Voltage imbalance in field coil - Electrical causes such as lack of air gap adjustment between pole and stator - Lack of adjustment of water turbine axis center - Problems in thrust metal, etc. As the above problems carry risk of causing wider damage, there are numerous risks in operation and care

	will be required from now on. Regarding the causes of failures, in addition to those arising from deterioration after 30 years of use, the following causes are involved. (1) Autonomous replacement of rotors During the rotor spider repairs conducted in 2001, since problems were found in the thrust metal, the Unit 4 rotor was attached to the Unit 5 generator. After that, work on the Unit 4 generator was suspended due to lack of funds. As a result, following emergency repair of the Unit 5 generator spider, the Unit 4 stator was installed. The Unit 4 generator suffered further major damage in 2009 when motoring occurred. At this time, adjustment of the assigned voltage and so on was insufficient, leading to electrical imbalance and impeding the operation. (2) Motoring As a result of motoring-induced coil heating brought about by grounding of station wiring in 2009, degradation occurred in insulation materials and this led to insulation failure. Figure 1-2-1 shows the concrete problem areas in detail, while photographs are shown in the annex.

In view of the above conditions, concerning the scope of the assistance, upon evaluating the technical validity of the requested contents, it was decided to conduct a field investigation and attach an order of priority to the requested contents. At this time, examination was conducted bearing in mind the scope indicated in Table 1-2-3.

Table 1-2-3 Contents of Equipment, Instruments and Parts for Rehabilitation of No. 4 Generator

Item	Contents
Restoration of parts broken by the accident of 2009	Renew the insulation of the stators and rotor coils. Specifically, through replacing the coil that carries current in the generator rotor and stator, renew the coil insulation that experiences temperature increase following use and degradation over an extended period. Since current flow through conducting wire generally tends to slow down when temperature increases, replacing insulated parts makes it possible to reduce temperature and improve safety and efficiency. Such repair work is referred to as insulation renewal. Moreover, through replacing the parts that connects coils to coils and securing balance, it is possible to minimize vibration and achieve smooth and stable rotation.
Overhaul in line with deterioration over time	Replace the parts (thrust bearings and air cooler, etc.) that can only be replaced when the generator undergoes disassembly.
Equipment improvement	Also conduct parts replacements (sensors, etc.) related to equipment improvement over the extend that is possible. Specifically, stable operation can be achieved through repairing the thrust metal and so on required for continuing operation at the same time as conducting insulation renewal of the coils that require the output recovery described above.

As a result of conducting analysis in Japan, the contents of the Project have been decided as shown in Table 1-2-4.

Table 1-2-4 Scope of the Cooperation

Originally Requested Plan	Plant following Analysis in Japan (Draft)	Qty
(1) Stator Core and associated parts (core stacking kit)	1. Stator Core and associated parts	1 set
(2) Stator Coil and associated parts (stator rewinding kit)	2. Stator Coil and associated parts	1 set

Originally Requested Plan	Plant following Analysis in Japan (Draft)	Qty
(3) Rotor Pole with field coil	3. Rotor Pole with field coil	1 set
(4) Rotor Rim support modification kit with tools	4. Rotor Rim support modification	1 set
(5) Lifting devises and sling wires	(Not adopted)	
(6) Replacement parts and instruments	5. Replacement parts and instruments (without rebabbitting thrust and guide bearings) (modification kit)	1 set
(7) Tools and equipment for site work	(Not adopted)	
(8) Current transformer	6. Current transformer	1 set
(9) Generator circuit breaker	(Not adopted)	
(10) Site Work	7. Site Work	1 set

Notes: Lubricating oils are not included in the above table, and are to be prepared by the Nigerian side.

Incidentally, some items were omitted from the request stage, and the reasons are indicated in Table 1-2-5.

Table 1-2-5 Reasons for Non-Adoption

Item	Order of Priority and Policy
Lifting devices and tools	These tools and equipment are needed for installation works. However, because they can be commonly used in all units and they can be procured by the local side with its own funding, they are omitted from the scope of assistance.
Generator circuit breaker	The generator circuit breaker is currently installed in the outdoor switchyard. The request seeks to install a new circuit breaker between the generator and transformer due to operating problems. It is assumed that it will be installed close to the exciting arrangement inside the power house. Since connection with the existing circuit breaker will become complicated and the installation space is limited, although it is not impossible to install, it has been omitted from the Project because its installation would entail changing the interface of the control device.

The “rebabbitting thrust and guide bearings” that were included in the remodeling parts requested by the Nigerian side refer to the repair (recasting) of existing metal parts (bearings). In the Project, existing metal that has worn contact surfaces will be replaced with new metal. The existing metal will be taken to the manufacturing plant to have its surfaces regenerated with a view to securing spare parts for use in emergencies. However, since the metal used is a special type that can only be stored for approximately 10 years, the likelihood of metal exchange during this period is low and expensively purchased parts could end up being scrapped without ever being used. Also, since it would be difficult for the Nigerian side to conduct repairs, and the cost of consigning repairs to the maker (transportation costs, etc.) would be extremely high, these parts have been omitted from the Project. Since emergencies would be extremely infrequent and parts could be procured if the need arose, this omission will not impact the Project.

1-3 Handling of Motoring Failure

The motoring failure of April 2009 occurred when lightning strike caused the power station power supply to fail. The details are not clear because there is no event recorder for automatically recording the protective relay operating conditions, circuit breaker operating information and other operating information, however, the following facts have been confirmed:

- When the motoring occurred, the circuit breaker didn’t automatically trip.

- Following the failure, an attempt was made to manually open the Unit 4 generator circuit breaker, however, because it was inoperable, the power station contacted the NCC and asked to be cut off from the circuit breaker on the 330 kV substation side.

In conducting rehabilitation of Unit 4 in this grant aid project, it is important that steps are taken to prevent a similar situation arising in future. Upon conducting survey, it has been confirmed that JHEP has implemented the following measures in the wake of the accident. As a result, it should be possible to appropriately cut off overcurrent caused by similar accidents in the future.

- It replaced the old pneumatic operating mechanism type Unit 4 generator circuit breaker with a spring powered stored energy operating mechanism type circuit breaker.
- It reviewed the distribution panel circuitry for tripping the circuit breaker from the protective relay at times of motoring.

1-4 Environmental and Social Consideration

As the Project includes the implementation of insulation renewal geared to ensuring the safe operation of existing generators, the following environmental and social consideration issues will arise in the works.

1-4-1 Environmental Impact Assessment

On checking with JHEP, there were found to be no particular impacts on the natural and social environment because the roads needed for the works are already in place, the development and utilization of hydropower resources is consistent with national policies and the Project entails repair of a generator at Jebba Hydro Power Station that was constructed 27 years ago. Therefore, the JHEP responded that there is no need to implement an environmental impact assessment (EIA) based on Nigerian legislation when it comes to implementing the Project.

1-4-2 Anticipated Impacts of Project Implementation

Since the Project entails the renewal and repair of the turbine and generator and other equipment of a hydropower station that was constructed 27 years ago, almost all the works will be conducted indoors and the works period is less than one year, it is thought that impacts on landscape, society and environment can be kept to a minimum. Since the Project site is located away from built-up areas within the power station grounds, there will be no impact when vehicles come and go for the works. Moreover, since there are security gates to access the power station, there will be extremely low risk of entry to the Project site by third parties. Moreover, since almost all the work will be conducted indoors and will generate only minor vibration, dust and noise, and the distance from residential areas is sufficiently far, there will be no impacts on neighboring residents. The coils to be removed contain asbestos, however, since this will be treated by operators according to domestic regulations, there won’t be any problem. Moreover, since the site work will entail the replacement of generator parts while the majority of parts manufacturing and processing will be conducted in well-equipped Japanese plants, there will be no impact on water and air quality in the site work.

1-4-3 Areas using Asbestos

Based on the results of the field survey, Table 1-4-1 shows the parts that contain asbestos. In the event

where insulation coil is replaced in the Project, since waste materials containing asbestos will arise, it will be necessary to remove and dispose of them according to the procedure described in 1-4-4 below. Concerning the concrete measures when removing, since Nigeria has no domestic regulations, it will be necessary to conduct work according to Japanese asbestos damage prevention rules (asbestos rules) and so on as indicated in Table 1-4-1.

Table 1-4-1 Parts and Equipment that Include Asbestos

		Use	Safety measures, etc. when removing
Existing stator frame 6-part core alignment and insulation paper	1 set	The stator frame is divided into a number of regions, and asbestos is used as insulating material in stator joints.	To counter risk of asbestos fly-off when disassembling the core, it will be necessary to conduct wet work and display ample care in work by conducting curing and so on. Since there are no provisions in Nigeria, Japanese provisions (asbestos rules) will be applied and workers will implement work in a wet environment upon wearing breathing apparatus and protective clothing.
Existing high-resistance corona shield	1 set	Top and bottom of all coil ends	Asbestos is attached to the coil surface by varnish, and the surface is also covered in tape. When disassembling the coil, since there is risk that the asbestos parts will rupture, it will be necessary to display ample care in work by conducting curing and so on.
Existing insulation materials between field coil layers	1 set	Between all coils	Asbestos is laminated on the inner side while the outer side is coated with varnish. When disassembling the field coil, since there is risk that the asbestos will fly off, it will be necessary to display ample care in work by conducting curing and so on.

1-4-4 Environmental Regulations in Nigeria concerning Asbestos

National Environmental (Construction Sector) Regulation, 2011 was announced in the Federal Republic Nigeria Official Gazette No.46 Lagos-17th May, 2011 Vol.98. According to this, the following points are prescribed concerning the handling of asbestos:

- Asbestos must not be used on construction sites.
- When starting dismantling and removal work and scrapping, the treatment of wastes must be consigned to an operator that is qualified to dispose of asbestos.
- When starting dismantling and removal work and scrapping, it is necessary for an inspector dispatched from the National Environmental Standards and Regulations Enforcement Agency to conduct inspection and give assessment regarding the impacts of asbestos at the place where works will be executed.
- The inspector will recommend the required methods for removing and scrapping asbestos in consideration of the quality and quantity of materials including asbestos.
- During and at the end of removal work, the dismantling and removal operator needs to submit notification to the National Environmental Standards and Regulations Enforcement Agency.

1-4-5 Treatment of Wastes

The removal and scrapping of asbestos in the Project will be conducted according to the above

guidelines, however, because the existing generator coils are the state assets of Nigeria, it is appropriate that the Nigerian side carry out their scrapping.

The environmental checklist and monitoring form for the Project are indicated in the appendices. The monitoring form indicates the items that need to be adhered to by the implementing agency and works contractor when removing and scrapping the asbestos. The Nigerian side will need to conduct monitoring according to this form and report the results to JICA.

1-4-6 Safety Measures during Works

Concerning work that entails handling materials including asbestos, it will be necessary to take measures to secure the safety of operators. Specifically, when conducting similar work in Japan, it will be necessary to at least adhere to the contents of Level 3 according to applicable Japanese legislation (asbestos regulations), and this will entail making operators wear breathing apparatus and protective clothing and work in a wet environment as indicated in Table 2-2-2. When conducting asbestos removal work, it will be necessary to comply with Nigerian regulations while adopting safe procedures and methods in reference to Japanese rules.

1-4-7 Other Points

Through limiting use of fossil fuels through conducting repair of equipment at a hydropower station, the Project will assist climate change mitigation measures in a developing country.

CHAPTER 2

CONTENTS OF THE PROJECT

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

Against a background of advancing national development, the peak demand for power in the Federal Republic of Nigeria has reached approximately 6,800 MW. Meanwhile, although the total plant capacity of existing generating facilities is given as 6,600 MW (with thermal power accounting for 70 percent and hydropower for 30 percent), actual output in July 2010 is 3,825 MW due to the failure to strengthen generating facilities and deterioration of equipment at hydropower dams, thus creating an absolute shortage in supply capacity.

Existing hydropower stations in Nigeria comprise Kainji Hydro Power Station[7] (rated output: 760 MW) and Jebba Hydro Power Station (rated output: 540 MW, operated by Jebba Hydro Electric Plc. (JHEP) on the Niger River, and Siroro Hydropower Station (rated output: 600 MW) on a tributary of the Niger; however, these power facilities are unable to provide an ample supply of power due to long-term stoppages arising from generator breakdowns and water level adjustments, etc.

2-2 Outline Design of Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

The basic policy is to repair the Unit 4 generator of Jebba Hydro Power Station in order to alleviate the stretched power supply situation in Nigeria. Specifically, the design will be compiled based on the basic policies of repairing the regions damaged in the accident of 2009, conducting replacement (overhaul) of parts that have become degraded over time and improving equipment.

2-2-1-2 Policies regarding Natural Conditions

(1) Design in consideration of temperature and humidity

Although the atmospheric temperature in the area around Jebba Hydro Power Station is high at 30°C to 40°C throughout the year, considering Jebba Hydro Power Station's long experience of plant operation over 27 years, it will not be necessary to consider heat from the generator due to recovery in output because parts procured under the Project will be furnished to a generation unit located in the powerhouse. Also, the Project does not require procurement of precision instruments/parts which need to be kept away from high temperature and high humidity.

(2) Design in consideration of rainfall

High rainfall is observed from May to October, however, the highest rainfall is limited to July and August. Since the deterioration of road condition is presumed on the roads connecting to Jebba Hydro Power Station, it is desirable to make a procurement schedule of equipment,

[7] A loan of 1.5 billion yen was given by the Overseas Economic Cooperatio Fund (OECF) in 1972, and a further 2.5 billion yen was loaned in 1974.

devices and parts avoiding the said period as much as possible; however, it will be necessary to compile a transportation plan with ample time to spare. Having said that, as most of the installation work will be implemented inside the powerhouse, it is not necessary to consider the effects of rain when compiling the schedule for installation of the equipment, devices and parts procured under the Project.

2-2-1-3 Policies regarding Social and Economic Considerations

As the Project site is situated far from town of Jebba and there are security gates to access the power station, thus, the Project will have negligible impact on third parties. Also, there will be no influence on neighboring residents because noise generated by the power station is small and the distance from residential areas is far enough.

Because roughly half of the people in Nigeria are Christians and the other half are Muslims, the staffs of Jebba Hydro Power Station similarly believe in either of the above religions. Therefore, it will be necessary to pay respect to the respective religious festive days and national holidays when the implementation schedule is studied.

2-2-1-4 Policy regarding Utilization of Local Enterprises

In Nigeria, there are foreign owned companies for general construction, electrical works and others. Thus, it is relatively easy to procure labor, transportation vehicles and machinery and materials for construction works locally. There are at least three local building firms that have worked as subcontractors for grant aid projects in the past, and it should be possible to order work other than activities related to generator performance to them. Also, the inland transportation of machinery and materials from the port to Jebba Hydro Power Station can be consigned to local operators.

On the other hand, although there are some local enterprises and technicians available for handling installation of power station machinery, materials and auxiliary units, they do not have experience of rehabilitation works on the same scale as the Project, and highly skilled technicians are required for the rehabilitation of machinery and materials as well as adjustment and testing in the rehabilitation works. Hence, when such machinery and materials procured under the Project are installed, it will be necessary to dispatch technicians from Japan and to provide management of quality and schedule and technical guidance to the local parties.

2-2-1-5 Policies regarding Operation and Maintenance

Since the commencement of operation in 1985, Jebba Hydro Power Station has a successful work record of operation and maintenance by its own staffs up to date, thus, technical staffs are highly skilled and experienced. Also, since the rehabilitation of generation units through the Project is mainly replacement and overhaul of existing materials, machinery and parts, the operation and maintenance methods that have already been established in Jebba Hydro Power Station can be sufficiently and fully utilized. However, in view of the accident experienced in 2009, the Nigerian side will need to conduct emergency-stop training of facilities based on various accident scenarios. Also, daily maintenance and checking activities will be required to make sure equipment is operated correctly at all times.

2-2-1-6 Policies regarding Procurement Scope and Technical Level of Equipment

In consideration of the above-mentioned conditions and policies, the procurement scope and technical level of machinery and parts shall be formulated based on the following basic principles.

(1) Policies regarding the scope of facilities, machinery and materials

To facilitate a technically and financially adequate outline design, through adopting standard materials that comply with international specifications such as IEC and so on and adopting common-use assembled parts and pole-mounted parts in power supply sections and cable connectors, it will be possible to mitigate the load arising from maintenance of inventory parts in the event of breakdown. In the generator repair work, types of dial thermometer, cable and limit switch, etc. will be minimized with a view to ensuring compatibility of materials and equipment and selecting the minimum required equipment composition, specifications and quantities.

(2) Policies regarding technical level

Specifications of each item of equipment and instruments required for rehabilitation of the target generation unit shall be designed in consideration of technical level of O&M Division of Jebba Hydro Power Station, which will be the implementation body of operation and maintenance after completion of the Project, and avoidance of complicated structure and technical requirements.

2-2-1-7 Policies regarding Construction/Procurement Methods and Construction Period

Marine transportation shall be the main method to transport procured goods and materials from Japan or the third country to Nigeria. Inland transportation distance is approximately 410 kilometers from Apapa Port, Lagos to the Project site of Jebba Hydro Power Station. Since the transportation distance is long as such and roughly one-quarter of the transportation road is in poor condition, it will be necessary to pay extra attention regarding the curing and packing of equipment and materials, and to implement safe and sure procurement without causing any hindrance to traffic.

Jebba Hydro Power Station is a hydropower generation facility where the installation and commissioning of generation units was executed by Japanese enterprise and generator manufacturer up to completion in 1985, and currently generator parts and so forth are still provided from Japan. Considering this situation, when the procurement schedule of goods and materials is formulated for the Project, since there is no direct shipment from Japan to a port in Nigeria, it will be required to trans-ship at nearby foreign ports in Korea, China or Singapore, etc. and thus approximately two months will need to be assumed for the transportation period.

Since the contents of procurement for the Project include long lead items and short lead items, the equipment will be transported when the short lead items are completed, and the installation schedule will be planned to coincide with this. Concerning the long lead items such as rotor poles and so on, these will require 10 months solely for manufacturing and approximately one year from the purchase order to arrival at site. Therefore, as the overall implementation schedule will be influenced by these long lead items, it will be necessary to minimize the period required for preparation of drawings, their approval and factory inspection.

2-2-2 Basic Plan (Construction Plan / Equipment Plan)

2-2-2-1 Overall Plan

Concerning the repair of the Unit 4 generator, the Project will entail the replacement of the stator and rotor coil used for generating power, the thrust bearings that contain the bearings for supporting the entire weight of the water turbine generator, the pumps and valves for supplying lubricating oil to the thrust bearings (including oil cooler for lowering the temperature of oil flowing to the cooling oil pipes in the thrust bearings), the air cooler for lowering the temperature of the cooling water for the overall generator, and meters such as the space heater and thermometer used for maintenance activities.

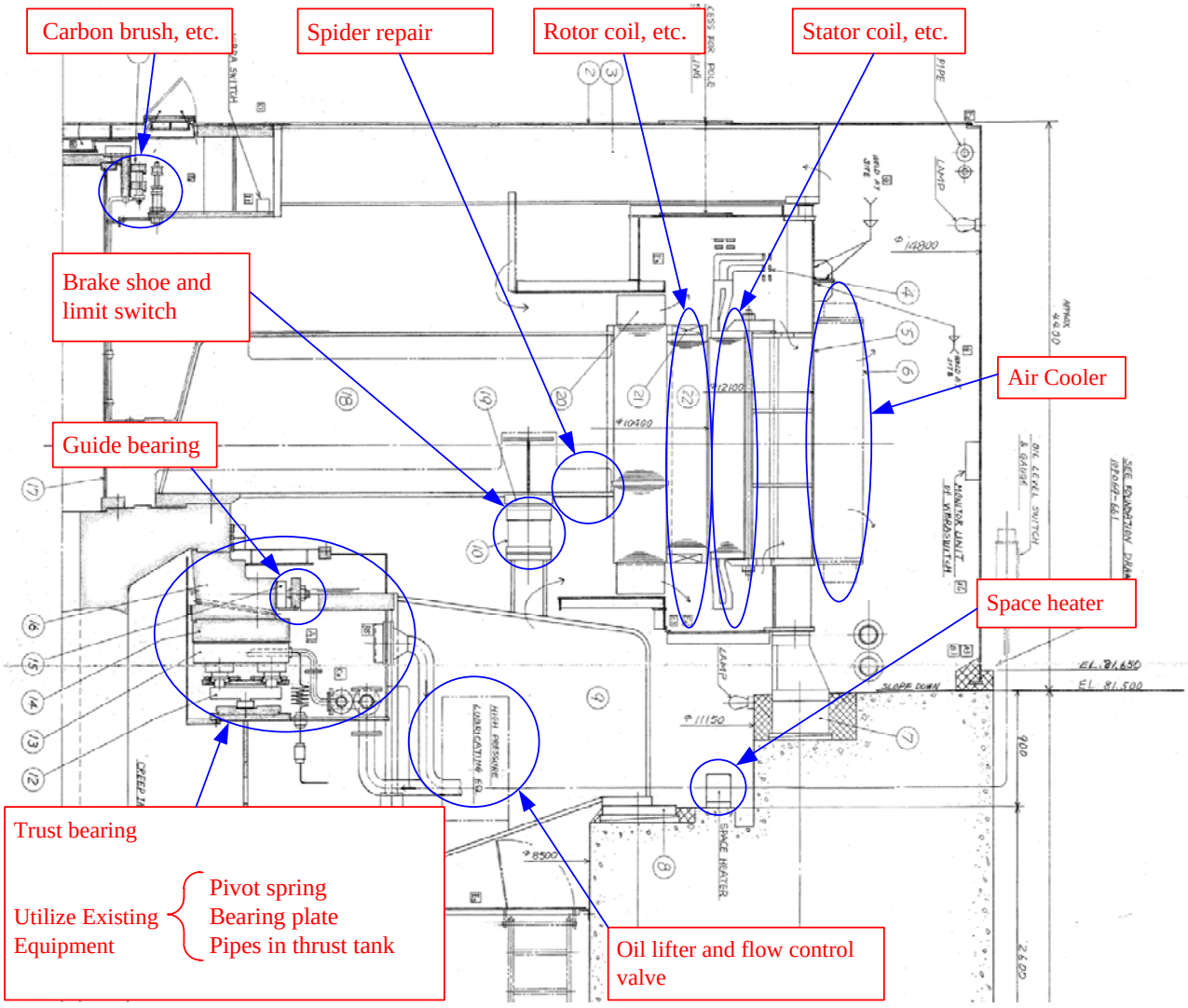


Figure 2-2-1 Overall Plan for Repair of Unit 4 Generator

2-2-2-2 Design Policy

In determining the scale and specifications for the Project, the following design conditions have been elaborated based on the results of examination of the above mentioned policies, principles and conditions.

(1) Proposed place of rehabilitation work

Place of rehabilitation work: Jebba Hydro Power Station existing generator unit No. 4

(2) Climate and Site Conditions

1) Designed atmospheric temperature: 40 degree Celsius (Highest)
2) Designed relative humidity: 95% (Highest: Dewfall shall not occur)
3) Site condition: Altitude (from the mean sea level): 100m

(3) Applicable Design Codes and Standards

	Codes and Standards	Application
(a)	International Electrotechnical Commission (IEC)	General electric appliances
(b)	International Organisation for Standardisation (ISO)	General industrial products
(c)	Japanese Industrial Standards (JIS)	General industrial products
(d)	The Institute of Electrical Engineers of Japan, Japanese Electrotechnical Committee (JEC)	General electric appliances
(e)	The Japan Electrical Manufacturers' Association (JEM)	General electric appliances
(f)	The Japan Electric Association Committee (JEAC)	General electric appliances
(g)	Japanese Cable Makers' Association Standard (JCS)	Electric cable
(h)	Electronic Industries Association of Japan(EIAJ)	General electric appliances
(i)	Electric Technology Research Association	General electric appliances
(j)	National Electrical Manufacturers Association (NEMA)	General electric appliances

(4) Units

In principle, the international unit system (SI Unit) shall be applied.

2-2-2-3 Configuration of Equipment

The following equipment configuration is proposed for procurement under the Project.

Table 2-2-1 Equipment Configuration

No.	Item	Quantity
1	**Stator Core and associated parts**	**1 lot**
1.1	Stator Core	1 Set
1.2	Stator Core Duct Spacer	1 Set
1.3	Stator End Spacer	1 Set
1.4	Stator End Clamping Plate	1 Set
1.5	Accessories for above	1 Set

No.	Item	Quantity
1.6	RTD for stator core	4 pcs
1.7	Finishing varnish for stator	1 Set
2	**Stator Coil and associated parts**	**1 lot**
2.1	Stator Coil	1008 pcs
2.2	Wedge	1 Set
2.3	Stator Coil Support Ring	1 Set
2.4	Bus lead for Inside of stator frame	1 Set
2.5	Insulation Cap	1 Set
2.6	Line and Neutral Lead	1 Set
2.7	Accessories for above	1 Set
2.8	RTD for stator coil	20 pcs
2.9	Current transformer for measuring instruments	1 Set
3	**Rotor Pole with field coil**	**1 lot**
3.1	Pole	64 pcs
3.2	Connection parts between Poles	1 Set
3.3	Pole Cotter and Liner	64 Sets
3.4	Field lead	1 Set
3.5	Finishing Varnish for Rotor	1 Set
4	**Rotor Rim support modification kit**	**1 lot**
4.1	Repair material for damaged spider	1 Set
4.2	Rotor rim keys	1 Set
4.3	Stopper for rotor rim keys	1 Set
4.4	Distance piece (Rotor rim support)	1 Set
5	**Replacement Parts and Instruments**	**1 lot**
5.1	Carbon Brush	44 pcs
5.2	Oil Deflector	1 Set
5.3	Flow Control Valve	36 pcs
5.4	RTD for Thrust Bearing Oil Temp.	1 pc
5.5	Thermal Relay for Air Cooler and Bearing	12 pcs
5.6	Dial Thermometer for Bearing	2 pcs
5.7	Oil Level Gauge	1 pc
5.8	Assembling parts for bearing	1 Set
5.9	Wiring material	1 Set
5.10	Installation materials (Bolts, nuts, etc.)	1 Set
5.11	Thrust and Guide Bearings	1 Set
5.12	High pressure oil pump set for Thrust Bearings	1 Set
5.13	Bearing oil coolers	1 Set
5.14	Bearing oil circulating pumps	1 Set
5.15	Air coolers	12 Sets
5.16	Brake Lining (shoe)	16 pcs
5.17	Dial Thermometer for Oil Cooler	2 pcs
5.18	Creep Detector	1 Set
5.19	Vibration detector and monitor	1 Set
5.20	Generator door switch	2 pcs
5.21	Water flow relay for coolers	2 pcs
5.22	Oil flow meter	1 pc
5.23	Limit switch for brake and jack	8 pcs

No.	Item	Quantity
5.24	Carbon Brush Folder	44 pcs
5.25	Space heater	12 pcs
5.26	Dial thermometer for air cooler	6 pcs
5.27	Spring Support for HITACHI PIVOT SPRING	1 Set

2-2-2-4 Equipment Plan

The equipment plan in the Project is described below. Coils will have Type F prepreg insulation, and no harmful substances such as asbestos will be used in insulation materials.

(1) Stator Core and accessories

Equipment	Contents
1) Stator core (see Figure 3-2-2)	The core is composed of laminated silicone steel plates with each plate having thickness of around 0.5 mm. After the existing core is removed, the new core will be formed by laminating on site. Lamination will be done by the half wrap method with air ducts attached. The core will be woven into a round shape on site and the finished product will be a high efficiency and solid structure.
2) Stator core duct spacer (See Figure 3-2-2)	The air duct on the stator core will be equipped with spacers made of steel. Spacers will be inserted between core packets to ensure that cooling air is efficiently carried to the core and coil. Also, it will be necessary to design the air cooler to ensure that cooling air is efficiently delivered.
3) Stator end spacer (See Figure 3-2-2)	As the basic spacer between the stator core and duct spacer, this will be given a solid structure. It will be made from non-ferric material. It will have ample strength regarding the weight of the stator core and duct spacer and its dimensions will be consistent with those of the existing generator. The structure will need to be designed to ensure that it can be certainly fitted.
4) Stator end clamping plate	The stator end cramping plate will be attached to the stator end spacer to ensure that the spacer core duct is soundly supported and fixed.
5) Accessories for the above	Core slot gauge, core guide key, cramp positioning bolts, core tightening bolt nuts, etc.
6) Resistance temperature detector (RTD) for stator core	This will be a thermometer that uses silver or copper as the resistance material, and the resistance value will be copper (0°C = 25Ω) or platinum (0°C = 100Ω). It will be fitted into the core duct spacer as the thermometer for measuring stator temperature. A total of four RTDs will be installed, and the temperature measurement range will cover from at least 0°C to 155°C.
7) Finishing varnish for stator	Insulating varnish will be sprayed onto the entire stator

	core in order to enhance the insulation effect and prevent rusting, dust and staining by mist oil, etc. The coating thickness over the entire stator core will be at least 50 microns. The varnish will be the Hitachi WB101 or an equivalent product (black color).

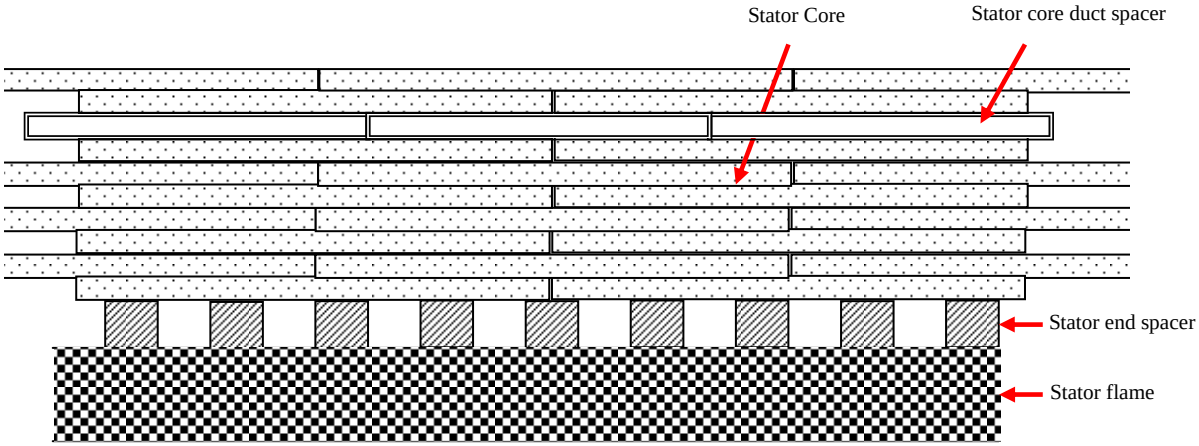


Figure 2-2-2 Stator Core Periphery

(2) Stator Coil and associated parts

Equipment	Contents
1) Stator coil (see Figure 3-2-3)	Phases: 3 Poles: 64 Slots: 504 Coils: 1,008 Connection method: 2Y Material: Coil (copper) and insulating materials (varnish and glass tape) Type of insulation: B
2) Wedge	Wedges will be arranged at the end of coils fitted into the stator core in order to fix the coils to the core. The material will be glass fiber. The wedges will have ample strength and be composed so that coils are firmly fixed and do not detach.
3) Stator coil support ring	Stator coil will be tied and fixed to the support ring with glass tape (glass). Material: Glass fiber
4) Bus lead for inside of stator frame	There will be total six wires comprising three phases (U, V, W) and neutral point (X, Y, Z), arranged in a circular pattern inside the generator to enable connection at the stator coil exit. The coil wire will comprise bus line between each phase and neutral point. Material: Copper
5) Insulation cap (see Figure 3-2-3)	This insulation material is for protecting the treated coil end.

	It will have a rubber cap structure with compound filled into air gaps to secure insulation. The insulation cap will be fixed with glass tape and serve to protect adequate insulation performance. Material: Rubber
6) Line and neutral lead	This is the terminal line and terminal for drawing electric power outside of the generator, and it will be composed of copper bars. It will comprise a structure with sufficient strength to fix the cable. Material: Copper
7) Accessories for the above (see Figure 3-2-3)	Liner, insulation materials, protective tape, RTD attaching materials
8) Resistance temperature detectors for stator coil (see Figure 3-2-3)	These resistance temperature detectors will measure the temperature in each coil of three phases (U, V, W) and 20 will be arranged. The arrangement will be 7 in the U phase, 7 in the V phase and 6 in the W phase.
9) Generator current transformers	These measuring instrument current transformers will be attached to the generator outlet lead in the U, V and W phases and at the neutral point.

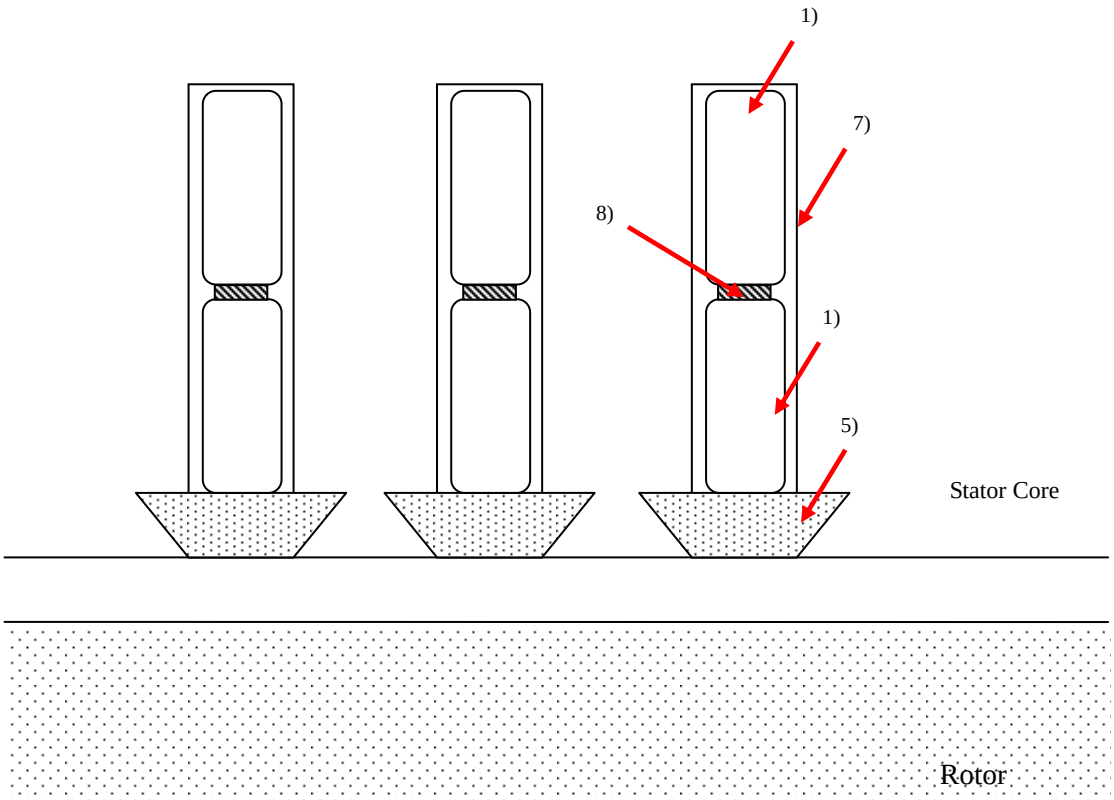


Figure 2-2-3 Stator Coil Periphery

(3) Rotor pole

Equipment	Contents
1) Pole (see Figure 3-2-4)	The field coil end will comprise glass fiber plates fixed in the vertical direction, and harmful materials such as asbestos will not be used in layers. Damper plates and brake winding will be included with the rotor poles linked by connection parts between poles. Material: Pole core (steel) and field coil (copper) Composition: Pole core (iron core) and field coils (magnetic field winding) Type of insulation: B Quantity: 64
2) Connection parts between poles	Materials and dimensions will be selected in consideration of dimensional change caused by centrifugal force, and the structure will be flexible. Material: Copper
3) Pole cotter and liner (See Figure 3-2-4)	The liner and cotter will be used to fix the poles to the rotor rim. Material: Steel (Cotter) Rolled steels for welded structure (Liner) Hot-rolled mild steel plates
4) Field lead	Possessing a plus pole and minus pole, the field lead will be connected with the field coils and collector rings of the No. 1 and No. 64 poles. The middle part will have a flexible structure that can withstand dimensional changes and vibration arising from expansion caused by generator heat and centrifugal force, etc. Material: Copper
5) Finishing varnish for rotor	Insulating varnish will be sprayed onto the entire poles in order to enhance the insulation effect and prevent rusting, dust and staining by mist oil, etc. The coating thickness over the pole will be at least 50 microns and the color will be red.

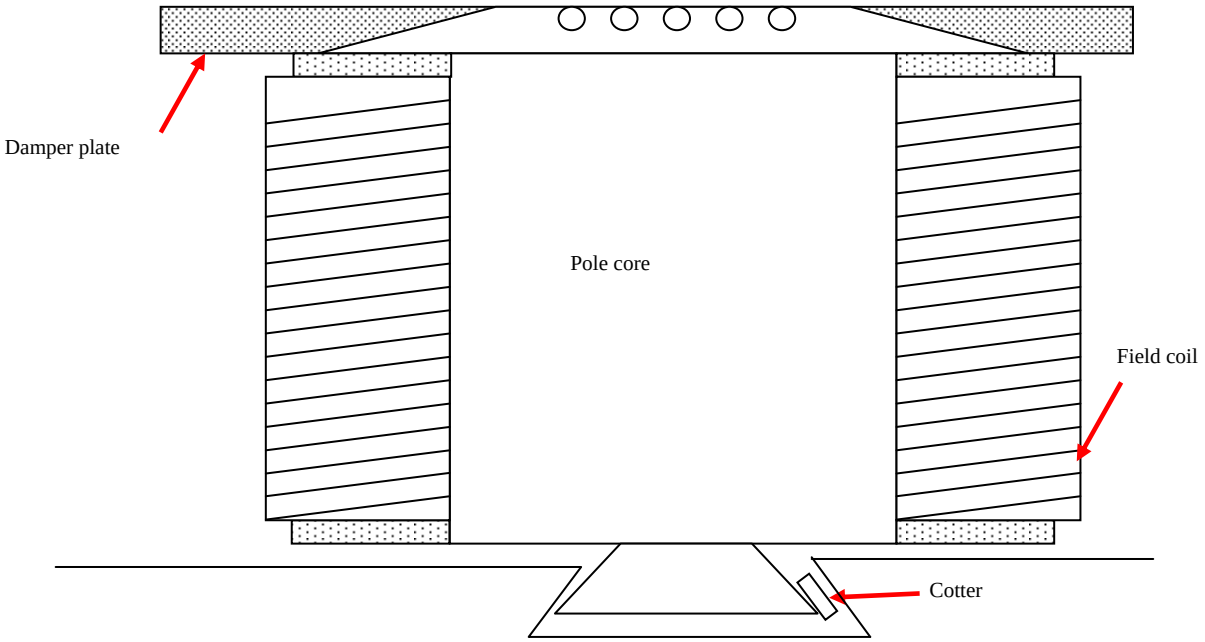


Figure 2-2-4 Rotor Pole Periphery

(4) Rotor Rim support modification kit

The rotor rims, which are fitted around the spider that rotates in the center of the generator, support 64 field coils (poles). Due to long-term operation, cracking and other critical damage has developed in the area connecting rotor rims to the spider, and future operation is threatened. Accordingly, the connection between spider and spider rims will be repaired to ensure stable future operation. The spider weighs approximately 40 tons while the entire rotor is roughly 450 tons.

Equipment	Contents
1) Repair material for damaged spider	Cotters (6pcs, steel), etc.
2) Rotor rim keys	Keys (10pcs, steel)
3) Stopper for rotor rim keys	
4) Stopper for rotor rim keys	Stopper plate (steel)
5) Distance piece (Rotor rim support)	Adjusting plate (steel) Replacement parts and instruments

(5) Replacement Parts and Instruments

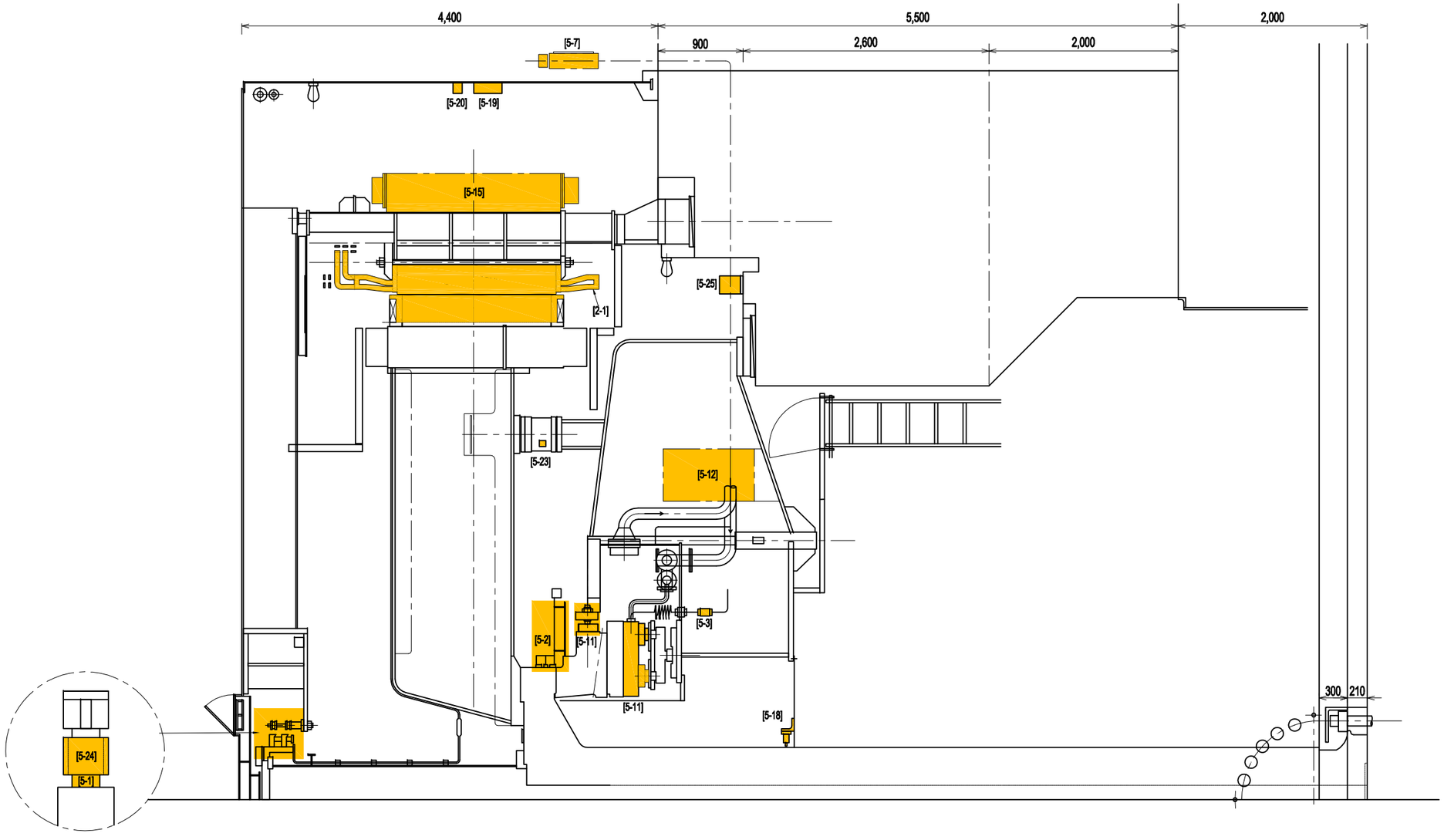
Equipment	Quantity	Contents
1) Carbon brushes	44	
2) Oil deflector	1 set	Temperature relay, lead wire and sensor
3) Flow control valves	36	
4) Resistance temperature detector for thrust bearing oil temp	1	
5) Thermal relay for air cooler and bearings	12	Temperature relay, lead wire and sensor

6) Dial thermometer for bearings	2	Thermometer, lead wire and sensor
7) Oil level gauge	1 set	Oil level gauge, lead wire and sensor
8) Assembling parts for bearings	1 set	
9) Wiring material	1 set	
10) Installation materials (Bolts, nuts, etc.)	1 set	
11) Thrust and guide bearing	1 set	
12) High pressure oil pump set for thrust bearing	1 set	High pressure pump, installation flange, packing, valves, supports and pipe set
13) Bearing oil coolers	1 set	Oil cooler, installation flange, packing, valves, supports and pipe set
14) Bearing oil circulation pumps	1 set	Pump, flange, packing, valves, supports and pipe set
15) Air coolers	12	Air cooler, installation flange, packing, valves, supports and pipe set
16) Brake liners (shoe)	16	Brake liners and shoes
17) Dial thermometer for oil cooler	2	Temperature relay, lead wire and sensors
18) Creep Detector	1 set	
19) Vibration detector and monitor	1 set	Vibration relay, attaching materials, lead wire and sensors
20) Generator door switch	2	
21) Water flow relay for coolers	2	
22) Oil flow meter	1	
23) Limit switch for brake and jack	8	
24) Carbon brush folder	44	
25) Space heater	12	
26) Dial thermometer for air cooler	6	Thermometer, attaching materials, lead wire and sensors
27) Spring support for HITACHI PIVOT SPRING	1 set	

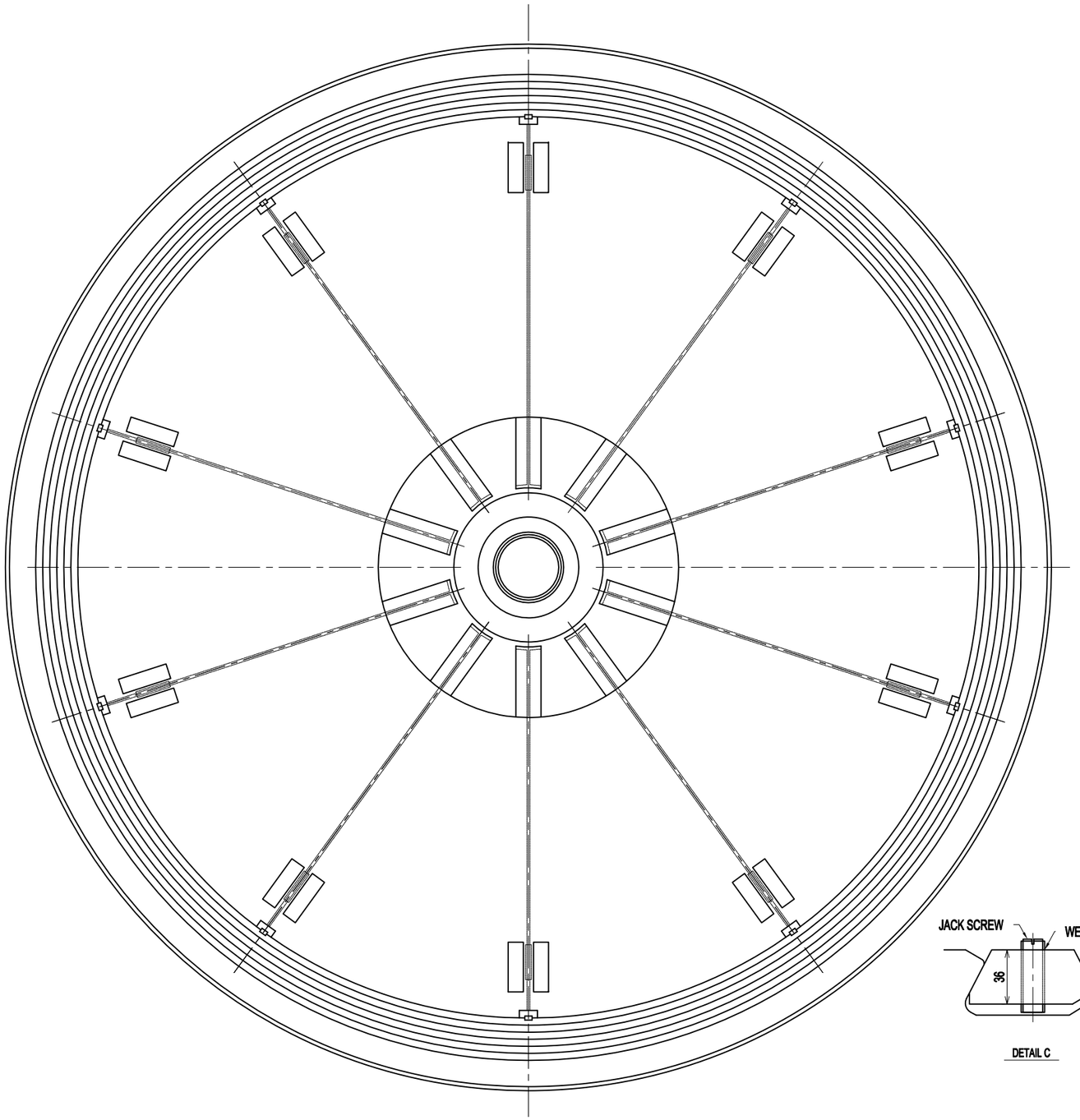
2-2-3 Outline Design Drawings

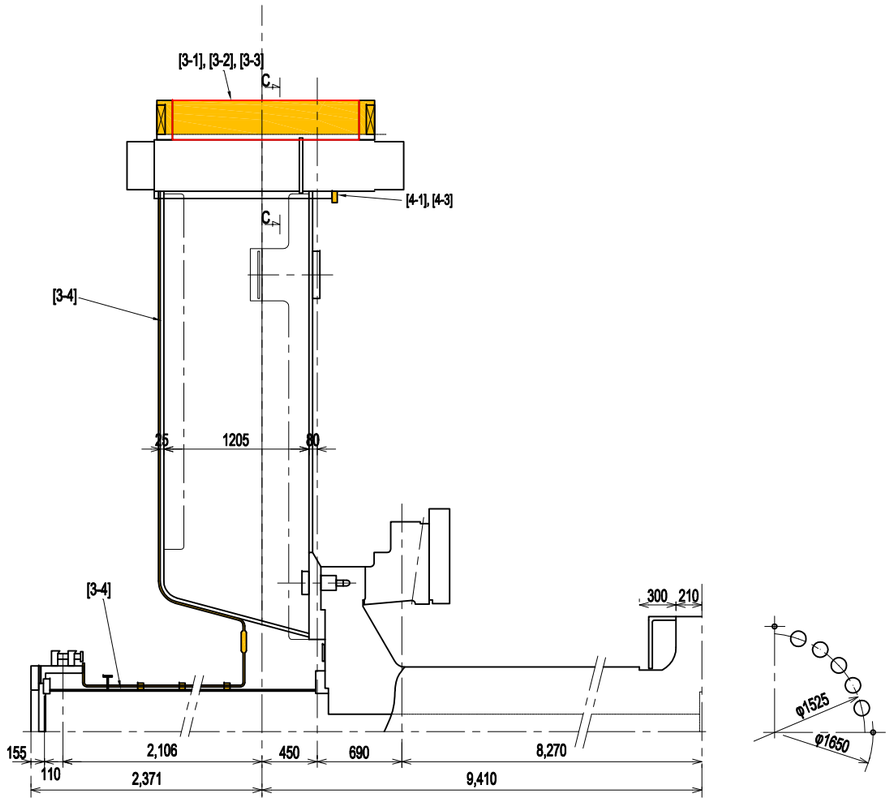
Outline design drawings (draft) for the Project facilities and equipment are as follows.

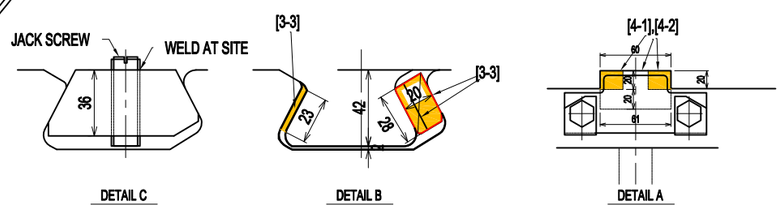
Drawing No.	Title
1	Sectional Assembly
2	Assembly of Rotor
3	Rotor Spider
4	Assembly of Stator Coil
5	Assembly of Line and Neutral Lead
6	Stator Winding Diagram
7	Assembly of Field Coils
8	Assembly of Thrust and Lower Guide Bearing
9	Meter Panel
10	Oil Coolers
11	Air Coolers



THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title SECTIONAL ASSEMBLY				DWG. No. 1
DATE	DESIGNED	CHECKED	APPROVED	REVISION
20th Feb. 2012	Ohsawa	Nakagawa	Tanaka	
YACHIYO ENGINEERING CO., LTD. TOKYO, JAPAN				







SECTION C-C

THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title ASSEMBLY OF ROTER				DWG. No. 2
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20th Feb. 2012	Ohsawa	Nakagawa	Tanaka	
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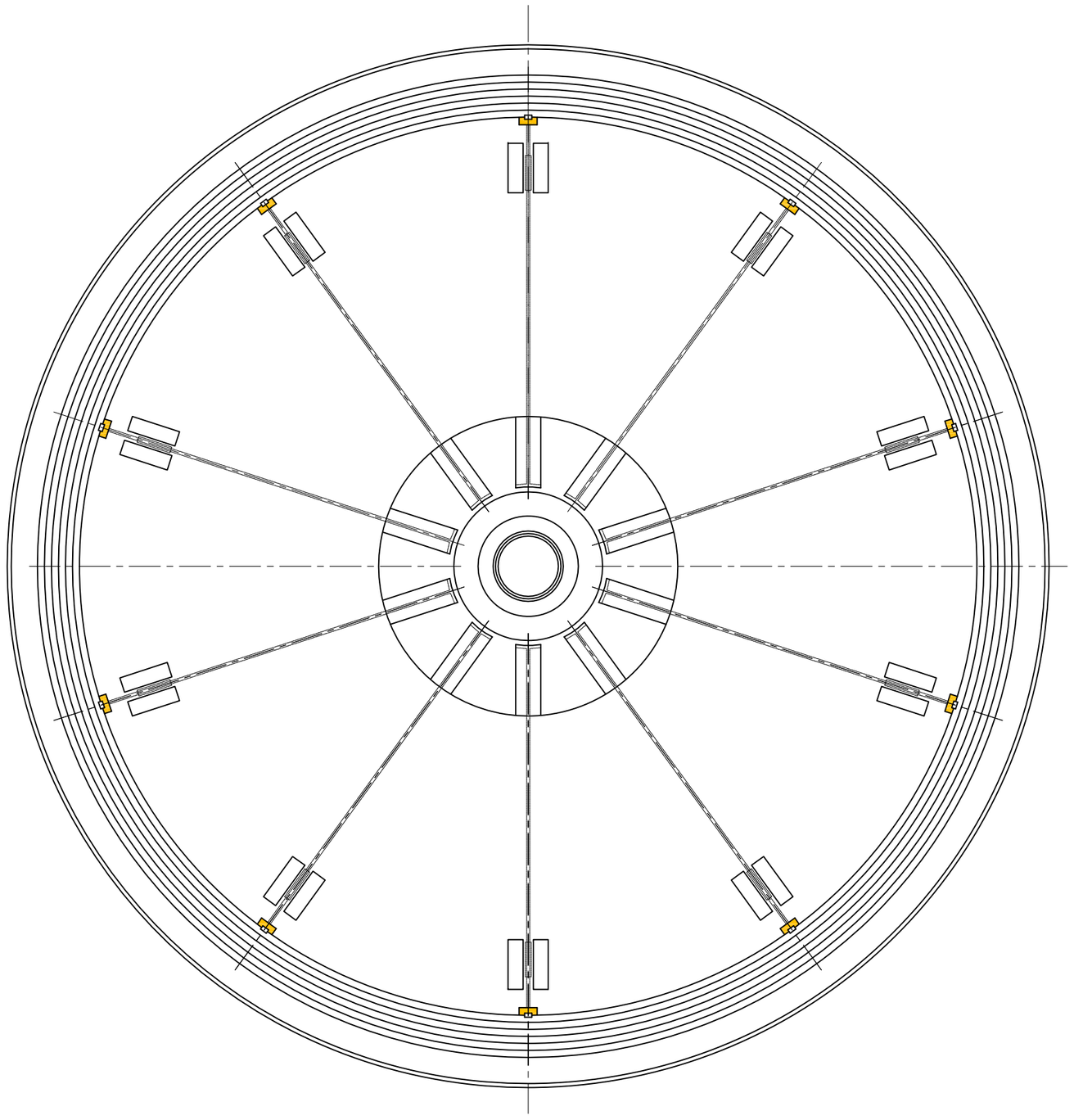

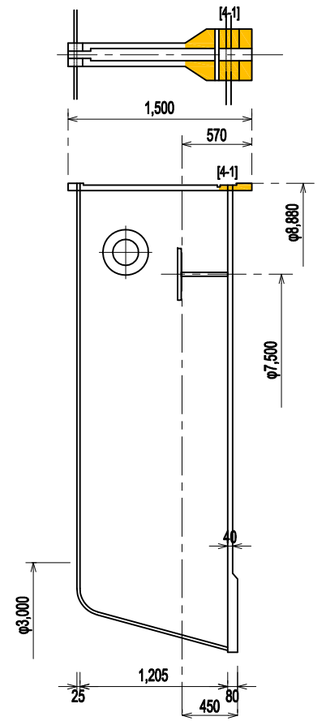

THE PROJECT FOR
EMERGENCY REPAIR AND OVERHAUL WORKS FOR
THE JEBBA HYDRO POWER STATION
IN THE FEDERAL REPUBLIC OF NIGERIA

SCALE

Title

ROTER SPIDER

DWG. No.

3

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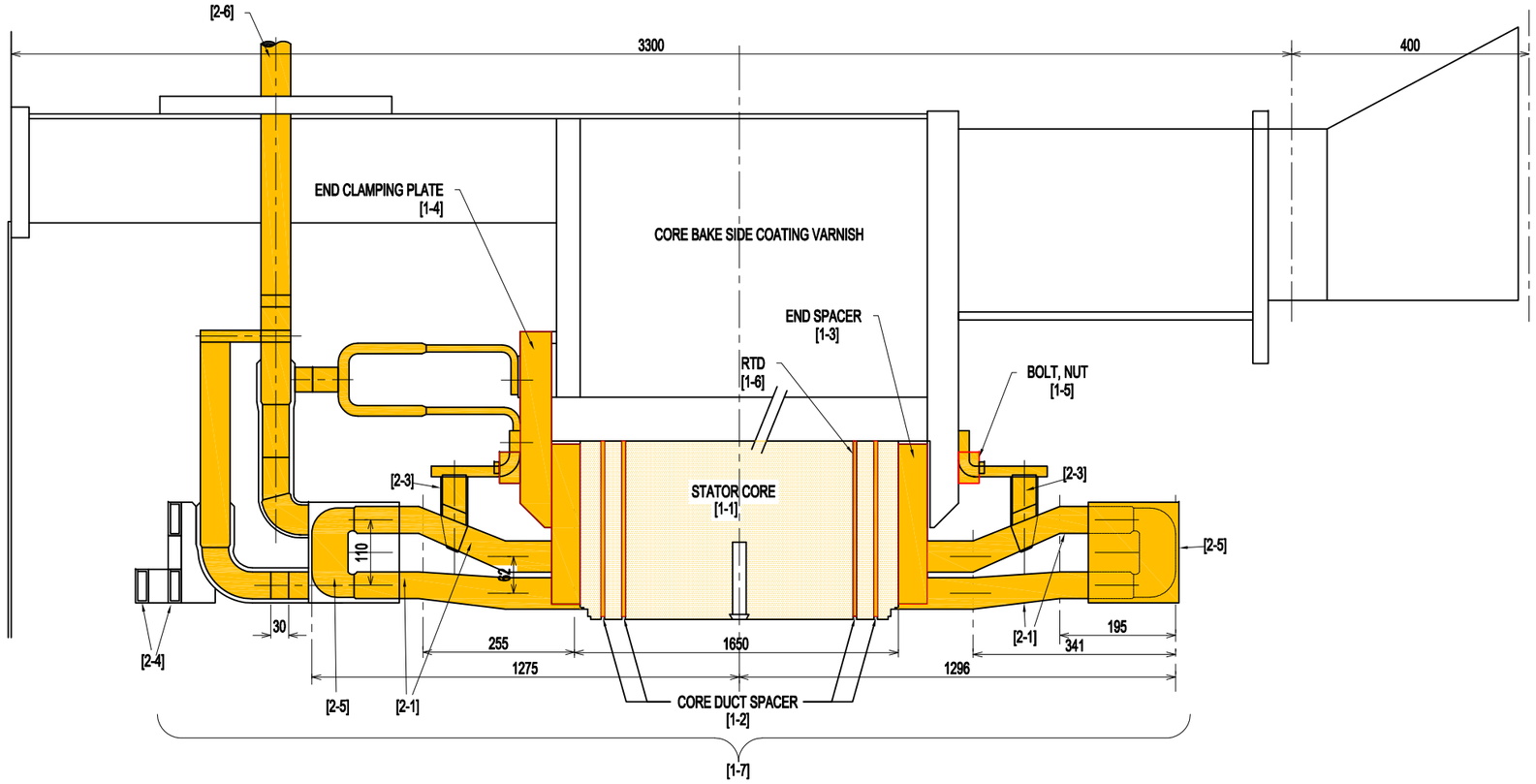

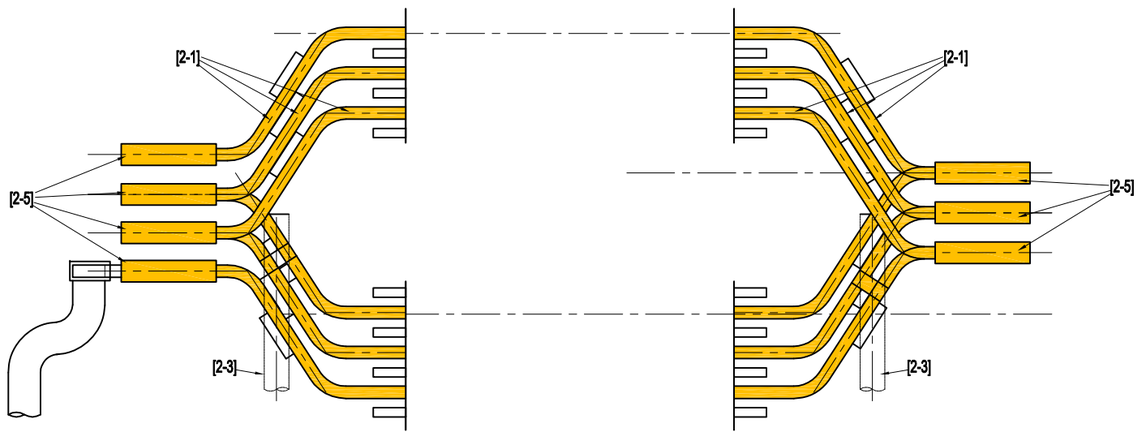

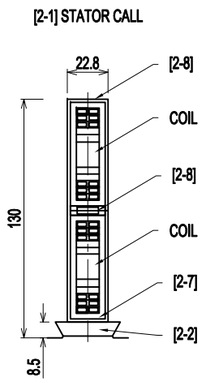

THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title ASSEMBLY OF STARTER COIL				DWG. No. 4
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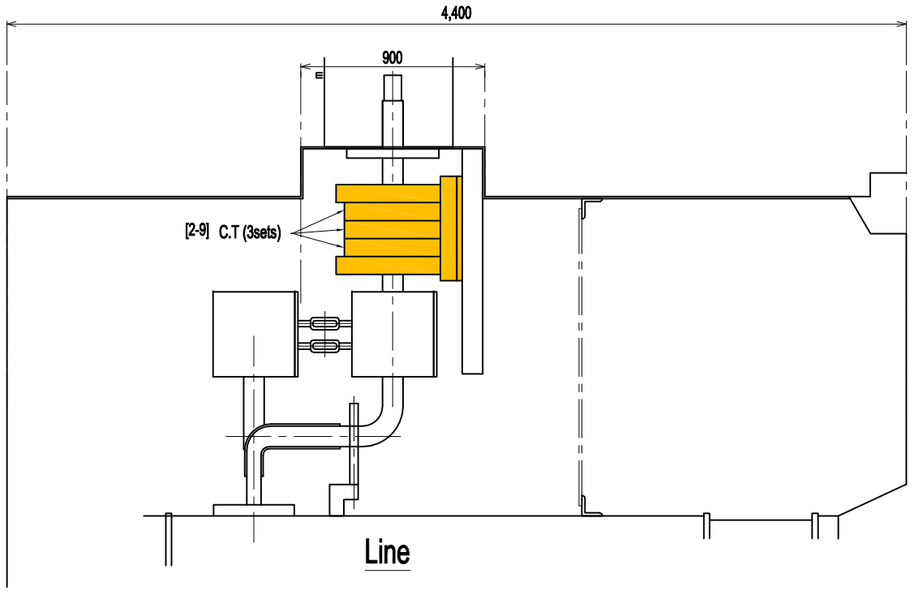

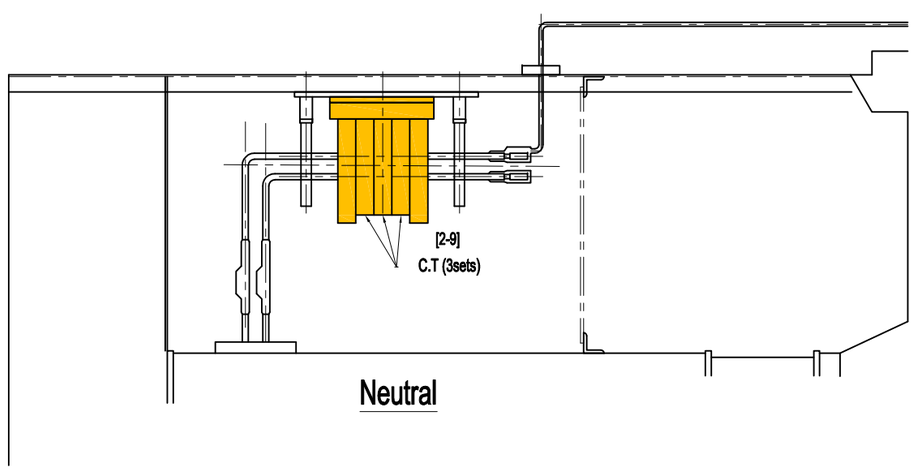

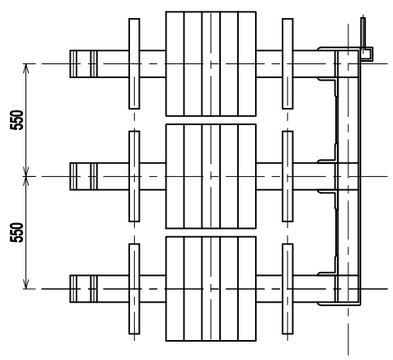

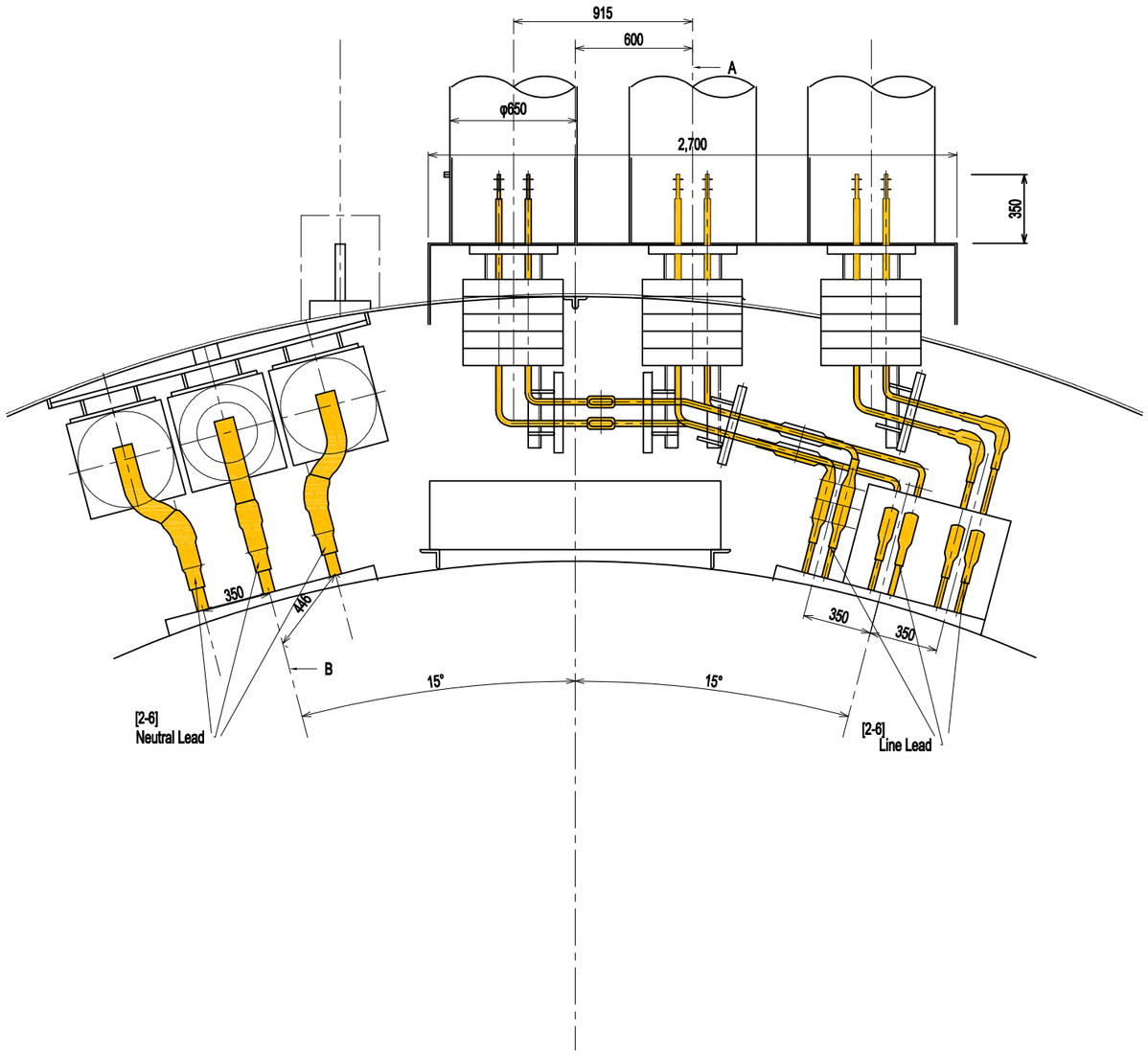

THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title ASSEMBLY OF LINE AND NEUTRAL LEAD				DWG. No. 5
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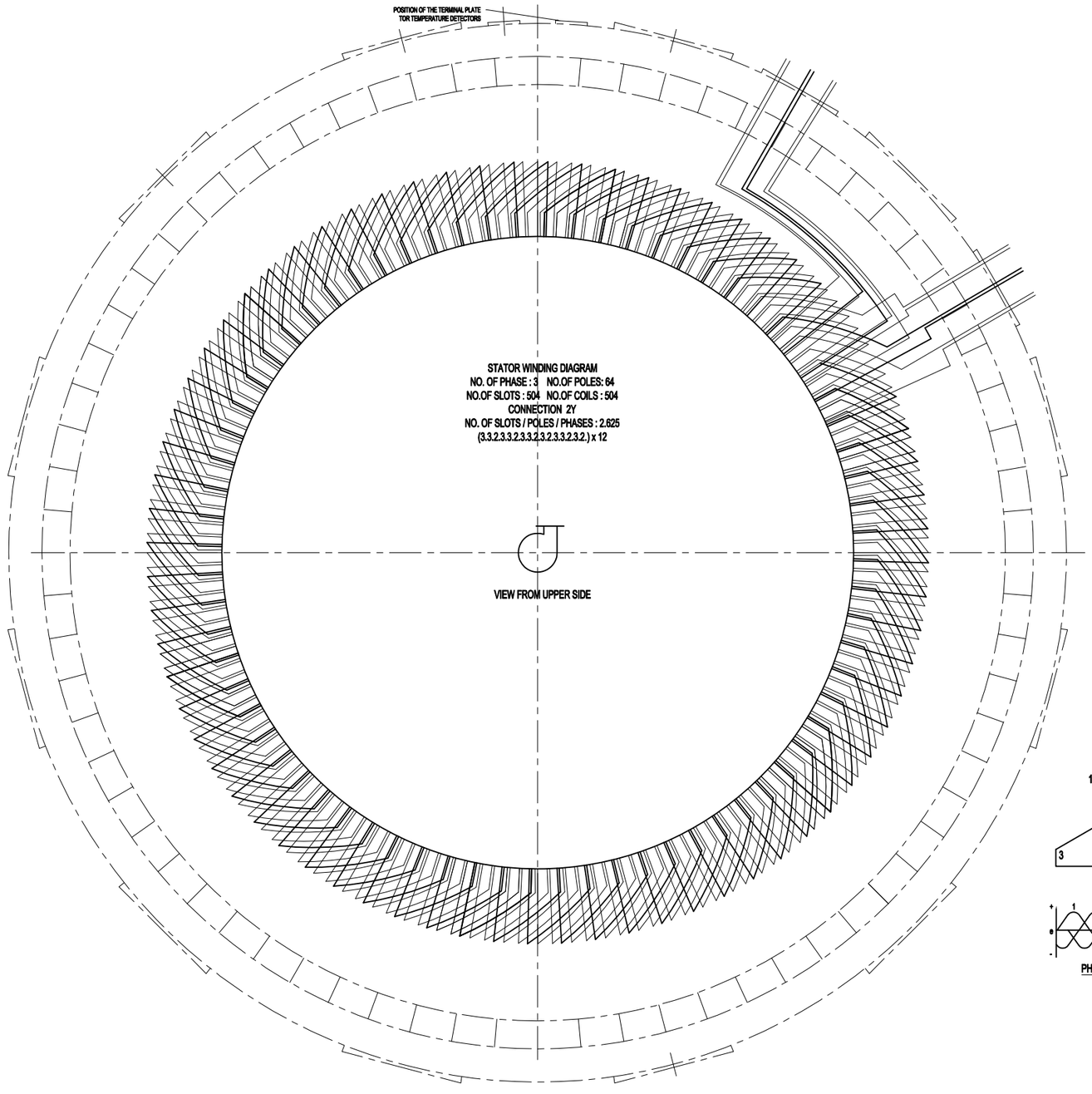

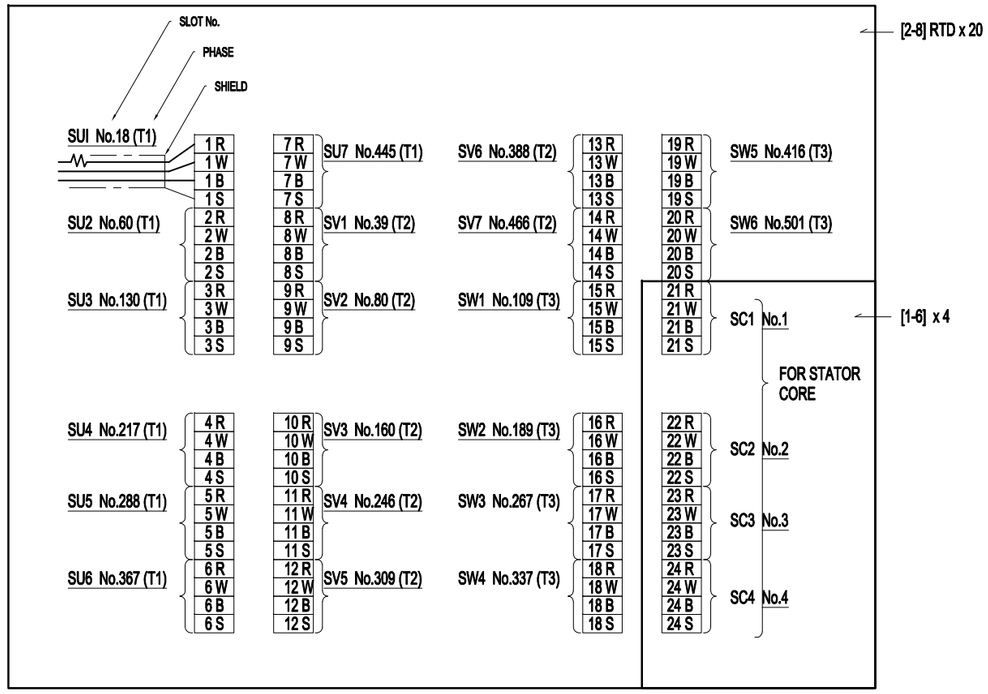

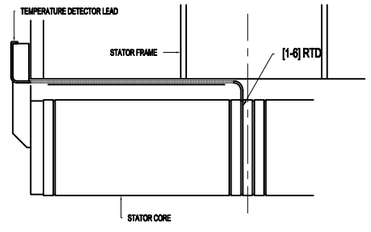

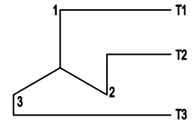

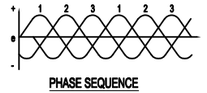

PHASE SEQUENCE

THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title **STATOR WINDING DIAGRAM**				DWG. No. 6
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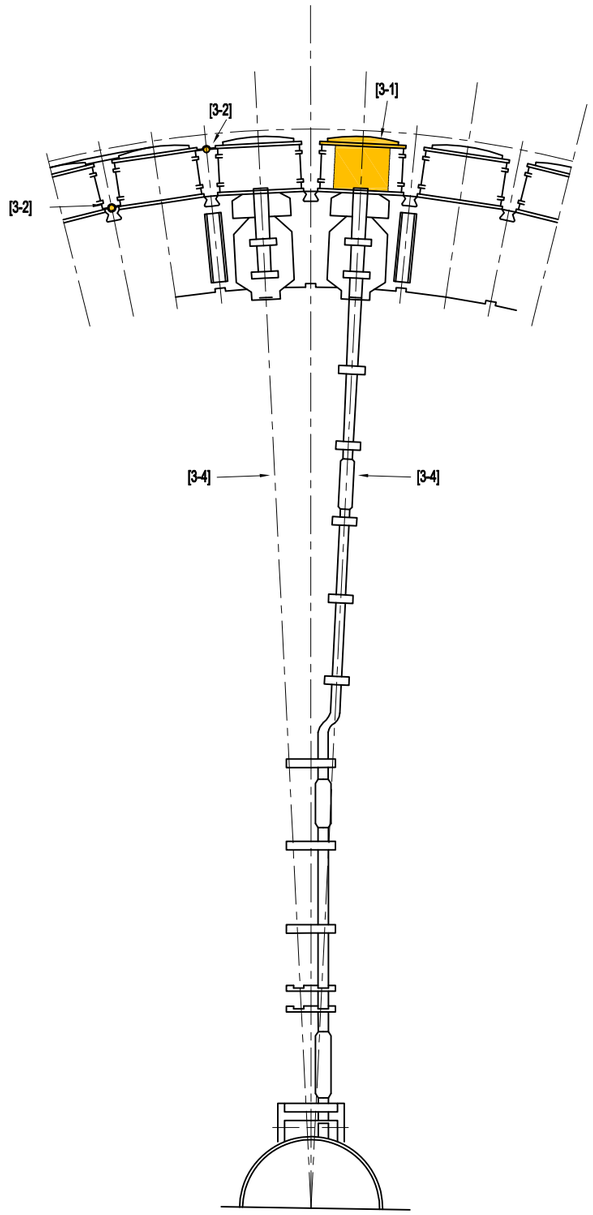
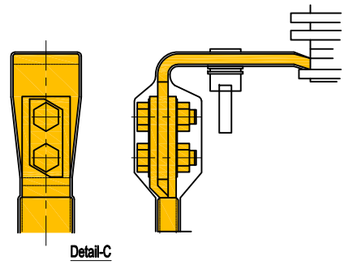
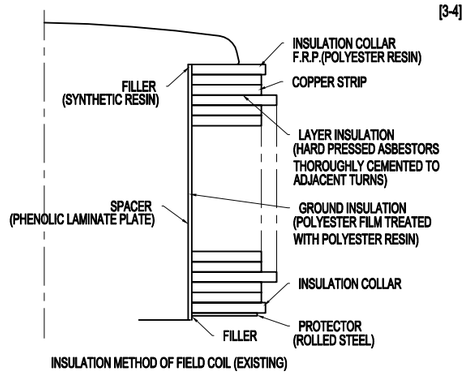
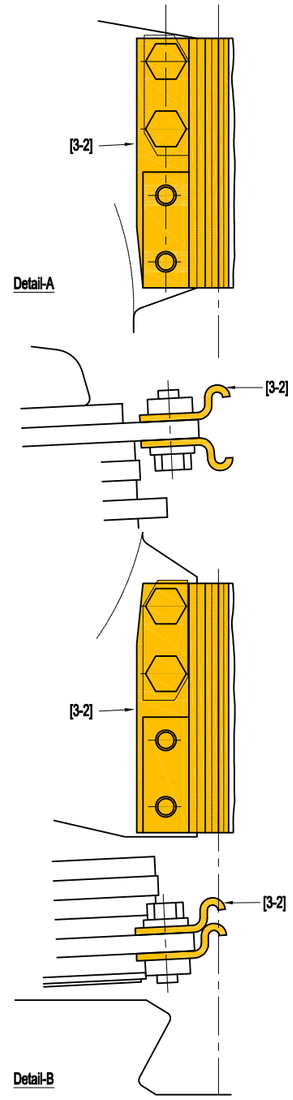






INSULATION METHOD OF FIELD COIL (EXISTING)



THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title ASSEMBLY OF FIELD COILS				DWG. No. 7
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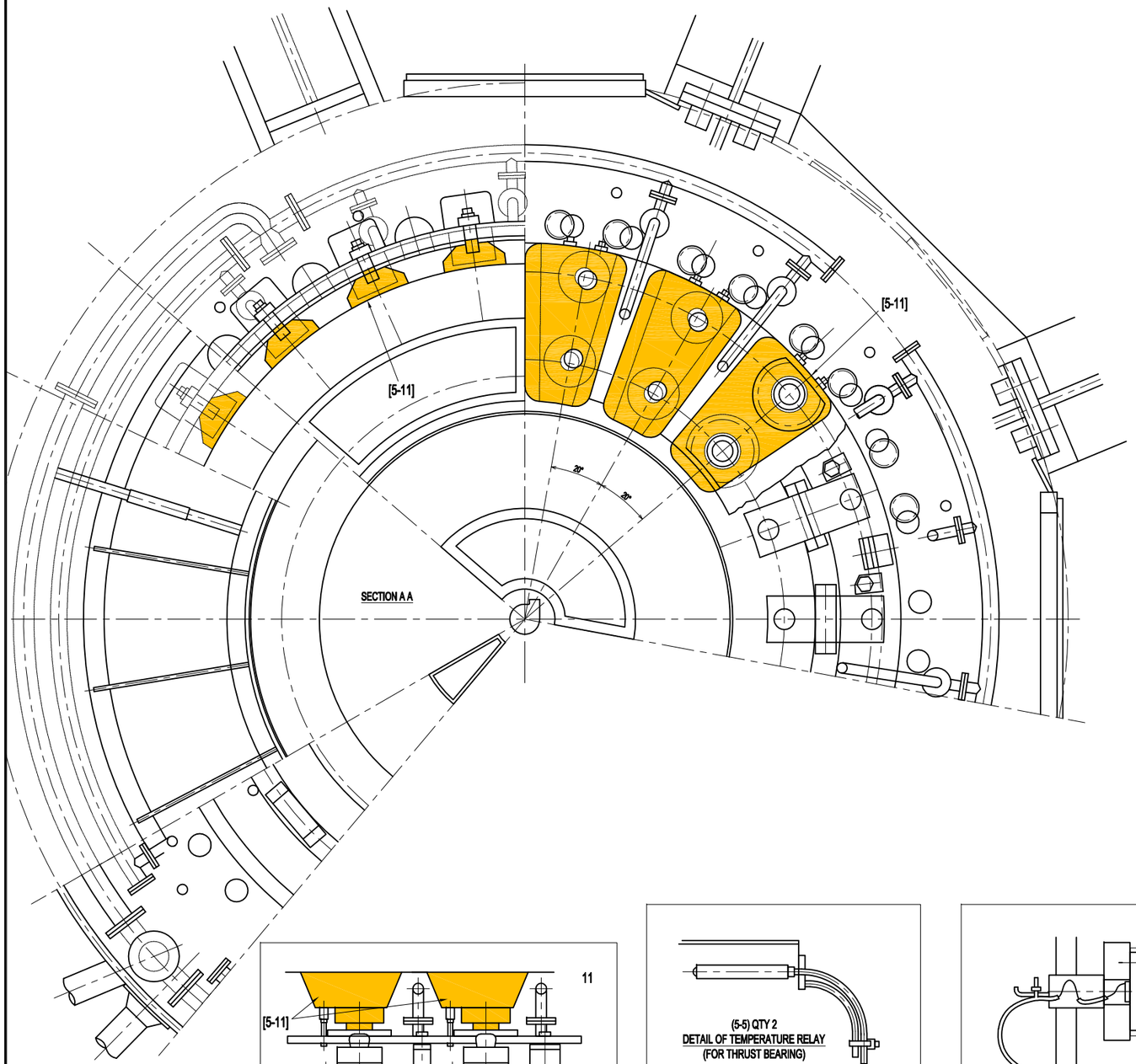

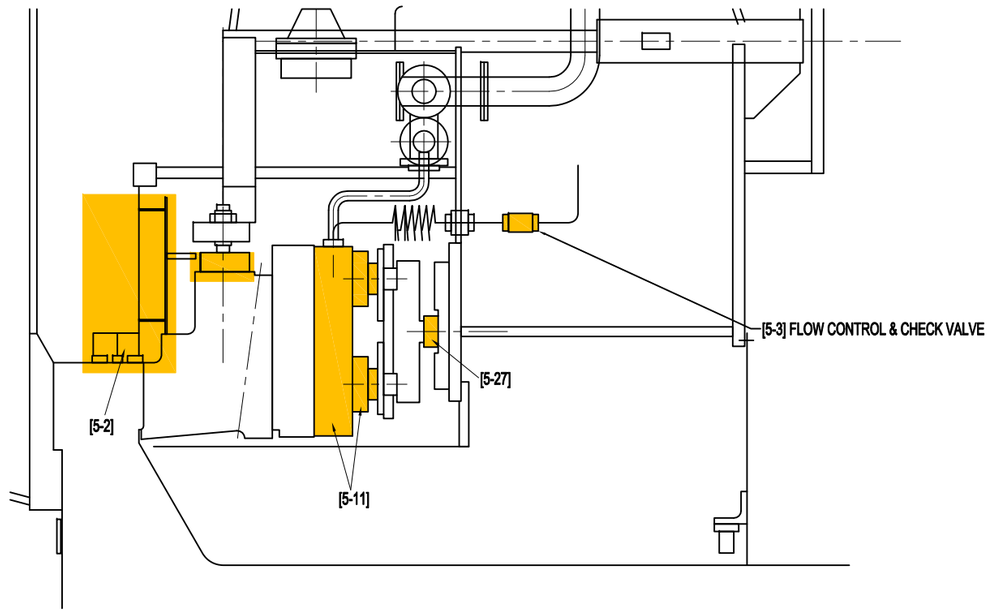

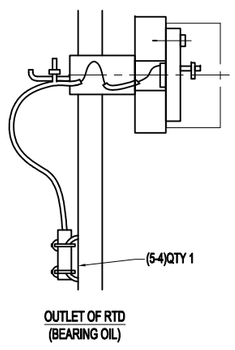

THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title ASSEMBLY OF THRUST AND LOWER GUIDE BEARING				DWG. No. 8
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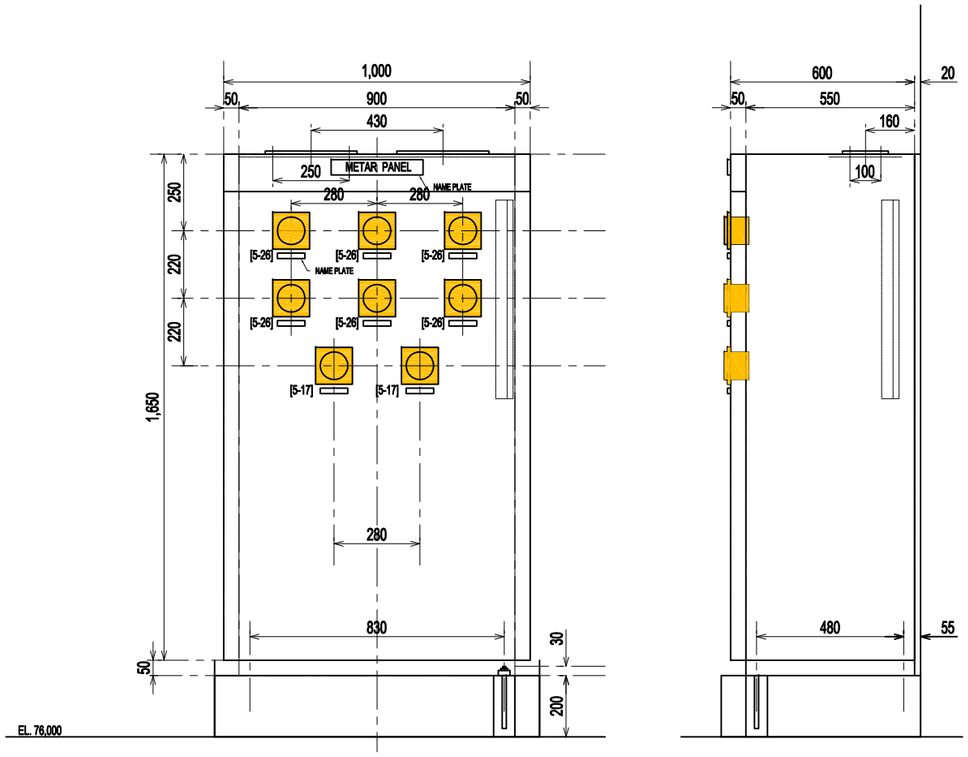

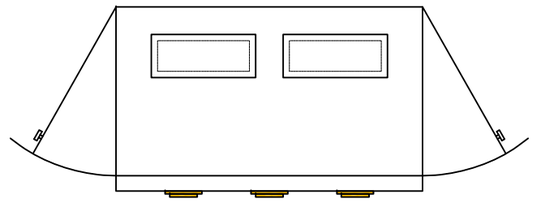

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THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title METER PANEL				DWG. No. 9
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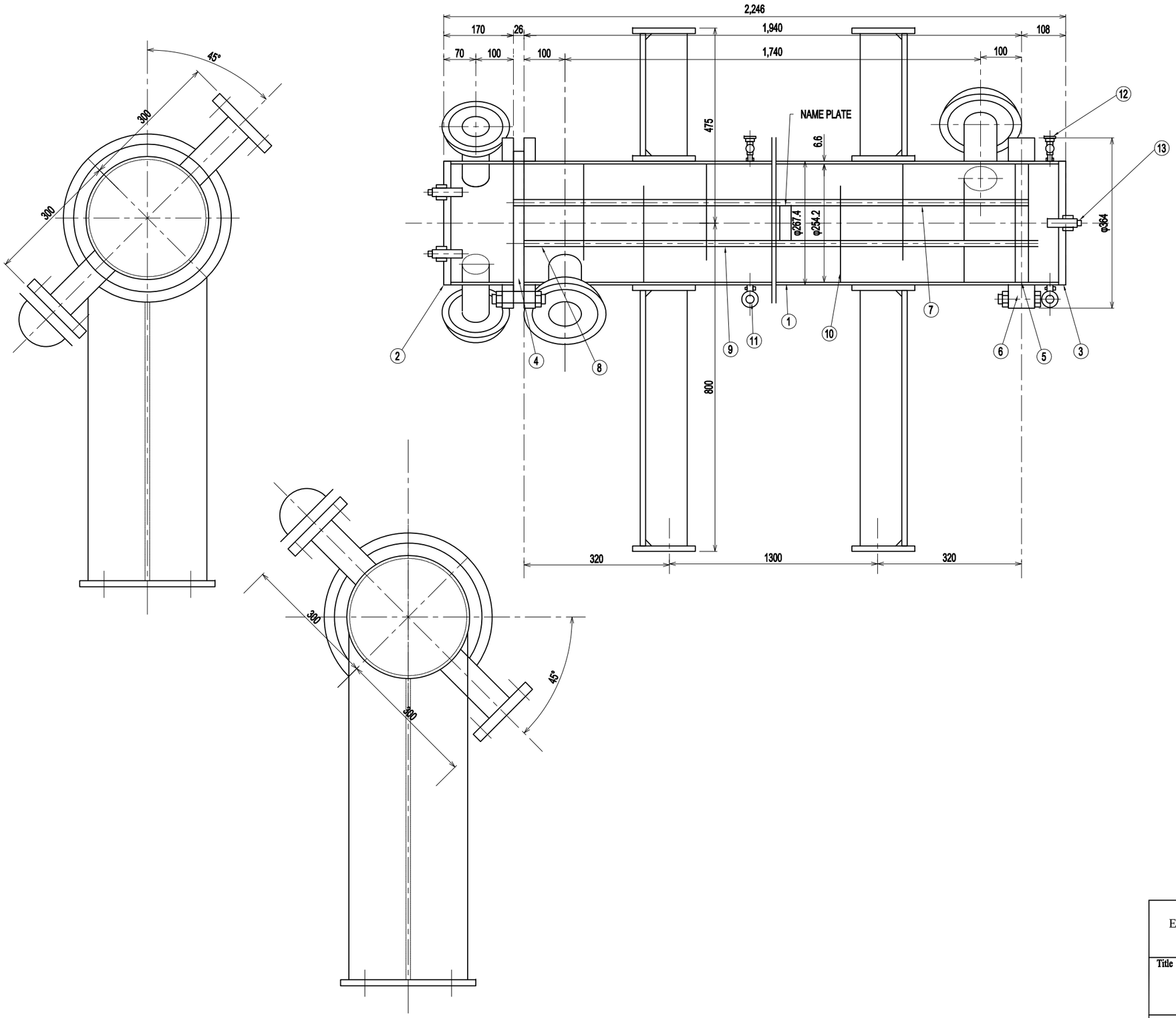

THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title OIL COOLERS				DWG. No. 10
DATE	DESIGNED	CHECKED	APPROVED	REVISION
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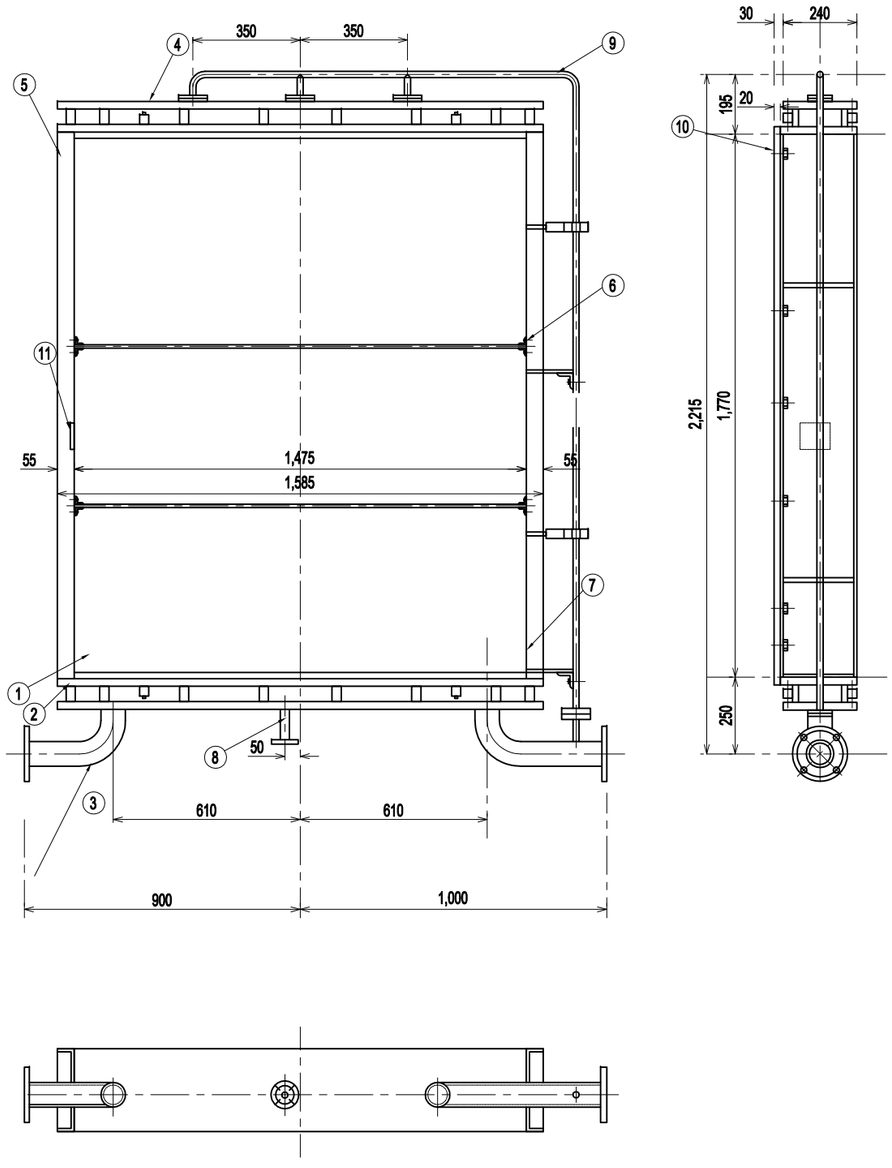

THE PROJECT FOR EMERGENCY REPAIR AND OVERHAUL WORKS FOR THE JEBBA HYDRO POWER STATION IN THE FEDERAL REPUBLIC OF NIGERIA				SCALE
Title AIR COOLERS				DWG. No. 11
DATE	DESIGNED	CHECKED	APPROVED	REVISION
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2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The Project will be implemented based on the Government of Japan's Grant Aid for Environment and Climate Change scheme. The Exchange of Notes (E/N) has been conducted and the Grant Agreement (G/A) has been concluded between the Government of Japan and Government of Nigeria, and the Project has been approved by the Government of Japan. The procurement agent will be recommended by the Government of Japan to the Nigerian side, and JHEP, acting as the mandatory, will manage the main Project works to ensure that the contract (tender and equipment procurement) is appropriately and smoothly executed. The following paragraphs describe the basic items and points requiring particular consideration in the event where the Project is implemented.

(1) Project Implementing Agency

The supervising government agency on the Nigerian side is the Federal Ministry of Power (FMOP), and the implementing agency is Jebba Hydro Electric Plc (JHEP). Following the completion of installation works in the Project, JHEP will be responsible for the operation and maintenance of equipment. In accordance with the framework of the Government of Japan's grant aid scheme, JHEP will conduct close liaison and discussions with the Japanese procurement agent recommended by the Government of Japan, the consultant and the contractor that are selected by the Japanese procurement agent; it will conduct adequate explanations and secure the understanding of residents around the target site (Jebba Hydro Power Station) for the contents of the Project, and it will conduct guidance to ensure that cooperation for implementation is obtained.

(2) Procurement Agent

The procurement agent will be recommended to the Nigerian side by the Government of Japan, while FMOP and JHEP, acting as the mandatories, will supervise work to ensure that the contract (detailed design, tender, equipment procurement and installation) is appropriately and smoothly executed, and will manage funds on behalf of the relevant agencies on the Nigerian side.

(3) Consultant

The procurement agent will conclude a design supervision contract with the consultant in order to supervise the detailed design of the Project facilities and equipment, preparation of tender documents, procurement and installation of equipment. The consultant will implement the Project detailed design, prepare the tender documents and supervise the installation and procurement work. Moreover, when the procurement agent so requests, it will assist the procurement agent in reviewing the tender qualifications and implementing the tender work.

(4) Contractor

In accordance with the framework of Japan's Grant Aid scheme, the contractor that has been selected by the procurement agent in competitive tender will implement the equipment and

materials procurement and installation works of the Project.

Following completion of the Project, since it will be necessary to continue supplying spare parts and conducting post-installation service to resolve breakdowns and so on, it will be necessary to conduct thorough liaison and coordination after the handover of equipment and materials.

2-2-4-2 Implementation Condition

(1) Suppliers

The Unit 4 generator targeted for rehabilitation is a large-scale unit with rated capacity of 96.4 MW and is produced by a Japanese manufacturer. Since there are no heavy electrical machinery makers that can manufacture generators of similar scale in Nigeria, it is desirable to procure the Project equipment from the same maker or a Japanese heavy electrical machinery maker that has experience of supplying hydroelectric generators of similar scale. As the Project entails the partial replacement and repair of a generator, it is desirable that the equipment required in the Project be procured from the heavy electrical maker that manufactured the generator.

(2) Important Points in Implementation Planning

1) The Project site has a dry season from November to April and a rainy season from May to October. Since the water volume in Jebba Lake is abundant during the rainy season, Jebba Hydro Power Station adopts a setup geared to increasing generated electrical energy during this period. Therefore, concerning the stoppage of Unit 4 due to the Unit 4 rehabilitation works, it will be necessary to appropriately set the works period to ensure that enough water flow is secured for conducting the final wet test.
2) After the procured equipment and materials have been landed at Apapa Port, Lagos, they will be transported overland to Jebba Hydro Power Station, however, because the route has damaged paving and is in poor condition in parts, it is possible that the transportation route and carrying capacity will be limited. Therefore, it will be necessary to pay attention to these points in the transportation plan and schedule planning.
3) The two overhead traveling cranes (225/50/15 t) installed in the powerhouse are currently not working due to broken brakes, control circuits and power collectors. Since these cranes are needed for regular maintenance work and also for the Unit 4 generator rehabilitation works, it will be necessary for the Nigerian Government to repair them by the start of the rehabilitation works. Moreover, because wire rope and other parts have been used beyond their service life, it will be necessary to replace such parts during the rehabilitation.
4) Among the existing products, the stator frame and other items contain asbestos. Since there is a risk that this will fly off when disassembling the core, it will be necessary to conduct wet work and take ample care in curing and so on. Since Nigeria has no domestic regulations, it will be necessary to apply Japanese asbestos damage prevention rules with workers wearing protective breathing apparatus and protective clothing and work being conducted in a wet environment. Moreover, coil surfaces are covered in varnish and exterior tape. When disassembling the coils, since there will be a risk of the asbestos parts being broken, it will be necessary to take ample care regarding curing and so forth.

Moreover, since such parts have laminated structure on the inner side, the outer surfaces are covered in varnish. When disassembling field coils, since there will be a risk of the asbestos flying off, it will be necessary to take ample care regarding curing and so forth

2-2-4-3 Scope of Works

The Japanese side will be responsible for the procurement, installation, testing and adjustment of the generator equipment and materials, while the Nigerian side will need to repair the crane required for the Unit 4 rehabilitation works and remove existing equipment in time for the said works.

Table 2-2-2 shows the detailed scope of works on the Japanese and Nigerian sides.

Table 2-2-2 Scope of Works on the Japanese and Nigerian Sides

No.	Item	Scope		Remarks
		Japanese Side	Nigerian Side	
1	Securing of storage site for equipment and materials		○	
2	Securing of disassembly and assembly space for carrying out winding repairs (inside the generator house)		○	
3	Securing of parking spaces during the works		○	
4	Work spaces inside and outside of the power station, site office and indoor and outdoor storage areas			
	(1) Electrical works			
	a) Power line expansion works		○	Expansion of existing low voltage lines and installation of watt-hour meters (up to the primary side)
	b) Installation of power receiving panel	○		As required
	(2) Water supply works			
	a) Water supply (public waterworks) works		○	
	(3) Drainage works			
	a) Sanitary sewage drainage works (sanitary sewage and rainwater)		○	As required
5	Site office furniture (desks, chairs)	○		
6	Manufacture and procurement of equipment and materials	○		
7	Transportation of equipment and materials	○		
8	Transportation and customs clearance procedures and tax handling			
	(1) Responsibility for ocean transport of equipment and materials to Nigeria	○		
	(2) Tax burden and customs clearance procedures at the port of unloading in Nigeria		○	
	(3) Transportation of procured equipment, etc. from the port of unloading to the inland site in Nigeria	○		

No.	Item	Scope		Remarks
		Japanese Side	Nigerian Side	
	(4) Exemption or bearing of domestic value added tax on procured materials and equipment in Nigeria		○	
9	Appropriate storage and safety management of equipment and materials in the temporary storage yard on the Project site and site office during the site works period	○		
10	Steps for acquiring the following authorizations: - Authorization needed for conducting installation works - Authorization for entering restricted areas		○	These authorizations need to be obtained before Project implementation.
11	Installation of equipment	○		
12	Temporary power interruptions during the works period		○	
13	Operating training and guidance for completion inspections and operation and maintenance of equipment and products	○		The Nigerian side will need to select the members to take part in training.
14	Operation and maintenance of the facilities and procured equipment		○	
15	Other costs not covered by the grant aid		○	
16	Payment of the following commissions based on the Banking Arrangement:			
	(1) Cost of opening an account with a foreign exchange authorized bank in Japan		○	Around 10,000 yen
	(2) Bearing of payment commissions		○	Around 0.1% of the project cost

Note: ○: Indicates the scope of responsibility regarding each item

2-2-4-4 Consultant Supervision

Based on the scheme of the Government of Japan's Grant Aid Program, the procurement agent will recruit a consultant to smoothly conduct the implementation design and execution supervision work according to the principles of the outline design. The procurement agent will conduct overall management during the period of execution. Under the execution supervision of the Japanese consultant, the procurement agent will implement site confirmation at the start of the work, witness the handing-over inspection and confirm other important points. Furthermore, an expert in Japan will attend plant inspections and pre-shipping inspections of equipment and materials manufactured in Japan with a view to ensuring that no troubles occur following delivery of materials and equipment to Nigeria. Furthermore, in line with the progress of the works, it will dispatch expert where necessary to supervise the works implemented by the contractor.

Moreover, where necessary, the expert will attend plant inspections and pre-shipping inspections of equipment and materials manufactured in Japan with a view to ensuring that no troubles occur following delivery of materials and equipment to Nigeria.

(1) Basic Concept of Execution Supervision

The procurement agent will supervise the progress to ensure that the works are completed on time, and in cooperation with the contractor, it will supervise and guide the contractor in order to secure the quality, performance and delivery deadlines specified in the contract and make sure that the works are carried out safely.

The major points to bear in mind in the consultant supervision are described below.

1) Schedule supervision

The procurement agent will compare progress with the implementation schedule decided by the contractor in the contract every month or every week in order to adhere to the delivery deadline given in the contract. In cases where delays are predicted, the procurement agent will warn the contractor, demand the submission and implementation of a plan of countermeasures and offer guidance to ensure that the works and delivery of equipment and materials are completed within the contract period.

- Confirmation of works performance
- Confirmation of equipment and materials delivery
- Confirmation of yield and actual numbers of engineers, skilled workers and laborers, etc.

2) Quality control

Supervision will be carried out based on the following items to determine whether the facilities and equipment satisfy the required quality stated in the contract documents (technical specifications and detailed design drawings, etc.). In cases where doubts arise over quality and performance, the procurement agent will immediately demand that the contractor make amendments, revisions or corrections.

- Checking of shop drawings and specifications of materials and equipment
- Attendance of plant inspections of materials and equipment and checking of plant inspection results
- Checking of shop drawings and onsite trial operation, adjustment and installation guidelines of materials and equipment
- Supervision of materials and equipment installation works and witnessing of trial operation, adjustment and inspection

3) Safety control

Discussions will be held and cooperation sought with responsible officers of the contractor and safety control will be exercised during the construction period in order to prevent industrial accidents. Important points to consider in safety control on the ground are as follows.

- Establishment of safety control regulations and appointment of manager
- Prevention of accidents through implementation of periodic inspections of construction machinery
- Planning of the works vehicles and construction machinery operating routes and thorough enforcement of safe driving
- Encouragement of laborers to utilize welfare measures and vacations

4) Fund supervision

The procurement agent will manage the Project cost indicated in the E/N exchanged between Japan and Nigeria on behalf of the implementing agency (JHEP). After the E/N, the Project funds will be transferred from JICA to the account established by the implementing agency with a Japanese bank. Then, after the procurement agent contract is concluded between the Nigerian side and the procurement agent, the funds will be transferred from the bank account on the Nigerian side to the account in the Japanese bank opened by the procurement agent. The procurement agent will pay the contractor(s) according to the conditions prescribed in the contracts.

(2) Overall relationships in Project implementation

Figure 2-2-5 shows the mutual relationships between Project officials including those during the consultant supervision.

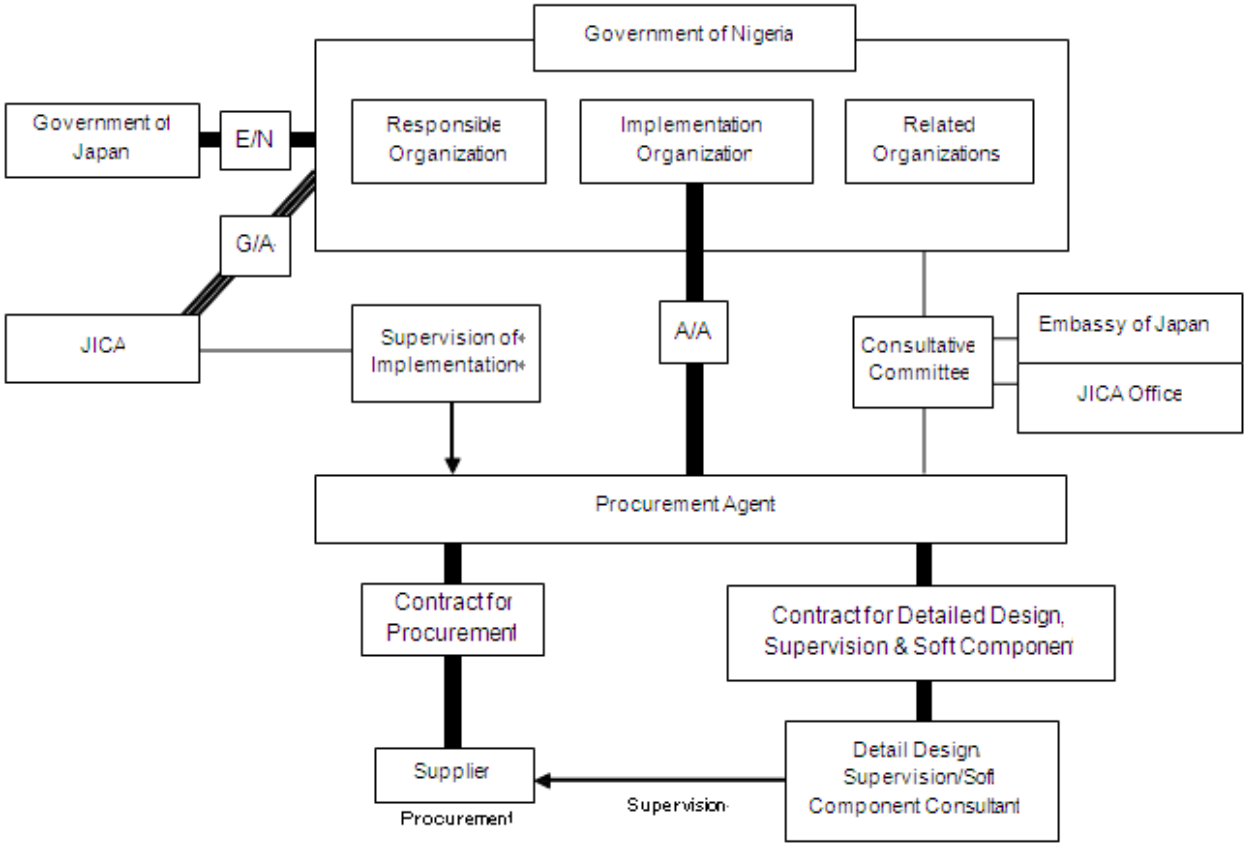

Figure 2-2-5 Project Implementation Interrelationships

(3) Works Supervisor

The contractor(s) will procure and install the equipment based on the contract made with the procurement agent. The contractor(swill conduct schedule supervision, quality control and safety control during the construction period, and the works supervisor of the consultant recruited by the procurement agent will supervise and instruct the contractors.

2-2-4-5 Quality Control Plan

The consultant's works supervisor will carry out supervision and checking based on the following items to ensure that the contractor secures the quality of Project facilities, equipment and materials stipulated in the contract documents (technical specifications and implementation design drawings, etc.). In cases where doubts arise over quality, the consultant will consult with the procurement agent and demand that the contractor make amendments, revisions or corrections. The procurement agent will check the work execution performance of the works supervisor and offer guidance where necessary.

Checking of shop drawings and specifications of equipment and materials

① Attendance of plant inspections of equipment and materials and checking of plant inspection results
② Checking of packing, transportation and on-site temporary storage methods
③ Checking of shop drawings and installation guidelines for equipment and materials
④ Checking of trial operation, adjustment, test and inspection guidelines of equipment and materials
⑤ Supervision of site installation works of equipment and materials and attendance of trial operations, adjustments, tests and inspections
⑥ Checking of completion documents

2-2-4-6 Procurement Plan

Apart from the works materials and expendable items for use in the Project works, the major items of equipment will be procured from Japan. The main items of equipment to be procured from Japan are as shown in Table 3-2-14.

2-2-4-7 Operation Guidance Plan

In order to enable effective operation of the supplied equipment after the handing over of the rehabilitated facilities, the techniques for operating and maintaining the equipment and materials procured and installed in the Project will be transferred to the Nigerian counterparts during the installation works and trial operation period.

The detailed OJT plan will be decided within the survey design works scheduled for implementation from now on.

2-2-4-8 Implementation Schedule

The Project has already been approved for implementation by the Government of Japan, and the Exchange of Notes (E/N) and Grant Agreement (G/A) have been concluded between the two countries. Following completion of the Survey, the Agent Agreement (A/A) will be concluded between JHEP, the implementing agency, and the procurement agent recommended by the Government of Japan and Project implementation will commence based on the scheme of the Government of Japan's Emergency Grant Aid. Project implementation is basically divided into four stages, namely ① implementation design and selection of works supervision consultant, ② detailed design and preparation of tender documents, ③ tender for selection of contractor(s) and signing of works contract, and ④ equipment

and materials procurement and installation works. Figure 2-2-6 shows the Project implementation schedule.

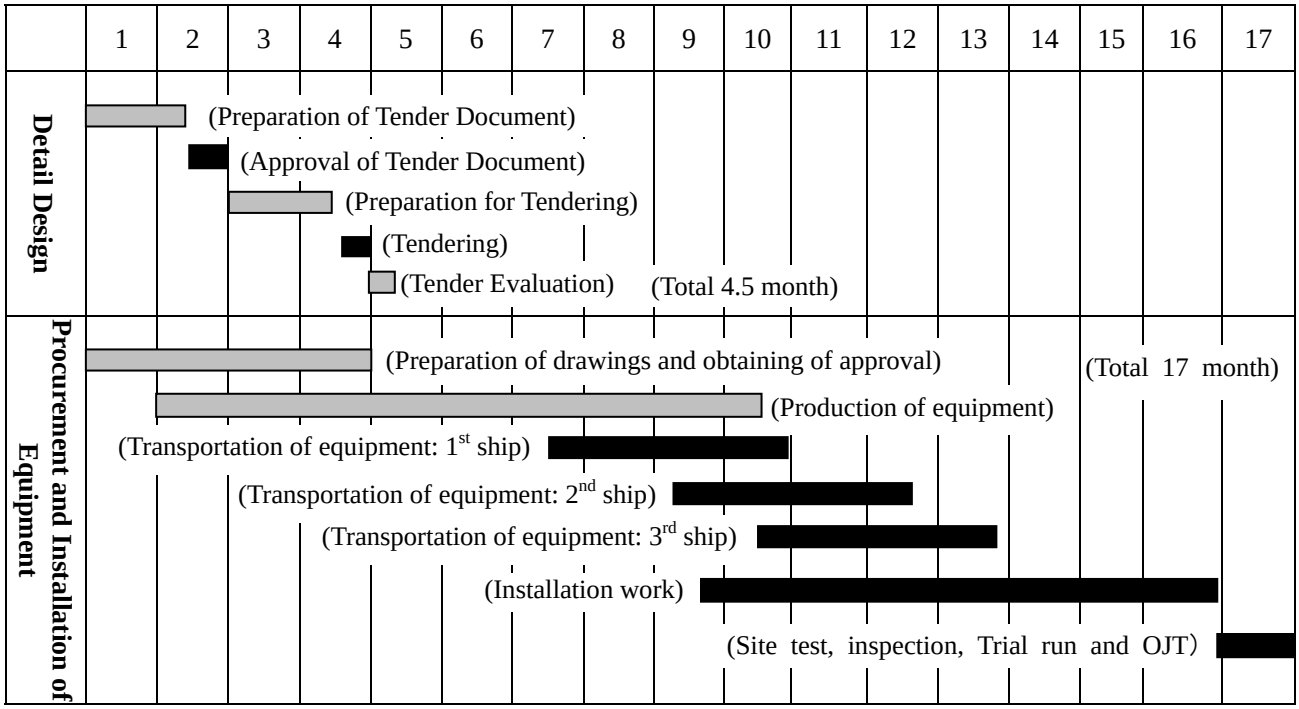

Figure 2-2-6 Project Implementation Schedule

2-3 Obligations of Recipient Country

When it comes to implementing the Project, in addition to the scope of works on the Nigerian side (Table 2-2-2) indicated in 2-2-4-3 Scope of Works in Execution and Procurement, items to be implemented or borne by the Nigerian side are as follows.

① To provide information and data necessary for the Project.
② To grant labor permits to Japanese persons (and/or corporations) dispatched for the purpose of the procurement and installation of Project equipment and materials and exempt them from or bear commissions (or business taxes).
③ To provide the conveniences necessary for entry to Nigeria and stay therein of Project personnel from Japan and third countries.
④ To appoint specialist engineers and technicians for the transfer of Project operation and maintenance technology and to attend equipment and materials quality inspections on site.
⑤ To repair the overhead traveling cranes in the powerhouse.
⑥ To secure operators for the overhead traveling cranes.
⑦ To install and adjust the exciter purchased by the Nigerian side.
⑧ To secure the special tools required for rotor rim repairs.
⑨ To secure tools for installation (including lifting devices and sling wires; details are shown in the appendices)
⑩ To maintain the speed governor on the Unit 4 generator.
⑪ To maintain power supply for the power plant.
⑫ To maintain shaft seals.

⑬ To maintain the servo motor of guide vane.

⑭ To secure the necessary budget and employees needed to properly and effectively operate and maintain the facilities constructed and equipment and materials procured under Japan's Grant Aid.

⑮ To secure the necessary budget and proper treatment of asbestos-containing wastes in accordance with appropriate procedure which satisfies related Nigerian regulation.

2-4 Project Operation Plan

2-4-1 Basic Concept

In order to conduct stable operation of the hydro power station, it is essential to conduct the appropriate operation and maintenance (O&M) of turbine and generator equipment, etc. and maintain the peripheral environment. Accordingly, it is desirable to implement appropriate preventive maintenance and regular maintenance geared to reducing breakdown rates in facilities and enhancing reliability, safety and efficiency.

Figure 2-4-1 shows the basic thinking regarding the maintenance of equipment and facilities in the hydro power station. According to this, it will be necessary to implement the maintenance of equipment procured and installed in the Project based on preventive maintenance.

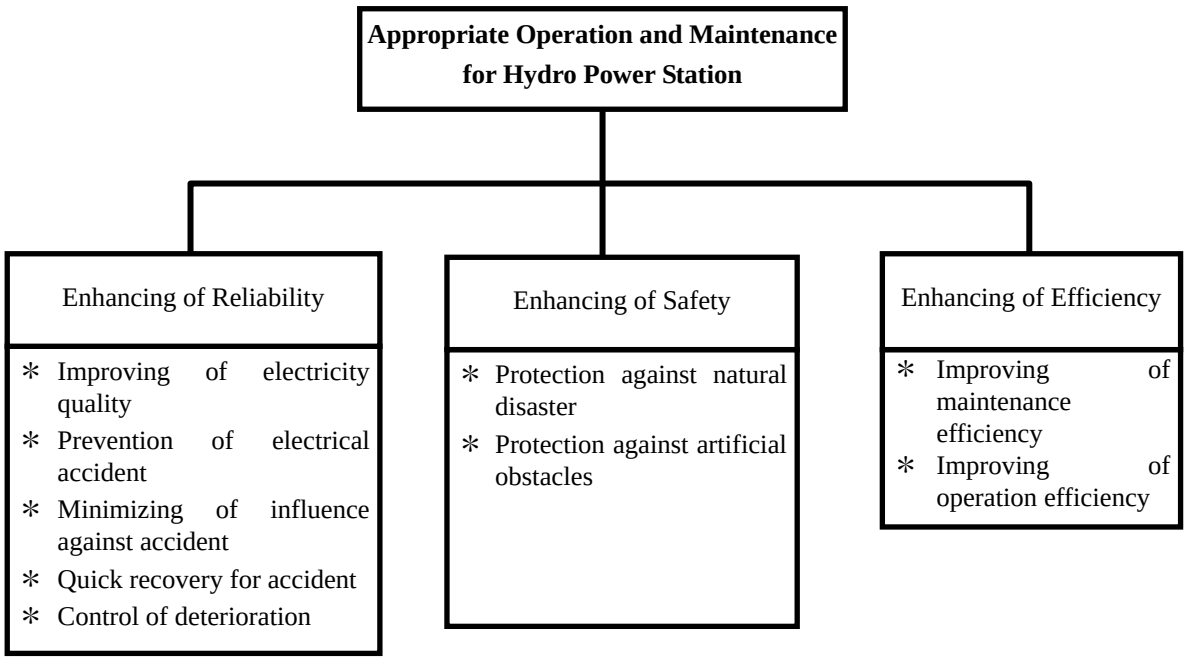

Figure 2-4-1 Basic Thinking on Maintenance of Hydro Power Station

In the Project, it is planned to implement OJT on turbine and generator operation and maintenance under guidance by an engineer dispatched from the Japanese contractor during the installation works and testing and adjustment period. At the same time, through providing the necessary spare parts, test apparatus, maintenance tools and O&M manual and proposing the operation and maintenance setup following the start of operation, the effects of operation and maintenance can be amply realized.

2-4-2 Operation and Maintenance Setup

With JHEP in charge of operation and maintenance following completion of the Project, under the supervision of PHCN (Power Holding Company Nigeria), the necessary organization and personnel for conducting appropriate operation of the power utility can be expected.

2-4-3 Periodic Inspection Items

2-4-3-1 Periodic Inspection of Water Turbine Generator

Table 3-4-1 shows the standard periodic inspection items for generator equipment to be procured and installed in the Project. As is shown in the table, equipment inspections are classified into the following three types:

① Patrol inspections in which abnormal heating or noises, etc. are inspected everyday based on the five senses;

② Ordinary inspections in which inspections are conducted on charged sections that cannot be inspected in routine patrols, for example, torque of equipment bolts, surface dirt on insulated objects, etc., and

③ Detailed inspections on functions of guide vanes, bearing speed governors and exciters and for maintaining precision of measuring instruments.

Ordinary inspections are normally conducted once every one or two years, while detailed inspections are conducted around once every four years. Moreover, it is desirable to replace parts such as meters and relays, etc. when they are found to have deteriorated performance, deteriorated insulation performance, worn contacts or altered characteristics in ordinary inspections and detailed inspection.

Table 2-4-1 Periodic Inspection Items in Standard Equipment

Inspection Item	Inspection Contents (Method)	Patrol Inspection	Ordinary Inspection	Detailed Inspection
Water turbine	Guide vane operating condition	○	○	○
	Water leaks around the guide vane, and state of weak point pins		○	○
	Leaks from joints	○	○	○
	Main bearings oil level and oil supply	○	○	○
	Main bearings temperature and cooling water level	○	○	○
	Abnormal vibration and noise	○	○	○
	Abnormalities in thermometer elements, relays and wiring, etc.		○	○
	Relationship between guide vane opening and output		○	○
	Vibration measurement		○	○
	Abrasion of main axis metal			○
	Abrasion of main axis sleeve, wear of water sealing packing			○
	Runner abrasion and measurement of runner liner gap			○
	Measurement of gap between guide vane shutter face and guide vane and casing			○
	State of abrasion of bearing bush			○
	Oil leaks from pressure oil introduction part and abnormalities in return mechanism			○
	Oil leaks from runner boss and runner servo motor			○
	Guide vane opening and runner vane opening			○
Generator	Rotor hub			

Inspection Item	Inspection Contents (Method)	Patrol Inspection	Ordinary Inspection	Detailed Inspection
	Cracks			○
	Rotor			
	Rotor coil			
	Rust			○
	Field coil			
	Winding staining		○	
	Insulation resistance	○		
	Damper winding			
	Discharge trace			○
	Condition of terminals			○
	Cracks			○
	Connecting terminals			○
	Fan			
	Bolt tightening			○
	Air gap			
	Gap disparity			○
	Stator			
	Stator core			
	External appearance			○
	Thermal transformation			○
	Rust			○
	Winding			
	Winding staining			○
	Condition of insulated items			○
	Insulation resistance	○		
	Core duct			
	Duct staining	○		
	Wedge			
	Winding cohesion			○
	Frame			
	Loose bolts			○
	Bearings			
	Bearings			
	Cracks and damage		○	
	Temperature	○		
	Oil box			
	Oil leaks	○		
	Lubricating oil			
	Oil level and staining	○		
	Water infiltration		○	
	Shaft seal			
	Insulation resistance			○
	Axial voltage	○		
	Brackets			
	Loose bolts		○	
	Vibration	○		

Inspection Item	Inspection Contents (Method)	Patrol Inspection	Ordinary Inspection	Detailed Inspection
	Space heater			
	Other items; absence of combustible items	○		
	Oil cooler, air cooler			
	Condition of air		○	
	Oil leaks		○	
	Rust and staining			○
	Pipes			
	Air, water and oil leaks	○		
	Oil pump			
	Oil leaks	○		
	Filter washing		○	
	Oil pump temperature	○		
	Oil pump vibration	○		
	Motor insulation			○
	Strange noise	○		
	Brake			
	Shoe condition			○
	Collector ring			
	Brush spark	○		
	Brush pressure		○	
	Brush condition		○	
	Collector ring surface			○
	Staining			○
	Others			
	Noise and vibration	○		
	Connection plugs		○	
	Interlocking circuits		○	
	Protective relays		○	
	Rotor stoppers		○	
	Condition of spare parts storage			○
Speed governor	Abnormality on speed governor potentiometer, attachment of dust to converters	○	○	○
	Heating, discoloring and disconnection of speed governor resistor	○	○	○
	Loose or stretched link pins or wires in speed governor return mechanism		○	○
	Clogging of speed governor strainer			○
	Lubrication of speed governor moving parts		○	○
Hydraulic devices	Operating state and abnormal odor in hydraulic device pumps	○	○	○
	Oil level and oil pressure in hydraulic devices	○	○	○
	Oil leaks from hydraulic device pipes and cages	○	○	○
	Cooling water level and oil temperature in hydraulic device oil collection tanks	○	○	○
	Abrasion of hydraulic device gear pumps and side gaps		○	○
	Abrasion of hydraulic device pumps and motor bearings		○	○
	Abrasion and wrapping of hydraulic device pilot valves			○
	Foreign materials and sludge in hydraulic device oil			○

Inspection Item	Inspection Contents (Method)	Patrol Inspection	Ordinary Inspection	Detailed Inspection
Other devices	Oil leaks from lubricating oil pipes	○	○	○
	Operating state of lubricating oil device oil collection tank oil level relays and limit switches		○	○
	Oil supply and oil level in lubricating oil devices	○	○	○
	Clogging of water feeder strainer			○
	Blocking of water feeder pipes and state of leakage		○	○
	Water supply to water feeder, operating state of current breaker relay			○
	State of drainage device water level detector			○
	Heating, vibration, drainage capacity and lubrication of drainage device pumps	○	○	○

2-4-4 Spare Parts Purchasing Plan

2-4-4-1 Categories of Spare Parts

The spare parts are generally classified according to the following uses:

① Expendable items: Parts that require replacement according to the condition of abrasion and degradation

② Replacement parts: Parts that need to be replaced for repair due to damage of existing parts

③ Emergency spare parts: Instruments that urgently need to be replaced to prevent interruption to power supply

2-4-4-2 Spare Parts Target Equipment and Purchasing Plan

Table 2-4-2 shows the expendable items, replacement parts and emergency spare parts for the synchronous generator targeted for rehabilitation in the Project. The quantities of replacement parts are based on a one year supply. However, since there are plans to purchase spare parts in the project that is currently being implemented by the Nigerian side on Unit 6 and in the repair of other generating units, there will be no plans to purchase spare parts in the Project.

Table 2-4-2 Expendable Items, Replacement Parts and Emergency Spare Parts

Item	Quantity	Expendable Item	Replacement Part	Emergency Spare Part	Explanation
Collector ring	1		○		This is a connecting device for transmitting exciter current from the exciter to the generator; it requires replacement around every 5~10 years.
Carbon brush	90	○			This exciter side sliding terminal for transmitting exciter current to the collector ring is made from carbon and needs to be replaced around once a year.
Brush holder	2		○		Device for storing the carbon brush
Spare coil (top)	10			○	Stator coil (collector ring side)
Spare coil (bottom)	5			○	Stator coil (water turbine side)

Item	Quantity	Expendable Item	Replacement Part	Emergency Spare Part	Explanation
Guide bearing	22			○	Guide metal used in the generator bearings
Thrust runner	2			○	
Brake shoe	8	○			Brake sliding surface
Spare current transformer	6			○	
Spare thrust bearing	18			○	
Oil filter	1			○	
Low pressure filter	50		○		
High pressure filter	50		○		

2-4-4-3 Budget Steps for Spare Parts

In the Project, as it will be necessary for the Nigerian side to procure at least one year's supply of expendable parts and replacement parts, it will need to budget for the purchase of expendable parts and replacement parts for a year after completion of the Project.

2-4-4-4 Test Apparatus and Maintenance Tools

It is necessary to procure the test apparatus and maintenance tools that are required to carry out appropriate maintenance. Test apparatus and maintenance tools are not included in the grant aid, however, Table 2-4-3 shows the necessary items and quantities for reference purposes assuming self-procurement by JHEP. In particular, maintenance tools are needed in order to operate and maintain the generator targeted for repair in the Project.

Table 2-4-3 Maintenance Tools Needed for Maintenance

Item	Quantity
1. Test apparatus	
(1) Universal tester	1 set
(2) Phase indicator	1 set
(3) Voltage detector	1 set
(4) Insulation resistance meter (mega)	1 set
(5) DC withstand voltage tester (0~100 kV, including DC voltage detector)	1
(6) Basic ground resistance meter	1
(7) Digital multi meter	1
(8) Clamp tester	1
(9) Others	1
2. Maintenance tools	
(1) Compressor (with die)	1 set
(2) Hydraulic jack	50
(3) Welder	5
(4) Burner	5
(5) Grinder	8
(6) Chain block	4
(7) Spider suspending gear	1
(8) Others	1 set

2-5 Project Cost Estimate

2-5-1 Initial Cost Estimation

The breakdown of the cost to be borne by Nigeria side based on the division of work between the two countries is shown in the table below based on the estimation conditions given.

(1) Costs to be borne by the Nigerian side (Approximately 106.8 million yen)

The contents and costs to be borne by the Nigerian side are as follows:

① Repair of overhead traveling cranes

Replacement and repair of parts such as brakes, connections, protective relays, collectors, motors, solenoids, switches, copper bars and so on: 152,000,000 NGN (approximately 80 million yen)

Jebba Hydro Power Station is equipped with two overhead traveling cranes, each fitted with 225 ton, 50 ton and 15 ton cranes. Currently these cranes are beset with the following failures and the power station is searching for an operator to carry out repairs.

Overhead traveling crane	Crane type	Status
A	225 t	× Broken down
	50 t	× Broken down
	15 t	× Broken down
B	225 t	○ In operation
	50 t	Δ It is operating, however, the wire holding the crane head has broken brakes and conditions are dangerous. Repairs are needed.
	15 t	× Broken down

In the Project, the Unit 4 generator rotor will be repaired, however, since this weighs up to 450 tons, it will be essential to have overhead traveling cranes. Therefore, the crane repairs must be finished before the start of the Project installation works.

② The exciter has already been purchased by the Nigerian side together with parts for Unit 6, and the replacement and adjustment work for this will be conducted at the same time as the Project works (but separate from the Project works): 15,200,000 NGN (approximately 8 million yen)

③ The station AC and DC power supply NFB is no longer in production and cannot be replenished. With spare parts running low, maintenance will be conducted until implementation to ensure that no troubles occur: 5,700,000 NGN (approximately 3 million yen)

④ Maintenance of water turbine shaft seal and servo (bolt tightening, seal replacement, etc.): 3,800,000NGN (approximately 2 million yen)

⑤	Overhead traveling crane operators during the installation works period (10.5 MM):	5,460,000NGN	(approximately 2.8 million yen)
⑥	Expendable items (1 year supply)	3,800,000 NGN	(approximately 2 million yen)
⑦	Tools	13,300,000 NGN	(approximately 7 million yen)
⑧	Authorization to Pay (A/P) fees:	Approximately 0.1% of E/N amount	(approximately 2 million yen)

(2) Estimation criteria

①	Estimation point:	August 2011
②	Exchange rate:	1 US$＝82.49 yen (TTS mean value from February to July 2011) 1 NGN=0.527 yen (TTS mean value from February to July 2011)
③	Works and procurement period:	The detailed design and equipment procurement and installation period is as shown in the implementation schedule.
④	Other points:	The Project will be implemented according to the Grant Aid Scheme of the Government of Japan.

2-5-2 Operation and Maintenance Costs

Jebba Hydro Power Station has continually operated the power station for 26 years since it was opened, and it will continue to operate and maintain the facilities and equipment provided in the Project. Moreover, as the Project entails repair of an already operating generator, it will not require any new employment of personnel.

Moreover, in order to soundly operate the generator to be rehabilitated in the Project, it will be necessary to always keep the spare parts (expendable parts and replacement parts) shown in Table 2-4-2 on hand and to budget for necessary parts (approximately 2 million NGN/year). Since repair and maintenance costs in the power station over the past five years have amounted to approximately 98 million NGN, it should be possible for Jebba Hydro Power Station to afford the cost of maintaining the equipment of Unit 4 that is to be rehabilitated in the Project.

CHAPTER 3

PROJECT EVALUATION

Chapter 3 Project Evaluation

3-1 Preconditions

3-1-1 Preconditions for Project Implementation

Project implementation is conditional on securing space for parts exchange work, obtaining environmental permission for wastes and implementing the obligations of the recipient country indicated in Section 2-3. Accordingly, in addition to definitely carrying out routine maintenance, it will be necessary for the contractor to appropriately treat waste according to the National Environmental Standard of Nigeria, to confirm the budget on the local side and bind a contract for the crane repair works, etc.

3-1-2 Preconditions and External Conditions for Achieving the Overall Project Plan

In order to realize and sustain the Project effects, the issues that need to be tackled by the Nigerian side will be as follows.

(1) Make sure that the water intake for the water turbine generator is enough for generating power.
(2) Make sure that sufficient budget is secured to pay for the personnel and materials needed for maintenance.
(3) Maintenance concerning power generation revenue is smoothly conducted and the financial condition is sound.
(4) Ensure autonomously procured cranes and tools are ready so that plans are not hampered on either side.

3-2 Necessary Inputs by Recipient Country

In order to realize and sustain the Project effects, the Nigerian side will need to tackle the following issues.

(1) Before start of works

① It will be necessary for the Nigerian side to complete the repair of the overhead traveling cranes in the power station building before the start of the Project works. In the Project, the Unit 4 generator rotor will be repaired, however, since this weighs up to 450 tons, it will be essential to have overhead traveling cranes. Therefore, the crane repairs must be finished before the start of the Project installation works.
② The Nigerian side will need to definitely procure the special tools required for rotor rim repairs and the tools required for installation works (including suspending apparatus and wire) in Unit 6. In the Project, the Unit 4 generator rotor will be repaired, however, since this weighs up to 450 tons, it will be essential to have special tools for suspending this as well as repair tools. Therefore, these tools must be procured before the start of the Project installation works.
③ The Nigerian side will need to secure the budget for its scope of works and definitely execute those works before the start of works by the Japanese side.

④ The Nigerian side will need to definitely make applications for permission to the Ministry of Environment concerning the works and waste products including asbestos before the start of works by the Japanese side.

(2) During works and after the start of operation

① In tandem with the generator procurement and installation works to be implemented by the Japanese side in the Project, the Nigerian side will need to smoothly carry out its obligations such as formulation and implementation of the power station operating plan, etc. It will be necessary to appoint responsible engineers for each target area in the Project in order to compile the schedule plan, staff plan and equipment and materials purchasing plan, etc. and generally expedite the works.

② The demand for electric power in Nigeria is growing rapidly in line with economic growth, etc. In line with this, generated electric energy at Jebba Hydropower Station is also increasing, and JHEP will need to secure autonomous and sustainable development with a view to securing revenue from power tariffs.

③ In order to secure a stable power station operating setup, it will be necessary to implement periodic dam patrol inspections, cut down trees around the dam and conduct preventive maintenance to ensure stable dam operation and avert accidents in civil engineering facilities such as the water discharge dam and gates, etc.

④ It will be necessary to promptly appoint the engineers who will take part in the Project OJT, dispatch them to the training and ensure that the contents are horizontally extended to the other engineers who can't take part in the training.

⑤ It will be necessary to take tax exemption measures and provide other conveniences regarding the necessary equipment and materials for the Project and the Japanese nationals who are dispatched.

⑥ Since the existing transmission substations and Jebba Hydropower Station are operated under different setups, it will be necessary for the Nigerian side to constantly share information and conduct maintenance for dealing with accidents and so on.

3-3 Important Assumptions

The external conditions that are required in order to realize and sustain the Project effects are as follows.

(1) Concerning the higher goal

- Policies concerning hydropower generation remain unchanged.
- The political and economic situation is stable.

(2) Concerning the Project objectives

- Operation and maintenance is carried out on a sustained basis.
- Tariff collections and financial support are continued.
- Security of facilities is maintained.

(3) Concerning the anticipated outputs

- The dam and power generating facilities are adequately operated.
- The operation and maintenance plan is implemented.
- Residents can afford the connection costs and electricity tariffs (government).

3-4 Project Evaluation

3-4-1 Relevance

As is indicated below, since the Project will contribute to the realization of Nigeria's development plans and energy policy and impart benefits to the general public including impoverished people, it is deemed to have high relevance as an aid undertaking.

(1) Benefiting population

As a result of Project implementation, it will be possible to supply stable power to approximately 140 million residents of Nigeria.

(2) Contribution to stable operation of public and social welfare facilities

Project implementation will contribute to the stable supply of electricity to public and social welfare facilities such as schools and hospitals. Since power facilities will be improved and problems such as power interruptions and voltage drop will be mitigated when operating x-ray and other medical instruments in the said public facilities and using power tools in industrial plants, it will become possible to use such instruments and tools for longer times, thereby making a contribution to improving the living conditions of residents.

(3) Project contributing to national development plans in Nigeria

Within the 7 Point Agenda proposed by President Yar'Adua in May 2007 in the areas of, (1) power and energy, (2) security, (3) land reform, (4) food security, (5) education, (6) wealth creation and (7) transport and infrastructure, power and energy is the most important item. According to the National Energy Policy, it is planned to expand the production and utilization of energy with a view to promoting industry.

Moreover, the Ministry of Energy is taking the initiative in compiling the Renewable Electricity Policy Guidelines aimed at expanding supply of power made using renewable energy sources, and the government considers it necessary to promote power supply from renewable energy sources as a means of bolstering power generation and supply capacity to match economic and social development, diversifying power generation sources from the viewpoint of energy security and promoting rural electrification. The Renewable Electricity Action Program is also currently being compiled in order to indicate concrete measures for manifesting the said guidelines in future. Project implementation will lead to the upgrading and expansion of renewable energy power generating facilities, thereby leading to major improvement in power interruptions and enhancing the power supply of Nigeria that is in need of urgent improvement.

(4) Japan's Grant Aid Scheme

The main equipment for the Project will be procured in Japan, and the work is scheduled to finish within the E/N time limit. Therefore, since the Project contents and schedule are feasible and reasonable for implementation within the scope of the grant aid scheme, it should be possible to implement without any major difficulty. Since JHEP is a state-run enterprise, the Project contents are both relevant and urgently required as described earlier and there is no problem concerning the maintenance setup, there should not be any impediments to implementing the Project under the Government of Japan's grant aid scheme.

(5) Necessity and superiority of using Japanese technology

The Unit 4 generator, which is targeted for improvement in the Project, is a large-scale unit made by a Japanese maker and possessing rated output of 96.4 MW. Since Nigeria has no makers capable of making a generator of similar scale, and the unit targeted for rehabilitation in the Project was made in Japan, there is deemed to be necessity and technical advantage in having a Japanese enterprise implement the Project work.

3-4-2 Effectiveness

The following effects are anticipated as a result of Project implementation.

(1) Quantitative effects

1) Maximum output

Unit 4 is currently unable to generate more power due to vibrations and so on even if the amount of water intake from the dam is increased. Since the Project will result in completion of repairs and upgrading of the meters required to monitor temperature, etc. in coils, thrust bearings and coolers, etc., it will become possible to safely acquire output and reduce the maintenance burden. Incidentally, as the reference value, output in 2010 has been adopted as the value for during and after 2009, when the accident occurred.

Indicator	Reference Value (2010)	Target Value (2016)
Maximum output (MW)	45.9 MW (47.6%)	96.4 MW (100%)

2) Available electric energy

Through replacing the rotor coils, stator coils and thrust bearings of generator unit 4 in the Project, vibrations during operation will be reduced and it will become possible to provide continuous power supply into the future. In other words, setting the annual generated amount of power of Unit 4 as the quantitative indicator, the goal is to restore stable power supply based on rehabilitation aiming to attain an average value of this generated amount equivalent to the value prior to the accident in 2009. Specifically, the goal shall be to achieve an average amount of power generation in three years after Project completion equivalent to the mean value of power generation in the 10 years prior to the accident. (The appendices indicate movements in the generated amount of power at Jebba Hydropower Station).

Indicator	Reference Value (mean value from 1999 to 2008)	Target Value (mean amount of generated power over 3 years from 2014)
Available electric energy (GWh/year)	226 GWh/year	226 GWh/year

3) Number of Serious Incidents

The operation of the No. 4 unit was suspended for three months following an incident in 2009. At present, it is somehow managing to operate but its shutdown due to vibration and other causes can be expected to occur at any time. Once rehabilitated, however, the number of emergency shutdowns lasting for one month or longer is expected to be zero.

Indicator	Reference Value (Prior to 2010)	Target Value (After 2014)
Number of serious incidents (those accompanied by shutdown for one month or longer)	1	0

4) Reduction in greenhouse gases

Reduction in greenhouse gases based on "2) Available electric energy" is as follow.

	Electric energy contributing to emissions reduction (GWh/year)	Baseline emissions (tCO_2/year)	Project emissions (tCO_2/year)	Leakage (tCO_2/year)	Total emissions reduction (tCO_2/year)
No.4 Generator	226	191,000	0	0	191,000

Repair of the 2G4 generator at Jebba Hydropower Station will not lead to additional power generation but rather maintenance of the status quo. Concerning the CO_2 emissions reduction effect enabled by extension of the generator service life, there will only be slight alleviation in the construction of fossil fuel-burning thermal power facilities.

(2) Qualitative effects (Project overall)

Current Conditions and Problems	Project Measures (target works)	Project Effects and Improvements
In Nigeria, power interruptions frequently occur due to deterioration and overload of power generation facilities, and these are impeding the development of local industries.	Repair of the water turbine generator meters and display lamps, etc.	Repair of the dial thermometer and so on will make it possible to manage temperature, conduct stable operation and prevent accidents. As a result, stable power supply will be realized, thereby enabling local manufacturing and industries to be vitalized.
In Nigeria, power interruptions frequently occur due to deterioration and overload of power transmission and distribution facilities, and these are impeding the stable operation of medical care agencies.	Repair of the water turbine generator coils and metal, etc.	Repair of the coils and metal will reduce vibrations and stabilize the power waveform of the generator. As a result, stable power supply will be provided to hospitals and universities, and contribution will be made to the stable

Current Conditions and Problems	Project Measures (target works)	Project Effects and Improvements
		operation and vitalization of such medical and educational facilities and enhancement of services for residents.
In Nigeria, power interruptions frequently occur due to deterioration and overload of power generation facilities, and these are adversely affecting the living environment of local residents.	Repair of the water turbine generator	Through the provision of stable power supply, the living environment of citizens in Nigeria will be improved.
Jebba Hydropower Station is incurring increasing maintenance costs due to frequently occurring failures and part replacements, and this is placing a burden on JHEP finances.	Repair of the water turbine generator	Upgrading of instruments in the hydropower station will lead to less frequent parts replacements and thus allow maintenance costs to be reduced.