SOP FOR OPERATION AND MAINTENANCE MANUAL FOR RURAL WATER SUPPLIES

SWWM- UTTAR PRADESH
Ministry of Drinking Water and Sanitation

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1.1 Objectives of Operation and Maintenance

The objective of an efficient operation and maintenance of a water supply system is to provide safe drinking water as per designed quality and quantity, with adequate pressure at convenient location and time at competitive cost on a sustainable basis

Operation refers to timely and daily operation of the components of a Water Supply system such as machinery and equipment, conveying mains, Over head reservoirs and distribution system etc., effectively by various technical personnel, as a routine function.

Maintenance is defined as the act of keeping the structures, plants, machinery and equipment and other facilities in an optimum working order. Maintenance includes preventive /routine maintenance and also breakdown maintenance. However, replacements, correction of defects etc. are considered as actions excluded from preventive maintenance.

Standard Operating Procedures

This Standard Operating Procedure is intended to identify what local operators should do in terms of routine O&M related to water sources, conveying ,pumping, storage and treatment units, and distribution systems including household connections.

2.1 O&M Plan

This plan contains procedures for routine tasks, checks and inspection at set intervals viz. daily, weekly, quarterly, semi-annually or annually.

2.1.1 Development of Individual Plan for O&M

The individual plan must be prepared scheme wise for all units and all pieces of equipment. Each unit must have a plan to fix responsibility, timing of action, and ways and means. Generally actions recommended by the manufacturer or by the site engineer in charge who has installed the equipment or who has supervised the installation can be included. Often the contractor's recommended operation and maintenance procedures at the time of design/ construction will be a good starting point for preparing sound program. This plan has to be followed by the O&M staff and also will be the basis for supervision/ inspection. It also may be used for evaluation of the O&M status and the delivery of designed outcome.

The agency in-charge for O&M of water supply shall become service oriented. It is essential that the organization responsible for O&M has well qualified, trained, experienced motivated and efficient staff to perform better.

2.1.2 Capacity building plans for O&M personnel

The training program to be organized for the personnel who are already available or chosen to carry out the action contained in the programme required to be trained through special courses or by "on the job training "to ensure that these personnel are thoroughly trained to carry out the action listed in the plan of maintenance. The supervisors can be trained initially who in turn may train the operators.

2.1.3 Plan for providing spares and tools

It is essential to ensure the availability of spare parts like stand by pump-sets, minimum numbers of different sizes of jointing materials assessed on the basis of lengths of pipe lines, all sizes of nuts and bolts, Bearings, pipe pieces of different sizes & materials, electric spares like MCBs, Relay etc. The availability of spare parts for repairs and replacements is to be ensured by ordering and delivery of spare parts by organizing an inventory system. The list of spare parts to be procured can be drafted on the basis of manufacturer's recommendations / consumption of material in previous years. The spare parts procured should be of BIS standard, with proper quality check.

2.2.4. Plan for water audit and leakage control

The availability of potable water (underground) is very limited, There are considerable losses in the water produced and distributed through leakages in pipelines, valves, public tapes un authorized service connection etc. Therefore it become essential to plan the conservative use of water i.e. water auditing/ leakage control through metering, improved O & M practices and awareness intervention.
users.

2.2.5. Plan for Information Education Communication (IEC) conservative use of water

The IEC activities is a very essential part for conservative use of water ,The awareness for conservative use of water can be generated among consumer by plays ,electronic media ,print media and by mouth publicity . The utility organization should prepare Information- Education-Communication material and use the services of voluntary organization/NGOs to create awareness among the public and consumers.

2.2.6. Reports and Record Keeping

A Reports and Record Keeping system shall be enforced to list all the basic data of each piece of equipment and the history of the equipment .A reporting system shall be provided for the operator to inform the supervisor /manager about the problems of each equipment requiring the attention to repair and replacement crew or other specialized service personal.

The success of operation and maintenance programme should result in decline of frequency of shutdowns, and emergency repairs. Improved O&M may result increased availability water supply and more revenue, Further, the cost of repairs may also reduce with the increase of equipment's life owing to the implementation of the maintenance program.

3.1 Components of Rural Piped Water Supply Scheme (PWSS)

The Rural Piped Water Supply Scheme Comprises of following components, the details of these components will be illustrated separately.

1 Ground water Bore well works.
2 Water storages.
3 Transmission System.
4 Pumping Machinery.
5 Disinfection.
6 Distribution system.

4.1 Mechanized Bore Well

4.1.1. Tube wells with Pump Sets

A tube well is a type of water well in which a long 100–350 mm diameter stainless steel tube or pipe is bored into an underground aquifer. The depth of the wells depends on the depth of the water level in the Aquifer.

Boreholes may be fully cased and screened in overburden/alluvium strata and the top of the borehole shall be sealed to prevent pollution through percolation of water into the borehole. After installation of bore, the top of the borehole at the riser pipe shall be caped to prevent contamination of the borehole by surface water and debris etc. An isolation valve and non-return valve are fitted on a horizontal section of the delivery pipe, adjacent to the bore well to prevent the backflow. Typically, the pump house or fabricated panel box is located next to the borehole and housed with the control panel for operation of the electric pump. Motor service frequency in terms of running hours shall be usually specified as per catalogue and indicated to

the operator. The manufacturer's O & M manuals should essentially be followed.

4.1.2. Preventive Maintenance

According to available data the specific yield of wells should be measured at annually and compared with the original specific yield by the trained staff/line Dept. and the record of the same shall be maintained. As soon as 10 to 15% decrease in specific yield is observed, steps should be taken to determine the cause and corrective measures should be taken accordingly. Rehabilitation procedures should be initiated before the specific yield has declined by 25%. A check list given below can be used to evaluate the performance of a well

i) Static water level in the production well
ii) Pumping rate after a specific period of continuous pumping
iii) Specific yield after a specified period of continuous pumping
iv) Sand content in a water sample after a specified period of continuous pumping
v) Total depth of the well
vi) Efficiency of the well
vii) Normal pumping rate and hours per day of operation
viii) General trend in water levels in wells in the area
ix) Draw down created in the production well because of pumping of nearby wells.

A significant change in any of the first seven conditions listed above indicates that a well or pumping rate is required. For, preventive maintenance programme well construction records showing geological condition, water quality and pumping performance shall be collected. The data of optimum and efficient limit of operation should be available which is created at the time of testing and commissioning of the well. This data is normally in the form of a discharge draw-down curve (called yield draw down curve). The pumping water level and draw down can be measured with the help of an electric depth gauge of an airline gauge.

4.1.3. Causes of Failure of Wells

Well may be failed due to inadequate design, faulty construction and operation, lack of timely maintenance. The main causes for source failure are categorized as under:

- Incorrect design: for instance use of incorrect size of screen and gravel pack, wrong pin pointing of well site resulting in interference.
- Poor construction e.g. the bore may not be vertical; the joints may be leaky, wrong placement of well screen, non-uniform slots of screen, improper construction of cement slurry seal to prevent inflow from Saline aquifer.
- Corrosion of screens due to chemical action of water resulting in rupture of screens.
- Faulty operation e.g. over pumping, may causes the rupture of strainer casing pipes due to piping action of water, poor maintenance.
- Adverse aquifer conditions resulting in lowering of the water table and deterioration of water quality.
- Mechanical failure e.g. falling of foreign objects including the pumping assembly and its components.
- Incrustations due to chemical action of water.
- Inadequate development of wells.
- Placement of pump sets just opposite the strainer casing pipes, causing entry of silt by rupturing slots of pipes.

4.1.4. Monitoring of silt coming out with water during pumping from source

Indication for silting

(i) Appearance of fine silt with water is an early indication of silting.
(ii) Reduction in depth of bore well/ opens well.

(iii) Reduction in yield of bore well.

Causes for silting

(i) Over pumping.
(ii) Improper sitting of casing pipe.
(iii) Improper jointing of casing pipes.
(iv) Placement of pump sets just opposite the strainer casing pipe.
(v) Poor development of bore wells.

Suggestions to overcome silting

(i) Periodical inspection of bore well.
(ii) Additional length of casing pipe may be inserted in the case of improper bore well assembly installation.
(iii) Flushing of bore well.
(iv) Re-development of bore well
(v) Replacement of pump sets with proper duty condition, with respect to the safe yield of the tube well.

4.1.5. Rejuvenation of Tube wells& Bore Wells

A decision whether to rejuvenate an old well or construct a new one based on the cost benefit analysis.

Following remedial measures can be taken for correcting situation mentioned at 4.2.3.2

4.1.6. Faulty Operation

Tube well should run in such a way that the pumping water level should always remain above the level of well screen. Over pumping will expose the well screen, which may result in incrustation and corrosion. Over pumping results in excessive draw down which may cause differential hydrostatic pressures, leading to rupture of well screen. Negligence in timely repair and maintenance may result in poor performance of the tube well. Therefore, before any permanent damage is done to tube well it should be ensured that the tube well is operated at its designed capacity and timely repair and maintenance are done

4.1.7. Adverse Aquifer Conditions

In adverse aquifer conditions where water table has depleted but the quality has not deteriorated, wells can generally be pumped with considerable reduced discharge.

4.1.8. Mechanical Failure

The falling of pumping set assembly and its components into the bore hole can be minimised by providing steel wire holdings throughout around the assembly length including pumping set or by providing and clamping a steel strip around the pumping assembly .However, in spite of proper care, sometimes foreign objects and pumping set assembly components may fall in the well. In corrosive water the column pipe joints and pump parts may get progressively weakened due to corrosion, get disconnected and fall into the well. However where well screen is not damaged, then by proper fishing the fallen objects can be taken out of the well making it functional again. Following are the one of the method taken for fishing out the fallen objects in the bore holes:

(a) Impression Block: An impression block is used to obtain an impression of the top of the object before attempting any fishing operation. Impression blocks are of many forms and design. An impression block made from a block of soft wood turned on a lathe. The diameter of the block is 2 cm less than that of drilled hole. The upper portion is shaped in the form of a pin and driven to fit tightly into the box collar of a drill pipe. To ensure further safety, the

wooden block is tied with wire or pinned securely to the collar. Alternatively, the block could be fixed to a bailer. A number of nails are driven to the lower end of the block with about 1 cm of it projecting out. A sheet metal cylinder of about 5 to 7 cm is temporarily nailed around the block to hold molten wax, which is poured into it. Warm paraffin wax, soap or other plastic material poured into the cylinder is left to cool and solidify. The metal cylinder is then removed; the nail heads hold the plastic material to the block. To locate the position of a lost object, the impression block is carefully lowered into the hole until the object is reached. After a proper stamp is ensured, the tool is raised to the ground surface, where the impression made in the plastic material is examined for identifying the position of the lost object and designing or selecting the right fishing tool.

(b) *Fishing Tools to Recover Fallen Objects:* The term 'fish 'describes a well drilling tool, pump component or other foreign body accidentally fallen or struck in bore wells. The type and design of fishing tools required for a specific job, depends on the positioning at which it is lying in the well and the type of object to be lifted/ fished. However, series of fishing tools suitable for different jobs are available in the market, which could be adapted or modified to suit a particular requirement. The following are some of the methods of fishing process:

External catch: Fishing tools that engage the fish on its outer diameter. These tools help to recover equipment down hole by using a grapple or by threading directly to its outside surface.

Internal catch: Fishing tools that engage the fish in its inner diameter. Similar to External Catch tools, this is achieved by a grapple or by threading directly to the fish's inside surface.

4.1.9. Gripping and Releasing Mechanism

The bowl of the overshot is designed with helically tapered spiral section on its inside diameter. The gripping member (Spiral grapple or basket grapple) is fitted in to this section. When an upward pull is exerted against a fish, an expansion strain is spread evenly over a long section of the bowl and the compression strain is spread evenly over a long section of the fish. No damage or distortion occurs to either the fish or the overshot. This design permits a far stronger tool with a smaller outside diameter than is possible with an overshot that employs a single tapered section which supports slips.

A *spiral grapple* is formed as a left hand helix with a tapered exterior to conform to the helically tapered section in the bowl. Its interior is whickered for engagement with the fish.

A *Basket grapple* is an expandable cylinder with a tapered exterior to conform to the helically tapered section in the Bowl, its interior is whickered for engagement with the fish. Two types of basket grapple are available to meet the need for catching various types of fish.

The basket grapple with long catch stop has an internal shoulder located at the upper end to stop the fish the best catch position. It is designed to stop and catch collars and tool joints with sufficient length left below the grapple to allow the joint to be packed off with a Basket control packer.

Grapple controls are of two types: Spiral grapple controls are used with spiral grapples: Basket controls are used with basket grapples. Grapple controls are used as a special key to allow the grapple to move up and down during operation while simultaneously transmitting full torque from the grapple to the bowl.

Spiral Grapple controls are always plain: Basket Grapple controls may be either plain or include a pack off in addition to the pack off mill teeth is included. In operation, the overshot functions in the same manner, whether dressed with Spiral Grapple parts or Basket Grapple parts.

During the engaging operation, as the overshot is rotated to the right and lowered, the grapple will expand when the fish is engaged, allowing the fish to enter the grapple. Thereafter with rotation stopped and upward pull exerted, the grapple is contacted by the tapers in the bowl and its deep wickers grip the fish firmly.

During the releasing operation, a sharp downward pump places the larger portion of the bowl tapers opposite the grapple breaking the hold. Thereafter, when the overshot is rotated to the right and slowly elevated, the wickers will unscrew the grapple off the fish.

Operation: Engaging and pulling the fish connect the overshot to the fishing string and run it in the hole. As the top of the fish is reached, slowly rotate the fishing string to the right and gradually lower the overshot over the fish. Allow the right hand torque to stock out of the fishing string and pull on the fish by elevating the fishing string. If the fish does not come, start the circulating pumps and maintain a heavy upward strain while fluid is forced through the fish.

4.1.9.1. Releasing from the fish

Drop the weight of the fishing string heavily against the over shot, then simultaneously rotates to the right and slowly elevates the fishing string until the overshot is clear of the fish. To release from a recovered fish, follow the same procedure while holding fish below the overshot.

4.2. Rotary taper Taps

Rotary taper taps are simple, rugged, dependable internal catch fishing tools.

Operation: Run the taper tap in the hole to the top of the stuck fish. Apply less than one point of weight; rotate the tap until the tapered threads have engaged the fish. Stop rotation and pull the fish from the hole.

Rotary taper, Taps are furnished in two types: Plain or skirt type, plain taper taps do not have a skirt thread provided on the shoulder. Skin type tapers taps are threaded for a skirt. A skirt is used when the hole size is drastically different from the fish size. The taper tap can be dressed with a skirt or a skirt and oversize guide. This will allow for the taper tap to be guided in to the fish more easily during the fishing operation.

4.3. Maintenance of Different types of Bore wells

Sl No		Type of Borehole	Activities	Probable Cause	Suggestions
I		DTH Bore	Silting	Over pumping, reduction of yield, improper sitting of casing pipe etc.	✓ Inspection of the b well to assess performance of yield ✓ Replace the pump- of proper duty-condi match with the yield the bore well. ✓ The appearance of silt with water is also early indication silting. ✓ Further pressing of whole pipe assembly the case of shal casings will arrest silting. ✓ In the case of hard r bore well, flushing v compressor from bottom arrest/remove the silt
			Decrease in yield	Adverse seasonal conditions, clogging of pores, parallel exploitation in the neighboring well, sinking of new well in close proximity etc.	✓ Periodical flushing essential for free flow water ✓ Adhering to st spacing norms to av interference of pump wells. ✓ The well may also subjected to Hyd fracturing. (Re CPHEEO O&M Man p45-47) ✓ Removal of silt and d throu Chemical/acid wash Refer CPHEEO O
					Manual p39-42)
		Drying up (very low yield) of bore well	-As above-		✓ Periodical flushing, Hydro-fracturing etc. ✓ In case of defunct even after flushing it can be used as recharge well.

		Mechanical Failure	Falling of foreign objects, pump assembly etc.	✓ Mechanical devises to lift the objects. ✓ Bore hole camera can also supplement excellent information of the cause and remedy. ✓ Removal of silt and clay through Chemical/acid wash. (Refer CPHEEO O&M Manual p39-42) ✓ Sometimes re-drilling may also prove to be success. ✓ In case no remediation is possible the bore well may be utilized for recharge
Ii	DR with MS casing	Silting	Over pumping	✓ Periodical inspection of the bore well to assess the performance of the well
		Decrease in yield	Adverse aquifer condition,	✓ Periodical flushing is essential for free flow of water in the aquifer
		Mechanical Failure		As given for DTH Bore
			Incrustation/corrosion to screens etc.	✓ Removal of incrustation through Acid wash.(Refer CPHEEO O&M Manual p39-42)
		-	-	✓ Systematic chemical sampling (quality testing) of the bore water must be undertaken
		-	-	✓ Surroundings of the bore well should kept

				clean and tidy
iii	DR with RCC casing (Not common)	As narrated in DTH bore		✓ As narrated in DTH bore
Iv	For PVC casing bores(Not more than 150 mt depth)	As narrated for DR bores with MS casing		✓ As narrated in DTH bore
v	Deep & Shallow Bore	Silting Decrease in yield	Over pumping Adverse aquifer condition	✓ Periodical inspection of the bore well to assess the performance of the well ✓ Periodical flushing is essential for free flow of water in the aquifer
		Drying up of bore well	Incrustation & silting of fractures & fissures	✓ Casing should be inserted up to the weathered zone
		Mechanical Failure	Falling of foreign objects	✓ Removal of silt and clay through chemical wash
				✓ In case of drip in the yield the well may be subjected to hydro-fracturing (Refer CPHEEO O&M Manual p45-47)
				In addition, the points described under Mechanical failure in DTH bore may also be followed

4.4. Re- Development of Tube Wells

Sometimes due to carelessness at the time of construction proper development of the tube wells not done which results in constant inflow of the sand particles causing choking of the filtering media and strainers. Such tube wells need re-development. The redevelopment of tube well will have following effects:

1. Re-development of well involves removal of finer material from around the well screen, thereby enlarging the passages in the water-bearing formation to facilitate entry of water
2. Re-development removes clogging of the water-bearing formation.
3. It increases the porosity and permeability of the water-bearing formation in the vicinity of the well.
4. It stabilise the formations around the well screen so that the well will yield sand-free water.
5. Re-development increases the effective radius of the well and, consequently, its yield.

4.5. Methods of Re-development

Following are the methods of well re-development:

4.5.1.1.1.1. Over-pumping with pump.

4.5.1.1.1.2. Surging with surge block and bailing.
4.5.1.1.1.3. Surging and pumping with air compressor.
4.5.1.1.1.4. Back-Washing.
4.5.1.1.1.5. High-velocity jetting.
4.5.1.1.1.6. Dynamiting and acid treatment.

For rehabilitation purpose any suitable method of re-development can be used as mentioned above. The largely used method is surging and pumping with compressed air.

4.6. O & M Staff Activities of Mechanized Bore Wells

(a) Daily O&M activities:

- Clean the pump house.
- Check available Voltage in every phase.
- Check reading on ammeter is normal – stop pump if electric motor is drawing too much current and report problems, open isolation valve.
- Check power factor.
- Confirm water is being delivered.
- Check for leaks in the rising main.
- Continue to check voltmeter and ammeter readings during the day.
- Maintain pumping log book and history sheets of tools, plants & equipment's.
- Observe the abnormal sound of pumping machinery by listening the changes in noise level.

(b) Weekly activities at the tank:

- Testing water quality using a Field Test Kit (for small schemes only).

(c) Annual activities may include:

- Remove the pump and rising main from the well and inspect.
- Check pipe threads and re-cut corroded or damaged threads.
- Replace badly corroded pipes.
- Inspect electric cables and check insulation between cables.
- Check as per Recommendations of manufacturer's operational manual.

4 . 7 . O&M Resources for Mechanized Bore Wells

Semi-skilled labour (pump operator) is required for pump operation and billing and collection. Skilled labour is required for pump and motor servicing and maintenance. Materials and equipment include pipes for the rising main, tools for maintenance and repair, oil for the motor, spare parts for the motor and electrical control panel. Finances would typically be from the household paying water charges, GP or VWSC resources and Government funds.

4.8. Artificial Re-Charging of Under Ground Source

The yield in the source can be improved by artificial recharging structures. Artificial recharge of ground water can be achieved by the following:

i) Stream flow harvesting comprising of
- Anicuts
- Gully plugging /small boulder dams

- Loose stone check dams (LSCD)
- Dams

ii) *Surface flow harvesting*
- Tank
- Ponds

iii) *Direct recharge*
- Recharge of wells
- Through injected wells
- Through roof top rain water harvesting structures

Note:-The O & M of such structures may be done as per the sustainability practices and manuals

5.1. O & M Activities

5.1.1. Operation Schedule

(i) *Mapping and inventory of pipes and fitting:* An updated transmission system map with location of valves, flow meters and pressure gauges is the foremost requirement of operation schedule. The valves indicated in the map should contain direction to open; number of turn to open, make of valve and date of fixing etc. the hydraulic gradient lines are to be marked to indicate the pressure in the transmission system. They can be used for identifying high pressure or problem areas with low pressure.

(ii) *System pressure:* It is essential to maintain a continuous positive pressure in the main at the time of transmission of water in the pipeline. Low pressure locations have to be investigated if necessary by measuring pressure with pressure gauge.

(iii) *System Surveillance:* The maintenance staff of the Department/ panchayat /VWSC Following activities are to be included in the schedule:

i) Develop and conduct a surveillance programme for leaks in pipelines, pipe joints and valves.
ii) Develop and conduct a water quality surveillance programme.
iii) Develop and conduct a programme for locating and repairing leaks including rectifying cross connections if any, arrange for flushing, cleaning and disinfecting the mains,
iv) Establish procedures for setting up maintenance schedules and obtain and process the information provided by the public and the maintenance teams about the pipeline leaks,
v) Establish repair procedures for standard services and with provision for continuous training of the team members,

vi) Procure appropriate machinery, equipment and tools for repair of leaks and replacement of pipes and valves,
vii) Allocate suitable transport, tools and equipment to each maintenance team,
viii) Establish time, labour and material requirement and output expected, time required and other standards for each maintenance task, and
ix) Arrange for monitoring the productivity of each maintenance team

A preventive maintenance schedule has to be prepared for:

(i) Maintenance of the pipelines with particulars of the tasks to be undertaken, works not completed, and works completed,
(ii) Servicing of valves, expansion joints etc.
(iii) Maintenance of valve chambers,
(iv) Maintenance of record of tools, materials, labour, and
(v) Costs required carrying out each task.

Activities for Preventive Maintenance

a) *Servicing of valves:* Periodical servicing is required for valves, expansion joints flow meter and pressure gauges. Corrosion of valves is the main problem in some areas and can cause failure of bonnet and gland bolts. Leaks from spindle rods occur and bonnet separates from the body. Stainless steel bolts can be used for replacement and the valve can be wrapped in polythene wrap to prevent corrosion. Manufacturer's catalogues may be referred and servicing procedure should be prepared for the periodical servicing.

b) *List of spare:* List of spares procured for the transmission system shall be prepared and the spares shall be procured and kept for use. The spares may include check nut, spindle rods, bolt and nuts are flanged joints, gaskets for flanged joints for all sizes of sluice valves, consumables like gland rope, grease, cotton waste, jointing materials like rubber gaskets, spun yarn, pig-lead and lead wool etc.

c) *List of tools*: The maintenance staff shall be provided with necessary tools/equipment's for attending to the repairs in the transmission system. These tolls may include key rods for operation of sluice valves, hooks for lifting manhole covers, pipe wrench, DE spanner set, ring spanner set, screw drivers, pliers, hammers, chisels, caulking tools, crow bars, spades, dewatering pumps

5.1.2 Maintenance of Pipelines

Pipeline bursts/main breaks can occur at any time and the O & M agencies shall have a plan for attending to such events. This plan must be written down, disseminated to all concerned and the agency must always be in readiness to implement the plan immediately after the pipe breaks reported. After a pipe break is located, determine which valve is to be closed to isolate the section where the break has occurred. Some important consumers may be on the transmission system and having an industrial process dependent on water supply which cannot be shut down as fast as the water supply lines are cut off and should be notified about the break down. These consumers have to be informed about the probable interruption in water supply and also the estimated time of resumption of water supply.

After the closure of the valve the dewatering/mud pumps are used to drain the pipe breakpoints. The sides of trenches have to be properly protected before the workers enter the pit. The damaged pipe is removed, and the accumulated silt is removed from inside the pipe and the damaged pipe is replaced and the line is disinfected before bringing into use. A report shall be prepared following every pipe break about the cause of such break, the resource required

5.1.3. Scouring of pipeline

Scouring is done to clean the transmission lines by removing the impurities or sediment that may be present in the pipe. This is particularly essential in the case of transmission lines carrying raw water.

5.1.4. Leakage control

(i) Visible leaks: The maintenance staff during surveillance operation can report visible leaks found by him to his superiors. Critical areas where leaks often occur have to be identified and appropriate correct measures have to be implemented.

(ii) Invisible leaks: Lead detection equipment have to be procured for detection of non-visible leaks and action to control these leaks should be initiated to control the overall problem of water lost.

5.1.5. Chlorine Residual Testing

A minimum free chorine residual of 0.2 mg/lit at the receiving reservoir of a transmission system is needed to be maintained. Absence of residual chlorine could indicate potential presence of contamination in transmission system.

The following steps which are required to be taken are:

1. Testing of residual chlorine
2. Checking the chlorination equipment at the start of the transmission system.
3. Searching for source of contamination along the transmission system which has caused the increase in chlorine demands.
4. Immediate rectification of the source of contamination

5.2. Telemetary and Scada System

Manual collection of data and analyzing may not be helpful in large undertaking if water utilities have to aim at enhanced customer service by improving water quality and service level with reduced cost. The substitution for manual system is adaptation of Telemetary and Scada. This topic is discussed in Chapter12of this Manual.

5.3. Records and Reports

1. Updated transmission system maps with alignment plans. Longitudinal sectional plans,
2. Record of daily readings of flow meter at upstream and downstream end of pipeline,
3. Record of water level of reservoir at both upstream and downstream end of transmission system.
4. Pressure reading of the transmission system.
5. Identification of persistent low pressure location along the pipeline.
6. Record of age of pipes.
7. Identify pipelines to be replaced.
8. Identify source of leaks.
9. Record of Bulk meter/water meter reading before the delivery into overhead tank.
10. Record of residual chlorine.

- Record on when the pipeline leaks were repaired or pipe changed & lines- need for interconnection.

6.0 Solar System: Refer separate manual for Solar system maintenance

7.0 Use of Field Water Testing Kit (FTK)

The field water testing kit is a simple device, which can be used for testing some critical water quality parameters in the field as it gives first-hand information on the quality of water. Whenever 100% accuracy is needed then laboratory test shall be carried out. This water testing kit can be used for regular Water Quality Monitoring Programs to be conducted at Village level. Panchayat level functionaries, NGOS and students of even 7^{th} and 8^{th} standards can easily do the experiments using this kit. The details of water sources and the quality of water in many villages can be collected and the data computerized at Panchayat level. The data will be much useful in planning and formulating various water supply schemes and will be useful for proper maintenance of rural water supply schemes. The kits can be used in Schools to promote the knowledge on water quality and help to develop a good practice and scientific culture among the students.

Water Testing Methodology

For testing the water in the field, the following aspects have to be clearly understood.

- Sampling procedures.
- Testing procedures.
- Reporting.

I. Sampling Procedure: (to be included as annexure)

- Before sampling, the source should be flushed adequately.
- For hand pump sources, before collecting the water, the water should be pumped for at least three to five minutes to clear all dirt, turbidity and slime.
- Water from wells should be taken in the middle at mid depth.
- For lakes, rivers and dams, the water should be collected near the off take point.
- The water should be collected after clearing the suspended and floating matter.
- Water for chemical examination should be collected in a clean white 250 ml capacity leak proof polythene container.
- Before collection of sample the container should be washed, rinsed with the water to be sampled for at least two to three times.
- The water should be then filled completely in the container without leaving any air space.
- Place a polythene sheet (10x10cm) over the cap and tie it with a rubber band or twine thread to avoid any leak
- Write the field code number (sample ID) on the container. The field code number and related source details should be separately recorded in a note book.
- The testing of sample should be completed within 12 hrs. from the time of collection.

II. Water Testing Procedure

- Pour 10-20 ml. of water into the 100 ml polypropylene/titration cup.
- By observing the water in the cup, record qualitatively the appearance, odor and turbidity.
- Using the pH paper, record the pH also.

1. Appearance: Record appearance as follows:

Colorless & clear/ Brownish/ slightly brownish / Greenish/ slightly greenish/ Blackish/ slightly blackish / slightly whitish / Turbid etc.

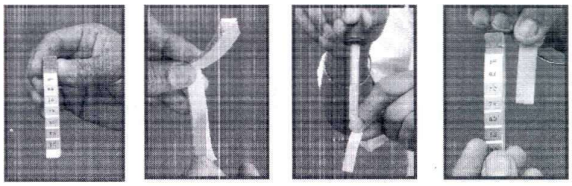
2. Odor: Record odor as follows:

None/ Soil Smell/ Algal Smell/ Objectionable Odor/ Slightly Objectionable Odor/ Rotten Egg Smell etc.

3. Turbidity: Record Turbidity as follows:

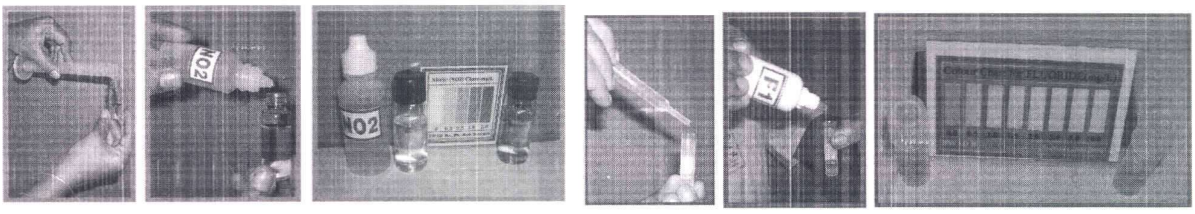
No turbidity/ slightly turbid/Moderately turbid/Highly turbid

4. PH: PH booklets have been provided to measure pH value of water. Tear a portion of the PH paper and hold it by your fingers. Using the ink filler add one drop of water sample on the paper. Wait for 10 seconds. The color change taking place on the wet portion of the pH paper is observed and compared with the pH chart provided in the cover page of pH booklet. Record the pH value.

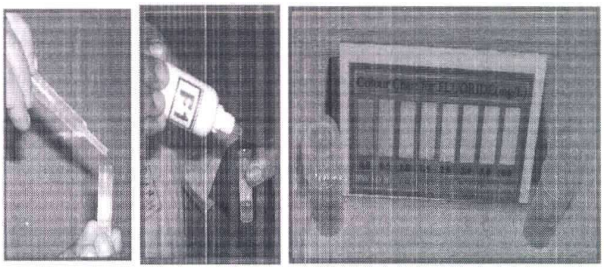


5. Alkalinity: Using the measuring cylinder, measure 20 ml of water sample and pour it into the clean titration cup. Add 5 drops of 'A1liquid. The water turns bluish green. Using the '1 mL syringe' provided in the kit, add 'A2' liquid. At the end point, the color of water changes into yellow or Orange. Record the number of divisions for which the 'A2' liquid has been consumed to reach the end point. Calculation:
Alkalinity mg/L = No. of Divisions of 'A2' added x 10

6. Hardness: Using the measuring cylinder, measure 20 ml of water sample and pour it into the clean titration cup. Add 5 drops of 'H l' and then 5 drops of 'H2' liquids. The



water in the titration cup turns *Pink* in color. Using the '1 mL syringe' add 'H3' liquid in drops. At the end point, the color of water changes into *Bluish color.* Record the number of divisions for which 'H3' liquid has been consumed to reach the end point.



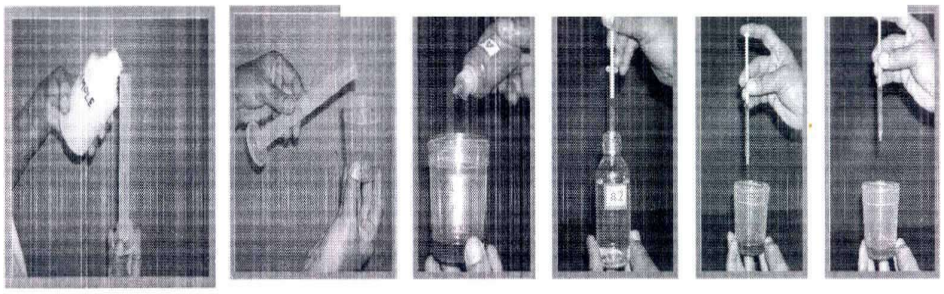
7. Chloride: Using the measuring cylinder, measure 20 ml of water sample and pour it into the clean titration cup. Add 5 drops of 'C1' liquid. The water turns yellow in color. Using the '1 mL syringe' add 'C2' liquid in drops. At the end point, the color of water changes to *slight reddish* in color. Record the number of divisions for which 'C2' liquid has been consumed to reach the end point.

Calculation: Chloride mg/L = No. of Divisions of 'C2' liquid x 10

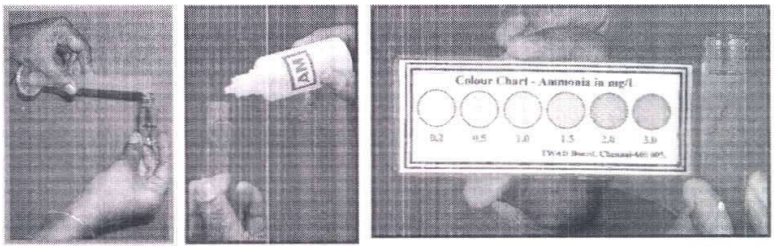
*8. Total Dissolved Solids (TDS):*The approximate value of TDS can be arrived at by the following calculation:

Calculation: TDS mg/L = (Alkalinity + Hardness + Chloride) x 1.2

9. Fluoride: In the 1.5 ml polypropylene tube, add 1.0 mL sample water. Add 5 drops of 'Fl' liquid. Mix. Gently. Compare the colour with "fluoride chart" provided and record the fluoride value.

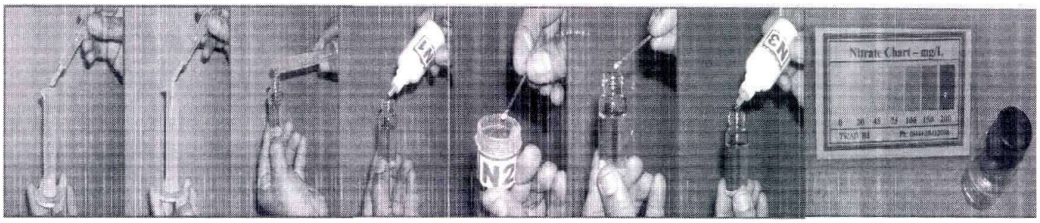


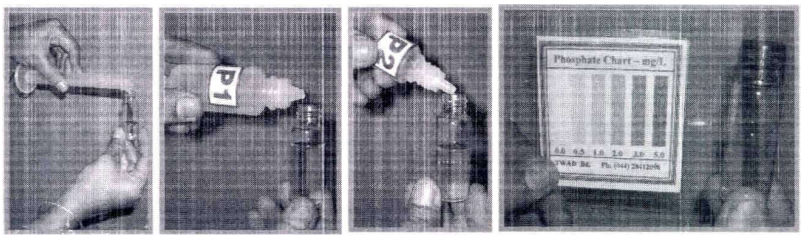
10. Ammonia: In the small glass bottle given, take 10 ml of water sample. Add 5 drops of' Amonia' liquid. Gently shake the bottle. If there is no ammonia, the color will not change. If ammonia is present, the water turns yellow, Compare the ''yellow colour developed with the 'ammonia chart' provided and record the ammonia value.

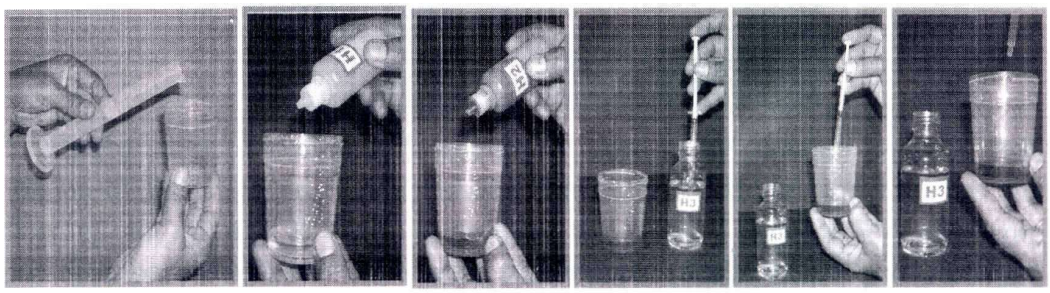


11. Nitrite: In the small glass bottle given, take 10 ml of water sample. Add 5 drops of 'N02' liquid. Gently shake the bottle. If there is no nitrite, the color will not change. If nitrite is present, the color of water will change into pink. Compare the 'pink' color with the 'Nitrite (N02) chart' provided and record the nitrite value

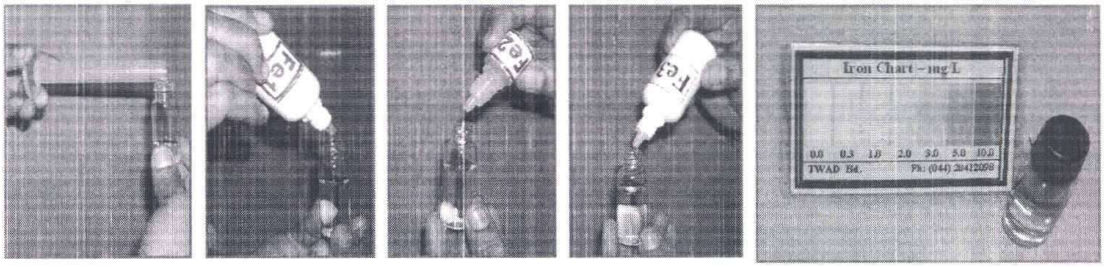
12 Nitrate: In the 10 mL measuring cylinder, take 1 mL of water sample. Add 9 mL distilled/bottled/mineral water and make up to 10 mL. Transfer this to the 10 mL glass bottle. Add 5 drops of 'NI'. Add a small pinch of 'N2'. Mix. Add 5 drops of 'N3'. Wait for 2 minutes. If there is no nitrate, the color will not change. If nitrate is present, the color of water will change into pink. Compare the 'pink' color with the 'Nitrate chart' provided and record the nitrate value.







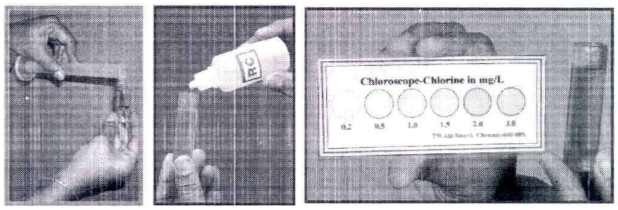
13. Iron: In the 10 mL glass bottle, take 10 ml of water sample. Add 5 drops of 'fell' liquid and then 1 drop of 'Fe2' liquid. Mix. Add 5 drops of 'Fe3' liquid. Mix. Wait for 2 minutes. For turbid samples wait for 5-10 minutes till a persistent colour develops. If there is no iron, the colour will not change. If iron is present, the colour of water will change into orange red. Compare the colour with the 'Iron chart' provided and record the value.



Sample ID:

14. Phosphate: In the small glass bottle given, take 10 ml of water sample. Add 5 drops of 'PI' liquid. Gently shake the bottle. Then add 1 drop of 'P2' liquid. Again gently shake. If there is no phosphate, the color will not change. If phosphate is present, the color of water will change into blue. Compare the 'blue' color with the 'Phosphate chart' provided and record the phosphate value.

15. Residual Chlorine: In the small glass bottle given, take 10 ml of water sample. Add 5 drops of 'RC' liquid. Slightly shake the bottle. If there is no residual chlorine, the color will not change. If residual chlorine is present, the color of water will change into yellow. Compare the yellow color with the 'chlorine chart' provided and record the residual chlorine value.



16. E.Coli/Fecal Coliform: The test is conducted using H2S vials (H2S vials have to be procured separately from the market). The water should be added up to the mark in the H2S vial. After screwing the cap, keep the vial for 24 hours. After 24 hours observe anyone of the following changes.

i) Black color = High level of contamination
ii) Turbid &; brownish = Moderate level of contamination
iii) No change in the honey brown color = Absence of E.-Coli Fecal Coliform

III. REPORTING:

The test results should be compiled in the following report form:

Test Report

Source Details

Location and address of the source Location and address of sampling point Name of Village/Habitation, Name of Panchayat, Name of Block ,Name of District ,Type of source Type of scheme, Open well/ Bore well/ Infiltration well/ Lake/ Dam/ Hand pump/ Power pump Surface, water etc. Collected by (Name, designation & Office)

1) Appearance

2) Odor
3) Turbidity
4) Total dissolved solids (maximum)
5) pH
6) Alkalinity as CaCO3, (maxim urn)
7) Hardness as CaC03 (maximum)
8) Chloride as Cl (maximum)
9) Fluoride as F (maximum)
10) Ammonia * as NH3
11) Nitrite** as N02
12) Nitrate as NO.., (maximum)
13) Iron as Fe (maximum)
14) Phosphate** as $P0_4$
15) Residual chlorine (minimum)*** as CL2 0.2 *mg/ L*

- No guideline value prescribed; however an ammonia level of greater than 1.0 mg/L indicates pollution taking place to the source.
- No guideline value prescribed; traces of nitrite and phosphate indicate pollution.
- To ensure effective disinfection, minimum residual chlorine of 0.2 mg/L should be present.

Report: The water shall be indicated as bacteriologically and potable/non potable

Record keeping formats:

- Water Supply Log Book (Annexure-A)
- Maintenance record keeping Format for Pump House & OHT. (Annexure-B)
- Maintenance record keeping Format for Network Maintenance. (Annexure-C)
- Diesel Generator Log Sheet (Annexure-D)

Water Supply Log Book (Annexure-A)							
Scheme ID							
District							
Block							
Scheme Name							
Sr. No.	Date	Pump Start Time	Pump Stop Time	Residual Chlorine Reading	Totalizer	Supplied Quantity	Sign of Operator
		(in 24 hr Format)	(in 24 hr Format)	PPM	Cubic Meter	Cubic Meter	

Maintenance record keeping Format for Pump House & OHT. (Annexure-B)							
Scheme ID							
District							
Block							
Scheme Name							
Sr. no.	Date	Maintenance detail	Problem Found	Rectification Done	Supervisor Sign	Maintenance Manager	Remerks

Maintenance record keeping format for network maintenance. (Annexure-C)										
Scheme ID										
District										
Block										
Scheme name										
Sr.no.	Date	Network leakage/No water flow				Rectification started	Rectification finish	Supervisor sign	Maintenance Manager	Remark
		Junction point (From)	Junction point (To)	Type of issue	Date of reporting					

Diesel Generator Log Sheet (Annexure-D)						
Scheme ID						
District						
Block						
Scheme name						
Sr.no.	Date	Start time	Stop time	Working hour	Diesel poured (Litre)	Signature

OPERATION & MAINTENANCE

OF WATER SUPPLY SCHEME-UPJJM

PREPARED BY	*CHECKED BY*	*APPROVED BY*
VIVEK KORI	*SANJAY SHARMA*	*SURESH JAYASWAL*
	UMANG MISHTRI	

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1. ***Main pump VFD panel:***

- **Introduction:** The objective of the VFD panel is to initiate and regulate the primary submersible pump of the tubewell. It utilizes both a 3-phase AC supply and DC supply sourced from the solar power plant, subsequently delivering 3-phase AC power to the submersible pump motor. Additionally, it facilitates data communication for various parameters including input voltage and current, output voltage and current, running frequency, power consumption, and more.

- **Operation instruction:** Follow the given steps for the safe operation of the VFD panel

1. Ensure that input and output cables/wires are properly connected, and no other power or control wires are open.
2. Select the power source for pump operation by using the rotary selector switch between 3-phase AC supply from DG/grid or DC supply from the solar power plant.
3. If operating over solar power, keep the switch on the DC side and turn the MCB ON.
4. At this point, the VFD drive receives supply and displays it.
5. To start the pump, use the ON/OFF switch.
6. After operating the pump, use the ON/OFF switch instead of the rotary selector and MCB switch to shut down the pump, as using them may cause damage to the VFD panel.

- **Troubleshooting:**

1. See the following table for detailed solution and check the corresponding abnormal state.
2. Eliminate the fault and ask for relative help.
3. Check to eliminate the fault and carry out fault reset to run the inverter.

❖ **Fault codes for Kaizen VFD:-**

Fault code	Fault type	Possible cause	Solutions
OUt1	IGBT U	1. The acceleration is too fast. 2. This phase IGBT is damaged internally. 3. Interference causes mis operation. 4. The drive wire is connected improperly.	1. Increase the acceleration time. 2. Change the power unit. 3. Check the drive wire. 4. Check whether the peripheral equipment has strong interference sources.
OUt2	IGBT V		
OUt3	IGBT W		
OV1	Overvoltage when acceleration	1. The input voltage is abnormal. 2. There is large energy feedback. 3. No braking components. 4. Braking energy is not open.	1. Check the input power. 2. Check if the DEC time of the load is too short or the inverter starts during the rotation of the motor or it needs to increase the energy consumption components. 3. Install the braking components. 4. Check the setting of relative function
OV2	Overvoltage when deceleration		
OV3	Overvoltage when constant speed running		
OC1	Overcurrent when acceleration	1. The acceleration or deceleration is too fast. 2. The voltage of the grid is too low. 3. The power of the inverter is	1. Increase the ACC time. 2. Check the input power. 3. Select the inverter with a larger power. 4. Check if the load is short
OC2	Overcurrent when deceleration		

Fault code	Fault type	Possible cause	Solutions
OC3	Overcurrent when constant speed running	too low. 4. The load transients or is abnormal. 5. The grounding is short circuited or the output is phase loss. 6. There is strong external interference. 7. The overvoltage stall	Circuited (the grounding short circuited or the wire short circuited) or the rotation is not smooth. 5. Check the output configuration. 6. Check if there is strong interference. 7. Check the setting of relative function codes.
UV	Bus undervoltage	1. The voltage of the power supply is too low. 2. The overvoltage stall protection is not open.	1. Check the input power of the supply line. 2. Check the setting of relative function codes.
OL1	Motor overload	1. The voltage of the power supply is too low. 2. The motor setting rated current is incorrect. 3. The motor stall or load	1. Check the power of the supply line. 2. Reset the rated current of the motor. 3. Check the load and adjust the torque lift.
OL2	Inverter overload	1. The acceleration is too fast. 2. The rotating motor is reset. 3. The voltage of the power supply is too low. 4. The load is too heavy. 5. The motor power is too small.	1. Increase the ACC time. 2. Avoid the restarting after stopping. 3. Check the power of the supply line. 4. Select an inverter with bigger power. 5. Select a proper motor.
SPI	Input phase loss	Phase loss or fluctuation of input R, S, T	1. Check input power. 2. Check installation distribution.
SPO	Output phase loss	U, V, W phase loss output (or serious asymmetrical three phase of the load)	1. Check the output distribution. 2. Check the motor and cable.
OH1	Rectifier overheat	1. Air duct jam or fan damage	1. Dredge the wind channel or

Fault code	Fault type	Possible cause	Solutions
OH2	IGBT overheat	2. Ambient temperature is too high. 3. The time of overload running is too long.	Change the fan. 2. Decrease the environment temperature.
EF	External fault	SI external fault input terminals action	Check the external device input.
CE	Communication error	1. The baud rate setting is incorrect. 2. Fault occurs to the communication wiring. 3. The communication address is wrong. 4. There is strong interference to the communication.	1. Set proper baud rate. 2. Check the communication connection distribution 3. Set proper communication address. 4. Change or replace the connection distribution or improve the anti-interference capability.
ItE	Current detection fault	1. The connection of the control board is not good. 2. Assistant power is bad 3. Hall components is broken 4. The magnifying circuit is abnormal.	1. Check the connector and repatch. 2. Change the Hall. 3. Change the main control panel.
tE	Autotuning fault	1. The motor capacity does not comply with the inverter capability. 2. The rated parameter of the motor is not set correctly. 3. The offset between the parameters from autotune and the standard parameter is huge 4. Autotune overtime	1. Change the inverter mode. 2. Set the rated parameter according to the motor name plate. 3. Empty the motor load. 4. Check the motor connection and set the parameter. 5. Check if the upper limit frequency is above 2/3 of the
EEP	EEPROM fault	1. Error of controlling the write and read of the parameters 2. Damage to EEPROM	1. Press STOP/RST to reset. 2. Change the main control panel.

PIDE	PID feedback fault	1. PID feedback is offline.	1. Check the PID feedback

Fault code	Fault type	Possible cause	Solutions
		2. The PID feedback source disappears.	signal 2. Check the PID feedback source.
END	Time arrival of factory setting	The actual running time of the inverter is above the internal setting running time.	Ask for the supplier and adjust the setting running time.
OL3	Electrical overload	The inverter will report overload pre-alarm according to the set value.	Check the load and the overload pre-alarm point.
ETH1	Grounding short circuit fault 1	The grounding of the inverter output terminal is short circuited. The current detection circuit is faulty. The actual motor power sharply differs from the	Check whether the motor wiring is proper. Change the Hall. Change the main control panel. Set motor parameters correctly.
ETH2	Grounding short circuit fault 2		
dEu	Velocity deviation fault	The load is too heavy or stalled.	1. Check the load and ensure it is normal. Increase the detection time. 2. Check whether the control parameters are normal.
STo	Maladjustment fault	1. The control parameters of the synchronous motors not set properly. 2. The autotuning parameter is not correct. 3. The inverter is not	1. Check the load and ensure it is normal. 2. Check whether the control parameter is set properly or not. 3. Increase the maladjustment detection time.

LL	Electronic underload fault	The inverter will report the underload pre-alarm	Check the load and the underload pre-alarm point.
tSF	Hydraulic probe	Hydraulic probe damage	Change the damaged hydraulic

Fault code	**Fault type**	**Possible cause**	**Solutions**
PINV	PV reverse connection fault	Incorrect PV wiring	Change the wiring direction of the positive and negative terminals and connect the cables again.
PVOC	PV overcurrent	1. The acceleration or deceleration is too fast. 2. The inverter power is too low. 3. The load transients or is abnormal. 4. The grounding is short circuited.	1. Increase the ACC or DCC time. 2. Select the inverter with a larger power. 3. Check if the load is short circuited (the grounding short circuited or the wire short circuited) or the rotation is not
PVOV	PV overvoltage	1. The solar cell panel input voltage is too high. 2. Model -4 is set as another model.	1. Reduce the number of solar cell panels that are wired in series. 2. Check and reset the model.
PVLV	PV undervoltage	1. The power of the solar cell panel series is too low or it is cloudy and rainy weather. 2. The motor start-up current is too high.	1. Increase the number of solar cell panels or perform the test in the normal sun light. 2. Change the motor.
E-422	Fault on communication with boost module 422	Improper contact with the communication cables	Check the four communication cables of 422 and ensure that they are connected properly.

OV	Bus overvoltage detected at the	The sun light changes suddenly.	Adjust the boost PI parameters. Enlarge the values of P19.07
A-LS	Weak light alarm	The sun light is weak or the solar cell panel configuration is insufficient.	The equipment automatically runs when the light becomes strong.

Fault code	**Fault type**	**Possible cause**	**Solutions**
			Check whether the solar cell panel configuration is proper.
A-LL	Underload alarm	The reservoir is empty.	Check the reservoir.
A-tF	Full-water alarm	The reservoir is full.	If the user has set the full-water alarm function, the equipment automatically stops when the full-water alarm time reaches the specified time. In this situation, the user does not need to perform any operation. Otherwise, check whether
A-tL	Empty-water alarm	The reservoir is empty.	If the user has set the empty-water alarm function, the equipment automatically stops when the empty-water alarm time reaches the specified time. In this situation, the user does not need to perform any operation. Otherwise, check whether

❖ **Fault codes for Fuji VFD:-**

Fault code	Fault type	Explanation
OC1	Overcurrent	Over current due to drive overload
OC2	Short circuit	Over current due to short circuit in the output circuit
OC3	Ground fault	Overcurrent due to the ground fault in the output circuit
OV1	Over voltage	Over DC link circuit voltage during acceleration
OV2	Over voltage	Over DC link circuit voltage during de-acceleration
OV3	Over voltage	Over DC link circuit voltage during constant run
LV	Under voltage	Drop in DC link circuit voltage
L in	Input phase loss	Phase loss in the input circuit
OPL	Output phase loss	Phase loss in the output circuit
OH1	Over heating Of the heat sink	Excessive heat sink temperature due to cooling system failure or over heating
OH2	External thermal relay tripped	Stops the inverter alarm through digital input (THR)
OH6	Charging resistor overheat	Excessive temperature of the charging resistor
OLV	Inverter unit overload	Stops the inverter on the base of temperature of cooling system and output current
OL1	Overload in motor 1	Stops running the inverter to protect the motor
Er8	RS485 error	RS 485 communication malfunction
Er2	Keypad communication error	Communication malfunction between keypad and inverter

❖ Fault codes for Vinworth VFD:-

Fault code	Fault Name	Description	Troubleshooting
Err01	Acceleration over current	1. Drive output circuit grounding or shorted 2. Acceleration time is too short 3. Manually boost the torque or V/F curve unsuitable 4. Voltage is too low 5. Start the rotating motor 6. Shock load on acceleration 7. Drive selection is too small	1. Peripheral trouble shooting 2. Prolong the acceleration time 3. Adjust the V/F curve or manually-torque-boost 4. The voltage adjusted to anormal range 5. Select start on rotational-speed tracking or Waiting for motor stopped 6. Cancel shock-load 7. Select drive with a larger power
Err02	Deacceleratio n over current	1. Drive output circuit grounding or shorted. 2. Deceleration time is too short. 3. Voltage is too low. 4. Shock load on deceleration. 5. No installation of braking resistor.	1. Peripheral troubleshooting. 2. Prolong the deceleration time. 3. Adjust the voltage to a normal range. 4. Cancel shock-load. 5. Install braking resistor.
Err03	Constant speed over current	1. Drive output circuit grounding or shorted. 2. Voltage is too low. 3. If there is shock-load during running. 4. Drive selection is too small.	1. Peripheral troubleshooting. 2. The voltage adjusted to a normal range. 3. Cancel shock-load. 4. Select drive with a larger power.
Err04	Acceleration Over voltage	1. Input voltage is high. 2. There is an external force during acceleration, dragging the motor to work. 3. Acceleration time is too short. 4. No installation of braking resistor.	1. The voltage adjusted to a normal range. 2. Cancel the external power or install braking resistor. 3. Prolong the acceleration time. 4. Install braking resistor.
Err05	Deacceleratio n Over voltage	1. Input voltage is high. 2. There is an external force during deceleration, dragging the motor to work. 3. Deceleration time is too short. 4. No installation of braking resistor.	1. The voltage adjusted to a normal range. 2. Cancel the external power or install braking resistor. 3. Prolong the deceleration time. 4. Install braking resistor.
Err06	Constant speed over voltage	1. Input voltage is too high. 2. There is an external force during running, dragging the motor to work.	1. The voltage adjusted to a normal range. 2. Cancel the external power or install braking resistor.
Err07	Bus under voltage	1. Momentary power failure. 2. The drive input voltage. 3. Bus voltage abnormal. 4. Rectifier bridge and buffer resistance are abnormal. 5. Drive board abnormal. 6. Control panel abnormal.	1. Reset failure. 2. Adjust voltage to normal range. 3. Ask for technical support. 4. Ask for technical support. 5. Ask for technical support. 6. Ask for technical support.
Err08	Short circuit	1. Drive output circuit shorted.	1. Peripheral troubleshooting.

		2. Acceleration/Deceleration time is too short. 3. Wirings between motor and drive is too long. 4. Module overheating. 5. Internal wirings of drive loosened. 6. Main board abnormal. 7. Drive board abnormal. 8. Drive module abnormal.	2. Prolong the acceleration/deceleration time. 3. Install the reactor or output filter. 4. Check and confirm the air channel unblocked, fans operation normal. 5. All cables plugged. 6. Ask for technical support. 7. Ask for technical support. 8. Ask for technical support.
Err09	Input phase loss	1. Power of three-phase input is abnormal. 2. Drive board abnormal. 3. Lightning board abnormal. 4. Main board abnormal.	1. Check and solve the problems in peripheral wirings. 2. Ask for technical support. 3. Ask for technical support. 4. Ask for technical support.
Err10	Output phase loss	1. Lead wire from drive to motor is abnormal. 2. Three-phase output of drive is unbalanced during motor running. 3. Drive board abnormal. 4. Drive module abnormal.	1. Peripheral troubleshooting. 2. Check and confirm the motor three-phase winding to be normal. 3. Ask for technical support. 4. Ask for technical support.
Err11	Motor overload	1. Motor protection parameters F11.17 set incorrectly. 2. Load is too large or motor rocked rotor. 3. Drive selection is too small.	1. Setting the parameters correctly. 2. Lowering the load and checking the conditions of motor and mechanical. 3. Selecting drive with a larger power.
Err12	Drive overload	1. Load is too large or motor rocked rotor. 2. Drive selection is too small.	1. Reduce load and check the conditions of motor and mechanical. 2. Select drive with a larger power.
Err14	Over heat	1. Ambient temperature is too high. 2. Air channel blocked. 3. Fans damaged. 4. Module thermistors damaged. 5. Drive module damaged.	1. Lowering the ambient temperature. 2. Cleaning up the air channel. 3. Replacing the fans. 4. Replacing the thermistors. 5. Replacing the drive module.
Err25	Drive loss load	1. Running current of drive is less than F11.22.	1. Confirm whether the load loss or parameters of F11.22/F11.23 conform to the actual running conditions.
Err41	Overload warning	Overload	1. Check F11.192. Select an AC drive of higher power class.
A33	Pre-warning of weak light	The output frequency remains lower than or equal to the lower limit of PI output frequency and continues in this state until it arrives at the delay time of weak light.	Check the set value of the lower limit of PI output frequency and the weak-light delay.

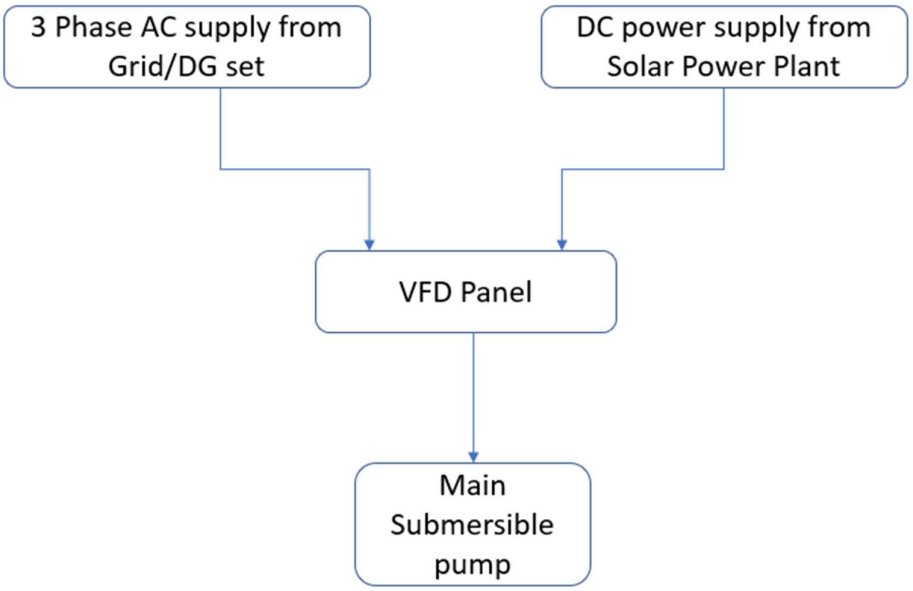
❖ **Fault codes for Delta VFD:-**

ID No.	Fault Name	Description	Troubleshooting
1	ocA	Over current during acceleration	Output current exceeds three times of the rated current during acceleration. When ocA occurs, the drive closes the gate of the output immediately, the motor runs freely, and the display shows an ocA error.
2	Ocd	Over current during Deacceleration	Output current exceeds three times of the rated current during deceleration. When ocd occurs, the drive closes the gate of the output immediately, the motor runs freely, and the display shows an ocd error.
3	Ocn	Over current during steady operation	Output current exceeds three times of the rated current during constant speed. When ocn occurs, the drive closes the gate of the output immediately, the motor runs freely, and the display shows an ocn error.
4	GFF	Ground fault	When the drive detects grounding short circuit on the output terminals (U/V/W), the drive closes the gate of the output immediately, the motor runs freely, and the display shows a GFF error.
7	ovA	Over voltage during acceleration	DC bus over-voltage during acceleration. When ovA occurs, the drive closes the gate of the output, the motor runs freely, and the display shows an ovA error.
8	Ovd	Over voltage during deacceleration	DC bus over-voltage during deceleration. When ovd occurs, the drive closes the gate of the output immediately, the motor runs freely, and the display shows an ovd error.
9	Ovn	Over voltage during steady operation	DC bus over-voltage at constant speed. When ovn occurs, the drive closes the gate of the output immediately, the motor runs freely, and the display shows an ovn error.

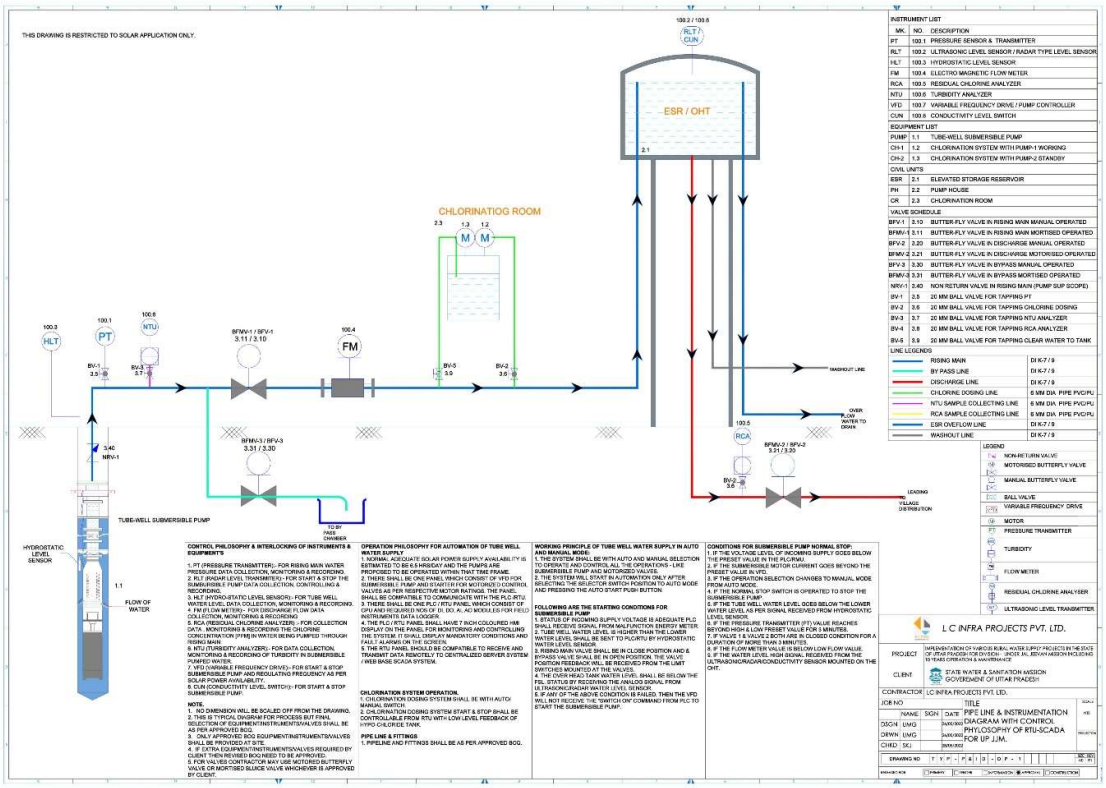
11	LvA	Low voltage during acceleration	DC bus voltage is lower than Pr.06-00 setting value during acceleration
12	Lvd	Low voltage during deacceleration	DC bus voltage is lower than Pr.06-00 setting value during deceleration
13	Lvn	Low voltage during constant operation	DC bus voltage is lower than Pr.06-00 setting value at constant speed
15	orP	Phase loss protection	Phase loss of power input
16	oH1	IGBT overheating	IGBT temperature exceeds the protection level
18	tH1o	IGBT temperature detection failure	IGBT hardware failure in temperature detection
21	oL	Overload	The AC motor drive detects excessive drive output current. Overload capacity: □ Normal duty: Sustains for one minute when the drive outputs 120% of the drive's rated output current. Sustains for three seconds when the drive outputs 150% of the drive's rated output current. □ Heavy duty: Sustains for one minute when the drive outputs 150% of the drive's rated output current. Sustains for three seconds when the drive outputs 200% of the drive's rated output current.
22	EoL1	Electronics thermal relay 1 protection	Electronics thermal relay 1 protection. The drive coasts to stop once it activates.
23	EoL2	Electronics thermal relay 2 protection	Electronic thermal relay 2 protection. The drive coasts to stop once it activates.
24_1	oH3	Motor over heating	Motor overheating (PTC) (Pr.03-00–Pr.03-01 = 6 PTC), when PTC input > Pr.06-30, the fault treatment acts according to Pr.06-29.
24_2	oH3	Motor overheating (oH3) PT100	Motor overheating (PT100) (Pr.03-00–Pr.03-01=11 PT100). When PT100 input > Pr.06-57 (default = 7 V), the fault treatment acts according to Pr.06-29.
26	Ot1	Over torque	When the output current exceeds the over-torque

			detection level (Pr.06-07) and exceeds over-torque detection time (Pr.06-08), and when Pr.06-06 or Pr.0609 is set to 2 or 4, the ot1 error displays.
28	uC	Under current	Low current detection
33	cd1	U-phase error	U-phase current detection error when power is ON
34	cd2	V-phase error	V-phase current detection error when power is ON
35	cd3	W-phase error	W-phase current detection error when power is ON
49	EF	External fault	External fault. When the drive decelerates based on the setting of Pr.07-20, the EF fault displays on the keypad
50	EF1	Emergency stop	When the contact of MIx=EF1 is ON, the output stops immediately and displays EF1 on the keypad. The motor is in free running.
58	CE10	Modbus transmission time-out	odbus transmission time-out occurs
61	Ydc	Y-connection / Δ connection switch error	An error occurs when Y-Δ switches
79	Aoc	U-phase over-current before run	U-phase short circuit detected when the output wiring detection is performed before the drive runs.
80	Boc	V-phase over-current before run	V-phase short circuit detected when the output wiring detection is performed before the drive runs.
81	coc	W-phase over-current before run	W-phase short circuit detected when the output wiring detection is performed before the drive runs.
82	oPL1	Output phase loss U phase	U phase output phase loss
83	oPL2	Output phase loss V phase	V phase output phase loss
84	oPL3	Output phase loss W phase	W phase output phase loss

❖ **Power flow chart for main pump:-**



❖ Pipe line and instrumentation diagram:-



2. *Tubewell submersible pump set:*

- **Introduction:** Submersible pumping set suitable for Tubewell Bore fitted with dynamically balanced bronze or stainless-steel impellers mounted on a stainless-steel pump shaft with protection sleeves, having stage bowls of closed-grained cast iron. The pump will be fitted with a built-in non-return valve and shall be suitable for direct coupling to the squirrel-cage, water-cooled type submersible motor suitable to operate on 415+/-10% V, 3-phase, 50 Hz.

- **Technical specifications:**

KSB SUBMERSIBLE PUMP SET TECHNICAL DATA

Sr No.	PUMP HP	STAGGING	RATED CURRENT	RPM	ACTUAL FLOW (LPM)	HEAD (mtr)	Shut off Head (mtr)	% EFFICIENCY
1	5	5	9.5	2850	336	45	58	74.3
2	7.5	6	13	2860	428	50	74	79.7
3	10	6	16.1	2830	582	50	68	81.3
4	12.5	7	20	2820	685	50	80	81.4
5	15	7	22.8	2810	920	50	86	82.2
6	17.5	6	30	2830	945	50	77	80.7
7	20	8	33	2855	1170	50	103	82.2
8	25	9	42	2891	1236	50	115	82.5
9	30	3	43.5	2885	1695	50	70	83
10	33	3	49.5	2900	1896	50	70	84.1
11	41	4	58.5	2905	2166	50	79	84.4

Size selection of column pipe:
1) 80 mm <600 LPM (0.86 MLD)
2)100 mm<1200 LPM (1.73 MLD)
3)150 mm<2000 LPM (2.88 MLD)

3. ***2 kW Inverter battery:***

- **Introduction:** A 2 kW capacity hybrid inverter is employed in the system. It is capable of being charged via DC power directly sourced from a solar power plant, and it also accepts 1-phase AC power supply from either the grid or a DG set. The inverter battery serves to fulfil the power requirements for 1-phase AC power supply within the campus.

- **Technical Specification:**
  - Input AC Supply- 1 phase 230 V AC, 50 Hz
  - Input DC Voltage- 80-110 V DC
  - Output supply- 1 Phase 230 V AC, 50 Hz
  - Battery Type- Lead acid type
  - Battery Capacity- 150 AH*2

4. ***DG set:***

- **Introduction:** Diesel generator (DG) sets of various capacities are utilized as backup power sources tailored to the requirements of borewell pumps. These DG sets ensure the provision of reliable 3-phase, 50 Hz AC supply in the absence of grid or solar power, facilitating the operation of pumps, instruments, and control panels within the campus.

- **Operation instruction:**

1. Pre-Operation Checks:
- Ensure that the DG set is properly fuelled and lubricated.
- Check the oil level and coolant level in the engine.
- Verify that the fuel supply is adequate and there are no leaks in the fuel system.

2. Start-Up Procedure:
- Turn the key or switch to the "ON" position to activate the electrical system.
- If equipped with a manual start, pull the starting handle or engage the starter motor.
- Monitor the engine gauges for any abnormalities such as low oil pressure or high coolant temperature.
- Once the engine starts, allow it to warm up for a few minutes before applying any load.

3. Load Application:
- Gradually apply the load to the DG set using the control panel or switchgear.
- Monitor the engine gauges and electrical parameters to ensure that the DG set is operating within its rated capacity.
- Avoid sudden changes in load that could put stress on the engine or electrical system.

4. Operation Under Load:
- Continuously monitor the DG set during operation for any unusual noises, vibrations, or fluctuations in electrical output.

5. Shutdown Procedure:
- Gradually reduce the load on the DG set by disconnecting electrical loads or switching them to an alternative power source.
- Allow the engine to idle for a few minutes to cool down and stabilize before shutting it down.
- Turn the key or switch to the "OFF" position to shut off the engine.
- Perform a post-operation inspection to check for any leaks, abnormal wear, or damage to the DG set.

6. Emergency Shutdown:
- In case of an emergency or abnormal condition, immediately shut down the DG set by turning the key or switch to the "OFF" position.
- Follow emergency procedures and protocols to address any hazards or risks associated with the DG set.

7. Regular Maintenance:
- Follow the manufacturer's recommended maintenance schedule for the DG set, including oil changes, filter replacements, and inspections.
- Keep a detailed log of all maintenance activities and any issues encountered during operation.

By following these operation instructions diligently, you can ensure the safe, efficient, and reliable operation of your DG set.

❖ **Cable selection guide for DG set & VFD:**

Sr no.	Pump HP	Pump kW	Rated current (Amp)	DG/ Stabilizer (KVA)	Rated current (Amp) 3ph	4 Pole MCB rating	Cable size (VFD to Pump)	Cable size (DG to VFD)
1	5	3.7	9.5	7.5	18	25	3 core 1.5 sq. mm copper	3.5 core 16 sq. mm aluminium
2	7.5	5.6	13	10	24	40	3 core 1.5 sq. mm copper	3.5 core 16 sq. mm aluminium
3	10	7.5	16	15	36	50	3 core 2.5 sq. mm copper	3.5 core 16 sq. mm aluminium
4	12.5	9.3	20	15	36	50	3 core 4 sq. mm copper	3.5 core 16 sq. mm aluminium
5	15	11.2	22.8	20	48	63	3 core 4 sq. mm copper	3.5 core 16 sq. mm aluminium
6	17.5	13.0	30	20	48	63	3 core 6 sq. mm copper	3.5 core 16 sq. mm aluminium
7	20	14.9	33	25	60	80	3 core 6 sq. mm copper	3.5 core 16 sq. mm aluminium
8	25	18.6	42	30	72	100	3 core 10 sq. mm copper	3.5 core 25 sq. mm aluminium
9	30	22.4	43.5	40	96	125	3 core 10 sq. mm copper	3.5 core 35 sq. mm aluminium
10	33	24.6	49.5	40	96	125	3 core 10 sq. mm copper	3.5 core 35 sq. mm aluminium
11	41	30.6	58.5	45	108	125	3 core 16 sq. mm copper	3.5 core 35 sq. mm aluminium

5. ***MLDB Panel:***

- **Introduction:** The MLDB (Main Line Distribution Panel) is a 1-phase, 50 Hz AC power distribution panel designed to efficiently distribute electrical power. Equipped with MCB switches, it serves to distribute and control the power sourced from a 2 kW inverter to field instruments, devices, and control panels within the system or facility.

6. ***Tubewell Automation Panel:***

- **Introduction:** The tubewell automation panel is equipped with an HMI (Human-Machine Interface) cum PLC (Programmable Logic Controller) and RTU (Remote Terminal Unit) device, enabling the control of various electrical devices such as pumps, electrically operated sluice valves, and chlorine dosing systems. This control process relies on communication between field instruments such as pressure transmitters, radar level transmitters, flowmeters, and hydrostatic level transmitters.

  The PLC programming orchestrates the control process, while the HMI serves as the interface between the PLC and human operators. Through the HMI, operators can access real-time information regarding the status of field instruments and devices, including:

  1. Pump status (running/stop)
  2. Actuator valve status (open/close)
  3. Water discharge
  4. Line pressure
  5. Overhead tank (OHT) water level, and more.

  The RTU device plays a crucial role by forwarding this data to the SCADA (Supervisory Control and Data Acquisition) server for remote observation and monitoring, enhancing operational efficiency and facilitating timely decision-making.

7. ***Actuator Control Panel:***

- **Introduction:** Power and control panel for electrically operated sluice valves, equipped with VFD drive to operate valves manually as well as automatically.

- **Operation instruction:** Follow the given steps for the safe operation of the VFD panel

1. Ensure that input and output cables/wires are properly connected, and no other power or control wires are open.
2. Select the power source for pump operation by using the rotary selector switch between 3-phase AC supply from DG/grid or DC supply from the solar power plant.
3. If operating over solar power, keep the switch on the DC side and turn the MCB ON.
4. At this point, the VFD drive receives supply and displays it.
5. To start the pump, use the ON/OFF switch.
6. After operating the pump, use the ON/OFF switch instead of the rotary selector and MCB switch to shut down the pump, as using them may cause damage to the VFD panel.
7. For manual operation of actuator valves pull the lever upward and rotate the wheel in a clock wise and anticlockwise direction to close and open the valve accordingly.

- **Technical specification:**

1. Input power- DC power supply (580-800 V DC), 3 phase 50 Hz AC power supply
2. Auxiliary power- 230 V, 1 phase 50 Hz AC power supply
3. Output – 415 V, 3 phase 50 Hz AC

8. ***Chlorine Dosing System:***

- **Introduction:** The chlorine dosing system is employed to administer liquid hypo chloride as a disinfectant. This dosing system comprises several components, including a liquid storage tank, dosing pump, UPVC fittings, piping, control panel, and stand for the entire system installation. To ensure continuous operation, two tanks are provided—one for active use and another as a standby reserve.

  To prevent the dosing pump from running dry, level transmitters are integrated into the system. The operation of the dosing pump is powered and regulated by a separate control panel. This control panel is also equipped with a buzzer to signal low levels, enhancing operational awareness. Additionally, indicator lamps provide visual cues regarding the system's status, ensuring efficient and reliable operation.

- **Components:**
  1. Storage tanks: Tank capacity 100 litter each 1 working & 1 standby
  2. Dosing pump:
     a. Dosing capacity- 0 to 6 LPH
     b. Power supply – 230 V, 1 phase, 50 Hz AC supply
     c. Dosing speed can be controlled by Analogue signal from PLC
  3. Control panel: Power and control the operation of dosing pumps manually and automatically
  4. Level transmitter: Prevents dry run of dosing pumps
  5. Stand: For entire system installation

- **Operation instruction:** The amount of liquid hypo chloride dosing is contingent upon several factors:

  1. Discharge of the tubewell submersible pump: The volume of liquid hypo chloride dosing is influenced by the discharge rate of the tubewell submersible pump. Higher discharge rates typically require proportionally larger doses of hypo chloride for effective disinfection.

  2. Chlorine concentration in hypo chloride: The concentration of chlorine present in the hypo chloride solution directly impacts the dosing requirements. Higher concentrations may necessitate lower doses, while lower concentrations may require higher doses to achieve desired disinfection levels.

  3. Dosing capacity of the pumps: The dosing capacity of the pumps, or their ability to accurately and reliably administer hypo chloride, plays a crucial role in determining the appropriate dosing amount. The capacity of the pumps must align with the dosage requirements to ensure effective disinfection.

  By considering these factors, operators can accurately determine the optimal amount of liquid hypo chloride dosing required for effective disinfection in various applications.

- **Dosing calculation:** Dosing calculation is provided for liquid sodium hypochlorite with a concentration of 100 g/L.

Regulator setting of Chlorine dosing pump (0-6 LPH)			
Sr.no.	Pump HP	Discharge (LPM)	% EFFICIENCY (0-100%)
1	5	336	1.7
2	7.5	428	2.1
3	10	582	3.0
4	12.5	685	3.5
5	15	920	4.6
6	17.5	945	4.7
7	20	1170	5.9
8	25	1236	6.2
9	30	1695	8.5
10	33	1896	9.5
11	41	2166	10.8

9. ***Pressure Transmitter:***

- **Introduction:** The pressure transmitter is utilized to measure the pressure of the discharge line from the tubewell pump. A digital monitoring display is directly mounted on the pressure transmitter, eliminating the need for an external power supply.

- **Technical specification:**

1. Input power supply- 24 V dc supply
2. Output signal- 0 to 20 mA
3. Measuring Range- 0 to 25 Bar
4. Type of instrument- 2 wire instrument
5. Display type- LCD display with 4 digit & bar graph

10.***Radar Level Transmitter:***

- **Introduction:** The Radar type level transmitter is utilized to measure the water level in Over head tank. It utilizes radar technology to determine the distance from the transmitter to the surface of the material being measured. By emitting high-frequency electromagnetic waves and analysing the reflected signal, radar level transmitters provide accurate and reliable measurements of liquid, even in challenging environments such as those with extreme temperatures, pressure, or dust.

- **Technical specification:**

1. Measuring range- 8 metre
2. Beam angel- 5 degree
3. Measuring frequency- 80 GHz
4. Pressure- 3 bar
5. IP-68
6. Working temperature- (-40 deg to 80 deg)
7. Bluetooth standard- 5.0

11.***Hydrostatic Level Transmitter:***

- **Introduction:** The hydrostatic level transmitter typically consists of a pressure sensor or transducer submerged in the liquid. As the liquid level changes, the pressure exerted on the sensor also changes. The transmitter measures this pressure and converts it into a corresponding electrical signal, typically a 4-20 mA output, which is proportional to the liquid level.

- **Technical Specification:**

    1. Range of instrument- 100 metre
    2. Pressure- 10 bar
    3. Output- 4 to 20 mA
    4. Type of instrument- 2 wire

12.*Electromagnetic Flowmeter:*

- **Introduction:** An electromagnetic flowmeter is a device used to measure the flow rate of conductive liquids in a pipe. As the conductive liquid flows through the pipe, it creates a voltage across the electrodes proportional to the flow velocity. The flowmeter measures this voltage and calculates the flow rate.

- **Installation instruction:**

Installation Instructions for Electromagnetic Flow Meter to Measure Water Flow:

1. Selecting the Installation Location:
- Choose a straight section of pipe with sufficient length upstream and downstream of the flow meter to ensure accurate measurements. Avoid locations near bends, valves, or pumps, as these can cause turbulence and affect the flow readings.

2. Preparing the Pipe:
- Clean the pipe thoroughly to remove any debris or obstructions that could interfere with the flow meter's operation.
- Ensure the pipe is free from leaks or damage that could affect the integrity of the flow measurement.

3. Mounting the Flow Meter:
- Mount the electromagnetic flow meter on the selected section of pipe using appropriate mounting hardware and gaskets to ensure a secure and leak-proof installation.
- Ensure that the flow meter is oriented correctly according to the manufacturer's recommendations, with the flow arrow indicating the direction of flow.

4. Electrical Connections:
- Connect the electrical cables from the flow meter to the appropriate power supply and signal processing equipment according to the manufacturer's wiring diagram.
- Ensure all electrical connections are securely tightened and insulated to prevent any risk of electrical shock or short circuits.

5. Grounding:
- Ground the flow meter according to local electrical codes and manufacturer recommendations to ensure safe and reliable operation.
By following these installation instructions carefully, you can ensure the accurate and reliable measurement of clear water flow rates using an electromagnetic flow meter.

❖ **Technical specification:**

1. Power supply- 230 V 1 phase, 50 Hz AC supply
2. Communication- 4 to 20 mA
3. Output frequency- 1 to 5000Hz
4. Display type- LCD 4 lines

13.*Chlorine & Turbidity Analyser:*

- **Introduction**: Water Quality analyser used for measuring free Chlorine and Turbidity. It is highly reliable analyser which provides accurate and real-time data for drinking water. It measures free chlorine in the range of 0 to 20 mg/L and Turbidity in the range of 0-400 NTU. A Controller Display unit, and a transmitter is 24V DC powered. It has 2 numbers of RS485 output and 1 relay output.

- **Technical specification:**
    1. Input supply- 24 V DC
    2. Current output- 4 to 20 mA
    3. Residual chlorine measuring range- 0 to 20 mg/l
    4. Turbidity measuring range- 0 to 400 NTU
    5. Relay output- 230 V , 5 A

- **Maintenance instruction:**
    1. The equipment cleaned regularly
    2. The fusible resistor should not be replaced by the operator
    3. For cleaning use a clean soft cloth, do not use acetone or any other cleaning agent.

14.***Actuator Valve:***

- **Introduction:** Actuator valves, or electrically operated sluice valves, serve the purpose of automating the operation of the tubewell. They facilitate the regulation of water supply between the overhead tank and the bypass chamber. Two actuator valves are employed—one at the rising main and the other at the bypass side—to control the flow.
  During instances of high turbidity in the water, the bypass valve opens while the rising valve closes. Conversely, when turbidity levels fall within acceptable limits, the rising main valve opens to fill the overhead tank, and the bypass valve closes. The operation of these actuator valves is overseen by an actuator control panel, which manages both manual and automatic regulation of the valves. This setup ensures efficient and responsive control over the water distribution process.

- **Operation instruction:**

  1. Manual Operation:
  - In manual mode, ensure that the actuator control panel is set to manual operation.
  - Use the manual override feature on the actuator valve to manually open or close the valve as needed.
  - Exercise caution and follow proper safety procedures when manually operating the valve to prevent accidents or damage.

  2. Automatic Operation:
  - Ensure that the actuator control panel is set to automatic operation mode.
  - Input the desired control parameters, such as pressure, flow rate, or turbidity levels, into the control panel.
  - The actuator valve will automatically adjust its position based on the input parameters to maintain the desired flow or pressure conditions.

- **Maintenance instruction:**

  1. Regular Inspection:
  - Conduct routine visual inspections of the actuator valve, including the valve body, actuator, and associated components.
  - Look for signs of wear, corrosion, leaks, or damage that may affect the performance or integrity of the valve.
  - Ensure that all electrical connections are secure and free from corrosion or damage.

  2. Lubrication:
  - Regularly lubricate moving parts of the actuator valve according to the manufacturer's recommendations.

- Use appropriate lubricants to ensure smooth operation and prevent excessive wear of mechanical components.
- Pay special attention to areas prone to friction, such as valve stems, seals, and bearings.

3. Calibration and Testing:
- Periodically calibrate the actuator valve to ensure accurate positioning and operation.
- Use calibrated instrumentation to verify that the valve responds correctly to control signals and maintains the desired position.
- Conduct functional tests of the actuator valve under normal operating conditions to confirm proper functionality and response.

By following these maintenance instructions, you can ensure the reliable performance and longevity of actuator valves in your system.

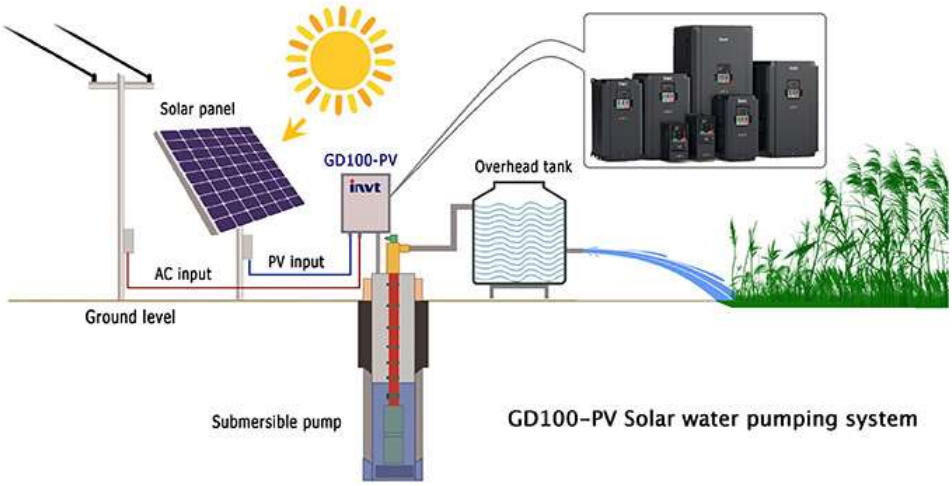
Introduction

Solar Photovoltaic (PV) Systems

A solar photovoltaic (PV) system is composed of **one or more solar panels combined with an inverter and other electrical and mechanical hardware that use energy from the Sun to generate electricity**. PV systems can vary greatly in size from small rooftop or portable systems to massive utility-scale generation plants

A typical photovoltaic system consists of some or all of the following components:

- Solar Panel - Converts sunlight to electricity/DC power
- Inverter - Converts DC power from the solar panel and battery to AC power.
- Battery(s) - Stores excess electricity generated by solar panel



Description Of Installed System at JJM Schemes

VARIOUS STANDALONE PV SYTEM

The system is a standalone system which is a system independent of the electricity grid, with the excess energy produced part of which being stored in batteries to be used and managed by an inverter. The size of the PV system installed as per specific requirements of the schemes.

The PV module used is a monoperc cell type specifically 400-550W (Make: Sova, Jakson, Bluebird). The inverter used is a VFD (Variable Frequency Drive, Make: Kaizen, Fuji, vinworth, delta) which is a multi-functional pump drive, combing functions of inverter, pump starter and controller.

An AC distribution board (ACDB) (also known as panel board, breaker panel, or electric panel) is present. The primary function of the ACDB is to serve as a control point to regulate all AC power to connected loads. It houses miniature circuit breakers to disconnect incoming and outgoing AC connections.

The images below show one of the installed systems at JJM schemes campus and its components:

Operations

Start Up Procedure

WARNING: You must follow the shutdown procedure in the order of the steps stated. Failure to follow the sequence can result in arcing and damage to the system. A fire is possible. Also, make sure all loads are off before you begin.

Note: *Next to the inverter is a start-up procedure label similar to this.*

TO RUN VFD OVER SOLAR POWER

STEP 1: Keep rotary switch in solar mode

⇓

STEP 2: Turn On DC MCB for Solar power supply

⇓

STEP 3: To start the pump rotate ON/OFF switch at ON side

TO RUN VFD OVER DG POWER

(Make sure DC MCB is in OFF condition)

STEP 1: Keep rotary switch in DG mode

⇓

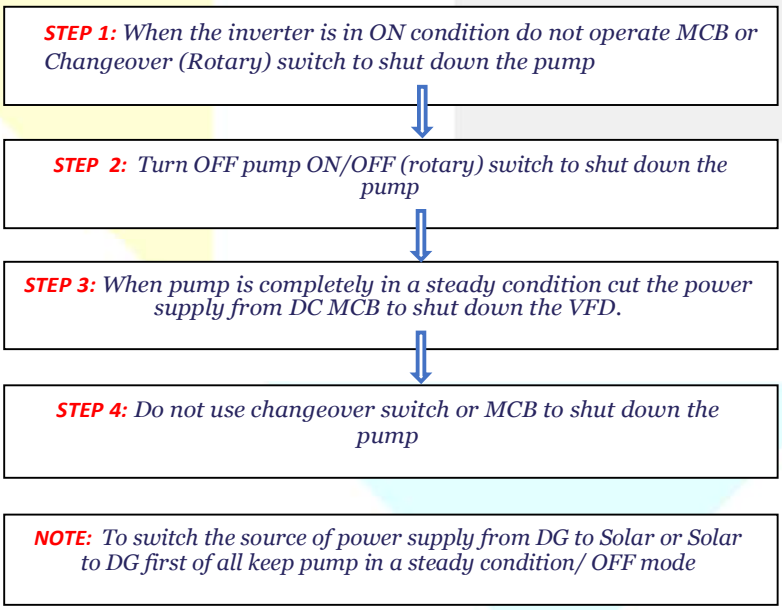
STEP 2: To start the pump turn ON the ON/OFF switch

Shut Down Procedure

WARNING: You must follow the shutdown procedure in the order of the steps stated. Failure to follow the sequence can result in arcing and damage to the system.

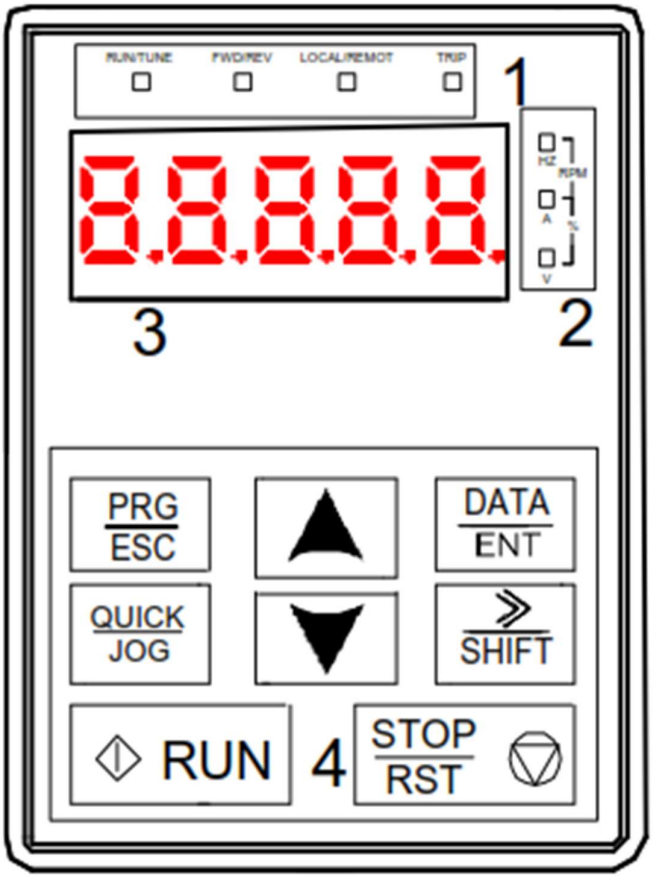
Note: Next to the inverter is a shutdown procedure label similar to this. After the inverter is powered OFF, there is still residual power and heat in the chassis, which may lead to electric shock or burning. Therefore, after the inverter is powered off, wait for 5 minutes if you will be opening the chassis of the inverter.

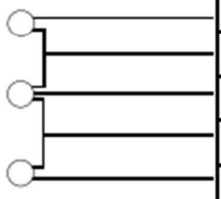
See shutdown procedure below:



Inverter Operation & Display Panel

The operation and display panel includes four buttons and an LCD display, indicating the operating status and input/output power information. See images below:



Serial No.	Name	Description		
1	State LED	RUN/TUNE	LED off means that the inverter is in the stopping state; LED blinking means the inverter is in the parameter autotune state; LED on means the inverter is in the running state.	
		FWD/REV	FED/REV LED LED off means the inverter is in the forward rotation state; LED on means the inverter is in the reverse rotation state.	
		LOCAL/REMOT	LED for keypad operation, terminals operation and remote communication control LED off means that the inverter is in the keypad operation state; LED blinking means the inverter is in the terminals operation state; LED on means the inverter is in the remote communication control state.	
		TRIP	LED for faults LED on when the inverter is in the fault state; LED off in normal state; LED blinking means the inverter is in the pre-alarm state.	
2	Unit LED	Mean the unit displayed currently		
			Hz	Frequency unit
			RPM	Rotating speed unit
			A	Current unit
			%	Percentage
			V	Voltage unit
3	Display zone	5-figure LED display displays various monitoring data and alarm code such as set frequency and output frequency.		

<table>
<tr><th>Serial No.</th><th>Name</th><th colspan="4">Description</th></tr>
<tr><td></td><td></td><td colspan="4"><table>
<tr><th>Display</th><th>Mean</th><th>Display</th><th>Mean</th><th>Display</th><th>Mean</th><th>Display</th><th>Mean</th></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>2</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td>4</td><td>4</td><td>5</td><td>5</td><td>6</td><td>6</td><td>7</td><td>7</td></tr>
<tr><td>8</td><td>8</td><td>9</td><td>9</td><td>A</td><td>A</td><td>b</td><td>B</td></tr>
<tr><td>C</td><td>C</td><td>d</td><td>D</td><td>E</td><td>E</td><td>F</td><td>F</td></tr>
<tr><td>H</td><td>H</td><td>I</td><td>I</td><td>L</td><td>L</td><td>n</td><td>N</td></tr>
<tr><td>n</td><td>n</td><td>o</td><td>o</td><td>P</td><td>P</td><td>r</td><td>r</td></tr>
<tr><td>S</td><td>S</td><td>t</td><td>t</td><td>U</td><td>U</td><td>u</td><td>v</td></tr>
<tr><td>.</td><td>.</td><td>-</td><td>-</td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td rowspan="8">4</td><td rowspan="8">Buttons</td><td>PRG ESC</td><td>Programming key</td><td>Enter or escape from the first level menu and remove the parameter quickly.</td></tr>
<tr><td>DATA ENT</td><td>Entry key</td><td>Enter the menu step-by-step.
Confirm parameters.</td></tr>
<tr><td>▲</td><td>UP key</td><td>Increase data or function code progressively.</td></tr>
<tr><td>▼</td><td>DOWN key</td><td>Decrease data or function code progressively</td></tr>
<tr><td>SHIFT</td><td>Right-shift key</td><td>Move right to select the displaying parameter circularly in stopping and running mode.
Select the parameter modifying digit during the parameter modification.</td></tr>
<tr><td>RUN</td><td>Run key</td><td>This key is used to operate on the inverter in key operation mode.</td></tr>
<tr><td>STOP RST</td><td>Stop/
Reset key</td><td>This key is used to stop in running state and it is limited by function code P07.04.
This key is used to reset all control modes in the fault alarm state.</td></tr>
<tr><td>QUICK JOG</td><td>Quick key</td><td>The function of this key is confirmed by function code P07.02.</td></tr>
<tr><td>5</td><td>Keypad port</td><td colspan="3">External keypad port. When keypads are valid, both the local and external keypad LEDs are on.</td></tr>
</table>

Maintenance

Common Tools Used

Multi Meter

Screw Drivers

Spanners

Hammers

Maintenance Warnings

WARNING: Do not attempt to clean or come in contact with the surface of a solar module with broken glass. This could result in a dangerous electric shock.

WARNING: Solar modules remain live during daylight hours, even when the DC isolator is off. Therefore, wiring etc. will still be energized even when the DC isolators are off. Hazardous voltages are present whenever solar panels are exposed to light.

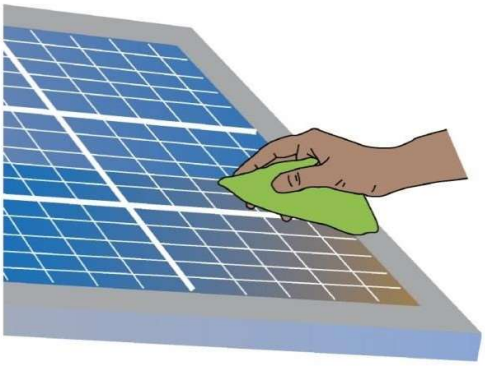
WARNING: The system should be shut down following the shutdown procedure before performing any maintenance.

WARNING: Read and obey all warning signs before performing any maintenance

CAUTION: Appropriate precautions must be taken when working at heights. Do not attempt to access the roof unless the precautions to prevent falling from heights are in place. GIZ recommends that only GHS focal persons/certified electrician who have been trained to work at heights conduct all solar system maintenance at height.

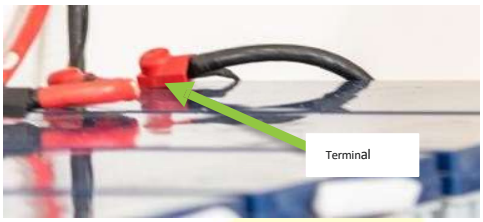
Maintenance Tips

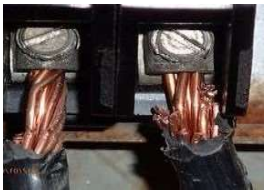
1. Clean solar panel with soft cloth or soft mop and water anytime it is dirty. Do this when panels are cool and do not use soap/detergent for cleaning. Also do not step on the solar panel nor use pressure washers for cleaning.



2. Trim trees that may create shade over the panels.
3. Clean inverter, DC and AC (Energy) box, and batteries when dusty with a dry soft cloth or soft hand dusting brush

4. Do not put anything on top of the batteries, keep it free and dry from any liquid especially water.
5. Battery terminals must be covered





6. Do not touch the battery terminals with metal objects; otherwise, you can get an electric shock.
7. Check connections for loose contact/connections and tighten them

DISALLOWED AC LOADS

Electric Kettle

Pressing Iron

Electric Immersion Boiler

Hair Dryer

Periodic Maintenance Schedule

SUB-SYSTEM OR COMPONENT	MAINTENANCE ACTION	FREQUENCY	REMARKS	RESPONSIBLE
SITE	Verify: 1. General Cleanliness (accumulation of debris around and/or under array/ batteries and environment). Follow tips above. 2. Check impact of bats on the roof and PV system 3. Check shading of solar panels from surrounding trees. In case of shading, cut parts of tree that are causing shadow.	Weekly	Clean if necessary	In - Charges/volunteers
PV MODULES	1. Verify Cleanliness (accumulation of dust or fungus on array) 2. Cleaning: Simply wash with water to remove layers of dust and dirt. Follow tips above.	monthly	Clean if necessary	In-Charges/volunteers
	1. Visual check of connectors and cables 2. Check roof for cracks and holes and repair where necessary 3. Clearing of obstructions of sunlight/shading to the panels (trees etc.)	Quarterly	Repair/ tighten if necessary Trim trees if required.	In-Charges/volunteers

	Check for visual defects including: 1. Fractures 2. Cracks and Chips 3. Browning 4. Moisture Penetration 5. Frame Corrosion	Biannually	Modules with visualdefects should be further inspected for performance and safety to determine the need for replacement.	Technical focal persons
	Verify Bypass Diodes	Annually	Any defective seals, clamps and bypass diodes are to be replaced	Technical focal persons
	Verify Mechanical Integrity of Conduits	Quarterly	Any damaged conduit is to be replaced	Technical focal persons
	Verify Insulation Integrity of Cables installed without conduit	Quarterly	Any damaged cableis to be replaced	Technical focal persons
WIRING INSTALLATION	Check Junction & Distribution Boxes for: 1. Tightness of Connections 2. Water accumulation/build up 3. Integrity of Lid Seals	Annually	Any defective seals,clamps, blocking diodes and surge arresters are to be replaced.	Technical focal persons
	4. Integrity of Cable Entrance and/or Conduit sealing 5. Integrity of Clamping devises			
ELECTRICAL CHARACTERISTIC	Measure Open Circuit Voltages	Annually		Technical focal persons
	Measure Short Circuit Currents	Annually		

PROTECTIVE DEVICES	Verify: 1. Integrity of Fuses 2. Operation of Circuit breakers and RCD's (perform short circuit tests) 3. Operation of Solar Array Isolation Devices 4. Operation of earth fault protection system **Earthing** Check for: 1. Tightness of Connections 2. Corrosion 3. Solar Panels earthing condition 4. Inverter earthing condition 5. Solar farm earthing condition Conducting an earth resistance test and confirming that value is within accepted limits.	Annually	Correct and improve earthing if necessary	Technical focal persons
BATTERIES	Check: 1. For carbons on the battery terminals. If found, grease the terminals 2. Voltages of the various batteries for their threshold Ensure long term record keeping of battery state of charge (soc)	Quarterly		Technical focal persons
INVERTER	1. Visual inspection, external cleaning and blowing of dust from vents and fan areas Use dry cloth to wipe away dust 2. Verify that LEDs are working properly and wiring is intact.	Quarterly		Technical focal persons
MOUNTING STRUCTURES	Visual check of stability, rigidity, fixing and tightening of the mounting rails, bolts and clamps on panels as well as other fastening devices to verify their integrity.	Quarterly		Technical focal persons
	Inspection for Corrosion	Biannually		