JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ARUSHA REGIONAL DEVELOPMENT DIRECTORATE
THE UNITED REPUBLIC OF TANZANIA

THE FEASIBILITY STUDY ON MONDULI TOWN AND THE SURROUNDING AREA WATER SUPPLY IN ARUSHA REGION

OPERATION AND MAINTENANCE MANUAL

JANUARY 1996

SANYU CONSULTANTS INC.
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Manual for Operation and Maintenance

1. General

The water supply systems to be implemented for the Project can be classified three types; the pump-up type, the gravity flow type, and the impounding type Operation and maintenance are to keep these facilities good conditions, and to utilize its maximum functions according to its objectives. The results of operation and maintenance give much influence not only to the expecting effects of those facilities but also to the durability of the facilities and also to the cost of maintenance. It is therefore necessary to carry out a suitable maintenance.
Outline of the operation and maintenance to each water supply systems mentioned above is described below.

2. Pump-Up Type

The water supply system as pump-up type in this Project is consisted of deep-well with submersible pump, water conveyance pump station, and water conveyance pipeline. The operation and maintenance of each facilities are as follows.

2-1 Deep-Well

- Surrounding area of the deep-well shall be keep clean not to contaminate the water collected by the deep-well.
- There deep-well pump stations shall be operate rotationally at regular intervals to maintain the aquifer good condition.
- Size and quantity of sand particle which is contained in the pumping-up water shall be measured at regular intervals.
- Attentions must be paid to the new groundwater development in the surrounding area.
- Operation data acquired at three deep-well pump stations shall be concentrate at one place to evaluate the groundwater conditions.

2-2 Submersible Motor Pump

Since the motor and the pump of the submersible motor pump is installed in the well, it is not possible to observe and check the operating condition directly by eyes. Therefore, the condition of the motor pump should be judged by the running currency, pumping up amount, pressure value of the compound gauge in daily operation.

(1) ACCEPTABLE WATER QUALITY STANDARD

Hydrogen ion concentration (PH)	:	6.5 ~ 8.0
Chlorine ion	:	200 ppm (MAX.)
Amount of sand contained	:	50 ppm (MAX.) (small sand 0.1 ~ 0.25)
Water temperature	:	32°C

(2) PRACTICAL OPERATION

- When the test operation is completed, the pump is available for the practical operation.

- Work out the operation of the pump according to the value of the pumping amount and the lift head indicated (listed) in the name plate. If each value is quite different from the value in the name plate, please contact the manufacturer.

- If the pumping amount is too little, the motor could be over-heated and burned out.
  Also, if the pumping amount is too much, oscillation happens and it may cause such failure as friction on bearing, and damage on the motor thrust.
  * When the compound gauge is not used, keep closing the valve of the gauge. If the valve is kept open, it might be damaged by accident.

HOW FREQUENT THE MOTOR CAN BE STARTED IN CERTAIN PERIOD OF TIME

Motor output	times/hour
22 kW or less	6 or less
37 kW or more	4 or less

Once the pump stops: more than 5 minutes of interval ford 22 kW or less
more than 10 minutes of interval for 37 kW or more

(3) MAINTENANCE AND SERVICE

1) ROUTINE CHECK

- Running currency : once / day
  Read and record if value is within the range of specification value, there should be no radical fluctuation of the value, movement of the hand of the ammeter should be stable.

- Voltage value : once / day
  Read and record the voltage value. Voltage value connects to the current value.

- Pressure on the ground : once / day
  Read and record the data on the compound gauge.

- Pumping up amount : once / week
  If a flow meter is attached, read and record the data. Later, the data can be used to judge the performance of the pump, whether it is still OK or being worn out due to friction.

- Insulation resistance value : once / month
  Remove the cable from the distribution panel and measure the resistance. Check whether there's substantial drop in the value.

- Oscillation and noise : once / week
  Check if there's abnormal oscillation and noise take.

- Water level of the well : once / week
  Check and record the water level of the well, so that the life of the well is estimated.

* Please continue to check and record each value of above 7 items as daily check of the pump. From those data, you can comprehend the condition of the pump as well as the well. And also the timing for the overhaul as well as the cause of the damage or accident can be predicted.

2) OVERHAUL

- Plan the first overhaul of the motor pump after 1 or 2 years from the first operation.

- Decide the time of 2nd overhaul based on the result of the 1 st overhaul checking.
  * It is recommended that you have extra pump as back-up during overhaul.

3) SUSPENSION OF OPERATION FOR LONG PERIOD

- If the motor pump is stopped for long time in the well, it should be operated for appx. 10~20 minutes twice a month.

- During the suspension period, the pump should be operated according the item 9-2 TEST OPERATION, in order to avoid locking of the pump caused by the rust of the casting, or quality of the water.

4) STORAGE OF THE PUMP - MOTOR
Store the pump and accessories indoor to keep their life longer.

- Pump
  Empty the water in the pump and dry it up completely.

- Motor
  Do not pull out the sealing liquid.
  It is generally required to keep the motor sealing condition as the sealing liquid may leak out when the motor is laid down.
  * Put the cover over the motor to avoid damage.
  * Temperature of the storage can be up to -10°C lowest.

- Cable
  Protect the edge of the cable from the moisture by covering it with vinyl bag or taping.
  Wind the cable to the drum can and prevent the damage.

- When the motor pump is used after the certain time of storage. Handle the motor pump according to the checking points in [3] INSPECTION BEFORE INSTALLATION. When the installation work is completed, the resistance value of the pump should be more than 1MΩ for the operation.

(1) Start and Operation

- Check to see if sufficient grease is in the bearings.
- Check to see if the pump can be rotated easily by hand.
- Check the sluice valve on the delivery side of the pump to see that it is closed.
- Turn the switch "on" and immediately turn "off". Check to see if the flexible coupling is turning in the direction of the arrow. As long as the electric wiring is not changed, this check is only necessary at the time of installation.
- Open the cock underneath the priming funnel to fill the pump with priming water. If the suction side pipe and the pump is filled with priming water, water will shoot out from the air cock at the top of the pump. This means that the air has been vented from the pump.
- As the pump is now ready for operation, start the motor or engine. If pressure gauge and vacuum gauge are used for the pump, their indicators will rise until they point to proper values.
- The pressure and vacuum gauges of the pump usually indicate values in terms of kg/cm^2 and mm Hg. The calculation of the column of water into meter is as follows:

  $1\ kg/cm^2 = 10\ m$

  $100\ mm\ Hg = 1.36\ m$
- Check to see that the pressure gauge, and vacuum gauge point proper values. Then gradually open the sluice valve. The water will discharge with great force.

(2) Operation

During operation, check the following at certain intervals.

- Check to see if there is any change in the noise of the pump.
- Check to see if there are any vibrations.
- Touch the bearings with finger to see if the bearings are unnecessarily heated.
- Check to see if the gland packing have become heated.
- Check the ammeter to see if unnecessary current is flowing. If there are any questionable phenomena mentioned above, the pump should be stopped and repaired as described elsewhere in this manual.

(3) Stopping

After work has been finished, stop the pump in the following order.

- Gradually close the sluice valve don the delivery side.
- Close the cocks of the pressure gauge and vacuum gauge.
- Stop the motor or engine.
- When the pump is not to be used for a long period of time,d or if there is a fear that water inside the pump will freeze, pull out the drain plug and drain water from the pump casing.

(4) Cautions

- Don't start the pump with the sluice valve left open, as it will cause unnecessary overloads on the motor or engine.
- Avoid operating the pump for a long period of time with the

sluice valve completely closed. When the pump is in operation for a long duration of time with the sluice valve completely closed, the temperature of the water within the pump will gradually rise, or the accumulated air, that has been sucked into the pump little by little, will cause and conditions as mentioned in the following paragraph (3).

- Pump should not be operated without water. When the pump is operated without water, there is fear of overheating the stationary and rotating parts.
- Do not tighten the glands too tightly, even if a small amount of water should leak from the glands. When the glands are bolted too tightly, the pump will require excessive power and shaft sleeves will wear down.
- Do not use the pump with low delivery pressure. As thrust is relieved by the Balance Disk in a Multi-stage volute pump, the pump should not be used with a head 30-40% lower than the designed head.

(5) Maintenance

The following maintenance of instruction apply to multi-stage volute pump and its bearing, gland packing, etc.

- Bearing
  As roller bearings are used, practically no work is required for maintenance, but grease should be supplied as described to attain better operation. Under ordinary working conditions (8 hour day) supply grease once in six months and under severe working conditions (continuous operation) supply once in three months. Before supplying grease, check grease within the bearing, and if very dirty, clear with benzene, gasoline, chemilor, or light oil. The check to see if the bearing works properly, and fill it with grease. Do not used too much grease. When filled too tightly, it will overheat the bearing. When grease within the bearing is not dirty, the bearing may be used without cleaning.
- Gland Packing
  The gland packing should be tightened to such degree that a small amount of water will drip. When the packing becomes damaged, the water will leak very much even if tightened. Furthermore, air will leak in. In such cases, the gland packing should be replaced with a new one.
- Drain Plug
  If the pump is not to be used for a long period of time, or if there is fear of freezing, drain the water from the pump by removing the drain plug at the bottom.

2-4 Motor

(1) Cleaning

- Clean the entire air path of motors with dry compressed air at regular intervals to remove dust deposits. If excessive dust deposits form in the air intake and discharge openings inside a motor, cooling air cannot flow freely and the motor may overheat.
- In totally enclosed motors, dust on the stator frame ribs and/or the cooling air paths in the noise-suppression cover and muffler, when provided, should be removed at regular intervals.

• In wound motors, carbon dust should be blown from the slipring assembly and winding surfaces.

(2) Bearings and lubrication

• Shielded bearings
Smaller and medium sized motors are provided with shielded type bearings. Such bearings are shielded on both sides with metal. They are sealed for bearing life and, therefore, require no regreasing. In many cases, it has been found sufficient to replace bearings only during motor overhauls.

• Prelubricated (Open type) bearings
Smaller and medium sized motors may have prelubricated bearings. Under normal operating conditions, the grease pack, in such motors at the factory, need not be changed for several years. Bearings should be removed and cleaned about every two years; bearing should be refilled with new grease when bearings are cleaned.

• Regreasable bearings
Large size motors are provided with regreasable bearings. The grade and amount of grease that should be used and the interval required for regreasing in normal service are indicated on the rating plate.

- Bearings should be relubricated at intervals indicated in number of operating hours while a motor is running.
- When regreasing, first clean the grease nipple and then force in the required amount of grease with a grease gun.
- If excessive grease is used when regreasing, the bearing temperature will rise to a temperature 5 to 10°C above the normal value and a slight noise may be detectable for a while. However, bearing conditions will stabilize within a few hours to one day, depending on the operating conditions.

• Use of different brands of grease for regreasable bearings.

- Different brands of grease should not be mixed.
Remember that some brands of grease may not match the bearing requirements of a motor.
- When using a brand of grease that is different from the original brand, be sure to follow the procedures below.
  a) Supply new grease while operating a motor or rotating the shaft by hand and open the grease outlet to thoroughly remove the original grease.
  b) Repeat the above procedure until the new grease comes out the grease outlet.
- As a result of repeating this procedure, the bearing temperature may rise to a higher than normal level. In such a case, the machine should be greased again after the temperature has decreased.

• Oil-lubricated bearings

- Check to see that the reservoir is filled with lubricant up to proper line on the oil level gauge.
- Replace lubricating oil once every six months to one year.
- Bearing noise (Regreasable bearings)
Bearing noise during operation can be classified as follows.
  a) Normal noise
  Normal noise is generated continuously. Normal noise consists of race, creak and cage noises.
  Creaks are sometimes considered unusual noises, but are not

an indication of defective bearings. Creaks will disappear with regreasing.

b) Unusual noise
   * Unusual noise consists of flow or inclusion noise
   * Unusual noise is heard intermittently, sometimes in conjunction with vibration, and is irritating.
   * When noise is detected, supply new grease and observe any changes in bearing noise that occurs. If after a while an irritating noise can still be heard, the bearing should preferably be replaced with a new one.

(3) Drain plug (when provided)
Drain water by opening the drain plug in the enclosure at regular intervals. The should be done at least once every six months. When water remains on the drive end of a totally enclosed horizontal motor, remove the tan cover of the non-drive end and open the other drain plug to remove the water.

2-5 Diesel Generator

(1) OPERATION

1) Instrumentation
While the engine is running, confirm the normal operation of the set by referring to the following instruments.

i) Engine Operating Panel
The following instruments, meters, etc. are mounted on the engine operating panel.

a) Tachometer
This meter indicates engine speed and integrated operating hours.
Exact adjustment of the speed should be based on the frequency meter.
50 Hz - 1500 rpm
60 Hz - 1800 rpm

b) Oil pressure gauge
In normal operation, the oil pressure gauge should indicate the lube oil pressure somewhere between 3 to 5 kg/cm^2.
Although oil pressure tends to be slightly high due to high oil viscosity for a while after starting, the pressure will be soon reduced to the normal as the engine warms up.
When oil pressure stays less than 2 kg/cm^2, determine the cause.
When the gauge pointer swings excessively, the foil level may be too low.
In such case, replenish with oil.

c) Water temperature gauge
The most appropriate temperature range is indicated as "80 to 95°C" on the meter.

d) Battery charging ammeter
This ammeter indicate with (+) indication a charging current to battery, or with (-) indication a discharging current from battery.

e) Battery switch

This switch is the main switch for all DC control circuits of the generating set.
Be sure to keep the battery switch turned "ON" during operation.
Should it be turned "OFF" during operation, the engine protective circuits may result in a malfunction.
Be sure to keep the battery switch turned "OFF" while the engine is at a stop.

f) Throttle handle
This handle is to increase and decrease the engine speed.

g) Starter switch
This is a switch to preheat and start the engine with the starter key.
Be sure not to switch off this switch while the engine is running.

h) Stop button
This is push button to stop the engine.

ii) Generator Control Panel
The following meters, instruments, etc. are provided on the generator control panel.

a) AC Voltmeter
This meter indicates generator output voltage. The pointer must always indicate the rated voltage during operation.

b) Voltmeter selector switch
With switching this selector switch, output voltage between U-V, V-W, or W-U phases can be indicated on the AC voltmeter.

c) AC ammeter
This ammeter indicates load current, which must be lower than the rating.

d) Ammeter selector switch
With switching this selector switch, the current in U, V or W-phase cable connected to loads can be indicated on the AC ammeter.
When the loads are balanced, those current values should be almost equal.

e) Frequency meter
This meter indicates the frequency of the generator output.

f) Voltage adjust rheostat
With this rheostat, the generator voltage can be adjusted to any point within the adjustable range of the rating ±5%.
The voltage is increased by turning it clockwise, and decreased by turning it counterclockwise.

g) Main circuit breaker
This breaker protects the generator from a short circuit or overload accident on the load side.
The breaker has two positions of OFF and ON.
In "ON" position, power is supplied to the load, and in "OFF" position, the load is disconnected from the generator.
If the breaker is tripped due to an overload, set it once to the OFF position, then reset it back to the "ON" position.

2) Checking Prior to Each Engine Starting

a) Check lube oil level

The oil level gauge (dipstick) is located on the side of the engine.
Check oil level in the oil pan while the engine stopped.

b) Remove the filler cap of the radiator, and check water level. Replenish with clean soft water if it is low.
c) Check fuel oil level.
d) Check for leaks of fuel oil, lube oil and cooling water.
e) Make certain the electrolyte level of the battery is above the top of the plates. Terminals and cable connections must be tight and corrosion-free.
f) Make sure V-belt is tight.
g) Make sure that the electrical devices and wiring are not loose, damaged, corroded or deformed.

3) Starting Procedure

a) Insert the engine starter key into the switch.
b) Turn on the battery switch.
c) Turn the key full clockwise, and the starter will start cranking the engine. Take your hand off the key as soon as the engine starts up, so the key will naturally return to the run position.

In case the engine would not start upon the starting attempt of about 10 seconds, make a next starting attempt after about 2-minute rest.

Caution: Do not make another starting attempt before the engine completely stops. Otherwise, the starter gear may be damaged.

d) Set the speed to 750 to 900 rpm, and keep the engine idling for warming-up for 5 minutes.
Note: Engine speed drops by turning the throttle handle clockwise, and rises by turning it counterclockwise.
e) See the oil pressure gauge, water temperature gauge, charging ammeter for their normal indication, and confirm that there is no abnormal vibration, striking or rubbing noise, and oil, water or fuel leakage.
f) Set the speed to the rating by pulling the throttle handle and pushing the button.
g) Set the output frequency (speed) to the no-load frequency with turning the throttle handle, while observing the frequency meter.
No load frequency for 50 Hz operation: Approx. 52.5 Hz
No. load frequency for 60 Hz operation: Approx. 62.5 Hz
h) Set the output voltage to the rated voltage by the voltage adjust rheostat on the generator control panel.
i) Turn on the circuit breaker to supply the power to load.

4) Shutdown Procedure

a) Turn off the circuit breaker.
b) Drop the engine speed to 750 to 950 rpm by pushing the throttle handle, and allow the engine to idle for about 5 minutes to cool-down.

c) Push the stop button certainly.
d) Set the starter key to the off position, and cut off the battery switch.

(2) Maintenance

1) General Instruction
The ultimate aim of maintenance is to maintain the set in optimum condition and to realize the longest life of the set.
The detection of faults before they develop into serious trouble will lighten the repair work. Regular cleaning and inspection will assure trouble-free operation. Personnel responsible for maintenances should set up a schedule for periodical inspection and cleaning to keep the equipment in good condition.

2) Safety Precaution
Observe the following rules.
a) All circuits must be considered "live" and dangerous.
b) Regard all exposed copper wire, terminals, and components as "live" and treat them accordingly.
c) Co not use metal rules, flashlights, metallic pencils, or any other exposed conductor while working near energized electrical equipment.
d) Take precautions to avoid grounding your body while using electrical measuring apparatus or adjusting the energized electrical equipment.
e) Be sure to de-energize all equipment before connecting or disconnecting test leads.
f) Before connecting an electrical measuring instrument to terminals of unknown voltage/amperage, select a higher meter range than that expected.

3) General Precautions
When the generating set is installed, overhauled or stored for a long period, be sure to check the items below before operating it.
a) Make sure all circuits comply with proper wiring diagrams.
b) Check lead and control cables for open circuits, incorrect/loose connections, and damage resulting from rough handling or improper installation.
c) Make sure electrical insulation is in good condition, i.e., clean, dry and of high resistance.
d) Check wiring, connections, load cables, and other components for excessive dirt and grime.

4) Cleaning

Cleanliness if of primary importance in preventive maintenance. Do not allow dust, moisture, oil or other substances to remain in or on the equipment. Above all, keep all insulation clean and dry, and free from dust, dirt and other foreign material such as copper, mica, etc. If such particles are allowed to build up, the windings may eventually be short-circuited or grounded.
Iron particles are especially harmful because they are continually agitated by magnetic pulsations. For these reasons, equipment must be kept clean, both externally and internally.

There are three ways to clean electrical equipment:
a) Wipe clean with a rag.
b) Blow off with low pressure compressed air.
c) Clean with a vacuum cleaner and suitable attachments.
Among the methods listed above, vacuum cleaner method is the most practicable for cleaning dust because the compressed-air method allows the dust to recollect. Also, a vacuum cleaner is capable of removing dust from the coils or the grooves between wires which cannot be reached.

5) Drying Insulation

It is sometimes necessary to dry the insulation in order to recondition the electrical equipment.
To remove moisture effectively from insulation, heat, blow dry air, or vacuum it.
There are two methods to heat insulation:
a) By external application of heat.
b) By providing electrical current at low voltage through the conductors.
Be sure to keep the temperature increase within the rated "Insulation Class" using temperature detectors which can detect the temperature of the hottest part. Heating should be done continuously because an interruption can allow moisture to be condensed into water. The drying should be done slowly, that is, for several hours to several days, in order to obtain good results.

6) Engine Electrical System

The engine electrical system includes the starter motor, battery charging generator, voltage regulator, storage battery, charging ammeter, protective devices, etc.
The charging system includes the battery, generator, and voltage regulator. The battery works as a power storage plant to supply electrical energy, and must be kept fully charged.
Excessive DC current to the battery can burn out the charging generator, and damage the battery. A voltage regulator is included in the circuit to prevent such damage.

7) Battery

If the electrolyte level of the battery is low, add some distilled water to bring the level up to bottom of the filler hole. Be sure filler plugs are tight and plug events are open. Measure the specific gravity of the electrolyte every 300 hours to make sure that its specific gravity is about 1.26 at 20°C.

8) General Bearing

Check the bearing every 500 hours and grease them if necessary.

3. Gravity Flow Type

(1) Intake Facility

- Regular inspection should be carried out regarding the following items.
- stability of fixed weir.
- leakage of water from the abutments or from the foundation.
- block-up of the screen pipe of intake by trash.

Regular estimation of doughty water discharge at the intake point should be carried out and confirmation should be make regarding the conveyance ability of the pipe-line.
Water quality analysis should also be carried out at the time of inspection for the fixed weir, and if aggravation of the water quality is found, necessary measures should be taken after examination of the cause.

(2) Pipes and Other Facilities

Inspection to the pipes, i.e. strength of pipe material, the leakage from the joint, etc. should also be carried out at the timed of inspection to the fixed weir.
Observation of inside of the Break Pressure Tank should be carried out and if blockade at the entrance of pipe is found, the obstructions should be removed immediately.
To ease maintenance of the pipe-line, circumference of the pipe-line should be every time clear by cutting the grasses or trees.

4. Impounding Type

4-1 Operation and Maintenance of Structures

In order to maintain dam safety after full storage, respective necessary supervision must be executed both during and subsequent to the period during which a steady state of dam behavior is achieved.

[Explanation]
In order to ensure the safety of the dam, suitable supervision is necessary for the dam structures, the reservoir and peripheral natural ground.
With regard to the supervision for the structure, monitoring and checks must be carried out and the necessary measures taken in the case of any abnormalities arising.

(1) Division of Supervision Period

Supervision is divided into the following three periods considering the behavior characteristics of the dam, and the frequency of monitoring and periodical inspection is set for each period.

1) First stage: Stipulated time span from the beginning of the initial ponding to after full storage.
2) Second stage: The period from the end of the aforementioned first stage until dam behavior has reached a steady state.
3) Third State: from the 2nd stage onwards.

(2) Monitoring

The necessary monitoring must be implemented in order to confirm the stability of dam behaviors and conditions. The outline for monitoring is given in Table 4-1-ref.1.

Table 4-1-ref.1 Outline for Monitoring

	First stage	Second Stage	Third Stage	Remarks
Leak-age	once/day	once/week	once/week	
Defor-mation	once/week	once/month	once/ 3 months	With regard to dams of less than 70m in height, dam monitoring in the third stage may be once every six months, and for upstream slop monitoring may be carried out when reservoir water level is lowered.
Seepage line	once/week	once/month	once/ 3 months	Monitoring is carried out only for homogeneous type dam

Note: On the basis of results of monitoring data, the frequency of monitoring may be altered. Where monitoring for a small dam in the empty period for the reservoir remains for a long time, monitoring during such periods may be omitted.

(3) Inspection

It is vital for either regular or temporary inspection to be implemented in order to observe the conditions for the dam body, the natural ground around abutments, and the outlet works. The outline for regular inspection is given in Table 4-1-ref.2.

Table 4-1-ref.2 Outline for Regular Inspection

Section to be inspected	Item to be considered	Number of inspection times			Remarks
		1st stage	2nd stage	3rd stage	
Dam body	Leakage, conditions of facing wall and slope of filldam	once/ week	once/ 2 months	*3 times/ year	* Before and after flooding periods and thaw periods
Natural ground around abutments	Leakage, cracks, land slip and landslide	once/ week	once/ 2 months	* 3 times/ year	
Outlet works	Leakage, abrasion and scour of spillway, presence of obstructions.	once/ month	once/ month	once/ month	

4-2 Operational Supervision

Suitable and safe operation and maintenance should be carried out with respect to the intake of water, flood control and discharge.

[Explanation]

in order to implement intake of water and safe flood control and discharge, dam operation procedures must be established in advance with subsequent supervision and operation of the gates and valves to be carried out on the basis of these formulated procedures.

4-3 Observation for Silting in the Reservoir

In the rainy reasons, the condition of silting in the reservoir should be observed once a month. Desilting should be carried out by the village people at a certain intervals, if heavy silting is found.

4-4 Maintenance of the Filters

Check the filtration capacity of the filter, the quality of the filtered water, and the conditions of hand pumps should be carried out at the time of activity mentioned above section 4-3.