

## **Section III**

# **Electromechanical Facilities**

# Contents

## Volume II

SECTION III ELECTROMECHANICAL FACILITIES.....	3
CHAPTER 1 OPERATION AND MAINTENANCE MANUAL.....	3
1.1 GENERAL.....	3
1.1.1 O & M Manual.....	3
1.1.2 List of As-built drawings.....	6
1.1.3 List of test records.....	6
1.2 MANAGEMENT OF POWER GENERATING FACILITIES.....	6
1.2.1 Operation of power generation facilities.....	6
1.2.2 Operation and maintenance of civil facilities.....	7
1.2.3 Operation and maintenance of transmission /distribution lines facilities.....	7
1.3 OPERATION OF SEQUENCE MODE.....	9
1.3.1 Normal starting sequence.....	9
1.3.2 Normal stopping sequence.....	10
1.3.3 Emergency stop.....	10
1.3.4 Black start procedure for O'Moleng power station.....	11
1.3.5 Control Block Diagram for O'Romis and O'Moleng Power Stations.....	12
1.4 ORDINARY MAINTENANCE.....	14
1.4.1 Categories of ordinary maintenance.....	14
1.4.2 Maintenance/Inspection record.....	14
1.4.3 Standard for work interval of equipment inspection and maintenance.....	14
1.5 PERIODICAL MAINTENANCE (FOR REFERENCE).....	15
1.5.1 Prevention and preservation technology.....	15
1.5.2 Maintenance/Inspection records.....	15
1.5.3 Standard work interval of equipment inspection and maintenance.....	15
1.5.4 Periodical detailed maintenance (for reference).....	15
1.6 WORK ORDER SYSTEM.....	15
1.6.1 Work order.....	15
1.6.2 Report analysis.....	16

1.6.3 WORK FLOW CHART (PDCA) .....	17
1.7 CHANGE OF GUIDE VANE (GV) OPERATION ZONE.....	18
1.7.1 Operation zone of GV .....	18
1.8. TROUBLE SHOOTING INSTRUCTION.....	22
1.8.1 Emergency Trip Relays .....	22
1.8.2 Alarm Relays .....	25
CHAPTER 2 MAINTENANCE WORK MANAGEMENT MANUAL.....	26
2.1 PURPOSE .....	26
2.2 SCOPE OF APPLICATION.....	26
2.3 DEFINITION OF TERMS.....	26
2.4. WORK ORGANIZATION.....	27
2.4.1 Duties of assignees .....	27
2.4.2 Confirmation of setting and restoring a work place .....	27
2.4.3 General managing of safety and sanitation of an aggregate work.....	35
2.4.4 Supervising contract work .....	35
2.4.5 Inspection organization for contractors.....	36
2.4.6 Relationship with other organizations .....	36
2.4.7 Relationship with manufacturers' technical supervisors .....	36
2.5 WORK PLAN.....	37
2.5.1 Yearly work plan.....	37
2.5.2 Monthly work plan .....	37
2.5.3 Work execution plan.....	37
2.6. PREPARATIONS FOR THE WORK .....	42
2.7 CHECK LIST .....	42
2.7.1 Safety work check list .....	42
2.7.2 Work management check list.....	42
2.8 WORK REPORT .....	43

### **Section III Electromechanical Facilities**

#### **Chapter 1 Operation and maintenance Manual**

##### **1.1 General**

This O & M Manual has been prepared for the purpose of comprehensive approach to operation and maintenance works of the generating facilities for Mondul Kiri Power Stations.

It is extremely important to use the instruction manuals of the equipment prepared by the manufacturers for the operation and maintenance work and refer to the list of manual in Clause 1.2. Also it is necessary to make use of the systems expressed in the manual securely, which is concluded based on the cooperation between management and technical staff.

Work relationship and burden sharing between the management and technical staff has been well explained in the following table:

Plan (P), Do (D), Check (C) and Action (A) as named PDCA which explains about the working sequence is described in Clause 1.6.

**RELATION BETWEEN THE MANAGEMENT AND THE TECHNICAL STAFF**

<b>ACTION STAFF</b>	<b>TARGET</b>	<b>RESPONSIBILITY</b>
<b>Management</b>	ALLOCATES a job to Technical Staff	SUPERVISES the Operation and Maintenance works
	EVALUATION of the jobs performed by the Tech. Staff	Activates the education programs in order to UPGRADE the Staff
<b>Technical Staff</b>	Perfectly CARRY OUT the jobs ordered by the Management	Understand various systems including software and hardware of the Power Station and should also be well VERSED in the maintenance activities of Power Station

Staff should be provided an opportunity to go through the manuals without any reserve. For this purpose a manual library should be established with adequate place in the administrative office.

##### **1.1.1 O & M Manual**

The related manuals and drawings of the each equipment have been provided in the Manufacturers' Maintenance & Operation Manuals as described bellows.

#### **Volume I**

##### **1) Civil facilities**

- 101. Hoist of diesel power station
- 102. Fuel oil storage tank

##### **2) Transmission line & Distribution line facilities**

- 201. 24kV Lightning arrester
- 202. 24kV Fuse cutout switch
- 203. 24kV Load break switch
- 204. Low Voltage distribution board
- 205. Indirect connected single phase energy meter type CE
- 206. 24kV Cubicle
- 207. Distribution transformers
- 208. Wiring diagram of substations

**3) Hydro generating facilities**

- 301. General layout for hydropower plant
- 302. Function block diagram specifications
- 303. Outline operation of the hydropower station
- 304. Maintenance manual for turbine
- 305. Instruction manual for On-the Job-Training (OJT)
- 306. Instruction manual for speed changer
- 307. Daikin oil cooling unit for O'Moleng P/S
- 308. Instruction manual for motor cylinder
- 309. Instruction manual for butterfly valves
- 310. Instruction manual for reduction gear
- 311. Maintenance manual for generator
- 312. Maintenance manual for switchboard
- 313. Flow chart for AVR failure investigation
- 314. Instruction manual for switchboard parts
- 315. Power capability curve for AC generator
- 316. Black start procedure at O'Moleng power station
- 317. Shop test records
- 318. Site test records
- 319. Wiring and terminal diagram
- 320. Trouble shooting

Reference data: What is electrical power ?

**Volume II :**

**1) Diesel Generation Facilities**

- 197. SG Governor (GOV)
- 198. Synchronizing motor for GOV

- 199. Exhaust gas turbocharger
- 200. Monitoring sensor
- 201. Converter for exhaust gas temperature sensor
- 202. Warning setting device for exhaust gas temp. switch
- 203. Gear pump
- 204. Fuel oil flow meter
- 205. Fuel oil filter
- 206. Fuel oil filter
- 207. Fuel oil filter
- 208. Float switch for fuel oil service tank
- 209. Float switch for fuel oil drain tank
- 210. Emergence stop valve
- 211. Air compressor
- 212. KUBOTA diesel engine
- 213. KUBOTA diesel
- 214. Pressure switch for air reservoir
- 215. Safety valve for air reservoir
- 216. Reduction valve unit
- 217. Centrifugal pump
- 218. Jacket water flow relay
- 219. Cooler water flow relay
- 220. Temperature control valve
- 221. Digital thermometer
- 222. Brushless AC generator
- 223. generator panel/ Auxiliary panel

**Volume III :**

**1) Operation Manual for Diesel Generation Facilities**

- 101. DAIHATSU diesel engine instruction book
- 102. Parts list
- 103. Shop test records
- 104. Site test records
- 105. Wiring and terminal diagram
- 106. Trouble shooting

## **2) Instruction Manual for Diesel Generation Facilities**

- 201. Blackout start procedure for diesel generating facilities
- 202. Automatic synchronizing device (ASD-6)
- 203. Analog power factor controller (APCF-1)
- 204. ACB TEMPOWER (AR208S)
- 205. Digital Indicators (K3HB)
- 206. Digital protection relay (CGP1)
- 207. DC-DC converter (VTE24)
- 208. AC-DC converter (ESW)
- 209. Batteries (MSE)
- 210. Capability curve for diesel generator

## **3) VHF Telecommunication System**

- 301. Operation manual
- 302. Maintenance manual

### **1.1.2 List of As-built drawings**

The as-built drawings will be submitted by the end of November 2008 by the Contractor in accordance with the Specifications, refer to Clause 1.2 O&M manual List.

### **1.1.3 List of test records**

The test records at site will be submitted by the end of November 2008 by the Contractor in accordance with the Specifications, refer to Clause 1.2 O&M manual List.

## **1.2 Management of power generating facilities**

In the operation and safety control of a hydropower station and diesel power station are necessary to predetermine basic safety items related to maintenance and operation as well as for safety management.

For this purpose, it is necessary to establish the basic policies that the operation procedure rules and the patrols, inspections and measurement criteria by which the operation and maintenance must be carried out according to the manuals in this Chapter.

### **1.2.1 Operation of power generation facilities**

Operation should be carried out in accordance with the operation procedure rule prescribing the operation sequence at ordinary times and the procedure of taking measures during abnormal state,

but the following items must be observed at ordinary items in order to take proper measures quickly and reliably after the occurrences of an accident:

- To have the full knowledge of the comprehensive power system and transmission lines
- To have the full knowledge of the manual and provision for operation rule
- To have the full knowledge of the performance and characteristics of equipment
- To have the full knowledge of control & protection circuits and auxiliaries
- To make study by using reference book, manuals for the equipment

Main precautionary items for the maintenance in daily patrol or inspections,

- To check the temperature at bearing, winding and elsewhere
- To check the vibration, noise and abnormal conditions at rotating parts
- To check the volume and quality of oil and cooling water, etc.
- To check the meters such as current, voltage, output, frequency, power factor, etc.
- To confirm the abnormal state at power stations and transmission lines.

In addition to the above mentions, low load operation that causes a low efficiency and adverse effects a hydro turbine and diesel engine should be avoided as much as possible, and efforts should be made to realize high efficiency operation.

Main precautionary items for the maintenance in daily patrol or inspections,

- To have a patrol and cleaning of the trash at intake screen
- To check the condition of each civil facility in the viewpoint of some damage, deformation, cracks, water leakage in structure.
- To check sand sedimentation in front of the intake and outlet, in the sedimentation basin, the waterway and the head tank.
- To check abnormal vibration in the penstock

### **1.2.2 Operation and maintenance of civil facilities**

For assuring the stable operation of power stations, the functions of civil facilities must be properly maintained to prevent accidents. To maintain the functions, the civil facilities should be periodically patrolled, inspected and measured, and the results be recorded.

It is also important to arrange the procedure for taking quick measures in case of emergency.

### **1.2.3 Operation and maintenance of transmission /distribution lines facilities**

For assuring the stable operation of 22kV transmission and 400V distribution lines facilities, the functions of the facilities must be properly maintained to prevent accidents, especially during rainy



season, to maintain the lines and poles and substation facilities should be periodically patrolled, inspected and measured, and the results be recorded.

It is also important to arrange the procedure for taking quick measures in case of emergency happened in the power system. The followings are pay attention for the safety and daily patrol.

### 1) Safety

In order to prevent the received electrical shock, the maintenance staff must take care near by the transmission line and substations when they have a trimming the trees or taking out the some goods on the lines. Therefore, they must stop the line charging and follow the procedure in the O & M manual. If they need to climb the concrete pole for maintenance, they must get permission from deputy director and/or chief of technical division.

### 2) Patrol

Normally, in the patrol of transmission lines and substations, the maintenance staff inspects the following facilities. The interval of patrol shall be follows in the maintenance manual.

#### (1) Outdoor substation cubicle

- Check of oil leakage, break of insulator, etc on 22kV/400V transformer:
- Check of some goods and vinyl, etc. on the conductor or transformer
- Check of noise, vibration slack of terminal screws, etc.
- Check of doors or cubicle on kiosk

#### (2)Transmission lines

- Check of break the insulators on the line poles
- Oil leakage of distribution transformers
- Check of touching the trees and conductors or other goods such as kites and vinyl
- Check of unusual noise, vibration on the line fittings
- Check of steal the electricity or wrong connection from the Wh-meter boxes

### 3) Operation and Maintenance

#### (1) Reading of Wh-meters on Transformer distribution panel

The Wh-meters installed in the distribution panels which use the current transformers (CT) for measuring.

In such case, the real energy consumption is conducted by multiplication of the CT ratio and the indicated kilo-watt hour (kWh).

For example, the Wh-meter of 50kVA transformer, there are CTs with 100/5A ratios. If the indicated value is 45kWh, the real value can be corresponded as follows;

$$45 \times 100/5 = 45 \times 20 = 900 \text{ (kWh)}$$

CT ratio is referred as multiplying factor for calculation. (refer to attached multiplying factor for CTs ratio)

(2) Last digit reading manner for Watt-hour meters in household

Reading manner of last digit of the Watt-hour meters should be kept constantly. The 1/10 digit number should be read to the smaller number as per attached instruction manual.

(3) Removing an obstacle from 22kV overhead line

In the case of removing obstacles on the 22kV lines or transformers, the staff should go to the objective place immediately, and to move the obstacles by using elevated working car, after line de-energizing with earthing by earthing tools. Refer to the instruction manual as attached.

(4) Transformer station check sheet

The transformers should be periodically patrolled by the staff. The patrol results should be recorded in the check sheet as attached.

(5) Transmission line restoration process from Diesel power station

In the case of black out in the 22kV power system; it means whole power stations are stopped, the restoration of 22kV system should be recovered from diesel power station. The operation procedure for 22kV transmission line switchgear is shown in the attached instruction manual.

### **1.3 Operation of sequence mode**

The power station is operated in starting and stopping by manual mode, but excitation, synchronizing/ parallel and loading in by automatic mode.

The control block diagram of start and stop is illustrated as follows. Please refer to the Instruction & Operation Manual of Volume I, 3) Hydro power generating facilities and also clause 1.3.5.

#### **1.3.1 Normal starting sequence**

1) Preparation

- To close the flushing gate of the intake weir
- To open the intake gate and intake water into the waterway system
- To confirm the Control source : 400/230V ac and 24V dc
- To confirm the Status indicator and lamp test switch : ON
- To confirm the lamps: 52-1 ON (red), 52-2 OFF (green),
- To confirm the status lamps GF1: STOP and PREPARATION ON
- To confirm the status lamps GF2: INLET VALVE(IV) and GUIDE VANE (GV)
- To set the change over switch 43-52-2 for automatic synchronizer to RUN side

2) Operation

- To operate SW 1 to OPERATION position
- Turbine starting is normally operated with open of inlet valve by Manual
- Generator is to run up to 1,000 rpm automatically, during running 41 excitation field switch ON and voltage build up

### 3) Synchronizing

- To confirm the Instruments of voltage, current, speed, etc.
- GV OPENED lamp light up and the automatic synchronizing start, at the synchronizing point, then circuit breaker 52-2: ON.

### 4) Load

- Load control switch : increasing 0 kW up to the rated out put 185kW.
- To confirm the meters Out put (kW), Var (var), Voltages, Currents, Speed, Power factor, frequency and wh-meter, etc.
- To confirm the line voltages, currents and wh-meter.

#### 1.3.2 Normal stopping sequence

- To confirm the line voltages, currents and wh-meter.
- To decrease the load to around 0 kW
- To operate SW 1: to STOP position
- To confirm the status lamps OPERATION : OFF and CB 52-2 : OFF (green) and LOAD lamp : OFF
- G V CLOSED lamp : OFF and voltage and output meter slows down,
- To fully closed the IV by manual, then INLET VALVE CLOSED lamp : OFF
- STOP lamp: ON and PERPARATION lamp: ON, the turbine stops completely.
- To close the intake gate

#### 1.3.3 Emergency stop

##### 1) General

- When the abnormal conditions would be found and to push the Emergency SW 5E: ON
- To stop the turbine/generator automatically, then 5E EMERGENCY STOP lamp is indicated in the fault indicator 30GF with Bell ringing,
- CB 52-2 : OFF (green) and OPERATION and LOAD lamps : OFF
- G V CLOSED lamp : OFF and voltage and output meter slows down,
- To fully closed the IV by manual, then INLET VALVE CLOSED lamp : OFF

- STOP lamp: ON and PERPARATION lamp: ON, the turbine completed stop.
- To stop the Bell and pushing the ALARM RESET SW.

2) In case of flood

- To determine whether operation should be stopped or not in case river becomes muddy and there is possibility that sand will enter into the facilities and affect the operation
- To inspect all facilities first prior to restart of operation (After flood)

3) In case of earthquake

- To check damages of all structures after earthquake
- To check damages of all electrical & mechanical equipment

4) In case of water shortage

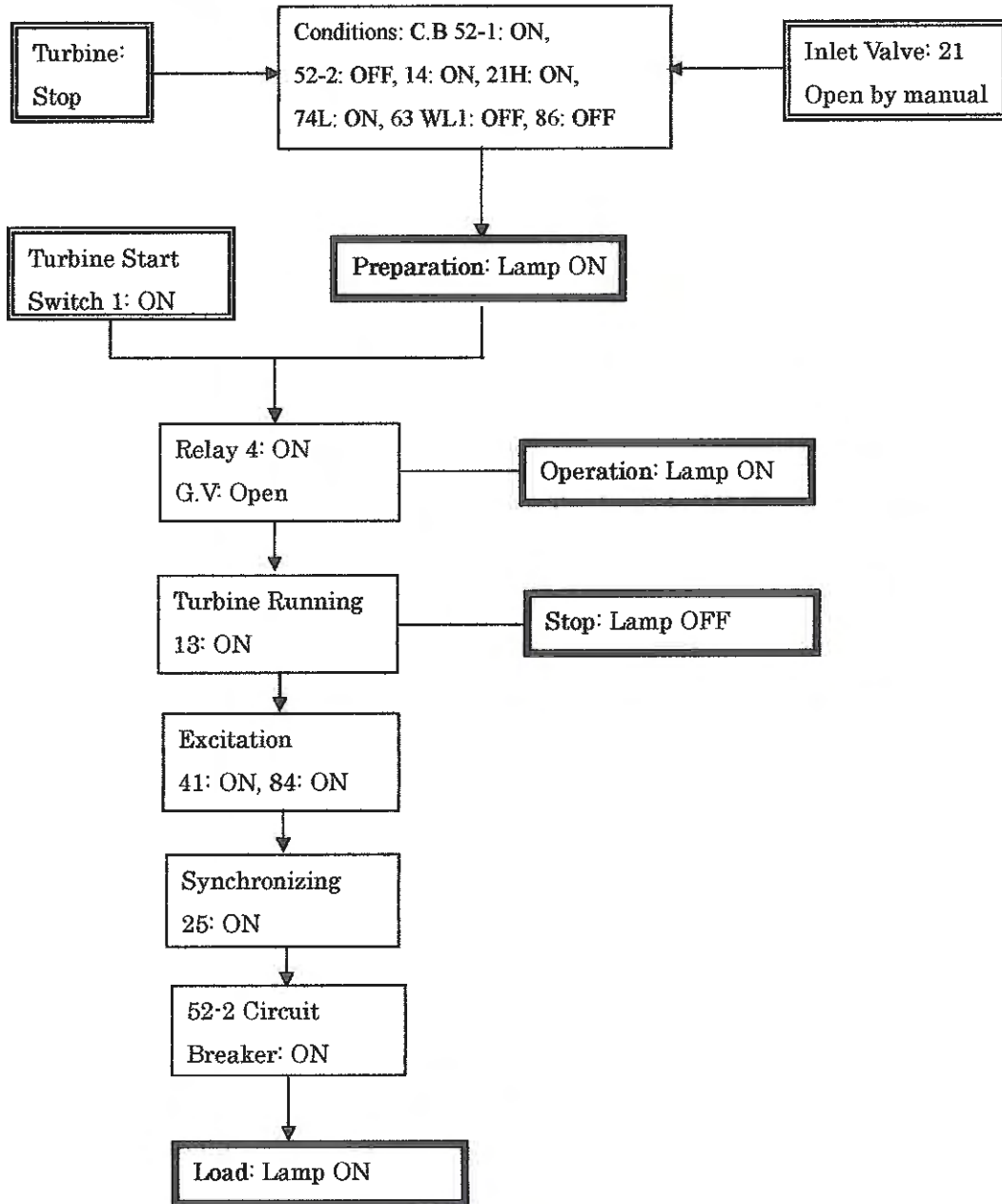
- To determine whether operation should be stopped or not to prevent bad effect to water turbine due to too little water

**1.3.4 Black start procedure for O'Moleng power station**

In case of black out of the power system, when Diesel Power station can not operate due to the periodic inspection and/or machine trouble, the power system can only be energized by hydropower station of O'Moleng with black start procedure as attached in Appendix-6  
But, the power system shall normally be energized by Diesel power station.

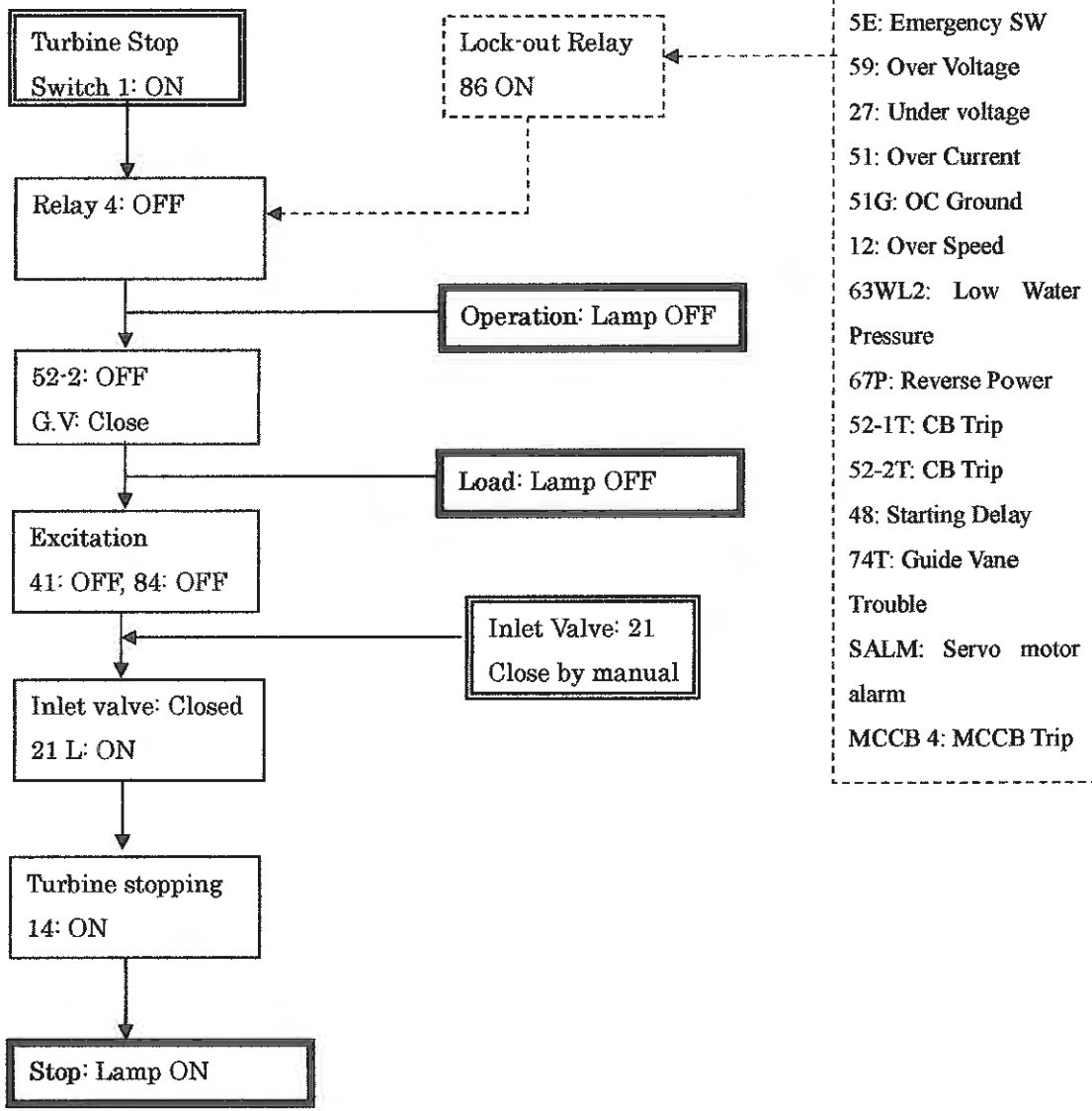
### 1.3.5 Control Block Diagram for O’Romis and O’Moleng Power Stations

#### For Starting Sequence



**For Stopping Sequence**

**Emergency Stopping**



## **1.4 Ordinary Maintenance**

Ordinary maintenance is done in the execution frequency of not more than one year.

### **1.4.1 Categories of ordinary maintenance**

#### **(1) Daily Maintenance (Patrol base)**

It is related to the whole of the power station in principle the daily patrol for two times a day. The first inspection will be at 9 o'clock in the morning by maintenance staff of daily working and the second, during unit(s) operation by operators (work shift staff) as a in house patrol.

Daily check list is shown here in after attached.

#### **(2) Weekly Maintenance (Patrol base)**

A day is decided, and whole of the power stations is patrolled on that day of the week, and replenished expendable supplies, and the change of the record paper which has been recorded and a simple repair is carried out, if necessary. Weekly check list is shown here in after attached.

#### **Monthly Maintenance (equipment wise)**

Based on one time in one month of maintenance is carried out mainly for the main unit and auxiliary equipment and changed over switching operating the preceding unit is carried out at the same time. The collection of the specified record is executed, and the inconvenience of the applicable equipment is repaired at the same time. Corresponding to the conditions of the equipment inconvenience, the main unit is requested to stop for a short period of time, and it is improved.

### **1.4.2 Maintenance/Inspection record**

Record collection by the Patrol check sheet compares with standard value at present. When a remarkable change is found out in the record value, validity to the standard value is examined. It is reported to the person in charge, and proper counter measure is taken. The records collected from weekly maintenance and monthly maintenance are reported in detail to compare with the record of the patrol. As per the reported record, a follow up maintenance is done securely with the case that the wrong point analyzed and predicted technically. The continuation of the record is absolutely important to judge the ageing deterioration of the equipment and facilities. The record, which had been accumulated a long time, is the property of the power plant. The station management should establish a system to analysis and manage these records.

### **1.4.3 Standard for work interval of equipment inspection and maintenance**

Ordinary maintenance interval for equipment shall be referred to attached sheets

### **1.5 Periodical maintenance (for reference)**

Periodical maintenance is scheduled stoppage of the generating facilities done in the execution frequency of one year and more.

#### **1.5.1 Prevention and preservation technology**

The thing of the prevention of preservation technology is trusted, and it makes use of regular maintenance and it is carried out efficiently and economically. It helps for the certain use of that technology.

When the function of the equipment and the facilities and performance can be confirmed fully by the application of the non-destruction maintenance (the out side diagnostic technology), the period maintenance can substitute for that result without disassembly of equipment and the facilities.

#### **1.5.2 Maintenance/Inspection records**

The details of the maintenance item, the contents of the maintenance work, the existence of the parts exchanged, the result of the management, examination and so on are to be recorded clearly.

It prepares for the technical management sheet, which can grasp the progress tendency of the deterioration of equipment and the facilities and comparison between measurement value and managing value or the standard value, which is easy to use. Periodical maintenance check list is shown here in after attached Sheets.

#### **1.5.3 Standard work interval of equipment inspection and maintenance**

Periodic maintenance interval for equipment shall be referred to attached sheets

#### **1.5.4 Periodical detailed maintenance (for reference)**

As per the target equipment, work contents, execution period, the periodical detail maintenance shall be ascertained and decided by the result of ordinary and periodical maintenance.

Periodical detailed maintenance check list is shown here in after attached sheets.

### **1.6 Work order system**

#### **1.6.1 Work order**

The maintenance work is done in the interval of one time or more in the week which is managed by WOS (Work order system in Mondul Kiri power stations. The maintenance of the hydropower plant and diesel power plant are divided into 3 kinds such as the ordinary maintenance (Patrol base), the periodical maintenance (equipment wise) and periodical detailed maintenance.

Computerized Maintenance and Inspection System must be established to apply in Modul Kiri



Hydropower plants and Diesel power plant. In this system, maintenance and inspection plan for the plant is made and for this each piece of equipment is identified and all works deemed necessary are defined and timed. Relevant information of each equipments and task including experiences is retained in system, which can be made available instantly on the screen, or in printed form. All the execution of maintenance works are planned as a result of the inspection, the work flow chart is as shown below.

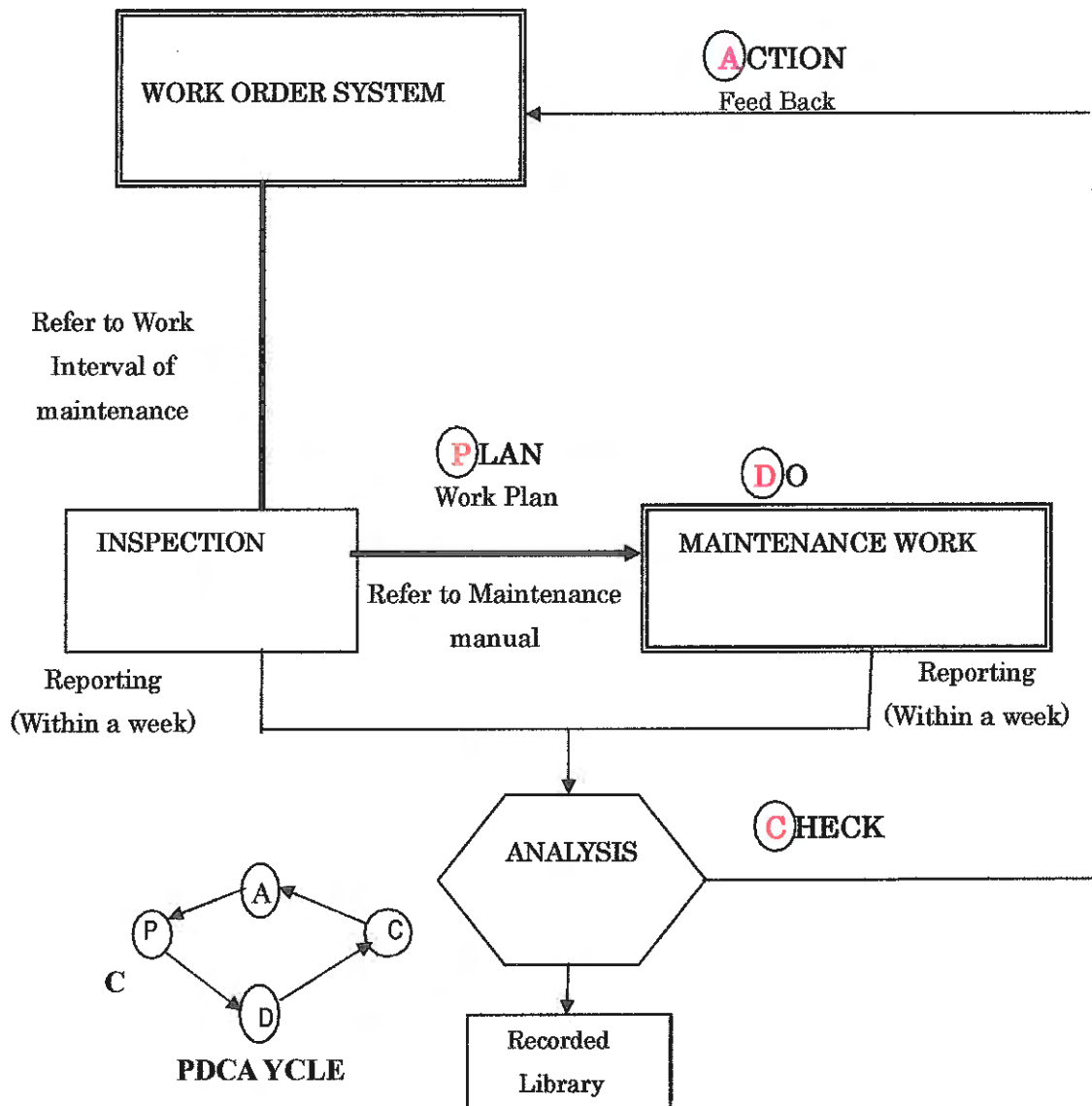
#### **1.6.2 Report analysis**

A record is taken, and that record is analyzed, judging the actual condition of the equipment complete maintenance work. A decision document is attached, and the report of analysis must be gotten by manager's approval and preservation within a week.

The points, which are analyzed in reports, are:

- 1) Comparison with the last record is done in detail. (Tendency comparison)
- 2) A deviation with the set point is examined. (Standard value comparison)
- 3) A wrong point is judged.
- 4) It thinks about the temporary treatment
- 5) A means to the perfect restoration is designed.
- 6) It is feed back to the work order system. (Refer to PDCA Work Order System)

1.6.3 WORK FLOW CHART (PDCA)



## 1.7 Change of Guide Vane (GV) Operation Zone

It is assumed that the changing for guide vane (GV) operation zone during dry season is based on the actual operation data (from December to May) of Mundul Kiri hydropower stations as follows.

### 1.7.1 Operation zone of GV

#### 1) 3/3 (1/3 + 2/3) GV Operation (100 to 40 % discharge)

Wet season can operate the full discharge zone of 100% to 37%, and output is available the rated 185kW to 70MW. The operation month will be June to December in data from 2008.

#### 2) 2/3GV Operation (70 to 30 % discharge)

In the beginning of January, as a just started water decreasing, the GV will change 2/3 GV operation zone, and then turbine output will be 120kW to 40kW by the end of February.

#### 3) 1/3GV Operation(35 to 15 % discharge)

In the midst of the water shortage in march and April, GV must change 1/3 operation zone and output will be 50- 40kW for only O’Romis power station. (O’Moleng is not required to change 1/3 GV due to dam water storage condition).

**Forecast of GV Operation Zone per Year**

					3/3GV						
2/3GV				2/3GV							
		1/3GV									
Jun	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

GV Opening (%) – Output (kW)			
Gen. Output( k W)	GV Opening (O'Moleng)	GV Opening (O'Romis)	Remark
30	30	26	Not normal operation
40	34	31	The least operation (output)
50	38	36	
60	40	40	
70	44	44	
80	48	48	
90	52	52	
100	56	56	
110	60	62	
120	68	68	

### Turbine Performance Curves (1/2)

Plant name : O'Moleng

Turbine type : HC-1R2G

Rating	Eff.head = 18.70 m Max Output= 215 kW				Max discharge = 1.45 m <sup>3</sup> /s Rotating speed= 253 min <sup>-1</sup>	
Guide vane	1/3+2/3					Max eff. point
Dischage [%]	100	80	60	40		84
Dischage[m <sup>3</sup> /s]	1.45	1.16	0.87	0.58		1.22
Efficiency [%]	81.0	82.8	78.3	67.6		83.0
Output [kW]	215	176	125	72		185

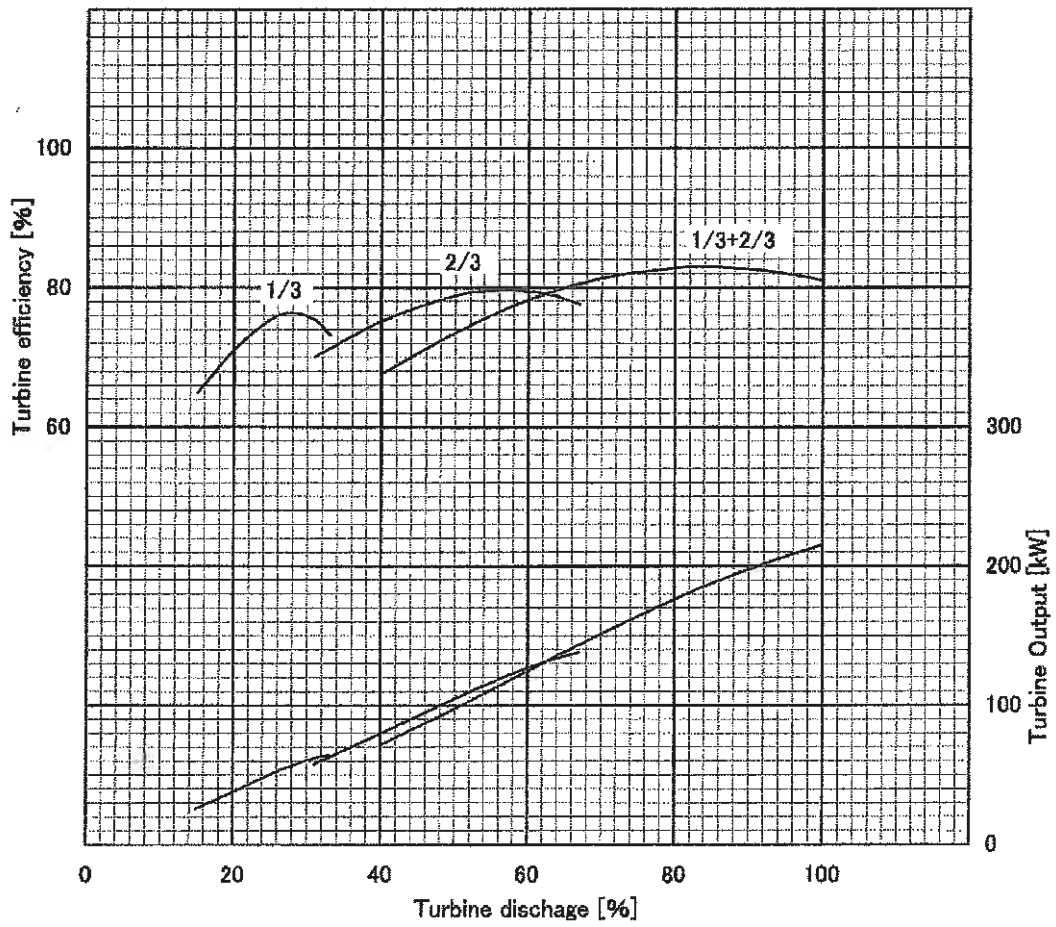
Rating	Eff.head = 18.70 m Max Output= 138 kW			Max discharge = 0.97 m <sup>3</sup> /s Rotating speed= 253 min <sup>-1</sup>	
Guide vane	2/3				Max eff. point
Dischage [%]	67	57	31		57
Dischage[m <sup>3</sup> /s]	0.97	0.83	0.45		0.83
Efficiency [%]	77.6	79.7	70.1		79.7
Output [kW]	138	121	58		121

Rating	Eff.head = 18.70 m Max Output= 64 kW			Max discharge = 0.48 m <sup>3</sup> /s Rotating speed= 253 min <sup>-1</sup>	
Guide vane	1/3				Max eff. point
Dischage [%]	33	28	15		28
Dischage[m <sup>3</sup> /s]	0.48	0.41	0.22		0.41
Efficiency [%]	73.2	76.4	64.9		76.4
Output [kW]	64	57	26		57

## Turbine Performance Curves (2/2)

Plant name : O'Moleng

Turbine type : HC-1R2G



## Turbine Performance Curves (1/2)

Plant name : O'Romis

Turbine type : HC-1R2G

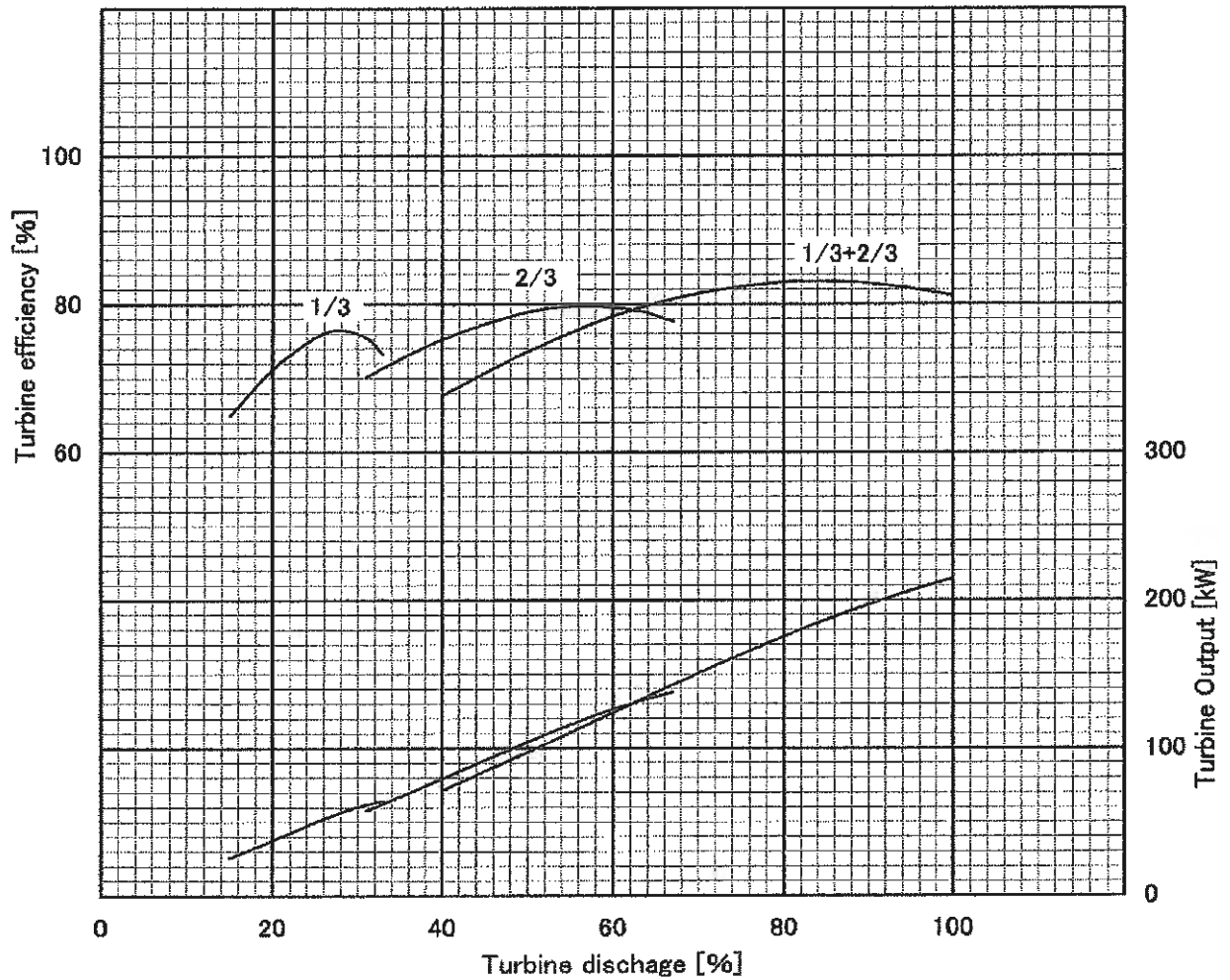
Rating	Eff.head = 25.70 m    Max discharge = 1.05 m <sup>3</sup> /s Max Output= 215 kW    Rotating speed= 378 min <sup>-1</sup>				
Guide vane	1/3+2/3				Max eff. point
Dischage [%]	100	80	60	40	84
Dischage[m <sup>3</sup> /s]	1.05	0.84	0.63	0.42	0.88
Efficiency [%]	81.1	82.9	78.4	67.7	83.1
Output [kW]	215	176	124	72	185

Rating	Eff.head = 25.70 m    Max discharge = 0.70 m <sup>3</sup> /s Max Output= 138 kW    Rotating speed= 378 min <sup>-1</sup>				
Guide vane	2/3				Max eff. point
Dischage [%]	67	57	31		57
Dischage[m <sup>3</sup> /s]	0.70	0.60	0.33		0.60
Efficiency [%]	77.7	79.8	70.2		79.8
Output [kW]	138	120	58		120

Rating	Eff.head = 25.70 m    Max discharge = 0.35 m <sup>3</sup> /s Max Output= 64 kW    Rotating speed= 378 min <sup>-1</sup>				
Guide vane	1/3				Max eff. point
Dischage [%]	33	28	15		28
Dischage[m <sup>3</sup> /s]	0.35	0.29	0.16		0.29
Efficiency [%]	73.3	76.5	65.0		76.5
Output [kW]	64	57	26		57

## Turbine Performance Curves (2/2)

Plant name : O'Romis  
 Turbine type : HC-1R2G



Dwg.No.	APPROVED	CHECKED	Plan	DRAWING	Date	2007/3/14
FT-153				H.SUZUKI	Tanaka Suiryoku Co.,Ltd	



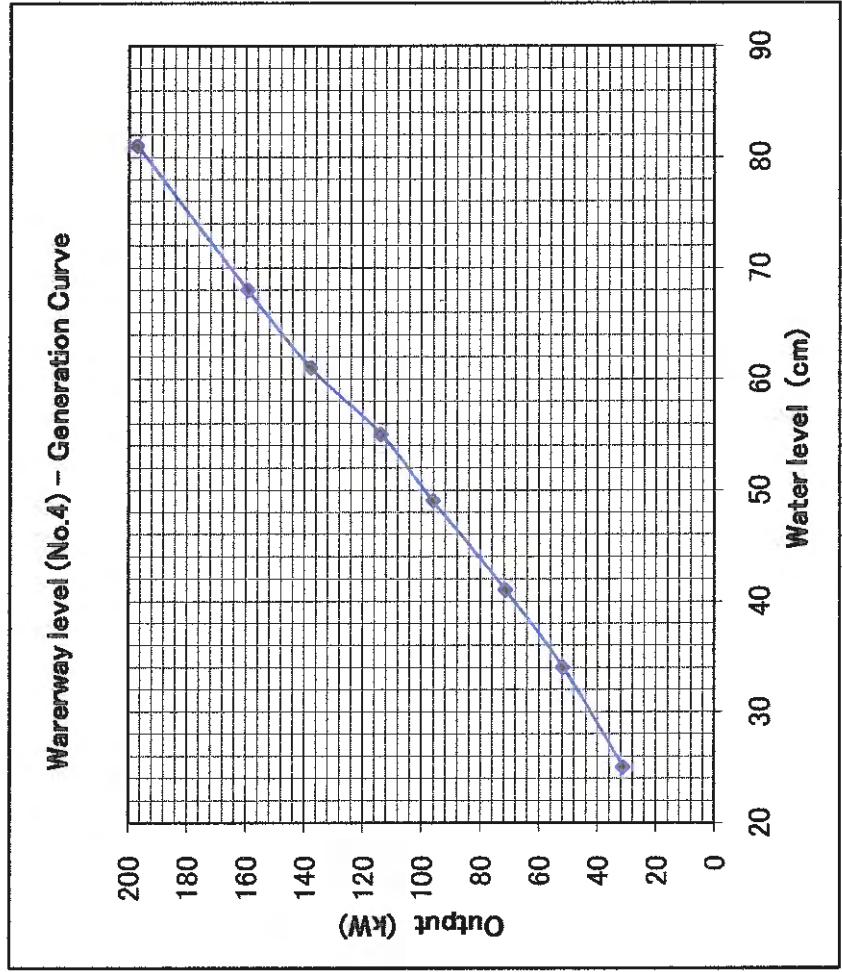
**Warerway level (No.4) – Generation Curve at O’Romis Hydropower Station**

Effective Head (m) 25.7  
 Discharge (m<sup>3</sup>/s) 1.05  
 Output(max.) (kW) 215

197

Turbine discharge (%)	Inflow m <sup>3</sup> /s	Turbine Efficiency	Output kW	Ratio %	Generator Efficiency	Output kW	Ratio %	Total Efficiency
100	1.05	81%	214	100	92%	197	100%	75%
80	0.84	82%	173	81	92%	160	81%	75%
70	0.74	81%	150	70	92%	138	70%	75%
60	0.63	78%	124	58	92%	114	58%	72%
50	0.53	79%	104	49	92%	96	49%	73%
40	0.42	75%	79	37	90%	71	36%	68%
30	0.32	75%	60	28	87%	52	26%	65%
20	0.21	71%	38	17	83%	31	16%	59%

Waterway level(No.4) cm	kW
81	197
68	160
61	138
55	114
49	96
41	71
34	52
25	31



Dependable Output (KW)	
Water level (cm)	Generator output (kW)
82	197
76	180
70	160
64	140
58	120
52	100
46	80
40	60
32	40
28	30
less	Stop



### 1.8. Trouble shooting instruction

Trouble shooting instruction (TSI) is concretely set up, as for that purpose, in order to expedite ability improvement of operator for the trouble shooting; and the aiding a judgment with no error and immediate effect like correspondence when it actually met with the trouble, because it demands strongly that to improve the reliability of the electric power supply and rapid and precise correspondence in trouble recent year. There are many amounts of information though the contents of trouble shooting instruction with simple expression, and the suitable software by the personal computer for purpose of this TSI management will be extremely desirable in the near future.

A simplified Trouble shooting procedure is provided by the actual problems and event as easily as possible.

The trouble shooting for "Emergency and Alarm Fault" is summarized in the following tables.

#### 1.8.1 Emergency Trip Relays

Relay Name ( No.)	Operation & Reasons	Trouble Shooting
<p><b>Over current (51)</b> Inst.: 10A Inv.: 4.5A and <b>Over current ground (51G)</b> Setting: 3.0A</p>	<p>Over current in generator circuit</p> <ol style="list-style-type: none"> <li>1. Overload</li> <li>2. Grounding of T/L</li> <li>3. Short circuit of T/L</li> <li>4. Grounding Gen.</li> </ol>	<ol style="list-style-type: none"> <li>1. Confirm the lamp &amp; 51 relay operate and gen. stop</li> <li>2. Check firing or not</li> <li>3. Try reset bottom ON</li> <li>4. If, reset OK, to start GEN. again after confirmation</li> <li>5. If remain the fault lamp, to take care the countermeasure.</li> </ol>
<p><b>Under voltage (27)</b> Setting: 90V, 2 sec.</p>	<p>Under voltage in generator voltage</p> <ol style="list-style-type: none"> <li>1. Overload</li> <li>2. Under excitation</li> </ol>	<ol style="list-style-type: none"> <li>1. Confirm the lamp &amp; 27 relay operate and gen. stop</li> <li>2. Check generator</li> <li>3. Try reset bottom ON</li> <li>4. If, reset OK, to start GEN. again after confirmation</li> <li>5. If remain the fault lamp, to take care the countermeasure.</li> </ol>

<p><b>Over voltage (59)</b> Setting: 120V, 2 sec.</p>	<p>Over voltage in generator voltage</p> <ol style="list-style-type: none"> <li>1. Over voltage of power system</li> <li>2. Grounding Gen.</li> <li>3. Over excitation</li> </ol>	<ol style="list-style-type: none"> <li>1. Confirm the lamp &amp; 27 relay operate and gen. stop</li> <li>2. Check generator</li> <li>3. Try reset bottom ON</li> <li>4. If, reset OK, to start GEN. again after confirmation</li> <li>5. If remain the fault lamp, to take care the countermeasure.</li> </ol>
<p><b>Reverse power (67P)</b> Setting: 10%, 5 sec.</p>	<p>Motoring of Gen.</p> <ol style="list-style-type: none"> <li>1. Revers power</li> </ol>	<ol style="list-style-type: none"> <li>1. Confirm the lamp &amp; 67P relay operate and gen. stop</li> <li>2. ~ 5. same as above.</li> </ol>
<p><b>Incomplete sequence (48)</b> Setting: 3 min.</p>	<p>Time delay for Gen. starting.</p> <ol style="list-style-type: none"> <li>1. Incompleted sequence circuit</li> <li>2. Starting relay (4)</li> <li>3. Limit switches</li> <li>4. Auxiliary relays</li> </ol>	<ol style="list-style-type: none"> <li>1. Confirm the lamp &amp; 48 relay operate and gen. stop</li> <li>2. Check preparation circuit</li> <li>3. Try reset bottom ON</li> <li>4. If, reset OK, to start GEN. again after confirmation</li> <li>5. If remain the fault lamp, to take care the countermeasure.</li> </ol>
<p><b>Emergency trip (5E)</b> Hand bottom</p>	<p>Emergency trip for Gen.</p> <ol style="list-style-type: none"> <li>1. Firing</li> <li>2. Leakage of water from penstock &amp; flood</li> <li>3. Mechanical trouble</li> </ol>	<ol style="list-style-type: none"> <li>1. To push the bottom 5E, And confirm the lamp &amp; 5E Relay, then stop the Gen.</li> <li>2. ~ 5. same as above.</li> </ol>
<p><b>Over speed (12)</b> Setting: 150%</p>	<p>Over speed for Gen.</p> <ol style="list-style-type: none"> <li>1. Trouble of speed detector</li> <li>2. Relay miss setting</li> <li>4. Auxiliary relays</li> </ol>	<ol style="list-style-type: none"> <li>1. Confirm the lamp &amp; 12 relay operate and gen. stop</li> <li>2. Check to speed detector</li> <li>3. Try reset bottom ON</li> <li>4. If, reset OK, to start GEN. again after confirmation</li> <li>5. If remain the fault lamp, to take care the countermeasure.</li> </ol>

<p><b>Water pressure low 2nd. (63W2)</b> Setting: -1.5m of head tank level</p>	<p>Penstock Pressure down in 2nd. Stage 1. Infow decrease 2. Leakage of water from penstock 3. Pressure switch</p>	<p>1. Confirm the lamp &amp; 63W2 relay operate and gen. stop 2. Check to pressure switch 3. ~ 5. same as above.</p>
<p><b>CB Trip (52-1T)</b> And <b>CB Trip (52-2T)</b> Setting: Inst.</p>	<p>Emergency trip relays . 1. Fault of electric circuit 2. Grid voltage down (52-1 trip) 3. Contro source down (52-2 trip) 4. CB operation</p>	<p>1. Confirm the lamp &amp; relays operate and gen. stop 2. Check to electric circuit 3. Try reset bottom ON 4. If, reset OK, to start GEN. again after confirmation 5. If remain the fault lamp, to take care the countermeasure.</p>
<p><b>Guide Vane trouble (74TF)</b></p>	<p>GV over torque 1. Potentio meter trouble 2. Open and close 3. Limit switches</p>	<p>1. Confirm the lamp &amp; 74TF relay operate and gen. stop 2. Check to servo motor of GV 3. ~ 5. same as above.</p>
<p><b>Servo mechanism trouble (SALM)</b></p>	<p>Servo mechanism trouble 1. Limit switches trouble 2. Servi motor pressure down 3. Auxiliary relays</p>	<p>1. Confirm the lamp &amp; relays operate and gen. stop 2. Check to limit SWs, relays 3. Try reset bottom ON 4. If, reset OK, to start GEN. again after confirmation 5. If remain the fault lamp, to take care the countermeasure.</p>
<p><b>Exciter source trouble (MCCB4)</b></p>	<p>Exciter power source down 1. AVR source trouble 2. Ex. Transformer trouble</p>	<p>1. Confirm the lamp &amp; relay operate and gen. stop 2. Check to MCCB 4 and circuit 3. ~ 5. same as above.</p>

### 1.8.2 Alarm Relays

Relay Name ( No.)	Operation & Reasons	Trouble Shooting
<b>Water pressure low 1st (63W1)</b> Setting:	Penstock Pressure down in 1st Stage 1. Inflow decrease 2. Leakage of water from penstock 3. Pressure switch trouble	1. Confirm the lamp & 63W1 Relays operate 2. Check to pressure relay 3. Try reset bottom ON 4. If, reset OK, to start GEN. again after confirmation 5. If remain the fault lamp, to take care the countermeasure.
<b>Magnetic Coil Circuit Breaker failure (MCCB1, 1A and 3)</b>	Exciter power source down 1. AVR source trouble 2. Ex. Transformer source 3. Servo motor source	1. Confirm the lamp & relay operate 2. Check to MCCB and circuit 3. ~ 5. same as above.
<b>Temperature High (38SD)</b> Setting: over 80□	Speed changer high temp. oil 1. Oil temperature meter trouble 2. Leakage of oil 3. Pressure switch trouble	1. Confirm the lamp & 38SD Relays operate 2. Check to oil temperature 3. Try reset bottom ON 4. If, reset OK, to start GEN. again after confirmation 5. If remain the fault lamp, to take care the countermeasure.
<b>Magnetic Coil Circuit Breaker failure (MCCB2 and CPFAN)</b>	Power source down 1. Station service source trouble 2. Control panel fan source trouble	1. Confirm the lamp & relay operate 2. Check to MCCB and circuit 3. ~ 5. same as above.

## **Chapter 2 Maintenance Work Management Manual**

### **2.1 Purpose**

This manual is issued by the administration office in accordance with “Operation and Maintenance Manual for power plant facilities”. This manual stipulates detailed items to be managed in a series of maintenance work of electrical equipment for a generating station, transmission/distribution lines and civil facilities (hereinafter referred to “maintenance work”), starting from the work planning and ending in work completion, for the purpose of preventing an equipment accident and labor injury, and completing the maintenance work in a total safety and reliable result.

### **2.2 Scope of application**

This manual shall be applied to the maintenance work to be executed by a Regional Power Supply Headquarter for electrical equipment for a generating station. When an item would become unsuitable caused by unusual scope or type of work, Head of the corresponding Headquarter shall determine suitable alternative measures or modifications on case by case basis.

### **2.3 Definition of terms**

Contract:	Work (including a consignment work and purchase of goods) shall be done by the contractor under a contract of owner.
Grounding for site work:	Grounding to protect working personnel from being injured, by discharging the voltage induced by neighboring circuits or the current charged in circuits in the case of work to be done with unit shutdown.
Aggregate work organization:	A working organization to combine two or more working units and Aggregate Head of the work organizations shall manage comprehensively these working units.
Single work organization:	A working organization to execute a single unit of work and Head or Supervisor of the work unit shall manage the work.
Release-Lock equipment:	A set of shutdown equipment isolated or relieved from the normal operating system for maintenance work purposes and these shall be locked (electrically or mechanically) in a shut down position to confine the work scope and secure safe work place, and shall not be included in work scope.

Head of the work:	Head of the work is a person in charge who shall be responsible for the whole work, supervision and witness or inspection of the work.
Head of the work organization:	It shall mean the Head of the work organization in the case of a single unit work, and Aggregate Head of the work organizations in the case of combined plural work units.
Contractor:	Contractor means contract or consignee worker and/or seller of goods.
Representative of Contractor:	Responsible person appointed as the representative of the contractor or as Head of the contract work.
Other organization:	Shall include whole of other departments such as Telecommunication dpt., Transportation dpt., Civil/Architecture dpt., Financial dpt., etc. in the province of Modul Kiri, and other companies.

#### **2.4. Work organization**

Work management organization and safety management organization shall be organized on starting each work unit, in which job assignment of each personnel and command-report lines shall be established for the purpose of securing smooth work progress and preventing equipment failure and human injury.

Work organization shall be prepared as a standard being particular circumstances and specifications of the work taken into consideration. Refer to Figure-1 in Appendix-11 as attached.

*(Reference-1: Work organization of locking/grounding in deployment consisting of two or more work with small number of members each will be submitted by the contractor.)*

##### **2.4.1 Duties of assignees**

Duties of each assignee (a person who is assigned or approved to complete a specified job) are shown on Table-2.1 (1/3 – 3/3) as attached.

##### **2.4.2 Confirmation of setting and restoring a work place**

###### **1) Division of the confirmation of setting and restoring a work place**

Each assignee shall be responsible for setting and restoring (hereinafter referred to setting and restoring of the work place, locking and grounding) and their subsequent confirmations.

An assignee could let a consignee be responsible for a part of jobs based upon “Consign contract of maintenance work for generating and substation equipment” in reference to Table-2.2.

**Table-2.1 (1/3) Assignment, Duties, Concurrent Positions in each Work Organization Category**

Assignee	Assignor	Assigning rule	Duties	Concurrent position	Note
General manager of aggregate work	Director	Assigned in case two or more work units are to be executed in a same site premise, or work site divisions overlaps each other.	<ol style="list-style-type: none"> <li>1. Prepare the general progress plan of aggregate work.</li> <li>2. Supervise comprehensively the aggregate work by coordinating with each Head of work or his members.</li> <li>3. General management of locking and grounding.</li> <li>4. Issue work instruction sheets.</li> </ol>	Concurrent position of other duty is allowed depending on the work scope or nature.	In the case of two or more work units concern
General head of locking and grounding	Director	As the general rule, assigned to General manager of aggregate work shall be assigned to this when the work place setting and restoring are common or relating to two or more separate subcontracts, under the condition General manager of aggregate work having been assigned.	Execute setting and restoring of each locking and grounding which is common to or affecting two or more work units by instructing the general head of execution of locking and grounding and the general head of confirmation of locking and grounding.	Concurrent position of other duty is allowed depending on the work scope or nature.	General team of locking and grounding
General head of execution of locking and grounding	General head of locking and grounding, subject to approval of Director	Assigned when the work place setting and restoring are common or relating to two or more separate subcontracts, under the condition General manager of aggregate work having been assigned.	Execute setting and restoring of locking and grounding in the scope of General team of locking and grounding in accordance with the instruction of General head of locking and grounding.	Concurrent position of other duty is allowed depending on the work scope or nature, except that of General head of locking and grounding.	General team of locking and grounding



Assignee	Assignor	Assigning rule	Duties	Concurrent position	Note
General head of witness on locking and grounding	General head of locking and grounding, subject to approval of Director	Assigned when the work place setting and restoring are common or relating to two or more separate subcontracts, under the condition General manager of aggregate work having been assigned.	Confirm setting and restoring of locking and grounding in accordance with the instruction of General head of locking and grounding.	Concurrent position of other duty is allowed depending on the work scope or nature, except that of General head of locking and grounding	General team of locking and grounding
Work supervisor	Director	Assigned for each work unit of subcontracts, consignments, purchase orders.	<ol style="list-style-type: none"> <li>1. Prepare individual work progress plan.</li> <li>2. Issue work instruction sheets.</li> <li>3. Supervise the work in accordance the subcontract.</li> <li>4. Manage each site of individual work</li> </ol>	Concurrent position of other duty is allowed depending on the work scope or nature.	Subcontract work (including purchase contract). Consignment work.
Head of the work	Director	Assigned for each work to be done by NEA's own teams.	<ol style="list-style-type: none"> <li>1. Prepare individual work progress plan.</li> <li>2. Issue work instruction sheets.</li> <li>3. Instruct each individual work.</li> <li>4. Get workers complete the work correctly and safely by letting them fully understand and perform the work.</li> <li>5. Manage each site of individual work</li> </ol>	Concurrent position of other duty is allowed depending on the work scope or nature.	



**Table-2.1.1 (2/3) Assignment, Duties, Concurrent Positions in each Work Organization Category**

Assignee	Assignor	Assigning rule	Duties	Concurrent position	Note
Witness person of the work	Director	Assigned for each subcontract work unit in case other organizations execute in a premise of generating station or substation	<p>1. Explain cautions in items of setting and restoring of work site necessary for the execution of the work.</p> <p>2. Confirm setting and restoring of work site necessary for the execution of the work.</p> <p>3. Witness other organization's work</p>	Concurrent position of other duty is allowed depending on the work scope or nature.	
Person who executes the work place setting	Head of the work, subject to the approval of Director	Assigned in each of all the work units.	<p>Execute the following items under instruction of Head of the work, etc.</p> <ol style="list-style-type: none"> <li>1. Operation of equipment for site work.</li> <li>2. Setting and restoring of locking, setting and restoring of grounding, setting and restoring of working place.</li> </ol>	Concurrent position of other duty is allowed depending on the work scope or nature, except the person who confirm the work place setting.	
Person who confirm the work place setting	Head of the work, subject to the approval of Director	Assigned in each of all the work units.	Confirm plan and execution of setting and restoring of the work place necessary for the work, under instruction of Head of the work.	Concurrent position of other duty is allowed depending on the work scope or nature, except the person who confirm the work place setting.	
Person in charge of safety	Assign: Head of Labor Department	In accordance with the organization chart of safety management.	<p>As the general coordinator acting on behalf of the organization head (Director) who is responsible for overall safety of the organization.</p> <ol style="list-style-type: none"> <li>1. Prepare the plan of safety transactions.</li> <li>2. Prepare reports of safety transactions.</li> <li>3. Instruct and advises the safety manager on safety management work in reference to the safety work plan, interpretation of its description and safety measures in the work.</li> <li>4. Plan and proposal on items directed by the organization head.</li> </ol>	Concurrent is not allowed for the safety manager.	

Table-2.1 (3/3) Assignment, Duties, Concurrent Positions in each Work Organization Category

Assignee	Assignor	Assigning rule	Duties	Concurrent position	Note
General manager of safety and sanitation (Station Master)	Director himself	Decision of Director	Direct the person in charge of safety, the safety manager, the sanitation manager so that the labor accidents may be prevented in the subject work, in accordance with labor laws and relating safety and sanitation regulations.		
Safety manager	Head of the labor Department	Assigned for each technology group	Shall take technical measures necessary for securing work safety under the direction of Director.	Concurrent position could be allowed provided that the duty as the Safety manager will not be hampered.	Position level shall be qualified as a Group leader, Section manager, Deputy section manager, or equivalent.
Work commander	Director, or the representative of subcontractor	In case the work items listed in Sub Table-1 (p. ) as a dangerous work or a harmful work.. Assigned one for each of the above mentioned items.	<ol style="list-style-type: none"> <li>1. Plan and confirm the safety measures to be taken in the subject work item.</li> <li>2. Let workers fully understand their work duties, and instruct them directly.</li> </ol>	Not allowed while he is at work.	Shall be appointed beforehand by a work specification document in case a Work commander is necessary for a subcontract work or consignment work.

Chief of the work	Head of Regional power supply head quarter, or the representative of sub-contractor	In case the work items listed in Sub Table-2 (p. ) as a dangerous work or a harmful work.. Person who have the certification valid for each of the above mentioned items.	1. Inspect and maintain equipment and materials to be used for the subject work items. Determine the method and procedure of the subject work. 2. Instruct the subject workers, and execute the subject work safely and correctly.	Not allowed while he is at work.	Shall be appointed beforehand by a work specification document in case a Chief of the work is necessary for a subcontract work or consignment work.
Safety supervisor	Director or the representative of sub-contractor	Assigned for the work which a safety supervisor shall be assigned to as is listed in Sub Table-3 (p. ), or the work which is deemed dangerous otherwise.	Supervise directly the work progress for watching and notify workers unsafe acts under the instruction of Head of the work.	Not allowed. Shall be a dedicated position.	Shall be appointed beforehand by a work specification document in case a Safety supervisor is necessary for a subcontract work or consignment work.
Person in charge of safety	Head of Labor Department		Support the Director in planning work procedure and safety measures. Require the safety manager for execution of the procedure and measures. Inspect them for proper progress and instruct and advise him on improper acts.	Concurrent with other duty is allowed	
Sanitation manager	Head of the labor department		Shall take technical measures necessary for securing work sanitation under the direction Director.	Concurrent position could be allowed provided that the duty as the Sanitation manager will not be hampered.	

The scope of the consigned jobs shall be ordered and specified by a written consign specification beforehand.

Table-2.2 Division of the confirmation of setting and restoring a work place

Equipment and scope of maintenance work	Division of work	
	Lock and Grounding for equipment	Work place division
1. Inspection of protective relays	C	C
2. Main unit and main circuit		B
1. High voltage cubicle internal inspection (including power receptacle devices with possible reverse voltage, as are used in dam, etc.) 2. Internal inspection of low voltage cubicles and power house internal circuits (including power receptacle devices with possible reverse voltage, as are used in dam, etc.) 3. Auxiliary equipment influencing the main unit (work which necessitates actions to remove influences, such as power OFF/ON, including power receptacle devices with possible reverse voltage, as are used in dam, etc.)		
4. Jobs to be done individually by lock grounding after completion of common lock grounding of the main unit, etc. 5. Auxiliary equipment not directly influencing the main unit (including jobs after (5) above)	B	A
6. Cranes, ventilators, lights, potable water equipment, etc. 7. Sirens, electric equipment for dam(excluding (3), (4),(5) above)	A	A

(Legend)

A: Could be assessed to consignee to set, restore (dismantle and mantle) or confirm.

B: Could be assessed to consignee to set or restore (dismantle and mantle).

C: Could be assessed to cooperate with.

## 2) Work organization of locks and grounding

### In the case of a single work organization

- (1) Person in charge of setting work place shall execute lock and grounding (hereinafter excluding class C grounding) for equipment in accordance with the order of head of the work, and confirmation shall be made by a person in charge.

When lock or grounding work is included in the contract, let the contractor do the lock or grounding under the responsibility of a responsible representative of the contractor. In such case the work supervisor shall witness the work.

### In the case of Aggregate working organization

- (1) An aggregate team shall be organized for lock and grounding work in the case of Aggregate working organization.
  - (a) This team shall consist of a head of the aggregate work, working person(s) who will do the actual work, and a person who will confirm the work results.
  - (b) In principle the aggregate team for lock and grounding work shall be single organization. In the case of the work where single team is not enough, for example covering both of an underground power house and an outdoor switching station, more number of teams shall be organized. In such case a head of the aggregate organization shall be responsible for all the work. He shall be responsible for instructing satisfactorily the setting and restoring lock and grounding work, watching the work, coordinating progress, etc.
- (2) Person(s) in charge of actual work shall execute the aggregate lock and grounding under instructions of head of aggregate lock and grounding work. The work shall be confirmed by a person in charge of the confirmation.
  - (a) For a separately named work, single work unit of lock and grounding shall be made based upon the procedure specified in a single work organization case.
  - (b) In a contract work, locations of the lock and grounding work shall be confirmed in pre-work meeting(s). The actual work of the locking and grounding shall be done together with the work person(s) of work place setting. In this case representative of the contract work shall witness the work.

## 3) Organization to execute the work site operation of equipment

Shall be done based on "2.4.2, 2) Work organization of locks and grounding"

4) Organization of setting the site work premise.

In the case of a single work organization

The work place shall be set by person(s) in charge under instructions of Head of the work, and shall be confirmed by person(s) in charge of the confirmation.

When a contractor is responsible for the work place setting, the setting work shall be done under the responsibility of the responsible person of the contractor. The work supervisor shall witness the work.

In the case of an aggregate work organization

Setting of the work premise shall be made similarly with that of a single work organization, with scope and work specifications subject to prior approval of the Head of aggregate work organization.

**2.4.3 General managing of safety and sanitation of an aggregate work**

When two or more number of contractors execute their jobs in a same work place, an aggregate managing organization shall be formed to effect a single management line in accordance with Industrial safety and sanitation law for the purpose of preventing labor accidents which would likely occur in the work place where contractors work together. In such case head of regional power supply headquarter shall assign a contractor the responsibility of representing the aggregate work organization in terms of safety and sanitation. Upon agreement of the assignment, the head of regional power supply headquarter shall request the assignee contractor to select both a general manager of safety and sanitation representing the aggregate contractors and a manager of safety and sanitation dedicated to that contractor. The general manager shall request each contractor to select a manager of safety and sanitation.

*(Reference-2 General safety and health management and, -3: Position of safety and health promotion committee in the work will be submitted by each contractor.)*

**2.4.4 Supervising contract work**

- (1) Contractor(s) shall execute the work management (quality management, progress management, labor management) while the owner shall make necessary supervisory jobs, such as instruction, approval, inspection, consultation, etc.
- (2) Contract documents shall explicitly indicate supervisory items by the owner, such as instructions, approvals, inspections, negotiable items, etc. For other items shall be specified by the head of regional power supply head quarter in writing.

#### **2.4.5 Inspection organization for contractors**

Independent tests of individual equipment after the work completion shall be made under each responsibility of corresponding contractor. Generalized test on the aggregate work shall be made under the responsibility of the owner.

- (1) Test items, specifications, test methods and safety measures shall be well studied and agreed between the owner and contractors and manufacturers beforehand.
- (2) Supervising engineers of contractors or manufactures, when requested to cooperate with the owner in doing the tests under agreements of the contract documents, shall be under the control of head of the work of the owner.
- (3) Locking and grounding necessary for tests shall be performed similarly as specified in "2.4.2, 2) Work organization of locks and grounding".

#### **2.4.6 Relationship with other organizations**

Treatment of other organization(s) working in premises of generating stations, transmission/distribution lines and civil facilities shall generally be in accordance with the following items.

- (1) Witness personnel shall confirm beforehand the representative of the organization(s) on the work organization and work procedure.
- (2) The witness personnel shall give the head of the organization the necessary instructions, such as the range of shutdown, locking, grounding, relationship with other work units, etc..
- (3) Locking and grounding of electrical equipment (excluding those belonging to other organizations) shall be done similarly as specified in "2.4.2, 2) Work organization of locks and grounding".
- (4) Witness personnel shall witness the setting of the work premise and restore made by the other organization, and shall negotiate with them as necessary.

#### **2.4.7 Relationship with manufacturers' technical supervisors**

A "manufacture's technical supervisor" who is invited by the owner shall be treated as shown below. The "manufacture's technical supervisor", as referred here, means an engineer invited under a separate agreement for the service of a manufacturer's engineer, who is not included in engineers of manufacturers in charge of the contract work.

- (1) Safety management shall be made under the responsibility of the manufacture's supervising engineer himself.

Head of the work organization shall the manufacturer's supervising engineer be well informed of the work organization structure, safety management rules, etc., which shall be



made in writing with signature of the engineer.

- (2) Head of the work organization shall request the supervising engineer for technical assistance, diagnostic judgment, etc. in accordance with the contract document of the supervising engineer service.
- (3) As a general rule, the supervising engineer's advice and communication shall be made directly with head of the work organization, except when this assistance is made directly with personnel in charge of the actual work as necessary by decision of head of the work organization. The scope of such direct assistance shall be explicitly agreed upon before it is processed.

## **2.5 Work plan**

It is necessary to plan the work procedure in a long run view to affect the maintenance work safely and properly, as show below.

### **2.5.1 Yearly work plan**

The yearly work plan shall be made showing the yearly comprehensive work progress plan, including planning, designing and completion of the work in consideration with the yearly amount of work and work suspension conditions, etc.( Form-1, as attached )

### **2.5.2 Monthly work plan**

The monthly work plan shall be made showing the recent month work plan, including progress plan of the month and labor distribution, etc. in reference to the actual progress and additional work of the last month observed on the yearly work execution plan and suspension plan.( if necessary)

### **2.5.3 Work execution plan**

Detailed plan shall be made for the actual execution of the work as shown below.

#### **1) Organization of the work execution**

Head of the regional power supply headquarter shall form the work organization and appoint or approve each assignee in consideration with the work scope size and type in accordance with "2.4. Work organization".

#### **2) Work plan documents**

The work plan documents shall be issued for the purpose of letting personnel who may concern fully know his work and perform safe and correct work as stipulated below.

The work plan document and the work sheet (Work management sheet, Safety confirmation sheet) as require by "Rules for the work sheet handling", shall be prepared by "Work



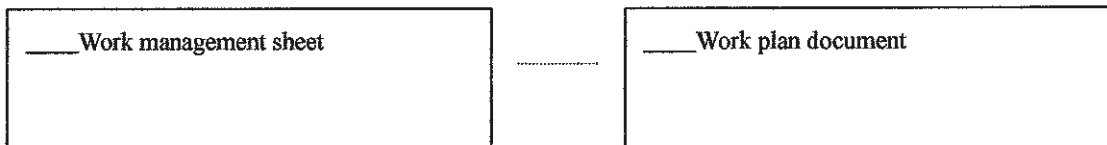
Management System” except in case the condition is by no means favorable in doing so.

(1) Unit of issuing the work plan documents

The work plan document shall be issued for every work unit which the work sheet (Work management sheet, Safety confirmation sheet) is issued.

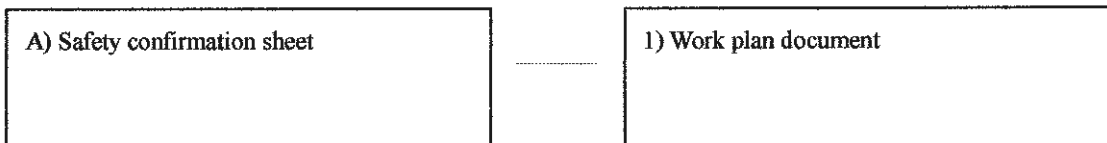
Relationship of the work plan document, the work management sheet and the safety confirmation sheet is shown by the following sketches.

- (a) In a single work organization case (The work which accompanies a relocation of equipment, or the work which shall be well informed to the operating team)



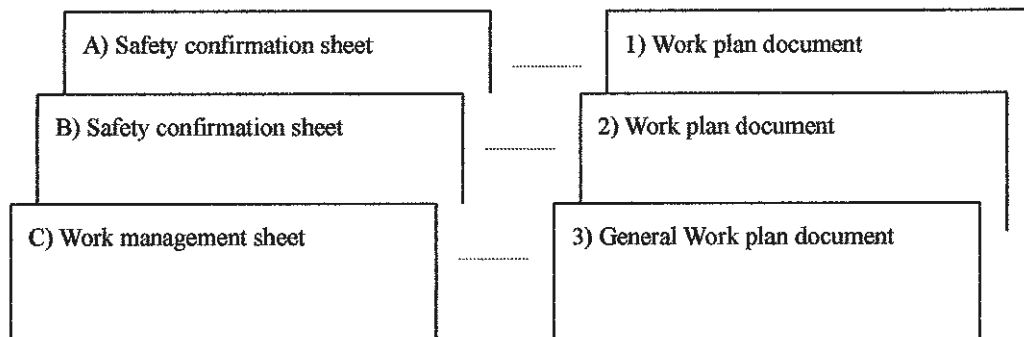
The work plan document could be substituted by the work management sheet in the case of a work unit which is simple and of small scope and the work sheet issuing is enough for confirming the work detail and securing safety.

- (b) In a single work organization case (The work which accompanies no relocation of equipment)



The work plan document could be substituted by the safety confirmation sheet in the case of a work unit which is simple and of small scope and the work sheet issue is enough for confirming the work detail and securing safety.

- (c) In the case of the aggregate work organization



(2) Issuing the work plan document for each unit of the work

The head of the work shall issue the work plan documents in accordance with Form and submit them to head of regional power supply headquarter (General manager of the aggregate work in the case of an aggregate work organization) making coordination and adjustment with persons who may concern in the work. (Form-3, as attached)

In the work to be done as “Consigned maintenance work in generating station or substation”, the work plan documentation could be proposed by the consignee on the condition that the consign agreement shall specify so beforehand.

The work plan documents shall contain all the necessary interactive item descriptions under the condition another organization’s work or a separate other contract is processed concurrently.

(a) Description items to be included in the work plan documents shall be described in accordance with Form -3.

(b) Additional attachments to the work plan documents

The following documents shall be attached to the work plan documents.

(i) Description of the work

Detailed description of the work is to be done in each job item.

(ii) Technical management sheet

The technical management sheet shall be prepared in a form of spread sheet which contain technical management items (management values, setting values, etc.) necessary for maintenance management of equipment under the maintenance work, on which inspection results shall be recorded in reference to these items for the purpose of judging the pass or reject, or preventing inspection items being neglected.( if necessary )

(iii) Shutdown scope sketch and Confirmation table of lock and grounding

- Shutdown scope sketch shall be prepared so that the scope of shutdown may be clarified on one line diagram(s) by showing the open/close of switch gears, locking status, equipment status under shutdown or in maintenance process, and locations of grounding, etc.

- Confirmation table of locking and grounding shall be contained in the corresponding shutdown scope sketch as practically as possible. The table shall show the equipment to be locked (including equipment to be held in open position), methods of locking, with or without of operation prohibition mark plate, category and location of grounding, and confirmation record boxes for locks and groundings.

- Shutdown scope sketch and Confirmation table of locking and grounding shall be prepared for every alteration made in locking and grounding during a bus bar switching over work.

A partial restore and re-locking, when necessary in the course of work, shall be so described.

(Form-5, as attached)

(iv) Work scope sketch

Sketches showing the clear scope of the work is in form of plan drawings of generating station, substation or equipment arrangement. Cautions shall be taken in preparing these sketches to hold appropriate safety distance to equipment and charging parts, and to ease watching various marks.

(v) Organization chart of the work

Chart showing the job command lines and the work limit, containing names of personnel, communication means in working time, and necessary items.( Fig-1, as attached)

(vi) Work progress chart

To be prepared so that the progress of the work shall be easily and duly watched.

(vii) Safety procedures in the work

To be prepared in accordance with separate "Guide for preparation of Safety procedures in the work".

(viii) List of equipment and materials

Lists showing necessary equipment, materials and tools. (if necessary)

(ix) List of safety mark plates and appliances

List showing necessary safety mark plates and appliances. (if necessary)

(x) List of qualified personnel

List showing personnel having qualifications necessary for the work. (if necessary) Safe work check list

Safe work check list to be prepared in accordance with Clause 2.7.1.

(3) Preparation of General work plan

In the case of the general organization of aggregate work, the general manager shall compile the work plan for each itemized work unit and coordinate Head of each work unit with interactive issues. He shall then prepare the general work plan (used as the work plan spread sheet as stipulated in the work sheet handling rule, hereinafter deemed the same) in accordance with Form -4, and submit the same simultaneously to Head of Regional power supply head quarter together with the work plan for each itemized work unit.

In the case of concurrent work with the other organization's work, he shall request such organization to submit the work plan, and add the identification name of the work and necessary descriptions to the general work plan.

(a) Items to be described in General work plan (Form-4, as attached).

(b) Attachments to General work plan

(i) General locking and grounding confirmation table

All the common locks and groundings affecting the work units contained in the general work

organization shall be described, which shall clarify the distinction of locking and grounding to be made by the general locking and grounding team, and open-lock equipment and remote/local change over switch and grounding to be confirmed by the control station.

(ii) General work organization chart

Comprehensive organization containing all the work units.

(iii) General work progress chart

Progress chart to ease watching all the work progress (including other organization's work) comprehensively.

(4) Approval of the work plan

Head of Regional power supply headquarter shall audit the submitted general work plan and individual work plans and approve them.

(5) Submitting information to operating department

Immediately after the approval of the work plan, the following information shall be given and confirmed to the operating department to enable the operating personnel determine operating procedures.

(a) List of the work titles

The cover page of the work plan or the general work plan

(Refer to Form -3 & 4)

(b) Work progress chart

Comprehensive progress for the work

(c) Sketch of the scope of shutdown equipment, and confirmation table of locking and grounding

Shall be renewed for every alteration made daily or hourly in the scope of shut down.

\*Shall be in accordance with "Sketch of the scope of shutdown equipment, and confirmation table of locking and grounding" of the work plan.

(d) Detailed progress chart of the inspection and test

Load patterns, withstand voltage test by the actual grid, circuit architecture, etc.

(e) Others

Shall be attached those which are necessary to be referred to in the items limiting operating conditions.

(6) Alterations in descriptions of the work plan

When an alteration becomes necessary in the work plan documents after the prior preparatory meeting was finished, the general manager or the head of the work shall consult well with

persons in concern and the operation master for the alteration, and let the concerned assignee and workers be well informed the alteration and accompanying measures subject to the approval of the head of regional power supply headquarter.

(7) Storing the general work plan and individual work plan

The work plan documents shall be kept filed for one year after the completion of the work.

## **2.6. Preparations for the work**

Before starting the work, preparations shall be made as shown below in order to precede the work in a well functioning deployment in accordance with the work plan.

## **2.7 Check list**

On starting the work, items necessary for the work management and safety management in the process, starting from the planning and ending in the completion, shall be confirmed on the following check lists so that the safe and appropriate work may be processed.

### **2.7.1 Safety work check list**

Head of the work and the work supervisor shall prepare "Safety work check list" stipulating the items to be confirmed, taking actual work site condition into consideration, in the process starting from the planning and ending in the completion, so that the work may be processed as planned and safely. Head of the work or the work supervisor shall confirm the necessary items in the process of the work using thus prepared "Safety work check list".

As the necessary minimum safety check items are stipulated to be referred at the beginning and the end of the work, these items can be easily confirmed by these work slips.(Form-10-1, as attached )

### **2.7.2 Work management check list**

Director shall confirm necessary check items and give appropriate instructions to person in concern, via assignees in reference to the following "Safety work check list".

Depending upon size or type of the work, Director shall have the general work manager confirm the same items as well.

#### **1) The work plan check list**

Items to be contained in the work plan, such as safety management items, work procedures, amount of labors, and work preparation status shall be checked. (Form-10-2, as attached)

**2) Preparatory meeting check list**

On having the preparatory meeting, major items to be discussed, items to be well informed, and identification of work organization shall be confirmed. (if necessary)

**3) Work processing check list**

Principally, the work progress and the safety management in the start and the end of the work shall be checked. (if necessary)

**4) Unexpected work check list**

In case an unexpected extra work occurs during the progress of the designed work, principally the contents of alterations and having persons in concern be well informed of the alterations shall be checked. ( if necessary)

**5) Emergency work check list**

In an emergency such as an urgent restoring work, items to be processed shall be checked. (if necessary)

**2.8 Work report**

After completion of the work, head of the work shall make and register the work report using the “Work management system”.

In the case of a consigned work under “Consigned maintenance work in power station”, it is permitted to have the consignee make and submit the work report, provided so specified in the consign contract.

## Appendix

Appendix-1	Daily operation record
Appendix-2	Weekly inspection record
Appendix-3	Maintenance interval
Appendix-4	Event Record
Appendix-5	Fault Record
Appendix-6	Black start procedure for O'Moleng power station
Appendix-7	Black start procedure for Diesel power station
Appendix-8	GV Switching procedure
Appendix-9	Single diagrams
Appendix-10	Form-1, 3, 4 and 5
Appendix-11	Figure-1 Work management and safety organization
Appendix-12	Operation Manual for Diesel Generator
Appendix-13	List of As Built Drawing (by Contractor)
Appendix-14	List of Operation & Instruction Manual (by Contractor)



## **Appendix-1 Daily operation record**

**Daily Operation Record (Diesel Power)**

Times	Generator(V)			TR	Hz	Speed	kW	Cos φ	GWH	Name of PS: Diesel Generator(A)			Bus (V)	Bus (A)	DATE: / / 2008			Weather:			Room	Vo meter			
	RS	ST	TR							R	S	T			DC	V	A	L.O	J.W	Ex.			38G	49GU	49GV
1:00																									
2:00																									
3:00																									
4:00																									
5:00																									
6:00																									
7:00																									
8:00																									
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17:00																									
18:00																									
19:00																									
20:00																									
21:00																									
22:00																									
23:00																									
24:00																									

Approved by Deputy Director \_\_\_\_\_ Confirmed by Chief \_\_\_\_\_ Total Running Hours: \_\_\_\_\_  
 Technical and Operation Div. T & O Division  
 Signature: \_\_\_\_\_ (1) \_\_\_\_\_ (2) \_\_\_\_\_ (3)  
 Note: 1) \_\_\_\_\_ Note: 1) \_\_\_\_\_





**Check Sheet of Periodical Inspection for Power Station Facilities  
Demonstration Project of Micro Hydropower Technology in Lao P.D.R.**

Date of Inspection :		Wether :					
Name of Inspector :							
1/3	Equipment	Check Items	Interval		Criterion	Results	Judgement and Remarks
			Daily	Periodic			
1	Turbine						
	Bearing	Sound, vibration and heating	o	3 Years	-		Replacement
	Bearing Temperature	Bearing Temperature, Grease	o	6 months	$\leq 40^{\circ}$ C Rise		
	Packing	Leakage	o		-		
	Sound	Noise	o	1 Year	Less than 90db		
	Vibration	Vibration	o	1 Year	35/1000 mm		
	Painting	Rust, corrosion	o	1 Year	-		
	Runner	Cavitation, defective		1 Year	-		Disassembly
	Shaft	Wear, damage		1 Year	-		Disassembly
	Grand Packing	Water leakage		1 Year	-		
Efficiency			3 Years	Approx. 80%			
2	Generator						
	Bearing	Sound, vibration and heating	o	3 Years	-		Replacement
	Bearing Temperature	Bearing Temperature, Grease	o	1 Year	$\leq 40^{\circ}$ C Rise		
	Packing	Leakage	o		-		
	Sound	Noise	o	1 Year	Less than 90db		
	Vibration	Vibration	o	1 Year	35/1000 mm		
	Painting	Rust, corrosion	o	1 Year	-		
	Insulation Resistance	Meggering by 2000V 1 min.		1 Year	$\geq 1$ M Ohm		Disassembly
3	Inlet Valve						
	Inlet Valve Body	Leakage, Vibration	o		-		
	Valve	Open-Close	o		-		
	Painting	Rust, corrosion	o	1 Year	-		







**Ccheck Sheet of Spare Parts for Power Station Facilities**  
**Demonstration Project of Micro Hydropower Technology in Lao P.D.R.**

Date of Inspection :

Name of Inspector :

	Spare Parts	Quantities	Remaining	Date of used	Date of used	Date of used	Remarks
1	For Turbine						
	Casing Ring	1 set	1 set				
	Packing Sleeve	1 set	0 set			1/17/2004	Replacement
	Bearing	1 set	0 set			1/17/2004	Replacement
	Grand Packing	6 sets	5 sets	2/9/2001	2/17/2003	1/17/2004	Replacement
	Felt Ring	2 sets	2 sets				
	O-ring	4 sets	3 sets				
	Gasket	2 sets	2 sets		2/17/2003		Replacement
	Coupling Parts	1 set	0 set			1/17/2004	Replacement
	Lantern Ring	1 set	1 set				
	Deflector	1 set	1 set				
	Pressure Gauge	1 set	1 set				
	Grease	10 kg	10 kg				
2	For Governor						
	Print Board	1 set	1 set				
	Triac	3 pcs.	3 pcs.				
	Power Fuse	3 pcs.	3 pcs.				
3	For Generator						
	Bearing	1 set	1 set				
	Speed Meter	1 set	1 set				
	Tacho-generator	1 set	1 set				
	AVR	1 set	1 set				
	Grease	10 kg	10 kg				
4	For Generator Panel						
	Fuse	100% used	100% used				
	Lamp Bulb	100% used	100% used				
	Magnetic Contactor for Main circuit	1 set	1 set				
	Circuit Breaker	1 set of each type	1 set of each type				

## **Appendix-2 Weekly inspection record**



**MONDUL KIRI HYDROPOWER STATION**

Weekly Inspection Report				O'Moleng P.S		
Date: 01 / 11 / 2008		(Sat.)	Time: 9:00~11:00	Signature by		
Inspector:		Weather: Fine	Room Temp.: °C	Chief:		
				Operator:		
No.	Inspection Items	Unit	Standard Value	Reading values		Remarks
				Previous	This time	
<b>1</b>	<b>Hydraulic Turbine</b>					
	Casing and Outer construction	OK /No	Normal			
	water leakage	OK /No	No leak			
	Oil leakage	OK /No	No leak			
	Ground packings	OK /No	No leak			
	Water outlet temp	°C	15- 35			
	Abnormal Sound or Vibration	OK /No	Normal			
	Bearing temperotures (turbine side)	°C	40- 50			
	Bearing temperotures (generator side)	°C	40- 50			
	Pressure of penstock	mAq	1.0- 1.2			
	Air Breather		Normal			
<b>2</b>	<b>Guide Vane Mechanism</b>					
	Casing and Outer construction	OK /No	Normal			
	Servomotor temperotures	°C	40- 50			
	Oil leakage	OK /No	No leak			
	Limit switches	OK /No	No leak			
	Guide Vane handle indicator	mm	Stroke 200			
<b>3</b>	<b>Speed Increaser</b>					
	Bearing housing construction	OK /No	Normal			
	water leakage	OK /No	No leak			
	Oil leakage	OK /No	No leak			
	Vibration	OK /No	Normal			
	Sound	OK /No	Normal			
	Smell	OK /No	Normal			
	Oil temperotures	°C	40- 50			
	Bearing temperotures (turbine side)	°C	40- 50			
	Bearing temperotures (generator side)	°C	40- 50			
<b>4</b>	<b>Inlet Valve</b>					
	Casing and Outer construction	OK /No	Normal			
	water leakage	OK /No	No leak			
	Abnormal Sound or Vibration	OK /No	Normal			
	Limit switches	OK /No	Normal			
<b>5</b>	<b>Generator</b>					
	Casing and Outer construction	OK /No	Normal			
	Oil leakage	OK /No	No leak			
	Abnormal Sound or Vibration	OK /No	Normal			
	Bearing temperotures (turbine side)	°C	40- 50			
	Bearing temperotures (generator side)	°C	40- 50			
	<b>Instruction</b>					
	1)					
	2)					
	3)					
	4)					
	5)					

## MONDUL KIRI HYDROPOWER STATION

Weekly Inspection Report				O'Moleng P.S		
Date: 01 / 11 / 2008		(Sat.)	Time: 9:00~11:00	Signature by		
Inspector:		Weather: Fine	Room Temp.: °C	Chief:		
				Operator:		
No.	Inspection Items	Unit	Standard Value	Reading values		Remarks
				Previous	This time	
<b>6</b>	<b>Control Panels</b>					
	<b>Power system operation</b>					
	Sending power (transmission line)	kW	≤ 185			
	Reactive power	Var	≤ 138			
	Line voltage	V	22,000			
	Line current	A	6			
	Frequency	Hz	50			
	Power factor	%	lag 1.0~0.8			
	Wh-meter (Sending)	kWh	total Wh			
	<b>Generator operation</b>	kW				
	Generator output	kW	≤ 185			
	Generator voltage	V	400			
	Generator current	A	333			
	Wh-meter (generation)	kWh	total Wh			
	Runing hours	h	total hours			
	Status indicator	OK /No	Normal			
	Fault indicator	OK /No	Normal			
	Lamp test	OK /No	Normal			
	Switches lamps	OK /No	Normal			
	Dammy load	OK /No	Normal			
	AVR	OK /No	Normal			
	Cooling fans(inside panel)	OK /No	Normal			
<b>7</b>	<b>400V/22kV Step-up Transformer</b>					
	Cut out switches, Arrester, Transformer	OK /No	No leak			
	Oil leakage	OK /No	No leak			
	Vibration	OK /No	Normal			
	Sound	OK /No	Normal			
<b>8</b>	<b>Power Station</b>					
	Penstock (leakage, vending, landslide, etc.)	OK /No	Normal			
	Powerhouse	OK /No	Normal			
	Dam	OK /No	Normal			
	Gates	OK /No	Normal			
	Access load	OK /No	Normal			
<b>9</b>	<b>Pole mounted Substations</b>					
	Load Switches	OK /No	Normal			
	22kV/400V Transformer	OK /No	Normal			
<b>10</b>	<b>Transmission/Distribution Lines</b>					
	400V Distribution lines	OK /No	Normal			
	22kV Transmission lines	OK /No	Normal			
	400V Transformer	OK /No	Normal			
	Line materials	OK /No	Normal			
<b>11</b>	<b>Wiring</b>					
	Wh-meters	OK /No	Normal			
	Wiring, etc.	OK /No	Normal			
	<b>Instruction</b>					
	1)					
	2)					
	3)					
	4)					
	5)					

Date :

ENG: 322kW, 1000min<sup>-1</sup>  
GEN: 300kW, 400V, 433AENG. TYPE: 6DL-16  
ENG. NO.: DL616Z0501

The kind of load		%	Standard at 100% Load							
Time of recording		O'clock-min								
Engine speed		min <sup>-1</sup>								
Generator	Output		kW							
	Voltage		V							
	Ampere		A							
	Frequency		Hz							
	Stator temperature	U Phase		°C						
		V Phase		°C						
W Phase		°C								
Bearing temperature		°C								
Fuel oil consumption		l/h								
(Accordance with ISO)		based on Gen. output	g/kWh							
		based on Eng. output	g/kWh (≤210+5%)							
Fuel pump rack reading										
Cooling water pressure	Jacket	MPa	For reference							
	Cooler	MPa								
Lub oil pressure	Bearing	MPa	(0.40~0.50)							
	Rocker arm	MPa	(0.06~0.12)							
Boost air pressure		MPa								
Fuel oil pressure		MPa	For reference							
Lub oil temperature	Oil cooler	Inlet	°C							
		Outlet	°C	(≤75)						
Cooling water temperature	Engine	Inlet	°C							
		Outlet	°C	(≤85)						
	Cylinderhead outlet	1	°C	Difference ≤±2						
		2	°C							
		3	°C							
		4	°C							
		5	°C							
		6	°C							
Air cooler	Inlet	°C								
	Outlet	°C								
Oil cooler outlet		°C								
Exhaust gas temperature	Cylinderhead outlet	1	°C	Difference ≤10%						
		2	°C							
		3	°C							
		4	°C							
		5	°C							
		6	°C							
	Turbo-charger outlet		°C							
Boost air temperature		°C	(40~50)							
Maximum combustion pressure	Comp. Press at 25% load 3.8 MPa	1	MPa	Difference ≤±0.3						
		2	MPa							
		3	MPa							
		4	MPa							
		5	MPa							
		6	MPa							
Room temperature		°C								
Air temp. at Turbo-charger inlet		°C								
F.O. temp. of F.O. flowmeter inlet		°C								
Humidity		%								
Atmospheric pressure		hPa								

## **Appendix-3 Maintenance interval**



**Ordinary Maintenance**

**Interval of Ordinary Maintenance**

Sr. No.	Classification of Equipment	Check Items	Check Interval				Remarks
			weekly	Once/ Month	Once/3 Months	Once/6 Months	
<b>1</b>	<b>Hydraulic Turbine</b>						
	1.1 Hydraulic Turbine	General Visual check	○				
		Check and Cleaning of the inside pit (outlet)			○		
	1.2 Inlet Valve	General Visual Check	○				
		External check and cleaning				○	
	1.3 Speed Changer	General Visual check	○				
		Oil checking of box and cleaning				○	
	1.4 Oil Cooling Unit	General Visual Check	○				
	1.5 Governor						
	1.5.1 Dummy Load Panel	General Visual check	○				
	1.5.2 Dummy Load Element	General Visual check				○	
	1.5.3 Servo motors	General Visual check	○				
<b>2</b>	<b>Generator</b>						
	2.1 Generators	General Visual Check	○				
	2.2 Automatic Voltage Regulator (AVR)	General Visual check	○				
		External checking			○		
	2.3 Excitation equipment						
	2.3.1 Brushless Exciters	General Visual Check	○				
	2.3.2 Exciter Transformer	General Visual Check	○				
	2.3.3 Exciter rectifier	General Visual Check	○				
	2.3.4 Field Controller	General visual check	○				
	[ Reactor Field breaker Field Resistor ]	External checking			○		
	2.3.5 Tacho-generator	General visual check	○				
<b>3</b>	<b>Transformer</b>						
	3.1 400V/22kV Transformer	General visual check	○				
		Changing of Taps (before dry season)				○	
	3.2 Cut out switches	Cut out switches				○	
	3.3 Arrestor	General visual check				○	
<b>4</b>	<b>Breaker</b>						
	4.1 Circuit Breaker	General Visual check	○				
		Check of the operation				○	
	4.2 Load Switch	General Visual check	○				
<b>5</b>	<b>Instrument Transformer (VT and CT)</b>	General Visual check	○				
<b>6</b>	<b>Cubicle</b>	General visual check	○				
<b>7</b>	<b>Electrical Wires and cables</b>						
	7.1 Electrical wire and insulators	General visual check	○				
	7.2 Power cables	General visual check	○				
<b>8</b>	<b>Protective Relays</b>						
	8.1 Transmission line protective relay equipment	General visual check	○				
		Automatic oscilloscope operational condition check				○	
	8.2 Generator and Bus Protective relays	General visual check	○				
<b>9</b>	<b>Automatic Control Unit</b>						
	9.1 System control unit	General visual check	○				
	9.2 Electronic control Unit	General visual check	○				
		Inspection at every three months			○		
		Inspection at every six months				○	

Ordinary Maintenance

Interval of Ordinary Maintenance

Sr. No.	Classification of Equipment	Check Items	Check Interval				Remarks
			weekly	Once/ Month	Once/3 Months	Once/6 Months	
10	Battery						
	10.1 Battery cells	Measurement of all batteries and uniform charging				○	
	10.2 Converter	General visual check	○				
	10.3 Chargers	General visual check	○				
11	Crane	General visual check				○	
	11.1 Gantry crane	General visual check	○				
	11.2 Monorail crane	General visual check	○				
12	Air Compressor	General Visual check	○				
		Operational condition check				○	
13	Transmission and Distribution lines						
	13.1 400V/22kV Transformer	General Visual check	○				
		Cleaning				○	
	13.2 Distribution Transformers	General Visual check	○				
		Cleaning				○	
	13.3 Load switches	General Visual check	○				
		Cleaning				○	
	13.4 Arrestors	General Visual check	○				
		Cleaning				○	
	13.5 Wiring and Wh meters	General Visual check				○	
14	Stand by Diesel Engine Unit	General visual check	○				
	Diesel Generator 300 kW	External check and cleaning		○			
		Startup tests		○			

**PERIODICAL DETAILED MAINTENANCE**

**Interval for Periodical Detailed Maintenance ( Power Station)**

No.	Classification of Equipment	Check Interval	Remarks
1	<b>Hydraulic Turbines</b>		
1.1	Hydraulic Turbines	1) General overhauling	Once/ 10 years
1.2	Inlet Valve	1) General overhauling	Once/ 10 years
1.3	Governors ( Including dummy load and control units)	1) To be checked using, as a guide, manuals the checking interval half that for hydraulic turbines	
1.4	Hydraulic Turbine operation controller Equipment	1) To be checked using, as a guide, manuals the checking interval half that for hydraulic turbines	
1.5	Speed Changer	1) To be checked using, as a guide, manuals the checking interval half that for hydraulic turbines	
1.6	Oil Cooler unit	Same as for item 1.5 Speed changer	
2	<b>Generators</b>		
2.1	Generators	1) To be checked using, as a guide, manuals the checking interval half that for hydraulic turbines	
2.2	Exciters	Same as for item 2.1 Generator	
		Rotary and stationary excitation equipment	
2.3	Automatic Voltage regulators (AVR)	Same as for item 2.1 Generator	
		1) The control part should be checked at the interval half that for (1) Generators as a guide.	
3	<b>Transformers</b>	1) When it has been confirmed, as a result of the analysis of gas in the oil, that there is an abnormality inside a transformer.	
4	<b>Breaker and Switch</b>		
4.1	Magnetic Circuit Breaker	1) The specified frequency refers to the cumulative number of current interruptions, the number of interruptions of rated current, the number of switching operation of load current and the number of switching operations; and in other words , it means the frequency or the value recommended by the manufacturer.	As specified
4.2	Vacuum Breaker	1) The specified frequency refers to the cumulative number of current interruptions, the number of interruptions of rated current, the number of switching operation of load current and the number of switching operations; and in other words , it means the frequency or the value recommended by the manufacturer.	As specified
4.3	Load Switches	1) The specified frequency refers to the cumulative number of current interruptions, the number of interruptions of rated current, the number of switching operation of load current and the number of switching operations; and in other words , it means the frequency or the value recommended by the manufacturer.	As specified
5	<b>Instrument Transformers (VT &amp; CT)</b>		As required
6	<b>Cubicles</b>		
6.1	Monitoring and control panels		As required
6.2	Relays for protection panels		As required
6.3	Station service panels		As required
6.4	Synchronizing unit		As required
7	<b>Electrical wire and insulators</b>		
7.1	Control cables		As required
7.2	Power cables		As required
7.3	Electrical wire and insulators		As required
8	<b>Automatic control equipment</b>		As required
9	<b>Surge Absorbers</b>		As required
10	Various types of transformers ( Including those for station service and those for local power distribution)	Same as for 3. Transformers	
11	<b>DC Power supply unit for controls</b>		
11.1	Battery		As required
11.2	Converter		As required
11.3	Chargers		As required
12	<b>Air compressors</b>		As required
13	<b>Lighting Arrester</b>		As required

## **Appendix-4 Event Record**









## **Appendix-5 Fault Record**

**FAULT RECORD FOR MONDUL KIRI POWER STATION, EUMP  
(Urgent Report)**

	Date			
	Fault time			
	Fault Power station			
	Power System Load	Total: kW		
	Out Put (kW)	O'Moleng	O'Romis	DG
		Output: kW	Output: kW	Output: kW
1	Status			
	Kind of Fault			
	Fault Indicators			
	Reasons why			
2	Countermeasure			
	Recovery time			
	Temporaly recover			
	Normal recover			
3	Operator name			
4	Approved by		Confirmed by	
	Note:		Note:	
5	Comments by JICA advisors team			

**FAULT RECORD FOR MONDUL KIRI POWER STATION, EUMP  
(Urgent Report)**

Date	1/30/2009		
Fault time	a.m 3:25		
Fault Power station	O'Romis		
Power System Load	Total: 80 kW		
Out Put (kW)	O'Moleng	O'Romis	DG
	Output: 40 kW	Output: 60 kW	Output: stop kW
1 Status	Blackout the power system for 15 minutes		
Kind of Fault	Head tank water level low		
Fault Indicators	Water pressure low (2)	Overvoltage	52-2 CB trip
Reasons why	At 3:25, Water level alarming, and operator just stopped the turbine. Then O'Mleng also stopped by low frequency due to the stop of O'Romis station.		
2 Countermeasure			
Recovery time	a.m 3:45		
Temporaly recover			
Normal recover	Normal starting turbine.		
3 Operator name			
4 Approved by		Confirmed by	
Note:		Note:	
5 Comments by JICA advisors team	When occurred the alarm of water level, the operator shall check the head tank and out put of O'R must decrease 40 or 30kW, and O'M must increase 40 to 60kW shortly. So that the system did not blackout. The operator must know the Alarm is only information to operators and for countermeasure.		

**Appendix-6: Black start procedure for  
O'Moleng power station**

## **Black Start Operation Procedure for O'Moleng PS**



**June 2009**  
**PREPARED by JICA Project Team**

## **Black Start Operation Procedure for O'Moleng PS**

### **I. Preparation for Black start**

- 1) To confirm the all LSB off in 22kV/400V Hospital and District Substations**
- 2) Outdoor DG starting for powerhouse lighting : ON**
- 3) Control Panel**

**Confirmation of all MCCB breakers: OFF**

**MCCB 1 and 1A: Control source**

**MCCB 2: P/S Lighting**

**MCCB 3: SERVO MOTOR**

**MCCB 4: AVR source**

**MCCB RCP 1: Receptacle source**

**MCCB Z 1: Aux. source**

**MCCB TC 1: TR Primary**

**MCCB CPC 2: Control source (Black Start)**

**MCCB Battery (Black Start DC 24 V)**

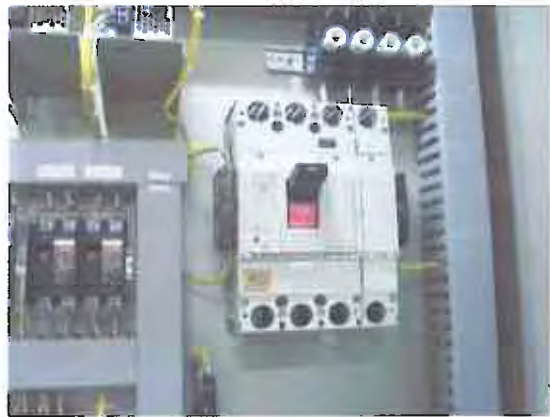


## II. Black Start for Turbine

1) To change 4 3 BS : ON (Black start Switch)



2) To confirm 5 2 - 1 : OFF

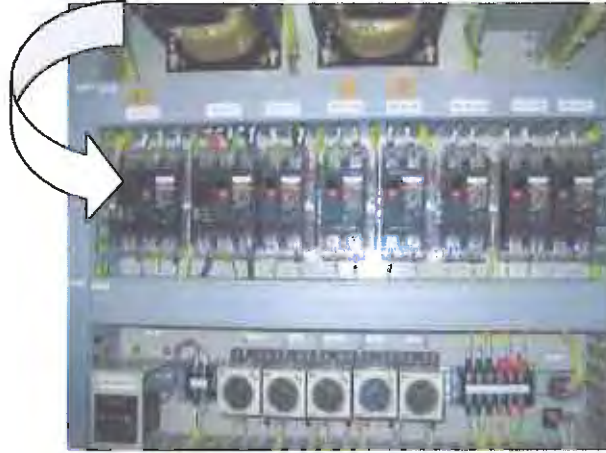


3) Reset of Fault Indicators and Targets



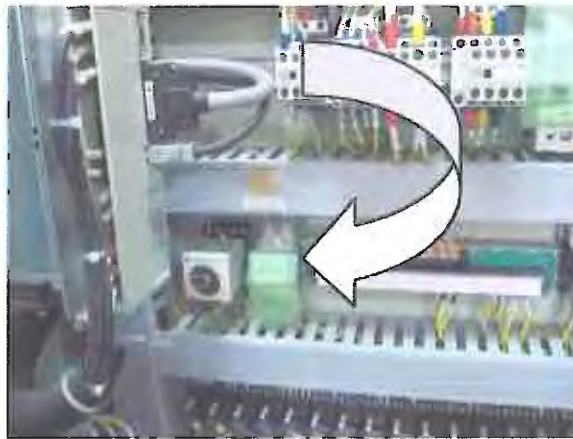


4) MCCB 4 AVR source : ON

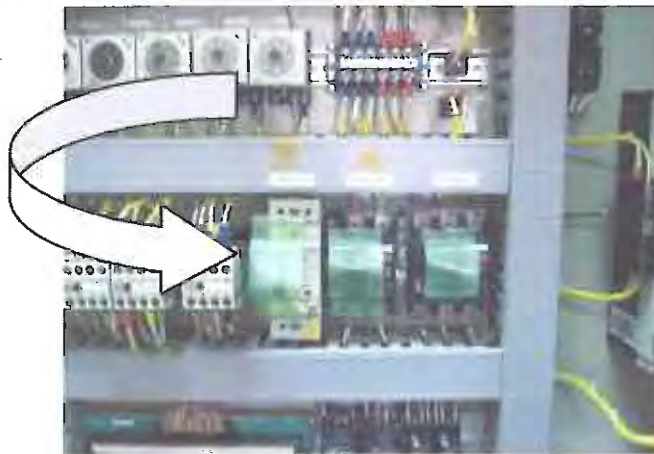


5) MCCB TC1 TR Primary : ON

6) MCCB CPC2 Control source (Black start) : ON



7) BATTERY breaker : ON



8) To insert a handle into Servomotor unit



9) To confirm to do like this for 2 times.

To charging Motor Spring by handle 5 2 – 2 (Indication “Red” )

To operate 5 2 – 2 : OFF (Indication “Green”)

To charging Motor Spring by handle 5 2 – 2 (Indication “Green” )



### III. Operation

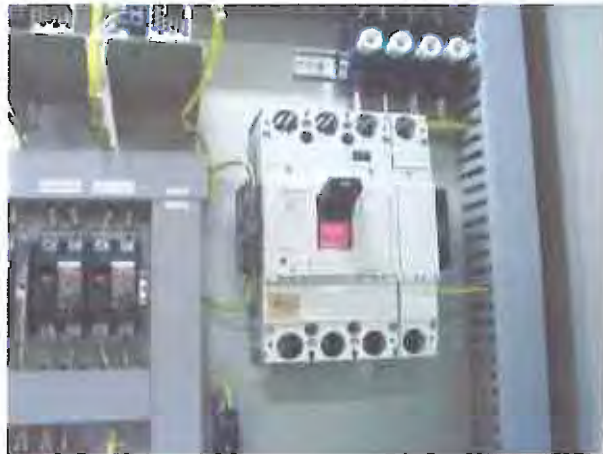
- 1) Inlet valve : OPEN
- 2) Be sure "PREPARATION" lamp is ON
- 3) # 1 : START, confirmation lamp on " OPERATION"



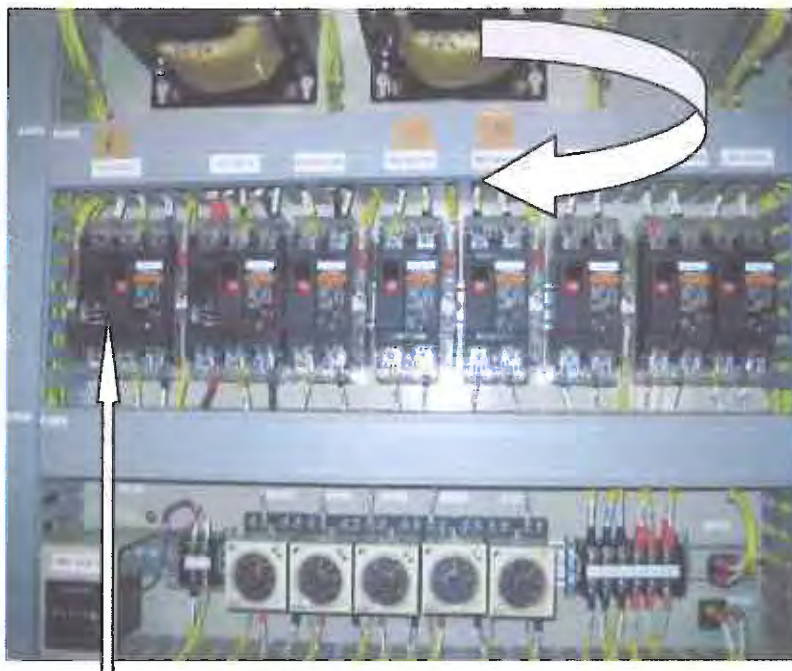
- 4) Turbine running and Turn Servomotor handle in "OPEN" direction.  
Turn the handle slowly until it reaches the near 100 to 150kW load and  
to set the lock bolt into Servomotor handle  
Turbine running and confirm meters 400V, 50Hz, 1,000 rpm.
- 5) 3 – 5 2 – 2 Switch : ON



- 6) 5 2 – 1 MCB : ON and to send power (kW) to the 22kV line



- 7) Breaker MCCB 1 and 1A: Control source : ON



- 8) To confirm Breaker MCCB 3: SERVO MOTOR : OFF
- 9) To increase the load into 22kV/400V lines , one by one. (increase the load at every 20% of the power generated.)
- 10) To start 0' Romis P/S and Parallel with 0' Moleng P/S
-

### Shutdown

- 1) # 1 : STOP
  - 2) Turn Servomotor handle in "CLOSE" direction.
  - 3) Close the inlet valve.
  - 4) To confirm STOP
  - 5) To take out a handle from Servomotor unit
  - 6) BATTERY breaker : OFF
  - 7) 4 3 B S : OFF
  - 8) All MCCB breakers: OFF
- 

### To start normal operation procedure.

- 1) Battery NFB : OFF
- 2) 43BS : OFF
- 3) Preparation of normal operation

**Appendix-7: Black start procedure for  
Diesel power station**



**BLACKOUT START  
PROCEDURE FOR  
DIESEL GENERATING  
FACILITY**  
on  
**Mondul Kiri  
Electrification Project**



October, 2008  
Prepared by: @Aristo@PTA@PTA@PTA

**1. PREPARATION FOR  
PANEL SIDE**

**CONTROL SOURCE : DC24V  
TO BE SUPPLIED**



**(1) All of auxillary motor  
switches on Auxillary  
panel to be selected to  
"Auto"**



**(2) Ventilation fan  
switch in Engine room  
to be selected to "Auto"**



**(3) Mode select switch  
on Generator panel to be  
chosen to "Auto"**



**(4) Blackout select switch  
on Generator panel to be  
chosen to "ON"  
( Confirm indication lamp turn on  
"READY TO START")**





## 2. PREPARATION FOR ENGINE SIDE



(1) Air pressure of Air reservoir to be kept between 22Mpa ~9.5Mpa.



Note: Charging air using by Engine driven air compressor, If air pressure was not enough.



(2) The Main valve of air reservoir should be closed.



(3) The Fuel Oil control handle of Engine to be positioned at "STOP"



(4) Give the Lub oil to all of valves & rocker arms, if Engine stopping more than three(3) days.

( Not required if Engine stopping within three(3) days)



**(5) Open the valve and push the hand priming pump.**  
**(Keep the LO pressure about 0.02Mpa or more during at least two(2) minute)**



**(6) Turn Flywheel while L.O priming.**



**(7) Set it back turning device & bar to right position, also close the valve of hand priming pump.**



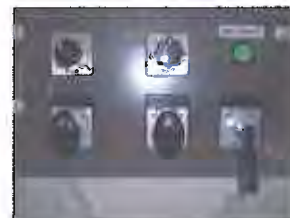
**(8) The FO control handle to be positioned at "RUN", and open the Main valve of air reservoir.**



### **3. START UP DIESEL GENERATOR**

**Following action to be taken after carried out above method.**

**(1) Turn "START" by Engine control switch on Generator panel.**



**(2) Confirm that the Power supply & Charge completed from D/G to BUS.**



**(3) Adjust Frequency (50Hz) by Speed control switch in accordance with required load (kW).**

