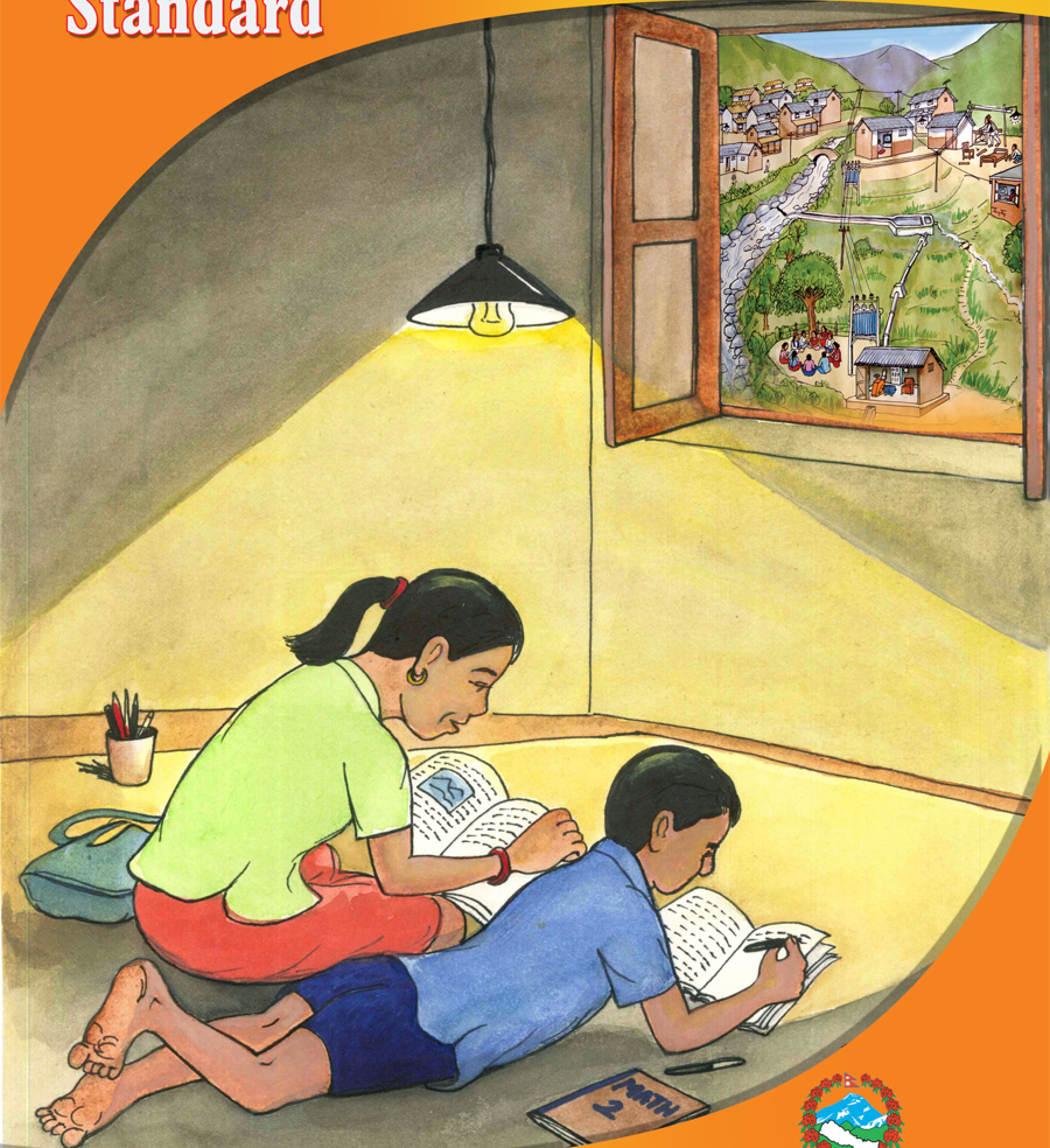
Reference Micro-hydropower Standard



Government of Nepal
Ministry of Science, Technology and Environment
Alternative Energy Promotion Centre (AEPC)

REFERENCE

MICRO HYDRO POWER STANDARD

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Abbreviations and Acronyms.

ABC	Aerial Bundled Cable
AC	Alternating Current
ACSR	Aluminium Conductor Steel Reinforced
AVR	Automatic Voltage Regulator
Cm	Centimeter
DANIDA	Danish International Development Agency
DIN	German Institute for Standardization
ELC	Electronic Load Controller
EN	European Standard
ESAP	Energy Sector Assistance Programme
FDC	Flow Duration Curve
Ft	Feet
GI	Galvanized Iron
HDPE	High Density Poly Ethylene
HYDEST	Hydrological estimating software produced by WECS
Hz	Hertz
IEC	International Electrotechnical Commission
IGBT	Insulated Gate Bipolar Transistor
IGC	Induction Generator Controller[2]
IMAG	Induction Motor as Generator
IPxx	Equipment Protection Classification (IEC 60529)
ISI	Indian Standards Institute
ISO	International Standardization Organization
kA	Kilo-ampere
Kg	Kilogram
kV	Kilovolt
kVA	Kilo-volt-ampere
kW	Kilowatt
kWh	Kilo watt-hour
L	Litre
l/s	Litre per Second
LA	Lightning Arrester
LT	Low Tension
LV	Low Voltage

M	Metre
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MGSP	Mini-Grid Support Programme
MH	Micro-Hydro
MHP	Micro-Hydropower Project
MIP	Medium Irrigation Project
mm	Millimeter
MS	Mild Steel
MV	Medium Voltage
NGO	Non Governmental Organization
NRREP	National Rural and Renewable Energy Programme
OC	Over Current
OV	Over Voltage
PCC	Plain Concrete Cement
PCD	Pitch Circle Diameter
PF	Power Factor (also referred to as)
PH	Powerhouse
PVC	Poly Vinyl Chloride
QAS	Quality Assurance System
R&D	Research and Development
RCC	Reinforced Cement Concrete
RCD	Residual Current Device
Sq	Square
V	Volt
W	Watt
WECS	Water and Energy Commission Secretariat

PREFACE

The Alternative Energy Promotion Centre (AEPC) was established in 1996. It has been executing the National Rural and Renewable Energy Programme (NRREP) since July 16, 2012 with single programme modality. Support to micro/ mini hydro development under Community Electrification Sub Component (CESC) has been one of the major activities of the programme within the NRREP.

AEPC has been preparing various guidelines for assisting prospective micro-hydro developers to implement micro/ mini hydro projects. This Reference Micro-hydropower Standard was prepared in 2005 by then AEPC/ ESAP programme. In response to the needs of micro/ mini hydro sector in Nepal especially in designing, manufacturing and installing the quality micro/ mini hydropower projects the standard has been updated and upgraded incorporating best practices. This standard draws heavily on the experience of a number of stakeholders and experts, and has thoroughly been tested on the practical applications.

I would like to express thanks to Universal Consultancy Services, Pvt. Ltd., Balaju, Kathmandu and the Community Electrification Sub-Component of AEPC/ NRREP for their contributions to the updating and upgrading of the guideline. I would like to thank all those who directly or indirectly helped in updating/upgrading this standard.

The standard shall be updated/ refined from time to time based on experience gained and technological advancement. All the users of the standard are requested to involve in the process of its refining as they had put their best efforts in the past while developing this standard. Any comment and feedback shall be forwarded to AEPC/NRREP.

Ram Prasad Dhital
Acting Executive Director
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PART I

INRODUCTION

1.1 Background

The micro-hydropower sector in Nepal has a long history. Since time immemorial, people in the rural areas have built water mills (*ghatta*) for harnessing waterpower to process agricultural products. Because Nepal has a huge potential for hydropower and a favorable geographical situation, innumerable *ghatta* exist, even today.

The formal use of micro-hydropower was initiated during the 1960s. In 19060 the Swiss helped establish a manufacturing company named Balaju Yantra Shala in Kathmandu. At the same time, United Missions to Nepal (UMN) established institutions to support technological development mostly in Bhutwal in western Nepal. In the 1970s, some private workshops based on indigenous knowledge and practices were established in both cities, primarily to produce and install small water mills, widely known as “turbine mills.” These mills were used extensively to process agricultural products utilizing direct mechanical power. Later generators were added to electrify the vicinity. The establishment of private manufacturing companies increased in the 1980s and later.

Most equipment and components (e.g., turbines, trash racks, MS pipes, conductors and load controllers) are manufactured in Nepal, but generators and valves are imported from abroad, especially from India and China, but sometimes from Europe.

Standardization, though in a limited manner, started in the late 1980s. Intermediate Technology Development Group (ITDG) and the Agricultural Development Bank of Nepal (ADB/N) initiated a joint program to enhance the technological base of micro-hydropower installations in the country.

The Alternative Energy Promotion Centre (AEPC) executed the Energy Sector Assistance Program (ESAP) with support from the Royal Danish Government (through DANIDA) and the Government of Nepal (GoN) from 1999 to 2012. Support to micro-hydropower development was one its major components. One of the objectives of this component was supporting a national framework which provided for the standardization of the implementation process of micro-hydropower service delivery as one of its most important activities. The Joint (GoN and DANIDA) Technical Review of the ESAP in 2001 reinforced the need for developing micro-hydropower standards in Nepal, and, indeed standards were developed.

Currently, the GoM and external development partners supporting Nepal’s rural and renewable energy sector have designed the National Rural and Renewable Energy Program (NRREP) to be implemented by the AEPC for five years from mid-July 2012 to mid-July 2017 using a single program modality. The Community Electrification Sub-component (CESC) of the NRREP is responsible for the coordination and implementation of community electrification activities throughout the country under a demand-driven and public-private-partnership approach. The component aims to install 25 MW of mini- and micro-hydropower with the capacity to serve 150,000 rural households during the project period.

In order to cope with the changing context of micro-hydropower development, the CESC has updated these Reference Micro-Hydropower Standards by incorporating the changes dictated by experience gained in the past.

1.2 Process of Developing Standards

The standardization process is a broad one falling under total quality-assurance system (QAS).

1.2.1 Sandards Development Process

The standards development process can be the divided into three phases:

- Development
- Implementation, and
- Refinement and Feedback.

Development Phase

There is much indigenous knowledge and expertise in the design, manufacture, and installation of micro-hydropower systems in Nepal. The development phase accomplished three key goals:

- Gathering of local knowledge and practices,
- Comparison with international practices and knowledge, and
- Preparation of various supporting guidelines and manuals, setting up institutions qualification of service providers and establishment service delivery mechanism.

To help see the standards implemented, various procedural guidelines and manuals were developed. Institutional arrangements were made at the central and local levels. The private sector engages in survey and design, manufacturing and installation, and the non-government (NGO) sector in facilitation at the local level. Provisions were made to qualify service providers. Delivery mechanisms for financial and technical support were institutionalized and put into operation.

Implementation Phase

The standards were tested in real projects keeping these goals in mind:

- Integration of the standards were into project implementation activities.
- Institutionalization of the Technical Review Committee for reviewing design and feasibility criteria.
- Conduction of seminars and workshops to exchange information exchange and get feedback and making international visits to gain exposure.

All the projects were developed following the procedural guidelines and standards so they would be eligible for the government subsidy for micro-hydropower installations. It was compulsory for service providers to comply with both guidelines and standards in order to meet pre-qualification of.

The multi-sector Technical Review Committee was institutionalized in the AEPC. It is responsible for making sure that the design and the construction of micro-hydropower schemes meet the standards and thereby that they continue to be productive. Feedback workshops are part of the regular process for exchanging information.

Refinement and Feedback Phase

Monitoring and evaluation are integral parts of standardization. Three methodologies were used:

- Performance check upon the completion of one year of operation,
- Power-output verification after commissioning, and
- Periodic supervision during and after construction.

The implementation process itself ensures that quality requirements are met. A part of the 10% of the subsidy amount is released to the installation company only after assessing the performance of the scheme after one year of operation. In addition, the subsidy is awarded according to the actual power output of the system. A power-output verification test is performed for each micro hydropower scheme. The scheme is periodically supervised both during and after its construction.

1.3 Theoretical Basis of Standardization Process

The theoretical basis for the development of standards is described below.

1.3.1 Process as a whole

The development of standards is a part of the overall QAS, which addresses the process from site identification to operations to capacity-building at all levels. Procedural guidelines, manuals, institutional set-ups, and established delivery mechanisms supplement the application of these standards.

1.3.2 Dynamism

The QAS is a dynamic system designed to incorporate innovations and experience gained. It was updated based on periodic feedback.

1.3.3 Good-Quality Incentive

The implementation and delivery modalities are framed in such a way that quality is maintained by the system itself. The approach makes the micro-hydropower owner community conscious of the need for a good quality scheme so that they will insist on it. In addition, because the amount of the subsidy is calculated based on the measured power output, there is an incentive to achieve the designed power output. Quality is further enhanced through proper survey design based on procedural guidelines, expert systems, and design aids, as well as trainings at all levels.

1.3.4 Board-Based Participation

In a QAS, all stakeholders are the part of the program. The following table illustrates the role sand responsibilities different stakeholders assume.

Stakeholder	Role	Responsibility
Developer and community	Demanding of quality and selection of consultant for study and design and contractor for installation	Ownership lies with the developer and community
Support organization (mostly local NGO and development organizations)	Facilitation of various activities to developer/communities, establishment of linkages between service providers and owner-communities	Making sure that owner-communities understand the process and their responsibilities
Private consulting companies	Survey, design and DFS report preparation	Adopting and adhering to standards and guidelines
Private installation companies	Supplying of equipment and installation of schemes, including civil construction or supervision	Generating agreed power output, upholding the one-year guarantee, and adhering to standards

Technical Review Committee	Assessment of surveys, designs, and feasibility	Ensuring standards are adhered to and establishing a feedback mechanism
Alternative Energy Promotion Centre	Preparation and updating of standards, guidelines, and modalities	Providing feedback, reviewing schemes, and ensuring that the QAS is implemented effectively

1.3.5 Self-Regulatory Capacity of Micro Hydropower Industry

The entire QAS, including the standards, is self-regulatory in nature. The table above demonstrates that the regulatory role is shared by different stakeholders. The AEPC plays a central but coordinates rather than regulates.

1.4 Overall Requirement of the Standards

The purpose of the Reference Standards is to improve the overall quality and safety of the electricity services provided by micro-hydropower installations. These standards have four aims, as follows.

- **Guaranteed power output:** Plant owners and end-users will receive what they have ordered from suppliers in terms of available power capacity.
- **Reliable operation:** During a specified service life, micro-hydropower installations will not suffer from frequent outages and repairs but will provide high-quality, continuous electricity service.
- **Safety:** Electricity can be dangerous to people, equipment and property even when generated in small plants and quantities. Adequate protection shall be provided not only at the powerhouse and generating equipment, but also at the consumer end as well as throughout the electrical transmission (including transformers, surge arresters etc). A micro-hydropower installation can destabilize and cause collapse or seriously damage hill slopes and associated property due to flooding and overtopping of canals and basins. To mitigate these risks, adequate design considerations shall be applied to the water conveyance system and associated structures.
- **Cost-effectiveness:** Electricity services should not be expensive, let alone unaffordable, for rural populations. Compromises, mainly in terms of convenience of operation and ease of maintenance, will be made in order that micro-hydropower installations are a cost-effective way of providing electricity.

PART II

REFERENCE STANDARDS FOR MICRO-HYDROPOWER

(Up to 100 kW)

2.1 Definition

Micro- and pico-hydro installations fall under the scope of these standards. They are defined as isolated hydroelectric-generating sets (for interconnected schemes another set of standards applies), associated civil works and electrical transmission and distribution lines with capacities up to 100 kW. The nominal generation parameters are understood to be 230 V/50 Hz supply voltage/frequency AC system. Micro- and pico-hydro installations provide basic electricity services for diverse end-uses including lighting and entertainment in households and institutions as well as the operation of electrical tools and machinery.

The standards for micro- and pico-hydro projects are similar. Where certain standards apply to only to the smaller type of schemes, this will be noted.

Micro/pico-hydro generating units can run in parallel with similar isolated units in a mini-grid or they may be connected to a local, regional or national grid. A separate set of standards will applies to the case of interconnected micro/pico-hydro schemes.

2.2 General Requirements

2.2.1 Definition

Micro-hydropower

- Micro-hydropower will comprise all hydroelectric generating units with capacities ranging from 10 to 100 kW

Pico-Hydro

- Pico-hydro shall comprise all hydroelectric generating units with capacities up to 10 kW. The turbine rotor used will be a pelton, cross-flow or propeller turbine.
- Turbine rotors shall be directly mounted on the generator shaft and pelton and cross-flow systems will be either vertically or horizontally mounted. Other systems like belt transmission shall be considered pico-hydro if the price-output relation is good and the design is proven reliable and efficient in the long term.

2.2.2 Implementation Process

- A pre-qualified consulting company from the AEPC shall be responsible for the carrying out the pre- and detailed feasibility studies and monitoring obligations.
- A pre-qualified installer/supplier company from the AEPC shall be responsible for installation/erection, testing/commissioning and warranty obligations.
- Any construction of local civil works and procurement of local construction materials by the entrepreneur or by community themselves shall be carried out under the supervision/instruction of a qualified technician from the company.

2.2.3 Standard Components of Supply/Construction

*2.2.3.1 **Micro/pico-hydro major components***

- **Civil works** including head works, water conveyance structures, powerhouse and electric line poles.
- **Hydro-mechanical equipment** comprising penstock pipes, water control, filtering

and regulation equipment (the servo motor unit).

- **Electro-mechanical equipment/Pico set equipment** comprising of a turbine-generator unit and electrical control and protection equipment.
- **Electrical transmission and distribution lines** including transformers, protection equipment, and service connections with rated (line–to-line) voltages of up to 11 kV.

Since technology is constantly beign developed and new technology and approaches may be required in special circumstances, proven new technology and case-by-case approaches/design that meet the overall requirement may also qualify for acceptance upon their approval by the AEPC.

2.2.3.2 Essential Tools and Spares

The following standard components for supply and construction are required:

- **Tools:** Essential tools for operation and maintenance (O&M) including at least appropriate sizes of screwdrivers, spanners, pliers, pipes, wrenches, and line and continuity testers, all kept in a suitable tool box.
- **Spare Parts:** Enough essential spares and consumables, including at least a suitable grease nozzle, control/protection fuse/MCB, and household load limiting glass fuses/MCB, for three years of plant operation, all kept in a suitable storage box.
- **Operating Manual:** An Installation, Operation, Maintenance and Trouble-Shooting manual with technical specifications written in language suitable for customer's/ operator's level of education
- **Signboard:** A signboard at least 3 ft x 2 ft shall be placed at the powerhouse indicating the name and capacity (kW) of the project as well as the dates it was started, tested, and commissioned; the name of the installation company and supporting organizations, total project cost, and other key details.

2.2.3.3 Company Obligations

- The company or its principal equipment supplier shall have a test plant facility for testing underwater pressure achievable by a single-stage lift pump with sufficient flow to rotate and generate the rated voltage/frequency.
- The company shall possess the necessary resources for survey/feasibility study, installation and testing, and after-sales services and training.
- At the test plant equipment shall be tested for satisfactory performances in terms of basic features including voltage generation, emergency shutdown and/or de-excitation, vibration, and temperature rise. Conducting these tests does not exempt the supplier from conducting quality checks at the site.
- A test plant or access to a test facility is obligatory.
- The installer shall train at least two operators in (O&M) and safety issues before putting the plan into service and leaving the site.
- The installer shall train at least two persons to assume responsibility for house-wiring before putting the plant into service and leaving the site.
- The installer shall complete a test run of continuous operation of at least 24 hours under full-load condition.
- Suppliers should provide one-year guarantees for electrical equipment and three-year guarantees for mechanical equipment which go into effect on the date of putting the plant into operation. They should also provide efficient after-sale services in the future.

2.3 Detailed Specification for Design, Fabrication and Installation

Deviation from these standards is acceptable as long as there is proven evidence that the proposed alternatives meet the requirements in terms of output, safety, reliability, and cost-effectiveness.

2.3.1 Design

2.3.1.1 Civil Works General Requirements

a. A flow duration curve (FDC) shall be established from regular stream-gauging during at least one lean season correlated to computations using approved methods such as HYDEST, MIP OR HydrA- Nepal. For micro-hydropower plants below 30kW, spot-gauging (a minimum of two measurements during the lean season) may suffice to establish a flow duration curve.

b. The design discharge of micro-hydropower plants when operating in stand-alone mode should be lower than the minimum flow derived from the FDC so that the design output is available all year round. If this is not possible, adequate an back-up power supply, load-shedding or other load-saving and management methods for the lean season have to be specified as an integral part of the design. Excess water quantities (remaining in the river even during the lean season) must be considered according to national laws and regulations. As per the "Flow Verification Guidelines," the design discharge should be available at micro-hydropower plants for at least 11 months a year.

c. The water conveyance system (excluding penstock and tailrace) shall be designed for a flow that exceeds the design flow by 10-20% (a higher value for long headrace canals) so that the water levels in the sand trap and forebay are never drawn below the normal design levels when continuously operating the system at full load.

d. A topographical survey of the site shall include a longitudinal profile of the whole water conveyance system as well as cross-sections showing geo-technical information, slope stability, gullies and other features. The intervals between the cross-sections depend on site characteristics but should typically be between 20 and 50 m.

2.3.1.2 Diversion and Intake

a. For stream gradients above 2.5%, a streambed intake is recommended; for all other cases, a lateral diversion is adequate.

b. The water intake shall be located on the river or stream bank in such a way that it can divert the required stream flow at all times and at all water levels in the river or stream (it may require a weir sill made of boulders and gabion boxes or stone masonry or RCC).

   The intake location and design should reject bed load and prevent excessive flood water from entering the system. The intake and weir should withstand a flood with a return period of at least 20 years for plants with capacities below 30kW. For all other plant capacities, the minimum return period of the design flood should be 50 years.

c. An intake orifice (submerged at all times) should be provided in order to reduce the abstracted flow when the river or stream is in flood.

d. A suitable gate (system) shall be provided in order to completely close off the system when required for the complete dewatering of the intake box for cleaning and repair work.

e. Provisions shall be made at the intake to exclude large floating debris and gravel from the diverted water. A coarse trash rack may be used for this purpose.

The above requirements do not apply to spring water sources that never flood.

2.3.1.3 *Gravel Trap and Sand Trap*

a. A gravel trap and/or sand trap is NOT required when tapping springs that never flood.

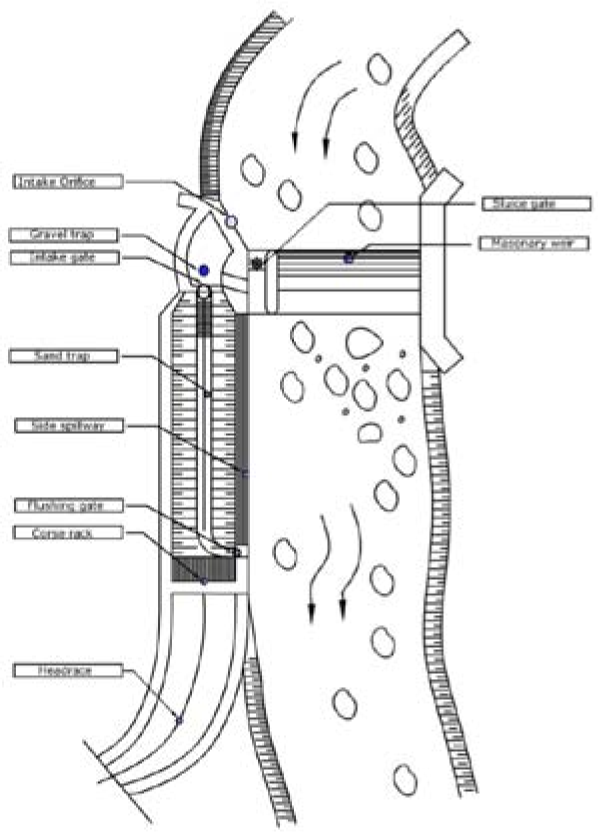


Figure 2.1: A typical intake with a sand trap

b. If the source stream carries a heavy bed load during floods, a gravel trap shall be provided just after the intake orifice. The gravel trap sluice gate should be sufficiently large so that supercritical flow conditions can be accommodated in the gravel trap to remove deposits.

   A gate at the intake orifice may be needed to regulate the inflow for that purpose.

c. The sand trap shall be able to settle at least 90% of grains larger than 0.2 mm for all micro-hydropower project installations with design heads of up to 100m. For pressure heads above 100 m, the settling efficiency for grain sizes above 0.2 mm should be better than 95%.

d. The longitudinal bed slope of the sand trap should not be less than 1:30 for lateral intakes and 1:20 for streambed intakes. The bed of the sand trap shall have a trough-like shape in order to facilitate sediment flushing.

   A sill at the end of the sand trap shall prevent the sand from being washed into the headrace canal/pipe. A flushing device in the form of a steel slide gate or cylindrical bottom outlet cum spillway shall be provided. The discharge capacity of the flushing gate/cone shall be large enough to completely lower the water level in the sand trap while maintaining full water inflow for proper flushing.

2.3.1.4 *Headrace*

a. Leakage from an unlined headrace canal shall not exceed 5 l/s per 100 m of canal length. In silty and clayey soil conditions, unlined canals can meet these requirements. In sandy and gravely conditions, lining with stone masonry or concrete or the use of a headrace conduit will be required. In steep terrain or landslide-prone areas, headrace pipes shall be used.

b. Plastic pipes (PVC or HDPE) must be buried at a minimum depth of 1 m from the ground surface to the top of the pipe to avoid exposure to sunlight and the risk of vandalism.

   Steel or cast-iron pipes from a pipe bridge shall be used to cross gullies or landslides. The inlet of such a piped section shall be at least two pipe diameters below the normal water surface in order to avoid vortices.

   A coarse trash rack shall be provided at the inlet of headrace pipelines with bends or other local disturbances. For straight pipelines less than 50 m long, a trash rack may not be required. The sizing of this coarse trash rack follows the same design requirement as outlines under the hydro-mechanical equipment section.

c. In long headrace canals and/or steep terrain, canal overflow spillways into existing gullies shall be provided along the canal to safely drain excess water without causing water to spill over the canal top and trigger soil erosion.

d. Air valves or vent pipes shall be provided to release trapped air along pipelines, which may accumulate during transient conditions or during pipeline filling at pipeline peaks or abrupt changes in slope.

2.3.1.5 *Forebay*

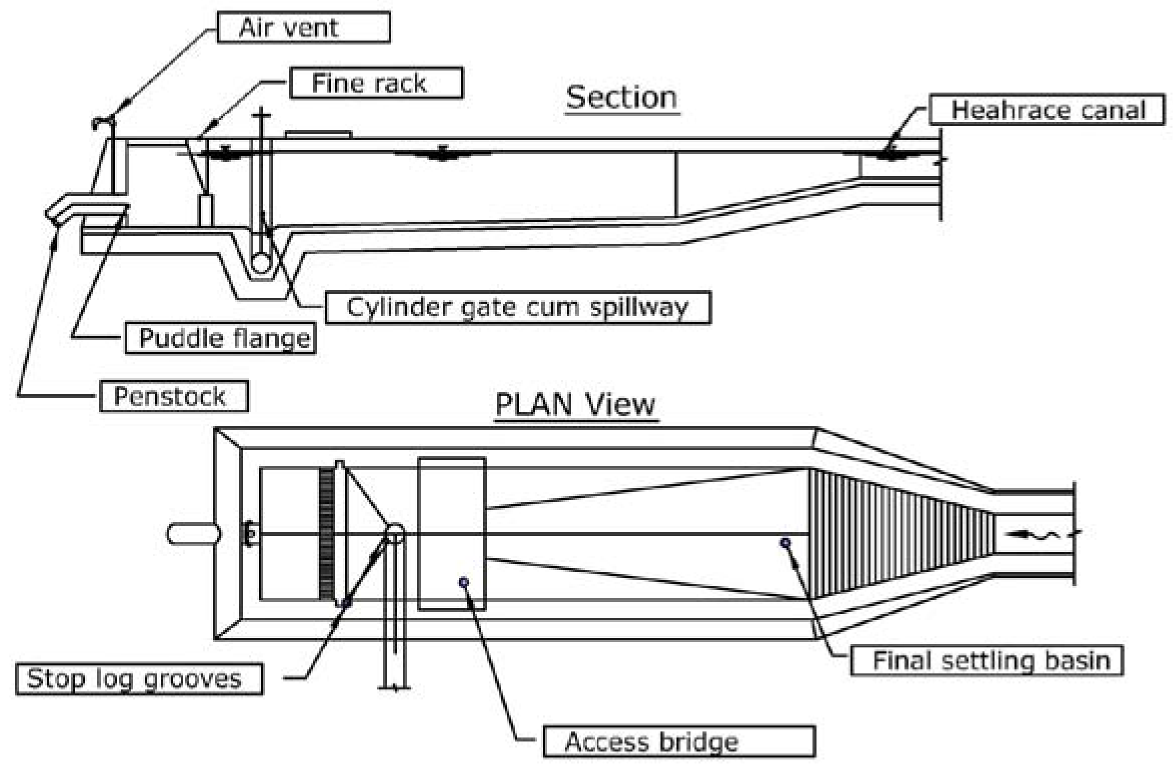


Figure 2.2: A typical forebay

a. The forebay in the form of a stone-masonry or RCC box connects the headrace to the penstock. It shall house an overflow spillway, drain valve or gate to flush sediment and a trash rack to intercept floating debris.

   An overflow spillway and drain valve combined in the form of a cylindrical gate is acceptable as long as its spilling capacity exceeds the scheme design flow by 20%. The permanent overflow spillway and drain shall be continued up to the nearest gully or back to the source stream (as determined by site condition). They may be in the form of conduits or canals and may include energy-dissipating structures.

b. The width of the forebay is determined by the required minimum size of the trash rack. The length of the forebay is determined by the required length of side spillway.

   The top of the penstock entrance shall be adequately submerged (to a depth two to four times the pipe diameter) below the normal water surface in order to avoid vortices, and in areas with heavy freezing, 0.30 m shall be added. The pipe invert shall be at least 0.20 m above the forebay floor.

   Where the forebay acts as a final setting chamber, sediment shall be prevented from entering the penstock by a sill that extends at least up to the top of the penstock.

   Leakage from the forebay shall not exceed 2 l/s in order to avoid soil erosion along the penstock route and around the forebay.

c. Leakage through the forebay headwall along the penstock pipe shall be prohibited by a puddle flange of rubber of MS material embedded in concrete. The minimum thickness of the concrete must be 0.25 m.

2.3.1.6 Penstock

a. The penstock pipe is specified under the hydro-mechanical equipment section. Penstock pipes made of plastic materials such as PVC and HDPE shall be buried at a depth of at least 1.0 m from the ground surface to the top of the pipe.

   In exceptional cases, where excavation is not possible and where vandalism can be excluded, HDPE pipes may be placed above ground. If vandalism is a problem, a steel pipe must be used. Buried plastic pipes should be bedded with granular material to avoid point-loading. The thickness of such bedding should not be less than 0.1 m.

b. Penstock support and saddles for above-ground GI and MS pipes shall be provided along the length of penstock to adequately support the weight of the pipe and water. These supports may be made of stone masonry or concrete.

c. Penstock support structures shall allow for the longitudinal movement of the pipe due to expansion and contraction with minimum friction. To do this, a base plate, along with layers of bitumen asphalt sheets or other materials (plastic or polyethylene sheets) shall be provided along the contact surface between the penstock and its support. Provisions shall be made to drain water (rain or leakage) from the contact surface of the pipe and saddle. Clearance between the pipe and the ground surface shall be at least 0.30 m as a minimum working space for maintenance.

d. Hydraulic forces in bends, contractions, expansions and valves, and forces from friction on saddles and temperature differences as well as from the weight of the pipe and water themselves shall be securely anchored and transmitted into the ground at adequate distances.

e. A breather pipe located within the first meters of the penstock length shall be provided so that air trapped in the penstock during filling can be released. The breather pipe also acts as a vacuum breaker when the penstock inlet gets completely blocked. The size of the breather pipe shall be such that air velocities remain below 30 m/s.

   Air valves or vent pipes shall be provided at all peaks or abrupt changes of slope along the penstock.

2.3.1.7 Powerhouse

a. Theinternal size of the powerhouse shall be adequate for the easy disassembly/assembly of equipment parts and the easy movement of the operator. There shall also be adequate level ground outside the powerhouse to assemble/disassemble equipment.

b. The elevation of the powerhouse shall be well above any known flood water level of the stream. For plant sizes below 30 kW, the design flood shall have a return period of at least 50 years. For plants above 30 kW, the return period shall be 100 years.

c. A powerhouse shall protect the generating and control equipment from adverse weather conditions and prevent access by unauthorized persons. These requirements can be achieved through the construction of a proper powerhouse with a lockable door and solid roof or, alternatively, with a cabinet whose side or top can be opened to access equipment. A semi-open powerhouse is not permitted.

   A surface drainage system shall be provided in and around the powerhouse. The powerhouse shall be ventilated and have windows for adequate daylight and insect screens at all openings. The powerhouse door shall be large enough to allow equipment to be safely installed. Doors should open outward. There shall be a flat and dry area inside or outside the powerhouse to serve as a working space for the repair and maintenance of equipment.

d. Plants 50 kW and above must provide a temporary or permanent hoist for use in turbine/generator installation and repair.

e. GI and MS penstocks as well as corrugated iron roofs and wall cladding shall be connected to the earthing system of the powerhouse.

f. The foundation for the MHP shall be made of reinforced concrete and shall be designed to withstand at least the short-circuit and torque static loading of the generator. Where two units are to be paralleled, the worst-case out-of-phase paralleling torque must be taken into account. Forces from the penstock and turbine isolation valve shall be taken up and transferred into the ground by a powerhouse anchor block made of reinforced concrete. They shall not be loaded onto the turbine casing.

g. Cable ducts in the powerhouse shall be provided with drainage. The powerhouse floor shall be sloped such that it prevents water from entering into the cable ducts.

h. There shall be provision for adequate natural as well as electric lighting inside the powerhouse.

2.3.1.8 Tailrace

a. In pelton and cross-flow installations, the tailrace shall be designed in such a way that the water level is at least 20 cm below the turbine runner at full flow.

b. Where possible, a V-notch weir shall be installed temporarily or permanently for use in verifying the efficiency verification of the generating unit.

c. Energy-dissipating measures shall be provided at the end of the tailrace.

2.3.1.9 Electric Line Poles and Foundations

a. The ground clearance and other details of electrical lines are described under Section 2.3.4.

b. All poles, regardless of material, shall be designed to withstand forces and wind speeds according to Nepal or Indian building codes. Cases of ice load and broken wires shall be taken into account where applicable.

c. The unbalanced force from conductor-tensioning or a change in the direction of the line shall be taken up by guy wires or other approved means.

d. Poles shall be set into the ground at least 0.6 m plus 10% of the pole length.

e. Guy wires are to be anchored in the ground by galvanized steel plates, concrete blocks or timber logs which are buried to a depth that ensure that the guy wire forces are balanced solely by the weight of the soil above the anchor.

f. A top-cap must be mounted on steel poles to prevent corrosion from the inside.

g. For low voltage (LV) overhead lines neutral wire must be placed on top.

Medium Voltage (MV) line poles, wooden poles must be treated. In case of metallic poles, a minimum of 2 mm thick mild steel (MS) galvanized pole or at least 3 mm thick mild steel pole must be primed with red oxide and painted shall be used.

2.3.2 Hydro-Mechanical Equipment

2.3.2.1 Trash Rack

a) A coarse trash rack shall be provided at the intake and upstream of piped headrace sections. Bar spacing should be 50 mm or larger.

b) The penstock inlet shall be protected by a fine trash rack (or a strainer for small flows). At design flow, the water velocity through the trash rack shall be less than 0.5 m/s. The surface area to be considered is the net opening.

c) The trash rack may consist of thinly spaced vertical steel bars or rods or a perforated plate with holes or slots. The distance between bars or the width of holes or slots shall not be larger than

- 0.5 times the nozzle diameter in the case of a pelton turbine with a fixed nozzle
- 0.5 times the maximum clearance in a pelton nozzle with a needle valve, or
- 0.5 times the distance between runner blades for all other turbine types

In the case of a strainer, the ratio between its length and diameter shall not exceed 2:1. A strainer is only allowed in micro-hydropower project installations in combination with a coarse trash rack upstream.

d) The trash rack/strainer shall be able to withstand the full water pressure of complete blockage with maximum water level upstream and no water downstream. It shall be divided into sections to enable manual transportation.

e) The trash rack should be placed at about 70° to the horizontal for ease of cleaning and should end above water level. A suitable cleaning tool must be provided

2.3.2.2 Gates

a) The main intake gates shall be closed during flowing water and emergency situations.

b) Simple sliding gates which lack a spindle or other hoisting device shall not be used for gates larger than 0.5 m wide and 0.5 m deep.

c) Sluice gates shall be able to withstand full water pressure upstream and no water downstream.

2.3.2.3 Penstock

a) Penstock pipe diameters shall be selected in such a way that total head loss at design flow does not exceed 5% of the gross head including bend and other local losses. Exceptions can be made in the case of long penstocks if they are justified on economic grounds.

The pipe-friction factors given by manufacturers shall be increased to allow for deposits and corrosion where applicable. In addition to pipe friction, losses at the trash rack (half covered with floating debris), pipe inlet, pipe connections (beads and couplings), pipe bends, bifurcations and off-takes, valves, and other places shall be considered.

b) The pressure rating of a pipe and its fittings shall be selected to safely accommodate the static pressure head plus the anticipated surge head as determined by the turbine guide-vane/valve closing time of nozzle blockage at any point. For surge computations, the instantaneous flow change due to the blockage of pelton nozzles shall be taken as 20% of full flow per nozzle.

c) No negative or positive pressure wave (water hammer) following valve closure or blockage shall cause damage at any point of the penstock. Ideally, the alignment of the penstock shall be steep after the forebay.

d) In the case of corrosive pipe materials, a corrosion allowance of at least 1.5 mm for plants with a gross head up to 30 m and at least 2 mm for those with a gross head 30 m and above shall be considered (see Painting Systems: Fabrication).

e) Steel penstocks should not be buried unless special corrosion protection is applied (see Construction and Fabrication).

f) Expansion joints shall be provided downstream of each anchor block unless other proven means of accommodating pipe elongation and contraction are used. Very long penstocks might require additional expansion joints.

g) Air valves or vent pipes shall be provided at peaks and at those vertical bends which follow a flat penstock section with a slope of less than 7° to the horizontal.

2.3.2.4 Turbine Safety Valve

a) A turbine safety valve shall be provided in all MHP installations in addition to any adjustable nozzle/needle valve or turbine guide-vanes. Only straight-through valves such as gate or wedge valves or butterfly valves are acceptable.

b) The pressure rating of the safety valve shall be able to withstand the maximum hydraulic pressure, including the anticipated surge pressure.

c) When butterfly or spherical valves are used, a manually operated lever-type actuating mechanism without gearing is not allowed.

d) A bypass consisting of a nominal bore at least 1.5 inch in diameter around the main valve shall be provided to equalize the pressure at pressure heads above 40 m and nominal bores of 250 mm and above.

e) A drainpipe and valve of suitable diameters shall be provided to allow for draining the penstock at closed/blocked main and turbine valves. At pressure heads above 40 m, an orifice plate downstream of the drain valve shall be provided to reduce water velocity and wear in the drain valve.

f) The main valve shall be equipped with an automatic shutdown device to ensure the safe closing down of the turbine upon ballast failure or other faults like a blocked or damaged turbine actuator.

- Equipment must be able to withstand the over-speed which may result in a shutdown situation.
- If, for reasons of cost, no shut-down device is installed, the plant must be equipped with a runaway-proof generator and turbine. The maximum admissible time for allowing a runway condition must be specified and the operator must close the plant down within that time.

2.3.3 Electro-Mechanical Equipment

2.3.3.1 Turbine

The selection and types of turbines with tested efficiencies is available in “Detailed Feasibility Study Guidelines.”

The typical efficiencies of rated output to be used in a feasibility study follow.

- **Pelton**
  - 10 – 50 kW : 70 – 75%
  - 50 – 100 kW : 75 – 80%
- **Cross-flow T-12**
  - 10 – 50 kW : 60 – 72%
  - 50 – 100 kW : 65 – 72%
- **Cross-flow T-15**
  - 10 – 50 kW : 60 – 75%
  - 50 – 100 kW : 70 – 78%
- **Francis** : 80 – 85%

For other turbine types, such as turgos and propellers, a preliminary offer with tested efficiencies shall be made available in the feasibility and detailed design studies.

Pico: *The efficiency of a pico-hydro scheme shall be at least 50% in the case of a pelton runner and at least 40% in the case of a cross-flow runner.*

2.3.3.2 Generator

a) The generator shall be able to continuously supply the desired output in the intended site conditions (altitude, ambient temperature, user load/power factor). The de-rating factors given by the supplier/manufacturer shall be applied.

b) Brush-type self-excited and self-regulated (s.e.s.r) generators shall be allowed in plants up to 10 kW but they should be of the rotating-field type. Brushless s.e.s.r. generators should be used above 10 kW.

c) Generator rotational speeds shall be 1500 rpm (+slip) or lower. In the case of direct coupling, generators with rotational speeds of 750 rpm or 1000 rpm are preferable for economic reasons.

d) If there is no automatic shutdown mechanism for generation faults, the generator shall be rated to withstand the runway speed for a defined time. If automatic shutdown is provided, the generator may be rated only for a short runway speed (e.g. one minute).

e) The largest motor to be started in an isolated system must not exceed 25% of the plant capacity for induction generators and 35% for synchronous generators unless it can be assumed customers with motor loads have soft-starting facilities (star-delta). (Attention: The motor may not be able to start if the base load of 75% or 65% is fully connected).

2.3.3.3 Speed Increaser/Reducer and Couplings

Where there are speed increasers between the turbine and generator synthetic (flat, toothed and V-) belts should be provided. Gear boxes are acceptable only under special circumstances (high gearing ratios). High-quality flat and wedge belts are recommended for full power ranges (10–100kW and above). Standard V-belts are accepted for outputs below 10 kW and may be accepted for higher output in special cases. All pulleys must be manufactured and balanced according to the specifications of the belt supplier.

2.3.3.4 Load Controller-Based Systems

Ballast dump load shall be in the form of water or air heaters which shall have at least the size of the plant (for isolated schemes). In the case of Thyristor-type ELC’s, the ballast load shall be at least 20% higher than the plant capacity.

Water heaters shall be placed in a large water tank (see Sizing: Fabrication section) with water supplied from the penstock or in an enlargement of the tailrace. Heater connections must not be placed outside the powerhouse and must always be accessible. The connector box must be ventilated to avoid condensation and the subsequent corrosion of connections. Air heaters must be installed to prevent fire hazard.

2.3.3.5 Flow-Controlling Governor

A flow-controlling governor is only required in installations with water-saving and storage requirements. As a minimum-flow design is recommended for isolated schemes, flow-controlling governors will not often be an economically feasible option.

2.3.3.6 Control Panel and Switchgear

a. The control panel shall incorporate those instruments and indicators which will enable the plant operator to understand and monitor the operating conditions at all times. At the least, the panel must display generated voltage/frequency, load current, ballast voltage or stepped indicators, and time totalizer. Time totalizer shall clock the generator operating hours, and hence, must be connected before the feeder breaker.

b. The switchgear shall comprise a molded-case circuit breaker (MCCB) for connecting the generator to the isolated grid and automatic disconnection upon faults. Other devices such as contactors or miniature circuit breakers (MCBs) may be used if a suitable means can be provided to achieve automatic tripping by the protection equipment. Static relays or semiconductor switches maybe used in isolated system if these two conditions are met:
   - There is no potential danger when the device is switched off.
   - An additional galvanic separation device is provided for maintenance purposes.

c. The rated breaking capacity of the switch gear shall be higher than the maximum possible fault current. In an isolated single-generator system, this is the short circuit current of the generator. The fault current of the synchronous generator shall be 11 times the nominal current unless otherwise specified by the manufacturer. For induction generators, the fault current shall be twice the normal current unless otherwise specified.

d. The use of a reliable three-phase kWh meter for load is highly recommended if an energy-based tariff system is established.

e. Control panels must not be fitted onto the turbine-generator unit.

2.3.3.7 Protection Equipment

a. **For a synchronous generator**: The protection devices for plants above 10 kW shall include over- and under-voltage, over-current, over- and under-frequency, while plants smaller than 10kW require only over-voltage and over-current protection but under-voltage and over- and under-frequency protections are highly recommended.

b. Three-phase systems require three-phase over-current protection. Other protection devices may be either single- or three-phase.

c. **For induction generators:** Protection devices shall include at least over-voltage. (Using a properly selected over-current breaker in the capacitor circuit may be an acceptable alternative.)

d. Protection against direct lightning strikes shall be taken as a peak current of 20 kA flowing through the arrester. Cable sections must be at least 16 mm^2 copper or its equivalent.

e. The generator shall either be short circuit-protected or shall be de-excited under short circuit. Any short-circuit protection device shall have its maximum current set at not more than 400% of the site-rated current.

f. PH earthing: see section 2.3.5.5

2.3.4 Transmission and Distribution Lines

2.3.4.1 General

a. ACSR and/or aerial bundled cables are to be used for overhead transmission and distribution lines. Cables for underground transmission lines must be armored, but non-armored PVC cables in protective conduit may also be used but only for short distribution lines, service lines, overhead distribution board connections, or in and around a powerhouse.

b. Poles should be sufficiently high to observe the following minimum ground clearances:
   - **230/400-V lines**
     - 4.5 m in off roads
     - 5.5 m along sides of roads
     - 5.8 m across roads
   - **1-kV and 11-kV lines**
     - 5 m in off-road
     - 5.5 m along sides of roads
     - 6 m across roads
   - A **horizontal clearance** of 1.2 m minimum shall be observed in all cases.

c. Underground lines shall be buried at these depths:
   - **LV-lines**
     - 0.5 m along non-cultivated land
     - 0.75 m along cultivated land
   - **MV-lines above 400-V and up to 1-kV:**
     - 0.75 m along non-cultivated land
     - 1 m along cultivated land
   - **MV-line above 1-kV and up to 11-kV**
     - Minimum 0.75 m regardless of location

d. The receiving-end voltage shall be limited to within -10% of the nominal value at any end of the distribution lines. The possibility of raising the sending-end voltage by a maximum 5% may be applied in order to allow for a maximum 15% drop in voltage (power loss not decisive).

e. The receiving-end voltage shall be limited to within -10% of the nominal value (230 V) at any end of the distribution lines. Power loss will not be a limitation as long as receiving- and sending-end voltages are kept within the specified limit by raising the sending-end voltage and provided that neither the generation voltage nor any intermediate voltage level exceeds the values recommended for any electrical component in between.

f. Maximum 11-kV transmission line-to-line voltage level will be permitted. MV-poles must be protected with barbed wire up to at a height of 3 m.

g. Drop-out fuses shall be provided at the medium voltage side. Any transformer and switch-gears along a transmission/distribution line shall be designed for continuous operation at full load.

h. Distribution lines/branches with more than 100 households or 20-kW (whichever is lower) shall have a back-up breaker in a distribution box in order to discriminate faults.

i. Lightning protection shall be provided for all current-carrying conductors at the start and the end of overhead transmission/distribution lines. Moreover, for MV-lines, lightning arresters shall be provided every 1000 m or at all transformers.

   For overhead LV distribution lines, lightning arresters shall be provided every 500 m and the neutral shall be placed on top.

   In the case of lightning-prone areas this neutral shall be connected to the earth approximately every 200 m using 2 m x 1'' GI earth pipe and minimum 20 mm^2 GI wire/strip or ACSR conductor. Lightning shall not be earthed at public places as far as possible.

j. The overload/over-current rating of each of the cascades of breakers along each distribution line shall be selected to cause the selective isolation of overloaded or faulty lines without causing any damage to the cables/wires or nuisance tripping of healthy feeder-line branches. Similarly, the service drop cable (typically 6 mm^2 AL) must be protected against overload and short circuit by a breaker (typically 20 A) in a distribution box. Where adjustable tripping devices are used, these are to be adjusted in order to minimize disturbance in fault conditions (selectivity). The supplier must mention the setting made upon commissioning in his documentation.

k. Overhead service connection shall be PVC cable (concentric or multi-core outdoor type) and the additional voltage drop shall not exceed 2%. Underground service connection shall either be armored cable or PVC cable in a protective conduit.

l. The lightning arrester earthing at the first pole near the powerhouse can be connected to the powerhouse earthing system if the distance is less than 10 m (see section 2.3.5.5). The connecting conductor shall be inserted in a HDPE conduit in the lowest 2.5 m of the pole (but avoid touching) and installed at least 0.5 m underground. If these rules conflict with the national regulations relevant to isolated grid or on-grid applications, the latter are to be applied instead.

2.3.5. Construction and Fabrication

2.3.5.1 Civil Works

a. Excavation in soils and loose rock shall be cut back to a stable slope or retained in position by continuous timbering. The depth of a non-retained vertical trench face is limited to 1.30 m.

b. The backfilling of trenches and other excavations shall be carried out in layers not exceeding 150 mm. While backfilling pipe trenches, special care shall be taken in ramming the fill by the sides of the pipe. To a depth of 300 mm above a pipe, the fill material used shall be free of stones greater than 25 mm in diameter.

c. The thicknesses of walls shall be at least 20 cm for cement mortar masonry (PCC at least 15 cm and RCC at least 10 cm) and at least 50 cm for earth mortar masonry.

d. Cement mortar for all masonry works in contact with flowing water shall be at least 1 part Portland cement to four parts sand (0-4 mm). Cement mortar not in contact with flowing water shall be in the ratio of at least 1:6.

e. Masonry walls should be a minimum of 300 mm thick at the top and increase in thickness so that the bottom is at least 0.65 times the height of the wall (see figure). The wall should be vertical on the

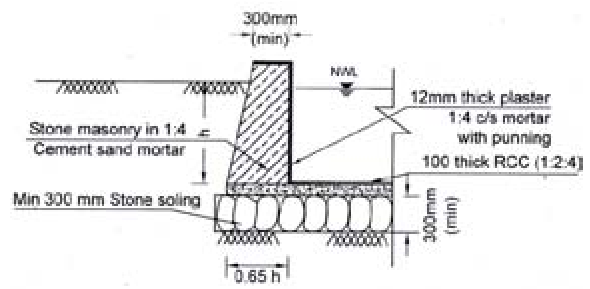


Figure 2.3: Masonry wall section

water-retaining side in order to increase the stability of the structure.

f. The base/slab of the water- retaining structure (settling basin, forebay etc.) should be made of RCC to reduce the problem of unequal settlement.
g. The concrete mixture for structural concrete (C20-1:2:4 to C25-1:1.5:3) shall be used. Concrete mixture for other works shall be 1:3:6 or better with up to 40% plums (stones <300 mm diameter or 1/3 of the least dimension to be concreted).
h. RCC works should use a minimum of 8 mm reinforcement bars at a maximum of 200 mm c/c spacing.
i. All concrete shall be moist-cured for seven days immediately after placement or until covered by further concrete, whichever is shorter.
j. Wire gabion boxes shall be made of galvanized wire of at least 3 mm in diameter with adequately sized selvage (along edges) and binding wires. The height of a box shall not exceed 50 cm. Diaphragm walls separating boxes into cells shall be spaced at maximum of 1 m. Boxes shall be filled by placing one clean, hard angular rubble stone at a time.

2.3.5.2 Hydro-Mechanical Equipment

2.3.5.2.1 Trash Rack

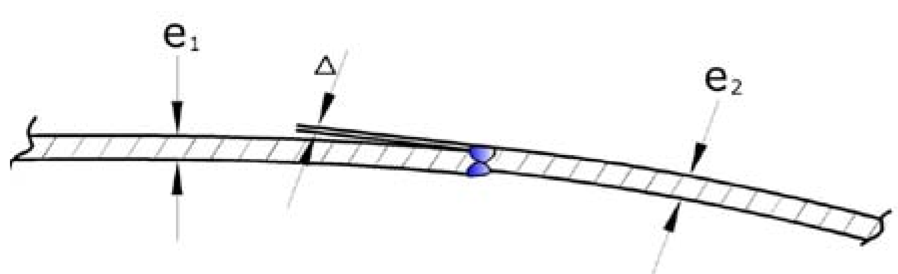
a. Trash racks/strainers should be fabricated so that it is possible to detach them from the concrete/masonry structure for maintenance.
b. Trash racks/strainers shall be corrosion-protected.
c. Galvanizing may be used if no sand blasting is available.
d. Any other method of corrosion protection must be agreed upon separately.

2.3.5.2.2 Sluice Gate

Sluice gates shall be MS welded construction comprising of a leaf and a frame made from angle bars with anchors for embedding in concrete. The minimum thickness of the leaf shall be 6 mm. The design shall be such that the gate leaf can be dismantled for repair or replacement. It shall be possible to lock the handle to avoid undesired opening or closing. The specifications for corrosion protection are identical to those specified for trash racks.

2.3.5.2.3 Penstock

a. Penstock pipes may be metallic or plastic. Steel pipes may be shop-welded or industrial pipes in sections of a length suitable for transportation, erection and connection. The tolerance on shape shall not exceed (0.005D+2) mm when measured on a pipe's outer diameter D. The displacement of the longitudinal joint of rolled and welded pipes shall not exceed e/10+2 mm, where e is the wall thickness of the pipe.



b. For flanged pipes, hydraulic (pressure) testing at the workshop shall be carried out for at least one in five sections for schemes with pressure heads less than 40 m. For higher heads, all sections shall be shop-tested. Test pressure shall be 1.5 times the static working pressure in the field. Non-flanged pipes shall be inspected visually for heads less than 40 m. For heads over 40 m, a certification from the supplier (pressure or x-ray testing) for all sections is required.
c. Steel pipe sections may be joined by site welding, mechanical couplings, bolted flanges or a combination of these. The pressure rating of the mechanical couplings shall be strictly observed.
d. The preparation of the weld seam (like chamfer and clearance) depends on the thickness of the materials and must be according to the relevant regulations. All welds exposed to pressure or forces must be executed by qualified (and certified) welders.
e. The circumferential joints of site-weld mild-steel penstocks shall have a displacement not exceeding e/10+2 mm, where e is the wall thickness of the pipe.

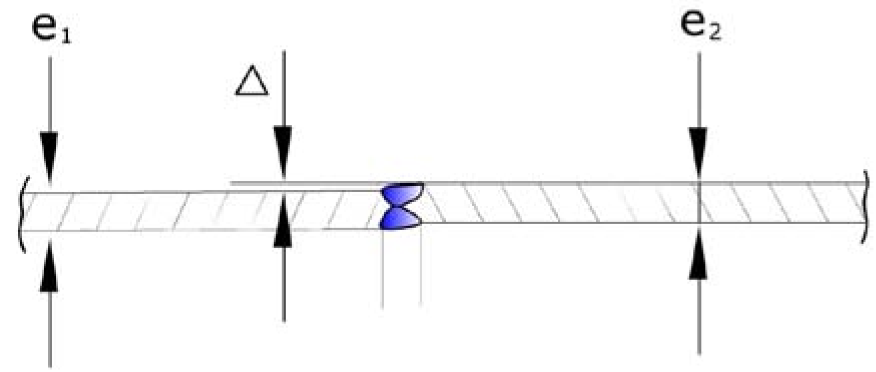


Figure 2.5: A circumferential joint

f. Flanges of MS penstocks shall have machined contact surfaces. The flange and bolt dimensions as well as flange thickness shall be as prescribed in international standards (Indian, DIN/EN or ISO) or as given in an approved structural analysis model.
g. Expansion joints in steel penstocks jointed by site welding may be fabricated from mild steel and may be of the sleeve type with asbestos packing rings and packing gland to stop water leakages. Mechanical couplings with rubber seals may also be used as expansion joints as long as their prescribed working gap limit is not exceeded.
h. Corrosion protection for above-ground steel penstocks shall comprise of one coat of a zinc-rich primer (50 μm dry film thickness) and two finish coats of tar epoxy (180 μm dry film thickness) or the equivalent. For buried steel penstocks, the finish coat shall consist of three coats of tar epoxy of a total dry film thickness of 450 μm. Internal coating is optional for pipe diameters below 300 mm. If no internal pipe surface painting is done, it must be specified in the offer/delivery.
i. Plastic pipes may be joined by butt-welding (HDPE), sockets (PVC) or mechanical couplings. When using butt-welding joints, the pressure rating of the pipe shall be reduced by a factor of 0.9 or less. In addition, the jointing parameters, especially the pressure to be applied when joining the pipe ends shall be controlled in such a way that weld beds protruding from the pipe surface do not exceed 2 mm in height.

2.3.5.2.4 Valve

Valves shall be in accordance with an approved industrial standard. The corrosion protection shall consist of a zinc-rich primer and epoxy-based finish coats of a total film thickness exceeding 250 μm.

2.3.5.3 Electro-mechanical Equipment

2.3.5.3.1 Turbine

a. The design dimensions and materials of all turbine parts and frames must be such that the stresses to which they may be subjected shall not render them liable to distortion, bending, vibration, excessive noise or damage under the maximum loading conditions which may be encountered under service conditions (including transient conditions with pressure surge and generator short-circuit torque). A corrosion allowance of 2 mm shall apply.

b. The turbine must safely withstand the maximum runaway speed on a continuous basis if no automatic shutdown device is installed. If this is not possible or deemed uneconomic, a fail-safe emergency shutdown mechanism must be installed. The required runaway conditions (speed and duration) shall be specified by the supplier of the shutdown mechanism.

c. The turbine runner and associated flow-regulating devices and nozzle shall be made of abrasion-resistant materials chosen so when the guarantee period or 4000 running hours have elapsed (whichever comes first), the loss of material shall not exceed 0.5 mm at any location provided that the de-sanding efficiency of the plant was as specified under this standard.

d. The turbine runner of a plant less than 50 kW or with a rotational speed of less than 600 rpm shall be statically balanced at the works. Turbines with outputs more than 50 kW or rotational speeds greater than 600 rpm shall be dynamically balanced. This requires the use of a balancing machine. For turbine runners with less than 10 kW output, static balancing may suffice for all speeds.

e. The turbine shall have an opening to quickly access the turbine from the powerhouse to allow for the cleaning of the nozzle or guide-vane and runner by trained local operators.

f. All removable parts such as the runner, nozzles, etc. shall have centering/ locating guides so that they can be removed and replaced without resulting in changes in the original alignment. All major parts related to this alignment shall be fixed with pins.

g. A pressure gauge shall be provided at the turbine inlet. The gauge shall be of class 2.5 or better with an air-bleeding valve.

h. The bearing of the turbine shall have a minimum service life of more than 40,000 hours at the intended normal operating condition. This will often be achieved by using grease-lubricated bearings.

i. All bearing seats must be measured with precision tools during manufacturing and assembling and the tolerance must be within the specification of the bearings.

j. All turbine surfaces made of steel shall be protected from corrosion by one coat of a zinc rich primer (50 µm dry film thickness) and two finish coats for tar epoxy (180 µm) or equivalent.

k. An as-built drawing must be prepared by the manufacturer for all parts that will need spares (runner, guide-vane, nozzle etc.). The spare supply shall be provided for 10 years and the drawings must be kept for 15 years.

l. The alignment and clearances for impulse turbines are as follows.

Jet of pelton turbines

- **Maximum misalignment:** 3% of nozzle diameter from nozzle axis to the PCD (pitch circle diameter)
- **Maximum eccentricity between nozzle and needle:** 3% of nozzle diameter

Cross-flow turbines:

- **Clearance runner/nozzle:** > 0.5 mm
- **Clearance guide-vane side plates:** 0.5 mm
- **Clearance guide-vane closed maximum:** 0.3 mm (top and bottom edges)

m. **Leakages:** If the design requires leakages outside of the housing, appropriate measures (drainage) must be used to avoid flooding and water in the powerhouse. The same applies to condensation water on pipes and housing. By no means shall water accumulate on the powerhouse floor and cause electrical danger to the operator, the generator or the control panel. (If all units are grounded, a wet floor will not present any danger.)

n. **Assembly and testing:** The turbine must be fully assembled at the production site. All flanges must be fitted using lithium-based water-resistant grease (to avoid corrosion. A pressure test 1.6 times the rated pressure must be conducted for two hours (the nozzle may be sealed with silicon during the test). To avoid costs and delay at the site it is recommended that the turbine is driven by a motor at the rated speed for 24 hours. The bearing temperature must be below 60 °C during this time. If this test is not to be conducted, it must be specified in the offer.

o. **Packing:** Equipment must be packed in such a way that transport to the site is possible and safe. It may be required to disassemble the equipment before packing so as not to exceed the maximum weight. The heaviest part must be specified in the offer if requested.

p. The turbine must have a waterproof rating plate with at least the following indications:

- Runaway Speed
- Design head
- Design flow
- Nominal speed
- Runaway speed
- Design shaft output
- Year of manufacture
- Name, address, telephone number of the manufacturer

q. Since turbines other than cross-flow and pelton turbines are sensitive to cavitation, the admissible suction head (the elevation from tailrace water level to the lowest point of the turbine runner) must be specified by the supplier in accordance with the site elevation and water temperature.

2.3.5.3.2 Generator

a. Generator efficiency (peak- and part-load and as a function of cos Φ, 1.0 and 0.8) shall be stated by the manufacturer in the quotation and the specifications.

b. The generator shall be able to withstand the environment in which it is installed. Those in enclosed areas should have self-ventilation and air-cooling. Enclosure protection should conform to IP 23 or better. It is recommended that the generator have a class F insulation or higher.

c. The over-speed capability of the generator must correspond to the duration of the runaway conditions of the turbine as specified above.

d. The bearings of the generator shall have a minimum service life of more than 40,000 hours in the intended normal operating condition. This often calls for grease-lubricated bearings.

e. Cable entry should be through glands of the proper size.

f. Generator earthing must be compliant to one of the relevant earthing schemes (TNC four-wire or TNS five-wire connection to the switchgear). Redundant earthing of the metal base frame is required. The base frame and generator shall be in good electrical contact (wired connection or special screws). Normal screws are not suitable due to the painted surfaces.

- **Synchronous Generator**

a. The generator should be of the self-excited type. It shall have black-start capability.

b. Any electronic voltage regulator shall be compatible with the electronic load controller system and shall protect generator excitation winding while operating at under-frequency. Synchronous generators above 10 kW shall have a brushless excitation system of the rotating diode type with an automatic voltage regulator. Suitable measures must be taken to avoid damage to the generator in under-frequency conditions (at full load down to the under-voltage tripping frequency and at no load below this frequency (see also 2.3.3.2).

c. The over load-capacity of a synchronous generator shall be greater than the tripping limit set at the over-load protection device.

d. A surge suppressor shall be provided where necessary to protect electronic and semi-conductor devices used in the generator from voltage surges.

- **Asynchronous Generator**

a. Excitation capacitors selected for an induction generator shall have a sufficient voltage rating to avoid the risk of damage. The voltage rating must be higher than the voltage attained under runway conditions unless the control system guarantees disconnection of both the capacitors and the load in less than 0.2 seconds when the over-speed limit is reached. In this case, the voltage rating must be for the over-speed tripping limit plus a margin covering the additional acceleration in 0.2 seconds.

Motors (IMAG) without modification should only be used for low-cost schemes below 10 kW. Large motors should specifically be modified or designed for generator operation.

Pico-Hydro Set

- *If an induction motor is used as the generator, it shall be a three-phase single-cage type made to work as a single-phase type. (A C-2C delta connection excitation capacitor is recommended.)*
- *Induction generator sizing shall take into account any de-rating to be applied for the given site and load condition. (It is recommended that the generator rating (rated voltage and current) not exceed 80% of the electrical motor rating.*
- *The protection class of an induction generator shall be IP44 or better.*
- *Excitation capacitors shall be continuous-duty type with voltage ratings over 440 V or more than that expected across its terminals in runaway conditions, whichever is the higher operating frequency. The frequency shall be 47.5-57.5Hz (50 Hz +15% / -5%).*

2.3.5.3.3 Speed Increaser/Reducer and Couplings

a. When using direct coupling between the turbine and generator, the short-circuit torque (asymmetric and out-of-phase paralleling in the case of two units) will determine the capacity of the flexible coupling.

b. There must be a protective cover to protect the rotating belt/pulley against accidental contact. The protection must be easily removable for maintenance.

c. Pulleys and couplings shall be at least statically balanced at the workshop before being dispatched to the site.

d. Couplings must be aligned according to supplier specifications, but it should be recalled this specification is not for 24-hour full load operation and that lifetime of a coupling can be considerably improved if the alignment is better than 0.03 mm. Axial and radial displacement of more than 0.3 mm will be rejected.

e. Pulleys must be aligned and belts tensioned according to the manufacturer's instructions.

2.3.5.3.4 Load Controller

a. Ballast heaters must be safely earthed and protected against corrosion.

b. Effective surge protection must be provided, especially for ELC electronics by fast-acting devices such as varistors. These devices shall be installed as close as possible to the electronics.

c. Under all loading conditions, as far as the input power is sufficient to meet the active load connected to the generator, the compounding excitation system shall maintain a steady-state voltage with deviations within ± 5% of the normal value. The ELC, too, should not deviate more than ± 5% of nominal value.

In the case of induction generator load controllers (IGCs), the steady-state voltage and frequency deviations shall be -10% to +5% and -5% to +15% of the normal values respectively, with the load power factor not worse than 0.8 (a low power factor may require adding a capacitor or compensating for the load directly). Prolonged transient conditions due to sudden load changes are not acceptable.

Pico-hydro: *In the case of pico-hydro, under all loading conditions, the steady-state voltage shall be within -10% and +5% of the nominal value. The frequency deviation shall be within -5% and +15% of the nominal value.*

Thyrister/triac or IGBT used in an IGC shall have a continuous current rating at least 20% higher than the rated current of the ballast. The voltage rating shall not be less than 1000 V for Thyrister and IGBT and 700 V for triac.

d. It shall be possible to tune voltage/frequency set points and controller characteristics (stability). These shall be properly set and locked before putting the system into normal operation. Transient voltage and frequency deviations due to sudden load changes shall be no more than 15% and 10% of the nominal values respectively (For flow control systems, higher frequency deviations might be accepted if they are properly specified). It is up to the system designer of the contractor/supplier to coordinate with the manufacturers/suppliers of other components to keep a steady state and ensure that transient voltage and frequency deviations are within the required limits.

e. A ballast heater may be either an immersion or space heater or a combination of both. Provisions shall be made to adequately cool/ventilate ballast heaters in all loading conditions such that the temperature rise is not detrimental to either the heater itself and/ or the objects/surfaces that come in contact with the hot water/ air.

If there is a separate water tank, it should be at least 25 l per kW of plant capacity; and the resistors must be totally submerged by at least 10 cm. In the case of immersion heaters, the heater cable connection compartment shall have holes to continuously drain out any water which seeps in or condenses.

Panel specifications: See the section on control panel and switchgears. Controller panels containing load controllers shall not be mounted on the generator.

Pico-Hydro: *The box containing the capacitor shall not be mounted on the generator, but it may be combined with the IGC box or switchgear and instrumentation panel.*

f. Proper measures must be undertaken to protect the controller against lightning and excessive voltage.

g. All functions of an ELC and IGC except short-circuiting shall be tested at the works.

2.3.5.3.5 Control Panel and Switchgears

a. Mounting panels and cubicles must be made of steel with appropriate painting or aluminum or fireproof isolating materials. Adequate ventilation shall be provided at the bottom and the top. With closed doors, equipment shall comply with IP21 or better standards and shall be insect-proof.

b. Cable entry should be through properly-sized glands if required to avoid damaging the cable. Cable terminations must be marked/numbered in accordance with the wiring diagram that must be supplied. All incoming/outgoing cables must end up at properly rated rail-mounted terminal connectors or standard terminal blocks.

c. All regularly operated emergency and control switches shall be accessible on the front of the panel without opening the door. MCCBs may be located inside a cabinet to avoid undesirable manipulation and to simplify wiring.

d. All electrical components should be able to operate continuously and reliably with output voltages up to the maximum over-voltage protection.

e. The internal layout of the control cabinet shall protect the operator against the accidental touching of phase conductors. At least class IP 10 is required, e.g. it must not be possible to touch the phase conductors with a 50 mm long object (a fist-length) from the front when the door is open. A transparent plastic cover is recommended for the bus-bars.

f. The breaking capacity of the line-break switch/MCCB shall be greater than the short-circuit current at this point.

g. An ELC in isolated mode should ensure that under/over frequency disconnects the load. In addition, under/over voltage protection is recommended to secure the installation and the consumers against AVR malfunction.

h. The following protection devices shall be required for IGC (isolated mode): over-/under-voltage shall disconnect the load; over-voltage shall also disconnect capacitor. Over/under-frequency protection is highly recommended, and might be combined with an emergency shutdown device.

i. Additional filtering might be necessary for over/under-frequency devices to work properly as the ballast generates a higher harmonic content of the voltage than the nominal values. Trip-setting shall be as follows (and apply to synchronous and asynchronous generators where applicable):

- Over-voltage at 115% U_n
- Under-voltage at 80%
- Over-frequency 115% F_n
- Under-frequency 90%

The equipment supplier shall re-check and confirm during fabrication/construction of the control panel that fuses/breakers are of adequate types and sizes and fit in the network of power/control circuits so as to provide optimum protection of the components (generator, cables, instruments, etc.) in the powerhouse.

2.3.5.4 Transmission and Distribution Lines

2.3.5.4.1 General

a. Both indoor and outdoor type transformers are accepted.

b. All metallic poles shall have a top cap (to keep water from entering) and a bottom plate (to keep water from seeping in and to improve stability and prevent toppling) welded to it. Their thicknesses shall be at least 2 mm and 4 mm respectively.

c. Holes/brackets made for insulator fittings shall meet these conditions:

- At least 300 mm conductor-spacing for lines up to 400 V
- At least 400 mm conductor-spacing for a 1000-V line
- At least 600 mm conductor-spacing for lines above 1000 V

d. Underground cable jointing shall be done using jointing kits of proper rating and type. Any terminations or tapping shall be done aboveground in lockable, vermin-proof, terminal or distribution board boxes. Outdoor terminal/distribution board boxes shall be weatherproof and rain protected.

2.3.5.5 Powerhouse Earthing

2.3.5.5.1 Protective Earthing

a. All exposed metal parts of electrical components in the powerhouse including the control panel, generator body, immersion heater tank, metal penstocks as well as corrugated iron roofs and wall cladding shall be interconnected and grounded. All earthing must be connected together to establish equi-potential at a common PE bus bar. Meshed connections increase earthing reliability. To prevent problems with circulating currents, thin conductor sections and large meshes should be avoided (see b).

b. The earthing of the foundation, turbine, generator and transformers must be done with equi-potential wires of no less than 10 mm^2 copper or its equivalent. Pressure compression cable shoes/lugs and their connecting nuts and bolts should be of non-corrosive material. All joints along the earth path shall be brazed.

c. Ground terminals of surge arresters located in the powerhouse can also be connected to the PE bus bar.

2.3.5.5.2 Neutral Earthing

a. Protective earthing for the equipment body and generator neutral shall be separate. The common PE bus bar should be separately connected to the neutral in the control panel at a single point. (TN-S wiring with removable screwed PE-N connections should be used in order to allow insulation tests.)

b. Earth resistance shall be according to valid regulations. This value may be exceeded for neutral earthing if an earth-leakage breaker (fault-current relay) is installed in the powerhouse.

2.3.5.5.3 Earth Electrodes (Earthing System)

a. Earth electrodes together with their earth conductors and other associated underground parts are referred to as the earthing system.

b. This system shall comprise two (or more) earth electrodes which should be reasonably spaced and installed 1 m outside the foundations of the powerhouse. Electrodes must be of one of the following types:

- Horizontal electrodes, each 5 m long with an area of 80 mm^2 galvanized steel (or copper) placed at a depth of 1 m or more.

- Earthing plates of 600 x 600 x 3 mm, usually copper.
- Vertical pipe or rod (galvanized steel or copper) at least 2.5 m long and 50 mm^2 in diameter.

c. It is recommended that an equi-potential loop (solid conductor or band) be provided around the powerhouse, buried at a distance of approximately 1 m from the powerhouse and at a depth of 1 m. The equi-potential loop should be used to connect the various parts of the earthing system.

d. Where reinforced concrete is used in the powerhouse and/or its foundation, the reinforcement steel shall be connected to the earthing system. Allow for at least two electrical connections (placed as wide apart as possible).

e. The section of the underground earthing system conductors must be at least 25 mm^2 copper or its equivalent. To minimize inductance, flat conductors (with the largest possible ratio between width and thickness and thus the biggest surfaces) are preferred. If possible, connections from above the ground to the earthing system shall include screw terminal connections which can be opened in order to measure earthing resistance.

f. Earthing should be done at an adequate depth, use appropriate fill material and include maintenance provisions (soaking, tightening connections, periodically measuring earth resistance) to obtain minimum earth resistance (not more than 10 ohms). Attention should also be paid to the connections to the reinforcement steel, which are made such that humidity will not ooze along the reinforcement steel into the concrete and cause internal rust, which can deteriorate the concrete from within.

g. Possible electrochemical reactions due to incompatible materials must be considered. Particularly, bare steel and copper shall not be mixed for the underground parts of the earthing system.

h. The surge arrester mounted on the first transmission line pole can be connected to the earthing system if the distance is short enough (<10m) and if local conditions (such as the proximity of other houses) allow for it.

2.3.6 Installation and Commissioning

2.3.6.1 Hydro-Mechanical Equipment

a. The completed penstock shall be pressure tested in the field. All joints shall be left open for visual inspection. A test pressure of 1.5 times the static working pressure shall be applied and held for 24 hours. Concrete anchor blocks shall be at least seven days old before any pressure testing is conducted. Welded sections in the concrete block should be tested at the works. Testing can be done separately for each section.

b. Prior to backfilling a final painting check must be performed on all site welds and spots with damaged painting.

c. The penstock shall be flushed prior to conducting turbine test runs, or other suitable methods shall be used to free the penstock of stones and sediment. Care must be taken not to create pressure shocks when flushing. On the other hand, significant flow is often needed to move stones out. (This provision does not apply when inside visual inspection is possible).

d. Penstock filling shall be carried out with a flow rate of about 10% of the design flow.

2.3.6.2 Electro-Mechanical Equipment

a. All power and control cables within the powerhouse shall be laid in covered cable ducts or on cable trays along the wall/ceiling as appropriate. All cables in the powerhouse shall be either armored or placed in protective conduits. All connections must use proper cable shoes and all cable traverses at the generator or control panel must use appropriately sized cable glands to avoid any damage to the insulation.

b. It shall be re-checked and confirmed during installation that fuses/breakers are of adequate type and size and fit in the network of power/control circuits so as to provide optimum protection from overload and short circuits.

c. The following tests should be conducted, duly recorded, and certified by the commissioning engineer. The concrete structures should be at least 28-days-old before they are tested and commissioned.

   1. Checking mechanical and electrical protection systems, generator phase rotation test, insulation tests of cables, generator and transformer, braking system where applicable.
   2. First rotation up to 20%, 50%, and 100% of the rated speed using a tachometer. Disable excitation if possible and make sure that the generator is electrically disconnected.
   3. No-load test with AVR/excitation tests.
   4. Loading tests (load acceptance, load rejection, output test, stability of controller, governor).
   5. **Optional:** Efficiency test of water to wire using a calibrated test ballast and instruments.

d. The efficiencies of any turbine produced in Nepal and generator to be reached during commissioning shall be at most the proportions of the rated flow indicated below unless specified otherwise (Turbine*Generator = Total):

Pelton

Up to 10 kW:	70%* 75% = 52.5%
10 – 50 kW:	75%* 80% = 60%
Above 50 kW:	80%* 85% = 68%

Cross-flow T-15

Up to 10 kW:	65%* 75% = 48.75%
10 – 50 kW:	75%* 80% = 60%
Above 50 kW:	78%* 85% = 66.3%

Francis Turbine 80%* 85% = 72.2%

For imported equipment and other turbine types such as Francis, Kaplan, and propeller, the efficiencies guaranteed by the manufacturer shall apply.

2.3.6.3 Transmission and Distribution Lines

a. Transformers shall be installed in such a way that non-insulated current carrying terminals/conductors are at sufficient height (at least 3.5 m from ground) and/or protected by fencing at sufficient distance to avoid accidental contact.

b. Trees along MV-ACSR overhead lines shall be trimmed to ensure that no falling tree will touch the current carrying conductors.

c. Unless metal distribution boards are grounded, they shall be installed at sufficient height (at least 3.5 m from ground). All distribution boards shall be lockable.

d. Earthing shall be provided to each lightning arrester along electrical lines, transformer body and transformer neutral on the secondary side (of distribution transformers). Earthing may be carried out with the following minimum specifications:

- 600 mm x 600 mm x 3 mm ground plate of copper or GI
- Minimum 50 mm^2 diameter copper or GI conductor
- 20 mm x 2.5 mm copper or GI strip with adequate depth

Fill material and maintenance provisions (soaking, tightening connections, earth resistance measurement) should be chosen in order to achieve the least resistant earth path for fault current and lightning strikes. Earthing methods different from those described above may be adopted as long as the ultimate requirement of effectively protecting people and property can be met by reducing fault voltage to acceptable limits or disconnecting faulty lines as the case may call for. All joints along the earth path shall be able to carry a lightning strike of 20 kA and the section must be at least 16 mm^2 copper or its equivalent. Pressure compression cable shoes/lugs and their connecting nuts and bolts should be made of non-corrosive material.

e. Dead ends and jumper lines of 1-kV and 11-kV overhead lines shall be erected with disc insulators. Shackle insulators of appropriate voltage rating may be used for voltages up to 1-kV in overhead lines. Stay insulators shall be provided on stay sets along 1-kV and for above overhead lines. Pole stays shall be used for all poles set at an angle and at the end of a line.

f. It shall be re-checked and confirmed during installation that fuses/breakers are of adequate type and size and fit in the network of power supply circuits so as to provide supply lines with optimum protection from overload/short circuits without any nuisance tripping of healthy lines.

2.3.7 Operation and Maintenance

2.3.7.1 General

The design engineer must compile a manual comprising a detailed description of the operating procedures and maintenance tasks as well as detailed drawings of all components in Nepali (or English). The following specifications must be included.

a. Addresses and phone numbers of suppliers and sub-suppliers for spare part ordering and guarantee claims

b. Technical descriptions and specifications relevant to O&M

c. Lubrication table and required lubricants for all bearings, gates, etc.

d. Operation instructions for start-up, shutdown, and emergency

e. Checklist for normal operation (bearings, instruments, belts, coupling rubbers, noise, vibrations, etc).

f. Checklist for fault detection and communication with manufacturer

g. Sample (master copy) of operation sheet for the operator (data, instrument readings, observations, reading interval, remarks and signature).

h. Sample (master copy) of maintenance sheet for the operator (lubrication intervals, check intervals, signature).

i. Diagram of power-station with description of all fuses (type, size)

(Note: The supplier's maintenance manual takes precedence over the rules laid out in this manual. The rules in this manual shall be applied only where no indications are given by the supplier.)

2.3.7.2 Civil Works and Hydro-Mechanical Equipment

a. The entire water conveyance system must be drained once a year for cleaning and to check for erosion damage around structures, cracks and settlement in concrete and masonry structures, leaks in canals and basins and corrosion damage.

b. Movable parts such as gates and hoists are to be greased regularly and test-operated at least once a month.

c. Faulty civil structures and damages must be repaired before the damage is aggravated.

d. The water conveyance system and the powerhouse and tailrace areas must be checked thoroughly after flood flows, especially if the plant was shut down during the flood.

e. Sand and gravel traps and the forebay must be checked for sediments at least monthly and flushed if required.

2.3.7.3 Electro-Mechanical Equipment

a. Bearings should be manually checked for vibration and excess temperature at least twice a week unless the control system provides automatic temperature monitoring. The temperature of the bearing housing of turbines and generators should not exceed 60°. The manufacturer's maintenance manual takes precedence over this specification.

b. The play of a bearing must not exceed 0.15% of the shaft diameter. Roller and ball bearings should be checked regularly for abnormal noise during operation. This applies to both turbine and generator.

c. The play of a guide-vane shaft shall not exceed 0.15 mm.

d. All screw connections of the foundation, turbine, generator and other vibrating parts should be checked one week and then four weeks after commissioning or any assembly work. Regular checks shall be made every six months.

e. Abnormal leakages are an indication that a seal or other worn-out parts should be changed. Leakages may also indicate loose screws.

f. Turbines should be dewatered and checked for abrasion damage on runner and nozzle/needle valve or guide-vane once a year.

g. The ventilator grill and air ducts of the generator are to be cleaned at least once every three months.

h. All terminals of the generator, load controller, transformer, etc. are to be checked, cleaned, and tightened where necessary once every three months.

i. The AVR boxes of the generator and controller should be inspected for dust, insects and other contaminants. Cables and channels must regularly be checked for damage by rats, insects or other animals.

j. Spare parts to be supplied by the electro-mechanical equipment supplier shall comprise all required parts to avoid a long-term shutdown of the plant.

It is highly recommended that the supplier have the following parts?

- 10% of bolts
- One set of gaskets and seals
- One set of bearings for the turbine and generator
- Other parts that wear out, like coupling rubbers or belts
- Electrical parts that frequently fail, like the rotating diodes of the generator, fuses, etc.

PART III

REFERENCE STANDARDS FOR ELECTRO-MECHANICAL EQUIPMENT

3.1 Reference standard of Mechanical components

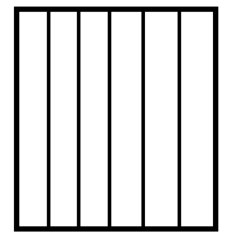
3.1.1 Trash Racks

Applications: Trash racks are used at intake and forebay.

3.1.1.1 Coarse Trash Rack

Applications: Coarse trash racks stops boulder, cobbles, floating logs and tree branches from entering the headrace.

Product description: Coarse trash rack is made of thick steel section to withstand impact from boulders. Trash racks are made of mild steel bars, bracing and frame.



Coarse Trash Rack

Specifications: Spacing of vertical bars – 50 mm or larger

Size: As per design/specification

Weight: Depends upon size

Installation: The bars of the trash racks will be oriented at an angle of 1:3 (horizontal: vertical).

Accessories: Cleaning tools

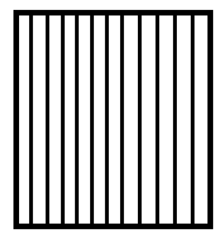
3.1.1.2 Fine Trash Rack

Applications: Fine trash rack stops leaves, twigs and floating materials from entering the penstock.

Product description: Fine trash racks are made of mild steel bars, bracing and frame.

Specifications:

- Spacing of vertical bars - 10 to 20 mm or
- half the nozzle diameter for Pelton turbine and
- half the distance between the runner blades for cross flow turbines



Fine Trash Rack

Size: As per design/specification

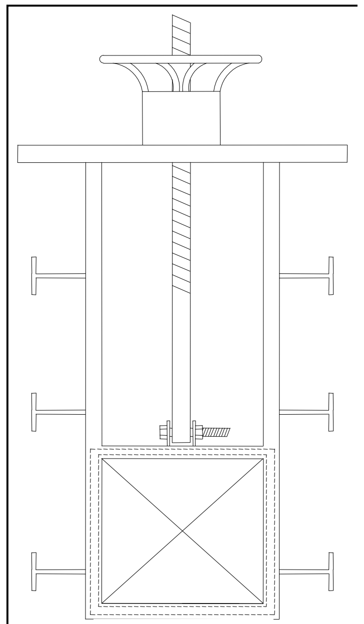
Weight: Depends upon size

Installation: The bars of the trash racks will be oriented at an angle of 1:3 (horizontal: vertical).

Accessories: Cleaning tools

3.1.2 Gates

3.1.2.1 Sluice Gate



Sluice Gate

Applications: Sluice gate is used for flow control in the headrace canal and flushing at de-silting basin and forebay tank.

Product description: Sluice gates are fabricated from mild steel by welding and machining. The gate slides over the guide as it is opened or closed by rotating a spindle.

Specifications: Sluice gate opening depends upon the discharge.

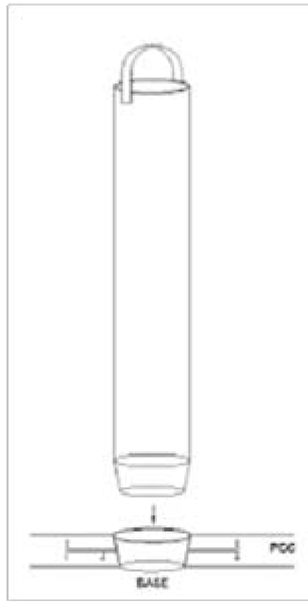
Size: Depends upon the discharge

Weight: Depends upon size

Installation: Generally installed at intake along headrace canal and at side wall of de-silting basin/forebay.

Accessories: Grease, washer

3.1.2.2 Vertical Flush Pipe



Applications: Vertical flush pipe is generally used to remove the stored sediment in the settling basin or a fore-bay.

Product description: This uses detachable vertical mild steel pipe.

Specifications: The diameter depends upon the discharge.

Size: Depends upon discharge and height of tank.

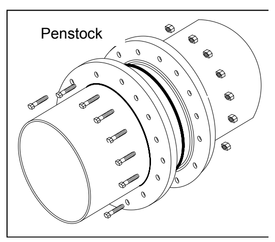
Weight: Depends upon size

Installation: Generally installed at settling area of de-silting basin/fore bay.

3.1.3 Penstock Pipe & Accessories

3.1.3.1 Penstock Pipe (MS)

Applications: The Penstock is a pipe that conveys water under pressure from fore bay to the turbine. Product description: Penstock pipes are fabricated from mild steel by welding.



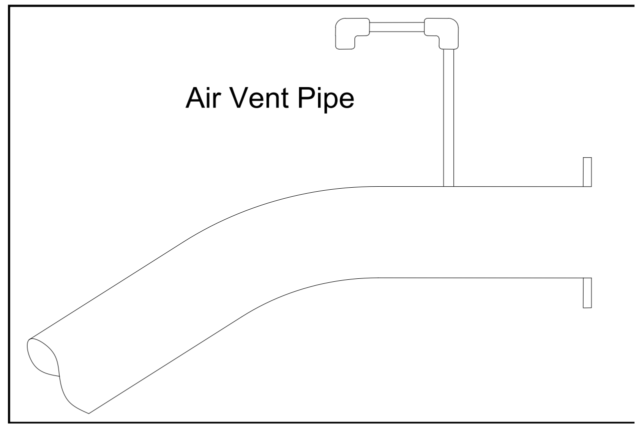
Specifications: The diameter and thickness depend upon head and discharge.

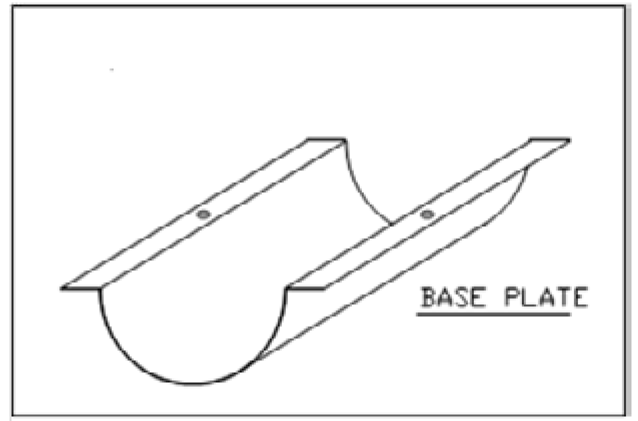
Size: Depends upon discharge

Weight: Depends upon size

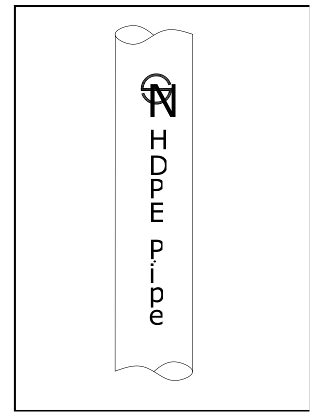
Installation: Penstocks are generally installed over ground from fore bay to power house.

Accessories: **Base plate, C-clamp, Nut, bolts, gasket and air vent**.





3.1.3.2 HDPE Pipe



Applications: The HDPE pipe is a pipe that conveys water in terms of headrace canal and or penstock pipe.

Product description: HDPE pipes are fabricated from high-density polyethylene.

Specifications: The diameter and thickness depend upon the discharge and head.

Weight: Depends upon size

Quality compliance/Certification: NS mark

Installation: HDPE pipes are generally installed underground about 1 meter bellow the original ground level.

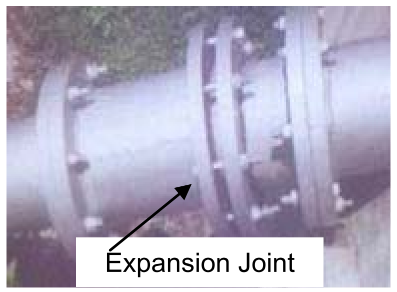
Accessories: Butt welding joints or nut, bolts and gasket.

Standard sizes of HDPE pipes

Outside Dia. in mm	2.5 kg/cm^2	4 kg/cm^2	6 kg/cm^2	10 kg/cm^2
	Avg. weight kg/m	Avg. weight kg/m	Avg. weight kg/m	Avg. weight kg/m
16mm	-	-	-	0.092
20mm	-	-	-	0.134
25mm	-	-	-	0.202
32mm	-	-	0.226	0.334
40mm	-	0.251	0.35	0.514
50mm	-	0.378	0.542	0.796
63mm	0.403	0.585	0.85	1.296
75mm	0.557	0.846	1.191	1.782

90mm	0.799	1.220	1.717	2.566
110mm	1.185	1.703	2.545	3.801
125mm	1.53	2.289	3.293	4.962
140mm	1.897	2.901	4.15	6.209
160mm	2.453	3.773	5.355	8.079
180mm	3.148	4.762	6.8	10256
200mm	3.875	5.89	8.391	12.62
225mm	4.822	7.445	10.544	16.014
250mm	6.012	9.187	13.041	19.757
280mm	7.471	11.455	16.327	24.708
315mm	9.417	14.508	20.694	31.16
355mm	11.957	18.382	26.243	39.635
400mm	15.221	23.343	33.309	50.344
450mm	19.163	29.251	42.065	63.598
500mm	23.836	36.406	51.90	78.735
560mm	30.358	46.648	66.445	-
630mm	38.553	59.049	84.132	-

3.1.4 Expansion Joint



Applications: To accommodate the change in length of mild steel pipes of various lengths and temperature ranges.

Product description: Expansion joints are fabricated from mild steel by welding.

Specifications: The diameter and thickness depend upon discharge and head.

Size: Depends upon discharge and pressure head.

Weight: Depends upon size

Installation Expansion Joints are installed below the anchor blocks and inside the power house.

3.1.5 Pressure Gauge

Applications: Pressure gauge measures pressure head at the end section of the penstock.

Product description: -

Specifications: The size of the pressure gauge depends upon the gross head of the scheme

Size: -

Weight: Depends upon size

Installation: Pressure gauge is installed just after the turbine or on the top of the adapter.

Accessories: -

3.1.6 Valve

3.1.6.1 Butterfly Valve

Applications: The Butterfly valve controls flow in penstock pipes or nozzle.

Product description: Butterfly valves are fabricated from cast iron, mild steel and alloy of aluminum.

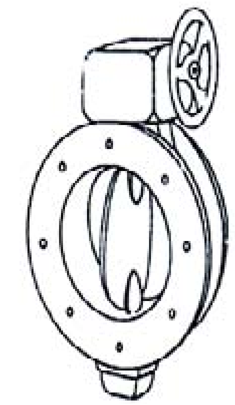
Specifications: The diameter is depends upon the head and discharge.

Size: As per table below

Weight: Depends upon size

Installation: The butterfly valve is installed in penstock end section to connect with the turbine manifold.

Accessories: Nut, bolts, grease and gasket.



Butterfly Valve

Standard size of gear type Butterfly valve

SN	Diameters
1	4” (100 mm)
2	5” (125 mm)
3	6” (150 mm)
4	8” (200 mm)
5	10” (250 mm)
6	12” (300 mm)
7	14” (350 mm)
8	16” (400 mm)
9	18” (450 mm)
10	20” (500 mm)

3.1.6.2 Gate Valve

Applications: The gate valve controls the flow of water into the turbine. This type of valve is used mostly in high head MHP (Generally > 150 m).

Product description: Gate valves are fabricated from cast iron, mild steel and brass.

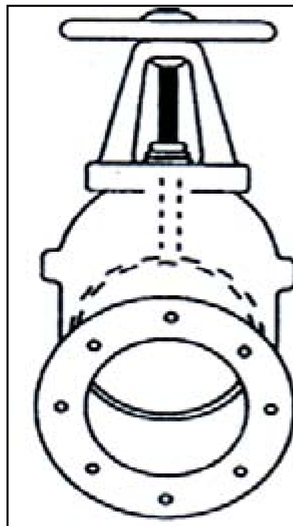
Specifications: The diameter depends upon head and discharge.

Size: 75mm- 500 mm

Weight: 10- 80 kg

Installation: The gate valve is installed in penstock end section to connect with the turbine manifold.

Accessories: Nut, bolts, grease and gasket.



Gate Valve

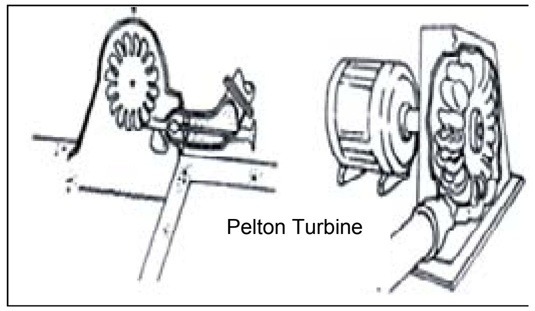
3.1.7 Turbine and Accessories

3.1.7.1 Pelton Turbine

Applications: The Pelton turbine converts the energy of falling water into mechanical energy.

Product description: The Pelton turbine is fabricated from mild steel by casting, welding and machining.

Specifications: The size of the turbine depends upon the head and discharge.



Pelton Turbine

Size: 150 -500 PCD Single Jet and Double Jet

Weight: 100-1400 kg

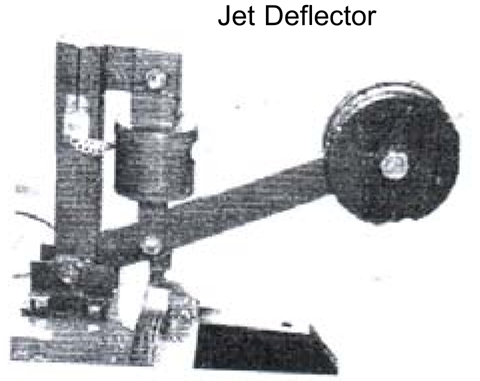
Installation: Pelton turbine is installed inside the power house over the base frame.

Accessories: Jet Deflectors Nut, bolts, base frame, adopter bearings, gasket and hand tools.

Standard size of Pelton Turbines

SN	Runner PCD in mm	Weight (kg)
1	150	100-150
2	200	450-470
3	250	500-550
4	300	560-600
5	350	600-650
6	400	700-750
7	450	800-850
8	500	900-1000

Jet Deflector



3.1.7.2 Cross Flow Turbine

Applications: The Cross flow Turbine converts the energy of falling water into mechanical energy.

Product description: The turbine is fabricated from mild steel by welding and machining.

Specifications: The size of the turbine depends upon the head and discharge. See below.

Size: Depends upon the head and flow.

Weight: Depends upon size

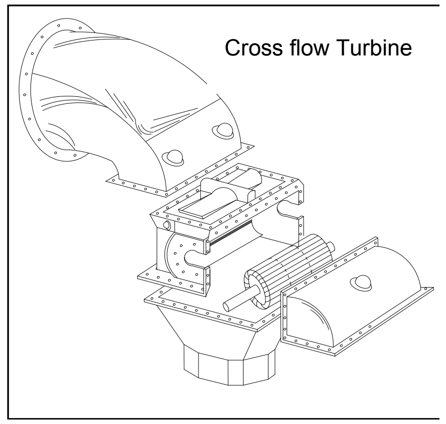
Installation: Turbine is generally installed inside the power house over the base frame.

Accessories: Nut, bolts, base frame, adopter, bearings, gasket and hand tools.

Standard size of Cross flow Turbine, Runner Diameter up to 300 mm

S.N	Width of Turbine	Weight (kg)
1	Up to 100 mm	125-150
2	101 to 200 mm	150-190
3	201 to 300 mm	191-230
4	301 to 400 mm	231-250
5	401 to 500 mm	251-280
6	601 to 800 mm	281-300
7	801 to 1000 mm	301-385

Cross flow Turbine



3.1.8 Power Transmission System (Driving System)

3.1.8.1 Pulley and Belt

Applications: The pulleys and belts will transmit power from turbine to generator shaft in the required direction and required speed.

Product description: The pulleys are made from cast iron and mild steel. The belts are made from rubber and nylon material.

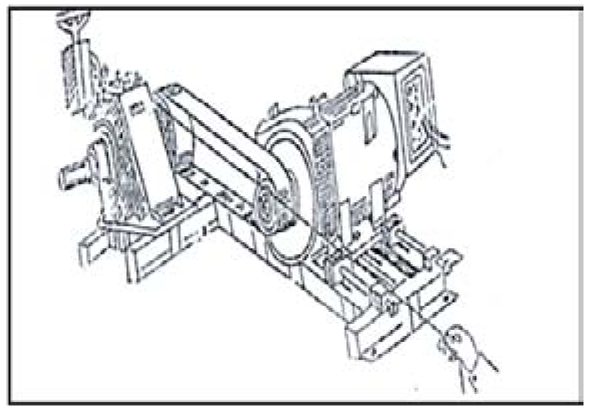
Specifications: The size of the pulley and belt depends upon transmitting power and distance. *See below.*

Size: Depends upon design

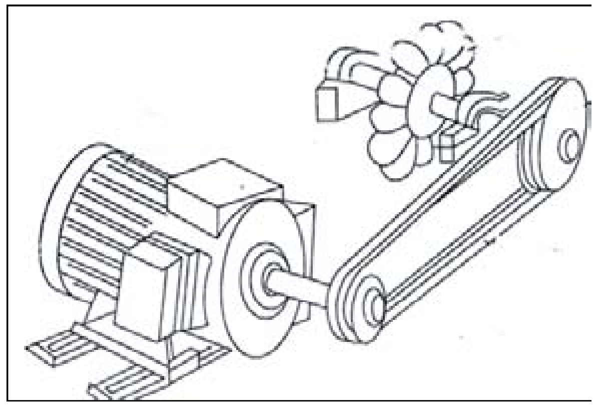
Weight: Depends upon size

Installation: Pulley is generally installed on the shaft and the belt is kept over the pulley.

Accessories: Nut, bolts, grease and hand tools.



Flat Pulley and Belt System

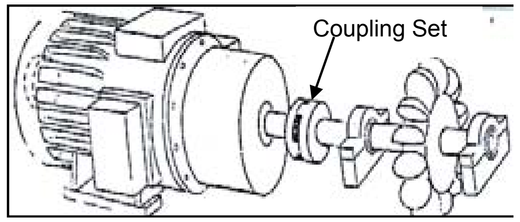


V Pulley and Belt System

Types, Applications Range of V-belt and Habasit belt

Type/size	Application range, kW	Diameter in inch	Quality certification
V Belt	Up to 20 kW	6,8,10,12,14,16,18,20,22,24	ISI
Habasit belt	10-100 kW	6,8,10,12,14,16,18,20,22,24	-

3.1.8.2 *Direct Coupling*



Applications: The system will transmit power from turbine to generator shaft in the required direction and required speed.

Product description: The coupling sets are made from cast iron, mild steel nylon and rubber material.

Specifications: The sizes of the coupling sets are depend upon transmitting power.

Size: Depends upon the Size

Weight: Depends upon size

Installation: Directly connected to generator and turbine shaft by the help of rubber bush.

Accessories: Nut, bolts, and hand tools.

Range for Fenaflex Couplings

Type/size	Power, kW @ 100 RPM	Country of origin/manuf.	QC
F-40	0.22	India Fenaflex Coupling	ISI
F-45	0.39	India Fenaflex Coupling	ISI
F-50	0.56	India Fenaflex Coupling	ISI
F-60	1.11	India Fenaflex Coupling	ISI
F-80	1.70	India Fenaflex Coupling	ISI
F-90	2.65	India Fenaflex Coupling	ISI
F-100	3.20	India Fenaflex Coupling	ISI
F-110	5.29	India Fenaflex Coupling	ISI
F-120	7.46	India Fenaflex Coupling	ISI

SKF Bearing

Inner dia. (mm)	Outer dia. (mm)	Width (mm)	Bearing no.
45	85	23	22209CCK
50	90	23	22210CCK
55	100	25	22211CCK
60	110	28	22212CCK
65	120	31	22213CCK
70	125	31	22214CCK
75	130	31	22215CCK
80	140	33	22216CCK
85	150	36	22217CCK
90	160	40	22218CCK
95	170	43	22219CCK
100	180	46	22220CCK

Source: M/S Maliram Shivkumar, Authorised Distributor SKF

3.2 Reference standard of Electrical components

3.2.1 Generation

3.2.1.1 Induction Generators

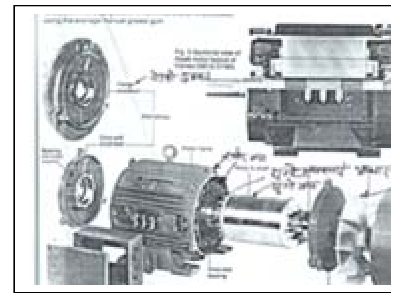
Applications: Induction generators are used for generation of electrical power up to 10 kW.

Product description: It comprises of squirrel cage induction motor with excitation capacitor.

Single phase IG: A three-phase, six terminal, originally star connected 400/380 volt motor reconnected as 230/210 volt delta connected motor, with excitation capacitance connected in C-2C configuration.

Three phase IG: Either delta or star connected motors can be used.

Induction Motors



Applications: Induction motors are integral part of induction generators.

Product description: Squirrel cage three phase motors in 220 V delta/380 V star connections.

Specifications:

Type	cage, TEFV
Voltage	220 V delta/380 V star ±5%
Frequency	50Hz ±3%
Efficiency	64-94% depending on the size of the motor
Insulation Class	B
Environment protection	IP44

Size: Available in different capacity.

Weight: -

Quality compliance/Certification: BS-5000

Installation: Horizontal or vertical with turbine in powerhouse.

Accessories: Bearing, fan

Reference standard of Induction Motors

Frame size	Power (kW)	Speed (rpm)	Approx. weight (kg)
PM 63	0.1	1400	
PM 80	0.4	1400	
PM 80	0.4	900	
PM 80	0.55	1400	
PM 80	0.55	900	
PM 80	0.75	1400	
PM 90S	0.75	920	
PM 90	1.1	1410	13
PM 90L	1.1	900	
PM 90 L	1.5	1420	16
PM 100L	1.5	940	

PM 100L	2.2	1420	21
PM112M	2.2	945	
100LB	3	1420	24
112M	4	1420	31
PM 112M	3.7	1420	
PM 132S	3.7	950	
PM132S	5.5	1445	40
PM132M	5.5	955	
PM 132M	7.5	1450	48
PM 160M	7.5	970	
PM160M	9.3	1450	
PM 160L	9.3	970	
SC 160L	11	1460	72
PM 160 L	11	970	
SC 160L	15	1470	87
SC 180L	15	970	
SC 180M	18.5	1460	
SC 200L	18.5	970	
SC 180L	22	1460	
SC 200L	22	970	
SC 200L	30	1470	
SC 225M	30	970	
SC 225S	37	1465	
SC 250M	37	975	
SC 225M	45	1465	
SC 280S	45	975	
SC 250M	55	1470	
SC 280M	55	985	
SC 280S	75	1480	
SC 315S	75	985	
SC 280M	90	1480	
SC 315M	90	985	
SC 315S	110	1480	
SC 315M	110	985	
SC 315M	125	1480	
SC 315L	125	985	
SC 315M	132	1480	
SCX 315L	132	985	
SC 315L	150	1480	
SCX 355X	150	985	

Capacitors

Applications: Capacitors provide excitation to the induction motors.

Product description: Plastic cased or aluminum self-healing polypropylene motor run capacitors are used. These are also available with stud mounting in aluminum case.

Specifications:

Max. continuous voltage 440VAC 50Hz

Capacitance tolerance ±5%

Temperature range 85°C

Size: Available in different capacity. *See below.*

Weight: -

Quality compliance/Certification: IS 2993 'SH' MPP, IS1526

Installation: C-2C connection for single phase generators star/delta for three phase generators

Accessories: -

Reference standard size of Capacitors

Value of capacitor (µF): 1.5, 2, 2.5, 3, 3.15, 4, 5, 10, 12.5, 15, 20, 25, 30, 36, 40, 45, 50, 72

3.2.1.2 Synchronous Generators

Applications: Synchronous Generators are used for generation of electrical power.

Product description: It is available in two types brush type and brushless type.

Brushed Type: Generators consists of a stator with field coils mounted on pole shoes, a rotor with a distributed armature winding and a static excitation unit mounted on to the non-drive end. Excitation unit derives its supply from the generator output itself. The excitation unit comprising a compounding transformer, capacitors and a bridge rectifier provides excitation power required by the generators.

Brushless type: Generators consist of a stator with a distributed winding, a rotor with wound salient poles and a rotating armature brushless AC exciter. The excitation regulator holds the output voltage constant and provides fast response to sudden load changes.

Brush Type Synchronous Generators

Applications: Electrical Power Generation.

Product description: Rotating armature, self-excited and self-regulated, brushed type, CM series

Specifications:

Type: Brush type, Slip ring type

Brush Type Synchronous Generator

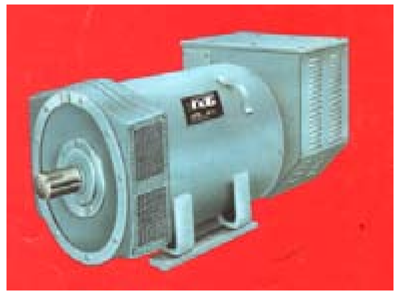
Voltage: 415V 3-phase and 240V for single phase, 0.8pf
Frequency: 50Hz
Efficiency: 76-88% for 1-phase, 82-94% for 3-phase
Speed: 1500 rpm, 50Hz
Connection: Star for 3-phase
Insulation Class: F
Environment protection: IP23
Size: Available in different capacity
Weight: Depends upon size
Quality compliance/Certification: BS-5000 part 99, IS4722
Installation: Horizontal, direct coupling or belt driven.
Accessories: Carbon brushes

Reference standard size of Brush Type Synchronous Generators

Frame size	Power (kVA)	Approx. Weight (kg)
G2S 132MA	5	
G2S 132MC	6	
G2S 132MD	7.5	
G2S 132LC	10	
G2S 160SC	12.5	
G2S 160MA	15	
G2S 132MR	6.5	
G2S 132MA	7.5	
G2S 132MC	10	
G2S 132LC	15	
G2S 160SC	20	
G2S 160MA	25	
G2S 160MB	30	
G2S 200SA	40	246
G2S 200SB	45	246
G2S 200SB	50	246
NB 180M1	20	216
NB 180L1	25	216
NB 200S	30	246
NB 200M	40	272
NB 200L	45	300
NB 200L	50	300

Brushless Type Synchronous Generators

Applications: Electrical Power Generation.
Product description: Rotating field, self-excited and self-regulated, brush less



Brushless Generator

Specifications:

- Type: Brushless type
- Voltage: 415V 3-phase and 240V For single phase, 0.8pf
- Frequency: 50Hz
- Efficiency: 77-78% for 1-phase, 84.5-90.3% for 3-phase
- Speed: 1500 rpm, 50Hz
- Connection: Star for 3-phase
- Insulation Class: F

Environment protection: IP21
Size: Available in different capacity
Weight: *Depends upon size*
Quality compliance/Certification: BS-4999/1977
Installation: Horizontal, direct coupling or belt driven
Accessories: AVR

Reference standard size for Brushless Type Synchronous Generators

Frame size	Power (kVA)	Approx. Weight (kg)
Single Phase		
G2R 160SB	12.5	215
G2R 160SC	15	225
G2R 160SC	20	275
G2R 160SC	26	305
G2R 160SC	30	360
G2R 160SC	40	385
Three Phase		
G2R 160SA	15	145
G2R 160SB	20	170
G2R 160SC	25	210
G2R 160MA	30	230
G2R 160MB	32.5	230
G2R 160MB	35	250
G2R 160MB	40	310
G2R 200SA	45	310

G2R 200SB	50	340
G2R 200SB	56	340
G2R 200SD	63	385
G2R 200SD	70	410
G2R 200SD	75	440
G2R 200MB	83	450
	90	485
G2R 200MD	100	540
NRF 250/2	100	645
NRF 250/3	110	645
NRF 250/4	125	530
NRF 280/1	140	630
NRF 280/1	150	680
NRF 280/1	160	750
NRF 280/2	180	755
NRF 280/2	200	805

AVR/Compounding Transformer

Applications: It keeps the voltage output of synchronous generator constant.

Product description: For providing excitation to AC exciter and ultimately to synchronous generator

Specifications:

- Input voltage 48V and 110V, 50 Hz
- Output current 3A max.
- Voltage regulation ±2.5%
- Voltage suppresser (MOV) 75V to 175V
- Soft starting feature

Size: Depends upon the size of generator.

Weight: Approximately 1-3 kg

Installation: Installed in the synchronous generator

3.2.2 Protection System

3.2.2.1 Load Controllers

Applications: It is used to maintain voltage and frequency constant and keeps the load constant.

Product description: Induction generator controller (IGC) Electronic Load Controller (ELC)

Induction Generator Controller

Applications: It is used to maintain constant load to the Induction Generator.

Product description: Electronic circuit board, used along with the ballast load.

Specifications:

Type: Two types, (NTU Design, and locally assembled)

Voltage: 415V 3-phase and 240V for single phase

Frequency: 50Hz Voltage ±2%

Size: Available in different capacity. *See below.*

Weight: 1-2 kg (board only); 25-50 kg (including panel box).

Quality compliance/Certification: BS-4999/1977

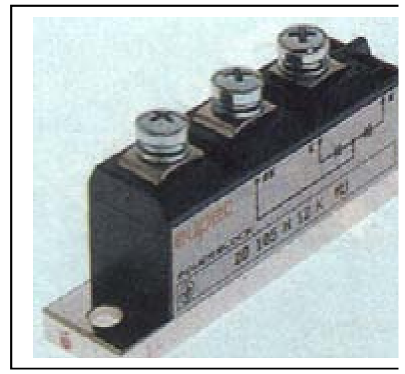
Installation: Mounted in the panel board in the power house of the plant.

Accessories: Thyristors, IGC Board, 18-0-18 transformer etc

Reference standard size for Induction Generator Controllers

SN	Capacity/Phase
1	IGC-P-L 1kW /1ph/220V
2	IGC-N 1kW /1ph/220V
3	IGC-P-L 2kW/1ph/220V
4	IGC-N 2kW/1ph/220V
5	IGC-P-H 3 & 4kW/1ph/220V
6	IGC-P-H 5 & 6kW/1ph/220V
7	IGC-P-H 7 & 8kW/1ph/220V
8	IGC-P-H 9 & 10kW/1ph/380V
9	IGC-P-H 5kW/3ph/380V
10	IGC-P-H 10kW/3ph/380V

IGC Board



NTU Pico-IGC board (single-phase)

Preesu IGC board (single-phase)

NTU standard IGC board

Preesu ELC (three-phase)

Thyristors

Specifications: GP-25, GP-46

Electronic Load Controller

Applications: It is used to maintain constant load to the Synchronous Generator.

Product description: Electronic circuit board, used along with the ballast load.

Specifications:

Type: Two types, (NTU Design, and locally assembled)

Voltage: 415V 3-phase and 240V for single phase

Frequency: 50Hz , Frequency Regulation ± 0.5-1%

Size: Available in different capacity.

Weight: 45-75 kg including panel box
Installation: Mounted in the panel board in the power house of the plant.
Accessories: Thyristors, ELC Board etc

Reference standard size for Electronic Load Controller

SN	Capacity/Phase
1	Up to 4kW/1ph/220V
2	4kW-8kW/1ph/220V
3	10kW - 15kW/3ph/380V
4	16kW - 20kW/3ph/380V
5	21kW - 25kW/3ph/380V
6	26kW - 35kW/3ph/380V
7	36kW - 45 kW/3ph/380V
8	46kW - 50kW/3ph/380V
9	51kW - 60kW/3ph/380V
10	61kW - 70kW/3ph/380V
11	71kW - 75kW /3ph/380V
12	76kW - 100kW /3ph/380V

OV/UV and OF/UF Protection System

Specification:
Input Voltage Range 140…300Vac
Output Relay Contact 250V/5A
Internal Power supply 12V+regulated
Low-voltage trip level 150…230Vac (adjustable)
High-voltage trip level 230…290Vac (adjustable)
Low-frequency trip level 35…50Hz (adjustable)
High-frequency trip level 50…65Hz (adjustable)
Trip indication 4 LEDs
Voltage trip delay 1s
Frequency trip delay 1.5s
Structure 3 Modules in PCB card

ELC Extension

Applications: It is used to switch the fixed Ballast load.
Product description: Reduced Thyristor, Ballast load to decrease the size of ELC.
Specifications:
Voltage: 220V
Sensing: Three phase
Output: 220V, 5A rated potential free contact
Weight: Approximately 1-1.5 kg board only

3.2.2.2 Ballast Tank and Heaters

Applications: It is used as a dummy load to work along with ELC or IGC to maintain constant load to the generator.
Product description: It is available as water immersion type or air heater. Water Emersion heater is used with Ballast tanks
Specifications:
Voltage: 220V
Sensing: Single Phase
Size: Available in different capacity.
Weight: Varies with size; 40-100 kg

Ballast Heater with Tanks

Specifications:
Thickness of the metal sheet: 3mm
Environment protection: black Japan paint

Reference standard size for Water Immersion Heater

SN	Specification
1	Water Heater with tank 3 kW/220V/1ph
2	Water Heater with tank 6 kW/220V/1ph
3	Water Heater with tank 9 kW/220V/1ph
4	Water Heater with tank 12 kW/220V/3ph
5	Water Heater with tank 18 kW/220V/3ph
6	Water Heater with tank 36 kW/220V/3ph
7	Water Heater with tank 54 kW/220V/3ph
8	Water Heater with tank 72 kW/220V/3ph
9	Water Heater with tank 100 kW/220V/3ph
10	Water Heater with tank 120 kW/220V/3ph

Air Heaters

Product Description: Manufactured out of chrome nickel steel tubing having mild steel fins to increase the surface draught area. Suitable for forced air heating air ducts, blower heaters, re-circulating ovens and other industrial process requiring heated air blast for drying, heat treating, annealing and for localized uniform heating of surfaces.
Specifications:
Voltage rating: 230V
Length: 250-1200mm
Quality compliance/Certification: IS 4159

Watt	500	750	1000	1500	2000	3000

Immersion Heater

Product Description: Manufactured out of nickel-plated copper tubing fitted with a metallic terminal cap. Suitable for heating water in industrial hot water baths, water-jacketed apparatus, tanks, side arm circulating process etc.

Specifications:

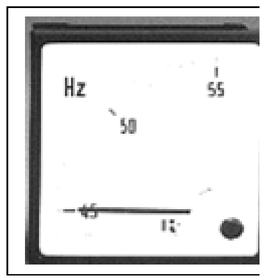
Voltage rating 230V/400V

Quality compliance/Certification: IS 4159

Reference Standard size

Watt	Depth of Immersion
1000	220mm
2000	220mm
3000	220mm
4000	260mm
5000	320mm
6000	380mm
9000	610mm

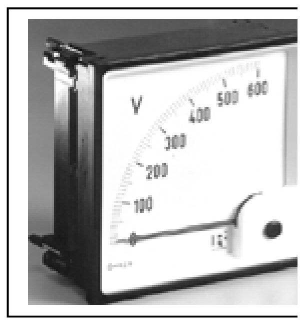
3.2.2.3 Meters, Main Switch and MCCB **Meters**

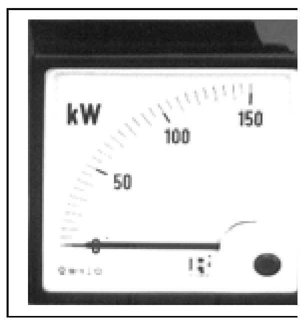


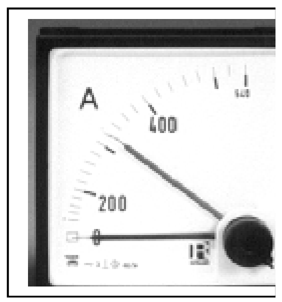
Applications: These are used in the main panel board of the power plant. Meter shows the generated frequency, voltage, current, power and energy from the generator as well as the load.

Specifications:-

Size: Available in different ranges







Main Switch

Applications: Main switch are used to isolate the load from the generator for maintenance purposes. Available in different sizes

Specifications:

Rated Voltage: 215V, 415V

Insulation voltage: 500V

No. of poles: three poles with isolable neutral

Quality compliance/Certification: IS4064

Type:

Rewire-able type for single phase

Rating (A): 20, 32, 63

HRC type switch fuse unit for 3-phase

Rating (A): 32, 63, 100

MCCB

Applications: Used to isolate the system and trip in fault conditions.

Specifications:

Operating voltage 415-550V

Mechanical life 30000 operations

Insulation voltage 750V

Operating temperature -5°C to +40°C

No of pole 3

Quality compliance/Certification: IS8828, IEC 898

Reference standard of MCCB

Type	Current rating (A)	Breaking capacity (kA)
DV100	32	10
	50	10
	63	10
	80	10
	100	10
DV125	25-32	30
	32-40	30
	40-50	30
	50-63	30
	63-80	30
	80-100	30
	100-125	30
DV160	128-160	30
DV200	160-200	30
DG250	200-250	25
DV400	250-300	25

Residual Current Devices (RCD)

Applications: It is used to sense the earth leakage current and isolate the system in fault conditions. Also known as Earth Leakage Circuit Breaker (ELCB)Product Description: RCCB and ELCB are the available

RCCB: Residual-current Circuit Breaker

ELCB: Earth Leakage Circuit Breaker

Specifications:

Voltage rating 240V, 50Hz

Tripping time 10-30msec

Quality compliance/Certification: IEC269, IS 12640

Reference standard of RCD

Rated fault current (mA)	Rated current (A)	No of poles
30	25	2
30	40	2
100	40	2
30/100	63	2
30/100	25	4
30/100	40	4
30/100	63	4
30/100	100	4

3.2.2.4 Earthing Systems

Applications: It is used to provide reference voltage for protection systems.

Product Description: It consists of earthing wire of copper and copper plate or GI rods. It is deeply buried inside the ground and in many cases salt and coal is used to increase the conductivity of the soil.

Sizes: Available in different sizes. *See below.*

Reference standard of Earthing Plate

Size of the copper plate (mm)	Thickness of the plate (mm)
300 X 300	1.5
300 X 300	3
450 X 450	1.5
450 X 450	3
600 X 600	1.5
600 X 600	3

3.2.2.5 Lightening Arrestors

Applications: It is used to protect the system against high voltage surges including lightning.

Product Description: Available in single phase or three phase and consists of varistorsn, zinc oxide elements with insulators.

0.5 kV Lightening Arrester

Specifications: Rated voltage 0.5kV

Type and designation MFTOVAR

Nominal discharge current 10kA

11 kV Lightening Arrester

Specifications:

Rated voltage 9kV

Nominal discharge current 10kA

3.2.2.6 Current Cut Outs

Application: these are used at the consumer house to limit the power supply. It allows only prescribed power to be available to the consumer.

Product Description: MCB, PTC, ECC are available.

3.2.3 Transmission and Distribution

3.2.3.1 Poles

Applications: It is used for supporting cables to the load center from power house.

Product description: Available in different kinds, wooden, tubular pipe, steel tubular, telescopic pole. The height of the pole ranges from 5 meter to 9 meter.

Wooden Poles

Applications: These should be buried 1.5 meter at least in the ground and plastic wrapping or applied oil to prevent it from damage.

Reference standard size for wooden poles provided by NEA

Pole height (m): 5, 5.5, 6, 7, 8 and 9

Tubular Poles

Applications: These poles are fabricated by the manufactures and are made up of available tubular pipes. It should be concreted at the base. These are made up of mild steels and red oxide is applied to give long life.

Reference standard size for Tubular Poles

Height (m)	Diameter (inch)	Weight (kg)
5	4”	60
5.5	4”	65
6	4”	70
7	4”	82
7.5	4”	87
8	5”	115
8.5	5”	122
9	5”	130

Telescopic Poles

Product Description: These are manufactured from 2 mm and above thick hot rolled steel. These are light poles of each 1.25m, 2m or 2.5m lengths and each one fits on top of the other. These are basically used for high voltage transmission.

Specifications:

Material: Mild steel

Steel Tensile Strength: 500 N/mm^2, 550 N/mm^2

Steel Yield Strength: 320,360,400 N/mm^2

Thickness: 2 mm and more

Steel Elongation: 8% or above

Zinc Coating: (gm/m^2) 460, 550, 610

Standard: JIS-G-3132

Reference standard size

Height (m)	Weight (kg)
7.0	69
7.5	96
8.0	88
9	146

Cross Arms

Application: These are used in the poles to carry the conductors. Generally used in high voltage transmission and distribution and in bends.

Specifications:

Material: Mild steel

Finishing: Galvanized

3.2.3.2 Insulators

Application: Insulators are used in the poles to hold the cables, prevents current leakage through poles.

Product Description: Are available in different types, shackle, pin and disc insulators. Shackle insulators are used in low tension line and pin and disc insulators are used high tension line (11 KV). Disc insulators are also used in the bends of the transmission line in the cross arms.

Low Tension Shackle Insulators

Specifications:

Rated voltage: 500V

Highest voltage rating: 1kV

Dry power frequency withstands voltage: 23 kV RMS

Weight power frequency withstands voltage: 10 kV RMS

Mechanical failing load (Minimum): 11.5 KN

Size:

Small: 55 X 55mm

Medium: 75 X 90mm

Large: 100 X 110mm

11kV Insulators

Specifications:

Rated voltage: 11kV

Highest voltage rating: 12kV

Average flashover voltage: Power frequency wet 40kV

Stay Wires

Application: Stay wires are used to hold the poles straight along the transmission line. It is used in the first pole, last pole and along the bends in the transmission route.

Product description: Stay wires are usually made of stranded steel that is heavily galvanized and having tensile strength of 7tons/cm^2. Stay set consists of MS rod, stay bow, stay insulator, check nut, thimble and anchor plate. Stay wires are 5-7 m in length.

Reference standard size:

7/12 with 3mm plate, 7/12 with 6mm plate and 7/12 stay cable only

3.2.3.3 Cables

Applications: Cables are used to transmit the generated electrical power from one point to other.

Product Description: Available in different types, ACSR conductors, power cables (Aluminum, Copper) armoured and unarmoured, PVC cables, concentric cable etc.

Aluminum Conductor Steel Reinforced (ACSR) Conductors

Application: These cables are used in transmission and distribution of electrical power from first pole to the load centre in case of overhead lines.

Product Description: It consists of a core of galvanized steel strand surrounded by a number of aluminum strands. The steel conductors used are galvanized in order to prevent rusting and electrolytic corrosion. The steel core takes a greater percentage of mechanical stresses while the aluminum carries the bulk of current. These are available in different sizes depending upon the amount of current to be carried. Commonly known with pet names of different cross section area;

Reference standard size

Conductor Code Name	Impedance (Ω/km)	Weight (kg/km)
Squirrel	1.419	80
Gopher	1.152	106
Weasel	0.975	128
Rabbit	0.640	214
Dog	0.418	394

Power Cable

Application: PVC power cables are used to transmit power from the generator to the control panel and distribution networks. Armoured power cables are used for underground power transmission and distribution purposes.

Product Description: The power cables are made up of either copper or Aluminum. They are available in armoured and unarmoured type.

Aluminum Conductor Power cable

Specifications:

Voltage rating: 650/1100V

Standard: IS1554/BS6346

Type: Armoured and Un-armoured

Core size: 2, 3, 3.5, 4

Cupper Conductor Power cable

Specifications:

Voltage rating: 650/1100V

Standard: IS1554/BS6346

Type: Armoured and Un-armoured

Core size: 2, 3, 3.5, 4

Control Cables

Application: These are used for fabrication of panel boards.

Product Description: These are available in PVC insulated copper conductor and multi core power cables.

Control Cable Power Conductor

Quality compliance/Certification: IS1554/BS6346

Type: Armoured and Un-armoured

Size: 1.5 sq. mm, 2.5 sq. mm

No. of cores: 2, 3, 4, 5, 7, 10, 12, 14, 19 and 27

Multi-core Power Flexible Wire

Type: 2, 3, 4 core

Size (sq. mm): 0.75, 1, 1.50, 2.50, 4, 6, 10

PVC Insulated Cables

Application: These cables are generally used for house wiring. Sometimes they are also used to transmit power in small micro hydro schemes and consumer connection from poles. Flexible wires are also used to connect household appliances and temporary extension of power.

Product Description: They are available in different sizes as per the current carrying capacity. It consists of numbers of copper wires of different diameter insulated in PVC.

Specifications:

Voltage rating: 650/1100-volt grade

Quality compliance/Certification: NS 344/IS 694/ BS 6004

Reference standard size

SN	Size	Type
1.	1/18	Single core
2.	3/22	Single core
3.	3/20	Single core
4.	7/18	Single core
5.	7/20	Single core
6.	7/22	Single core
7.	7/16	Single core
8.	19/18	Single core
9.	19/16	Single core

PVC Flexible Cables

Reference standard size

SN	Size	Type
1.	14/60	Medium
2.	14/60	Special thick
3.	23/60	Special thick
4.	40/60	Heavy
5.	14/60	Twin-parallel
6.	23/60	Twin-parallel
7.	40/60	Twin-parallel
8.	23/60	Twin round
9.	40/60	Twin round
10.	23/60	Three core round
11.	40/60	Three core round

Concentric Cables

Application: These cables are used for consumer service connection from LT lines. Sometimes they are also used for distribution in the overhead lines.

Product Description: These cables are concentric and are available in single concentric cables.

Standard: BS 6346/ NEA specification

Reference standard size

SN	Size	Current rating in still air (A)	Resistance (Ω/km)
1.	6 Sq.mm (0.01)	30	4.76
2.	25 Sq.mm (0.04)	70	1.14

3.2.3.4 Transformers

Applications: They transfer electrical energy from systems of one voltage to systems of another voltage. Transformers are used to step up or step down the voltage. It helps to reduce the transmission losses in the system. In the power house, generated voltage is stepped up and at the load center the transmitted voltage is stepped down.

Product description: Available in dry type and oil type

Class A: dry type transformers: core and windings are not contained in an insulating liquid. Heat losses are dissipated direct to the ambient air, hence large surface area and low current density.

Class O: oil immersed transformers: core and winding are contained in mineral oil or similarly flammable synthetic liquid with a fire point < 300°C which is simultaneously coolant and insulating medium.

Single Phase 230V-1KV (1000V), Dry Type

Specification:
Phase 1
Frequency 50Hz
Insulation Class H
Insulation Voltage 1000V
Impedance 4%
Quality compliance/Certification: ISO 9002

Reference standard size

Power (kVA)	Weight (kg)	No load loss (W)	Load loss (W)
1	20	10	35
2	30	15	60
3	45	25	85
4	52	35	105
5	60	40	130
10	75	60	250

Single Phase 230V-11KV, Oil Type

Specification:
Phase 1
Frequency 50Hz
Insulation Class A
Insulation Voltage 11000 V
Impedance 3%
Quality certification: ISO 9002, IEC76

Reference standard size

Power (kVA)	Oil (Liters)	Weight (kg)	No load loss (W)	Load loss (W)
5	25 - 34	100	40	130
15	40	160	80	370
25	60	210	130	500

Three Phase 400v-11KV

Specification:
Phase 3
Frequency 50Hz
Insulation Class A
Insulation Voltage 11000 V
Impedance 4%

Reference standard size

Power (KVA)	Oil (Liters)	Weight (kg)	No load loss (W)	Load loss (W)
15	80	250	95	470
25	90	290	110	650
50	125	410	170	1050
100	200	620	300	1850
125	220	780	370	2100
160	240	950	440	2350

Isolators

Applications: These are used to isolate the load from supply and are manually operated.

Specifications:
Rated voltage I5kV
Rated normal current 600A
Short time withstand current 25KArms 3s

DO Fuses

Application: These are used for the protection of transformers and with isolators.

Specifications:
Rated voltage I5KV
Rated breaking capacity 100A
Impulse withstand voltage 95kv

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Appendices

APPENDIX A:

Quality Supervision Format for Micro Hydro Plants under Construction

Community Electrification Sub Component (CESC)

QUALITY SUPERVISON FORMAT FOR MH PLANTS UNDER CONSTRUCTION

General Instructions:

1. *Photographs showing site progress work and specific problems noticed should be attached in the report*
2. *Fill all information requested in the format and provide comments as necessary*
3. *Use additional sheets if space provided is not sufficient*

A. General Information:

Site visit team:

SN	Name	Designation	Signature
1			
2			
3			
4			

Project Name: Location (District/VDC):

Gross Head:_____(m) Design Discharge:____(l/s) Installed capacity: ____(kW)

No. of HH:______ Subscribed power per HH: _____Watt

Ownership: (I) Private (II) community (III) Other, Specify ________

Name of Installation Company:_____________________________________

Starting of construction as per contract: _______________________________

Expected date of completion as per contract: ___________________________

Will the project be competed on time: ( ) Yes ( ) No

If not, at earliest the scheme will be completed by: ____________________

Reasons for delay:

……

……

B. Technical Aspect

I Local Material collected for civil Construction:

Local Material	Types /Quality	Comments
Sand:		
Stone:		
Gravel:		
Wood:		
Others (if any)		

II Civil Construction: Status and quality of works:

Items	Description with specification of installed and or available at site	Comments on deviation from detailed feasibility Report/drawing
1. Intake		
2.Gravel trap		
3. Headrace		
4. Settling basin		
5. Forebay		
6. Anchor blocks & Support piers		
7. Penstock alignment		
8. Power house		
9. Machine foundation		
10. Tail Race		

Comments/Suggestions on Quality of Works:

Your Comments on the major deviations from detailed feasibility study/contract document:
……
……
……
……

What are the major recommendations that you have made or would like to made to the working team at the site in the civil Parts:
……
……
……
……

II Electromechanical Installation: Status and quality of works:

Items	Description of the component with specification, installed or available at site	Comments on deviation from detailed feasibility Report/drawing
Gate Valve		
Turbine		
Transmission system		
Generator:		
Load Controller		
Transmission and distribution		
Earthing and lightning protection		
Other items (if any)		

Comments/Suggestions on Quality of Works:

Your Comments on the major deviations from detailed feasibility study/contract document:
………
………
………
………

What are the major recommendations that you have made or would like to made to the working team at the site in the Electro-mechanical Parts:

………
………
………
………

IV Installation Company (Contractor)/manufacturer:

Name(s) & qualification(s) of company's site in charge:

……………………………………………………………………………………………………

From start of construction how many days has the site in charge been in the site?

……………………………………………………………………………………………………

SN	Other Manpower	Nos.	Remarks
1	Engineer		
2	Overseer		
3	Junior Technician		
4	Others (specify)		

C. Market aspects:

Details of entrepreneurs/end use owners:

Name of entrepreneur/ end use owner	Type, location &Capacity	Work progress & estimated time of completion

Specific comments/concern that the entrepreneurs/end use developer have
………
………
………
………
………

D. Socio-economic aspects:

Community contribution and participation (for community owned scheme):
Has the Community participation (in terms of labor contribution/mass meetings etc) been?

( ) Very active

( ) Active

( ) Not so active

( ) No participation at all

Was the community involved in setting the tariff: (..) Yes ( ) No

Specific comments/concerns that the community members have:

………
………
………
………

Are there water right problems? ( ) Yes ( ) No.

If yes, give a brief description:
………
………
………
………

Other legal issues:
………
………
………
………

What are the major social problems identified and remedial measures suggested by the community/developer?

Problems identified	Suggestions for improvement

E. Institutional aspects

Proposed staff for plant operation and maintenance

Position	Qualification

Will the above staff able to independently operate the plant (..) Yes ( ) No

Have the staff received any training on plant operation & management (..) Yes ( ) No

Type of training required:

………
………
………
………

In case of privately owned plant, what will the role of the developer be in the operation and maintenance of the plant?

………
………
………
………

F. Financial aspects:

Record Keeping and Accounting:
Is a record book being kept and regularly filled?……… (..) Yes ( ) No

Is account book being kept and regularly filled?……… (..) Yes ( ) No

Funding sources:

Subsidy	
Bank loan	
Local contribution	

Status of the Equipments and materials at site:

Has a storeroom been provided at site (storage of electromechanical equipment, cement etc)?

( ) Yes (.) No

How well the store inventory has been maintained? Who takes care about the store?

………………………………………………………………………………………………………

………………………………………………………………………………………………………

G. Comments

List any specific comments that theses may have

1. Management committee Chairman

………
………
………
………

2. Installation company representative

………
………
………
………

APPENDIX B:

Testing and Commissioning Format of Micro Hydro Plant

Community Electrification Sub Component (CESC)

Testing and Commissioning Format of MH Plant

A. Salient Features of the Plant –

Name of plant:	Name of Owner:
Location:	
Manufacturer:	Supplier/Installer:
Ownership: Private/community	No of households:_____/_____(Designed/Actual)
Gross head________ m; Design flow __________ l/s Rated output kW _____________ System: single-phase/Three-phase Voltage ______ V; Maximum Current____________ A	
Start of Construction of project: _____________day/month/year Commissioning date: _____________day/month/year	

B. Technical status of the plant:	
B.1 Intake	
Type of intake:	Permanent/Temporary
If permanent any cracks observed:	Yes/No
Any leakage observed:	Yes/No
Trash rack at intake:	Installed/Not installed
If installed, Clearance: ______ mm,	
Any structured cracks observed:	Yes/No
Type of Trash rack:	metal / local (specify)
Flow controlling mechanism: Sluice gate / wooden stop logs / bush-boulder /Others (specify) ………	
Remarks on Intake – Briefly discuss any major defects observed………………………………………………………	
B.2 Head race	
Length of head race (section 1): _______ m Section: Rectangular/Trapezoidal/Triangular	Type of head race (section 1): open earth / open cemented / HDPE conduit / others (specify)
Length of head race (section 2): _______ m Section: Rectangular/Trapezoidal/Triangular	Type of head race (section 2): open earth / open cemented / HDPE conduit / others (specify)
Length of head race (section 2): _______ m Section: Rectangular/Trapezoidal/Triangular	Type of head race (section 2): open earth / open cemented / HDPE conduit / others (specify)
Any leakage observed:	Yes/No
Any cracks observed:	Yes/No
Remarks on Head race – Briefly discuss any major defects observed ………………………………………………….	

B.3 Fore bay

Type of Fore bay:	Stone masonry in c/s / RCC / Others (specify)
Trash rack:	Installed/Not installed
If installed, Clearance: ______ mm,	
Any structured cracks observed:	Yes/No
Type of Trash rack:	metal / local (specify)
Spillover:	incorporated/not incorporated
Flushing arrangement:	Works well/ defects observed
Air vent pipe:	installed/not installed

Remarks on Fore bay – Briefly discuss any minor/ major defects observed:

B.4 Gravel Trap/ Settling Basin

Type:	Stone masonry in c/s / RCC / Others (specify)
Flushing arrangement:	Works well/ defects observed

Remarks on Gravel Trap – Briefly discuss any minor/major defects observed

B.5 Penstock pipes

Penstock Length (section 1 / top): ______ m	Section 1: HDPE / GI / MS; Thickness ________ mm; OD _________ mm; ID ________ mm; Class _________
Penstock Length (section 2 / mid): ______ m	Section 2: HDPE / GI / MS; Thickness ________ mm; OD _________ mm; ID ________ mm; Class _________
Penstock Length (section 3 / bot): ______ m	Section 3: HDPE / GI / MS; Thickness ________ mm; OD _________ mm; ID ________ mm; Class _________
Any leakage observed in Penstock:	Yes/No
Ground clearance maintained:	Yes/No (Minimum 300 mm should be observed)
Expansion Joint:	Flange connected/Welded
Any leakages in expansion joint:	Yes/No
No of joints:	_____ Nos
Maximum expansion measured:	J1=_____ J2=______ J3=______ J4=_______
HDPE conduit buried:	Yes/No
Pipe intake clearance:	_________
No of Penstock Sections:	_________

Remarks on Penstock pipes – Briefly discuss any major defects observed

B.6 Anchor Blocks/Support Pier

Any cracks observed in Anchor blocks:	Yes/No
Any cracks observed in support piers:	Yes/No

Remarks on Anchor blocks/support piers – Briefly discuss any minor/major defects observed ……………

B.7 Powerhouse

Powerhouse size (internal):	L _____ m x B _____ m x H _____ m
Construction:	Stone masonry in c/s / Dry stone / Others (specify)
Powerhouse roof:	Corrugated GI / Plain GI / Others (specify)
Powerhouse floor:	Compacted earth / Dry stone slabs / Cemented
Adequate working space for O/M:	Yes/No
Cleanliness:	Yes/No
Adequate lighting in PH:	Yes/No
Free of undue leakages:	Yes/No
Tailrace safely disposed off:	Yes/No
Earthing done properly:	Yes/No (Earth resistance < 10 ohm:)

Remarks on Powerhouse – - - - - - - - Briefly discuss any major defects observed

B.8 Tailrace

Construction:	Stone masonry in c/s / Earth / Others (specify)
Section:	Rectangular/Trapezoidal/Triangular
Condition of tailrace:	good/bad/worst
Any cracks observed in structure:	Yes/No

Remarks on Tailrace – Briefly discuss any major defects observed

B.9 Turbine and Driving System	
Type of Turbine:	Pelton / Crossflow/ Francis/ Other
Number of jet (if Pelton)	_________ jets
Pressure gauge installed:	Yes / No
If Yes, Size of gauge:	_________kg/cm^2
Pressure head during plant operation:	_________kg/cm^2
Pressure head during plant closure:	_________kg/cm^2
Type of valves installed:	Spear valve / Gate valve:
Runner mounting:	Vertical / Horizontal
Driving System:	
Type of Belt:	V-Belt/Flat Belt OR Direct coupling
Size:	________
Alignment:	Well aligned/deviation observed
Remarks on Turbine and driving system – – Briefly discuss any major defects observed	

B.10 Generator			
Specification:			
Type:		Synchronous / Induction	
Phase:	3-phase/1-phase	Voltage:	________V
Capacity:	_______kW/kVA	PF	________
RPM	_______ rpm	Full load current:	________ Amp
Frequency:	________Hz		
Insulation class:	______	Protection class:	________ IP
Manufacturer:	_____________________		
Earthing done properly:		Yes/No (Earth resistance < 10 ohm)	
Remarks on Generator: - Briefly discuss any major defects observed			

B.11 Load Controller and Ballast		
Load controller type:		ELC/ELC-Extension/IGC:
Capacity:	________kW	
Rating voltage:	________Volt	Current: ________ Amp
Condition of load controller:		operates well/ deviation observed
Ballast:		
Ballast heaters type:		Immersed in tail race / Immersed in separate water tank / Wall mounted space heaters / Others (specify)
Ballast heater specifications: __________ volts; __________ watts; Quantity ___________ nos.		
Remarks on Load Controller: - Briefly discuss any defects observed.		

B.12 Control Panel and Switchgear

Protection provided:	Yes	No
Over voltage / under voltage:	___	___
Over frequency/ under frequency:	___	___
Overload/Short circuited:	___	___

Are the installed fuses / breakers are of adequate size: Yes/No

Size of MCCB/MCB: _______Amps Rated breaking capacity of the breaker: _______ K Amp

Type of Fuse installed: HRC/KIT-KAT Rating: _______Amps

Emergency switch and feeder switch working properly: Yes/No.

Lightning arrestors installed at the power house: Yes/No.

Measuring instruments incorporated in the Control panel to measure the following:

1.	Main voltage and Ballast voltage	Yes ( )	No ( )
2.	Load currents	Yes ( )	No ( )
3.	Frequency	Yes ( )	No ( )
4.	Power (kW) if provided	Yes ( )	No ( )
5.	Energy (KWh) if provided	Yes ( )	No ( )
6.	Indicator lamps	Yes ( )	No ( )
7.	Time totalizer (turbine operating hours)	Yes ( )	No ( )

Remarks on Control Panel and switchgears – Briefly discuss any defects observed

B.13 Cable, Connections and supply

Type of power cable used in the power house:	Copper/Aluminium
Size of Cable	________mm^2
Cable jointing and connections properly?	Yes/No
Type of Service cable used for hooking up:	Concentric/ Twin flat/ others
Size of Cable:	________mm^2
Tapping connection done properly?	Yes/No
Consumer end voltage within limit?	Yes/No (Additional voltage drop should not exceed 2%)
Receiving end voltage at peak load:	At start of village: ________Volt
	At mid of village: ________Volt
	At end of village: ________Volt

B.14 Transmission/distribution lines

Type of transmission/distribution	Overhead/underground
Length of the system:	__________m;
Type of cable:	ACSR/ABC/PVC
Type of Pole:	Mild Steel / Wood

- Lightning arrestor installed at each end of line and at every lightning prone areas of the system. Yes/No
- If neutral on top, is it grounded directly? Yes/No
- Are Earthings provided to each lightning arrestor? Yes/No
- Are all joints along the earth path being brazed/soldered? Yes/No
- Should line patrolling be carried out before commissioning? Yes/No
- Is measured Ground resistance < 10 ohm? Yes/No
- Are Fuses/switches (DB) provided at branch point of the distribution lines for load more than 10 kW are of adequate type and size and fits in the network of power supply. Are DB boxes weatherproof and rain protected? Yes/No
- Shall pole stays be used at all poles at angle and at line ends? Yes/No
- Preservative or anti corrosion paint (Black Japan paint) applied on pole foundation? Yes/No
- Safety clearances adequate? Yes/No

  General clearances: Ground to Wire: Off road: _______m

  Across road: _______m

  Along sides of motor road: _______m
- Insulator type acceptable? Yes/No

Remarks on electrical lines: Briefly discuss any defects observed in construction, finishing, cable jointing and terminations, service cable tapping, bedding, clearance and safety of transmission and distribution system.

B.15 Subscriber connection

Power limit	25 W	50 W	75 W	100 W	125 W	150 W	200 W
Number							
Limit switch type							
Remarks							

B. 16 Manuals and other related documents

All the specified manuals are supplied **(Acceptable)** ☐
Few of the specified manuals are supplied **(Not acceptable- Non Critical)** ☐
Non of the specified manuals are supplied **(Not acceptable- Critical)** ☐

Confirm supply of following manuals:

(a) Operation, Maintenance and trouble shooting manual Yes/No
(b) Check list for fault detection and communication with manufacturer, checklist for normal operation (bearings, instruments, belts, coupling rubbers, noise vibrations) Yes/No
(c) Technical manual of as-built plant Yes/No
(d) Sample (master copy) of operation sheet for the operator (e.g. data, instrument readings, observations, reading interval, signature etc) Yes/No
(e) Sample (master copy) of maintenance sheet for the operator (lubrication intervals, check intervals, signature etc). Wiring diagram of power station with description of all fuses (type and size) Yes/No
(f) Address, phone number of suppliers and sub-suppliers for spare parts ordering and guarantee claims. Yes/No
(g) Wiring diagram of power station with description of all fuses and switches (type and size) Yes/No

Remarks:

B.17 Spares parts and tools			
List the spare parts and tools supplied to the plant:			
Spare parts		Tools	
Description	Remarks/Condition	Description	Remarks/Condition
Comment on supplied v/s quoted list of spare parts and tools:			
Recommend any additional spare or tool that is required for the site and equipment condition:			

B.18 Other remarks and observations –

a. All power and control cable within the powerhouse are armored cable (or PVC cables in HDPE conduit) and are either buried or in trench:

Yes ( ) No ( )

b. Power and control cable terminations within control boxes are marked/numbered and connected through terminal connectors.

Yes ( ) No ( )

c. Equipment outer surface is painted with matching color where needed.

Yes ( ) No ( )

d. Equipment metal parts are earthed with all different parts connected in parallel to one star-point.

Yes ( ) No ( )

e. Connecting underground cables along straight-through sections are done using jointing kits.

Yes ( ) No ( )

Requirements as per the prevailing standards for MHP Installations should be met.

C. Performance Check of the Installation –

C.1 Situation 1 – Static condition (Nozzles, valves all closed; fore bay drain closed; Approximately required amount of water diverted toward head race and penstock pipe slowly filled and water expelled via spillover channel.)

Note static head indicated by pressure gauge in powerhouse, Hg = _____ m (1 bar = 1 kg/cm^2 = 10 m)

1. **Flow-controlling mechanism at intake**

a. Flow can completely be blocked if desired, and amount of water flowing toward head race can be controlled (**acceptable**) ▢

b. Flow cannot be stopped and controlled (**not acceptable – non critical)** ▢

2. Free board in Headrace Canal

a. Free board of at least 30 cm or half the height of water at design flow is maintained throughout **(Well and Acceptable)** ▢

b. Free board of at least 10 cm is maintained throughout (**acceptable**) ▢

c. Free board less than 10 cm (**not acceptable– non critical**) ▢

3. Head Race performance:

a. Minor leakage or no leakage through headrace **(Acceptable)** ▢

b. Minor leakages but in many portion of the headrace (**Not acceptable– non critical**) ▢

c. Major leakages and cracks in the structure (**Not acceptable–critical**) ▢

4. HDPE pipe Burial

a. All HDPE sections along head race are buried or covered (**acceptable**) ▢

b. Any portion not buried or not covered (**not acceptable – critical**) ▢

5. Spill way

a. All of design flow can safely be expelled from the spillover channel (**acceptable**) ▢

b. All design flow can not be expelled safely from spillway channel (**not acceptable – critical**) ▢

6. Penstock

a. No water leakage from penstock joints/welded section (**Acceptable**) ▢

b. Water leakage from penstock joints/welded section (**not acceptable – Critical**) ▢

7. Support piers and Anchor blocks

a. Metal penstocks are adequately supported to form straight lengths (**acceptable**) ▢

b. Penstock line sagging (**not acceptable – critical**) ▢

c. Cracks in the structure (**not acceptable – critical**) ▢

8. Earth resistance Test

a. Neutral earthing at powerhouse < 10 ohm (**acceptable**) ▢

b. > 10 ohm **(not acceptable – non critical)** ▢

c. > 50 ohm **(not acceptable – critical)** ▢

Give the Value:………… ohm

d. Any other remarks for performance check during static condition

(Requirements as per the prevailing standards for MHP installation should be met)

C.2 Situation 2 –Dynamic condition

(All valves are slowly opened to maximum open condition so as to operate the set at full flow condition. Fore bay should still be filled with water up to the spillover channel crest level. Bring more water if required.)

Note dynamic head indicated by the pressure gauge in powerhouse, Hn = ____________ m

Note water discharge at tail race, Q = _________ l/s (approximate measure by means of weir at tailrace)

1	Gen. volt _____ V	Gen. Freq. ___ Hz	Feeder line current ____ A	Ballast volt/current _____ (full ballast; no village load)
2	Gen. volt _____ V Volt. change ___ V	Gen. Freq. ___ Hz Freq. change __ Hz	Feeder line current ____ A	Ballast volt/current _______ (village load ~ 50% of rated plant capacity)
2a	Switch OFF village load	Time to return to steady state condition: ___________ sec		
2b	Switch ON village load	Time to return to steady state condition: ___________ sec		
3	Gen. volt _____ V Volt. change ____ V	Gen. Freq. ____ Hz Freq. Change __ Hz	Feeder line current ____ A	Ballast volt/current ___(set ~ zero) Pf of village load _______
3a	Switch OFF village load	Time to return to steady state condition: ___________ sec		
3b	Switch ON village load	Time to return to steady state condition: ___________ sec		
3c	Remarks – power factor of village load should be maintained at no worse than 0.8. For this, if some tube lamps are used, total wattage due to tube lamps should not be more than about one-third of total wattage due to incandescent lamps (or resistive loads).			
4	Calculate approx. total power produced, P = Generated voltage x Feeder line current x Power factor * **Give the Value power produced**, P: __________**kW** Guaranteed power produced (**acceptable**) Guaranteed power not produced (**not acceptable – critical**) (* *Provide separate power measurement and calculation sheet. The payment will be made in advance as per above power output, however the final adjustment on the subsidy amount will be based upon the POV carried out by IREF.*)			
5	Calculate approximate power factor = Cos [$\tan^{-1}$ {P2 x 1.73} / {P1 + P2}], Where, P1 = total resistive wattage; P2 = total tube lamp wattage; power factor of tube lamp 0.5			
6	Calculate water to wire efficiency = P x 102 / (Hg x Q) =			
7	Calculate MHP efficiency = P x 102 / (Hn x Q) =			
8	As per the prevailing standards for MHP installation/ commissioning of the plant, following tests are mandatory during commissioning: • Checking operation of mechanical and electrical protection systems; Compared to nominal values trip setting of the protection devices should be as follows (both synchronous and induction generator where applicable) 1. Over voltage at 10% 2. Under Voltage at 20% 3. Over frequency at 15% 4. Under frequency at 10% • Insulation test of cables, generator, transformer and braking system • No-load test with AVR/ Excitation tests • Loading test (Load acceptance, load rejection, output test, stability of controller/governor) • Efficiency test water to wire using calibrated test ballast and instruments			

C.3 Other tests and observations on dynamic situation:

1. Check for unusual noises and vibrations, bearing temperature and other anomalies: (with short circuited generator terminals and without excitation):

A=Acceptable: **NA**=Not acceptable

Rated Speed	Vibration	Noise	Bearing Temp	Body Temp
20%	Un-noticeable **(A)** Minimum **(A)** Noticeable **(NA)**	Uniform high pitch sound **(A)** Non uniform high or low pitch sound **(NA)**	Cool to touch **(A)** Hot to touch **(A)** Too hot to touch **(NA)**	Warm to touch **(A)** Hot to touch **(A)** Too hot to touch **(NA)**
50%	Un-noticeable **(A)** Minimum **(A)** Noticeable **(NA)**	Uniform high pitch sound **(A)** Non uniform high or low pitch sound **(NA)**	Cool to touch **(A)** Hot to touch **(A)** Too hot to touch **(NA)**	Warm to touch **(A)** Hot to touch **(A)** Too hot to touch **(NA)**
100%	Un-noticeable **(A)** Minimum **(A)** Noticeable **(NA)**	Uniform high pitch sound **(A)** Non uniform high or low pitch sound **(NA)**	Cool to touch **(A)** Hot to touch **(A)** Too hot to touch **(NA)**	Warm to touch **(A)** Hot to touch **(A)** Too hot to touch **(NA)**

2. Power cables' temperature (near termination/contact point)
   a. Cool (**acceptable**)
   b. Warm (**not acceptable – critical**)

3. Meter readings as compared to readings of a hand held test meter readings
   a. – Within 5% (**acceptable**)
   b. More than 5% (**not acceptable – non critical**)

4. Earth fault test trip and simulation test (in case of under ground lines)
   a. Successful (**acceptable**)
   b. Unsuccessful (**not acceptable – non critical**)

5. 110% sustained over current simulation test result
   a. De excites (**acceptable**)
   b. Under-voltage operation below 20% (**not acceptable – critical**)
   c. Feeder breaker trips (**acceptable**)
   d. Generator over heats (**not acceptable – critical**)
   e. Nothing happens (**acceptable** provided feeder load switching off does not cause more than 10% over voltage or excitation breakers trip)

6. 120% sustained over current simulation test result
   a. De excites (**acceptable**)
   b. Under-voltage operation below 20% (**not acceptable – critical**)
   c. Breaker trips (**acceptable**)
   d. Generator over heats (**not acceptable – critical**)
   e. Nothing happens (**not acceptable – critical** – this may cause over voltage even for ballast heaters when feeder load gets switched off)

7. Sustained over 10 % voltage simulation test
    a. Excitation breakers trip (**acceptable**)
    b. Nothing happens (**not acceptable – critical**)
8. For both synchronous and induction generator,
    a. Steady state voltage deviation: within - 5% to +5% (**acceptable**)
    b. Beyond –5% to + 5% (**not acceptable – critical**).
9. For synchronous generator (ELC),
    a. Steady state frequency deviation: within –5% to +5% (**acceptable**)
    b. Beyond –5% to +5% (*not acceptable* **– critical**).
10. In case of induction generator (IGC),
    a. Steady state frequency deviation: within –5% to +10% (**acceptable**)
    b. Beyond –5% to +10% (*not acceptable* **– critical**)
11. Transient voltage and frequency deviations due to sudden load changes
    a. Within 15% and 20% respectively (**acceptable**)
    b. Beyond that (**not acceptable**)
12. Any other remaining remarks or observation on dynamic test performed–

    (Requirements as per the prevailing standards for MHP installation should be met)

D. MHP Installation completion certification and remarks –

1. Installation fully accepted with 1 year warranty

Signature of NRREP technician	Signature of Entrepreneur	Signature of Installer
Name:	Name:	Name:
Date:	Date:	Date:

2. Installation conditionally accepted provided all defects are of non-critical type and that they would be corrected within defects correction period of 1 year. (" Non critical")

Signature of NRREP technician	Signature of Entrepreneur	Signature of Installer
Name:	Name:	Name:
Date:	Date:	Date:

3. Installation not accepted as one or more of the defects are of critical type.

("NOT accepted - critical")

Signature of NRREP technicians	Signature of Entrepreneur	Signature of Installer
Name:	Name:	Name:
Date:	Date:	Date:

Witness 1:	Witness 2:	Witness 3:

Note: Please also attach the photographs of various civil and electromechanical components along with the testing commissioning format.

Power Output Test [POT]

Form

Power Output Test [POT] Form for Micro Hydropower Plant

Government of Nepal Ministry of Science, Technology and Environment
National Rural and Renewable Energy Programme
Alternative Energy Promotion Centre

Name of the Scheme: …………………………………………………… **Owner of the Plant:** ……………………………………………

Location:Village………………………………… **VDC**………………………………… **Ward No.**………….. **District:**……………………………

Obs. No.	VILLAGE LOAD POWER													Freq Hz	BALLAST POWER							Weir Height in m	Discharge lit./sec.	Pressure guage Kg/cm2	Valve Position	Remarks
	V_{RN} Volt	I_R Amp	p.f.	P_R kW	V_{YN} Volt	I_Y Amp	p.f.	P_Y kW	V_{BN} Volt	I_B Amp	p.f.	P_B kW	Total Power $P_R+P_Y+P_B$ kW		V_R BVolt	V_Y BVolt	V_B BVolt	P_R kW	P_Y kW	P_B kW	Total Ballast Power $P_R+P_Y+P_B$					
1																										
2																										
3																										

Design Net Head: …..m **Design Flow:** ……lps **Design Power:**…..kW **Minimum Power Required:**

Actual Net Head: ……m **Actual Flow:** …… lps **Actual Power:** ………. kW **Stream Flow by the intake:** ………lps

I/We hereby ceritify that I/we have measured and verified power output from this micro hydro plant. I/We hereby certify that the measured power output for the designed flow of this installation is …………….. kW.

Data Recorded By	Name	Signature and Date
Owner's Representative		
Installer's Representative as witness		
NRREP Representative as witness		

- Approximate power factor = Cos [$\tan^{-1}$ {P2 x 1.73} / {P1 + P2}], Where, P1 = total resistive wattage; P2 = total tube lamp wattage; power factor of tube lamp 0.5
- Ballast Power= $[\{V_{ballast}\}^2/\{V_{gen}\}^2]*P_{Ballast\ Heater}$
- The ballast voltage is non sinusoidal. Therefore a digital meter will usually not give a correct reading, unless it is true RMS meter. The standard panel box meter will give comparatively more accurate reading otherwise.

Flow Measurement

Flow measurement using the salt dilution method or area velocity method to be carried out at the proposed headwork site. Use the following data sheet for the flow measurement with Salt Dilution method.

Water flow measurement by salt dilution method of ………………………………River

Date/Time:

Weather:

Salt used: ………. Gram Water temp:

Baseline Conductivity: …………………… mS (i.e. conductivity in the river before pouring salt solution)

Salt constant k = …………………….

Time (sec)			05	10	15	20	25	30	35	40	45	50	55	60	Sum
Water conductivity in µS	Minutes	1													
		2													
		3													
		4													
		5													
		6													
		7													
		8													
		9													
		10													
TOTAL:															

Area (A) under the curve =

Note that the "Area" here is the area under the graph of conductivity in µ∑ in the vertical axis and time in seconds in the horizontal axis excluding the baseline conductivity (i.e., conductivity measure before pouring the salt solution upstream). Hence, the units of "Area" under the graph are µS Sec.

$$Q = Mk/A$$

Note:

- Use separate sheet if other method has been used for flow measurement.
- Give minimum estimated flow using MIP method.

Household Connection Description Form

Name of the Project : ………………………………………………………………Micro Hydro Project

Address : VDC.: …………………………… Ward No. ……… District : ……………………..

No. of H/H as per design : ………………

SN	VDC	Ward No.	Tole	No. of H/H as per design	No. of connected H/H	Remarks
Total Households						

……………………………………

VDC Representative

Name :

Designation :

Date :

APPENDIX C:

Quality Monitoring Format for Operational Micro Hydro Plants

Community Electrification Sub Component (CESC)

QUALITY MONITORING FORMAT FOR OPERATIONAL MH PLANTS

General Instructions:

1. *Photographs showing functional status and specific problems noticed should be attached in the report*
2. *Fill all information requested in the format and provide comments as necessary*
3. *Use additional sheets if space provided is not sufficient*

A. General Information:

Site visit team:

SN	Name	Designation	Signature
1			
2			
3			

Project Name: Location (District/VDC):

Gross Head:_____(m) Design Discharge:____(l/s) Installed capacity: ____(kW)

No. of HH:______ Subscribed power per HH: _____Watt

Ownership: (I) Private (II) community (III) Other, Specify ________

Name of Installation Company: ____________________________________

Date of operation of the plant: _____________________________________

Date of Official Testing and Commissioning: __________________________

If not commissioned, Expected Date of Official Testing and Commissioning_________________

If the commissioning process has been delayed, Reasons for delay:

……

……

……

B. Technical Aspect:

I Civil Structures: Quality of works:

Items	Description with specification of constructed component	Quality Aspect & Operational problems noticed
1. Intake		
2.Gravel trap		
3. Headrace		
4. Settling basin		
5. Forebay		
6. Anchor blocks & Support piers		
7. Penstock alignment		
8. Power house		
9. Machine foundation		
10. Tail Race		

History of floods and landslide:

Year and Month	Parts damaged	Cost of R & M	Plant shutdown period

Comments/Suggestions on Quality of Works:

Your Comments on major quality deviation from MGSP Standard & Operational problems noticed:
……
……
……

What are the major recommendations that you would like to made in the civil parts from quality aspects:
……
……
……

II Electromechanical Installation: Quality of works:

Items	**Description with specification of installed component**	**Quality Deviation & Operational problems noticed**
Gate Valve		
Turbine:		
Drive system		
Generator:		
Load Controller		
Transmission and distribution		
Service Main		
Earthing and lightning protection		
Other items (if any)		

Observation on Dynamic situation

a. Vibration on machine: noticeable / unnoticeable
b. Noise: Normal and Uniform ( ) Abnormal and Non uniform: ( )
c. Generator body temperature: Normal warm / hot / too hot
d. Bearing temperature (Turbine): (Generator):
e. Meter readings and condition:
g. Voltage at sending end and fluctuation with in observation time:
h. Frequency deviation:
i. Voltage at far most receiving end:
j. Others.

Comments/Suggestions on Quality of Works:
Your Comments on the major quality deviation from MGSP Standard & Operational problems noticed:

………

………

………

What are the major recommendations that you have made or would like to made in the Electro-mechanical Parts:

………

………

………

Over all Quality of Works:

- What components/ equipments are still not supplied or not installed which were proposed in the design/contract? What impacts will these changes have?
- Services provided by the installation Company (Contractor):

  During Installation: Satisfactory / unsatisfactory/ poor

  During first year of operation: Satisfactory / unsatisfactory/ poor

  Further comments from the developer:

  ……………………………………………………………………………………………………

  ……………………………………………………………………………………………………

C. Market aspects:
Household Demand

Total Household connected:	Household estimated to be connection during Connection:					
Subscribed power	…W	…W	…W	…W	…W	…W
No. of HH						
Limit switch type						
Remarks						

Details of entrepreneurs/end use owners:

S N	Entrepreneurs	End uses	Capacity (kW)	Operating hours per day	Operation days/year	Tariff
1.						
2.						
3.						
4.						

Specific comments/concern that the entrepreneurs/end use developer have

………

………

………

………

D. Socio-economic aspects:

- Community participation:
- Involvement of community during tariff determination:
- Perception of the villagers:
- Is there any Water right problems…………Yes/No?

  If yes mention the type of the problem and possible solution.
- Is there any conflict between users and owner?
- Mention if there are any problems from the user side.

- What are the major problems identified and measures suggested by the community/developer?

Problems identified	Suggestions for improvement

E. Institutional aspects

- Users Committee/Developer contribution/commitment/services:

- Availability of the Manager/operators and their services:

- Difficulties in the tariff collection:

F. Financial aspects:

Record Keeping:

Is log book being kept and regularly filled?……………………………….. Yes/No

Is account book being kept and regularly filled?……………………………… Yes/No

History of short/long term shut down of the scheme:

Components/parts failed	Date of short down	No of days	Cost of Repair and maintenance

G. Repair and Maintenance:

Is there a maintenance schedule?………………………………………………….. Yes/No

Do the operator/manager follow the maintenance schedule?………………… Yes/No

Is oiling and greasing done regularly?……………………………………... …. Yes/No

If yes, how frequently:…………………………………………………………………

Is operational/maintenance and trouble shooting manual available and used? Yes/No

Has the availability of water for turbine reduced after installation………Yes/No, if Yes mention the reason:

………
………
………
………
………………………………………………………………………………………………………

Is there any technical repair workshop facility nearby? ……… . Yes/No, if yes mention the services available:

………
………
………
………………………………………………………………………………………………………

Which spare parts and tools are kept and maintained?

Spare Parts		Tools	
Description	Remarks/Condition	Description	Remarks/condition

Is there any specific spares part or tool that had been proposed but not supplied by the Installer/ Manufacturer? If yes mention the component and also try to explore the reason behind?
……..
………
……..

H. Comments

1. Management committee Chairman

2. Operator

3. Consumers

APPENDIX D:

One Year Guarantee Check for Micro Hydro Plants

Community Electrification Sub Component (CESC)

ONE YEAR GUARANTEE CHECK FOR MH PLANTS

General Instructions:

1. *Photographs showing functional status and specific problems noticed should be attached in the report*
2. *Fill all information requested in the format and provide comments as necessary*
3. *Use additional sheets if space provided is not sufficient*

A. General Information:

Site visit team: **Date:**

SN	Name	Designation	Signature
1	…………………………………… (Representative of NRREP technician)		
2	…………………………………… (Representative of Users' Committee)		
3	…………………………………… (Representative of Installer)		

Project Name: Location (District/VDC):

Gross Head:_____(m) Design Discharge:____(l/s) Installed capacity: ____(kW)

No. of HH:______ Subscribed power per HH: _____Watt

Ownership: (I) Private (II) community (III) Other, Specify ________

Name of Installation Company: ____________________________________

Date of operation of the plant: _____________________________________

Date of Official Testing and Commissioning: __________________________

Any problems reported at the time of Official Testing and Commissioning_________ Yes/No

If Yes, What were the problems and have they been addressed by the time of one-year guarantee check

……………………………………………………………………………………………………

……………………………………………………………………………………………………

B. Technical Aspect:

I Civil Structures: Quality of works:

Items	Quality Aspect & Operational problems noticed
1. Intake	
2.Gravel trap	
3. Headrace	
4. Settling basin	
5. Forebay	
6. Anchor blocks & Support piers	
7. Penstock alignment	
8. Power house	
9. Machine foundation	
10. Tail Race	

History of floods and landslide:

Year and Month	Parts damaged	Cost of R & M	Plant shutdown period

II Electromechanical Installation: Quality of works:

Items	Quality Deviation / Operational problems noticed
Gate Valve	
Turbine:	
Drive system:	
Generator:	
Load Controller	
Transmission and distribution	
Service Main	
Earthing and lightning protection	
Other items (if any)	

Observation on Dynamic situation

a. Vibration on machine: noticeable / unnoticeable
b. Noise: Normal and Uniform ( ) Abnormal and Non uniform: ( )
c. Generator body temperature: Normal warm / hot / too hot
d. Bearing temperature (Turbine): (Generator):
e. Meter readings and condition:
g. Voltage at sending end and fluctuation with in observation time:
h. Frequency deviation:
i. Voltage at far most receiving end:
j. Others.

Comments/Suggestions on Quality of Works:

Your Comments on the major quality deviation from MGSP Standard & Operational problems noticed:

………
………
………
………

What are the major recommendations that you would like to made in the civil parts from quality aspects:

………
………
………
………
………

What are the major recommendations that you would like to make in the Electro-mechanical Parts:

………
………
………

Overall Quality of Works:

- What components/ equipments are still not supplied or not installed which were proposed in the design/contract? What impacts will these changes have?

- Services provided by the installation Company (Contractor):

  During first year of operation: Satisfactory / unsatisfactory/ poor

Further comments from the developer:

………
………
…………………………………………………………………………………………………

C. Market aspects:

Household Demand

Total Household connected:	Household estimated to be connection during Connection:					
Subscribed power	…W	…W	…W	…W	…W	…W
No. of HH						
Limit switch type						
Remarks						

Details of entrepreneurs/end use owners:

S N	Entrepreneurs	End uses	Capacity (kW)	Operating hours/day	Operation days/year	Tariff
1.						
2.						
3.						
4.						

Specific comments/concern that the entrepreneurs/end use developer have

………
………
………
………

D. Socio-economic aspects:

- Community participation:

- Involvement of community during tariff determination:

- Perception of the villagers:

- Is there any conflict between users and owner?

- Mention if there are any problems from the user side.

E. Institutional aspects

- Users Committee/Developer contribution/commitment/services:

- Availability of the Manager/operators and their services:

F. Financial aspects:

Record Keeping:
Is log book being kept and regularly filled?………………………………. Yes/No

Is account book being kept and regularly filled?……………………………… Yes/No

Is the plant able to collect the tariff in time? If not how difficult is there in the collection and what are the reason behind such difficulties?

……

……

………..

History of short/long term shut down of the scheme:

Components/parts failed	Date of short down	No of days	Cost of Repair and maintenance

G. Repair and Maintenance:

Is there a maintenance schedule?………………………………………………….. Yes/No

Do the operator/manager follow the maintenance schedule?…………………. Yes/No

Is oiling and greasing done regularly?………………………………………... …. Yes/No

If yes, how frequently:…………………………………………………………………

Is operational/maintenance and trouble shooting manual available and used? Yes/No

Has the availability of water for turbine reduced after installation………Yes/No, if Yes mention the reason:

……

……

……

Which spare parts and tools are kept and maintained?

Spare Parts		Tools	
Description	Remarks/Condition	Description	Remarks/condition

Is there any specific spares part or tool that had been proposed but not supplied by the Installer/Manufacturer? If yes mention the component and also try to explore the reason behind?
……..

……...

H. Comments:

1. Management committee Chairman

2. Manager/Operator

3. Your Overall comments: